New Trends in Agriculture, Forestry and Aquaculture Sciences

Editor:
Prof. Nilda Ersoy Ph.D.

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AMENDMENTS IN THE EIA REGULATION FOR 2022 IN TURKEY: QUO VADİS?

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1. INTRODUCTION

Environmental Impact assessment (EIA) is the assessment of the environmental consequences of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action. In this context, the term "*environmental impact assessment* (**EIA**)" is usually used when applied to actual projects by individuals or companies. EIA is also a tool of environmental management forming a part of project approval and decision-making (Eccleston, C.H., 2011; MacKinnon, Duinker, Walker, 2018). In 2nd the Environmental Law, Environmental Impact Assessment (EIA) refers to (i) determining the positive and negative effects of the planned projects on the environment, (ii) taking measures to prevent negative effects or minimize them to a degree that will not harm the environment, (iii) to the works to be carried out in determining and evaluating the selected location and technology alternatives and monitoring and controlling the implementation of the projects (OG, 1983).

In 10th article of the same law "*institutions, organizations and enterprises that may cause environmental problems as a result of the activities they plan to carry out are obliged to prepare an EIA Report or a project presentation file. Approval, permission, incentive building and use licenses cannot be granted for these projects unless the EIA* "**Positive Decision**" or "**EIA is Not Required**" *decision is taken; investment cannot be started for the project and tender cannot be made*" it is said.

The purpose of EIA can be listed to support the targets of environmental protection and sustainable development to integrate environmental protection with economic decisions during the planning phase of an operation, to predict environmental, social, economic and cultural consequences of the intended activity, and to evaluate to be minimized the negative effects planned activity (Bobat, 2014).

When the Environmental Impact Assessment (EIA) process is mentioned in Turkey, the Environmental Law and the EIA Regulation come to mind first in terms of legislation. Because the EIA report takes its legal basis first from the Environmental Law, and then from the EIA regulation issued in accordance with this law. The Environmental Law came into force in 1983. 10th article of the Environmental Law stipulated that institutions, organizations and enterprises that may cause environmental problems as a result of the activities they plan to carry out should receive an EIA report and stated that this process will be regulated by a regulation to be issued by the Ministry. Unfortunately, the entry into force of this regulation, which is referred to as the EIA Regulation, was in 1993.

EIA Regulation had amended once in 1997 and 1999, three times in 2000, twice in 2002, 2003, 2004, 2008 and 2009, once in 2011 and 2013, twice in 2014, 2016, 2017 and 2018 and in three times 2019, at total of 22 times. And it has been repealed 6 times up to 2022. Finally, on July 22, 2022, the EIA Regulation was amended again, and the regulation dated 2014 has lost its validity (Table 1) (ÇŞİDB, 2022a). There is no other regulation in the legislation on nature and environmental protection that is so played out and amended so often.

When all the changes made to the regulation are examined, it can be said that the first regulation dated 1993 is the best regulation. Because the changes that were made later and are thought to be caused by investment pressures, especially in the oil and mining and energy sectors, have moved away from the goal of environmental protection a little more every year, and each change has aimed to pave the way for investors a little more (Bobat, 2016). With the changes made after 1997, it is clearly seen that the EIA regulation is gradually moving away from the purpose contained in the Environmental Law. The results of the policies of the political powers that have made the EIA process no longer an "obstacle" in front of the investor are also clearly visible in the EIA statistics. 69.158 EIA are "not required", 1.221 EIA are "required", 6.489 EIA "positive" and 63 EIA "negative" decisions were made among 1993-2021 (Figure 1) (ÇŞİDB, 2022b). EIA applications in the oil and mining sector rank first among other sectors, followed by energy, waste-chemical, agriculture-food, industry, transportation-coastal and tourism-housing sectors respectively (Figure 2 and 3).

Table 1. Amendments and Repeals in EIA Regulations in Turkey

Year	Amended Law, Circular or Regulation
1983	Environment Law, Official Gazette(OG) No : 2872/1983
1993	EIA Regulation, OG No : 21489/1993(the first regulation)
1997	New EIA Regulation, OG No : 23028/1997
1999	Amendment in the EIA Regulation OG No : 23785/1999
2000	Adding a Paragraph to 28th Article of EIA, OG No : 24020/2000
2000	Addition of a Temporary Article to the EIA Regulation, OG No : 24185/2000
2000	Amendment in the EIA Regulation, OG No : 24212/2000
2002	New EIA Regulation, OG No : 24777 /2002
2002	Making Changes to 18th Article of EIA Regulation, OG No : 2002/24900
2003	New EIA Regulation, OG No: 25318/2003
2004	Amendment in the EIA Regulation, OG No : 25672/2004
2008	New EIA Regulation, OG No : 26939/2008
2009	Amendment in the EIA Regulation, OG No : 27437/2009
2011	Amendment in the EIA Regulation, OG No : 27905/2011
2011	Amendment in the EIA Regulation, OG No : 27980/2011
2013	Amendment in the EIA Regulation, OG No : 28609/2013
2013	New EIA Regulation, OG No : 28784/2013
2014	New EIA Regulation, OG No : 29186/2014
2016	Amendment in the EIA Regulation, OG No : 29619/2016
2017	Amendment in the EIA Regulation, OG No : 30077/2017
2018	Amendment in the EIA Regulation, OG No : 30451/2018
2019	Amendment in the EIA Regulation, OG No : 30750/2019
2019	Amendment in the EIA Regulation, OG No : 30825/2019
2019	Amendment in the EIA Regulation, OG No : 30962/2019
2022	Last EIA Regulation, OG No : 31907/2022

Environmental impact assessment processes are important processes in terms of pre-evaluating, predicting the damage that a project will cause to ecosystems and taking precautions according to the available data. For this reason, it should be borne in mind that behind the climate change, biodiversity loss, species extinction, loss of forests and wetlands created by man and deepened by the system crisis, and all kinds of destruction that occur on ecosystems, there is actually an EIA process that is not really being operated.

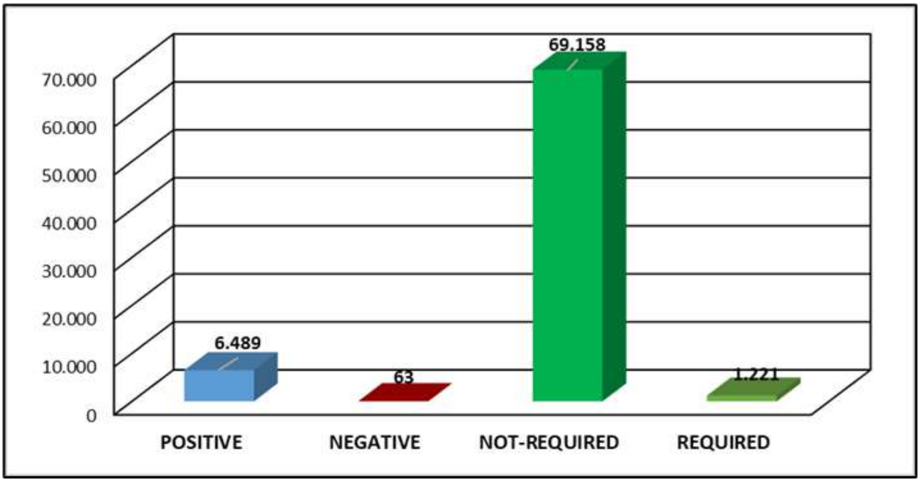

Figure 1. EIA decisions among 1993 and 2021

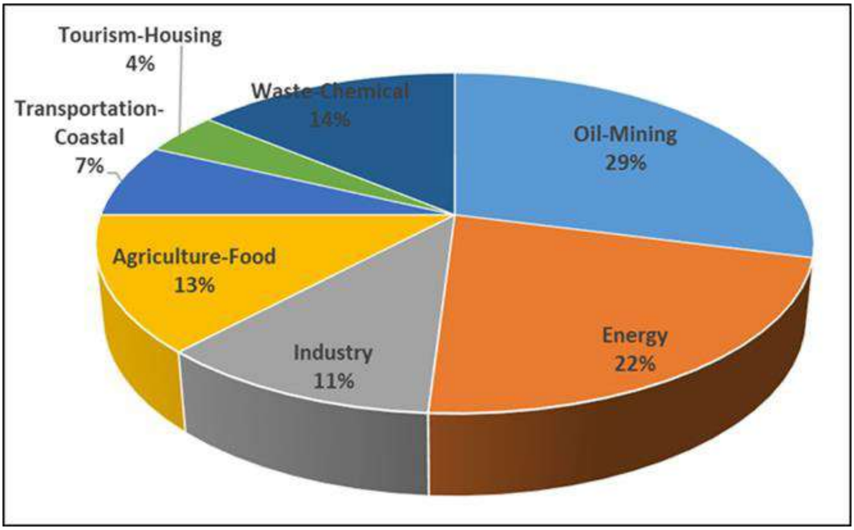

Figure 2. Sectoral breakdown of "**EIA positive**" decisions

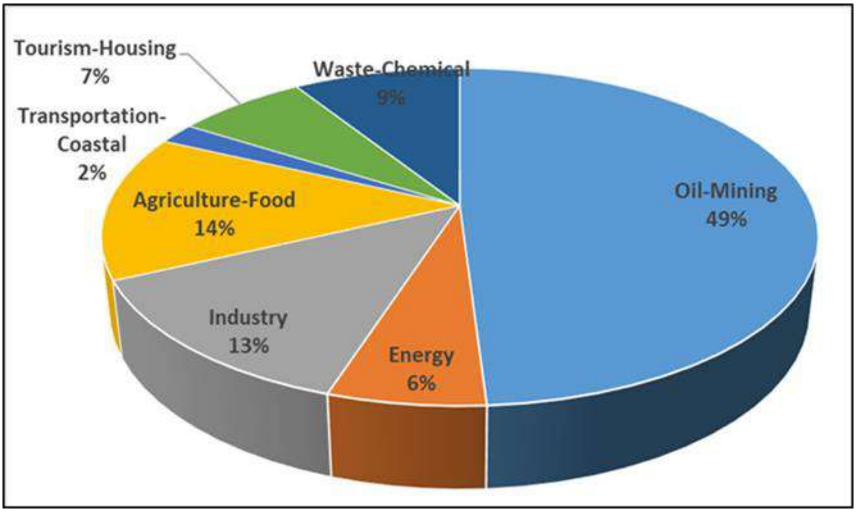

Figure 3. Sectoral breakdown of "**EIA not required**" decisions

With the regulation published in the Official Gazette dated July 29, 2022 with the number 31907, the Environmental Impact Assessment (EIA) Regulation dated 2014 was repealed and the new EIA regulation had published (OG, 2022). In a statement made by the Ministry on the subject, it has stated that the changes made to the regulation that was published and entered into force were made "*within the scope of the green development goals*"(ÇŞİDB, 2022c).

In this article, the amendments made in the EIA regulation and their effects and where the environmental impact assessment has evolved towards are examined.

2. AMENDMENTS IN LAST EIA REGULATION: QUO VADİS?

Since the day it entered into force, the EIA regulation, which has been partially amended 22 times and completely amended 6 times, has been amended once more. Thus, the EIA regulation, which has become almost a formality for the companies and in which the environmental impacts of the project to the region are evaluated, has been scythed once again. According to the new amendment, certain stages of EIA processes were eliminated, and the effects of the project were limited to the area where it will be applied. According to the statement made by the Ministry of Environment, Urbanization and Climate Change via the official website regarding the publication of the new Environmental Impact Assessment Regulation dated 29.07.2022 (ÇŞİDB, 2022c) "*revisions have been made to existing definitions, and new definitions have been added to the application. Amendments have been made for the more effective implementation of administrative parts. Arrangements have been made to enable the public to be* *informed and the number of communication ways in participation has been increased with "the Stakeholder Participation Plan*" put into effect. Taking into consideration of the environmental impacts of activities/projects, adjustments in Annex 1 and Annex 2 Lists have been made, the number of activities that are required to prepare an EIA Report has been increased, and even some sectors have been included in the Annex 1 List regardless of the threshold value. For a more comprehensive and detailed examination of the environmental impacts of the activities/projects included in the Annex-2 List, cumulative impact assessment, preparation of an environmental and social action plan, preparation of a sustainability and environmental monitoring plan have been made mandatory. Zero Waste Plan, Greenhouse Gas Reduction Plan, Impacts on Climate Change, Environmental Monitoring Plan, Environmental and Social Management Plan, etc. it has been made mandatory for many plans to be included in EIA Reports under the "**Sustainability Plan**".

When the provisions of the regulation are examined, it is seen that this claim does not reflect the truth in the full sense. In particular, the claim that this regulation was issued in accordance with the "*Green Development Goals*" is quite exaggerated.

It is true that in the new regulation, the scope/number of projects to which Environmental Impact Assessment will be applied has been increased, as claimed by the Ministry. To give an example, all wind power and hydroelectric power projects are included in the scope of EIA projects without any capacity conditions. Likewise, the exception regarding the projects "*Coal extraction with open operation method in the working area exceeding 150 hectares (as a total of excavation and casting area)*", which was included as an exception in the previous regulation, has been completely abolished. Coal extraction projects with the open operation method will now be evaluated according to the land surface of 25 hectares and above, like other mining projects.

However; again, to give an example from the mining sector, facilities that previously performed at least one of the crushing, screening, washing and ore preparation processes of 400,000 tons per year or more have been excluded from the project to be applied to the EIA. Considering that these facilities are integral parts of mining projects, it is doubtful how missing these facilities, which leave chemical waste, emit dust and smoke, from the EIA process will contribute to green development. Especially considering that these facilities are among the facilities prohibited from being established and operated in terms of the legislation on the protection of olive groves, it will not be difficult to predict the possible damages that this regulation will create.

One of the most notable items in the regulation is that core drilling was excluded from the scope of the EIA.

With the definition of ”**Suspended Announcement**" and the changes made in some articles of the regulation depending on this, the methods of informing citizens about the decisions made as a result of the EIA processes have been narrowed. This narrowing inevitably seriously undermines the rights of citizens to apply to the judicial authorities for the struggle for nature protection and, it is clearly contrary to the right to access information, which is a fundamental right.

With the amendment in article 4, project stakeholders were added to the participants of the public information meeting. With this amendment, it has been made possible not to allow any negative voices to be raised against the projects, to bring stakeholders who have an interest in the project and the public face to face at meetings and to create an environment open to provocation.

With the regulation published in today's issue of the Official Gazette, the authority to make “*EIA Positive*”, “*EIA Negative*”, “*EIA Necessary*” or “*EIA Not Necessary*” decisions about the projects subject to the regulation will belong to the Ministry of Environment, Urbanization and Climate Change, as before. However, in cases deemed necessary, the ministry will be able to transfer the authority to make the “*EIA is Necessary*” or “*EIA is Not Necessary*” decision to the Provincial Directorates of Environment, Urbanism and Climate Change instead of the governorates by determining their boundaries. With the amendment in Article 5, the Ministry of Environment, Urbanization and Climate Change and related institutions have been made effective in the decisions of the EIA reports. According to the provisions of the Regulation, before the decision is made; if it is determined that the implementation of the project is not in compliance with the relevant legislation, the EIA process will be terminated regardless of the stage.

By amending the article 6 the provision "*EIA Positive*” or “*EIA Not Required*” decision does not constitute an obstacle to applying for incentives, approvals, permits and licensing processes was added.

The definition that "*representatives from various organizations can also be called as members of the commission meetings*", contained in Article 8 has been changed to be "*representatives can be included in the commission and can call to meetings as a member*".

Stakeholder effectiveness was increased with the amendment made to Article 9. Thus, it will be ensured that situations such as Public participation meetings should not be held were prevented.

By shortening the periods related to the EIA processes in article 10 and 11 it will be prevented the projects from being on the agenda continuously with the EIA processes.

Article 12, "*Review The opinion of the institution/organization that does not express an opinion within 30 calendar days from the date of the evaluation meeting is considered as positive. In case additional time is needed to express an opinion, the request is forwarded to the Ministry in writing by the relevant member of commission. The requests of institutions/organizations for additional time are taken into account by the Ministry*," was amended. Thus, it will be tried to prevent even the possibility of a slightly negative opinion towards the projects for which the EIA report was prepared.

Article 14 has amended as "*The 'EIA Positive*" decision shall be deemed invalid in the event that the investment is not started for the project for which the *'EIA Positive*' decision has been made within 5 years without force majeure" in the form of changes the time periods are shortened and the projects are intended to be implemented as soon as possible.

With an addition in Article 18, it was foreseen that the implementation processes of the projects will be monitored by the ministry. This shows that instead of monitoring the negative effects of projects, monitoring the implementation processes of the project attracts more attention of the ministry.

With the regulation, the obligation to prepare an EIA report in case of capacity increase or area expansion is planned for projects that are considered out of scope, was also added to the projects that are exempt by law. With an amendment to Article 20, the way to increase project capacities was paved. It is understood that the negative effects of the project can reach an insurmountable magnitude with capacity increases.

The sentence in Article 24 "*Projects planned for capacity increase and/or expansion to be carried out in projects with* ***'EIA Positive'*** *or* ***'EIA Not Required'*** decision" was removed. Thus, as stated in Article 20, capacity increases are being normalized by removing them from extraordinary situations.

In Article 26, "Institutions/organizations that will prepare an EIA Application File, an EIA Report or a Project Presentation File are obliged to obtain a Qualification Certificate from the Ministry. The procedures and principles related to the issuance of the Qualification Certificate, the supervision of the institutions / organizations to which the Qualification Certificate is issued and the cancellation of the document are regulated by the Ministry" was amended. Thus, the procedures and principles were put in a position to be changed directly by the ministry.

In Article 28, the provision "*The Ministry may issue communiques on the implementation of this Regulation if it deems it necessary*" was amended as "*The Ministry may issue regulations on the implementation of this Regulation if it* *deems it necessary*". With this regulation, the amendment authority was given to the ministry without even the need for notification.

Transportation projects are also being exempted from EIA by being included in the scope of Annex 2. While it was necessary to make a decision that EIA is not required for 200 housing units or more in public housing projects, this number was increased to 300 in the new amendment.

According to the new amendment, certain stages of the EIA processes have been eliminated, and the effects of the project have been limited to the area where it will be applied. In scope of new regulation, only the location of the project will be subject to evaluation and, for example, agricultural areas, wetlands, archaeological sites around the project site will not be assessed in the EIA report. The judicial decisions taken in this direction before will also be ignored.

3.DISCUSSION

In order to be able to say that the new EIA Regulation really makes a contribution to environmental democracy, it is essential to make arrangements that guarantee the participation of the public in decision-making processes, the right to say and decide, especially on environmental issues. However, in this regulation, the regulations on the participation of the public in the EIA processes do not go beyond being symbolic. There is also no regulation in this regulation that the promise that the people will say about these processes and the decision that they will make will be taken into account on the administrative floor. To make matters worse, the definition of "*Folk*" has also been narrowed in this regulation. In the new regulation, "*Folk*" has been reduced to "**citizens of the Republic of Turkey and foreigners residing in Turkey**". This change pushes important legal person organizations such as associations, foundations, professional chambers, bar associations that support local people out of the EIA processes.

As if this blow to environmental democracy and participation rights was not enough, with an arrangement such as the "**Stakeholder participation plan**" added to the new regulation, the authority to determine who, in what way, using which methods and tools to communicate and inform from the already distressed "**public**" quota is also being given to EIA firms which is following the EIA process on behalf of the investor.

The process of invalidating the "**EIA positive**" or "**not required**" decision is being made more difficult. A new definition is included in the regulation and this definition is clarified: "**Force majeure**". As a legal term, force majeure, in its simplest and most understandable form, is defined as "a situation that cannot be avoided" and is generally accepted as one of the reasons that eliminate liability.

The phrase force majeure was also present in the old regulation, and in the event that the investment is not started without force majeure within 5 years, it had being created an exception in the regulation related to the invalidation of the project. But the definition of this force majeure had not been in the old regulation. This also led to a number of controversies. It is understood that the new regulation wants to put an end to these discussions by defining force majeure. But the definition available is extremely inconvenient. Force majeure defined in the regulation as follows: For projects of which had been made a decision that EIA is "**positive**" or the EIA is "**not required**”, within the validity period of the decision an external actual situation such as a natural disaster, a state of emergency and administrative judicial decisions that will directly prevent the start of the investment (if there is a decision to stop or cancel the execution in such a way as to affect the completion of the entire project). The problem with this definition is that it makes the judicial processes part of the force majeure. However, judicial processes do not fall under the definition of force majeure in any way. If a cancellation lawsuit is filed against a project, this lawsuit primarily means a rule of law audit. In such a way that judicial processes, on the one hand, while conducting a rule of law audit, on the other hand, reveal the imperfection of the administration's services. If a project is canceled with the decision made as a result of the lawsuit, what is actually proven is that the permits granted by the administration to the sued project are illegal. It is the clear that the administration is not conducting the EIA process in accordance with the law.

Indeed, if the administration does not fulfill or properly fulfill its authorization, supervision and control obligation in the EIA process, and as a result, a loss arises, if the administrative action leading to this loss becomes the subject of a cancellation lawsuit, it is no longer a force majeure cause, but as “*a service defect*” should be mentioned. With the new regulation, the acceptance of force majeure administrative judicial processes actually means giving the investor an extra-legal assurance in the way of “*don't worry if you lose the case, we will find a way to implement your project*”.

From this point of view, the fact that motivation guiding the new regulation is not to prioritize sustainable life, environmental democracy and the rights of participation, but that was unsustainable for an economy, environment, and future generations to continue to violate the rights of nature, and more shiny and fancy presented with a package.

The content and the skeleton of the EIA, the relevant public organization, university, professional chamber, trade union, etc., were being determined at the capacity determination meetings attended by the commission, which was formed with the participation of organizations. After the public participation meeting, the opinions and objections were being evaluated by the commission, which also included experts. This commission was deciding how the EIA special format should be the scoping meeting, which had an important place in the EIA process, was abolished. Only the Ministry will do this now. The ministry has monopolized this business on its own. The Commission was also excluded from the process and its participation was restricted.

It is not regulated how individuals and communities who share their objections to the project by participating in physical meetings at the Ministry, prevent the meetings from being completed and turn them into a discussion forum will participate in the Review Evaluation Commission meeting to be held online. In this case, the microphones will be turned off at the contested points and public objections will be blocked. The right to participate in the online meeting process may be violated.

According to the article added to the regulation with the title “Determination of the scope and special format of the Commission", it was decided to prepare a Special Format of the EIA Report by the ministry in accordance with the opinions and recommendations of the EIA commissioner's institution, organizations, and the public.

Institutions and organizations authorized by the Ministry will be able to make changes to the EIA Report no more than twice. If the correction is not deemed sufficient by the commission, the situation will be determined by a report and the EIA process of the project will be terminated.

In this context, the EIA process regarding the project presentation file, the deficiencies of which are not completed within six months, will also be terminated. If the investment is not started without force majeure within five years for the project decided “**EIA is Not Required**”, and if the application is not made to the Ministry within one year for the projects decided “**EIA is Required**”, the decision taken on this issue will be considered invalid.

4.CONCLUSION AND RECOMMENDATIONS

The priority of developing countries is mostly focused on three important issues such as economic development, controlling the rate of population growth and meeting the increasing energy needs. In this context, the environment and protection are hardly on the agenda of both local and national managers.

Turkey got acquainted with environmental laws in the 1990s, but has not yet been able to internalize the long-term commitment to environmental protection, as environmental problems have not been given more attention. Therefore, the EIA has not matured in Turkey due to limited capabilities and capacities. The EIA system used for environmental problems in Turkey is not effective and applicable in terms of implementation, review, evaluation, decision-making process and monitoring-control-evaluation of problems.

The steps of the project cycle are not fully integrated into the environmental assessment process and the findings of the EIA studies carried out in the decision-making process are not taken into account. The institutional structure, legal basis and transaction process of the current and new EIA system are not satisfactory, especially at the implementation stages.

The main problem arises from inadequacies and omissions in practice. For example, the public information meeting has completely lost its function and turned into a formality. However, as if this were not enough, the definition of public has been changing in the new EIA regulation, preventing the participation of non-governmental organizations and paving the way for companies to take a more active role in the participation meeting under stakeholder participation. But, the people are exercising a democratic right and show that they do not approve of turning a right stipulated by law into a formality (Bobat, 2013a,b).

Another formality is that the Ministry makes a "positive EIA" decision on paper without even going to the area where the project will be carried out, based on the fact that the "extraordinary environmentalist" EIA reports submitted to them are sufficient. This seriously raises doubts about the accuracy and scientific nature of the Ministry's assessments.

Technical guidelines for the implementation of EIA at the general and sectoral levels are lacking. Factors of the scientific and methodological basis of the EIA, such as analytical methods and techniques, the structure of related sciences, support for research and interdisciplinary approach, require more careful and detailed study. Turkey is a country with extremely diverse ecological conditions and various economic, social and cultural structures. Therefore, there are different factors in the dynamics of environmental awareness (Bobat, 2011).

It is seen that many of the regulations that take up space in the new regulation are actually aimed at eliminating the deficits caused by the bad spelling language of the previous regulation and making the EIA processes a little simpler and clearer.

In the new EIA regulation, the number of activities within the scope of EIA has been increased. But there was no need to change the entire regulation or make a completely new regulation for this. Only the replacement of the October 1 List was enough. The current regulation has been amended many times since 1993 and has been repealed 6 times. Some of the regulations contained in the most recently implemented regulation were positive regulations that should be corrected by judicial decisions. Now another goal is being pursued in changing all these regulations. The aim here is to ensure that the EIA regulation and the

EIA process are carried out under the control of the project owners by making changes in some small details in line with the interests of the project owner's.

In Turkey where has a natural protected area, a conservation basin, a forest, and historical protected area on all sides, the fact that 69,158 "EIA is not required", 1,221 "EIA is required", the fact that 6,489 "EIA positive" and "63 EIA" negative decisions have been made among 1993-2021 shows that the EIA reports and EIA procedures has not been took into account by the Ministry of Environment, Urbanization and Climate Change (Bobat, 2017). In the meantime, it is necessary not to lead to a misunderstanding, as 63 projects cancelled, which were given a negative EIA report. These projects have been amended in various ways, some projects have been re-applied by dividing them into parts, and a significant part of them are being implemented with positive EIA or not necessary EIA decisions.

The EIA Regulation is being transformed into an arbitrary regulation by the ministries. At the same time, this leads to serious confusion in the system of judicial practice. In this way, it is not possible to settle the environmental impact assessment process and implement it in accordance with its purpose. In order for legislation to be settled, case law to develop and be applicable, the EIA Regulation should not be changed frequently. Frequent changes and new regulations reduce the expected effect.

In conclusion, the regulation are clearly contrary to the Environmental Law, which is a superior legal norm. According to this principle, which is called the "Hierarchy of Norms", the regulation, which is the lower norm, is contrary to the laws, international conventions, which are the upper norm, and those who contradict them cannot carry judgments. This principle acts as a legal audit function in itself. Despite the legal regulation, citizens are prevented from exercising their participation rights by the regulation, non-governmental organizations, professional organizations, trade unions are excluded from the areas where they will exercise their rights by the provisions of this regulation. This is also contrary to Environmental Law, which is the upper norm and also forms the legal basis for this regulation.

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A REVIEW OF FACTORS INFLUENCING THE FRACTURE TOUGHNESS OF WOOD

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1.Introduction

It is necessary to understand well the concepts of stress and strain and to know the relationship between them in order to predict the failure of materials used in engineering. Objects first begin to change shape under increasing external stress and then break by losing their strength. Deformations under low stresses are elastic, but permanent plastic deformation occurs when the stress exceeds a certain limit (Hibbeler, 2014).

The separation of a solid body into two or more pieces under the stresses applied to it is called a fracture. Fracture types can be classified as ductile fractures or brittle fractures based on their stress-strain curves (Callister and Rethwisch, 2014). Ductile fractures are characterized by significant plastic deformation before and during crack propagation (Gross and Seelig, 2017). Such a crack is often stable, meaning that it does not propagate further as long as the applied stress does not increase. In a brittle fracture, on the other hand, there is little plastic deformation and the cracks can propagate very rapidly. Such a crack can be called unstable and crack propagation continues spontaneously without increasing the magnitude of the applied stress (Callister and Rethwisch, 2014). Ohring (1995) mentioned that brittle fracture is undesirable and must be avoided because it often occurs without warning and often leads to major disasters.

The process of fracture is typically described as one that, when a significant force is applied, changes the structure of a material by causing bonds to break and new surfaces to develop (Vasic, 2000). A fracture occurs in three basic steps: crack formation, crack propagation, and failure, as shown in Figure 1. After initial necking begins, small cavities or microvoids form inside the cross-section (Figure 1b). These microvoids increase in size, merge to form a crack perpendicular to the direction of stress (Figure 1c), and lead to complete fracture of the part (Figure 1e).

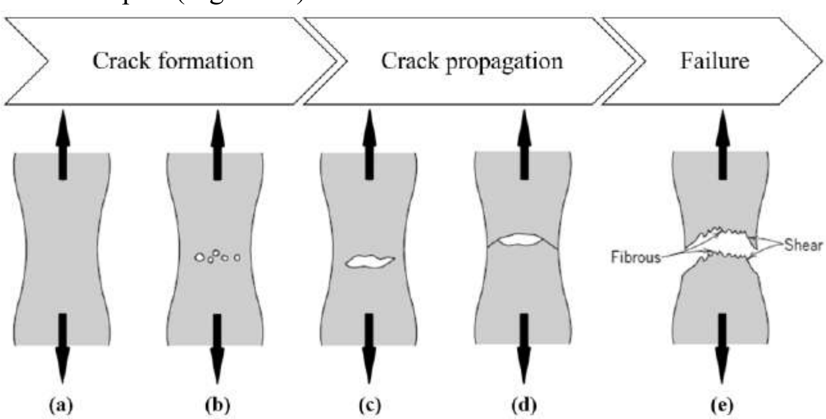


Figure 1. A typical illustration of fracture failure in ductile fracture; initial necking (a), small cavities or microvoids formation (b), microvoids enlarge, come together and coalesce to form a crack (c), crack propagation (d), final fracture (e) (Callister and Rethwisch, 2014).

2.Fracture Mechanics

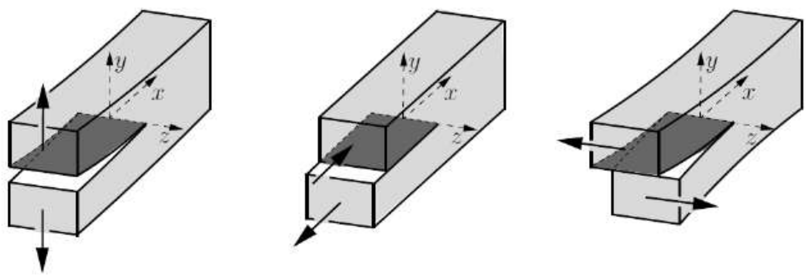
Fracture mechanics has been used for many years as a tool to determine stresses to prevent catastrophic failure of isotropic materials (Mukam-Fotsing, 2001). The first successful analysis of a fracture-related problem was performed by Griffith in the early 1920s (Griffith, 1920). Griffith's approach was based on fracture energy. This approach introduced the first relationship to determine the stress that a brittle material can withstand without breaking when cracks are present. According to this approach, the crack begins to propagate when the elastic energy generated by the stresses around the crack is equal to the surface energy of the newly formed crack surfaces. The approach was first applied to brittle glass, but not to engineering materials such as steel, aluminum, wood, etc. In the 1940s, Hollomon and Zener also applied Griffith's approach to the brittle fracture of metallic materials (Zener and Hollomon, 1944; Hollomon and Zener, 1946). In the 1950s, Irwin proposed a new theory that provided an analysis of brittle fracture from a different perspective (Irwin and Gravel, 1952; Irwin and Gravel, 1954; Irwin, 1957). Irwin (1957) developed a stress intensity factor "K" to characterize the intensity of elastic crack tip fields and symbolize linear elastic fracture mechanics (LEFM). Fracture mechanics was first applied to wood in 1961 (Atack et al., 1961). Walsh (1972) mentioned that LEFM is ideally suited for wood because a wood member generally fails like a brittle material under tensile or shear loading. For predicting the failure loads of wood members having stress concentrations brought on by knots, notches, cracks, and other discontinuities, fracture mechanics provides a rational approach (Patton-Mallory and Cramer, 1987). According to Zink et al. (1995), fracture mechanics can be used to estimate the strength of dry wood when it is subjected to tensile loads at a large angle to the direction of the grain.

The local stress at the crack tip of a loaded part serves as the basis for the stress intensity factor, which depends on the applied load, specimen geometry, and crack length. (Barson and Rolfe, 1999; Vasic, 2000; Smith et al., 2003). The stress intensity factor is defined as below:

$$K = \sigma\sqrt{\pi a}\, f(a/W) \quad (1)$$

where K is the stress intensity factor (MPa $m^{1/2}$), $f(a/W)$ is a dimensionless geometry parameter, σ is the nominal stress (*MPa*), and *a* is the crack length

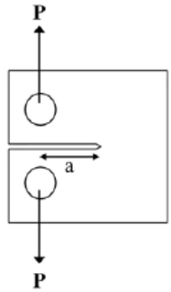
(m). As soon as K reaches a critical level ($K = K_C$), a crack in a loaded material will begin to grow. The fracture toughness of a material is frequently referred to as the K_C, which describes the material's resistance to crack propagation (Smith et al., 2003). Existing cracks in the material can be propagated in three different fracture modes depending on three different loading conditions (Figure 2): Mode I - tensile mode, Mode II - in-plane shear mode, and Mode III - out-of-plane shear mode (Conrad et al., 2003). Crack propagation depending on the loading mode may also occur as a combination of different modes. Mode I is the most important case for most materials (Smith et al., 2003) because it occurs under tension loading. The most typical failure modes observed in a wooden building are modes I and II, whereas mode III fracture occurs in wooden beams with side checks (Patton-Mallory and Cramer, 1987). Frequently, modes I and II combine to cause cracking along the grain direction in wooden parts (Qiu et al., 2012). Tan et al. (1995) examined the fracture toughness of wood that failed in modes I and II and came to the conclusion that the values of mode II were 4-5 times greater than the values of mode I.



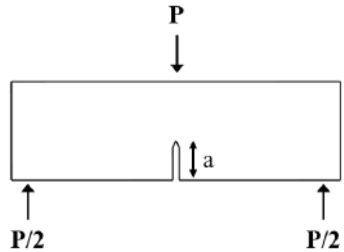
(a) (b) (c)

Figure 2. Illustration of the three different fracture modes as a function of three different loading conditions: Mode I (a), Mode II (b), and Mode III (c) (Gross and Seelig, 2017).

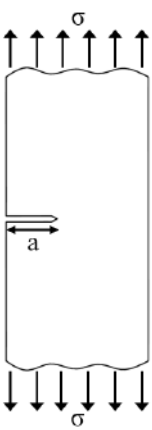
Although there are no standardized test methods for determining the fracture toughness of wood, the ASTM standard (E399-09) for metallic materials is used as a reference in the literature (2009). The fracture toughness of a wood specimen can be evaluated using a variety of specimen configurations subjected to tensile, shear, or bending loads, i.e., compact tension (CT), single-edge-notched tension (SENT), and single-edge-notched bending (SENB). Typical test configurations for determining fracture toughness in modes I and II are shown in Figures 3 and 4.



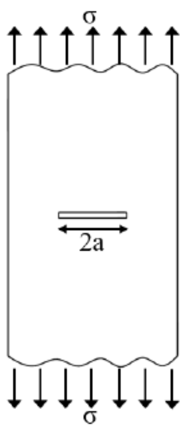
(a) Compact tension



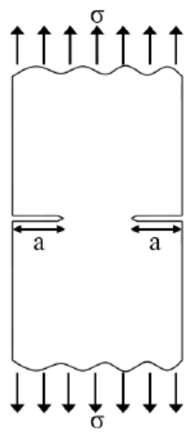
(b) Single-edge-notched bending



(c) Single-edge-notched tension

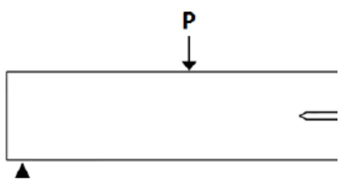


(d) Center-notched tension

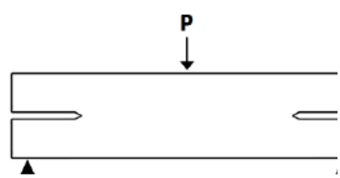


(e) Double-edge-notched tension

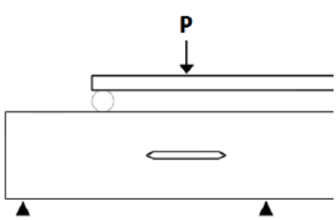
Figure 3. Typical test setups for evaluating the mode I fracture toughness of wood specimens.

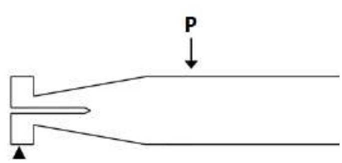


(a) Single end-notched beam

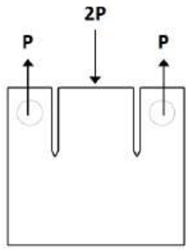


(b) Double end-notched beam





(c) Center-slit beam (d) Tapered end-notched beam



(e) Compact shear specimen

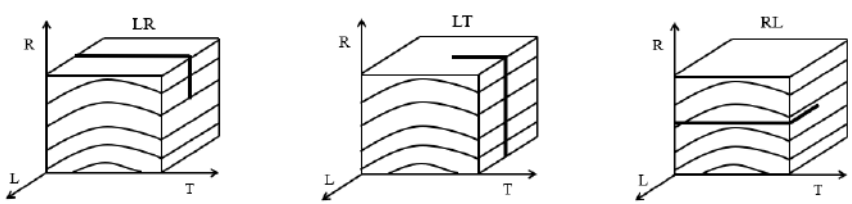
Figure 4. Typical test setups for evaluating the mode II fracture toughness of wood specimens.

1.Factors Influencing the Fracture Toughness of Wood

Fracture toughness is defined as a material property of wood that is not affected by its geometry (Mall et al., 1983). However, it is strongly influenced by the natural features of the wood material as well as by environmental conditions (Porter, 1964; Johnson, 1973; Schniewind et al., 1982; Mall et al., 1983; Petterson and Bodig, 1983; Ashby et al., 1985; Reiterer and Tschegg, 2002; Smith et al., 2003).

1.1 Grain Orientation

In its three different grain orientations—tangential (T), radial (R), and longitudinal (L)—wood is an orthotropic material with independent mechanical properties. Depending on how the material is loaded in relation to the axis of grain orientation, wood has a different fracture and failure properties. Figure 5 shows principal crack propagation systems. Each of the systems is designated by two letters, the first of which specifies the orientation of the grain perpendicular to the crack plane and the second of which specifies the direction of crack propagation. For example, LT indicates that the crack grows in the tangential direction on the longitudinal direction perpendicular to the crack plane.



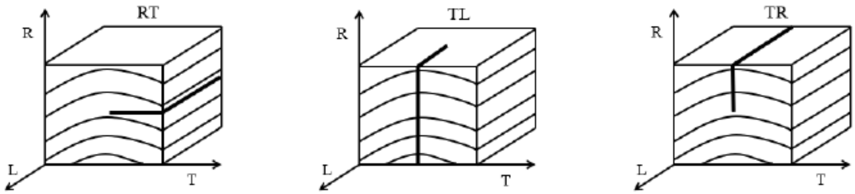


Figure 5. Crack growth directions with respect to the radial (R), tangential (T), and longitudinal (L) axes of the wood grain orientation axis.

Schniewind and Centeno (1973) investigated the fracture toughness of air-dried Douglas-fir in all six principal crack propagation systems (Figure 5). The results showed that two principal crack propagation systems, LT and LR, were significantly higher than the others. According to the position of the crack plane and the direction of crack propagation, the six major crack propagation systems may all be split into two groups. As a result, two groups were established: one for the LT and LR systems (K_{IC} values between 2.42 and 2.69 MPa $m^{1/2}$) and another for the RL, RT, TL, and TR systems (KIC values between 0.31 and 0.41 MPa $m^{1/2}$).

Barrett (1976) mentioned that the four crack propagation systems in which tensile stresses are applied perpendicular to the grain direction (RL, RT, TL, and TR) are of practical importance. Because wood has low strength and stiffness values perpendicular to the grain, the RL and TL crack propagation orientations have been investigated the most frequently (Kretschmann et al., 1991; Smith et al., 2003; Kretschmann, 2010; Qiu et al., 2012).

Konukcu (2022a) investigated the fracture behavior of southern yellow pine in the RL and the RT crack propagation systems using the SENB test method in mode I. The fracture toughness, which indicates the resistance against crack initiation, was found to be significantly higher in the RL than in the RT. For the TR and TL crack propagation systems, Konukcu (2022b) also studied the fracture behavior of southern yellow pine and red oak using the CT test method in mode I. For each of the two crack propagation systems, the findings revealed that red oak had significantly different fracture behavior than southern yellow pine. Although the fracture toughness of the TR was higher than that of the TL, there was no significant difference in crack propagation between the two systems for southern yellow pine. Tables 1 and 2 summarize the fracture toughness values of various wood species in modes I and II as determined in the literature.

Table 1. Fracture toughness values of various wood species in mode I.

Species	Crack system	Fracture toughness (MPa $m^{1/2}$)	Reference
Balsa	TL	0.11	Wu (1967)
	RL	0.11	
Douglas fir	LT	2.42	Schniewind and Centeno (1973)
	LR	2.69	
	TL	0.31	
	TR	0.35	
	RL	0.41	
	RT	0.35	
Hard maple	TL	0.49	Johnson (1973)
Lauan		0.48	
Paper birch		0.56	
Red Oak		0.41	
Western red cedar	TL	0.19	
	RL	0.25	
Mahogany	TL	0.48	Williams and Birch (1976)
	TR	0.35	
Loblolly pine	TL	0.34	Petterson and Bodig (1983)
Redwood		0.18	
Western hemlock		0.37	
Western larch		0.41	
Douglas fir	TL	0.32	Kretschmann (2010)
Ponderosa pine		0.29	
Red spruce		0.42	
Southern pine		0.38	
Scots pine		0.44	
Sugar maple		0.48	
Western hemlock		0.38	
Yellow-poplar		0.52	
Douglas fir	RL	0.36	
Scots pine		0.50	
Sugi	TL	0.21	Ohuchi et al. (2011)
	TR	0.25	
	RL	0.30	
	RT	0.20	
Southern yellow pine	RL	0.36	Konukcu (2022a)
	RT	0.33	
Southern yellow pine	TL	0.38	Konukcu (2022b)
	TR	0.39	
Red oak	TL	0.61	
	TR	0.78	

Table 2. Fracture toughness values of various wood species in mode II.

Species	Crack system	Fracture toughness (MPa m$^{1/2}$)	Reference
Balsa	TL	0.29	Wu (1967)
	RL	0.28	
Western hemlock	TL	2.24	Barrett and Foschi (1977)
Douglas fir	RL	2.24	Murphy (1979)
Red spruce	TL	2.18	Mall et al. (1983)
Douglas fir	RL	2.23	Kretschmann (2010)
Red spruce	TL	2.19	
	RL	1.67	
Southern pine	TL	2.07	
Scots pine		2.05	
Western hemlock		2.24	

Mindess and Bentur (1986) observed the crack propagation of air-dry Douglas-fir wood with three different grain orientations (0°, 45°, and 90°) under a scanning electron microscope. The observations show that the cracks generally propagate along a straight path parallel to the grain, regardless of the orientation of the crack tip. Kretschmann (2008) also investigated the effect of annual ring orientations (0°(RL), 22.5°, 45°, 67.5°, and 90°(TL)) of loblolly pine wood on fracture toughness under mode I loading. The results show that the fracture toughness was very sensitive to the orientation of the annual rings. The value of fracture toughness increased with decreasing ring orientation with a maximum increase of 27%.

3.2 Moisture Content

It is well known that the mechanical properties of wood are affected by moisture content (MC). The fracture toughness of wood may be questioned with a greater MC since its plasticity may rise during crack propagation, according to Atack et al. (1961). Reiterer and Tschegg (2002) also mentioned that the ductility of wood increases with a higher MC. The specific fracture energy of wood also increases with increasing MC. This means that at higher MCs, more energy is required to separate a wood sample into two halves.

Previous studies have shown that increasing the MC of wood species reduces their fracture toughness (Reiterer and Tschegg, 2002; Vasic and Stanzl-Tschegg, 2007; Tukiainen and Hughes, 2016a). It has been investigated how MC affects the fracture toughness of wood in a variety of environments, from oven-dry to wet (> 30% MC) (Porter, 1964; Johnson, 1973; Mindess, 1977; Ewing and Williams, 1979; Schniewind et al., 1982; Petterson and Bodig, 1983; King et al., 1999). King et al. (1999) investigated the effects of MC on mode I fracture toughness of Pinus radiata (Monterey pine) using the SENB test. According to the results, the fracture toughness of dry wood was higher than that of wet wood in every crack propagation system except TR. Conrad et al. (2003) explained this situation by the fact that the crystal structure of microfibrils is disturbed by increasing water at higher MC. Table 3 summarizes the fracture toughness values of different wood species at different MC. According to research by Ewing and Williams (1979) on the effects of specimen thickness and moisture content on the fracture toughness of pine timber, the value of fracture toughness drops below or above MC at 11.2% but achieves a maximum at this moisture content. Kretschmann et al. (1991) also found that fracture toughness increased with decreasing MC of the wood. The results showed that the fracture toughness in mode I reached the maximum value at about 8% MC, while the maximum value in mode II was reached between 7.5% and 10% MC. However, the values of fracture toughness in modes I and II decreased with further drying.

Table 3. Fracture toughness values of various wood species at various levels of moisture content.

Species	Crack system	MC (%)	Fracture toughness (MPa $m^{1/2}$)	Reference
Scots pine (thickness: 6 mm)	TL	0	0.34	Ewing and Williams (1979)
		7	0.42	
		11.2	0.42	
		14	0.37	
		20	0.36	
Scots pine (thickness: 12 mm)		0	0.37	
		7	0.45	
		11.2	0.48	
		14	0.33	
		20	0.38	
Sugi	TR	17.1	0.23	Schniewind et al. (1982)
		saturated	0.17	
Hinoki		16.1	0.24	
		saturated	0.16	
Buna		15.1	0.71	
		saturated	0.40	
Southern pine	TL	4	0.47	Kretschmann and Green (1996)
		7	0.51	
		12	0.47	

		18	0.38	
		saturated	0.29	
Pine	LR	6	3.47	Prokopski (1996)
		9	2.57	
		12	2.31	
Monterey pine	LT	air-dried	2.69	King et al. (1999)
		100	2.21	
	LR	air-dried	2.39	
		100	1.88	
	RL	air-dried	0.49	
		100	0.21	
	RT	air-dried	0.35	
		100	0.24	
	TL	air-dried	0.28	
		100	0.27	
	TR	air-dried	0.20	
		100	0.24	

3.3 Density

Table 4 summarizes the values of the fracture toughness of various types of wood as a function of their density. The fracture toughness of wood increases as its density increases. (Schniewind et al., 1982; Petterson and Bodig, 1983; Ashby et al., 1985; Conrad et al., 2003). According to Kretschmann et al. (1991), wood that failed in both modes I and II had a positive correlation between its density and its fracture toughness values. Ashby et al. (1985) studied the fracture toughness of various wood species (ash, balsa, beech, pine, and teak) and related them to their density. The results show that there is a positive correlation between fracture toughness and density. In addition, the following equations were established:

$$K_{IC}{}^{n} = 20(\rho/\rho_s)^{3/2} \quad (2)$$

$$K_{IC}{}^{a} = 1.81(\rho/\rho_s)^{3/2} \quad (3)$$

The following relationships were also found by Leicester (1983):

$$K_{IC}{}^{n} = 0.0047\rho \quad (4)$$

$$K_{IC}{}^{a} = 0.00063\rho \quad (5)$$

Fonselius and Riipola (1992) mentioned that there is also a positive correlation between mode II fracture toughness and density:

$$K_{IIC} = 180 + 3.60\rho \quad (6)$$

where *n* is cracking perpendicular to the grain (LR, LT), *a* is cracking along the grain (RL, TL, RT, TR), K_{IIC} is the mode II fracture toughness, ρ is the density of the wood (kg m^{-3}), and ρ_s is the density of the cell wall of the wood (1500 kg m^{-3}).

Schniewind et al. (1982) used five softwood and nine hardwood species in TL and LT systems to investigate the effects of density on the fracture toughness of wood. According to the results, density and fracture toughness had a strong association, with coefficients of determination for the TL and LT systems being 0.77 and 0.81, respectively. Reiterer et al. (2002) found quite similar results to those reported in the literature. According to the results, fracture toughness was strongly influenced by density. The linear regression results provided good fits for the RL and RT crack propagation systems, with regression values of R=0.98 and R=0.99, respectively. Konukcu et al. (2021) investigated the effects of the growth ring on mode I fracture toughness of southern yellow pine and red oak in the RL crack propagation system. According to the results, the fracture toughness of red oak was generally significantly higher than that of southern yellow pine. Differences in density between growth rings were evaluated. In both species, latewood had the highest density, followed by earlywood and the interface between latewood and earlywood. The results also show that there was a positive linear relationship between the fracture toughness and density of southern yellow pine and red oak, with coefficients of determination of 0.60 and 0.61, respectively. Konukcu (2022c) also studied the effects of density of the crack-tip location on the fracture toughness of southern yellow pine wood in radial-longitudinal crack propagation direction under mode I loading. Higher-density crack-tip locations were shown to be more resistant to crack initiation. The findings generally demonstrated that density had a considerable impact on fracture toughness and that there was a close relationship between the two.

Table 4. Fracture toughness values of various wood species depending on their densities.

Species	Crack system	Density (kg m^{-3})	Fracture toughness (MPa $m^{1/2}$)	Reference
Balsa	TL	150	0.08	Schniewind et al. (1982)
Beech		600	0.49	
Birch		720	0.61	
Douglas fir		550	0.26	
Lauan		580	0.35	
Madrone		660	0.62	
Hard maple		610	0.47	
Ponderosa pine		420	0.28	
Tanoak		690	0.61	
Balsa	LT	180	0.63	
Beech		590	2.81	
Birch		710	3.30	
Douglas fir		530	1.77	
Lauan		580	2.70	
Madrone		670	1.96	
Hard maple		610	2.80	
Ponderosa pine		400	1.77	
Tanoak		710	3.26	
Ash	RL	676	1.07	Ashby et al. (1985)
Balsa		101	0.06	
Beech		670	0.84	
Pine		572	0.41	
Teak		725	0.51	
Alder	TL	510	0.33	Reiterer et al. (2002)
Ash		701	0.65	
Oak		553	0.41	
Spruce		479	0.31	
Alder	RL	510	0.67	
Ash		701	1.16	
Oak		553	0.83	
Spruce		479	0.49	
Southern yellow pine	RL			Konukcu et al. (2021)
Earlywood		351	0.36	
Interface		451	0.39	
Latewood		601	0.45	
Red oak				
Earlywood		564	0.85	
Interface		585	0.93	
Latewood		670	0.97	

3.4 Temperature

Table 5 summarizes the values of fracture toughness of different wood species at different temperatures. Temperature also affects the fracture properties of wood (Porter, 1964; DeBaise, 1970; Schniewind et al., 1982; Reiterer, 2001; Smith et al., 2003). Porter (1964) studied the effect of temperature (20, 40, 60, and 80°C) on the fracture toughness of western white pine in crack propagation systems LR and LT. The results show that fracture toughness decreases with increasing temperature at high MCs (above 10% MC). However, higher fracture toughness values were obtained at low MCs (below 10% MC) when the temperature increased. Schniewind et al. (1982) also found quite similar results with Porter. They investigated the effects of moisture content (air-dry and wet) and temperature (20, 40, and 60°C) on the fracture toughness of wood using three Japanese species (Sugi, Hinoki, and Buna) in TR crack propagation systems. The results show that the fracture toughness values of wood generally decreased with increasing temperature, and the highest fracture toughness values of the three wood species were obtained at a temperature of 20°C. Reiterer (2001) investigated the effect of temperature (20, 40, 60, and 80°C) on the mode I fracture behavior of spruce and beech wood in the RL crack propagation system. The results show that the value of fracture toughness decreases with increasing temperature for both spruce and beech. The largest decrease was observed between 20 and 40°C. The fracture surfaces of the wood species were also compared using a scanning electron microscope. For spruce with a temperature of 20°C, the surface was rougher and more cell wall fragments torn out of the cell walls were visible than for the surface at 80°C. This means that more energy was required at lower temperatures to initiate the propagation of the fracture.

Table 5. Fracture toughness values of various wood species at various levels of temperature.

Species	Crack system	Temperature (°C)	Fracture toughness (MPa $m^{1/2}$)	Reference
Sugi	TR	20	0.23	Schniewind et al. (1982)
		40	0.22	
		60	0.18	
Hinoki		20	0.24	
		40	0.20	
		60	0.20	
Buna		20	0.71	
		40	0.60	
		60	0.50	

Beech	RL	20	1.70	Reiterer (2001)
		80	1.05	
Spruce		20	0.50	
		80	0.35	

Tukiainen and Hughes (2016b) also investigated the effects of moisture content (air-dried and wet) and temperature (22 and 50°C) on the fracture behavior of spruce and birch in crack propagation systems RT and TR. According to the results, fracture toughness values were generally higher in the RT crack propagation system than in the TR. However, the differences were not significant. When the temperature increased from 22°C to 50°C, the values of fracture parameters decreased, but the effect was much smaller than the MC effect. Dourado and de Moura (2019) investigated the effect of temperature on mode I fracture behavior of Pinus pinaster wood (maritime pine or cluster pine) in the RL crack propagation system. The temperature used in the study ranged from 30 to 110°C. From the results, it can be concluded that Pinus pinaster is not significantly affected in the temperature range of 30-90°C, although the visible difference was observed at temperatures above 90°C. According to the scientists, this is mainly due to thermal degradation of lignin and evaporation of free water.

4 Conclusion

Fracture mechanics, in general, can be expressed as a branch of science that studies the deformation and fracture of a material based on the formation of macro and micro cracks. A fracture will begin to spread when the stress intensity factor reaches a critical value ($K = K_C$). The critical stress intensity factor, which is frequently referred to as the fracture toughness of a material, establishes the material's resistance to crack propagation based on the local stress at the crack tip of a loaded component. It is well-known to everyone that wood is an orthotropic material with unique and independent mechanical characteristics in three-grain orientations: longitudinal (L), radial (R), and tangential (T). Its natural characteristics have a big impact on its mechanical capabilities. Fracture toughness is also defined as a material property of wood that is not affected by its geometry. However, it is strongly influenced by the natural features (e.g. grain orientation and density) of the wood material as well as by environmental conditions (e.g. moisture content and temperature).

5 References

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SOIL ORGANIC MATTER: THE BASIS OF SOIL QUALITY AND PRODUCTIVITY

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Soil Organic Carbon (SOC)

Soil organic carbon (SOC) is the basis of soil quality and productivity (Lal., 2003). Why? Because it improves the soil structure, improves the soil's physical and biological health, acts as a buffer against harmful substances, and most importantly offers the plant nutrients in the composition to the plants (Haynes and Naidu.,1998).

The organic matter (OM) content of undisturbed, healthy soil is around 5%. This rate can be up to 10% in soils with high OM. In poor soils that are constantly processed, used intensively, and poorly managed, it decreases even below 1%. Accordingly, the map of the carbon (C) stocks in Turkey's soil is below 2% (Fig. 1).

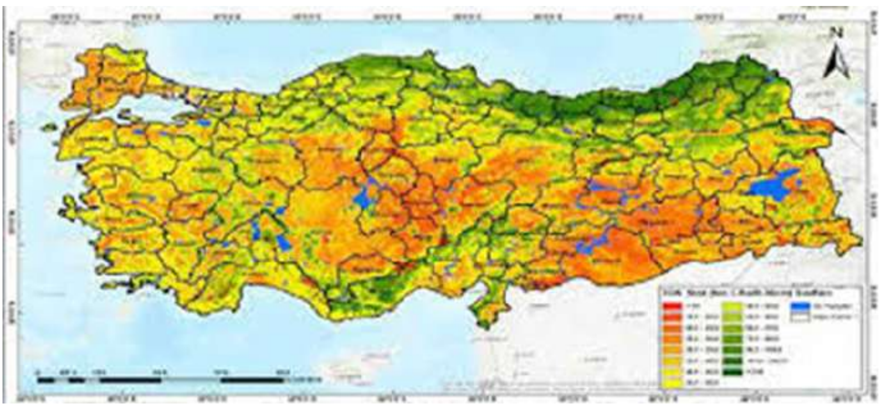

Fig. 1. Soil carbon stocks map in Turkey (ÇEM, 2018)

It is known that organic carbon (OC) deficiency is the root cause of many soil problems, and it is stated that its improvement eliminates these problems. If an effective yield can't be obtained, as in the previous years, along the country, one of the reasons is insufficient SOM. Because the amount of use water and the usefulness of nutrients are mostly related to the OM of soil (Schmidt *et al*.,2011).

The positive reflection of the increase in SOC on plant quality and productivity has been shown in many national and international studies. Therefore, it is essential to give priority to taking all kinds of measures to preserve and even increase SOC for sustainable healthy soil management.

Soil OC; It increases the soil resistance to erosion, keeps it in place, and increases the penetration of soil precipitation and the soil retention rate. It ensures that the fertilizers given to the soil are kept and prevents them from moving away from the soil. By preventing erosion, and keeping the soil and plant nutrients, which are fertilizers, in place, the amount of sediment carried by rivers will decrease; Surface and underground freshwater resources will also be protected

(Berhe et al., 2007). Briefly, SOC is directly proportional to quality and productivity.

Soil Organic Matter (SOM)

The soil organic matter is like the blood of the human body, which is an expression of how healthy the system is. The soil organic matter content decreases with tillage and plant production. These processes effectiveness relies on the environment temperature. In other words, organic matter loss with tillage occurs very quickly in warmer climates. If the environment is suitable, some of the total OM (TOM) decomposes very quickly and its amount decreases. The level of soil organic matter can be kept at a certain level and its decrease can be prevented with the help of adequate fertilization, crop rotation, and appropriate tillage techniques (Saffigna et al., 1989).

It is possible to gather the impacts of organic materials on soil productivity under three main groups. First, it improves the physical soil properties by balancing the soil's water-holding capacity, balancing the aeration capacity of the soil, providing easy heating of the soil, reducing the cream layer formation in the soil and soil cracking, and reducing soil erosion (Gould., 2015).

Secondly, it helps to make useless plant nutrients in the soil useful, facilitating the nutrition of the plant, keeping the soil pH in balance, increasing the soil nutrient holding capacity and reducing the washing of soil nutrients, preventing toxicity by buffering the soil, helping to reduce the soil salinity, organic matter (Kladivko 2001). While it decomposes in the soil, it gives the nutrients to the soil, helps the plant to be fed, and improves the chemical soil properties by encouraging the root development of the plant.

Third, soil organic matter, incompletely decomposed OM is an energy source and nutrient for soil organisms (microorganisms). By helping to increase the soil microorganisms population, it increases the microbiological activity in the soil by showing positive stimulating impacts on the growth of the plant root system with the organic compounds (humic and fulvic acids) that it gives to the environment during the OM decomposition in the soil (Jones et al., 1994).

Reasons for Increasing Organic Matter

One of the reasons for increasing OM is that urban waste and plant residues can be utilized (Fig.2). Another is to improve soil structure, increase water retention, increase N and S content, increase cation exchange capacity and provide pH buffering ability.

Fig. 2: Organic Waste (Buğday Derneği, 2017)

Increasing OM helps improve poor aeration and water infiltration properties in clay soils act as a cover on the soil surface, prevents soil crusting (cream layer), reduces the risk of erosion, or prevents the soil from getting too hot.

If there is a OM with high concentration in soil, it ensures that the sand particles are held together in sandy soils, allowing the soil to hold more water, and in clayey soils that tend to compress, it provides more aeration, allowing air and water to move more easily.

With SOM decomposition by microorganisms, nutrients gradually become useful to plants, and in this way, the washing of nutrients, especially in the nitrogen form, is prevented. Therefore, SOM has a positive impact on both physical andchemical soil properties (Lavelle et al., 1997).

To ensure OM recycling in cultivated lands by processing, plant residues, green manure, animal manure, compost, urban and industrial wastes and finally plant residues are applied to agricultural lands, and the most important OM sources are recycled. In this sense, the root systems of grasslands and forage legumes play a very important role in OM's contribution. To ensure SOM continuity, plants that increase OM (green fertilizers) should be included in the planting.

Microorganisms and Soil Productivity

Soil productivity is closely related to the activities of soil organisms and the direction of their reactions. Elements such as N, P, C, S, Fe, and Mg needed by plants are converted into useful forms by microorganisms after various syntheses and analyses. Microorganisms create such processes while providing their own nutritional and energy needs. And they also make the soil more productive. They help to improve soil structure, increase nutrient availability, and suppress plant diseases, all of which can enhance plant growth and yield (Balesdent and Balabane., 1996).

For example, in nitrogen fixation; Microorganisms capture the free air nitrogen (N_2) and turn it into a form that plants can use. Or, by decomposing plant and animal tissue residues, they release the C held in their bodies in the form of CO_2, while some other nutrients are released at the end of this mineralization process. Generally, soil biomass and the numbers of individual microorganism groups decrease with depth along the soil profile. This general soil profile distribution is due to the presence of substrates and inorganic nutrients that provide energy to microorganisms and other soil organisms, mostly near the soil surface.

The most important element of soil quality is SOM and the number of soil microorganisms. The most important criterion in soil productivity is the number of soil living things. These living things need organic matter, which is basic food and energy source, to continue their lives.

Soil Organic Matter and Productivity Relations

Organic matter plays a very important role in many chemicals, physical, and biological soil properties (Büyükkılıç Yanardağ et al., 2019). If there is sufficient and highly decomposed SOM, soil formation is directly or indirectly affected. It is difficult to even call the land layer covering the earth's surface without SOM. The presence of decomposed OM in soil formation indicates the beginning of biological activity (microbial activities) and synthesis.

Plant and animal creatures living on undecomposed parent material complete their lives as time progresses and leave their residues in this part. These residues are then mixed with the weathered mineral mass. This relationship between mineral matter and OM becomes tighter over time and the natural soil mass gradually begins to form.

Nutritious humus; It forms the main food source of soil microorganisms, and is readily broken down by the effect of biological factors. Soil organisms get the building materials and energy they need from such materials. Nutritive humus determines the character and activity of microorganisms by providing organic and inorganic nutrients necessary for organisms and making the soil a more suitable environment for these organisms, which is the most important source of N and C in the soil (Heal et al. 1997).

Heterotrophs living in the soil provide the energy they need by oxidizing the C in organic compounds. Carbon dioxide (CO_2), which is formed by the oxidation event and mixed with the atmosphere, is the most important C source for higher plants and autotrophic soil creatures. High plants and autotrophic soil creatures form the organic materials necessary for their structures, thanks to the CO_2 they take from the air and photosynthesis and chemosynthesis. These synthesized organic substances are broken down by heterotrophic organisms in the soil when the plants die, and CO_2 is formed again.

The main importance of perennial humus is due to the soil nutrients and their effects on water and aeration. Permanent humus is a very important component of the soil, as it is a nutrient store. It can change the nutritional elements, that is, to adsorb the nutrients in the form that can be taken by the plants (Wolters and Joergensen., 1992). Permanent humus can hold 2-4 times more water than clay colloids due to its high ion exchange capacity. Permanent humus, together with nutritive humus, also has a positive impact on the soil structure. For instance, heavy-textured soils are loosened by the influence of humus; on the other hand, light-textured soils show aggregation. Studies conducted on soils for many years have revealed that soil productivity and yielding capacity are immediately proportional to the amount of OM they contain.

Conclusion

The most important element of soil quality and productivity is SOM and the number of soil microorganisms. The most important criterion in soil productivity is the number of soil living. These living things need organic matter, which is basic food and energy source, to continue their lives. The higher the SOM content is the higher its agricultural production capacity. If the SOM is insufficient, the number of soil microorganisms will also decrease and the soil production capacity will decrease.

The healthier and more productive the soil is the more SOM. Therefore, it is our duty to increase or protect organic matter, that is SOC. Soil organic matter management is very important in this respect (Fig.3). Soil organic matter management plays a crucial role in improving not only for soil but also for water and air quality.

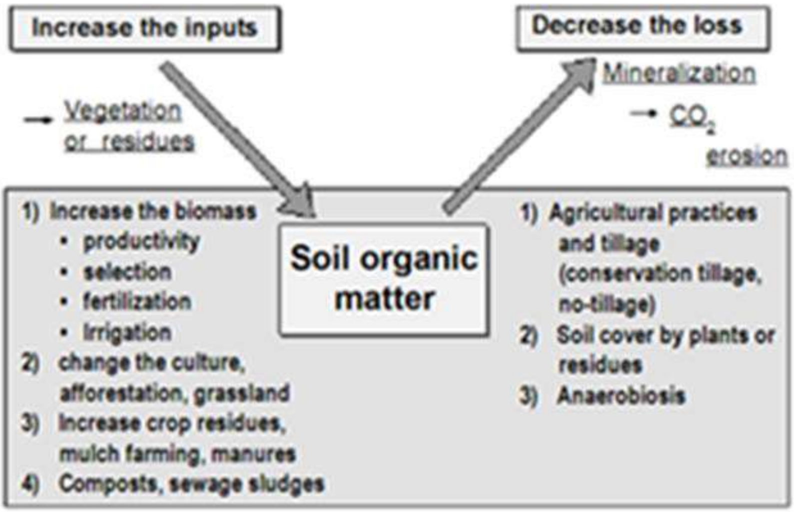

Fig. 3: Management of soil organic matter in agriculture (Lal, 1999; Batjes, 1996).

The positive reflection of the increase in SOM on plant productivity has been shown in many national and international studies. Therefore, it is necessary to give priority to taking all kinds of measures to preserve and even increase SOM for sustainable healthy soil management. İncrease inputs of the SOM and decreasing the losses are very necessary ways to the management of SOM in agriculture (Fig. 3) In summary, the state, farmers, industrialists, consumers, and non-governmental organizations, everyone should know their responsibilities and work consciously together to protect the land and make agriculture and food sustainability.

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APPLICATION OF MOLECULAR MARKERS IN PLANT BIOTECHNOLOGY

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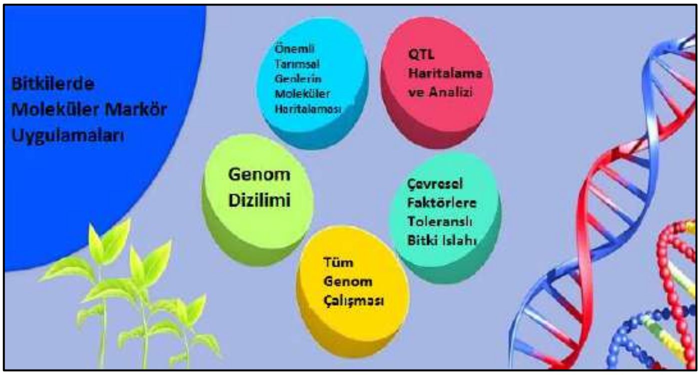
GİRİŞ

Biotechnology is one of the most popular and innovative scientific fields today. Plant biotechnology is one of these fields and molecular marker technologies used in this field appear as a very important biotechnological tool. Advances in molecular marker technology changed the fate of plant breeding in the 1980s. started to change. Different types of molecular markers have been developed and sequencing Advances in technology have accelerated crop development. In solving some problems encountered in classical breeding methods, marker-assisted selection (MAS) emerges as an alternative and auxiliary technique (Nadeem et al., 2017). Molecular markers refer to any gene region or gene region-associated DNA fragment in the genome whose phenotypic expression is easily distinguishable and used to identify an individual and mark a chromosome, nucleus, or locus (Schulmann, 2007). Markers identify genetic differences that may arise due to nucleotide changes or mutations at genome loci. It shows the polymorphism between organisms or species, making it possible to identify (Collard et al., 2005). Molecular markers are used in many different fields such as QTL (Quantitative Trait Loci) analysis, genetic mapping, detecting mutant genes associated with inherited diseases, species identification, crop breeding, population history, epidemiology and food safety studies (Hartl and Jones, 2005). In addition, molecular marker technology is frequently used in studies where genome regions associated with various stress factors are determined and information about genome structure is obtained. Molecular marker methods are based on the principle of identifying polymorphic regions in double-stranded DNA. It usually occurs in non-coding parts of DNA. DNA markers are accepted as an unlimited number theoretically, unlike morphological and biochemical markers, they are not affected by environmental factors and plant development stages. Qualitative and quantitative features determined by DNA markers are used in plant breeding, selection, genetic mapping, species identification and determination of genetic distance between genotypes (Bilgin and Korkut, 2005).



Features of Molecular Markers

The properties that should be found in molecular markers can be listed as follows:

• It can be observed in all tissues,

• Must exhibit highly polymorphic behavior and be able to distinguish between different genotypes,

• Must have codominant inheritance and heterozygous individuals, homozygous distinguishable from dominant individuals,

• It should be found frequently in the genome,

• It should show uniform distribution in the genome,

• It should show selective, neutral behavior,

• Easy access should be provided and the application cost should be low,

• It should be highly reproducible,

• It should provide easy and fast evaluation suitable for automation,

• A marker analysis on the same genetic material is always the same should yield results.

Molecular Marker Types

In terms of the methods used, molecular markers can be divided into two main groups as Markers Based on Hybridization and Markers Based on Polymerase Chain Reaction (PCR). Examples of markers based on hybridization; RFLP (Restriction Fragment Length Polymorphism) to PCR-based markers for example; SSR (Simple Sequence Repeat or Microsatellites), RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism), ISSR (Inter Simple Sequence Repeat) can be given. Apart from these marker systems; SRAP (Sequence Related Amplified Polymorphism), SCAR (Sequence Characterized Amplified Regions), STS (Sequence Tagged Site), CAPS (Cleaved Amplified Polymorphic), ALP (Amplicon Length Polymorphism) as well as SNP (Single Nucleotide) based on DNA sequencing Polymorphism) markers and MP-PCR (Microsatellite Primed Polymerase Chain Reaction), AP-PCR (Arbitrarily Primed Polymerase Chain Reaction), AS-PCR (Allele Specific Polymerase Chain Reaction), DAF (DNA Amplification Fingerprinting) strategies are also used to determine polymorphism.

Molecular Markers Based on Hybridization

RFLP (Restriction Fragment Length Polymorphism): It is based on the principle that the genomic DNA isolated from the cells is specifically cut by DNA cutting enzymes that recognize nucleic acid sequences from a certain point and the different cut structures around the DNA where the probe DNA hybridizes are detected. RFLP is the first non-PCR-based marker system developed. RFLP markers are codominant (Bark and Havey, 1995). This feature, it is possible to characterize heterozygous individuals. RFLP, which was widely used until the emergence of PCR-based techniques, has been a technique whose use was limited to special studies due to its disadvantages and advantages of PCR-based techniques. Advantages of the RFLP technique; It is possible to transfer between species, genera and even families, it is very reliable in terms of reaching the same results in different laboratories and by different researchers, RFLP markers are used in the identification and characterization of heterozygotes because they are codominant, they show moderate polymorphism. Disadvantages of the RFLP technique; analysis is expensive, time consuming and requires a lot of labor, in most cases, the radioactive labeling method is widely used, high quality DNA (10-20 μg) is needed, RFLP markers do not show random distribution across the genome due to the clustering of poorly replicated sequences at certain points in the genome. This adversely affects mapping. This can cause widespread large gaps to appear in maps obtained with RFLP markers.

Molecular Markers Based on Polymerase Chain Reaction (PCR)

Developed by researchers from Cetus in the mid-1980s, cloning techniques, sequence analysis and DNA mapping, such as basic molecular biology research started to be used. PCR is the enzymatic synthesis of DNA in vitro. The key role in the development of the PCR technique was the temperature obtained from *Thermus aquaticus*. The discovery of the resistant polymerase enzyme (*Taq* DNA polymerase) has played out. This enzyme, natural DNA replication, which can take place in the cell under normal conditions, has been carried out under laboratory conditions with the help of special devices called 'thermocycler'. Botstein et al. (1980), with the introduction of the PCR technique, RAPD, SSR, AFLP marker systems were also developed. The method uses a small amount of specific DNA fragments as a result of a series of enzymatic reactions. It is based on the principle of being reproduced millions of times. However, the elements that can be replicated are not the entire DNA, but some desired or randomly synthesized regions of DNA.

Since the DNA sequence is different in each genotype, different DNA products are obtained in each genotype even if the same primers are used, and these different productions are used as genetic markers. For this purpose, many different types of DNA markers are used and continue to be developed. DNA markers such as SSR, RAPD, AFLP and ISSR are PCR-based markers that are widely used in studies.

- **SSR (Simple sequence repeat or Microsatellites):** SSRs, or microsatellites, are composed of 2-6 nucleotide groups that are sequentially repeated and dispersed throughout eukaryotic genomes. These groups are denoted, for example, (AT)n, (GT)n, (ATT)n, (GACA)n, and n denotes the number of sequential repeats. The most common SSR sequences are dinucleotide (AC)n, (AG)n, (AT)n, trinucleotide (TCT)n, (TTG)n or tetranucleotide (TATG)n. Since the DNA sequences surrounding microsatellites are generally conserved between individuals of the same species, they allow selection of overlapping SSRs in different genotypes by amplification with PCR primers. The difference in the number of consecutive SSR repeats results in amplification of fragments of different length in the PCR result. These repeats are highly polymorphic due to mutations that cause changes in the number of repeating units even between very close species and cultivars (Gupta et al., 1994). Using the conserved DNA sequences surrounding SSRs as primers, different alleles at a locus can be detected by the PCR method. However, in order to use this method, the primer sequences of the relevant loci must be known beforehand. This is a very difficult job. Once the primers to be used are determined, they can be easily used by different researchers. The most important disadvantage of microsatellites is the difficulty of developing new markers. For the development of new markers, it is necessary to find genomic DNA clones by hybridization with probes containing repeated oligonucleotides, determine nucleotide sequences, and develop specific starter DNAs for the start and end sites of repetitive structures. This is an expensive and labor-intensive process. After SSR was first described in humans (Litt and Luty, 1989), the same findings were quickly used in other organisms. made in mice studies (Love et al., 1990), pigs (Johansson et al., 1992) and cattle (Kemp et al., 1993) continued with the studies. Markers, which are very important for many species in plants, have been successfully isolated and started to be used in research. The use of SSR technique in genetic mapping studies in plants is increasing day by day due to the advantages it provides. Since SSRs are highly polymorphic, they give a lot of information in plants. In addition, its codominant (co-dominant) marker and ease of PCR increase the rate of use (Röder et al., 1995). In recent years, SSRs have been used successfully in different plant species in many molecular genetics laboratories around the world. Wheat (Röder et al., 1995), wild wheat (Pestsova et al., 2000), soybean (Akkaya et al., 1992), corn (Senior and Heun, 1993), and potato (Provan et al., 1996) plants in which SSRs have been successfully are examples.

- **RAPD (Random amplified polymorphic DNA):** RAPD markers can be traced back to genomic DNA using simple, short oligonucleotide primers. It is defined as the amplification of randomly dispersed regions (Williams et al., 1990). Using starter DNAs (primers) of 10 nucleotides in length It is a method based on the duplication of random DNA regions on the genome, only one type of primer is used. This primer used runs in the 5′→3′ direction on both DNA strands. Therefore, the amplification of two regions close to each other on the DNA to which the primer used can bind is performed. Amplification products can be separated by agarose or polyacrylamide gel electrophoresis and visualized by ethidium bromide or silver nitrate staining. The RAPD technique is the preferred marker for reasons such as ease of application in marker technology, the availability of synthetic oligonucleotides in large numbers and ease, and the need for a small amount of DNA, unlike RFLP. Like other PCR-based techniques, it is reported that the RAPD technique is preferred more in mapping and characterization studies because it requires less time, work and cost (Devos and Gale, 1992). In particular, the RAPD method is preferred because it requires very little template DNA and gives the expected results in many plant species. The reason why the RAPD-PCR method is extensively used in the investigation of genetic variation, in the extraction of genetic maps of plants and in selection with the help of markers, the method is cheaper than other molecular methods, requires less DNA and because it is suitable for automation.

Advantages of the RAPD technique:

- It gives quick results, is cheaper and requires less labor.
- A small amount of DNA is sufficient.
- Polymorphism rate is high.

Disadvantages of the RAPD technique:

- Reliability is limited.
- Different results can be obtained in different laboratories, even when switching from one thermocycler device to another, different results can be obtained.
- Being a dominant marker may cause difficulties in transferring the markers obtained in this way to other maps.

The RAPD technique has been used successfully in different plant species in many molecular genetics laboratories around the world. For example; wheat (Devos and Gale, 1992), barley (Tinker et al., 1993), corn (Osipova et al., 2001), beans (Tiwari et al., 2005), chickpeas (Hajj-Moussa et al., 1996) and potatoes (Hu and Quirose, 1991), the RAPD technique has been used effectively. Ravi et al. (2003) used RAPD and SSR marker techniques comparatively in cultivated rice and wild rice in order to evaluate the relatedness between species. The researchers stated that the results of the SSR technique compared to the RAPD technique gave more accurate information in the determination of genetic relatedness.

- **AFLP (Amplified fragment length polymorphism):** The reproducibility and polymorphism level of the AFLP technique is higher than the RAPD-PCR method. In this technique, genomic DNA is first cut by two cleavage enzymes, one of which recognizes six bases and the other four bases. DNAs with synthetic nucleotide sequences are added to the ends of the cut pieces. Relatively specific DNA amplification is made using starter DNAs (primers) that also carry the nucleotide sequence of the added synthetic DNA. This replication is carried out in two stages. In the first stage, pre-production is performed, in which selective amplification is performed according to the first nucleotide after the sequence recognized by the DNA cutting enzymes from both ends. In the actual production, selective production is made for the second and third nucleotides after the cutting enzyme recognition site by using the parts obtained in the pre-production. Since all the initiators also carry the nucleotide sequence of the synthetic ends, the production is done under very specific conditions. The polymorphism rate of the technique is very high. Cost, labor requirement and reliability lie between RAPD and RFLP. It is well suited for fingerprint analysis as it scans multiple loci simultaneously and effectively. Among the important disadvantages of the AFLP technique are that it mostly gives dominant markers and it is difficult to transfer between different genetic maps.

Advantages of the AFLP technique:

- It is slower than RAPD and faster than RFLP.
- The cost is between RAPD and RFLP in terms of labor and reliability.
- It is very suitable for fingerprint analysis because it scans a large number of simultaneously.

- They are more numerous than RAPD and RFLP.
- No prior knowledge of genomic DNA is required.
- Polymorphism rate is very high.
- Because of these features, it is suitable for automation.

Disadvantages of the AFLP technique:

- It is mostly a dominant marker. However, recently codominant reported in the marker.
- It is difficult to transfer between different genetic maps.

- **ISSR (Inter simple sequence repeat):** The ISSR method stands out as a method that is based on the random distribution of repeated nucleotide units such as 2, 3, 4, 5 in eukaryotic genomes in the genome independent of the location, but is much more sensitive and reproducible than the RAPD method (Zietkiewicz et al., 1994). ISSR markers are an effective technique that can be applied to many field crops in the determination of genetic diversity, phylogenetic studies, creation of genome maps, and evolutionary biology (Reddy et al., 2002). ISSR markers are fast to use, easy to apply and have longer primers because they are highly reliable (Bornet and Branchard, 2001). Using ISSR primers that provide sufficient information provides a low cost, time saving and ease in genetic analysis. The low productivity of RAPD markers, the high cost of AFLP markers, and the need for sequence information to synthesize the primary SSR markers pose important limitations in many studies. ISSR markers are an important technique in overcoming many of these constraints (Zietkiewicz et al., 1994).

- **SNP (Single Nucleotide Polymorphism):** SNP (Single Nucleotide Polymorphism), known as single nucleotide changes in the genome sequences of individuals in populations, is a variation that occurs in many living species, including plants. Addition and deletion are the main causes of nucleotide sequence change in the formation of SNPs; it is used as an effective tool in gene mapping, breeding and map-based cloning studies with the help of markers. SNP formations are generally common in non-coding DNA regions or if they occur in coding regions it may cause a change in the amino acid sequence, or it may not cause any change in the amino acid sequence and there will be no change in the gene product (Sunyaev et al., 1999). Allele-specific hybridization or allele-specific oligonucleotide hybridization (ASO), which has been used in SNP characterization studies in recent years, is the hybridization-based identification of single nucleotide positions in different DNA targets. DNA chips and allele-specific PCR used in SNP-based genotype characterization attract attention in terms of obtaining excess product and being suitable for automation (Sobrino et al., 2005).

- **CAPS (Cleaved Amplified Polymorphic Sequence):** It is a technique based on the fragmentation of DNA regions amplified by PCR using appropriate primers with restriction enzymes (endonuclease) and resulting in DNA particle length polymorphism. CAPS markers are codominant, locus specific and can easily distinguish between homozygous and heterozygous alleles (Konieczny and Ausubel, 1993). The advantages of the CAPS method include the need for a very low amount of DNA, the ability to discriminate codominant alleles, and its simplicity and cheapness. DNA sequence changes due to mutations can affect the recognition sites of endonucleases and create a limiting effect, thus preventing high polymorphisms such as SSR and AFLP (Weiland and Yu, 2003).

- **SRAP (Sequence-Related Amplified Polymorphism):** It is a PCR-based marker system targeting open reading regions (ORF) and the front primers consisted of 17 nucleotides and the reverse primers consisted of 18 nucleotides. In these primer types, the non-specific 10-11 base part of the core sequence consisting of 14 nucleotides at the 5' end is the filler sequence, followed by the CCGG sequence for the pre-primers, and the AATT sequence for the reverse primers. The SRAP technique is simple, inexpensive, has a high rate of polymorphism, is suitable for gene tagging and cDNA fingerprinting, provides convenience in sequencing selected bands (Li and Quiros, 2001) and is used in genetic mapping, gene tagging and genetic diversity studies in different plant species (Budak et al. et al., 2004).

- **TRAP (Target Region Amplification Polymorphism):** It is a fast and effective method using bioinformatics tools and EST databases to generate polymorphic markers for candidate gene regions in the target based on PCR (Hu and Vick, 2003). Two kinds of 18 nucleotide long primers are used to generate the marker. One of the primers is the constant primer designed according to the EST sequences in the database, the other primer targeting exons or introns carrying AT or GC rich core region. The TRAP technique is used in the production of genetic markers for specific gene sequences, in germplasm genotype characterization and in the production of genetic markers for agronomically important characters in marker-assisted breeding studies (Hu et al., 2005).

SONUÇ

Molecular markers are used effectively in plant varieties breeding and selection studies with the help of markers, phylogenetic studies, and evolutionary relationships. In recent years, molecular markers have also been used effectively to investigate the responses of plants to climatic changes, which are dangerous at the global level. It has been revealed by marker studies that micro-geographical genetic changes occur in plants exposed to changes such as global warming. Molecular markers are also of vital importance in revealing the genetic structure changes caused by environmental and other changes. As a result, molecular marker technologies have brought new dimensions to plant biotechnology studies and have made great contributions to plant genetics, plant breeding and plant genomics studies.

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THE IMPORTANCE OF SOIL ORGANIC MATTER CONTENT IN DESERTIFICATION

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INTRODUCTION

The term of desertification was first mentioned in 1927 by L. Lavauden, a French botanist and ecologist who witnessed the land degradation in North and West Africa (Aubréville, 1949). Later in 1949, Aubreville, although he did not define desertification clearly, thought that desertification was "the destruction of fertile land due to soil erosion caused by man and its transformation into a desert" (Görcelioğlu, 1992). Desertification is one of the most important global and regional environmental issues that human beings face today, and it must be taken seriously (Türkeş, 2012a). When desertification, which has multifaceted effects and interactions, is defined scientifically; climatic and ecological changes, physical, biological, political, social, cultural and economic factors, especially in arid, semi-arid, arid-semi-humid and humid-semi-humid areas and in regions dominated by semi-arid subtropical Mediterranean climate regardless of drought/humidity class. It is the process of land degradation or reduction in ecological functionality and productivity, which is formed by the relationships and complex interactions between these factors (Türkeş, 2012b). In brief, desertification is the ecological degradation process that occurs because of an economically and biologically productive land being less productive (Türkeş, 2012a).

Desertification affects arid regions in many parts of the world, hinders the development of economies, has significant negative effects ranging from the impoverishment of the population in large areas and the danger of hunger for this population (Özdemir and Bahadır, 2009). In this context, it has become necessary to take measures to combat desertification.

Soil losses due to environmental problems such as desertification, land degradation and erosion as a result of natural or human effects, deterioration in the physical, chemical and biological properties of the soil and changes in the ecological balance have increased the importance of soil protection and management and made it necessary to take measures. Considering the occurrence of such natural events in large areas and the fact that the monetary budget will be too much in an effective struggle; The financial means of the country's economies in combating desertification and erosion will not be sufficient. For this reason, in natural events that are effective in such large areas and that will harm both the country's economy and ecological balance if no precautions are taken, ecosystems can be examined and indicator components can be revealed and applications can be made in small areas.

One of the most important components in desertification and land degradation is the soil and its properties. The physical and chemical properties of the soil are very important issues that should be emphasized in terms of soil development and utilization. Physical properties of the soil; depth, granularity, structure and porosity, density, stoniness and, depending on these, soil water, soil air, soil temperature and color. The chemical properties of the soil (soil organic matter content, etc.) include the analysis of soil formation and development, as well as the evaluation of the plant nutritive power of the soil and increasing the power. In soils with good physical properties, the plant root system develops sufficiently. However, it is not possible to obtain products in nutrient-poor soils (Kantarcı, 2000). In soils where plant root development is sufficient, vegetation properties are better and, accordingly, soil losses due to erosion are less common. Soil organic matter content is high in soils with good plant growth and vegetation structure. Soil organic matter content is an extraordinary complex of substances in terms of composition. This substance complex can include undecomposed plant and animal organisms, intermediate products of decomposition, and various substances up to highly stable, amorphous, brown or black material that has completely lost its structure (Dündar, 1987). Humus, which is one of the important components of the soil organic matter content and which is formed by decomposing from the dead cover on the soil, infiltrates the soil with precipitation water and mixes with the soil as a result of biological factors, and has important and positive effects on the physical and chemical properties of the soil and the nutrition of the plants (Kantarcı, 2000).

THE RELATIONSHIP BETWEEN DESERTIFICATION AND SOIL PROPERETIES

It is suitable for the conditions of natural conditions for the soils to reach a certain maturity and productivity. In a mature soil developed under the influence of a temperate and humid climate, horizon layers such as A- B- C are generally seen, while in arid regions this development usually consists of A- C layers. In semi-arid climates, since the potential evaporation is greater than the amount of precipitation, the water entering the soil during the rainy season first moves down for a while; Meanwhile, the decomposition of the minerals is ensured by the hydrolysis effect. However, it constantly carries the decomposition material up. With the onset of the dry seasons, the existing water in the lower layer moves to the upper layers and evaporates there, leaving the salts it brings with it. Thus, there is a layer rich in salts on the surface (Uluocak, 1974).

It is known that soil formation in arid and semi-arid regions is mostly in A-C horizons. Accordingly, the soils in our semi-arid areas are generally clayey and calcareous. The pH are slightly alkaline (between 7 and 8 pH) since the soils generally contain lime and the lime is not washed away due to a small amount of precipitation. pH values may be higher in saline, alkaline or gypsum soils. Soils in semi-arid areas have generally destroyed vegetation as a result of overgrazing and Ah horizons of soils have been eroded away. For this reason, it caused the soil organic matter content to be too low (Anonim, 2013).

Calcification: It is the most common soil phenomenon in arid lands. Calcification occurs in temperate climates in regions with an average annual precipitation of less than 600 mm. This event occurs when the water-soluble salts such as Ca and Mg carbonate collect under the soil from the precipitation waters and then the salts come back to the soil surface thanks to the plant roots. Calcification; It is common in chernozem, chestnut colored soils and brown steppe soils (Uluocak, 1974).

Salinization: It is a typical phenomenon seen in arid and semi-arid lands. If a white color occurs on the soil surface due to the accumulation of chloroid, sodium sulfate, Mg and Ca salts due to lack of drainage, it is called "white saline" or "white saline". If it turns dark with the effect of sodium carbonate, it is called "black saline" or "black saline" (Uluocak, 1974).

SOIL ORGANIC MATTER CONTENT AND IMPORTANCE

Soil organic matter is the organic compounds formed by plant and animal residues in the soil from decomposition to mineralization (Pakkaner, 2015). Soil organic matter with high polyphenol content shows slow decomposition (Sargıncı, 2014). Soil consists of organic matter, plants and residues of living things living in the soil. Most of the soil organic matter leaves, fruit, seeds, cones, bark, branches, etc. constitutes (Kantarcı, 2000). Temperature, soil moisture and soil pH are the main factors affecting the decomposition in the soil. The temperature increases decomposition to a certain extent, then stabilizes. As soil moisture increases, the rate of decomposition decreases. Decomposition is faster in soils with pH close to neutral. In the event of decomposition, bacteria show the effect of decomposition more easily, while fungi and actinomycetes take a longer time to decompose (Kılınç and Kutbay, 2008). The organic matter content of soils, which have significant effects on plant growth and the presence of plant nutrients that are effective in plant growth, are classified as in Table 1. Soil organic matter is collected under three main substances: humus, plant roots and soil organisms. 85% of soil organic matter consists of humus, 10% of plant roots and 5% of soil organisms (Maltaş and Tavalı, 2014). Animal and vegetable matter decomposes to form humus, which is a small organic matter (Çepel, 1988).

Table 1. Soil organic matter (SOM) classification (Pakkaner, 2015)

SOM Content (%)	Consideration
<1	Very Low
1-2	Low
2-4	Medium
>4	High

Peat, leonardite and gidya (immature coal) formed by the accumulation of organic compounds in aqueous environments in the past have formed important sources of organic matter. The soils of Turkey (except the Black Sea region) are generally poor in terms of organic matter content, and it is known that 65% of our country's soils have low and very low organic matter content (Saltalı, 2015). The amount of organic matter in the soil is closely related to the climate, soil texture, topography, drainage, the composition of the organic material mixed with the soil, the type of plant grown on it, and the treatments applied to the soil, from very small amounts to 20%. In general, coarse textured soils contain less organic matter than heavy textured soils. Soils with more than 20% organic matter are called organic soils. Of these, those containing 20-50% organic matter are called muck, and those containing 50-80% organic matter are called peat soils (Minasny and McBratney, 2018).

The organic matter in the soils was generally collected in the upper part, from the soil surface to a depth of 25-40 cm. As you go down to the lower parts, there is a significant decrease in the amount of organic matter. In general, the amount of organic matter in our country's soil is very low. Except for natural meadows with high ground water, the amount of organic matter can reach up to 3% in other soils. Soils that do not contain organic matter or contain very little organic matter lose their fertility in a short time. Soils must be enriched with organic matter in order not to lose their yield strength and not to deteriorate their physical properties (Moreno et al., 2006).

With the decomposition of organic matter, first energy and protein, then nutrients and sticky liquids are released (Öztürk and Özdemir, 2006). Organic matter adheres the fine grains of dusty and clay soils and makes the pores of the soil larger. This feature increases the water holding capacity of the soil. Increasing the water holding capacity is especially important for sandy soils (Kantarcı, 2000). Organic matter is the storehouse of plant nutrients in the forest ecosystem. Organic matter is the most important factor in plant production in forest soils that cannot be fertilized or have high fertilization costs (Kantarcı, 2000). The organic matter content of soils is the most important indicator of soil quality and sustainable ecogeomorphological systems (Sparling 1991; Imeson

1995). According to Pardini et al. (2000) and Nunes (2011) described the limit value of soil organic matter content as 1.70% as the beginning of desertification.

CONCLUSION AND RECOMMENDATIONS

Soil losses due to environmental problems such as desertification, land degradation and erosion because of natural or human effects, deterioration in the physical, chemical and biological properties of the soil and changes in the ecological balance have increased the importance of soil protection and management and made it necessary to take measures. Considering the occurrence of such natural events in large areas and the fact that the monetary budget will be too much in an effective struggle, the financial means of the country's economies in combating desertification and erosion will not be sufficient. For this reason, in natural events that are effective in such large areas and that will harm both the country's economy and ecological balance if no precautions are taken, ecosystems can be examined and indicator components can be revealed and applications can be made in small areas. Loss of organic matter, which is among the factors that cause desertification and land degradation, is an indicator of desertification tendency. In this context, Pardini et al. (2000) and Nunes (2011) hypothesis that 1.70% of the limit value of soil organic matter content indicates a tendency towards desertification; As a result of the application, the soil organic matter content can be an indicator soil feature in desertification. Considering that desertification and land degradation, which have gained great importance in recent years, is a problem that has occurred centuries ago with small but not felt changes, studies carried out considering the multiple interaction of desertification are important in combating desertification.

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MORPHOLOGICAL AND ECOLOGICAL FEATURES OF HELIOTROPIUM LASIOCARPUM FİSCH. & C.A. MEY.

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INTRODUCTION

Our country has a very rich and interesting structure in terms of floristics. It is possible to explain this richness and interestingness of our country in terms of flora, with the large number of endemic and rare species it contains. Because the total number of plant species grown in our country is almost close to the total number of species in the European continent. The main reasons for this wealth are; Climate differences, topographic diversity, geological and geomorphological diversity, different aquatic environment diversity such as sea, lake, river, height differences ranging from 0-5000 m, being at a place where three different plant geography regions meet, Anatolia being the gene center of many genera, It can be listed as the high species endemism in Anatolia and the presence of rootstock species of many cultivated plants in and around Anatolia (Göktürk 2015).

Considering the geographical landforms of Turkey along with these factors; mountains, plains, alpine regions, etc. Our country is very diverse with its many different areas, which is a significant factor in the richness of the flora. Along with these factors, another reason for the diversity of flora in Anatolia is the changes in the climate of our country during the ice ages that covered Europe at intervals in the fourth time. A very rainy climate prevails in Anatolia during the ice ages, when the European flora suffered great losses due to severe cold. For this reason, a hydrophilic forest vegetation spread over large areas in Anatolia in these periods. Dry periods followed the rainy periods and the steppe flora developed in Anatolia during these periods. These successive climatic differences were another factor in the emergence of this rich flora of Anatolia (Guyot 1937). These factors once again revealed the importance of flora studies and the beginning of floristic research in Turkey dates back to the 16th and 17th centuries. These surveys were generally carried out by European travelers. At the end of the trips made by European travelers in our country, he wrote travel books mentioning the plants of our country, and these travel names were accepted as the first works about the Flora of Turkey (Baytop 2004).

In addition to the flora studies of foreign travelers, Evliya Çelebi (1611 – 1682), the famous Ottoman traveler of the 17th century, has an important place. Evliya Çelebi traveled throughout his life and wrote a 10-volume travelogue. He also included plants in his travel book, recorded the trees of the region, the flowers, fruits, and vegetables grown there, introduced herbal products and drugs, gave importance to the local names of the plants, tried to introduce the interesting and special useful plants of the region. Also, Monumental Trees caught his attention and described them. There are about

30 trees, 35 fruits, 10 grains and legumes, 15 vegetables, 30 flowers and 8 wild herbs in Thrace and Anatolia in his travel book (Baytop 2004).

Today, the studies that are the basis for the creation of the Flora of Turkey are carried out by three famous botanists Edmond Boissier (1810 - 1885), Dr. Arthur Huber – Morath (1901 – 1990) and Prof. It was carried out by P. H. Davis (1918 – 1992) and today's Flora of Turkey was created (Baytop 2004). Floristic and systematic studies on the plants of Turkey have increased gradually in the last century with the creation of this fundamental work, and studies in this field have intensified by showing great developments in the last 25-30 years.

In this thesis, *Heliotropium lasiocarpum* Fisch. & C.A. Soil and climate characteristics of fruit, morphological and ecological characteristics were examined. It is thought that the study is specific in parallel with the literature studies and will contribute to future studies.

MATERIAL and METHOD

Collection of plant specimens

The plant materials required for the research were collected from a height of 1280 m in Yapraklı District of Çankırı province in September-October 2017. For the identification of plants, attention was paid to their collection during vegetation periods. In addition, environmental characteristics and morphological features of the plant were recorded during the collection. Care was taken not to lose the morphological features of the collected samples.

Morphological analysis

While collecting the samples, considering that they can be used in future scientific studies, care was taken to ensure that they can be used for many years, and some of the samples were turned into herbarium material. For the morphological characteristics of the samples, after the plant samples were collected, plant height (cm), leaf width (cm), leaf length (cm), petiole (cm), leaf shape, corolla (mm), calyx tube (mm), inflorescence (cm), measurements and observations were made on the fruit.

Soil analyzes

Taking soil samples

The surface soil sample of the research area was taken in September 2017. Since the plant specimen is a herbaceous taxon, the roots of the plants are not deep, but close to the soil surface (Figure 1). For this reason, three soil samples were taken from 0-30 cm depth for surface sampling. Soil samples with degraded natural structure were poured into crates and dried in the laboratory. Soil samples that became air-dried were beaten, passed through a 2 mm sieve, and made ready for analysis.

Figure 1. Taking soil samples

Some physical and chemical analyzes of soil samples

In soil samples; With the texture hydrometer method (Gee & Bauder, 1986), soil reaction (pH) and electrical conductivity (EC) 1/5 ratio was prepared in the soil-water mixture with a glass electrode (McLean, 1982; Pansu & Gautheyrou, 2007), the lime content (CaCO3) was determined by using Scheibler calcimeter as stated by Pansu and Gautheyrou (2007), and the organic matter and total nitrogen (N) content of the soils were determined by Jackson's modified version of the Wakley-Black method (Jackson, 1969).

Climate of the research area

In the province of Çankırı, which is in the transition zone between the Central Anatolia and the Black Sea regions, the climate type of both regions is observed. The distribution of precipitation throughout the year is uneven, and the northern aspects receive more precipitation than the southern aspects. Since the effect of the Black Sea climate is seen in the northern aspects, the amount of precipitation is higher than in the southern aspect. The plains and valleys in the inner parts of the south are hot, while the high places are cool. In the mountainous parts of the north and south, snowfall is observed more in winter (Gül et al. 2006).

The climate of the research area was determined using Thornthwaite. Thornthwaite formula provides the opportunity to specify the climatic characteristics of a region in many ways and includes the main lines of climate classification. The fact that it considers other important factors such as the amount of precipitation and temperature, which plays a role on precipitation efficiency, as well as the water holding capacity of the soil, the latitude of the geographical region, and the ability to show the precipitation efficiency in a graphic way distinguishes this method from others (Kılınç et al., 2006, Çepel 1995, Kantarcı 2000). According to the Thornthwaite method of the research area; It turns out to have a “humid, microthermal, fully continental climate with little or no excess water throughout the year” indicated by the symbols BC'rw_2 (Figure 2.).

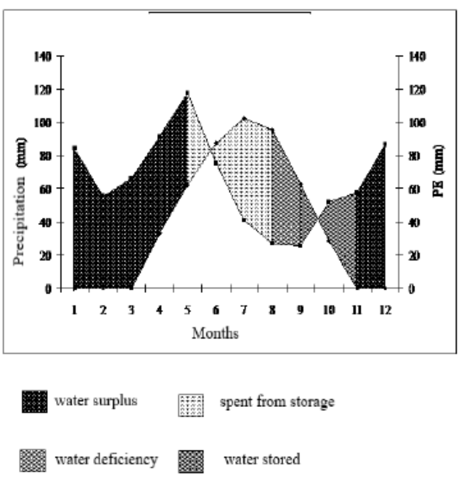

Figure 2. The water balance graph of Yapraklı according to the Thornthwaite method

RESULTS

Morphological findings

Family *Boraginaceae* Annual, biennial, or perennial herbs, rarely small shrubs or trees; The leaves are alternate, without stipules, simple, often have a dense hairy cover (Indumentum). Most of the plants belonging to this family are used to obtain ornamental plants, spices, and dyestuffs. Active substances of the family, Mucilage derivatives (Arabinose, Glucose and Galactose), -Pyrolizidinalkaloids (Amabilin, Supinidin, Lycopsamin, Intermedin, 7-Acetyl-Lycopsamine and 7-Acetylintermedin) -Also tannins, saponins, resin, starch, silicate, C, and minerals (Baytop 1999, Heywood 1978).

The genus *Heliotropium* L. generally consists of semi-shrub perennial and annual herbaceous plants. For medicinal use, this genus acts as an antidote to all deadly poisons. It is also antipyretic, bile enhancer and wound healer (Baytop 1999).

The species of *Heliotropium lasiocarpum* Fisch. & C.A. May.; The calyx lobes are lanceolate, with a relatively broad base. Subpatent in the case of fruit, the tip distinctly curved; The stigma is dwarf-conical, bare, the tip is bisected. Nutlets are almost densely hairy (Davis 1965-1988).

While the measurements made for fruit (number) and corolla color, which are among the morphologically observed characters, were compatible with Davis (1965-1988)'s studies, plant height (cm), plant hair density, leaf shape, leaf width (cm), leaf length (cm), petiole (cm), leaf shape, corolla (mm), calyx tube (mm), inflorescence (cm) were revealed for the first time in this study (Table 1.).

Table 1. *Heliotropium lasiocarpum* Fisch. & C.A. May. Comparative morphological character measurements of the species Davis (1965-1988) and our study.

Morphological Character Measurements	Davis (1965-1988)	Our study (2017)
Plant height (cm)	-	40-100
Plant hair density	-	Dense
Leaf shape	-	Ovoid
Leaf width (cm)	-	0.8-1.4
Leaf length (cm)	-	1.0-2.6
Petiole (cm)	-	0.8-1.6
Corolla (mm)	-	4-5
Corolla color	Yellowish-white	White
Calyx tube (mm)	-	3-4
Inflorescence (cm)	-	3.5-9.8
Fruit	4	4

Findings on soil properties

Physical and chemical soil properties in soil samples taken from the study area; pH, soil organic matter (SOM), total nitrogen (TN), texture (sand, dust, and clay content) and EC- total salt (TS) content were investigated (Table 2). The soils of the study area are clayey (C) soils with fine texture. The organic matter content of the soil is relatively high as clay. As a matter of fact, Bot and Benites (2005) stated that the clay content affects the amount of organic matter, and the amount of organic matter is high in soils with high clay content. The organic matter and nitrogen classes of the examined soil samples are good and there are no factors limiting the development of plant material. Soil reaction varied between the lowest values of 7.29-7.36 and showed slightly alkaline properties. At the same time, all the investigated soils showed slightly saline characteristics. When examined in terms of lime content, the soils are classified as calcareous (according to Ergene 1993).

Table 2. Physical and chemical analysis results of soil samples C: Clay, pH: Soil Reaction, $CaCO_3$: Lime content, SOM: Soil Organic Matter, TN: Total Nitrogen, EC: Electrical Conductivity, TS: Total Salt.

No	Location	PHYSICAL ANALYSIS Bünye (%)				CHEMICAL ANALYSIS										
		Sand	Clay	Dust	Soil Type	pH	Class	$CaCO_3$ (%)	Lime Class	SOM (%)	SOM Class	TN (%)	TN Class	EC (dS/m)	TS (%)	Class
1	Çankırı-Yapraklı	10	67	23	C	7.29	Slightly Alkaline	14.68	Limy	5.13	Good	0.26	Good	2.04	0.16	Lightly Salted
2	Çankırı-Yapraklı	8	68	24	C	7.35	Slightly Alkaline	14.45	Limy	4.92	Good	0.25	Good	1.98	0.10	Lightly Salted
3	Çankırı-Yapraklı	3	71	26	C	7.36	Slightly Alkaline	14.39	Limy	4.78	Good	0.24	Good	1.99	0.10	Lightly Salted

DISCUSSION AND CONCLUSION

Heliotropium lasiocarpum Fisch. & C.A. May. The morphological and ecological general soil and climate characteristics of the species were examined and revealed for the first time. With this research, the plant sampling study was carried out completely, and at the same time, *Heliotropium lasiocarpum* Fisch. & C.A. May. General information about the characteristics of the growing environment of the plant is given.

Among the morphologically observed characters, the measurements made for corolla color and fruit were compatible with Davis (1965-1988)'s studies, while plant height (cm), plant hair density, leaf shape, leaf width (cm), leaf length (cm), The measurements made for petiole (cm), corollo (mm), calyx tube (mm), inflorescence (cm) were presented for the first time in this study.

Heliotropium lasiocarpum Fisch. & C.A. May. As a result of the evaluation of the soil analyzes of the areas where the species is found, it was determined that the SOM content of the investigated soil properties and the amount of clay in the soil increased. At the same time, the SOM and nitrogen classes of the examined soil samples are in good grades and there is no factor limiting the development of plant material. The fact that all the examined soil samples are slightly salty and calcareous indicates that the plant species develops in habitats with these characteristics. However, it is thought that the deterioration of soil properties because of sudden changes in such areas or soil losses because of erosion and the increase in the effects on the anthropogenic area will affect the continuity of the plant.

As a result of this study, *Heliotropium lasiocarpum* Fisch. & C.A. May. The general soil and climate characteristics of the species were examined in terms of morphological and ecological aspects. In this context, when the study is evaluated, *Heliotropium lasiocarpum* Fisch. & C.A. May. It has been determined that there is a positive relationship between the species and the ecological characteristics such as soil and climate characteristics.

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IMAGE AUGMENTATION IN AGRICULTURE USING THE ALBUMENTATIONS LIBRARY

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1. INTRODUCTION

Computer vision is a sub-field of artificial intelligence. It includes studies on the perception and understanding of the visual world by digital imaging sensors. Computer vision studies consist of three basic steps: taking the image as an image or video with a camera, processing, and then interpreting the image. Sensors used for image acquisition include color cameras, multispectral or hyperspectral sensors for understanding invisible biological processes, or sensors to be used for various geometric measurements (Yao et al., 2019; Dang et al., 2020; Kang et al., 2021; Gila et al., 2022).

Computer vision is used to solve various agricultural problems, such as autonomous driving of agricultural robots, which has emerged as an efficient alternative to human labor (Basso, 2018; Vrochidou et al., 2022). With cameras and various localization algorithms, robots can find their locations and destinations in fields or orchards and perform tasks autonomously (Gai et al., 2021). The production status of fruits and vegetables can be monitored with visual quality control (Mansuri et al., 2022), tree and plant counts (Donmez et al., 2021), harvest forecasts can be made (Faisal et al., 2020; Ballestros et al., 2020) and diseases and pests that may occur can be followed (Dubey et al., 2020) by using computer vision. There are computer vision applications that enable disease detection in plants and spraying only where needed (Terra et al., 2021). Studies are carried out on applications that provide mechanical or chemical removal by detecting the locations of weeds by imaging sensors (Wu et al., 2019; Rai et al., 2022). There are computer vision studies on animal tracking, counting, and health control in barns and poultry houses (Mönck et al., 2018; Ratnayake et al., 2021; Chen et al., 2020). Computer vision is also used in fish farms to determine water quality, health status, number, and maturity of fish (Betancourt et al., 2020).

Today, significant progress has been made in the field of computer vision with the help of deep neural network methods. There is an increase in the success and prevalence of studies carried out in this field, due to the ease of access to graphical processing units (GPUs) with high processing power on desktop computers or in the cloud environment (Justus et al., 2018) and the free use of software frameworks such as Tensorflow and PyTorch, which enable the development of deep neural network applications by researchers.

Images need to be collected and labeled to create the training dataset that will be used to train deep neural networks. If we are trying to solve an image classification problem, each of the collected images must be labeled to get the correct class label. In object detection problems, the surrounding of the relevant objects on the images must be enclosed in a rectangle, while in object segmentation problems, the outer contour of the object must be marked. Although there are some online tools for labeling data, this process is usually done manually and requires a workforce. Correct labeling directly affects the success of the deep neural network model. For this reason, labeling should be done by experts who have knowledge of the specific domain of the problem. Data labeling can be a very costly process depending on the size of the project (Sudharshan et al., 2019).

If further data collection is difficult or not possible, the images collected can be augmented using digital methods (Hauberg et al., 2016). Image augmentation is the artificially enlarging the training dataset by applying various operations on the original data. Machine learning models based on deep neural networks, especially used in the development of computer vision applications, need a large number of labeled images to give good results and prevent overfitting (Lu et al., 2022). However, collecting sufficient training data is often a very difficult task. In many cases, adequate data collection and labeling is difficult or even impossible. There are significant deficiencies in the publicly available dataset in the agriculture domain (Lu and Young, 2020). Studies have shown that the use of image augmentation increases model accuracy, generalization, and is beneficial in controlling overfitting in the model (Zhang et al., 2020).

In this study, we examine the effect of image augmentation on classification success for a dataset used for agricultural purposes. We used Albumentations (Buslaev et al., 2020) image augmentation library which allows us to fine-tune the image augmentation steps with its parametric structure.

2. MATERIAL AND METHODS

In the study, we used a citrus leaf dataset containing 3 different diseases and 1 healthy leaf class (Rauf et al., 2019). The dataset consists of 594 images in total. There are 169, 163, 204 images in black spot, canker, and greening disease classes, respectively. There are 58 images of healthy leaves. The images are in RGB (red-green-blue) format with 256x256 dimensions. Python codes to download the dataset from the tensorflow data sets and to list images and labels in the tables are shown in Figure 1. Examples of images in the dataset are shown in Figure 2.

```
    # load the dataset
citrus, info = tfds.load("CitrusLeaves", with_info=True, split="train",
as_supervised=True)
# convert dataset to pandas dataframe
df = pd.DataFrame(list(citrus))
df[1] = df[1].apply(lambda x: x.numpy()) #convert labels to numpy array
df[0] = df[0].apply(lambda x: x.numpy()) #convert images to numpy array
df.columns = ["image", "label"] # change column names of dataset
```

Figure 1. Python codes for reading dataset

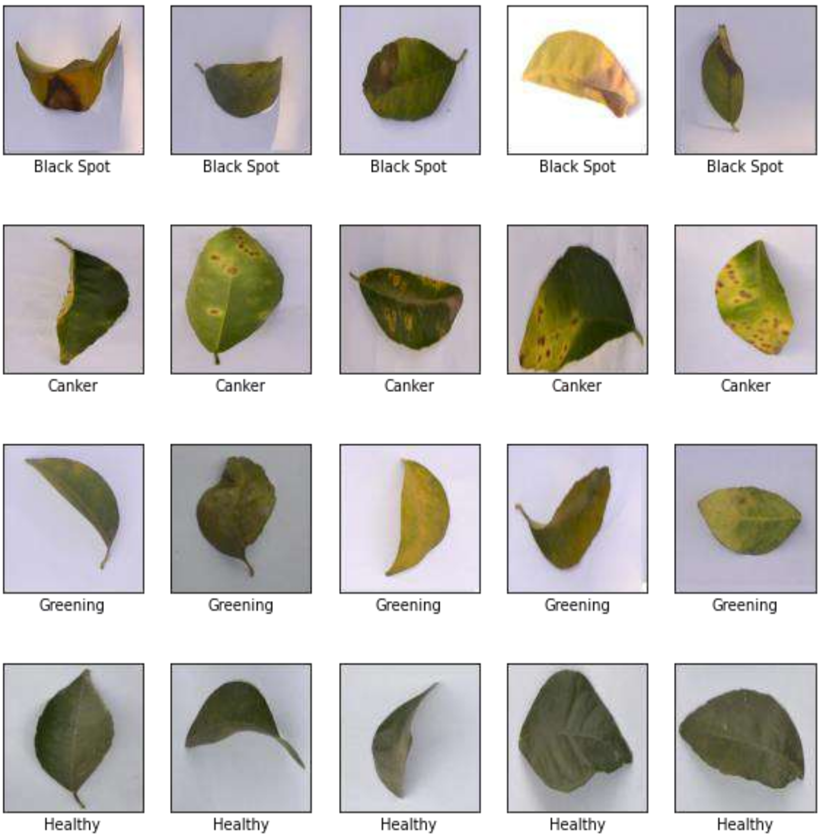

Figure 2. Examples of classes in the dataset

We used image augmentation functions of the Albumentations library such as Blur, RandomCrop, HorizontalFlip, RandomBrightnessContrast, RandomRain, Solarize, Superpixels, RandomSnow, RandomFog, MotionBlur, RandomSunFlare, ISONoise to enlarge the training dataset. In Figure 3, the Python codes that make a list of the image augmentation methods we apply are seen.

```python
# Create list of augmentation methods
def create_augmentation_list(p=0.5):
 a = A.Blur(p)
 b = A.RandomCrop(width=256, height=256, p)
 c = A.HorizontalFlip(p)
 d = A.RandomBrightnessContrast(p)
 e = A.RandomRain(p)
 f = A.Solarize(p)
 g = A.Superpixels(p)
 h = A.RandomSnow(p)
 i = A.RandomFog(p)
 j = A.MotionBlur(p)
 k = A.RandomSunFlare(p)
 l = A.ISONoise(p)

 augmentation_list = [
 (a, "Blur"), (b, "Random Crop"), (c, "Horizontal Flip"),
 (d, "Random Brightness Contrast"),(e, "Random Rain"), (f, "Solarize"),
 (g, "Superpixels"), (h, "Random Snow"), (i, "Random Fog") ,
 (j, "Motion Blur"), (k, "Random Sun Flare"), (l, "ISO Noise")]

 return augmentation_list
```

Figure 3. Python codes of the function listing the image augmentation methods

Figure 4 shows the results of these image augmentation functions on a sample image. The effects of the augmentation functions used on the image are given below.

Blur: This function blurs the input image with a random-sized kernel. In this study, the kernel size randomly varied between 3 and 7. **Random Crop:** Makes a random crop in the desired sizes on the image. **Horizontal Flip:** Makes the given image randomly horizontally flip. **Random Brightness Contrast:** Randomly changes the brightness and contrast of the given image. In the study, the brightness and contrast values varied between -0.2 and 0.2. **Random Rain:** Adds a rain effect to the given image. **Solarize:** Inverts all pixel values below the threshold value. In the study, the threshold value was taken as 128. **Superpixels:** Converts the given image to a partially or completely superpixel representation. **Random Snow:** It adds a snow effect to the given image by bleaching out some pixel values. Random Fog: Adds a fog effect to the given image. **Motion Blur:** It applies motion blur to the given image by applying the kernel according to the kernel size selected randomly between 3 and 7. **Random Sun Flare:** Simulates a sun flare on the image. **ISO Noise:** Adds noise to the given image. In this study, noise was added, with an intensity ranging from 0.1 to 0.5 and a color burst with a random value between 0.01 and 0.05.

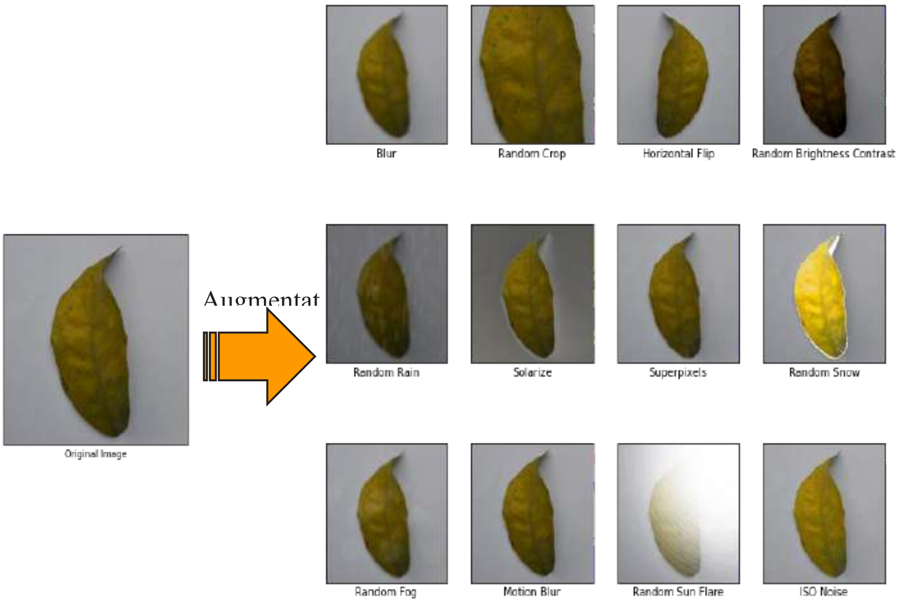

Figure 4. Data augmentation samples

Albumentation library allows for stochastic and pipeline-based augmentation. In the study, first of all, we divided the original dataset into two parts, training and test dataset, considering the ratio between classes. There are 397 images in the training dataset and 197 images in the test dataset (Figure 5).

```
# Split dataset into training and test sets
X_train, X_test, y_train, y_test = train_test_split(df["image"], df["label"],
test_size=0.33, random_state=42)
```

Figure 5. Python codes to split images into training and test datasets

We created an augmented training dataset by applying a randomly selected augmentation function to each image in the training dataset three times. In other words, the augmented training dataset is 3 times larger than the training dataset and has 1191 images. Augmentation steps are given in Figures 6 and 7.

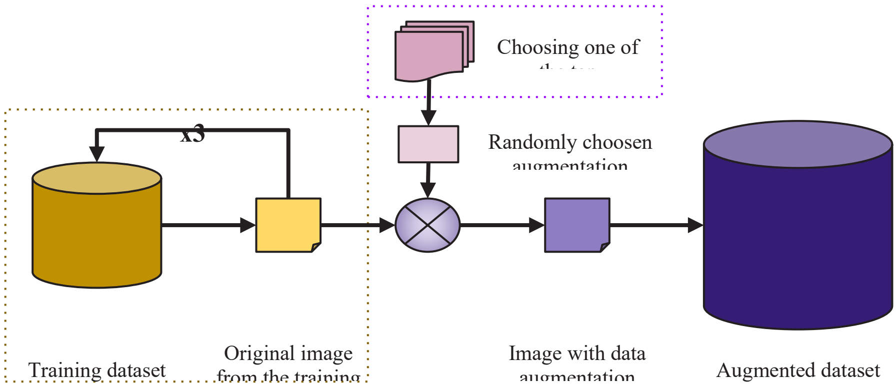

Figure 6. Data augmentation pipeline

```
    # create augmented image and label list
X_augmented = []
y_augmented = []
augmentation_list = create_augmentation_list(p=0.5)

for i in range(3): # this range is identifying that augmented dataset will be 3 times
bigger than original one
 for index in X_train.index:
  img = X_train[index]
  label = y_train[index]
  rand = random.randint(0,11) # choose random augmentation method from our
augmentation list
  augmentor = augmentation_list[rand][0]
  transform = A.Compose([augmentor])
  img_aug = transform(image=img)
  X_augmented.append(img_aug["image"])
  y_augmented.append(label)
```

Figure 7. Python codes used to create the augmented training dataset

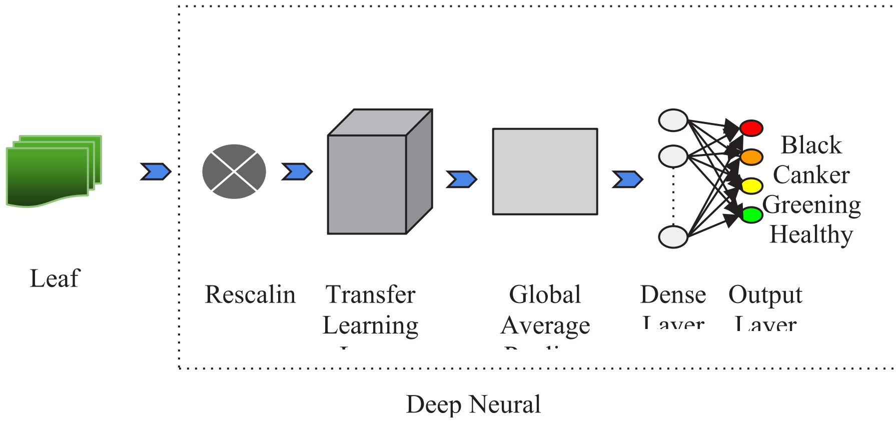

Figure 8. Structure of the deep neural networks model

In the study, we used the deep neural network model seen in Figure 8. The Python codes that we used to create the model are given in Figure 9. We normalized the pixel values of the images in RGB format between 0 and 1 in the rescaling layer so that the pixel values of the images are suitable for deep neural network training. Normalized images pass through the transfer learning layer (Zhuang et al., 2020) layer which uses the EfficientNetB0 feature extractor (Montalbo and Alon, 2021) feature extractor. The extracted features obtained in the transfer learning layer are vectorized through the global average pooling 2D layer and come to the output layer by passing through a dense layer consisting of 256 neurons. The softmax function is used in the output layer as an activation function. This function returns the probability values of which of the four classes the given image belongs to. The sum of the four predictions is equal to 1.

We trained two deep neural network models, which have identical network structure, using the training dataset and the augmented training dataset. We used Adam (Kingma et al., 2014) as the optimization algorithm and sparse categorical cross entropy (Rajagopal et al., 2022) as the loss function. We freeze all layers of EfficientNetB0 and trained deep neural networks for 5 epochs (learning rate=0.0001), then unfreeze the last 10 layers of EfficientNetB0 for training and continued training for another 55 epochs. In the fine-tuning phase, where the last 10 layers of EfficientNetB0 are unfreezed for training, we reduced the learning rate to 0.00001 (Figure 10).

```
    # converting our training, test and augmented training datasets into
tensors
train_images = tf.convert_to_tensor(X_train.to_list())
train_labels = tf.convert_to_tensor(y_train.to_list())
test_images = tf.convert_to_tensor(X_test.to_list())
test_labels = tf.convert_to_tensor(y_test.to_list())
train_images_augmented = tf.convert_to_tensor(X_augmented)
train_labels_augmented = tf.convert_to_tensor(y_augmented)

# specifiy the image size and create base model for transfer learning
IMG_SHAPE = (256,256,3)
base_model = tf.keras.applications.efficientnet.EfficientNetB0(include_top=
False)

# define and compile our ML model
inputs = tf.keras.Input(shape=IMG_SHAPE)
x = tf.keras.layers.Rescaling(1./255)(inputs)
x = base_model(x, training=False)
x = tf.keras.layers.GlobalAveragePooling2D()(x)
x = tf.keras.layers.Dense(256, activation="relu")(x)
outputs = tf.keras.layers.Dense(4, activation="softmax")(x)
model = tf.keras.Model(inputs, outputs)
model.compile(optimizer=tf.keras.optimizers.Adam(),
        loss=tf.keras.losses.SparseCategoricalCrossentropy(),
        metrics=["accuracy"])


history = model.fit(train_images, train_labels, epochs=5) # train 5 epochs for
heating the model parameters
```

Figure 9. Python code to build and train deep neural network models

```
    # unfreeze last 10 layers of transfer learning model to continue training
base_model.trainable = True
fine_tune_at = 10

for layer in base_model.layers[:fine_tune_at]:
 layer.trainable = False

    # train 55 more epochs
model.compile(optimizer=tf.keras.optimizers.Adam(lr=0.00001),
          loss=tf.keras.losses.SparseCategoricalCrossentropy(),
          metrics=["accuracy"])

history_tuning = model.fit(train_images, train_labels, epochs=60, initial_epoch=history.epoch[-
1])
```

Figure 10. Python codes created for the fine-tuning of deep neural network models

The performances of the model trained using the training dataset and the model trained using the augmented training dataset; evaluated on the test dataset. For this evaluation, we compared the labels predicted by the models with the actual label values of the test dataset. We used precision, recall, f1-score and accuracy metrics for comparison (Figure 11).

```
    # test the model with test dataset
y_pred = model.predict(test_images)
y_prediction = [item.argmax() for item in y_pred]
y_test = np.array(test_labels).tolist()
print(classification_report(y_test, y_prediction))
```

Figure 11. Python codes used to test the developed models on the test dataset and obtain comparison results

In a classification model, positive and negative samples classified as true are called True Positive (TP) and True Negative (TN), respectively, and positive and negative samples classified as false are called False Positive (FP) and False Negative (FN), respectively.

$$Accuracy = \frac{TN+TP}{TN+FP+TP+FN} \quad \text{(Eq.1)}$$

$$Precision = \frac{TP}{TP+FP} \quad \text{(Eq.2)}$$

$$Recall = \frac{TP}{TP+FN} \quad \text{(Eq.3)}$$

$$f1\ score = 2\ x\ \frac{Precision\ x\ Recall}{Precision + Recall} \quad \text{(Eq.4)}$$

We use the Python v3.8 programming language and the Tensorflow v2.10.0 library to program the deep neural network models. The Albumentation v1.2.0 library was used to enlarge the training dataset with image augmentation. We wrote the codes in Google Colab environment and used a NVIDIA SXM4 40GB GPU to accelerate the deep neural network model training.

3. RESULTS AND DISCUSSION

Table 1: Statistical results of the model trained with the Training dataset

	Precision	**Recall**	**F1-Score**	**Accuracy**
Black Spot	0.67	0.80	0.73	0.81
Canker	0.94	1.00	0.97	
Greening	0.81	0.64	0.72	
Healthy	0.95	0.95	0.95	

The results of the classification metrics we obtained in the model trained with the training dataset are shown in Table 1. In an ideal classification model, the FN and FP values should be equal to zero, so the precision and recall values should be equal to 1. When both precision and recall values are large, the f1-score will be large. The fact that the f1 score is close to 1 is an important metric that shows the success of a classification model. In this model, it is seen that the precision, recall and f1-score metrics in black spot and greening disease classes are lower than canker disease and healthy classes. The overall accuracy of the model is 81%.

Table 2: Statistical results of the model trained with augmented training dataset

	Precision	Recall	F1-Score	Accuracy
Black Spot	0.87	0.88	0.88	0.91
Canker	0.98	0.96	0.97	
Greening	0.90	0.88	0.89	
Healthy	0.95	1.00	0.97	

The classification statistics of the model trained with the augmented training dataset are given in Table 2. As can be seen, in this model, the precision values of the black spot and greening diseased classes increased by 30%, 11%, the recall values increased by 10%, 38%, and the f1 score values increased by 21% and 24%, respectively. The overall accuracy metric of the model increased from 81% to 91%.

These results are obtained from two identical models with the same network structure. It is seen that the model trained with the augmented training dataset has higher classification success. Image augmentation also increased the balance between classes. Interclass precision, recall, and f1 scores are closer to each other.

4. CONCLUSIONS

Image augmentation methods increase model accuracy, generalization, and can be used for control overfitting in deep neural network models used for agricultural purposes. It is very difficult to collect and label a sufficient number of images in computer vision applications to be used in agriculture. Also, machine learning models for agriculture domain are required to be robust against variabilities such as weather, brightness, etc. For this reason, it is crucial to use image augmentation for both enlarging training dataset and increasing dataset variability to have more robust models.

Albumentation library contains more than 70 image augmentation features. Its stochastic and pipeline-based structure makes it easy to use in projects. It can be used not only in image classification problems, but also in object segmentation and detection problems. The codes we have written in the study can be accessed at http://github.com/erayonler/image-augmentation-in-agriculture.

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ADDITIONAL RECORD OF SHORTFIN MAKO SHARK, ISURUS OXYRINCHUS RAFINESQUE, 1810 (CHONDRICHTHYES: LAMNIDAE), FROM THE NORTHEASTERN MEDITERRANEAN SEA COAST OF TURKEY

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INTRODUCTION

The shortfin mako shark, Isurus oxyrinchus Rafinesque, 1810, is a member of the Lamnidae family. Isurus oxyrinchus is a large pelagic shark, widespread in temperate and tropical oceans to depths of 888 m. The species reaches a maximum size of about 445 cm total length (Weigmann 2016; Rigby et al., 2016). The species has low biological productivity with a triennial reproductive cycle and late age at maturity. It is caught globally as target and bycatch in coastal and pelagic commercial and small-scale longline, purse seine, and gillnet fisheries. It is generally retained for the high-value meat as well as its fins (Rigby et al., 2016). The globally trend analysis of the biomass of Isurus oxyrinchus stock revealed with the highest probability of 50-79%, 30-49%, 30-49% reduction and over three generation lengths with consistent with a median decline of 1.2%, 0.6%, 0.9% for north Atlantic stock, north Pacific stock and Indian Ocean, respectively (Rigby et al., 2016). Further to the above data and trend analyses, steep declines have occurred in the Mediterranean Sea; Ferretti et al. (2008) compiled nine time series of abundance indices from commercial and recreational fishery landings, scientific surveys, and sighting records, to reconstruct long-term population trends of large sharks in the northwestern Mediterranean Sea (Ferreti et al., 2008).

Elasmobranch or cartilaginous species around the world are known to be in staggering decline. According to The International Union for Conservation of Nature (IUCN) Red List, one in four fish in the subclass elasmobranchii (sharks and stingrays) is estimated to be threatened with extinction. Their primary threat is overfishing, but lack of data makes stock assessment difficult. Official catch data under-represents shark and stingray taxa caught in Mediterranean fisheries. Mediterranean elasmobranch species are at risk of extinction and many have a regionally high and deteriorating threat status compared to their global status (Cashion et al., 2019). Basic ecological datasets such as distribution areas and abundance amounts are needed to protect the more popular shark and stingray populations in the world and especially in the Mediterranean, and to establish effective conservation plans. Conservation status of Isurus oxyrinchus according to the IUCN threatened status are “Endangered (EN)" (Rigby et al., 2019) and also it is listed on Annex I of United Nations Convention on the Law of the Sea (UNCLOS), Annex I of the Convention on Migratory Species (CMS), Migratory Shark Memorandum of Understanding and Appendix II: Migratory species conserved through agreements of CMS (CMS, 2015; Ergüden et al., 2021).

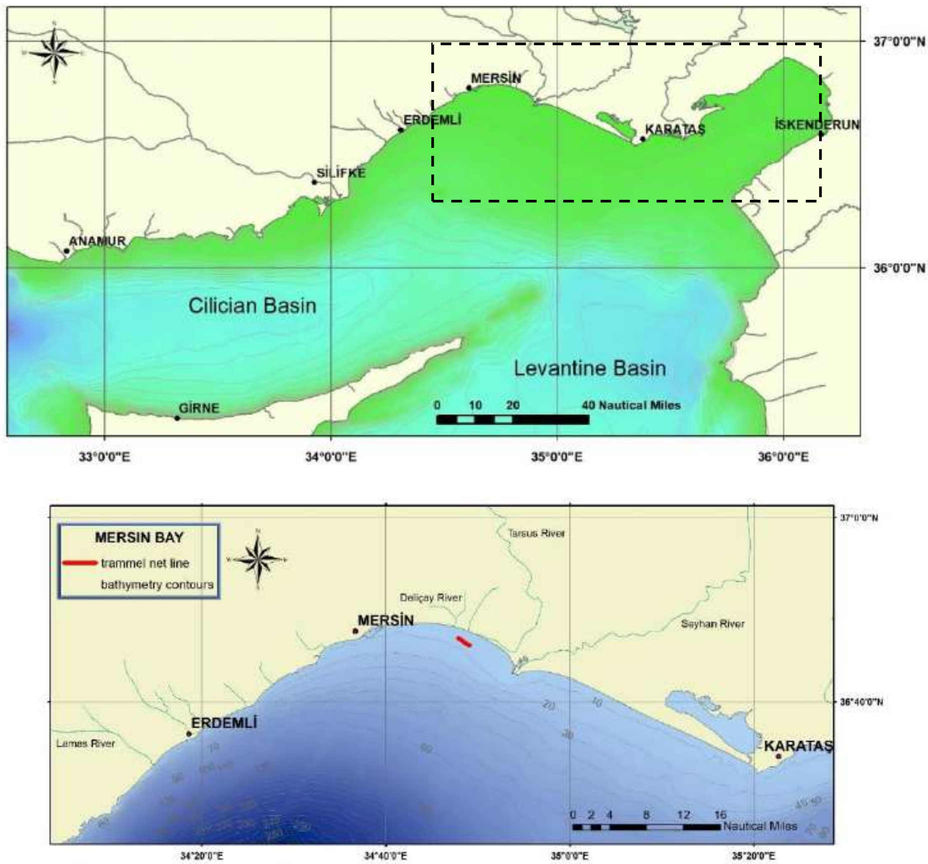

Fig 1. Map of the Mersin Bay in northeastern Mediterranean Sea (dotted frame), indicating the capture site of Isurus oxyrinchus by trammel net line (red line)

Isurus oxyrinchus seem to a one of the predominant shark species in the Mediterranean and is not targeted by commercial fisheries, but they are caught incidentally as bycatch in Turkey. Damalas and Vassilopoulou (2011) reported 30 elasmobranch species in a central Aegean Sea. Deval et al. (2011) reported 18 elasmobranch species (9 shark and 9 rays) bycatch species in Gulf of Antalya, eastern Mediterranean. In 2012, the General Fisheries Commission for the Mediterranean (GFCM) banned retention and mandated careful release for the Isurus oxyrinchus and 23 other elasmobranch species listed on the Barcelona Convention Annex II. Implementation by GFCM has been effective in Turkey, and under existing Turkish regulations, Isurus oxyrinchus and 20 other elasmobranch species are forbidden to catch, retain, land or trade (Official Gazette, 2020) and evidence of illegal behaviour can result in a fine.

A current checklist of Turkish waters was reported 68 cartilaginous species that represented 78% of cartilaginous fauna of the Mediterranean (Bengil and Başusta, 2018). The Aegean and Levantine Seas (the northeastern Mediterranean) are known to be important habitats for cartilaginous fish as breeding and nursery grounds (Turan et al., 2016; Bengil, 2020; Bengil and Başusta, 2018). Isurus oxyrinchus is a solitary and cosmopolitan species (Last and Stevens, 1994) and is distributed worldwide in temperate and tropical waters (Ebert, 2013; Bengil et al., 2019). Although Mediterranean Sea is, in general, located in temperate climate band, the northeastern Levant basin (36°-37° N) shows subtropical characteristics, with a 23.9°C mean annual surface temperature. In addition to high temperature, the region is characterized by high salinity and extreme oligotrophy (Gücü and Bingel, 1994). Coastal surface waters of Mersin Bay located on the wide shelf zone of Cilician Basin are mainly productive due to terrestrial inputs of organic and inorganic matter by major rivers and direct discharges of partially treated wastewaters from domestic and industrial sources (Tuğrul et al., 2019; Akçay et al., 2022). The regional rivers (Ceyhan, Seyhan, Tarsus, Göksu, Lamas) in the Cilician Basin introduce large amounts of nutrients and total suspended solids to the coastal zone of the northeastern Mediterranean Sea influencing the nutrient and particulate matter cycling in the inner bay and shelf waters (Akçay et al., 2022).

The first record of Isurus oxyrinchus in Turkish waters was reported by Akşıray (1954 in Bilecenoğlu et al., 2002). Although Isurus oxyrinchus has been reported in the western and central Mediterranean and the Aegean Sea, reported for only fourth time off Levantine Sea. Ergüden et al. (2013) reported the catch of a young male specimen of Isurus oxyrinchus, 69.8 cm TL and 2.2 kg total weight, was caught by a purse seine boat in 2010, at a depth of 54 m south of Iskenderun Bay. In the elasmobranchs survey in the Iskenderun Bay between 2009 and 2010, single capture was recorded for Isurus oxyrinchus as a rare species between 50-100 m for feeding to a short period or caught on a migration corridor (Yağlıoğlu et al., 2015). Recent occurrence of Isurus oxyrinchus reported in the northeastern Mediterranean, a young female specimen, 100 cm TL was caught by a longline off Dana Island in Mersin Bay in 2020, at a depth of 72 m (Ergüden et al., 2021).

Recent investigation (Table 1) and also news from social media in the northeastern Mediterranean Sea is a potential nursery area where bycatch of the species from trawl, longline, purse seine, set nets consists almost exclusively of juvenile individuals. In the present study, it is reported on a recent capture of a young Isurus oxyrinchus in the Mersin Bay, Turkish coastal side northeastern Mediterranean Sea. Morphometric measurements of the present specimen are given in Tablo 2.

MATERIAL AND METHODS

Although Isurus oxyrinchus has been reported in the western and central Mediterranean and the Aegean Sea, it is reported for only the fourth time off Turkey's northeastern Mediterranean shores (Table 1). A young individual of Isurus oxyrinchus was caught by a commercial fisherman using trammel net (3000 m) from the (36°46′55″N - 034°47′49″E and 36°46′4″N - 034°49′15″E, Fig 1) in coastal waters of the Mersin Bay, between Deliçay River and Tarsus River at a depth around 6-7 m on May 18, 2022. The trammel nets were lowered before sunset, usually parallel to the bathymetric line and retrieved before sunrise. The fishing trials lasted between 10 and 12 hours. The young female specimen is now being preserved in the Museum of Systematics at Faculty of Fisheries of Mersin University, under the reference number MEUFC-22-11-135.

Fig 2. Close-up view of the head, mouth and teeth and also lateral view of present Isurus oxyrinchus 68 cm TL, young female from Mersin Bay, Turkey (All photos by Esin Yalçın)

Fig 2. Close-up view of the head, mouth and teeth and also lateral view of present *Isurus oxyrinchus* 68 cm TL, young female from Mersin Bay, Turkey (*All photos by Esin Yalçın*)

Table 1. Previous records of *Isurus oxyrinchus* from Turkish waters

Location	Gear	♀♂	Length (cm)	Weight (kg)	Depth (m)	Date	References
off Marmaris, Aegean Sea	Fishing net	♀	-	-	-	1950s	Kabasakal and De Maddelena (2011)
Izmir Bay, Aegean Sea	-	-	-	-	-	1969	Geldiay (1969)
Saros Bay, Aegean Sea	Hook and Line	♂	123.6	14	-	March 2012	Kabasakal and Kabasakal (2013)
Iskenderun Bay, Mediterranean Sea	Purse seine	♂	69,8	2.28	54	2010	Ergüden et al. (2013)
Fethiye coast, Mediterranean Sea	-	♀	200	-	-	June 2000	Kabasakal (2015)
Mersin Bay, Mediterranean Sea	Longline	♀	-	-	-	2000	
Mersin Bay, Mediterranean Sea	Drift net	♂	250	-	-	January 2011	
Iskenderun Bay, Mediterranean Sea	Purse seine	♀	380	-	-	2012	
Antalya Bay, Mediterranean Sea	Handline	♂	100	-	-	November 2013	
Antalya Bay, Mediterranean Sea	Stationary net	♀	120	-	-	April 2015	
Foça coast, Aegean Sea	Stationary net	♀	65	4	-	May 2015	
Edremit Bay, Aegean Sea	Net set	♂	74.7	2.75	20-25	April 2016	Tunçer and Kabasakal (2016)
Izmir Peninsula, Aegean Sea	Purse seine	-	180.9	-	-	1990s	Kabasakal (2017a)
Kuşadası coast, Aegean Sea	-	-	-	-	-	December 2016	

Antalya Bay, Mediterranean Sea	Pelagic longline	♀♂	-	-	-	2000s	Kabasakal (2017b)
Izmir Bay, Foça, Aegean Sea	Gillnet	♀	76.5	2.75	4	May 2015	Bengil et al. (2019)
Gökova Bay, Aegean Sea	Longline	♂	94.3	5.98	-	February 2016	
Fethiye Bay, Aegean Sea	-	-	-	-	-	May 2017	
off Dana Island, Mersin Bay, Mediterranean Sea	Longline	♀	100.2	-	72	May 2020	Ergüden et al. (2021)
Mersin coast, Mediterranean Sea	Trammel net	♀	68	1.92	6-7	May 2022	This study

Table 2. Some morphometric measurements of the present specimen, *Isurus oxyrinchus*

Measurements (cm)	***Isurus oxyrinchus*** ♀
Total length (TL)	68.0
Fork length (FL)	59.5
Standard length	54.0
Head length	22
Mouth length	6.5
Mouth weight	-
Snout length	0.8
Eye length	1.3
Eye height	1.45
Space between nasal holes	2.7
Pre-branchial length	16.5
Pre-orbital length	5.8
Pre-D1 fin length	27.5
Pre-D2 fin length	48
Pre-pectoral fin length	19.5
D1 fin length	6.5
D1 fin height	5
D1 fin base	6
D2 fin length	2
D2 fin height	1.2
D2 fin base	0.7
Pectoral fin length	11.5
Pectoral fin base	3

Pelvic fin length	4.5
Pelvic fin base	2.5
Anal fin1 length	2.2
Anal fin1 base	0.7
Anal fin2 length	-
Anal fin2 base	-
Tail holder length	-
Caudal upper lobe length	14
Caudal lower lobe length	9
Weight (kg)	1.92

RESULTS AND DISCUSSION

Data revealed that the present specimen is a young female of *Isurus oxyrinchus*. Its photographs were taken (Fig 2) and morphometric measurements of the specimen were recorded (Table 2), measured 68 cm in total length (TL) and weighed 1.92 kg. This record is critical to identify and assess the status of possible nursery areas for endangered elasmobranchs to help future conservation efforts and highlight the importance of shark conservation. The occurrence of this young specimen of *Isurus oxyrinchus* in the Mersin Bay, northeastern Mediterranean may suggest that this area is potentially a breeding or nursery ground. Thus, further studies are needed in this region to monitor this species in the northeastern Mediterranean. Monitoring studies should be considered as a high priority area for the conservation of this species in the region. The northeastern Mediterranean is known to be important habitats for cartilaginous fish as breeding and nursery grounds (Turan et al., 2016; Bengil 2018; Bengil and Başusta, 2018; Bengil, 2020; Ergüden et al., 2021), the present study also supports that. Unfortunately, this potential coastal breeding and nursery ground of lamniform sharks in the norheastern Mediterranean Sea, same as northern Aegean Sea off Turkish coast (Tunçer and Kabasakal, 2016), is also a remarkable fishing ground of trawler, purse seiner and also artisanal fishermen, where small-scale fisheries are active the year round. Consequently, this additional record can contribute to future assessments of this rare species and in the description of its geographic distribution.

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ADDITIONAL RECORD OF LEOPARD WHIPRAY HIMANTURA LEOPARDA MANJAJI-MATSUMOTO & LAST, 2008 (CHONDRICHTHYES: DASYATIDAE), FROM THE NORTHEASTERN MEDITERRANEAN SEA COAST OF TURKEY

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INTRODUCTION

Himantura leoparda is a species of Myliobatiformes in the family whiptail stingrays. They are listed as “Vulnerable (VU)” by IUCN (Rigby et al., 2016). It is known that elasmobranchs or cartilaginous species in the world show an alarming decrease. According to The International Union for Conservation of Nature (IUCN) Red List, one in four fish in the subclass elasmobranchs (sharks and stingrays) is estimated to be threatened with extinction. Their primary threat is overfishing, but lack of data makes stock assessment difficult. Official catch data under-represents shark and stingray taxa caught in Mediterranean fisheries. Mediterranean elasmobranch species are at risk of extinction and many have a regionally high and deteriorating threat status compared to their global status (Cashion et al., 2019). Basic ecological datasets such as distribution areas and abundance amounts are needed to protect the more popular shark and stingray populations in the world and especially in the Mediterranean, and to establish effective conservation plans.

In recently, *Himantura leoparda* is recorded viviparous species of whipray described closely related to *Himantura uarnak*, with both species having a similar shape and dorsal disc pattern (Manjaji-Matsumoto and Last 2008). *Himantura leoparda* possesses characteristic that ring from a leopard pattern on the dorsal surface of the body. Therefore, spotting patterns are useful as a character to distinguish between the species. The *Himantura leoparda* can be distinguished by its unique arrangement of midscapular denticles and the leopard-like markings on the dorsal surface of adults and large specimens (Manjaji-Matsumoto and Last 2008; Last and Stevens 2009; Rigby et al., 2016). However, the identification of stingrays is generally done through a morphological approach, using the reticulation pattern and body shape. This species also has a subtle difference in squamation and body shape, as well as the development of a color which is unique and complex (Rigby et al., 2016). Aside from this, the body shape of *Himantura leoparda* is rhomboidal, not quadrangular as in *Himantura uarnak* and *Himantura undulata* (Manjaji-Matsumoto and Last, 2008; Arlyza et al., 2013). Additionally, *Himantura leoparda* was identified via the combination of main morphological characters by Saad et al. (2021): disc rhomboidal much broader in adult than in embryos, anterior margins of disc double convex, angular margin rounded, snout displaying an apical lobe, eyes and nostrils moderately large, mouth slightly arched with four papillae on floor, disc entirely smooth in embryos, heart-shaped scapular denticles developed in adult, smaller denticles along disc midline to tail base, outer margin of pectoral more or covered with spaced denticle, tail exhibiting a sting and covered by small denticles rather abundant at its base. Disc covered with large thick dark brown irregular rings often incomplete dorsally, central area of each ring yellowish, leopard-like rings, spots and rings largest over middle of disc, increasing posteriorly, decreasing towards disc margins, tail with dark spots similar in size of those in disc, covered with dark bands posteriorly to sting, ventral surface of disc and tail uniformly beige.

The specimen is described and comments on the distribution and the real status of this species in the area are provided.

MATERIAL AND METHODS

A live specimen of the whipray *Himantura leoparda* was sampled (with 44 mm codend mesh size) off southeast Turkey (Levantine Sea, Northeastern Mediterranean, Fig. 1) adjacent to Mersin Bay on a sandy-muddy bottom at slope depths between 20-25 m (36°45′7″N - 034°46′19″E and 36°39′54″N - 034°55′22″E, Fig 1) on board commercial bottom trawl vessel (18 m length, 400 HP) on September 29, 2022. Speed and duration of trawl operations were kept constant at 2.5 knots and 4 hours, respectively. The female specimen caught with her tail cut off (Fig 2) and measured, immediately, the specimen was photographed and released to the sea alive carefully. The species caught as bycatch, elasmobranchs (sharks and stingrays) species are not commercially valuable in Turkey, generally release to the sea alive or dead.

Disc covered with large thick dark brown irregular rings often incomplete dorsally, central area of each ring yellowish, leopard-like spotted form and an atypical form with finer spots, rings largest over middle of disc, increasing posteriorly, decreasing towards disc margins, tail with dark spots similar in size of those in disc, covered with dark bands posteriorly to sting, ventral surface of disc uniformly beige (Fig 2 and Fig 3). This description is in total accordance with Manjaji-Matsumoto and Last, 2008 although the tail is missing. In addition to these, short descriptive characters of this species by Borsa et al. (2013) are as follows: all ocellae have interrupted contour; the ocella shape is recognizable in some instances but generally cannot be inferred. In this study, on present individual, ocellae contours are mixed polygons and consistent with definition above.

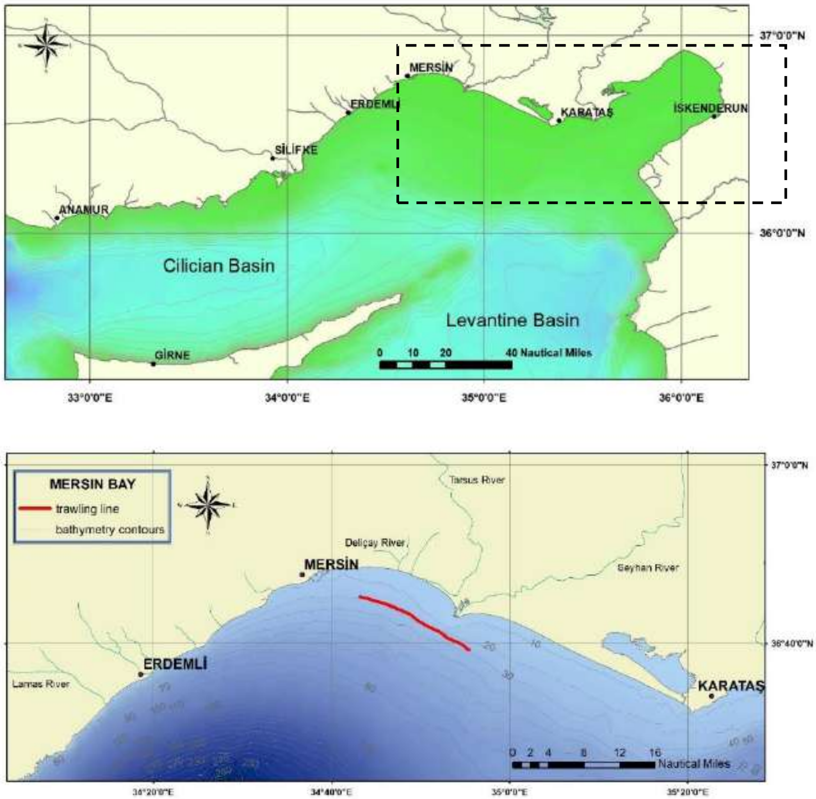

Fig 1. Map of the Mersin Bay in Northeastern Mediterranean Sea (dotted frame), indicating the capture site of *Himantura leoparda* by trawlling line (red line)

Fig 2. The specimen Himantura leoparda caught with her tail cut off

Fig 3. Characteristic spotting patterns on dorsal surface of the specimen *Himantura leoparda* (from the front)

RESULTS AND DISCUSSION

Himantura leoparda is widely distributed in the tropical Indo-Pacific region from South Africa, Eastern India and Sri-Lanka, throughout southern India, including the Philippines, southern Japan, Taiwan, New Guinea and Northern Australia from Coral Bay to Cape York Peninsula (Manjaji-Matsumoto and Last 2008). Since *Himantura leoparda* is of Indo-pacific origin, assumed that it migrated into the Mediterranean Sea through the Suez Channel (Serena, 2005; Yucel et al., 2017). Of the 31 species belonging to the genus Himantura Müller and Henle, 1837 *Himantura leoparda* (Manjaji-Matsumoto and Last, 2008) is one of two species in the Mediterranean Sea (Saad et al., 2021). Yucel et al. (2016) identified for the first time a *Himantura leoparda* in the Mediterranean by using both morphological and molecular techniques as well as providing the first DNA barcode record of the species. It can also be stated as *Himantura leoparda* inhabits and reproduces on the Turkish coasts of the Northeastern Mediterranean Sea, confirmed by DNA barcoding (Yucel et al., 2016). Furtherly, a second record occurred from the coast of Lebanon (Bariche et al., 2020) and third record occurred from the coast of Syrian (Saad et al., 2021). In the Turkish coasts of Northeastern Mediterranean Sea, the latest study reported that first information on the age and feeding of an individual *Himantura leoparda* caught as bycatch from the Mersin Bay by commercial purse seine from 16 m depth in March 2022. The morphometric measurements of the specimen reported and age of the individual was aged to 10 years old. Diet analysis showed that Indo-Pasific species *Erugosquilla massavensis* individuals were dominant prey in the stomach contents of *Himantura leoparda* (Başusta and Başusta, 2022). The morphometric measurements of this study and previous records of *Himantura leoparda* from Northeastern Mediterranean Sea are summarized in Table 1.

Table 1. Previous records of *Himantura leoparda* from Eastern Mediterranean Sea

Location	Gear	♀ ♂	Disk Width (cm)	Weight (kg)	Depth (m)	Date	References
Northeastern Mediterranean, Turkey coast	Trawl	♀	135.2	55	130-150	January, 2016	Yücel et al. (2016)
Lebanon coast	*Scuba diver photo	-	-	-	6	September, 2018	Bariche et al. (2020)
Syria coast	Longline	♀	131	54	110-120	November, 2020	Saad et al. (2021)
Mersin Bay, Turkey	Purse seine	-	132.7	65.45	16	March, 2022	Başusta and Başusta (2022)
Mersin Bay, Turkey	Trawl	♀	120	50	20-25	September, 2022	This study

A current checklist of Turkish waters was reported 68 cartilaginous species that represented 78% of cartilaginous fauna of the Mediterranean (Bengil and Başusta, 2018). The Aegean and Levantine Seas (the Northeastern Mediterranean) are known to be important habitats for cartilaginous fish as breeding and nursery grounds (Turan et al., 2016; Bengil, 2020; Bengil and Başusta, 2018). Although Mediterranean Sea is, in general, located in temperate climate band, the Northeastern Levant basin (36°-37° N) shows subtropical characteristics, with a 23.9 °C mean annual surface temperature. In addition to high temperature, the region is characterized by high salinity and extreme oligotrophy (Gücü and Bingel, 1994). Coastal surface waters of Mersin Bay located on the wide shelf zone of Cilician Basin are mainly productive due to terrestrial inputs of organic and inorganic matter by major rivers and direct discharges of partially treated wastewaters from domestic and industrial sources (Tuğrul et al., 2018). The regional rivers (Ceyhan, Seyhan, Tarsus, Göksu, Lamas) in the Cilician Basin introduce large amounts of nutrients and total suspended solids to the coastal zone of the Northeastern Mediterranean Sea influencing the nutrient and particulate matter cycling in the inner bay and shelf waters (Akçay et al., 2022). Consequently, Mersin Bay, the nutrient-rich waters with rivers input of the bay and gradually deepening bathymetric structure with sandy and muddy bottom maybe favourable environmental conditions to develop and reproduce for *Himantura leoparda*. On the other hand, a recruitment supported by migrations from the Red Sea through Suez Canal remains one of the best parameters which could enhance the successful establishment of a viable population of *Himantura leoparda* in the region (Saad et al., 2021).

The fifth capture of *Himantura leoparda* constitute the additional record for the Northeastern Mediterranean coast of Turkey and this additional record can contribute to future assessments of this rare species and in the description of its geographic distribution. However, only five captures of the species are reported to date and more records are needed to determine its real status of this recent Lessepsian migrant in the Northeastern Mediterranean.

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IMPACT OF SMALL BUSINESS ON ANIMAL WELFARE USING TOPSIS MULTI-CRITERIA DECISION MAKING

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1. INTRODUCTION

Animal welfare is defined as the animal's being in harmony with its environment, its ability to adapt to its environment without suffering, and its ability to lead a healthy life both psychologically and physically. In other words, it shows the state of the individual's relationship with his/her environment and this situation can be measurable. Welfare is defined as the physical and mental behavior associated with the presence of positive emotions and the absence of negative emotions in animals. While animal welfare aims at a life free from feelings and thoughts such as stress and pain, the lack of response to stress in animals explains it as an indicator of well-being. The most important factors in the decline of animal welfare are the characteristics such as the short life span of the animal, stress, diseases, body damage, weak reproductive efficiency, and low immunity (Gök et al., 2021; Önder and Tırınk, 2022).

While animal welfare positively affects the productivity of animals, it constitutes an important role of sustainable livestock practices. The implementation of animal welfare practices will positively affect the increase in production economically and ecologically, as well as the increase in sustainability animal husbandry (Şahin and Ercan, 2010; Küçükönder et al., 2013).

It is often difficult to explain cattle holdings with statistical methods in order to interpret and evaluate them in terms of animal welfare. Thus, there is a need to scale the animal welfare characteristics, which is an abstract concept, with concrete criteria. For this purpose, animal welfare evaluation criteria have been applied in order to measure cattle holdings according to animal welfare. In the application, a total of 7 criteria were evaluated, including area per animal, social relationship, barn floor type, ventilation, lighting, care and nutrition. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which is the most preferred among the Multi-Criteria Decision Making (MCDM) methods, was used to evaluate the 7 criteria discussed in the application. MCDM method provides to reach the most appropriate compromise solution by evaluating different approaches and alternatives according to their decision-making values (Tuğrul, 2022a; Ulutaş and Topal, 2020).

The TOPSIS method was introduced in 1981 and is a method developed to solve the problems of MCDM methods. This method is also explained as a method of ranking alternative preferences by proximity to ideal solutions (Tuğrul, 2022c).

The aim of this research is the applicability of TOPSIS method, in order to examine animal welfare of small-scale cattle holdings registered in Şırnak-İdil District Directorate of Agriculture and Forestry. In this book, 7 different criteria were evaluated for the evaluation of small-scale cattle holdings according to animal welfare. These criteria were evaluated as area per animal, social relationship, barn floor type, ventilation, lighting, care and nutrition (Chen, 2000).

In this study, after the Introduction part, the theory of the MCDM method is explained in detail. This book, the data on which the method is applied, the purpose of the study, the solutions of the methods and its application in the excel program are shown in detail. Finally, in the conclusion part, the aim of the study and its general evaluation were made.

2. MULTI-CRITERIA DECISION MAKING

Decision making is the physical, emotional and mental choice of people to choose and choose between possibilities, ways and means for various purposes. In addition, decision making enables choosing among alternatives according to criteria or criteria in achieving a stated goal. Decision making is becoming a complex process in almost every field. The decision maker can classify the alternatives by choosing and sorting among the alternatives. The decision maker should evaluate the criteria and decide on the most suitable one among the alternatives. The decision-making process can be listed as the decision maker, alternatives, criteria, the decision maker's choices and decision results.

MCDM is explained as methods that form a sub-branch of the decision unit that emerged in the 1960s and classify different alternatives. MCDM aims to select the most suitable alternative. Also, the MCDM method is explained as a problem solving process by making the alternatives understandable against conflicting criteria in decision making (Çaylak, 2019).

The MCDM method uses qualitative and quantitative data to make the most appropriate decision in solving problems. The MCDM method is the appropriate method used to select and rank alternatives among conflicting criteria (Tuğrul, 2022b).

2.1. Multi-Criteria Decision Making Method (MCDM)

Decision-making problems are the process of choosing the most appropriate decision among the alternatives. In multi-criteria decision problems, there are many methods used to evaluate and interpret alternatives (Süzülmüş and Polat, 2022).

2.1.1. TOPSIS Method

This is a method developed to evaluate MCDM problems. The evaluation of alternatives is examined in two parts as positive and negative ideal solutions. This method is evaluated by ranking the preferences by proximity to ideal solutions. For this purpose, when all criteria are examined, the most suitable alternative is called the ideal alternative, and the worst one is called the negative ideal alternative. Thus, this method can be explained as arranging the alternatives from the closest to the farthest solution to the ideal solution (Tuğrul, 2022d; Yong, 2006).

The most important reason why the TOPSIS method is preferred among the MCDM methods is that it ranks the alternatives that are closer to the positive ideal solution first in the ranking of the alternatives. Thus, TOPSIS is widely preferred in many areas (Mendoza et al., 2008).

The most important advantages of choosing the TOPSIS method can be listed as the application and calculations of the method are easy, the method is suitable for the use of subjective and objective criteria, the method is logical and understandable, the method has the ability to determine the most suitable alternative in a short time, and finally, it obtains results quickly. The disadvantages of the method are that when a new alternative is added or removed, the sequence of alternatives can completely change, excessive deviation of a value from the ideal solution affects the choice of alternatives, and finally, use of the method is not preferred when the alternative values change too much. In addition, the reason why TOPSIS method is preferred more than other MCDM making methods is that the calculations of the process steps are quite simple (Demir, 2019; Tuğrul, 2022a).

The following steps are defined for performance evaluation according to the TOPSIS method:

Step 1: Determining the method objectives and evaluation criteria

Step 2: Build the decision matrix (A) and the Normalized decision matrix (R). Alternatives are indicated by $(x_1, x_2, \dots, x_p)$ in their rows, and evaluation criteria are indicated by $(y_1, y_2, \dots, y_n)$ in their columns.

Table 1. Decision Matrix

		Criteria			
		$\boldsymbol{y_1}$	$\boldsymbol{y_2}$	...	$\boldsymbol{y_n}$
Alternatives	$\boldsymbol{x_1}$	a_{11}	a_{12}	...	a_{1n}
	$\boldsymbol{x_2}$	a_{21}	a_{22}	...	a_{2n}
	...	...	...	...	...
	$\boldsymbol{x_m}$	a_{m1}	a_{m2}	...	a_{mn}

After the alternatives and criteria are created, with m being the number of alternatives and n the number of criteria, the pxt-sized decision matrix created by the decision maker is created as in equation 1.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (1)$$

In the matrix $A = \left[a_{ij}\right]_{mxn}$, a_{ij} values show the value of the criteria according to the alternatives. After the decision matrix is obtained, R matrix is created by appliying the equation (1).

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{n} a^2{}_{kj}}} \tag{2}$$

The matrix representation of the calculated R matrix is as in the equation (3).

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{3}$$

Here i: $1,2,\ldots,n$ and j: $1,2,\ldots,m$.

Step 3: Build the normalized decision matrix (V). First of all, the weight values of the criteria $\left(w_j\right)$ are determined so that $\sum_{j=1}^{n} w_j = 1$. Since the weight values are determined according to the degree of importance of the criteria, the weight values reveal the subjective feature of the TOPSIS method in the decision-making step. Then, the values in each column of the R matrix are multiplied by the corresponding w_j values and the weighted V is formed as in the equation (4).

$$V_{İj} = (w_j x R_{ij}) \tag{4}$$

Step 4: Creating positive and negative ideal solutions. Here, using the weighted normalized decision matrix, positive and negative ideal solution sets of each criterion are obtained. If the criteria being evaluated are utility-based, the positive ideal solution takes the largest value of the weighted normalized decision matrix, and the negative ideal solution takes the smallest value. Also the criteria are the cost basis, the opposite of the benefit criterion values occurs (Süzülmüş and Polat, 2022).

For obtaining the positive ideal solution set, the largest value of the column values of the weighted criteria of the V matrix is given if it is the maximum, and the smallest value of the column values is given if the relevant criterion is minimum oriented. In order to obtain the negative ideal solution set, if our goal is minimum, the minimum value of the column values of the weighted criteria of the V matrix is taken, and if the relevant criterion is maximum directional, the maximum value is taken (Tuğrul et al., 2020).

Positive and Negative ideal solutions are explained as in equation (5),(6). In this equation, J is the benefit and J' is the cost value.

$$A^{+} = \{(max_i v_{ij} | j\varepsilon J), (min_i v_{ij} | j\varepsilon J')\} \quad (5)$$

$$A^{-} = \{(min_i v_{ij} | j\varepsilon J), (max_i v_{ij} | j\varepsilon J')\} \quad (6)$$

is in the form. The values obtained from the equation (5) are $A^{+} = \{V^{+}{}_1, V^{+}{}_2, \dots, V^{+}{}_n\}$ and the values obtained from the equation (6) are $A^{-} = \{V^{-}{}_1, V^{-}{}_2, \dots, V^{-}{}_n\}$ is being created.

Step 5: Calculation of separation measures. The deviation values of the alternatives are explained as positive and negative ideal distance. These distances are seen in the equation (7) and (8).

$$S^{+}{}_i = \sqrt{\sum_{j=1}^{n} (v_{ij} - v^{+}{}_j)^2}, \quad i = 1,2, \dots, m \quad (7)$$

$$S^{-}{}_i = \sqrt{\sum_{j=1}^{n} (v_{ij} - v^{-}{}_j)^2}, \quad i = 1,2, \dots, m \quad (8)$$

In this equation, positiveand negative ideal distance values are formed as much as the number of alternatives (Olson, 2004; Süzülmüş and Polat, 2022).

Step 6: Calculating the relative closeness to the ideal solution. The relative closeness values of each alternative to the ideal solution are calculated by applying positive and negative ideal distance measures. These calculations are shown in equation (9).

$$C^{*}{}_i = \frac{S^{-}{}_i}{S^{-}{}_i + S^{+}{}_i}, \quad i = 1,2, \dots, m \quad (9)$$

In this equation, the relative closeness values to the ideal solution take values in the range of $0 \leq C^{*}{}_i \leq 1$ (Krohing and Pacheo, 2015; Tuğrul, 2022d).

3. APPLICATION

3.1. Data Used in the Application

The data used in the application part of the research were taken from 7 small-scale enterprises registered to the Şırnak-İdil District Directorate of Agriculture and Forestry. These enterprises, which are considered in practice, are obtained from the center of the İdil district or from its villages. The names of the villages where the small-scale enterprises are located and the number of animals are shown in Table 2.

Table 2. Village Names and Number of Animals of Small-Scale Businesses

Rank No	Village	Number of Animals
B1	Hendek	76
B2	Kayı	69
B3	Kozluca	38
B4	Şekerköy	71
B5	Tözal	34
B6	Yağmurca	47
B7	Yukarı	15

3.2. Evaluation of Small-Scale Cattle Farms by Animal Welfare

In the study, small-scale cattle holdings primarily dealt with the evaluation of scales according to animal welfare. The decision maker in the evaluation was determined by the Veterinarian working in the Şırnak-İdil District Directorate of Agriculture and Forestry. The evaluation features and animal welfare evaluation criteria are given in Table 3. These criteria were 7 criteria as Space per Animal (C1), Social Relationship (C2), Barn Floor Type (C3), Ventilation (C4), Lighting (C5), Care (C6) and Nutrition (C7). Considering the qualitative and quantitative evaluation features of these criteria, the veterinarian has scored between 1-5 values.

Table 3. Animal Welfare Evaluation Criteria

	Evaluation Features				
C1: Space per Animal	4 m^2	5 m^2	6 m^2	7 m^2	7 m^2 >
C2: Social Relationship	Not group	Group	By gender	By age	Family heifer
C3:Barn Floor Type	Concrete	Plastic	Metal grid	25 cm straw	50 cm straw
C4: Ventilation	Very bad	Bad	Avarage	Good	Very good
C5: Lighting	Very bad	Bad	Avarage	Good	Very good
C6: Care	Very bad	Bad	Avarage	Good	Very good
C7: Nutrition	Very bad	Bad	Avarage	Good	Very good

The Veterinarian in Şırnak-İdil District Directorate of Agriculture and Forestry explained the scoring values of 7 different criteria in Table 3 as in Table 4. The value of 1 in Table 3 is considered as "the lowest welfare (very bad)" and the value of 5 as "the highest welfare (very good)".

3.3. Application of TOPSIS Method in Small-Scale Cattle Farms

Step 1: Determining the method objectives and evaluation criteria: First of all, the criteria created in small-scale cattle enterprises for the purpose of the study were selected as animal welfare criteria and were weighted according to the degree of importance by the Specialist Veterinarian. The weights of these criteria are given in Table 4.

Table 4. Weights of Criteria

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
Weight	0.15	0.14	0.14	0.14	0.14	0.14	0.15

Step 2: Calculation of the decision matrix: In Table 5, there are 7 small-scale enterprises in the rows of the decision matrix in the TOPSIS method and the criteria applied in decision making (C1, C2, C3, C4, C5, C6, C7) in the columns.

Table 5. Decision Matrix in Small-Scale Cattle Farms by Animal Welfare

				Criteria			
Businesses	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
B1	1	1	1	3	3	3	3
B2	1	1	1	3	3	4	3
B3	3	2	1	4	3	3	4
B4	1	1	1	2	3	3	3
B5	3	2	1	3	3	3	3
B6	3	1	1	2	3	4	3
B7	4	1	1	4	3	4	4

According to the veterinarian, in order of importance of the animal welfare evaluation criteria, "C7: Nutrition" is the 1st, "C6: Care" is the 2nd, "C1: Area per animal" is the 3rd, and "C4: Ventilation" is the 4th. “C5: Lighting” in the rank, “C3: Barn floor type” in the 6th place, and “C2: Social relationship” in the 7th place.

With 7 small scale enterprises and 7 evaluation criteria, the decision matrix is 7x7 and is formed as shown in equation 10. The decision matrix is created by taking the values in Table 4.

$$A = \begin{bmatrix} 1 & 1 & 1 & 3 & 3 & 3 & 3 \\ 1 & 1 & 1 & 3 & 3 & 4 & 3 \\ 3 & 2 & 1 & 4 & 3 & 3 & 4 \\ 1 & 1 & 1 & 2 & 3 & 3 & 3 \\ 3 & 2 & 1 & 3 & 3 & 3 & 3 \\ 3 & 1 & 1 & 2 & 3 & 4 & 3 \\ 4 & 1 & 1 & 4 & 3 & 4 & 4 \end{bmatrix}_{7x7} \tag{10}$$

Here, a_{ij} values in the $A = \left[a_{ij}\right]_{7x7}$ matrix show the values that the criteria take according to the enterprises. After the decision matrix is created, the Normalized decision matrix (R) is created by using the equation (10). The r_{11} value of the R matrix is obtained by dividing the a_{11} element of the A decision matrix by the square root of the sum of the squares of the first column elements of the A matrix and is calculated as an example in equation (11).

$$r_{11} = \frac{1}{\sqrt{1^2+1^2+3^2+1^2+3^2+3^2+3^2+4^2}} = 0.13 \quad (11)$$

R matrix is created by calculating all the criteria as in equation (11).

Table 6. Normalized Decision Matrix

CriterionWeight(W)/ Business	**C1 0.15**	**C2 0.14**	**C3 0.14**	**C4 0.14**	**C5 0.14**	**C6 0.14**	**C7 0.15**
B1	0.13	0.27	0.37	0.36	0.37	0.32	0.34
B2	0.13	0.27	0.37	0.36	0.37	0.43	0.34
B3	0.40	0.55	0.37	0.48	0.37	0.32	0.45
B4	0.13	0.27	0.37	0.24	0.37	0.32	0.34
B5	0.40	0.55	0.37	0.36	0.37	0.32	0.34
B6	0.40	0.27	0.37	0.24	0.37	0.43	0.34
B7	0.53	0.27	0.37	0.48	0.37	0.43	0.45

Step 3: Calculation of the V matrix. At this stage, first of all, weight values for the evaluation criteria are created (Table 4). The resulting weighted normalized decision matrix is given in Table 7.

Table 7. Weighted Normalized Decision Matrix

CriterionWeight(W)/ Business	**C1 0.15**	**C2 0.14**	**C3 0.14**	**C4 0.14**	**C5 0.14**	**C6 0.14**	**C7 0.15**
B1	0.02	0.03	0.05	0.05	0.05	0.04	0.05
B2	0.02	0.04	0.05	0.05	0.05	0.06	0.05
B3	0.06	0.08	0.05	0.06	0.05	0.04	0.06
B4	0.02	0.05	0.05	0.03	0.05	0.04	0.05
B5	0.06	0.11	0.05	0.05	0.05	0.04	0.05
B6	0.06	0.08	0.05	0.03	0.05	0.06	0.05
B7	0.08	0.10	0.05	0.06	0.05	0.06	0.06

Step 4: Calculation of Positive and Negative ideal solution: These values of the ideal solutions are given in Table 8.

Table 8. Ideal Solutions

	C1	C2	C3	C4	C5	C6	C7
A^{+}	0.08	0.11	0.05	0.03	0.05	0.04	0.05
A^{-}	0.02	0.03	0.05	0.06	0.05	0.06	0.06

5. Step : Calculation of discrimination measures: Positive and Negative ideal distance values were calculated by using Equation (7) and Equation (8) equations. The deviation values of all the calculated alternatives are given in Table 9.

Table 9. Distance to Positive and Negative Ideal Solution Values

Alternatives	$S^{+}{}_{i}$	$S^{-}{}_{i}$
B1	0.104	0.024
B2	0.115	0.017
B3	0.047	0.084
B4	0.084	0.042
B5	0.028	0.092
B6	0.087	0.062
B7	0.038	0.092

Step 6: Calculation of the proximity with respect to the ideal solution: At this stage, using the Positive ideal distance and Nesative ideal distance measures, the closeness values $(C^{*}{}_{i})$ of each alternative to the ideal solution were calculated using Equation 9. The closeness values of all alternatives according to the ideal solution are shown in Table 10.

Table 10. Proximity Values According to the Ideal Solution

Alternatives	$C^{*}{}_{i}$
B1	0.187
B2	0.128
B3	0.641
B4	0.333
B5	0.766
B6	0.446
B7	0.707

When the alternatives are ranked according to the closeness (C^*_i) value to the ideal solution, the ranking of the enterprises most suitable for animal welfare among small-scale enterprises is given in Table 11.

Table 11. Most Appropriate Small-Scale Cattle Farming Ranking

Rank	Business Name	Business Code	Result
1	Tözal	B5	0.766
2	Yukarı	B7	0.707
3	Kozluca	B3	0.641
4	Yağmurca	B6	0.446
5	Şekerköy	B4	0.333
6	Hendek	B1	0.187
7	Kayı	B2	0.128

When Table 11 is examined, it is concluded that the best Small-Scale Cattle holding is Tözal and the worst one is Kayı.

4. CONCLUSION

The correct analysis and interpretation of data determines the future status of a business. Making the data applicable and analyzing and interpreting it with the most appropriate method provides an important competitive advantage to the business owners. For this purpose, MCDM method was applied to reveal the relationships between the data.

MCDM methods consist of approaches and methods that have many conflicting criteria and try to create the most appropriate solution. Thus, the decision maker makes a more successful and scientific decision by applying MCDM methods to solve the problems. MCDM methods are suitable methods to identify and rank one or more alternatives among the criteria.

In this book, TOPSIS method, which is one of the MCDM methods, has been applied for the selection and ranking of Small-scale Cattle holdings suitable for Animal Welfare. As a result of all the calculations, it has been concluded that the TOPSIS method will be efficient and effective in solving the problem of evaluating animal welfare in cattle enterprises. In addition, when studies on animal welfare were investigated, it was seen that the criteria evaluating animal welfare were not used in cattle enterprises and MCDM methods were not applied. Thus, it is thought that this study will be useful to researchers. In subsequent studies, it has been shown that MCDM methods can also be applied when evaluating animal enterprises according to animal welfare criteria. In addition, it is suggested that researchers can apply other MCDM methods besides TOPSIS method.

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INSECT BIO-DIVERSITY AND EVALUATION OF USING INSECT AS BIO-INDICATOR FOR SUSTAINABILITY OF PROTECTED AREAS*

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** A part of this study was published about the workshop titled "Knowledge Transfer between Turkey and EU Countries for Nature Protected Areas and Establishing a Communication Network"*

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Floristic studies have been performed very important role for determining of habitat classification and protection nowadays. According to FFH and NATURA 2000 directives generally plants and plant assemblages are used for classification of habitat types. There are 9 main habitat types in Annex I, EU Natural Habitat Types of Community Interest Whose Conservation Requires the Designation of Special Areas of Conservation in the criteria of NATURA 2000. (1) Coastal and halophytic habitats, (2). Coastal Sand Dunes and Inland Dunes, (3) freshwater habitats, (4) Temperate Heath and Scrub, (5) Sclerophyllous Scrub (Matorral), (6) Natural and Semi-Natural Grassland Formations, (7) Raised Bogs and Mires and Fens, (8) Rocky Habitats and Caves and (9) Forests.

The floristic studies have been proved that plants can be used as bio-indicator for habitat description, destruction and protection. The habitat classification in directive of NATURA 2000 has been prepared regarding with mostly plant species.

Annex IV showed protected habitat types listed only five groups of indicator insect (Insecta=Hexapoda) groups belonging to arthropods. These orders are; Coleoptera, Lepidoptera, Mantodea, Odonata and Orthoptera with 24, 40, 1, 13, and 10 species, respectively.

Only 88 species of insect which performed very important role for the food chain and nature because of their amazing abundance (70% in whole alive) when we compare with the other species living in the world given in the list (Annex IV) are not enough for protection of the habitats.

Using insects as bio-indicator for habitat description, destruction and land sustainability are not widespread although insect species easily respond to environmental changes. The reason for this is due to the scarcity of studies on this issue. Although the scientific studies have been verified that insects can be used as indicator for habitat description, destruction, sustainability of protected areas and sensitivity of them for environmental modification as much as plant species, the studies about using insect as bio-indicator are inadequate. When population of insect and plant species are compared the result of overwhelming superiority of insects according to plants can be met with astonishment by the people away from the subject. Not only plant but also all living species (fish, reptiles, mollusks, amphibians, spiders, scorpions, crustaceans, birds, lichens, ferns, mosses, algae and fungi) constitute approximately 65% of insect species.

There are more than a million described species of insect, and an estimated by scientist 6-10 million species total (HyperTextBook, 2011). Insects has been living for 4 million years are found in every above-ground environment, open ocean, high altitudes, caves, an deven highly measured pH and salty water where no one can survive (Big Site of Amazing Facts, 2011).

Species of insect range in size from 0.139 mm (0.00547 in, fairyfly) "*Megaphragma caribea* (Hymenoptera: Trichogrammatidae)" to 567 mm (22.3 in, stick insect), *Phobaeticus chani* (Phasmatodea (Phasmida)) (Bian et al., 2016).

Although most people don't think of insects when the word "animal" is mentioned, they are both the most successful and numerous. The global insect biomass is estimated at 10^{12} kg, with approximately 10^{18} distinct individuals (WiseGeek, 2011). The other amazing sample is one square mile of land contains more insects than the total number of human beings on earth (Big Site of Amazing Facts, 2011).

Between 7100 and 10 thousand new species of insects have been described every year however the scientist beleive that most of the insect species have been not difined (Big Site of Amazing Facts, 2011). Although some insects annoy us by damaging crops, spreading disease, household items, biting people and pets, these represent approximately about 17% of all the almost a million species. Most of the insect species serve a very valuable purpose in our planet. These serve as pollinate crops; food for birds, fish, frogs, and other animals; destroy other harmful insects; give the human honey, bees wax, shellac, and silk; and keep the land clean by feeding on dead animals and plants.

Can insect species be used as bio-indicator as well as plant species for habitat description, destruction and sustainability of protected areas because of the fact that the insect species can choose their own habitat for reasons of food, climate and other environmental conditions? Some studies have made the availability of insect species as biological indicators gave positive results.

The availability of insect species as a biological indicator can be selected according to the following criteria;

(1) **Taxonomically well-known and stable** For monitoring populations of the insect species studied should be well known and not show variations in different areas (Hellawell, 1986; Landres ve ark., 1988; Noss, 1990; Pearson ve Cassola, 1992; Johnson ve ark., 1993; Pearson 1994)

(2) **Biology and general life history well understood**. Although it is difficult yo quantitatively establish which taxa have well-known biology and natural history, the breadth of studies on the taxon from around the world would serve as a demonstration of the level of this knowledge (Soule, 1985; Kelly ve Harwell, 1990; Noss, 1990; Regier, 1990; Kremen, 1994; Pearson 1994).

(3) **are cost-effective to measure and can be accurately estimated by all personel (even non specialists) involved in the monitoring** (Pearson ve Cassola, 1992; di Castri et al., 1992; Pearson 1994; New, 1998).

(4) **Higher taxa occupy a breadth of habitats and a broad geographical range: Taxon should be found in a large habitat type.** (Pearson ve Cassola, 1992; Pearson 1994).

(5) **Provide early warning of natural responses to environmental impacts**. (Kelly ve Harwell, 1990; Pearson 1994; Kremen 1994; New, 1998).

(6) **Patterns observed in the indicator taxon are reflected in other related and unrelated taxa:** Obviously if a taxon is going to be selected to reveal patterns for other taxa, any evidence that the potential indicator actually reflects significant patterns among other taxa is vital (Pearson ve Cassola, 1992; Pearson 1994).

(7) **Potential economic importance:** . The sociological justification associated with indicator taxa is often one that requires mollification more than major economic impact (Pearson ve Cassola, 1992; Pearson 1994).

(8) **Differences of population of indicator species should be recognized in the habitat affected by antropogenic affects.** (Kelly ve Harwell, 1990; Noss, 1990; Regier, 1990; Johnson ve ark., 1993; Kremen, 1994; Pearson 1994).

(9) **Distribution of indicator species should be well-known and wide distributed.** (Noss, 1990; Regier, 1990; Pearson 1994; McGeoch, 1998; Lawler ve ark., 2003).

(10) **Indicator species should live in limited place for measuring its sensitivity** (Landres ve ark., 1988; Johnson ve ark., 1993).

(11) **Indicator species should be exist in the habitat as dominant species** (New, 1998)

These criteria shows that some species has more possibility than others to be indicator species for some environmental factors. The question is how the insect species can be used as indicator:

First step is starting with another question; why (and what for) should we use the insect as bio-indicator? For the first, researcher had better find which insect or insect groups are affected with which factor(s) (environmental, climate, soil pH, micro and macro elements, heavy metals, anthropogenic affects, plant assemblages and plant species, etc) and how the insect species react for these factor(s). There are 3 interactions categories in insect assemblages when one factor is present in the habitat. These interactions are; presence/absence, differentiation in population density, and non-interaction species.

(1) *presence-absence*: Environmental impact may cause of not allow survival of some insect species in to the habitat. Therefore this species may be adversely affected and they migrate out of the habitat. If the habitat type is suitable for survival of the insect species, in other words, the insect species are capable of being exist in only this kind of habitat type the species must migrate to habitat which has same or similar characteristics. If the species cannot find the similar or same habitat

for living species can be extinct. Some of the species can be affected positively for the factor and species immigrate to habitat. Presence-absence status of the species may also be called migration and immigration.

(2) *differentiation in population density*: Environmental impact which has just occurred in the habitat negatively or positively influences population of some insect species. The reason of population increasing and decreasing of the insect species can be explained with being positively and negatively influenced by the factor.

If presence/absence situation or population density of the insect species are affected by the factor(s) the species has more chance than other to be used bio-indicator for such as description of habitat type, destruction of habitat, environmental effects, etc.

(3) non-*interaction species*: Presence/absence situation and population dynamic of some insect species may not be affected by the factor(s) which has just occurred in the habitat. In other words, factor(s) does not affect negatively or positively of their existence. Non-interaction insect species cannot be used as bio-indicator because of their non-interaction sense.

Anthropogenic effect(s) can negatively or positively influence diversity of the habitat. Sometimes, negative factor just occurred in the habitat can increase insect diversity cause of migration insect species coming inside the habitat. Temporary increasing of insect diversity does not mean that habitat intact. The biological diversity of habitat management should be done repeatedly. Periodically measured of biodiversity in the long term provide sustainability of habitats and protection. Result of biological diversity parameters which will be measured before and after recreation activities especially in protected areas can show habitat changes over time.

Second step to understanding of choosing indicator species is to find out whether the species chosen as bio-indicator cause of presence/absence situation and variation of population dynamic can be used in different bio-geographic zones or not. Two different hypothesis are written below;

Hypothesis 1 is “the species can not be used as indicators for different parts of the world because of the different biogeographic zones”. The species suitable for monitoring are not always the best ones for inventory and vice versa because indicators appropriate for monitoring must be sensitive to anthropogenic disturbance, while indicators for inventory must identify biogeographic zones, areas of endemism and community types. Because species have different ecological requirements, some species are better indicators than others. If there is a species that cannot be used as indicator due to the differences in biogeographic zones, a new indicator species can be found for the area using the methods of selecting indicator species?

Hypothesis 2 states that "the species can be used as indicators for different parts of the world notwithstanding the different biogeographic zones". No matter how the biogeographic zones differ from each other, the species, which are identified as specific, can be used as indicators for some determined factors globally. It is very essential to find a specific indicator species for same factor across the world (such as for determining habitat, environmental effect, etc. so that they would not be affected by biogeographic zones for the purposes of program monitoring. The selection of indicator species will supply early warning signals for ecological problems and will support the sustainable land usage in the areas of conservation (Aydın & Kazak, 2010).

Choosing of habitat is extremely important to take correct result from the studies of determination of biological indicator insect species. One of the most important criteria in determination of insect species as indicator is selection of habitat as a homogeneous. It is more difficult to find indicator species in the habitat with two or more different factors than in the habitat with unique factor. That's why chosen at least two habitats type must be equal (with soil properties, elevation, plant species and even plant assemblages, etc) and only one factor (cattle grazing, fertilization, tourism activity, etc) should be different. It is easy to choose equal habitat types especially in protected areas. If the study is carried out in non-protected areas, habitat can be divided into parcels. Both the studies carried out in natural or un-natural areas habitat types must be carefully selected. Otherwise the other factor which could not be recognized can affect species population dynamics and/or presence-absence situation of insect species. Such cases the result will be calculated incorrectly. Habitat must be selected according to NATURA 2000 and FFH directives and the expert maybe asked to help for selecting habitat type. One example is, selecting habitat in Mediterranean coastal sand dune dominated by plant species *Euphorbia terracina*, entitled different name from the sand dune habitat dominated by *Juniperus* species (**22. Sea dunes of the Mediterranean coast**: 2220 Dunes with *Euphorbia terracina*; 2250 Coastal dunes with *Juniperus* spp.; 2270 * Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*). The studies of bio-diversity and selecting indicator insect species can be failed when the habitat type chosen only for differentiation of such as soil properties and altitude.

The structure of selected habitats according to the criteria should be considered. Before starting study of bio-diversity and using species as indicator habitat type chosen for plant assemblages, altitude, soil properties etc should be considered for differentiation. Sometimes only human activities may cause of changing insect assemblages in this manner insect bio-diversity in the habitat. If the choosing homogeny habitat type were not paid attention for some anthropogenic affects such as tourism, cattle and sheep grazing, researcher(s) would not be able to take correct results. Therefore difference between habitats should be chosen for one factor which researcher(s) should consider. For example, there had better single difference between two selected Mediterranean salt meadows (*Juncetalia maritimi*) habitats can be goat path.

One other important issue is that the other habitats types around the selected habitat. The study would be failed if there was agro-ecosystem where applied pesticide around the selected habitat. Homogeneity could be changed as negative way because of the agro-ecosystem around the selected habitat and goat path which was chosen as unique factor could not be investigated with correct way to measure reaction of present/absence situation and population of insect species. Fig 2 provides some examples of correct and incorrect habitat elections.

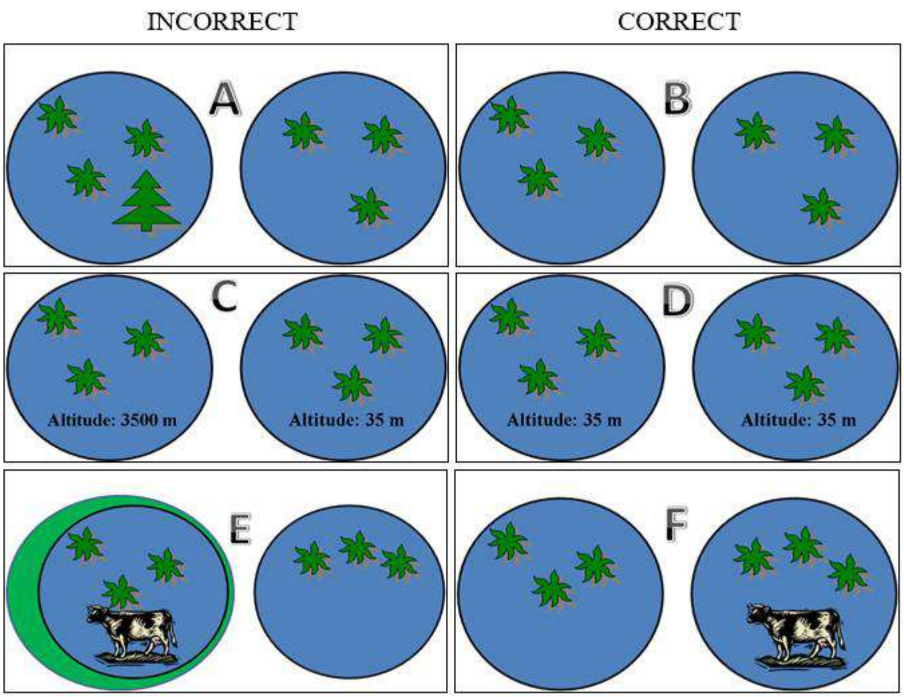

Figure 2. Some samples of correct and incorrect selecting habitat types in the bio-diversity studies (A: Different plant canopy; B: Same plant canopy (One different factor can be chosen in one habitat); C: Different altitude (Only influences of elevation factor can be tested for the insect); D: Similar or same altitude (One different factor can be chosen in one habitat); E: Two factors affect to habitat; agro-ecosystem and cattle grazing F: Unique factor: cattle grazing).

For the first stage, habitat ought to be chosen in same geographical region. Insect species chosen as indicator in one geographical region can be test with future studies whether the species can be used as indicator for same factor in different geographical regions. If the species can be used as indicator only in one geographical region hypothesis I is valid; if the species can be used as indicator also in other geographical regions, Hypothesis II is valid.

Insect species that can be used as biological indicators of habitat selection according to the criteria in determining the sampling method to be applied in selected regions is also extremely important. Collected insect species must represent habitat type with acceptable application of sampling method. The sampling methods should be set up the place where ought to correspond to habitat.

Another criterion to be addressed to determine the sampling method under the same conditions and applied to each selected habitat depending on the genus and / or family of target insect species in accordance with specifications. One of the most common used sampling method is pitfall trap to sampled ground beetles, Carabidae, dung beetles Scarabaeidae, and darkling beetles Tenebrionidae belonging to order Coleoptera. Also the other sampling methods such as insect net, sweeping method, soil-sieving method, can be used in suitable habitats. It is clear that even light trap which most commonly used for fauna studies can sample mentioned families. If the light trap is wanted to use for measurement of biological diversity and determination of indicator insect species in one habitat can result in error due to the possibility of withdraw insect species from other habitat types with light trap. That's why light trap is rarely used for sampling night butterfly species and measurement of bio-diversity in very large habitats.

The most widely used sampling method to sampled ground beetle, dung beetle, and darkling beetle (ground dwelling insect) is pitfall trap. Dry pitfall traps consist of a container (tin, jar or drum) buried in the ground with its rim at surface level used to trap mobile animals that fall into it. Pitfall trap is an essential tool for catching and studying ground-dwelling insects, particularly springtails and ground beetles. There are advantage as well as disadvantages of pitfall trap. There are inevitably biases in pitfall sampling when it comes to comparison of different groups of insects and different habitats in which the trapping occurs. An insect's trappability depends on the structure of its habitat (e.g. density of vegetation, type of substrate). Intrinsic properties of the insect itself also affect its trappability: some taxa are more active than others (e.g. higher physiological activity or ranging over a wider area), more likely to avoid the trap, less likely to be found on the ground (e.g. tree-dwelling species that occasionally move across the terrain), or too large to be trapped (or large enough to escape if trapped). Trappability can also be affected by conditions such as temperature, wind or rain, which may alter the animal's behavior. Windy, rainy and cold weather, even the flight activity of insect species is weak and should be noted that they prefer to hide. Nevertheless if application of sampling methods are essential the factor (e.g. differentiation time, environmental effects) must be noted, repetition number had better be increased, or insect species should be evaluated with other statistically methods (multivariate analyze, etc). The capture rate is therefore proportional not only to how abundant a given type of animal is (which is often the factor of interest), but how easily they are trapped. Comparisons between different groups must therefore take into account variation in habitat structure and complexity, changes in ecological conditions over time and the innate differences in species. If the pitfall traps are not controlled periodically enough some predator species like members of Carabidae can eat other insect species. Pitfall traps can be affected some environmental factors (wind, rain, etc) in habitats (e.g. beach, sand dunes) and it is very difficult to set up pitfall traps in these kind of habitats. Sand carried by wind can cover all pitfall traps in short time and sampling method can be failed. In this condition only suitable sampling method can be chosen for all habitat types. If homogeny sampling method cannot be chosen different sampling methods can be applied for habitat properties however each data taken from each sampling method must be evaluated separately by scientist (Data taken from habitats pitfall traps were set up should be measured independently and data taken from different sampling methods never be calculated together.

Implementation of the sampling methods at different times is other problems trapping. For example, sweep method applied during in the morning in habitat A cannot be compared the sweep method applied during in the evening in habitat B. Standardization of controlling sampling methods at the same time is essential. If the selected habitat is very large and/or habitats are very far from to each other application time can be standardization (e.g. First day: Habitat A, controlled in the morning, Habitat B, controlled noon time, Habitat C, controlled in the evening; Second day: Habitat A, controlled noon time Habitat B, controlled in the evening, Habitat C, controlled in the morning, Second day: Third day: Habitat A, controlled in the evening; Habitat B, controlled in the morning, Habitat C, controlled noon time). That’s why number of repetitions is very important and must be elaborated.

Data taken from different application of sampling method can be defectively influenced in both studies of determination of bio-diversity and indicator insect species. For example, insect net applied in Habitat A for the duration of five minutes should be applied same duration in Habitat B.

Even light traps which are not used very often in the study of measurement of bio-diversity and indicator insect species can be affected by wind, month status, differentiation of application period of light trap.

Using morpho-species in the study of measurement of bio-diversity and determination of indicator insect species:

It is not essential to know taxonomic name of the insect species in the study of bio-diversity. The reason of this bio-diversity parameters are calculated with species richness and individual number of the species. Morpho-species should be identified very carefully with morphological features of the insect by the taxonomist. All insect except identify insect as species level must be classified at least family level however described as genus level would be eliminate the fault. One identify key (wing veins, the structure of pronotum, antenna, and other distinctive anatomical structure by looking at similarities) should be prepared for the insects determined as the level of family and genus to identified them as morpho-species. (Lodge & Cantrell, 1995; Clauson, 2002, Krell, 2003; Ryder ve ark., 2005; Borgelt & New, 2006; Dudgeon, 2006; Yanoviak ve ark., 2006; Grimbacher & Stork, 2007; Stireman, et al., 2009; Derraik, et al., 2010).

On the other hand, the insect must be identified as species level in the study of determination of indicator species. It is extremely important to ask for help expert as a priority in our country to determine insect bio-diversity of our country.

Importance of Biomass in the study of measurement of Bio-diversity

In ecology, biomass is the mass of living biological organisms in a particular area area or ecosystem at a given time. How biomass is measured depends on why it is measured. Sometimes biomass is considered the natural mass of organisms *in situ*, just as they are. In more stricter scientific practices, biomass is measured as the mass of organically bound carbon (C) present. The total living biomass on the planet is about 560 billion tones C (Bar-On et al., 2018). Most of this biomass is found on land, with only 5 to 10 billion tons of C found in the oceans. On land there is about 1000 times more plant biomass (phytomass) than animal biomass (zoomass). About 18% of the plant biomass is eaten by the land animals. But animal biomass in the ocean is about 30 times greater than plant biomass. Most of the ocean plant biomass is eaten by ocean animals (Bar-On et al., 2018).

All this information shows that biomass is important for measure biodiversity in ecosystem function. When measured of parameter of biological diversity in a habitat, insects and their interactions with each other and their environment and their importance in the food chain, specifies it discussed the need for the measurement of the biomass. For this reason, the species interactions with each other and their environment and their importance to the ecosystem would be more appropriate.

Importance of measurement of Bio-diversity parameters and determination of indicator insect species

Biodiversity is the degree of variation of life forms in a particular ecosystem, biome or an entire planet. Biologists often define biodiversity as "the sum of genes, species, and ecosystems of a region". One advantage of this definition is that it seems to describe most situations and provides a unified view of the traditional three levels at which biological is defined: species diversity, ecosystem diversity, and genetic diversity. (Wellend, 2005).

Diversity can be measured at different scales. These are the three indices used by ecologists:

Alpha diversity refers to diversity within a given area, community or ecosystem and is measured by counting the number of taxa within the ecosystem (usually species). Beta diversity is species diversity between ecosystems; this involves comparing the number of taxa that are unique to each of ecosystems. Gamma diversity is a measurement of the overall diversity for different ecosystems in an area (Sahney & Benton, 2008).

Species richness, diversity, dominancy and evenness of insect in ecosystem are measured by bio-diversity parameters such as Shannon-Wiener Diversity, Simpson Diversity, Simpson Dominancy, Shannon Evenness and Simpson Evenness.

Examining of periodically measured of biological diversity parameter values in a particular region may be able to monitor habitat structure and functioning changes over time. Measurement of insect bio-diversity provide to understand that one factor especially in protected areas may either positively or negatively affect to species.

A factor enters the habitat can be the source of changes of species migrate/immigrate (presence/absence) and population densities (for details, presence-absence, population density and the principles of non-interaction section).

Decrease or increase in the measured values of species richness and diversity of habitat, does not mean that factor which including in subsequently to the habitat and expected to be measured affects environment with positive or negative ways. Therefore, the parameters of biological diversity should be measured not only once, but also measured often and periodically. The following example describes result of how bio-diversity parameters are affected by the factor including in subsequently to the habitat.

(1). Measurement: Result of bio-diversity parameters in habitat: (without factor(s))

Species richness (s): 5

Individual numbers of species: 5, 8, 9, 11 and 15

Diversity index (H): 1.55 (Shannon-Wiener)

Evenness (H/ln(s)): 0.96

(2). Measurement: Result of bio-diversity parameters in habitat affected by environmental effect:

Species richness (s): 6

Individual numbers of species: 5, 8, 9, 11, 15, 15

Diversity index (H): 1.73 (Shannon-Wiener)

Evenness (H/ln(s)): 0.96

(3). Measurement: Individuals of species are affected by environmental effect:

Species richness (s): 6

Individual numbers of species: 5, 8, 1, 11, 15, 20

Diversity index (H): 1.56 (Shannon-Wiener)

Evenness (H/ln(s)): 0.87

(4). Measurement: Species richness is negatively affected by environmental effect:

Species richness (s): 5

Individual numbers of species: 5, 8, 0, 11, 15, 45

Diversity index (H): 1.30 (Shannon-Wiener)

Evenness (H/ln(s)): 0.80

This may appear unusual, not seen frequently in the measurement of biological diversity of habitats high likelihood is possible. According to assumption given as four stages, the first stage explains normal bio-diversity result of natural habitat without any factor. Species richness and insect diversity is changed and increasing in second stage by the factor including in subsequently to the habitat however third stage shows that this is the first step of habitat destruction and species assemblages is changed because of variation of species dominancy and rare species in the habitat. Last stage shows while one rare species migrated from habitat (migrated insect species can be extinct if it cannot find alternative habitat to live) population of immigrated species increase and be dominant species among the rest of the species. Therefore diversity parameter is calculated less than first stage.

Sometimes even measured alpha-diversity of habitats shows complex species richness and diversity as well as beta and gamma diversity. The interaction between species might not be a simple shape as in the imaginary example given above. Sometimes one species including in subsequently to the habitat can affect other species with positive or negative way as being the food chain which is a complex structure. Therefore solution and understanding of complex relation of insect species together in protected areas make it easier to make a comment about measured parameters of biological diversity into the habitat.

Classifications of bioindicators have been divided into three categories by McGeoch (1998): (1) environmental (2) ecological (3) biodiversity indicators. The main difference between them is that environmental and ecological indicators are used to detect changes in the environment while biodiversity indicators reflect the overall diversity of the biota. Revealed environmental and ecologic indicators from calculating bio-diversity parameters are a helpful factor for conservation and sustainability of land.

To use insect as indicator for habitat description, habitat destruction, environmental and anthropogenic effects

Even though insect species sampled not with standardization methods and period may provide some information about habitat type mentioned the species cannot be used as bio-indicator. Fauna studies usually verify presence of insect species in the area however insect biodiversity cannot be measured with the data taken randomly sampled insect species. Fauna studies may be thought that it can be first step of bio-diversity studies. Sampling methods must be standardizing to use insect species as indicator for habitat description. Indicator species can be evaluated according to presence/absence situation and population dynamic of insect with different statistical methods (e.g. indicator species analyze-ISA, univariate analysis) and indicator species may describe habitat type in a bounded geographical region. Sometimes insect species can be used as indicator for habitat description in different geographical regions.

The following four imaginary stages reflect possibilities of indicator species to be chosen according to data taken by insect species living in different geographical zones.

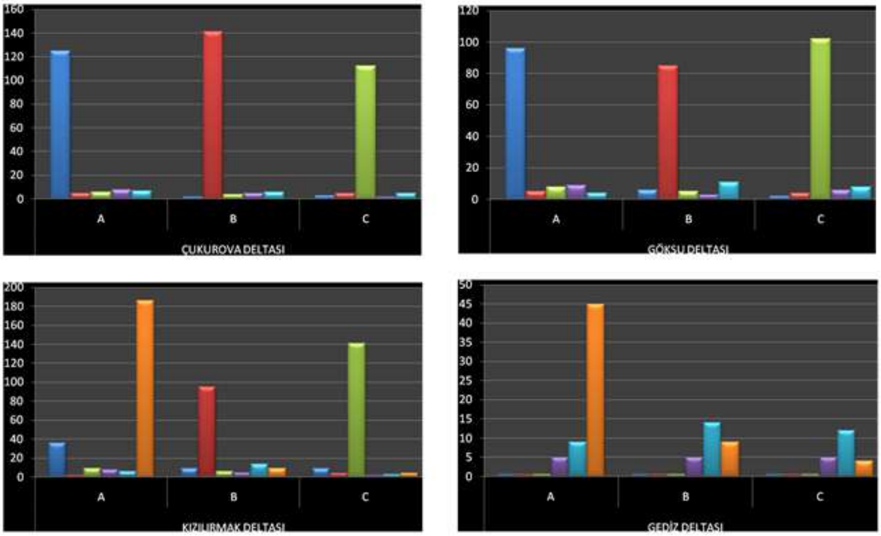

Figure 3. Possibilities of indicator species according to data taken by insect species living in different geographical regions (imaginary).

Three different habitat types, named A, B, and C were chosen in Çukurova, Göksu, Kızılırmak and Gediz deltas. There are 5, 5, 6, and 3 insect species in Çukurova, Göksu, Kızılırmak and Gediz Deltas, respectively. (Figure 3).

Imaginary graphs related with possibility of using insect as indicator in different geographical areas show that the insect species signed blue, red and green color has more chance to be used as indicator than others for habitat description (A, B, and C respectively) in Çukurova and Göksu deltas.

While similar results are found in habitat B and C in Kızılırmak delta the other species (signed orange) which cannot be observed in Çukurova and Göksu deltas is seen more dominant and more chance to use as indicator for habitat description than insect signed blue. The insects signed blue, red and green cannot found in Gediz Delta but insect signed orange color is found as the most dominant insects in their own habitat A similar with Kızılırmak Delta. Habitats B and C are found to be similar evenness between population of insect species in Gediz, most probably indicator species would not be found (Figure 3).

Sometimes probability of using insect species for represents habitat type limited by the geographical zone. Therefore, indicator insect species which would be chosen for identification of habitat, environmental factors, human activities and/or habitat destruction must specialize to habitat and/or factor in the habitat (e.g. environmental effects, anthropogenic affect). The study should be repeated in same and different geographical region to use insect as biological indicator hence faults will be reduced and correct indicator can be selected for correct effect.

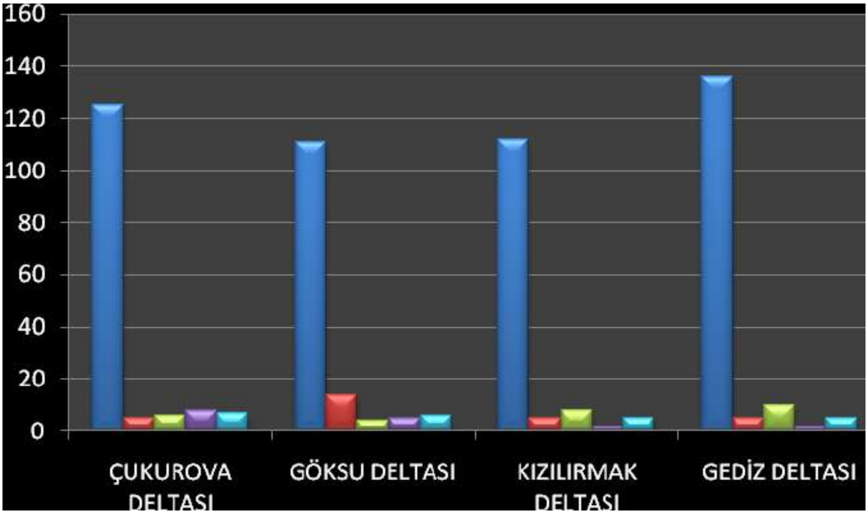

Figure 4. Population dynamic of sampled insect species in same habitat type in Çukurova, Göksu, Kızılırmak and Gediz (imaginary).

The graph is given with Figure 4 shows population of insect species in same type of habitat (e.g. salt meadow habitats where non-human activity, homogeny plant canopy and same environmental factors) in Çukurova, Göksu, Kızılırmak and Gediz deltas. The insect species signed with blue color is sampled as dominant species and it has more chance to be used indicator species than others in the same type of habitat even at the different geographical regions. This situation can be explained by the changing population density which influential in determining the indicator species.

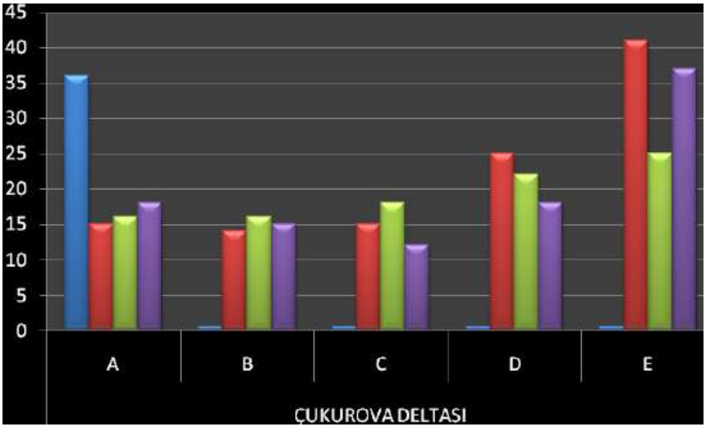

Figure 5. Population dynamic of insect species in different habitat types in Çukurova Delta (imaginary).

Figure 5 shows that the insect signed with blue color is found only in habitat A and not found the rest of the different habitat types. Sometimes presence/absence situation of insect species can be used for the criteria of describing habitat type.

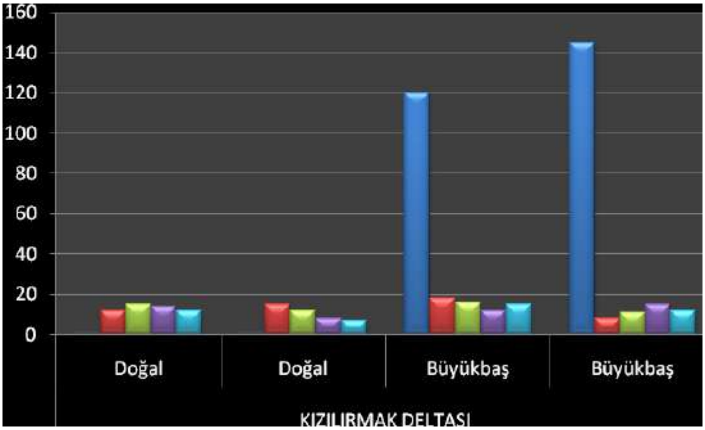

Figure 6. Variations of insect species richness and evenness cause of cattle grazing factor in same type of habitats in Kızılırmak Delta.

Species richness and evenness in natural habitats can be affected by the factor including in subsequently to the habitat (Figure 6). Variation of insect species can be observed when compare insect assemblages, populations and presence/absence situation of insect species in natural and un-natural habitats. While some of the insect species react to factor including in subsequently to the habitat with variation of their population presence/absence situation of some insect species can be affected negatively or positively by the factor. Figure 6 shows two natural and two un-natural habitat (factor is cattle grazing) in Kızılırmak Delta. Presence situation of the insect species signed with blue color is positively affected by cattle grazing (Figure 6). Same species is not found in natural habitat even though except cattle grazing, all habitats have same features. Mentioned insect species, signed with blue color, is seen to be positively affected by cattle grazing and not indicator for habitat type.

Some species can be used biological indicator for both habitat and environmental effect. For example one of the dung beetle *Scarabaeus sacer* (Coleoptera: Scarabaediae) is positively affected by cattle grazing and sheep grazing in sand dune while same species is not affected by same factor in salt marsh and salt meadow habitats where there is high percentage of clay and hard to dig and its presence/absence situation is not calculated as statistically important. Biology, behavior, functions in food chain, etc. of the indicator insect species should be investigated. Salt marsh and salt meadow habitats are not suitable to be presence for *S. sacer* because of hard soil features.

Because of differences of habitat features while insect species can be used as indicator for factor “x” in habitat A, same insect species cannot be used as indicator for the same factor in habitat B.

Variations of the samples can be increased with measurement of bio-diversity which mostly used for ensuring sustainability of protected areas and determination of indicator insect species. Increasing studies of determination of insect bio-diversity and using indicator insect species in our country will provide both protection of habitat and come into open insect bio-diversity which is little known.

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THE EFFECTS OF DIFFERENT DIETARY PATTERNS OF EISENIA FOETIDA ON VERMICOMPOST BIOCHEMICAL CONTENT

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1. Introduction

Recently, organic farming has been receiving attention since healthy nutrition have gained great popularity. One of the methods in organic farming is vermicomposting which is a process using earthworms to transform organic material to humus-like material called as vermicompost (Huang et al., 2014; Lim et al., 2015; Wang et al., 2017). In other words, vermicomposting by earthworms is a kind of waste management system. As a consequence of this technology, it is possible to transform worthless and biodegradable organic wastes to valuable products such as fertilizers. Therefore, the effect of vermicompost on the soil fertility is extensively studied by many researchers (Huang et al., 2014; Lazcano et al., 2011; Lim et al., 2015; Singh and Wasnik, 2013; Wang et al., 2017). Indeed, researchers have reported that vermicompost has a higher quality of nutrient content than conventional manure (Wang et al., 2017). Furthermore, the duration of plantation with inorganic fertilizers has been showed to be longer than that of organic fertilizers. Long-term application of inorganic fertilizers without organic supplements could also potentially ruin the characteristics of soil. Thus, vermicompost can increase the soil productivity, even in a shorter time, and be used for getting qualified crops (Bachman and Metzger, 2008; Lim et al., 2015; Sim and Wu, 2010).

On the other hand, earthworms have been stated as soil engineers because of their effect on soil characteristics. They digest the food by the enzymes present in this secretion and defecate as a valuable mixture for soil fertilization. Earthworm activity is also used for the organic waste-management and consequently to obtain high-quality vermicompost. One of the common earthworms is the *E.foetida* "red California worm" that has been using in vermicomposting process (Arancon et al., 2004; Aynehband et al., 2017; Doan et al., 2013). *E.feotida*, red California worm is little, thin and delicate as compared to other earthworms. Therefore, they can move more easily than other kinds of worms. They are more fertile and thus they can reproduce rapidly. They have many enzymes, useful microorganisms, bacteria fixing nitrogen, growing hormones acting as an antibiotic in their secretion. Hereby, they provide more valuable compost for plantation in soil than conventional composts (Rosik-Dulewska et al., 2014).

Soil is a natural material covering the earth's surface with physical, chemical and biological features that are able to support plant growth. Hence, soil is very important food source for both animal and human being. Organic soil formation occurs in swamps and wet areas. It comprises about 20% to 30% of the total matter. Organic matter includes both living and non-living materials.

Microorganisms like bacteria, fungi and macroorganisms like worms, insects, plant root, and dead body particles are examples for living constituent of organic soil. Organic soils are important for a high quality of crop production. Therefore, it has also economical importance in agricultural output (Sen, 2003).

A plant tissue contains about 95-99.5% of carbon, hydrogen, and oxygen provided mainly from air and water; 0.5-5% other elements provided from the soil. Nitrogen, phosphorus, and potassium are more abundant than other elements so that called as the major macroelement of soil. They are used as fertilizers to get high-quality agricultural output. Among macroelements, nitrogen has the most striking effect on plant growth. In a plant body, nitrogen is necessary for cell building. Amino acids, nucleic acids, enzymes, hormones, and compounds that play a role in energy metabolisms such as ADP and ATP are synthesized from nitrogen in plant tissues. Phosphorus is also an important element for plant growth. Phosphorus widely exists in plants as a part of nucleoproteins. Nucleoproteins (DNA and RNA) are crucial macromolecules bearing the genetic code of living cells. Phosphorus takes part also in the structure of other macromolecules such as lipids and proteins. Furthermore, it participates to the metabolic pathways that require energy (within the structure of ATP/ADP) such as synthesis of starch and cellulose. Phosphorus contributes to acid/base balance in the organisms, too. Potassium is mainly abundant in the intracellular part of the cell. It functions as an osmotic balancer. Furthermore, it also plays an important role as a cofactor in the key steps of metabolic reactions. The presence of NPK should be adequate, not too high and not too low. Both low and high availabilities disturb the plant growth and cause bad quality of the yield. These nutrients as well as minerals can be partly supplied by the soil and must be partly put in together with some fertilizers and organic manures. Farmers should know the NPK constituent, so that how much NPK they should add these minerals as fertilizers into the soil to optimize crop fertilization (Roy et al., 2006).

2. Materials and Methods

E.foetida were taken 0,3 g for vermicomposting. Three groups were fed by peels of banana, quince, and apples for 4 months. The fourth one was fed by a mixed waste of each fruit for the same period as other groups. Fresh fruit peels were chopped by mixer and 300 g of fruit wastes were placed on each group box at two times a week. At the end of the feeding period, five different vermicompost sample from each groups are taken and the NPK contents are determined. All analyses were done in a quality control laboratory of a compost factory in Adana, Turkey.

2.1. Sample preparation

Samples obtained were prepared according to the descriptions in The Institute of Turkish Standards (TSE) book (TSE, 2010). Briefly, the vemicompost samples were washed with distilled water and dried at room temperature. After dried, the samples were thoroughly ground in a porcelain mortar. Then, were sieved through 0.5 mm mesh. After sieving, the residue on the sieve was ground again and sieved. This procedure was repeated until not to retain any residue on the sieve.

2.2. Humidity determination

The ratio of humidity was determined by gravimetrically (TSE, 2010). A small glass container including 4-5 g (± 0.05) sample was measured on a scales. Then it was set in a oven (Gallerkamp; 70°C) for 2-3 hours. After this duration it was cooled at room temperature and measured on a scales again. The humidity ratio was calculated from the difference between two measures and expressed as % humidity. The result was calculated by the following formula, simply:

% humidity= (g original sample - g oven-dried sample x 100)/ g oven-dried sample

2.3. Organic matter (OM) determination

A glass container containing oven-dried sample was placed in a ash oven (Gallerkamp) by gradually setting 550 °C. The temperature of oven was gradually raised until ash was produced completely. The final ash was weighed and result was calculated by following formula, and expressed as % OM (Herlich, 1990).

% OM= 100- (% humidity + % ash)

2.4. NH_4-N determination

Ammonium was determined by modified Kjeldahl's method. The method is based on the titration of excess sulfuric acid by sodium hydroxide. In summary, ammonium which was come up as a reaction of sample with excess sodium hydroxide was distilled (Automated Foss Kjeltec instrument) and retained in a sulphuric acid solution. At the end of the distillation excess amount of sulfuric acid was determined by titration with a same equivalent sodium hydroxide solution. The amount of ammonium nitrogen was calculated by substraction of the final sulfuric acid molar concentration from initial one. The results were converted to % (g 100 g^{-1}) by the calculation table as indicated in TSE book (TSE, 2010).

2.5. NH_2-N determination

This method is based on the formation of a yellow product originated from the reaction of urea with p-dimethylaminobenzaldehyde (DMAB). Briefly, 1 g sample was placed into the 500 ml volumetric flask. 1 g charcoal and 250 ml distilled water were added. 5 ml zinc acetate solution and 5 ml potassium ferro siyanide solution were added and shaked. Total volume was completed to 500 ml and let stand until precipitation was settled. Then, it was decanted through whatman no 40.5 ml of clear filtrate was pippeted into a test tube. 5 ml of DMAB was addded and let stand for 10 min. The colored product was assayed spectrophometrically (Hitachi) in 420 nm. The results were calculated by comparing the those obtained from standart urea solution and expressed as % (g 100 g^{-1}) (Helrich, 1990).

2.6. Phosphorous (P) determination

Phosphorous was assayed according to the spectrophometric molybdovanadophospahte method. Briefly, the filtrate obtained from the steps as explained for N determination above was treated with molybdovanadate reagent yellow-colored product emerged from the reaction of phosphorous with the molybdovanadate reagent was read at 430 nm. The same procedure was applied to the standart phosphorus (KH_2PO_4) solution. Standart curve was created from the results of standart solution and sample was calculated by using this curve (Helrich 1990). Results were expressed as % (g 100 g^{-1}).

2.7. Potassium (K) determination

Potassium was measured by flame photometry (Sherwood; automated analyzer). Brieflly, 1 g vermicompost sample was washed with distilled water and extracted with ammonnium oxalate. After filtration, the sample was analyzed on the automated flame phometry and calculated from standart curve obtained from solutions containing 0, 10, 20, 30, 40, 50, 60, 70, 80 mg l^{-1} (ppm) of potassium (Helrich, 1990). The results were expressed as % (g 100 g^{-1}).

2.8. Statistical analysis

The results were evaluated by Mann-Whitney/Kruskal Wallis statistical methods using SPSS program (means ± standart deviation).

3. Results and Discussion

The highest amount of N, P, and K were found in the banana group (3.71 ± 0.04, $P<0.001$; 0.32 ± 0.01, $P<0.001$; 2.13 ± 0.08, $P<0.01$, respectively) (Table 1).

Table 1. The effect of quince, banana, apple and mixed fruit wastes feeding on soil properties

Variables	Quince group (1) (n=5)	Banana group (2) (n=5)	Apple group (3) (n=5)	Mixed group (4) (n=5)	*P*
NH_4 (g 100 g^{-1})	0.73±0.01 (2,4)*	0.81±0.01(1,3,4)	0.73±0.01 (2,4)	0.50±0.01(1,2,3)	0.0008***
NH_2 (g 100 g^{-1})	0.90±0.01 (2,3,4)	2.90±0.03 (1,3,4)	1.12±0.02 (1,2,4)	1.05±0.02 (1,2,3)	0.0004***
Total N (g 100 g^{-1})	1.64±0.01 (2,3,4)	3.71±0.04 (1,3,4)	1.85±0.03 (1,2,4)	1.55±0.01 (1,2,3)	0.0005***
Total P (g 100 g^{-1})	0.18±0.01 (2,3,4)	0.32±0.01 (1,3,4)	0.21±0.01 (1,2,4)	0.24±0.01 (1,2,3)	0.0004***
Total K (g 100 g^{-1})	0.68 ± 0.08 (2,4)	2.13±0.08(1,3,4)	0.68±0.08 (2,4)	0.93±0.08 (1,2,3)	0.0015**
OM (%)	90.42± 0.06(2,3,4)	79.82±0.06(1,3,4)	87.36±0.76(1,2,4)	63.87±0.80(1,2,3)	0.0005***

* $P<0.05$, ** $P<0.01$, *** $P<0.001$; Numbers existing on parameters refers to groups that are different, significantly between each other

Although N values of apple group is highest comparing with those of quince and mixed groups, mixed group had the highest values of P and K values as compared by apple and quince group. The highest OM was found in quince group (90.42 ± 0.06, $P<0.001$). The humidity remains unchanged. Furthermore, all variables were compared as pair for each group by Mann Whitney-U test. For variables NH_4 and K; groups that are significantly different as follows : (1-2; 1-4; 2-3; 2-4; 3-4). For variables P, OM, humidity, NH_2 and total N; groups that are significantly different as follows: (1-2; 1-3; 1-4; 2-3; 2-4; 3-4).

1, 2, 3, 4 refers to quince group, banana group, apple group and mixture group, respectively.

The purpose of this study was to determine the quality differences of vermicomposts produced by *E. foetida* fed with different fruit wastes for four months. In the literature, there have been several reports related to the effect of vermicompost on plant growing including fruit, vegetables and flowering plants (Arancon et al., 2004; Huang et al., 2014; Wang et al., 2017). Since the vital nutrients have been shown generally to be higher in vermicompost than traditional fertilizers, the vermicompost has been suggested to be better supplement for plant growing (Huang et al., 2014; Lim et al., 2015; Wang et al., 2017). Roy et al. (2010) showed that plant growing properties such as height, shoot and root weight, were highest in the vermicompost-treated plots comparing with the compost and plots containing only soil.

Since *E. foetida* was established well in producing high-quality vermicompost, it has been used in many studies associated with organic agriculture (Arancon et al., 2004; Aynehband et al. 2017). Warman et al. (2010) studied on the quality of vermicompost produced by *E. foetida* fed with three type organic wastes. Their study indicated that vermicomposts from all type feedstocks increased the variables of plant growing compared to control. Furthermore, the studies on the determination of vermicompost quality showed that NPK contents are good indicators of the quality. In related studies, Pramanik et al. (2009) and Doan et al. (2013) reported that vermicompost application to soil increased N and P content. In the present study, NPK contents of four experimental groups were determined and compared among each other. It is found that the NPK content of banana group (3.71±0.04; 0.32±0.01; 2.13±0.08, respectively) was highest among those of all groups. Further tests carried out with banana leaf biomass amended with cow dung improved NPK contents significantly has been showed promising results of waste mineralization and earthworm growth which corroborated with our findings (Mago et al., 2021). Another study reported a gradual increase in the NPK content of vermicompost in response to growing amounts of banana peel (Mohanapriya et al., 2021). OM content of all samples are also detected and found that the value of quince group was highest (90.42 ± 0.06) among all. NPK content in the fourth group which is a mixture of all groups was not so high (1.55 ± 0.01; 0.24 ± 0.01; 0.93 ± 0.08, respectively). It was probably due to the low values of quince and apples bringing down the average. NH_4 content of quince, banana and apple groups are similar (0.73 ± 0.01; 0.81 ± 0.01; 0.73 ± 0.01, respectively), but mixture group has the lowest NH_4 value (0.50 ± 0.01) among all. Possibility of chemical reactions occurred between the fruit wastes might be the reason for the low values of NH_4 of mix group. However, in a similar study, Huang et al. (2014) investigated the soil properties treated with compost from cow dung and vermicomposts obtained from *E. foetida* fed by banana, cabbage, lettuce, potato and watermelon. According to their results, N value of the vermicompost from banana group was the lowest among the others. Further, OM of banana group was higher than cow compost but not different from others. This means that the quality of compost differs according to the types of fruit and/or vegetable wastes. Therefore, this experiment should be repeated with many different fruit and/or vegetable wastes to find out the most qualified vermicompost as a further study.

3.1. Effects of vermicompost production on economics: agricultural sector and waste management systems

As proven by several studies stated above, vermicompost improves fertility in terms of the physical and chemical properties of the soil. In one of the related researches, the combining manure and inorganic fertilizers resulted with a 26 % increase in yield and a 40 % increase in market value as compared to the use of inorganic fertilizer or manure alone (Lim et al., 2015). Therefore, vermicomposts should be extensively applied to organic farming areas to replace, or alternatively, combine with inorganic fertilizers.

Since vermicompost will increase the organic matter of the soil, a significant amount of economic profit can be obtained due to the potential decrease in costs of production through the conservation and improvement of soil health. Moreover, vermicompost will increase the economic profit of the farmers because the water holding capacity of the soil will increase and the need for using chemical fertilizers will decrease.

Unfortunately, as the prices of fertilizers increase, fewer farmers will be able to buy fertilizers and leading soil to suffer from nutrient deficiency. The decrease in fertilizer quantity will also decrease the yield from the unit area. Turkey only uses half of the amount of nitrogen, phosphorus, and potassium required for soil and plant already. In addition, the increasing prices of fertilizers will increase the cost of production of farmers, leading to a decrease in quantity produced and demanded.

However, if the need for chemical fertilizers to produce agricultural goods is decreased, the price fluctuations of chemical fertilizers will not affect the farmers. If farmers can produce their own compost using earthworms, it would be a cost-effective system for waste management besides its sustainable and ecological properties.

If farmers use the vermicompost they produce themselves, Turkey’s dependence on foreign sources will decrease. As the cost of production of farmers will be lower, the supply will increase. This will lead to a decrease in the prices of agricultural goods and thus increasing the demand for them. As a result, not using chemical fertilizers will potentially increase the revenue of farmers as well as their profit.

Since the final product of vermicomposting is considered an environment-friendly fertilizer for agricultural applications, it could be advisable for waste management. If organic wastes are used to make vermicompost in houses, then there will be a significant reduction in total waste collection-transportation and disposal. To reduce costs in waste management system is important since the equivalent cost of the waste management sector varies between 0.2 and 0.5% of the Gross National Product (Öztürk, 2017).

4. Conclusion

Vermicomposting is cost-efficient for farmers and vermicompost usage will increase productivity. In addition government will benefit from the vermicomposting as it eases the burden of costs of waste management system. It is good for consumers since vermicomposting reduces the cost of production, consumers can enjoy decreasing prices in the long run. As wastes are transformed into vermicompost, it will reduce the waste management costs that will save money for the government. According to the analysis results of around 1.1 million samples collected by TAGEM's Soil and Water Resources Research Institutes in the 1990s from our country's soil, 90.1 % of our soils contain less than 3 % organic matter. This statistic shows the necessity of vermicompost usage. Especially the vermicompost taken from the worms fed with quince scraps could be used since the content of it has the highest organic matter, to obtain more valuable organic fertilizer in terms of both ecological and budget-friendly farming. For further research, the effects of making vermicomposts obtained from different fruit scraps collected from juice factories as a good waste resources, should be investigated.

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CHITIN/CHITOSAN-BASED BIOPLASTIC PRODUCTION FROM CRAB SHELLS

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INTRODUCTION

Plastics used in many areas of life today are petroleum-derived and called artificial organic polymers (Suman et al., 2020). Therefore, many types of plastics such as polyethylene, polystyrene and polypropylene begin with the word "poly". They have the potential to be used in almost all domestic and industrial applications due to their excellent mechanical properties such as being lightweight and particularly resistant to the passage of water and gases. However, due to these mechanical properties, they are not easily degraded in natural environments, cannot be composted, and can remain in the oceans and landfills for hundreds of years (Chamas et al., 2020). This situation has turned into a serious environmental issue as a result of the increasing demand for the use of plastics in almost all areas of life, together with the developing industry and population growth. With the low rate of recycling of traditional plastics, landfills, seas and lakes have started to fill with plastic waste (Evode et al, 2021). The fact that plastics originate from fossil fuels also means that they are not sustainable. In addition, since the carbon emission is high during the production of petroleum-derived conventional plastics, their carbon footprints are also high. In recent years, many researchers have been working on developing biopolymer-based plastics to ensure sustainable and environmentally friendly use of plastics (Mashood et al., 2022).

Bioplastics are defined as environmental-friendly plastics that are easily degradable in nature and an excellent alternative of petroleum-derived plastics. All raw materials and additives used in the production of biodegradable bioplastics must be of natural and biological origin. Therefore, the decomposition products are also non-toxic and do not harm the environment and human health. It is believed that synthetic biodegradable materials such as starch-based bioplastics, chitin/chitosan-based bioplastics will be more widely used in the future and will replace petroleum-derived plastics (Huang et.al., 1990, Bezirhan Arikan and Bilgen, 2019).

Chitin is the second most abundant natural polymer after cellulose and consists of a linear chain of (1 → 4) linked 2-acetamido-2- deoxy-β-D-glucopyranose units. The main source of chitin (in % of dry matter) in nature are crustaceans such as shrimp, crab and lobsters (58%-85%), insects (20%-60%) and fungi (from trace to 45%) (Kucukgulmez, 2018). However it is commercially obtained only from shellfish exoskeletons. Especially crab and shrimp shells are used as an easily accessible source of chitin as they are found as waste in the marine food industry. Deacetylated derivative of chitin called as chitosan (Kumari and Rath, 2014).

Chitosan-based bioplastic production has become a topic of interest for researchers in recent years (Mujtabaa et.al., 2019). Chitosan is often used as a food additive or packaging material as a preservative to delay microbial growth in food and at the same time improve food quality and shelf life. The solubility of chitosan varies depending on the degree of deacetylation, the distribution of acetyl groups along the main chain and the molecular weight. It has been reported by many researchers that chitin and chitosan are very good adsorbents in water and wastewater treatment. Both are also used in the pharmaceutical and cosmetic fields, offering a wide range of applications including agricultural, food and biotechnological uses. The use of chitin and chitosan obtained from marine biomass sources in the production of bioplastics is becoming more and more important in order to create environmental awareness about the damage caused by petroleum-based plastics and to reduce the dependence of countries on natural resources.

Turkey, which has a wide coastline, is among the countries where seafood wastes produced in large quantities. Especially the residues of the seafood consumed in the restaurants are not used for any purpose and sent to the landfills together with the household wastes. Unfortunately, this situation also causes an increase in the volume of landfills, as well as an increase in waste containing important substances such as chitin and chitosan. The production of chitin and chitosan from these wastes, which are an abundant and renewable resource, increases the potential of these polymers to be used in the production of bioplastics in the future. Fish scale, fish bone, crab shell, lobster and shrimp shells can be used as the main raw material rich in chitin. These wastes are first separated from their proteins, and the protein released at this stage can also be recovered. The synthesis of bioplastics is carried out by combining pure chitin, which can be obtained after the separation of proteins and other minerals with alkaline pretreatments, alone or with another main raw material such as corn/potato starch with the help of a plasticizer like glycerol. Although chitin/chitosan-based bioplastics produced by these and similar processes are especially preferred as food packaging, they can also be used in many other areas where traditional plastics are used.

CASE STUDY

MEDITERRENIAN SEAFOOD RESTAURANT WASTE CRAB SHELLS: A SOURCE FOR CHITIN/CHITOSAN-BASED BIOPLASTIC PRODUCTION

Materials

In this study, two main seafood restaurant's waste crab shells collected from Mersin City, Turkey. Crab species were identificated. Crab species used for this study were shown at Fig 1.

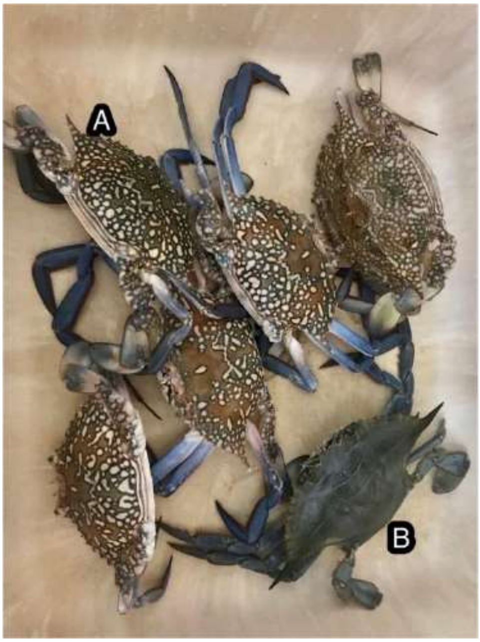

Fig 1. Crab species used in this study
A) *Portunus pelagicus* **B)** *Callinectes sapidus*

Autoclave Assisted Exraction Process of Chitin

Autoclave assisted process was used to extract the chitin from collected crab shells as an alternative process to regular isolation processes developed by different researchers (Rhazi et.al., 2000; Tolaimate et.al., 2000; Tolaimate et.al., 2003; Tolaimate et.al., 2008; El Montassir et.al., 2014; Arrouzei et.al., 2017).

Deproteinization of the raw material was carried out using the principle of alkaline treatment with NaOH (1M) in autoclave at 121°C temperature and 1.2 atm pressure for 15 min. The reaction is followed by measuring the pH after cooling step and residue rinsed with DI water up to neutral pH. The demineralization is carried out in autoclave at 121°C temperature and 1.2 atm pressure for 15 min. using hydrochloric acid (1M), 100 mL of acid are used per 10 g of raw material. The reaction is followed by measuring the pH after cooling step and residue rinsed with DI water up to neutral pH and chitin dried 60°C in an oven for 24 hours.

In order to determine the efficiency of the autoclave assisted process, a portion of the chitin sample extracted as a result of this process was collected for comparison with the commercial chitin FT-IR analysis.

For the preparation of chitosan, adopted Kurina process was used (Kurina, 2001). Chitosan was prepared by deacetylation of chitin with 50% NaOH in autoclave at 121°C temperature and 1.2 atm pressure for 20 min. The reaction is followed by measuring the pH after cooling step and residue rinsed with DI water up to neutral pH and chitosan dried 60°C in an oven for 24 hours. Chitin extracted processes and chitosan production illustrated at Fig 2.

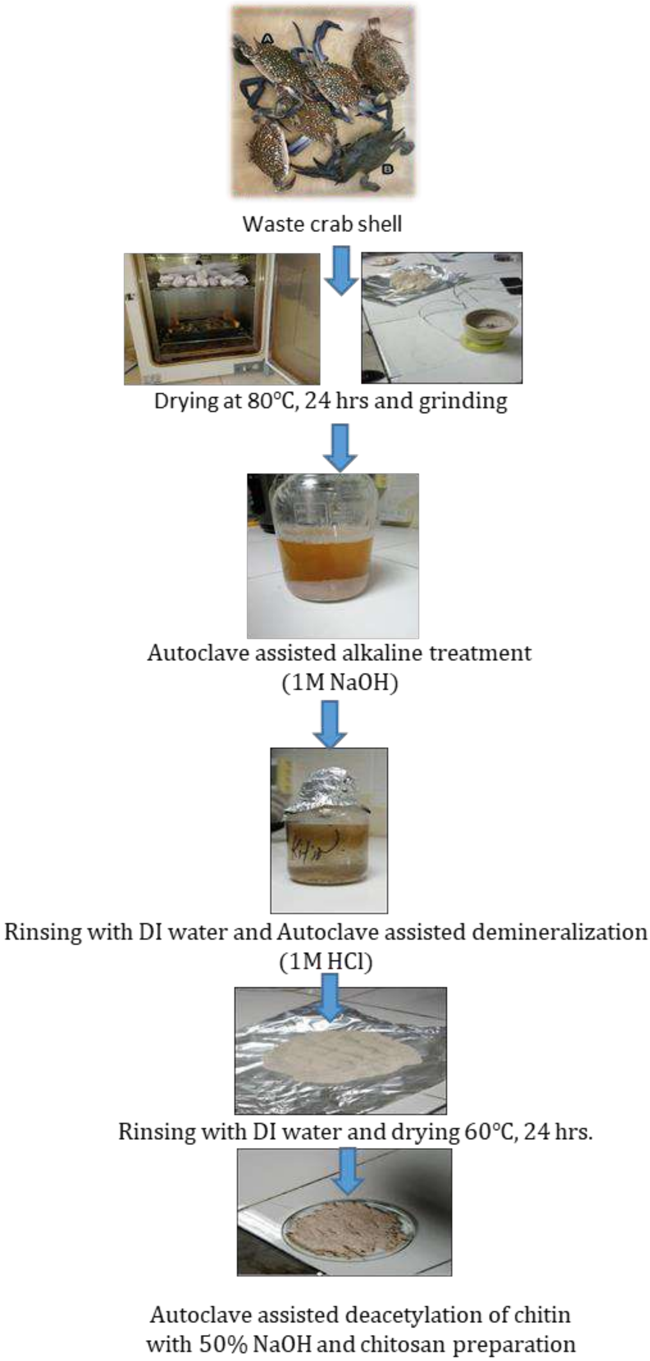

Fig 2. Schematic illustration of extraction steps of chitin and production of chitosan.

Degree of deacetylation was measured by titration method (Wojtasz-Pajak et.al., 1998; Tolaimate et.al., 2000, Czechowska-Biskup et.al., 2012). Dried chitosan (0.2 g) was dissolved in 20mL 0.1 M HCl and 25mL DI water. After 30 minutes continuous stirring, next portion of DI water (25 mL) was added and stirring continued for 30 minutes. When chitosan was completely dissolved, solution was titrated with a 0.1 mol/L NaOH solution. Degree of deacetylation (DA) of chitosan was calculated according to equation (1).

$$\boldsymbol{DA}(\%) = 2.03\frac{V2-V1}{m+0.0042(V2-V1)} \quad \ldots\ldots \qquad \ldots\ldots\ldots\ldots(1)$$

Where: m was weight of sample V1, V2 were volumes of 0.1mol/L NaOH solution corresponding to the deflection points, 2.03 was coefficient resulting from the molecular weight of chitin monomer unit and 0.0042 was the coefficient resulting from the difference between molecular weights of chitin and chitosan monomer units.

FT-IR Analyses of Chitin extracted from Crab Shells

FT-IR analysis was performed only for the chitin extracted from the *Portunus pelagicus*, since the amount was higher than *Callinectes sapidus*.

After otoclave-assited extraction process, chitin samples were dried at 60ºC for 24h. Solids were ground to fine particulates with a mortar and pastle. Ground dry residues of crab chitin and commercial chitin (MP Biomedicals LLC, unbleached, CAT #101334) was analyzed by the same equipment and compared. FT-IR spectra of the samples in KBr disc form were run in a Perkin/Elmer spectrometer 1725X with a resolution of 4 cm_1 and 32 accumulations. KBr discs were prepared in the usual way from very well dried mixtures of about 1 mg of the sample and 100 mg of KBr. Results recorded in the middle infrared (4000 cm-1- 400 cm-1) area.

Preparation of bioplastic sample from crab shell chitosan

Dried chitosan, vinegar, glycerin and DI water (1:1:1:10; w:v:v:v) was added into a baker and mixed. This mixture was heated in water bath at 100 °C and mixed for gelatinisation about 20 min. The gelatinised mixture was poured into a petri plate as sheet form and dried at 60°C for 24 hrs in an oven.

Measurements of water absorption of chitosan-based bioplastics

Water absorption of chitosan based bioplastic was measured according to ASTM D570-81. Bioplastic samples were dried in an oven at 50 °C for 24 h and cooled in a desiccator before weighing. Samples were submerged in distilled water at 25 °C. After 2 h, samples were removed, their surface water dried with a paper towel, they were immediately weighed, and re-submerged into the water. They were weighed again after another 24 h following the same procedure. Water absorption was calculated as a percentage of initial weight (Paetau et.al.,1994; Liu et.al.,2005). All water absorption measurements were performed in three replications.

Results and Discussion

In the study, the effect of autoclave assisted process on the alkaline extraction of chitin from crab shells, different from the methods mentioned in the literature, was determined. The reaction efficiency of the deproteinization and demineralization stages in chitin extraction is increased, the reaction time given in the literature is also significantly reduced by the use of autoclave. The reaction was carried out in an autoclave instead of a hot water bath, which is the method specified in the literature. In the study, the deproteinization stage was completed in 15 minutes with the autoclave assisted process. Similarly, the demineralization step performed in the autoclave was completed within 15 minutes. According to titration method and equation 1, degree of deacetylation of waste crab shell chitosan was calculated as 65±0.89 %.

The curves of the FT-IR analysis performed to compare the chitin extracted with this process with the commercial chitin are given in Fig 3. Curves show that the chitin obtained from crab shells and commercial chitin are quite similar.

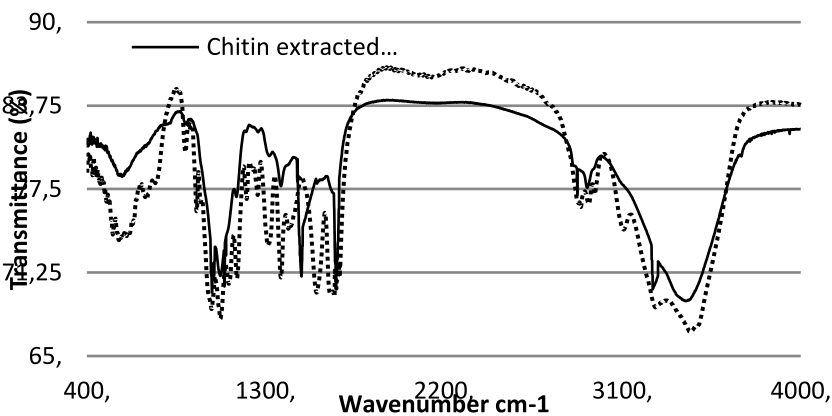

Fig 3. FT-IR spectrum of waste crab shell chitin and commercial chitin

It was determined that the amount of chitosan obtained from Portunus pelagicus was higher between the two studied species (Table 1). Therefore, these samples were used in bioplastic production studies.

Table 1. Chitosan amount extracted from two different crab species

Crab species	***Sample (g)***	***Chitosan (g)***	***Chitosan %***
Portunus pelagicus	80±0.3	5.2±0.1	6.5
Callinectes sapidus	50±0.1	2.3±0.3	4.6

Chitosan-based bioplastic sample prepared with waste crab shell chitosan as a raw material shown at Fig 4. Although the chitosan based bioplastic structure obtained as a result of the study is similar to starch based bioplastics, a small amount of samples could be produced due to the low amount of chitosan studied. Water absorption of chitosan based bioplastic was determined as 52% for 2hrs and 56% for 24hrs.

Fig 4. Bioplastic sample produced from waste crab shell chitosan

In the study, an autoclave assisted process was used in order to reduce the reaction time and therefore the cost in the extraction of chitin from crab shells. Tolaimate et.al. (2008), reported that the deproteinization phase was completed from 6-12 hrs depending on the process temperature (80-120 °C). However, in this study it was completed in 15 minutes at 120 °C by using autoclave-assisted process. Therefore, it has been shown that pressure as well as temperature increases the reaction rate. As a result of effective extraction in a short time, the operation cost is also reduced and the convertibility of the study to the industrial scale has been increased.

FT-IR spectra show that chitin extracted from crab shells in this study has a similar structure to commercial chitin (Table 2). This is supported by the characteristic absorption band (1650-1321 cm-1) of chitin containing N-acetylated amino groups (Querioz et.al,2015).

Table 2. Characteristic absorbent bands in FT-IR spectra of waste crab shell chitin and commercial chitin

Commercial chitin	**Waste crab shell chitin**	**Functional groups**
Wavelenght (cm^{-1})	Wavelenght (cm^{-1})	
3437	3430	(O-H) group
3265	3239	N-H stretching
2932	2943	CH_3 stretching
2891	2668	CH_2 symmetric stretching
1648	1656	C=O group in $NHCOCH_3$ (characteristic of N-acetylated amino group of chitin)
1554	1482	Amide II band
1074	1093	C-O stretching
1029	1031	C-O stretching

The conversion of N-acetylated amino (-NH-CO-CH3) groups on chitin to amino (-NH2) groups is called deacetylation. At the end of this process, although not all of the N-acetyl-D-glucosamine groups can be converted, their numbers decrease compared to the D-glucosamine groups. This is indicated by the degree of deacetylation (DA). No and Meyers (1995) reported that the DA of chitosan ranged from 56% to 99%, with an average of 80%. Calculation of DA value as 65±0.89% in this study showed that autoclave assisted deacetylation with 50% NaOH was an effective method.

Considering the bioplastics of the studies used in the Table 3, results showed that the starch-based commercial bioplastic used in the studies of Bezirhan Arıkan and Bilgen (2019) has the lowest water absorption capacity as 7.48%. This effect is believed to be a result of additives used in commercial bioplastics. Therefore, it is necessary to add different additives to produce a water-resistant chitosan-based bioplastic. However, in order not to reduce the degradability of bioplastics in nature, it is important that the additives to be used are environmentally friendly.

In order to determine the usage areas of bioplastics, water absorption capacity analysis data were used. According to the water absorption capacity analysis of chitosan-based bioplastic produced from waste crab shells which is higher than commercial bioplastics, it is thought that it may be possible to use the product as food packaging. However, if the product is to be used in liquid storage, additives will need to be added to the bioplastic in order to reduce its water absorption capacity.

Table 3. Water absorption capacities of different bioplastic samples studied by different researchers.

Bioplastic	**Water Absorption Capacity (%)**	**References**
Starch Based Commercial	7.48	Bezirhan Arıkan and Bilgen (2019)
Cottonseed Protein (CP)	40.90	Yue et al., (2012)
CP cross-linked with formaldehyd	37.23	Yue et al., (2012)
CP cross-linked with glyoxal	33.27	Yue et al., (2012)
CP cross-linked with glutaraldehyde	32.43	Yue et al., (2012)
Cassava-Starch Based	26.00	Christwardana et al. (2021)
Starch Based (40% glycerol, 10% starch)	85.00	Nasir and Othman (2021)
Corn-Starch Based (30% newspaper pulp fiber, 70% bioplastic)	22.69	Sujuthi and Liew (2016)
Potato-Starch Based (30% newspaper pulp fiber, 70% bioplastic)	32.35	Sujuthi and Liew (2016)
Cassava-Starch Based (30% newspaper pulp fiber, 70% bioplastic)	39.48	Sujuthi and Liew (2016)
Chitosan Based	56.00	This study

Conclusion

The results of the case study showed that the structure of chitin obtained from seafood restaurant wastes is quite similar to that of commercial chitin and it is a suitable raw material for bioplastic production. In addition, it has been determined that it is possible to obtain at least 1 kg of chitin per month even from the wastes of a single restaurant. These results show that the use of chitin and chitosan, which will be extracted only from seafood wastes thrown from restaurants, can make a significant contribution to the economies of countries and that the wastes that go to landfills and cause environmental pollution can be converted into environmental-friendly bioplastics.

Experimental results showed that chitosan-based bioplastic with high water absorption capacity is not a suitable material for liquid storage. However, if some important properties such as density, tensile strength, thermal stability and weathering properties are improved with natural additives, it impossible to used them as a food packaging material.

Acknowledgements

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CURRENT STATUS OF CLASSIFICATION OF COMMERCIAL FISHING GEARS AND METHODS IN TURKISH FISHERIES IN CONSIDERATION OF INTERNATIONAL STANDARDS

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1. Introduction

One of the most important difficulties for the management of Turkish Fisheries is that fishing gear is not classified according to the scientific basis and international standards. In Turkish fisheries, fishing gear can have different names in different regions or fishing gear specific to only one region can be used (Tokaç, 2012). This difficulty is manifested in the collection of fisheries data, in official inspections, and in particular official statistics. Personnel responsible for statistics and official inspectors should be able to classify different fishing gears used in commercial fishing in seas and inland waters, with short but adequate descriptions of fishing gear, which they can also see in figures.

The Fishing Notification, which includes technical measures, is the main instrument in the regulation of fisheries in Turkey. In the last Notification (Notification 5/1), which is valid for 4 years as of September 1, 2020, regulations and restrictions have been introduced for 20 different fishing gears (Anonymous, 2020; Dereli et al., 2021). On the other hand, the fishing vessels in the seas and inland waters are considered into 11 groups, taking into account the fishing gear they used, (including trawl vessel, purse seine vessel, carrier boat, gillnets, beam trawl and dredges, longline and hooks, encircling and set gillnets-*voli ağları* in Turkish, seine nets-*sürütme ağları* in Turkish, stationary blanket nets-*çökertme ağları* in Turkish, fyke net and other gears) were examined in the official statistics (TUIK, 2022).

Correct identification and classification of fishing gear are also necessary for the understanding and correct application of the technical measures regarding fishing gear in fisheries management by all stakeholders (inspection staff, fishers, and NGOs) and international harmonization when necessary. The standard classification should be developed to identify the fishing technology for the compilation of catch and effort data and to support fish stock assessment (FAO, 2022a).

The standart classification assists international organizations (FAO Members, regional fisheries organizations) and fisheries statisticians and managers in accurately reporting fisheries by relating catches to fishing gear. It provides information to identify of fishing gear for monitoring, control and surveillance personnel and contributes to the prevention of illegal, unreported and unregulated (IUU) fishing. Classification also provides context and references for relevant types of fishing gear in some conservation topics and can be used by students and researchers in fisheries and marine conservation as references.

Although there are catalog-style publications (Prado and Dremiere, 1990; Nédélec and Prado, 1999; Gabriel et al., 2005) in which the world's fishing gears are classified and their technical details are given, generally accepted international classification was approved firstly in 1980 and the revised current version was approved in 2016 (FAO, 2022b). He et al. (2021) provided definitions and illustrations of the configuration and mode of operation of typical fishing gears in line with the current classification.

In Türkiye, information on types of fishing gear was also provided in some textbooks used in undergraduate fishing education (Mengi, 1977; Sarıkaya, 1980; Hoşsucu, 1991; Çelikkale et al., 1993; Taşdemir and Özyurt, 2004; Tokaç, 2010; Akyol, 2022). In addition, there are many studies presenting technical plans and usage methods of fishing gear used in sea and inland water fishing in Türkiye. Unfortunately, only in two studies (Tokaç et al., 2010; Tokaç, 2012) based on the old version of FAO approved in 1980, fishing gears used in Turkish fisheries was defined and classified.

Therefore, it is aimed to reveal the current status of the classification of commercial fishing gears and methods in Turkish fisheries in consideration of international standards needed in fisheries management. In this context, the historical development and current state of the internationally accepted fishing gear classification (FAO, 2022a and c), the place of fishing gear used in Turkish fisheries in the classification, and studies that present the technical plans of fishing gears used in Turkish fisheries are presented.

2. Followed Method

A literature review covering the studies carried out to determine technical plans and to classify of fishing gears used in Turkish fisheries was undertaken. The reports of the Coordinating Working Party on Fishery Statistics (CWP) within the Food and Agriculture Organization of the United Nations (FAO) were examined for the international standard statistical classification of fishing gear.

3. International Standard Statistical Classification of Fishing Gear and Current Classification in Türkiye

The International Standard Statistical Classification of Fishing Gear (ISSCFG) provides a global structure for the classification of fishing gear and provides for national or regional variations to be included at sub-levels of the classification. The ISSCFG was originally adopted during the 10th Session (Madrid, 22-29 July 1980) of the Coordinating Working Party on Fishery Statistics (CWP). The ISSCFG standard abbreviations are based on the alpha-codes (FAO, 2022b) (Table 1).

The definition and grouping of fishing gear used in Turkish fisheries were made by Tokaç (2012) based on ISSCFG, 1980 and FAO/ICES Fishing Gear Classification, and technical drawings of some widely used fishing gear are also given. The classification made by Tokaç (2012) for Turkish fisheries was presented in Table 1 together with the international classification.

Table 1. International standard statistical classification of fishing gear (ISSCFG, 1980) and main fishing gear categories used in Turkey Fishery (Tokaç, 2012) (SA: Standard abbreviations).

International Standard Statistical Classification of Fishing Gear (ISSCFG, 1980)			Main Fishing Gear Categories Used in Turkey Fishery (Tokaç, 2012)
Gear Categories	**SA**	**ISSCFG Code**	
SURROUNDING NETS		**01.0.0**	**Surrounding Nets**
With purse lines (purse seines)	PS	01.1.0	
One boat operated purse seines	PS1	01.1.1	***Surrounding nets with purse line (one-boat operated purse seine)*** 1-Operated by mechanically (Anchovy-sardine, gray mullet, bonito, mackerel, tuna purse seiner) 2-Operated by hand
Two boats operated purse seines	PS2	01.1.2	
Without purse lines (lampara)	LA	01.2.0	
SEINE NETS		**02.0.0**	**Seine Nets**
Beach seines	SB	02.1.0	Beach seines (hauling by fishermen via manpower to the coast)
Boat or vessel seines	SV	02.2.0	Boat seines (hauling by mechanize to the boat)
Danish seines	SDN	02.2.1	
Scottish seines	SSC	02.2.2	
Pair seines	SPR	02.2.3	
Seine nets (not specified)	SX	02.9.0	
TRAWLS		**03.0.0**	**Trawls**
Bottom trawls		03.1.0	***Bottom trawls***
Beam trawls	TBB	03.1.1	Beam trawls
Otter trawls1	OTB	03.1.2	Single bottom otter trawls
Pair trawls	PTB	03.1.3	
Nephrops trawls	TBN	03.1.4	
Shrimp trawls	TBS	03.1.5	
Bottom trawls (not specified)	TB	03.1.9	
Midwater trawls		03.2.0	***Midwater trawls***
Otter trawls[1]	OTM	03.2.1	Single boat mid-water trawl
Pair trawls	PTM	03.2.2	Mid-water pair trawl
Shrimp trawls	TMS	03.2.3	
Midwater trawls (not specified)	TM	03.2.9	
Otter twin trawls	OTT	03.3.0	
Otter trawls (not specified)	OT	03.4.9	
Pair trawls (not specified)	PT	03.5.9	
Otter trawls (not specified)	TX	03.9.0	
DREDGES		**04.0.0**	**Dredges**
Towed dredges	DRB	04.1.0	Towed dredges

Hand dredges	DRH	04.2.0	Hand dredges
			Mechanized dredges
			Boat dredges
LIFT NETS		**05.0.0**	**Lift Nets**
Portable lift nets	LNP	05.1.0	
Boat-operated lift nets	LNB	05.2.0	
Shore-operated stationary lift nets	LNS	05.3.0	Stationary lift nets (shore or shallow water)
Lift nets (not specified)	LN	05.9.0	
FALLING GEARS		**06.0.0**	**Falling Gears**
Cast nets	FCN	06.1.0	Manuel cast nets
Falling gear (nei)	FG	06.9.0	
GILL NETS AND ENTANGLING NETS		**07.0.0**	**Gill nets and Entangling Nets**
Set gillnets (anchored)	GNS	07.1.0	***Set gill nets***
Driftnets	GND	07.2.0	***Drift nets***
Encircling gillnets	GNC	07.3.0	***Encircling gill nets***
Fixed gillnets (on stakes)	GNF	07.4.0	
Trammel nets	GTR	07.5.0	***Entangling/Trammel nets*** (Single trammel nets, Double trammel nets, Triple trammel nets)
Combined gillnets-trammel nets	GTN	07.6.0	***Combined (gillnets-trammel nets) nets***
Gillnets and entangling nets (not specified)	GEN	07.9.0	
Gillnets (not specified)	GN	07.9.1	
TRAPS		**08.0.0**	**Traps**
Stationary uncovered pound nets	FPN	08.1.0	
Pots	FPO	08.2.0	Pots
Fyke nets	FYK	08.3.0	Fyke nets
Stow nets	FSN	08.4.0	Stow nets
Barriers, fences, weirs, etc.	FWR	08.5.0	Barriers
Aerial traps	FAR	08.6.0	Aerial traps
Traps (not specified)	FIX	08.9.0	
HOOKS AND LINES		**09.0.0**	**Hooks and Lines**
Handlines and pole-lines (hand-operated)[2]	LHP	09.1.0	
Handlines and pole-lines (mechanized)[2]	LHM	09.2.0	
			Single hook lines
			Multiple hook lines
Set longlines	LLS	09.3.0	Set longlines
Drifting longlines	LLD	09.4.0	Drifting longlines
Longlines (not specified)	LL	09.5.0	
			Vertical set lines
Trolling lines	LTL	09.6.0	***Trolling lines***
Hooks and lines (not specified)[3]	LX	09.9.0	
GRAPPLING AND WOUNDING		**10.0.0**	**Fishing by Grappling and Wounding**
Harpoons	HAR	10.1.0	Harpooning
			Speargun fishing

HARVESTING MACHINES		**11.0.0**	**Harvesting Machinery**
Pumps	HMP	11.1.0	Fish pumps
Mechanized dredges	HMD	11.2.0	Mechanized dredges
Harvesting machines (not specified)	HMX	11.9.0	
			Mechanized hydraulic dredges
MISCELLANEOUS GEAR[4]	MIS	**20.0.0**	**Other Fishing Gears**
RECREATIONAL FISHING GEARS	RG	**25.0.0**	**Recreational Gears**
GEAR NOT KNOWN	NK	**99.0.0**	**Other Unknown or Uncoded Gears**

[1]Fisheries agencies may indicate side and stern bottom, and side and stern midwater trawls, as OTB-1 and OTB-2, and OTM-1 and OTM-2, respectively

[2]Including jigging lines

[3]Code LDV for dory-operated line gears will be maintained for historical data purposes

[4]This item includes: hand and landing nets, drive-in-nets, gathering by hand with simple hand implements with or without diving equipment, poisons and explosives, trained animals, electrical fishing

The revised current Classification (ISSCFG, 2010-Rev.1) was endorsed and adopted for CWP Member's implementation by the CWP at its 25th Session (Rome, 23-26 February 2016). The current international classification (ISSCFG, 2010) was presented with description of the revision from 1980 version to 2010 (Rev.1) version in Table 2.

Major changes in the 2016 revision include (He et al., 2021):

a. Reducing subclasses (tiers) from three to two to simplify reporting processes without loss of data integrity at the international level.

b. The category of “recreational” fishing gear has been removed as it has been determined that this is not a vehicle category but a purpose, scale and management category.

c. The revised classification scheme does not include target types in gear classification and definition. The classification focuses on the physical properties of the gear, how it is operated, and the mechanism of fish capture.

Table 2. Revised international standard classification of fishing gears (ISSCFG, 2010) and description of the revision from 1980 version to 2010 (Rev.1) version (Fishing gears deleted in Rev.1 were shown with a strikethrough) (SA: Standard abbreviations).

Gear Categories	SA	ISSCFG code		Description of the Revision from 1980 version to 2010 (Rev.1) version
		1980 Version	2010 (Rev.1) Version	
SURROUNDING NETS		01.0.0	**01**	Numeric code revised
Purse seines	PS	01.1.0	01.1	Numeric code revised
~~One boat operated purse seines~~	~~PS1~~	~~01.1.1~~		Deleted
~~Two boats operated purse seines~~	~~PS2~~	~~01.1.2~~		Deleted
Surrounding nets without purse lines	LA	01.2.0	01.2	Numeric code revised
Surrounding nets (nei)	SUX		01.9	Numeric code revised
SEINE NETS		02.0.0	**02**	Numeric code revised
Beach seines	SB	02.1.0	02.1	Numeric code revised
Boat seines	SV	02.2.0	02.2	Numeric code revised
~~Danish seines~~	~~SDN~~	~~02.2.1~~		Deleted
~~Scottish seines~~	~~SSC~~	~~02.2.2~~		Deleted
~~Pair seines~~	~~SPR~~	~~02.2.3~~		Deleted
Seine nets (nei)	SX	02.9.0	02.9	Numeric code revised
TRAWLS		03.0.0	03	Numeric code revised
Beam trawls	TBB	03.1.1	03.11	Numeric code revised
Single boat bottom otter trawls	OTB	03.1.2	03.12	Numeric code revised
Twin bottom otter trawls	OTT	03.3.0	03.13	Designation and numeric code revised
Multiple bottom otter trawls	OTP		03.14	New insertion
Bottom pair trawls	PTB	03.1.3	03.15	Designation and numeric code revised
~~Nephrops trawls~~	~~TBN~~	~~03.1.4~~		Deleted
~~Shrimp trawls~~	~~TBS~~	~~03.1.5~~		Deleted
Bottom trawls (nei)	TB	03.1.9	03.19	Numeric code revised
Single boat midwater otter trawls	OTM	03.2.1	03.21	Designation and numeric code revised
Midwater pair trawls	PTM	03.2.2	03.22	Numeric code revised
~~Shrimp trawls~~	~~TMS~~	~~03.2.3~~		Deleted
Midwater trawls (nei)	TM	03.2.9	03.29	Numeric code revised
Semipelagic trawls	TSP		03.3	New insertion
~~Otter trawls (not specified)~~	~~OT~~	~~03.4.9~~		Deleted
~~Pair trawls (not specified)~~	~~PT~~	~~03.5.9~~		Deleted
Trawls (nei)	TX	03.9.0	03.9	Numeric code revised
DREDGES		04.0.0	04	Numeric code revised
Towed dredges	DRB	04.1.0	04.1	Numeric code revised
Hand dredges	DRH	04.2.0	04.2	Numeric code revised
Mechanized dredges	DRM		04.3	Moved from Harvesting Machines
Dredges (nei)	DRX		04.9	New insertion
LIFT NETS		05.0.0	05	Numeric code revised
Portable lift nets	LNP	05.1.0	05.1	Numeric code revised

Boat-operated lift nets	LNB	05.2.0	05.2	Numeric code revised
Shore-operated stationary liftnets	LNS	05.3.0	05.3	Numeric code revised
Lift nets (nei)	LN	05.9.0	05.9	Numeric code revised
FALLING GEAR		06.0.0	06	Numeric code revised
Cast nets	FCN	06.1.0	06.1	Numeric code revised
Cover pots/Lantern nets	FCO		06.2	New insertion
Falling gear (nei)	FG	06.9.0	06.9	Numeric code revised
GILLNETS AND ENTANGLING NETS		07.0.0	07	Numeric code revised
Set gillnets (anchored)	GNS	07.1.0	07.1	Numeric code revised
Drift gillnets	GND	07.2.0	07.2	Designation and numeric code revised
Encircling gillnets	GNC	07.3.0	07.3	Numeric code revised
Fixed gillnets (on stakes)	GNF	07.4.0	07.4	Numeric code revised
Trammel nets	GTR	07.5.0	07.5	Numeric code revised
Combined gillnets-trammel nets	GTN	07.6.0	07.6	Numeric code revised
Gillnets and entangling nets (nei)	GEN	07.9.0	07.9	Numeric code revised
~~Gillnets (not specified)~~	~~GN~~	~~07.9.1~~		Deleted
TRAPS		08.0.0	08	Numeric code revised
Stationary uncovered pound nets	FPN	08.1.0	08.1	Numeric code revised
Pots	FPO	08.2.0	08.2	Numeric code revised
Fyke nets	FYK	08.3.0	08.3	Numeric code revised
Stow nets	FSN	08.4.0	08.4	Numeric code revised
Barriers, fences, weirs, etc.	FWR	08.5.0	08.5	Numeric code revised
Aerial traps	FAR	08.6.0	08.6	Numeric code revised
Traps (nei)	FIX	08.9.0	08.9	Numeric code revised
HOOKS AND LINES		09.0.0	09	Numeric code revised
Handlines and hand-operated pole-and-lines	LHP	09.1.0	09.1	Numeric code revised
Mechanized lines and pole-and-lines	LHM	09.2.0	09.2	Numeric code revised
Set longlines	LLS	09.3.0	09.31	Numeric code revised
Drifting longlines	LLD	09.4.0	09.32	Numeric code revised
Longlines (nei)	LL	09.5.0	09.39	Numeric code revised
Vertical lines	LVT		09.4	New insertion
Trolling lines	LTL	09.6.0	09.5	Numeric code revised
Hooks and lines (nei)	LX	09.9.0	09.9	Numeric code revised
~~**GRAPPLING AND WOUNDING**~~		~~10.0.0~~		Deleted
~~Harpoons~~	~~HAR~~	~~10.1.0~~		Moved into Miscellaneous Gear
~~**HARVESTING MACHINES**~~		~~11.0.0~~		Deleted
~~Pumps~~	~~HMP~~	~~11.1.0~~		Moved into Miscellaneous Gear
~~Mechanized dredges~~	~~HMD~~	~~11.2.0~~		Moved into Dredges
~~Harvesting machines (not specified)~~	~~HMX~~	~~11.9.0~~		Deleted
MISCELLANEOUS Gear			10	Numeric code revised
Harpoons	HAR		10.1	Numeric code revised

Hand implements (Wrenching gear, Clamps, Tongs, Rakes, Spears)	MHI		10.2	New insertion
Pumps	MPM		10.3	Numeric code revised
Electric fishing	MEL		10.4	New insertion
Pushnets	MPN		10.5	New insertion
Scoopnets	MSP		10.6	New insertion
Drive-in nets	MDR		10.7	New insertion
Diving	MDV		10.8	New insertion
Gear nei	MIS	20.0.0	10.9	Numeric code revised
~~**RECREATIONAL FISHING GEAR**~~	~~RG~~	~~25.0.0~~		Deleted
GEAR NOT KNOWN		99.0.0	99	Numeric code revised
Gear not known	NK		99.9	New insertion

5. Conclusion and Recommendations

International classifications (ISSCFG, 1980 and 2010) were initially designed to improve the compilation of harmonized catch and effort data in the fishery statistic questionnaires and fish stock assessment exercises, it has also been found useful for fisheries technology development and the training of fishers. These classifications have been used in particular for reference in work dealing with the theory and construction of gear and for the preparation of specialized catalogues on both artisanal and industrial fishing methods (FAO, 2022b).

The reclassification of fishing gear used in Turkish fisheries is urgently needed according to the current international classification (ISSCFG, 2010) for several reasons. One of the main reasons is that the classification made by Tokaç (2012) took into account the first classification in 1980. As can be seen in Table 2, a major revision was made to the current classification (2010, Rev.1) approved in 2016.

New bans and changes in the current fishing regulations change the list of fishing gear currently used, and thus the classification needs to be updated. Some fishing gears (driftnets, single boat mid-water trawl) stated to be used in Turkish fisheries by Tokaç (2012) were prohibited from use according to Notification 5/1 (Anonymous, 2020), and therefore they are not currently used in fishing. In addition, fishing gear, which is theoretically known to be in the group of beach seine and boat seine, is expressed with local names such as "ığrıp", "trata", "tarlakoz" and "manyat" under the heading "Kıyı sürütme ağları" in Turkish in the Notification. The use of these gears in seas and inland waters were prohibited, with 2 exceptions. Exceptionally, the use of "manyat" in shrimp fishing in the Sea of Marmara and the use of "ığrıp" and "manyat" in big-scale sand smelt fishing in inland waters are permitted. The definitions and the differences of these fishing gears were not specified in the Notification, therefore, difficulties are inevitable during the implementation of technical measures and data collection for statistics.

Another reason is the changes in the variety and quantity of fishing gear due to the increase in the cost of some fishing methods and the decrease in catch in Turkish fisheries. Tosunoğlu and Ünal (2021) reported that the increase in costs in longline fishing has made the use of vertical lines, specific squid (calamary) hand lines, and different types of hand lines and fishing rods more widespread in Gökçeada small-scale fishery in the North Aegean Sea. Due to the scarcity of bluefish, sardine, and chub mackerel, fishing gears were used less frequently for these 3 species in the last decade (Tosunoğlu and Ünal, 2021; Ünal et al., 2022). In addition, it was stated that shrimp, common spiny lobster, sardine gill nets, and red mullet trammel nets have been no longer used in Foça in the Middle Aegean Sea (Güçlüsoy et al., 2023).

Making a fisheries inventory by describing the structural (technical plans) and operational characteristics (fishing methods) of the fishing gear is essential for classification. Therefore, the creation of an inventory of Turkish fisheries should be the primary task of the institutions responsible for fisheries management and researchs.

As a result of the inventory study, if fishing gears with different construction or working characteristics from the ISSCFG classification are detected, these should be reported to the relevant authorities. In the current ISSCFG classification, the sub-title of encircling gillnets under the title of gillnets and entangling nets includes only gillnets. However, there are also many types of trammel nets ("voli" and "alamana" nets in Turkish names) used in the form of encircling in Turkish fisheries. For this reason, a title such as "encircling nets" instead of "encircling gillnets" in the ISSCFG classification of FAO will cover all gillnets and trammel nets used encircling, and thus encircling trammel nets will also be included in the classification.

In conclusion, following the completion of the inventory work, fishing gear and methods in Turkish fisheries should be classified, taking into account the revised international classification and supported by technical plans. Thus, it is thought that togetherness can be achieved in fisheries management practices, and confusion in defining the fishing gear in statistical studies and inspections will be eliminated.

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BIOCHAR APPLICATION AND DROUGHT STRESS TOLERANCE IN PLANTS: OVERVIEW AND IMPLICATIONS

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INTRODUCTION

Biochar application in the soil increases the organic matter content, improves water holding capacity, enhances plant root growth, and regulate nutrient uptake. The biochar-induced improvements in morphological and physiological characteristics of the plant ultimately leads to an increase in biomass and yield (Gonzaga et al., 2019; Guo et al., 2021; Zhao et al., 2022).

Drought

Drought is a condition resulting from a lack of precipitation in any region, which creates significant water imbalance and moisture deficiency for crop production. Due to climate changes, it is predicted that the world will become hotter and drier and as a result, there will be a lack of water (Batool et al., 2015). Drought stress significantly limits growth, disrupts the physiological processes of the plant, and causes significant yield losses, especially in arid and semi-arid regions (Batista et al., 2019; Sattar et al., 2019).

Effective coordination of carbon assimilation and transpiration is essential for optimum water use efficiency, biomass production and yield (Blum, 2011). Irregular closure of the stomata leads to insufficient CO_2 supply for photosynthesis, followed by lower demand for ATP and NADPH (Ehsen et al., 2019). This will result in a significant reduction in the photosynthetic electron transport chain and the formation of reactive oxygen species (ROS) (Foyer and Noctor, 2009).

Under drought stress, photosynthesis and biomass production are significantly reduced. In severe drought conditions, higher accumulation of reactive oxygen species occurs in the leaves. These free radicals cause lipid peroxidation and membrane disruption in plants (Mannan and Shashi, 2019).

These negative changes that occur in the plant limit growth and lead to a decrease in yield.

What does biochar do?

Biochar application may increase the tolerance of soil-plant systems against extreme weather conditions, provide enzymatic activity with its high surface area and porosity, retains water and nutrients in the soil, and improves the bio-physico-chemical properties of the soil (Enders et al., 2012; Baronti et al., 2014). It also creates a suitable habitat for the development of beneficial soil microflora. Therefore, biochar can be considered as a soil conditioner in sustainable agricultural systems (Khorram et al., 2018; Gullap et al., 2022; Kumar et al., 2022). An increase in studies on biochar in the last decade shows that the interest in biochar has increased (Ali et al., 2017). Biochar application provides a good environment for carbon sequestration, acts as a pool for greenhouse gases, prevents CO_2 release and reduces soil organic matter decomposition (Jones et al., 2011). Moreover, it decreases methane and nitrous oxide emissions from the soil (Kumar et al., 2022).

Biochar application causes good electrical conductivity, aggregate formation, high water holding capacity and low bulk density (Kumar and Bhattacharya, 2021). Herath et al. (2013) observed that after the application of biochar, the number of pores and water-holding capacity of the soils increased while the bulk density decreased. The increase in water holding capacity especially due to biochar is of great importance in the improvement of soils under drought stress (Baiamonte et al., 2015).

In many parts of the world soil organic matter is extremely low. This problem is very evident in agricultural areas in Mediterranean countries due to the factors such as overgrazing, intensive farming practices and fire (Paneque et al., 2016). Due to its porous structure and high water holding capacity, biochar can be used an ameliorant against drought stress. Biochar which is formed by the pyrolysis of plant materials and contains a high percentage of total organic carbon (30-70%) and mineral substances is used in drought conditions to improve soil properties and functions such as soil water holding capacity and soil productivity (Lehmann et al., 2011; Ali et al., 2017).

The application of biochar to the soil also increases the microbial interaction and activity in the soil (Pietikäinen et al., 2000), retention of nutrients (Lehmann et al., 2003) and the water holding capacity. However, the type of raw material significantly affects the biochar properties (Ali et al., 2017).

The effectiveness of biochar to be used to increase yield depends on the physical and chemical properties of biochar such as soil type, climate, plant species, porosity, surface area, type of feedstock, pyrolysis conditions (temperature, time, aeration), application rate and method (Baronti et al., 2014; Paneque et al., 2016). Biochar application increases the drought resistance of plants by improving the soil structure, water holding and ion binding capacity, together with adequate mineral transport to plant tissues (Cheng et al., 2012; Deng et al., 2019). However, the use of biochar in inappropriate doses causes greenhouse gas emissions, so it should be used carefully (Zhang et al., 2021).

The application of biochar to acidic soils leads to the promotion of soil microorganisms such as the preservation of pH, the increase of nutrients and their assimilation, plant growth promoting rhizobacteria and arbuscular michorizal fungi and supports the growth of plants by synthesizing phytohormones (Mehari et al., 2015; Hashem et al., 2019).

Application of biochar to maize in loess soil was found to increase plant growth (Zhao et al., 2016). Most of the studies investigating the effects of biochar on plant growth are related to total biomass production, revealing the necessity of investigating other parameters which are an indicator of plant physiology in order to better understand how growth will be affected (Paneque et al., 2016).

In maize-cabbage crop rotation, the application of biochar-based slow-release fertilizer significantly increased plant growth, nitrogen utilization efficiency, yield and quality (Zhao et al., 2022). The use of nitrogen fertilizer together with rice biochar increased the shoot, and root biomass, nitrogen use efficiency and grain yield (Liu et al., 2022).

Bradyrhizobium sp. and biochar applications significantly increased growth, biomass, nitrogen, phosphorus uptake and nodule formation in *Lupinus angustifolius* L. (Egamberdieva et al. 2017). In a study conducted on potatoes, it was revealed that the application of biochar with *Rhizophagus irregularis* decreased leaf area, water use efficiency and nitrogen and phosphorus content but did not affect root biomass and soil pH (Liu et al., 2017). The effectiveness of biochar in soils is variable and biochar with different raw materials can increase plant growth and soil-water relations in some soils under drought conditions (Tayyab et al., 2018).

Due to the presence of sufficient mineral substances in biochar, an increase in chlorophyll content of plants has also been observed (Milla et al., 2013). Similarly, Liu et al. (2017) emphasized that biochar can increase SPAD value and alleviate drought stress in potato plant. The biochar induced increases in stomatal conductivity (Solaiman et al., 2010), water holding capacity (Igalavithana et al., 2017), and leaf water content (Uzoma et al., 2011) has also been reported in different plant species.

Biochar applications improve soil structure by increasing soil aeration, porosity, biological and water retention activity. Thus, the plants growing in that soil increase the water use efficiency (Licht and Smith, 2018), chlorophyll and nutrient content, plant biomass, transpiration rate, stomatal conductivity, antioxidant activity, photosynthesis efficiency and cause a decrease in oxidative stress (Kumar et al., 2022).

Effect on plant morphology and yield

Biochar increased the yield of sorghum (Laghari et al., 2016) and quinoa (Ramzani et al., 2017) by increasing the water-holding capacity of the soil.

Biochar to maize grown in drought conditions increased plant height and leaf area (Haider et al., 2015; Verdiana et al., 2017). In areas with limited semi-arid water, the use of hardwood biochar significantly affected the physical properties by reducing the bulk density of the soil, but it was observed that the effects on the plants' available water content was insignificant. Biochar application increased plant height, chlorophyll content, and vegetative dry biomass, however, water productivity and yield remained unchanged (Singh et al., 2022).

Biochar increased the growth of quinoa, leaf nitrogen content and water use efficiency (Kammann et al., 2015), similarly, nitrogen and total phosphorus content in maize stem and seed (Yin et al., 2022) and growth and yield of maize (Mannan and Shashi, 2019) in drought conditions. It has also been reported that biochar will be effective in mitigating the interactive effects of drought and salinity stress, increasing productivity and water use efficiency in soybean (Zhang et al., 2020).

Effect on plant physiology

Studies carried out under drought stress have revealed that photosynthesis was positively affected by biochar application in sunflowers (Paneque et al., 2016).

In a study conducted with sorghum in arid conditions, it was determined that biochar application did not have a significant effect on gas exchange, water use efficiency, stomatal size and density, biomass and grain yield (Deng et al., 2019). In contrast, the application of biochar to wheat in drought conditions has been observed to improve physiological properties such as water use efficiency, leaf chlorophyll content and stomatal conductivity (Haider et al., 2020).

Biochar improves cation exchange capacity (Atkinson et al., 2010, Chintala et al., 2014), basic ion uptake (N, K, P, Ca and Mg), supporting the plant physiologically to maintain growth in arid conditions (Karhu et al., 2011; Scott et al., 2014). As a result of the application of biochar to the maize in arid conditions, it was revealed that some physiological properties such as chlorophyll a, chlorophyll b, chlorophyll a + b and chlorophyll a / b), relative moisture content, turgor potential, osmotic potential and water potential were significantly improved (Sattar et al., 2019). In arid conditions, the net photosynthetic yield increased significantly in chickpeas treated with biochar and arbuscular mycorrhizal fungi due to the increase in chlorophyll synthesis (Hashem et al., 2019). Ippolito et al. (2012) emphasized that 2% of biochar increased the moisture content by 3-7% and as a result, the rate of photosynthesis was also increased.

Biochar application Maize straw biochar application under salinity and drought conditions increased the antioxidant activity and nutrient content of maize, resulting in an increase in biomass by more than 60% (Ndiate et al., 2021). Biochar increased the photosynthesis rate of wheat and clover in arid conditions (Blackwell et al., 2007; Solaiman et al., 2010), while soybean hazelnut biochar increased growth by affecting plant physiology and biochemistry (Gullap et al., 2022).

Effect of biochar on soil physio-chemical properties

Biochar application provides improvement of polluted soils, enhances physical properties as soil aeration, porosity, organic matter (Jien and Wang, 2013; Qin et al., 2016; Butnan et al., 2017; Zhao et al., 2019), soil water holding capacity (Brockhoff et al., 2010; Verheijen et al., 2019), nutrient uptake, and modifies chemical properties of soil such as pH, N, P, K, Ca, Mg and cation exchange capacity (Blanco-Canqui, 2017; Zygourakis, 2017; Razzaghi et al., 2020; De la Rosa et al., 2022).

Biochar application reduces bulk density (Herath et al., 2013; Rogovska et al., 2016; Saffari et al., 2021; Zhang et al., 2021), in some studies, it was determined that the bulk density did not decrease significantly at an application dose of <10 $mg.ha^{-1}$ (Usowicz et al., 2016; Xiao et al., 2016). There are various mechanisms underlying the decrease in bulk density after biochar application. One of them is that biochar has a lower bulk density than soil. The second is that biochar interacts with soil particles, improving aggregation and porosity, thus reducing mass density in long term. After biochar application, the decrease in soil bulk density and particle density, the increase in soil aggregation directly affect the porosity in the soil. The increased soil porosity caused by biochar application may have positive effects for the movement of water, heat and gases in the soil (Blanco-Canqui, 2017).

CONCLUSIONS

Drought severely hampers plant morpho-physiological growth and reduces final yield. Biochar application has been gaining importance in recent times due to its role in the improvement of soil physical and chemical properties, carbon sequestration, soil fertility, mitigation of greenhouse gas emissions and plant growth enhancement particularly under abiotic stress conditions. Biochar in drought conditions poses positive effects on chlorophyll content, plant relative water content, gas exchange properties and photosynthesis. The response to biochar varies with the type of biochar used, pyrolysis temperature, application time and method, plant species, soil type, and abiotic and biotic stress conditions. Biochar increases seed germination, plant growth, flowering, and resistance to abiotic stress conditions. The use of biochar as a soil conditioner reduces the soil bulk density, increases the water holding capacity of the soil, pH, cation exchange capacity, soil electrical conductivity, soil aeration and microbial activity, thus providing favorable conditions for seed germination, root development and microbial functions, it also immobilizes pesticides and heavy metals and pollutants. In the long term, the relationship between plant, soil and biochar in field conditions, its effects on yield and its role in reducing greenhouse gas emissions should be investigated.

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A BRIEF REVIEW STUDY ON PAPER BASED PACKAGES AND COATING TECHNIQUES

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Introduction

Forest resources and forest products play an important role in the manufacture of many products in various fields. Paper is a popular forest product that is used as an intermediate material in a variety of industries, including the packaging industry.

This chapter aims to provide readers with general information and current trends regarding expected package features, packaging materials, and, in particular, paper-based packages developed using coating techniques. As with the impact of environmental awareness and various dietary habits that affect our lifestyle and the Covid process, the way we consume food and related packaging has changed significantly in the last few years. The food packaging industry, in particular, has paid close attention to the development of biodegradable and biopolymer films and coatings. In comparison to traditional packaging materials, biopolymer films have been fundamentally simplified, increasing their recycling potential. The coating biopolymers can interact with paper substrates to form a new class of multi-materials. These materials have significant properties due to their advantages over synthetic petroleum-based films and present environmentally friendly solutions for mankind and nature.

1. What is packaging?

Packaging is not a contemporary invention; it dates back to the origin of human civilisation. Our ancestors, early hunter-gatherers, put some primitive packages out, made of annual and woody plants and animal hide and wools to transport their belongings (Morris, 2018).

Protection, inclusion, performance, and informing are the basic functions of packaging. The most important of these is undoubtedly the duty to protect the product. In other words, the goal is to deliver processed fresh products to consumers of the desired quality while retaining their post-processing properties (Gopinathar et al., 2016). The properties of the packaging material used in the manufacture of the package that protects the product inside from various external influences must be compatible with the functions specified. To protect the product, it is necessary to identify the external factors to which the package will be exposed while being transported, distributed, or waiting on the shelf. Foods, in particular, are sensitive to one or more of the following factors: moisture, oxygen, light, and odour. In this context, it is critical to select the appropriate packaging based on the product and the surrounding environment (Üçüncü 2007; Weligama Thuppahige and Karim, 2022).

2. Packaging materials

Packages can be made of a variety of materials, including glass, metal, plastic, paper, board and multi-materials. Depending on its properties and the intended application of the packaging, any material may have various advantages and disadvantages.

The raw material of paper and cardboard packaging is cellulose an abundant material found in nature such as the cell walls of plants, vegetable fibres and cotton (Khandelwal and Windle, 2013). Paper and cardboard are preferred because they take up little space and are durable during transportation. Cardboard packages, which can be made in a variety of qualities and weights, can be found in an infinite number of shapes and appearances. The advancement of the paper-making machine, as well as the process of wood pulping and paper printing techniques, in the past, set the ground for the mass production and growth of paper-based packaging (Twede, 2005).

A wide range of production is made as packaging paper among the papers produced today. Paper and cardboard packaging are among the most cost-effective packaging options. More durable but thin, light, and cost-effective cardboard is produced by using less raw material. In terms of the ease of production and economics of paper and cardboard packaging, it is a highly preferred type of packaging. Furthermore, when the hardness, burst strength, protection, moisture and water barrier values of paper and cardboard packaging are insufficient, these packages are subjected to a variety of processes based on the characteristics of the products to be placed inside (Shen et al., 2021). The cardboard can be impregnated or laminated and supported by another inner packaging. The application areas for new designs and cardboard packaging have also expanded (Marsh and Bugusu 2007).

Multimaterials, also known as composite packages, are formed by fusing the entire surfaces of at least two different materials. The goal of combining different materials is to increase durability, flexibility, and to combine the unique properties of the materials. Plastic-aluminum, cardboard-polyethylene, paper-polyethylene, plastic-paper-aluminium, and paper-aluminium composite packaging groups are examples of composite packages.

3. Reasons for Preferring Paper Packaging

The petroleum-based plastic packages have non-biodegradable nature hence their disposal procedure causes various environmental concerns (Baroneet al., 2021). Conversely, the limited reserves of petroleum resources, as well as the demand for product packaging in tandem with population growth and the need for packaging production materials, have pushed manufacturers to seek alternative raw material sources. It paved the way for biodegradable packaging to be produced (Weligama Thuppahige and Karim, 2022). In this content, biodegradability can be defined as the ability of organic materials refers to their capacity to break down into more basic elements as a result of microbial activity (DeBruyn, et al., 2015).

Paper is an environmentally friendly and biodegradable substance, this fact makes it one of the most commonly used packaging materials (Herrera et al. 2017). The main component of paper material, cellulose, is insoluble in most common organic solvents and can easily transmit water-soluble substances via capillary forces. Because of its porous structure, paper can contain a variety of substances and be made into a thermally and chemically stable material (Klemmet al.,1998). As a packaging raw material, paper is simple to process and store, and it can be safely disposed of or even recycled if desired. Paper is typically utilized at the primary (i.e., in direct contact with food goods) and secondary (i.e., for transportation and storage of primary packaging) levels because of its reputation as being environmentally beneficial (Khwaldia et al., 2010). Paper materials are known to be eco-friendly and are widely used in food packaging. When used as food packaging, however, it faces the risk of moisture and oxygen penetration due to the porous structure caused by the distribution of the fibres that make up a network of paper (Andersson, 2008; Zhang et al., 2014). This is a factor that reduces the shelf life of its products, but it is a disadvantage that can be overcome through various industrial applications.

4. Expectations From Paper Based Food Packages

In today's culture and supply networks, the packaging is crucial to the safe distribution of goods. Basically, a food package must also protect the food or beverage from contamination, physical, environmental, and mechanical effects, convey information about the product within and perform promotional functions (Marsh and Bugusu 2007). Additionally, it must be manufactured in an economically, ecologically, and legally appropriate manner (Robertson, 2005; 2009). Maintaining freshness while distributing products to consumers are critical in terms of food safety and public health (Misra et al., 2017; Ghasemi-Varnamkhasti, et al., 2018). Monitoring and determining the freshness of meals has become a must (Dudnyk et al., 2018; Pavase et al., 2018).

The permeability of the packaging is also crucial in terms of the freshness of the product contained within it. Permeability is a property that measures how easily a gas or vapour that is being transported may flow through a porous material

(Gajdoš et al. 2000; Pauly 2003; Siracusa, 2012). It is critical to accurately determine the permeability of the packaging because product reactions can occur due to permeability to moisture, oxygen, carbon dioxide, light, or odour. Table 1 summarizes these potential changes (Stehle 1997; Üçüncü, 2007).

Table 1 Product reactions caused by the permeability of the packaging

Take / Overtake		Given / Missing
• softening / loss of brittleness • clumping / loss of flowability • loss of resolution • melting • crystallization • chemical reactions • enzymatic reactions • microbiological reactions	water vapour moisture	• drying • hardening • crumbling • water loss in oil emulsions • frost burn in deep frozen products • concentration changes in liquids • microbiological reactions
• oxidation • accelerate the growth of aerobic microorganisms • chemical reactions / oil oxidation	oxygen	• Change of redox potential • Aerobic microorganism growth arrest / defective maturation • prolongation of product durability • color defects
• suppression of microorganism growth • prolongation of product durability	Carbon dioxide	• facilitating microbial growth • shortening of product durability • changes in gas partial pressures in packaging / vacuum effect in loose soft packs
• promote the initiation and acceleration of oxidative reactions • protein changes • taste defects	light	-
• absorbing foreign odors • adverse changes in product-specific aroma through enzymatic interactions	aroma/fragrance	• loss of typical aroma

The permeability of any package is intimately related to its perforation features. The term of perforation can be described as a parameter that primarily controls the rate at which packaging products breathe (Mistriotis et al. 2011). In order to improve moisture retention of the produce and lengthen shelf life, perforations such as micro-, macro-, and laser perforations are used in packaging for perishable food goods. The perforation process increases the product's freshness and shelf life and decreases food waste by allowing air to circulate inside and allowing for breathability. Materials like bags and films that are used to package fruits and vegetables frequently have micro perforations.

Keeping the moisture and gas transmission, or wetting and barrier properties, of a package made of paper material under control, prevents swelling of the fibres forming the paper and quality loss of the packaged product. Therefore, the form and mechanical strength of the package can be preserved practically. Further treatment of paper with external barrier coatings can improve these expected features (Rastogi and Samyn, 2015). The packaging material with a good air barrier can effectively resist oxidation deterioration and so extend food shelf-life (Siracusa, 2012). Paper-based packages covered in a film with a low oxygen permeability coefficient can accomplish this. Because the gas and moisture content in food packaging should be at the right level, the degree of permeability of the film to be coated on the paper is considerably significant (Del-valle et al., 2004, Kirwan and Coles, 2011).

5. Coating Techniques for Making Paper Usable as Packaging

The coating technique is frequently used in flexible packaging to protect paper from moisture, enhance barrier qualities, and prevent direct contact between the base material and the product (Khwaldia et al., 2010; Wang et al.,2020; Shen et al., 2021). Product quality and safety are significantly influenced by the barrier qualities of the paper package (Malhotra et al., 2015; Guillard et al., 2018)

The effect of various coatings on the air permeability of paper samples was investigated. Whereas the uncoated paper had a high air permeability value due to its porous structure, the coating technique reduced the air permeability values of the same base sheets, as revealed by prior research (He et al., 2020; He et al., 2021). By covering the surface of the paper, the coating colour fills the surface pores between the fibres, fillers, and other additives within the paper network. Aside from that, when coated and uncoated papers are compared at the same grammage values, the coating process decreases ink absorption and dusting while increasing surface strength, gloss, and opacity. How these changes manifest in the final product depends on the type and quantity of the coating's chemical constituents as well as the coating apparatus and finishing techniques (Lehtinen, 2000).

Various techniques for coating the paper surface can be used, including extrusion coating, curtain lining, size press coating, bar coating, and dip coating (Rastogi and Samyn, 2015). Several factors, including processing speed, required coating laydown rate, coating viscosity, and type of paper material, the influence which coating method is best suited for a given application.

5.1. Extrusion

The extrusion method provides homogeneous coating, and reduces risks of pinholes and cracks due to continuous and solvent-free applications; these benefits make this approach preferable for industrial applications (Gregory, 2005). However, in some cases, the need to increase the coating grammage, as well as the variation in coating speed and effectiveness based on the properties of the polymer and material to be coated, can be considered limiting factors (Rastogi and Samyn, 2015). As shown in Figure 1, a thin coating of very hot molten coating colour (polymer) is transferred and pressed, into a base substrate paper passing through a cooled nip roll assembly (Gregory, 2005).

5.2. Curtain Lining

The curtain coating is a suitable method for producing a multilayer coating structure on paper material. Thanks to this technique, extremely thin top coatings can be applied onto the closed and sealed barrier layer. This provides high-barrier qualities and good printability of packaging materials. Furthermore, depending on the mineral pigments used, top-coating parameters such as thickness, porosity, surface energy, and absorptivity can be tailored (Bollström et al., 2013). Figure 2 depicts the process of applying curtain coating to paper surface (Méndez, 2005).

5.3. Size Press

Size press is an widely accepted method for surface sizing in the paper mills (Lavoineet al.,2014b). For this technique, the consistency of the coating colour is arranged at less than 10% in order to process at an accepted viscosity value. However, because of the restrictions of consistency, in some cases, the coating is not able to cover the paper surface completely and hence the desired barrier properties are not obtained (Rastogi and Samyn, 2015). Figure 3 shows a transfer of the coating colour to paper using the size press method.

5.4. Bar (Rod)

The bar coating technique is also known as rod coating. Because of its ease of use and low cost in comparison to other coating methods, bar coating is widely used for paper coatings. The experimental setup is illustrated in the Figure 4. This technique allows the needed coating thickness to be attained fast and without problems or additional costs. Rods of varying sizes and grooves are used to adjust the thickness of the coating on the base paper (Kunam, et. al., 2022). During the application method, the two basic factors that can be modified are rod speed and diameter (Afra et al. 2016; Jin et al., 2021).

5.5. Dip

Coating with the dip method is most commonly used in laboratories for research and development because it is a simpler method than other coating methods that can be accomplished with a simple mechanism. Figure 5 depicts the experimental setup for the dipping method. The thickness of the coating layer can be adjusted using this technique, but it is not suitable for industrial applications because coating colour cannot be uniformly distributed (Kunam, et. al., 2022). The main disadvantage of dip coating is that it takes a long time (Tosi et. al., 2022).

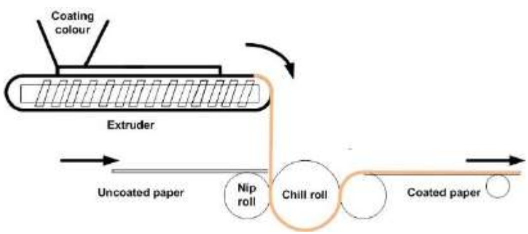

Figure 1 The machinery diagram for the extruder coating technique

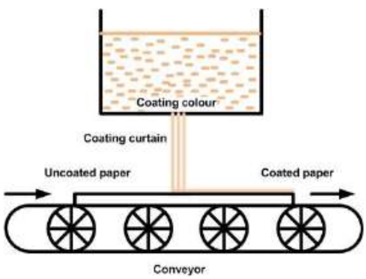

Figure 2 The coating application by curtain lining technique

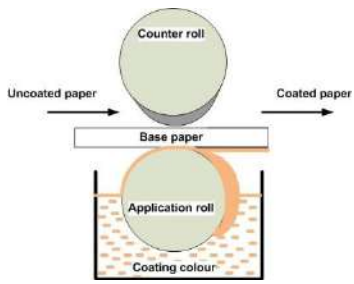

Figure 3: The size press procedure for coating application

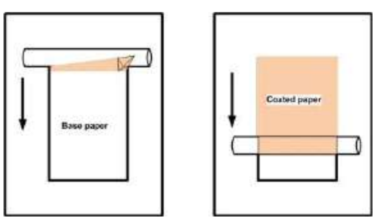

Figure 4: Colour coating application using the bar/rod technique

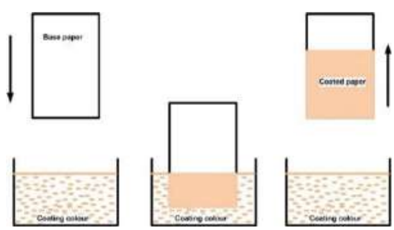

Figure 5: Setup for coating experiments using the dipping method

6. Trends in Paper Packaging

The fundamental goal of today's packaging industry is to explore and develop the use of environmentally friendly recyclable natural materials in packaging, and then commercialize them (Morris, 2018).

Utilizing a combination of materials frequently results in the finest possible packaging features at the lowest possible cost. As a result, plastic packaging films are frequently proceeded with various materials, including paper or paper-based products (Mangaraj et al., 2009). The packaging industry is a significant consumer of resources, using around 50% of the paper produced in Europe (Coelho et al., 2020). Especially by coating, micro perforation, lamination, co extrusion, or polymer blending food packages can be improved. (Brody et al. 2008). Synthetic polymer coating and lamination with plastic or aluminium foils have been used to achieve adequate barrier properties for food packaging. However, these procedures adversely affect the low recyclability, lack of biodegradability, and sustainability of packaging (COST-FP1003, 2014; Bobu et al. 2016).

Plastics (Ong et al., 2022), glass (De Feo et al., 2022), and metals are major components used to impart barrier properties to food packaging (Mujtaba et al., 2022). Polymers used in the plastics industry include polyamide (PA), polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP) and polyvinylchloride (PVC) (Jain and Tiwari, 2015; Luzi et al., 2019). Polyolefins (polyethylene), waxes, ethylene vinyl alcohol (EVOH), and polyvinylidene chloride (PVDC) are examples of polymers that provide a significant barrier coating in food packaging materials against water and oxygen absorption (Mangaraj et al., 2009). They are typically based on fossil-oil or synthetic polymers, and dominate the market due to their low cost (Rastogi and Samyn, 2015). However, the use of fossil fuel-based materials in the packaging industry causes serious environmental pollution, food safety issues (Lu et al., 2014; Xiao et al., 2016; Zhang et al., 2019; Shao and Chen 2020) and raises overall recycling costs by making recycling difficult, and can pose a variety of risks in terms of human health and environmental effects (Bohlmann et al., 2004; Shen et al., 2020; Mujtaba et al., 2022).

As a result, one of the current research topics is the development of new food packaging materials that are biologically degradable, environmentally friendly, non-toxic, and can gain barrier properties against moisture, oxygen, carbon dioxide and lipids through industrial processes (Weligama Thuppahige and Karim, 2022; Cheng et al., 2022). This way, it will be possible to prevent food deterioration and environmental damage caused by packaging materials (Divsalar et al., 2018; Vaezi et al., 2019; Thuppahige and Karim, 2022).

Biopolymers are biodegradable materials derived from renewable resources that can be used to replace fossil fuel-based materials in barrier coatings in paper-based packaging. The biocompatible properties and non-toxicity of biopolymers provide significant benefits to recycling systems and environmental protection (Rastogi and Samyn, 2015). Some studies have also demonstrated that biopolymer films for packaging have good barrier performance (Ley et al.,2010; Tang et al., 2012). Some biopolymers, such as polysaccharides, proteins, lipids, and polyesters, have already been used to improve the barrier properties of paper and cardboard-based materials through coating (Andersson, 2008; Khwaldia et al., 2010).

The surface coating with biodegradable polymers (whey protein isolate WPI/cellulose and poly(vinyl butyral PVB/zein) were also be used to improve the water barrier property of cardboards made from paper (Han et. al, 2010). Similarly, many chemicals such as chitosan (Ham-Pichavant et al., 2005), fluorocarbon (Aulin et al., 2008), fluorinated copolymers (Itami et al, 2006; Iengo and Gavezotti, 2007; Hagiopol and Johnston, 2011) hydroxypropyl-cellulose (Leminen et al. 2015), starch and bentonite clay (Khairuddin et al. 2019) treatment of paper-based materials have been widely used to achieve oil-resistant packaging. One of the recent works showed (Wang et al.,2020) that the cellulose stearoyl ester (CSE)-coated papers had a lower tensile index and a higher elongation at break in comparison to the uncoated specimens, indicating the flexibility of CSE coated paper. Additionally, by offering a barrier property of up to 90%, the sheets coated with CSE have greatly increased their water-repellent (hydrophobic) qualities. Another work demonstrated that coatings of microfibrillated cellulose (MFC) using a simple rod-coating method improved the mechanical properties and gas barrier of paper (Aulin et al., 2010; Lavoine et al., 2014a; Lavoineet al.,2014b). These results (Wang et al.,2020) have been accepted as promising for improving the moisture barrier features of packaging. It will be possible to extend the shelf life of the items packaged in paper-based packages as well as the physical and mechanical performance of the paper by improving the moisture barrier property of those packages (Jantanasakulwong et al.,2016). Table 2 classifies biopolymer films made from various biobased materials (Mellinas et al., 2016).

Table 2 Biopolymer films derived from various biobased materials

Biobased Materials		
Polysaccharides	**Proteins**	**Lipids**
• Cellulose • Starch • Pectins • Seaweed extracts • Gums • Chitosan	• Animal source - Casein - Whey protein - Gelatin - Egg albumin • Plant source - Corn - Soybean - Wheat - Cottonseed - Peanut - Rice	• Animal oils • Vegetable oils • Fats • Waxes • Natural resin • Essential oils • Extracts • Emulsifier • Surface active agents

In terms of current global production capacities, biodegradable materials (45%) outnumber non-biodegradable materials (41%). However, this capacity has not yet been utilized to its full potential. The main causes of this are the ineffective determination of the usage area of biodegradable materials and the lack of the necessary precautions (European Bioplastics nova-institute, 2020).

When using biopolymers as a paper coating material, nanotechnology applications are used to improve the properties and give new functions to the final coated paper. Nanotechnology advancements have provided opportunities to improve paper surface coatings through the use of bio-based nanofillers such as nanocellulose (Dufresne, 2013) and nanoclays (Sanchez-Garcia and Lagaron, 2010), as well as various pigments (Hladnik and Muck, 2002; Kugge and Johnson, 2008), minerals (Daoud et al., 2004) and ceramics (Dufresne, 2013). It is also believed that developing packaging films with high barrier properties by modifying nanocellulose, lignin nanoparticles, and bio-polyester-based materials in paper-based materials known as nanocomposites will be functional in the future (Mujtaba et al., 2022).

As inferred, the topics of shelf life extension and waste reduction have been issues of current food packaging literature (Manfredi et al., 2015; Berthet et al., 2015; Gutierrez et al., 2017; Guillard et al., 2018; Yildirim et al., 2018; Wikström et al., 2019a; Wikström et al., 2019b). By extending the shelf life of food and preventing food waste, packaging can lessen the environmental effect of a product (Lockrey et al., 2019). There has also been some investigation into the features and innovations in food packaging that are meant to reduce food waste (Wikström et al., 2019a; Wikström et al., 2019b).

Conclusive Remarks

Environmentally friendly production, recycling processes, extending product shelf life, and reducing waste products have become significant issues for people's health and natural resource management as environmental awareness has grown. As a result, developing new techniques for paper coatings, as well as incorporating biopolymers into paper-based materials and selecting biodegradable layers to improve package properties, is critical. It is possible to be environmentally responsible by taking into account all of the factors associated with consumer behavior, expected features of paper-based packages, technological applications, and the selection of eco-friendly materials. Hence, reviewing new trends and applying coating techniques to paper-based packaging are quite essential.

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APPLICATIONS OF SULFATED POLYSACCHARIDES FROM GREEN MARINE MACROALGAE FOR SUSTAINABLE AQUACULTURE

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Introduction:

The aquaculture sector continues to grow and make an increasing contribution to the world's food resources. In addition, aquaculture needs to be developed in a socially, economically and environmentally sustainable way in line with the United Nations sustainable development goals (Tacon et al., 2022).

The rapid depletion in terrestrial resources has brought oceans and seas, whose value has not been fully realized, to the agenda (Choudhary et al., 2021). The oceans and seas, which cover more than 70% of the Earth's surface, provide a rich source of natural products due to the abundant diversity of organisms. As one of these sources, macroalgae contain essential amino acids, fatty acids, polysaccharides (PSs), antioxidants, minerals, bioactive peptides and vitamins they have been used as a healthy food supplement in both humans and animal husbandry (Hentati et al., 2020; Salehpor et al., 2021).

In addition, it has been reported that macroalgae improve the immune system, show antimicrobial properties, promote the development of beneficial bacteria in the intestinal microbiota, improve intestinal function, reduce the negative effects of stress and increase the well-being of fish and other aquatic products (Hoseinifar et al., 2022; Rouhani et al., 2022). On the other hand, it has been suggested that it can help relieve pressure on wild fish stocks by providing an alternative source to fishmeal (Saleh, 2020).

PSs, especially sulfated polysaccharides (SPs) obtained from macroalgae, are thought to have an important role in displaying these beneficial properties. In this section, it is aimed to discuss the applications of Ulvan, the most important SP obtained from green macroalgae, as a functional feed additive in fish and other aquatic organism diets within the scope of recent studies in aquaculture. Furthermore, a projection will be presented by considering the potential benefits of Ulvan in the future of aquaculture, in the light of available data.

Polysaccharides from green macroalgae

Marine macroalgae have recently received increasing attention as they can be used as natural renewable resources suitable for a range of industrial applications such as food, feed, health and bioenergy (Saleh, 2020; Ktari et al., 2022).

Macroalgae are multicellular and macroscopic autotrophs that are taxonomically classified into three groups as Chlorophyta (green algae), Rhodophyta (red algae) and Ochrophyt (brown algae) according to the colors of the thallus (Choudhary et al., 2021).

Green macroalgae meet less than 1% of the total marine macroalgae production (Figure 1). Although the other important part is obtained from red algae and brown algae, intensive production is concentrated on eight genera (Cai et al., 2021).

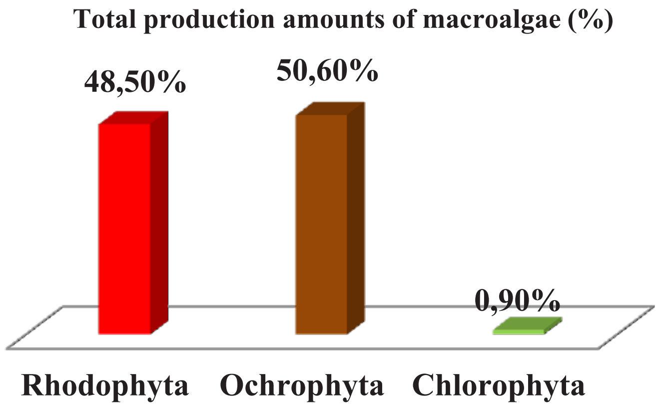

Figure 1. % Total production amounts of macroa algae (FAO, 2022)

However, in terms of species diversity, it has a number close to brown algae (Figure 2).

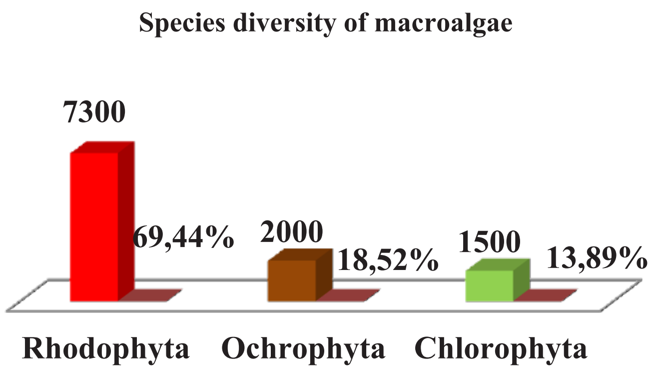

Figure 2. Species diversity of macroalgae (FAO,2022)

Although production figures are low, an increasing trend in productivity and diversity has been observed in certain markets for green marine macroalgae, generally in the food sector.There has also been an increasing interest in green marine macroalgae as novel properties such as bioactive compounds have been discovered in aquaculture (Moreira et al., 2022).

Macroalgae have become high value-added products that can be used in many areas due to the PSs they have in their composition, especially SP (Garcia-Vaquero et al., 2017).

Sulfated polysaccharides and Ulvan

Polysaccharides are the main components of the cell wall of macroalgae and are usually in the range of 5 to 75% of their dry weight (DW) depending on the species, age or harvest season (Hentati et al., 2020).

SPs, a class of complex PSs containing sulfate groups (Pomin, 2012). Macroalgae, which are enormous sources of SP, are mainly obtained from brown algae as fucoidan, red algae as carrageenan and agar, and green algae as ulvan (Gupta & Abu-Ghannan, 2011; Mohan et al., 2019; Bakky et al., 2022).

Having unique structural properties, SPs interact with some matrix and cellular proteins, resulting in a variety of physiological responses. However, the molecular structure of SPs varies according to the type of algae from which they are extracted, their age and extraction methods (Kang et al., 2022).

Recently, studies on the bioactivity of SPs, which have long been used as stabilizers and gelling agents in food, drugs and nanomaterials, are emerging (Nigam et al., 2021; Patel et al., 2022).

Ulvan's outstanding chemical and physicochemical properties have made this polysaccharide family attractive candidates for new functional and biologically active polymers in many different fields. The main areas of these fields are pharmacy, feed, agriculture and aquaculture (Lahaye & Robic, 2007).

Ulvan

The cell wall carbohydrate amounts of green algae vary between 38% and 54%, while their ulvan content varies between 8% and 36% (Lahaye & Robic, 2007; Kidgell et al., 2019).

Green seaweeds polysaccarides can be divided two major groups such as uronic acid rich (sulfated) PSs represented by the ulvans and uronic acid limited PSs represented by sulfated galactans, arabinopyranans and mannans (Tuvikene et al., 2010; Synytsya et al., 2015; Zhao et al., 2015; Perez et al., 2016; Kidgell et al., 2019).

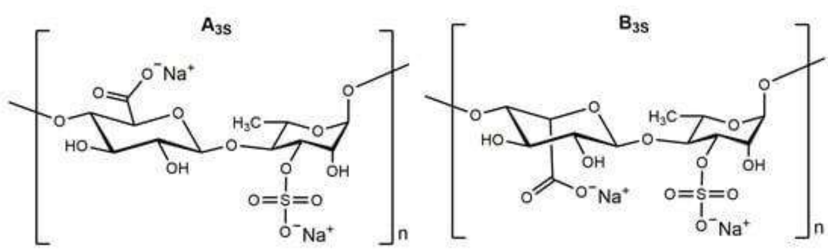

Figure 3. Different Structures of Ulvan (Kidgell et al., 2019)

Ulvan known as water-soluble polysaccharide has been reported to have heterogeneous composition due to repeated sequences of disaccharides such as sulfated rhamnose, uronic acids (glucuronic or iduronic acids), and xylose (Otero et al., 2021).

Ulvan consists of approximately 65% ulvanobiuronic acid and 30% uronic acids, with minor amounts of galactose, mannose, and arabinose (Pangestuti & Kurnianto, 2017).

Ulvan applications in aquaculture

SPs from green seaweeds have been widely used due to their biological activities and potential for application in food, pharmaceutical and biomedical applications, as well as nutraceuticals in aquaculture (Cindana Moo et al., 2020; Ponce et al., 2020; Klonklaew et al., 2021).

Various PS such as Ulvan, Alginate, Fucoidan, Laminarin, Carragean and Agar extracted from marine macroalgae and containing bioactive content have shown immunostimulating effects in fish and shrimp (Ponce et al., 2020; Harikrishnan et al., 2021). PSs have been claimed to cause an increase in leukocyte count, phagocytic activity and interleukin expression in various fish species (Quezada-Rodriguez & Fajer-Avila, 2017). This hypothesis has also been proven by in vivo studies on fish that ulvan has immunostimulating properties (Quezada-Rodriguez & Fajer-Avila, 2017; Ponce et al., 2020; Harikrishnan et al., 2021).

Effects of Ulvan as Growth Promoter in Aquaculture

Although it varies depending on the species, feed expenses constitute approximately 50-80% of the production cost in aquaculture. Therefore, the aquafeed use process needs to be managed effectively (Hodar et al., 2020). Nowadays, the search for alternative sources of feed ingredients continues due to increasing cost and uncertainty regarding the continuous supply of common feed ingredients (Saleh, 2020).

It has been demonstrated that ulvan is not disrupted in the human gastrointestinal tract, but is selectively assimilated in specific organs and tissues without obvious signs of toxicity in normal cells. It has also been suggested that ulvan can be used as a source of metabolism since it provides a significant amount of energy when consumed by humans (Cindana Moo et al., 2020).

Some studies have been conducted to investigate the effectiveness of ulvan, the main polysaccharide of green macroalgae, in fish and shrimps (Table 1). It has been reported that ulvan, as a SPs, plays a very important role in major physiological functions such as growth and immunity in animals (Lauzon &

Serrano, 2015). Akbary & Aminikhoei (2018a) reported that water-soluble PSs extracted from *Ulva rigida*(WSEU) showed a growth-promoting effect when added to *Litopenaeus vannamei* feed, with the best results being obtained at a rate of 1.5 g kg^{-1}. In grey mullets (*Mugil cephalus*), it was stated that the best growth performance was observed in those fed with 1g kg^{-1}supplemented groups (Akbary & Aminikhoei,2018b). On the other hand, Declarador et al. (2014) reported that diets supplemented with ulvan were not effective on the growth performance of shrimps.

Recently, a study was conducted to investigate the effectiveness of ulvan in *Labeo rohita*. It has been reported that when ulvan polysaccharide, which is commercially supplied from a company, is added to the feeds as 50 mg kg^{-1}, an increase in growth performance is obtained (Harikrishnan et al., 2021).

Table 1: Recent growth studies with Ulvan in aquatic species

Aquatic species	Days	Doses	Growth	S. Dose	Ref.
Oreochromis niloticus	90	0.1-0.5-%	⇨	NS	1
Mugil cephalus	56	5-10-15 mg kg^{-1}	↑	10 mg kg^{-1}	2
Labeo rohita	60	25-50 mg kg^{-1}	↑	50 mg kg^{-1}	3
Oncorhynchus mykiss	56	0.5-1.5 g kg^{-1}	↑	1.5 g kg^{-1}	4
Fenneropenaeus merguiensis	42	1-2-3 g kg^{-1}	↑	1-2-3 g kg^{-1}	5
Litopenaeus vannamei	21	0.05-0.10-0.15%	⇨	0.21%	6
L. vannamei	56	0.5-1-1.5 g kg^{-1}	↑	1.5 g kg^{-1}	7

Abbreviations: S. Dose: Suggested dose; NS: Not Suggested; (↑):increased or improved; (↔):not affect; Ref.:References 1- Quezada-Rodriguez & Fajer-Avila, 2017; 2-Aminikhoei & Akbary, 2018b 3-Harikrishnan et al., 2021; 4-Safavi et al., 2019; 5-Liu et al., 2020; 6-Lauzon&Serrano, 2015; 7-Aminikhoei & Akbary, 2018a

Bioactive properties of Ulvan in Aquaculture

It has emerged substantial worldwide awareness of the restrictions on antibiotics and other chemicals used to prevent and treat disease in aquaculture due to hazards to fish, the environment and consumers (Quezada-Rodriguez & Fajer-Avila, 2017).

Therefore, researchers are increasingly interested in natural compounds extracted from terrestrial or aquatic plants that have an effect on the physiological defense of fish, provide resistance to disease under stressful conditions, stimulate the immune system, and minimize the use of antibiotics (Quezada-Rodriguez & Fajer-Avila, 2017). For this purpose, some studies were carried out in aquaculture with one of the potential candidates, ulvan, and promising results were obtained (Table 2 and 3) (Fernandez-Diaz et al., 2017; Akbary & Aminikhoei, 2018b; Klongklaew et al., 2021).

Ulvan has proven beneficial to humans due to its immunostimulating effects and its ability to alter the human gut microbiota (Cindana Moo et al., 2020). Similarly, Liu et al. (2020) reported that ulvan obtained from *Enteromorpha* sp. positively affected the intestinal microbiota of banana shrimps (*Fenneropenaeus merguiensis*). In studies conducted with ulvan in aquaculture, it has also been shown to have strong antioxidant, antibacterial (Ponce et al., 2020), antiviral (Raguraman et al., 2020) and immune regulatory effects (Harikrishnan et al., 2021).

Declarador et al. (2014) reported that shrimp fed a purified (from *Enteromorpha intestinalis*) 1.5g kg^{-1}ulvan diet exhibited 77% higher total haemocyte count and respiratory burst activity than the control group and activated cellular immunity. Declarador et al. (2014) also suggested the amount of ulvan to be added to the feed as 0.21% for *L. vannamei* and 0.15% for *Penaeus monodon* to maximize immune responses.

In another study, it has been claimed that ulvan may be an effective immunostimulant for *L. vannamei* and *P. monodon*, as immunological parameters such as total hemocyte count, respiratory burst, and phenoloxidase activities all increased in shrimp fed diets containing ulvan (Lauzon & Serrano, 2015).

Similarly, a study on the addition of ulvan to *L. vannamei* diets, it was reported that antioxidant activity increased, the immune system improved, and a decrease in mortality was observed when infected with *Photobacterium damselae* bacteria (Akbary & Aminikhoei 2018a,b; Klongklaew et al., 2021).

Regarding antioxidant defenses, Akbary & Aminikhoei (2018a) found that glutathione peroxidase and catalase activities increased in *L. vannamei* fed a diet containing 1.0 g kg^{-1}WPEU and 1.5 g kg^{-1}, while MDA content was lower. Indeed, lysozyme and phenoloxidase activities of shrimps receiving 1.0 g kg^{-1}

WPEU and 1.5 g kg^{-1} WPEUwere significantly higher (Akbary & Aminikhoei, 2018a).

In another study investigating the effectiveness of Ulva in gray mullets by Akbary & Aminikhoei, (2018b), it was reported that the best results were obtained with 10 mg kg^{-1} in antioxidant activity, immune response and resistance to *P. damselae*.

Ulvan, extracted from *Ulva ohnoi*, has been shown to trigger multiple signaling pathways of the immune system in different tissues when given to sole fries by injection (Ponce et al., 2020). In addition, it was reported that when ulvan was injected into sole fish following experimentally infected with *Photobacterium damselae* subsp. *piscicida* (Phdp) bacteria, mortality rates were decreased. Therefore, it has been suggested that it can also be used as a vaccine adjuvant against Phdp (Ponce et al., 2020).

Serrano & Tumbokon (2022) showed that ulvan added to *P. vannamei* diets as 1 g kg $diet^{-1}$ for 35 days modulates the immune system. They stated that immune related genes suppressed in shrimp experimentally infected with WSSV showed an upregulation trend in shrimp fed with ulvan-added feed, providing resistance to the virus.

Harikrishnan et al. (2021) reported that 50 mg g^{-1} ulvan added to *Labeo rohita* diets provides improvements in parameters such as immunity, antioxidants and significant protection when experimentally infected with *Flavobacterium columnaris*.

Moreover, it has been claimed that ulvan can be processed as a nanocarrier. Fernandez-Diaz et al. (2017) reported that hybrid polysaccharide nanoparticles consisting of ulvan-chitosan exert an immunostimulatory effect on macrophages of sole fish (*Solea senegalensis*). The obtained results showed that ulvan has significant potential for oral administration of active compounds in aquaculture.

It has been reported that different results were obtained in studies with ulvan supplementation in several fish species. While it was reported that the addition of ulvan did not affect the growth performance of Nile tilapias (*Oreochromis niloticus*) (Quezada-Rodriguez & Fajer-Avila, 2017), significant increases were reported in *Solea senegalensis* (Ponce et al., 2020) and *Labeo rohita* (Harikrishnan et al., 2021).

Table 2: Recent Immunity studies with Ulvan in aquatic species

Aquatic species	Days	Doses	Immunity	S. Dose	Ref.
Oreochromis niloticus	90	0.1-0.5-%	PA	NS	1
Solea senegalensis	7	5mg fish^{-1}	IRGE(↑)	NS	2
Labeo rohita	60	25-50 mg kg^{-1}	PA(↑) RBA(↑) ACP(↑) Lyz(↑) IgM(↑)	50 mg kg^{-1}	3
Paralichthys olivaceus	3	4-20-100 µg fish^{-1}	IRGE (↑) ACP (↑) Lyz (↑)	NS	4
Fenneropenaeus merguiensis	42	1-2-3 g kg^{-1}	Lyz (↑) ALP (↑) Phe (↑)	1 g kg^{-1}	5
F. indicus	25	0.1-0.2-0.3-0.4 g kg^{-1}	ProP (↑) Lyz (↑)	NS	6
Penaeus monodon	14	4 g kg^{-1}	THC (↑) DHC (↑) Phe (↑)	4 g kg^{-1}	7
P. monodon	14	0.5-1-1.5 g kg^{-1}	THC (↑) RBA (↑) Phe (↑)	1-1.5 g kg^{-1}	8
Litopenaeus vannamei	21	0.05-0.10-0.15%	THC (↑) RBA (↑) Phe (↑)	0.21%	9

Nd: Not detected; R. Dose: Recommended dose; NS: Not suggested; ProP: prophenoloxidase activity; Lyz: lysozyme activity; THC: total haemoycte count; RBA: respiratory burst act ivity;DHC: differential haemocyte count; Phe: phenoloxidase activity; PA:phagocytic activity; IRGE: Immune related gene expressions; ACP:alternate complement pathway; IgM:ImmunoglobulineM; ALP:alkaline phosphatese;(↑):increased or improved; Ref.:References 1-Quezada-Rodriguez & Fajer-Avila, 2017; 2-Ponce et al., 2020; 3-Harikrishnan et al., 2021; 4-Yang et al., 2019; 5- Liu et al., 2020; 6-Velmurugan et al., 2015; 7-Manilal et al., 2009; 8- Declarador et al., 2014; 9-Lauzon&Serrano, 2015

The biological activities of PSs, including ulvan, are directly related to their chemical structure (Kidgell et al., 2019). It was stated that some of these biological activities may have attributed from the sulfate group from SP molecules(Kang et al., 2022).

Table 3: Recent Disease Resistance studies with Ulvan in aquatic species

Aquatic species	Days	Doses	A.M.A.	S. Dose	Ref.
Mugil cephalus	56	5-10-15 mg kg^{-1}	Pd (↑)	10 mg kg^{-1}	1
Solea senegalensis	7	0.5 mg $fish^{-1}$	Phdp (↑)	NR	2
Oreochromis mosambicus	15	Ulvan & SN	Pa	-	3
Litopenaeus vannamei	60	1-5-10 mg mL^{-1}	WSSV (↑) YHV(↑) Vibrio sp. (↔)	5-10 mg mL^{-1}	4
L. vannamei	28	1-5-10 g kg^{-1}	Vp (↑) YHV (↑) WSSV (↔)	5g kg^{-1}	5
L. vannamei	56	0.5-1.0-1.5g kg^{-1}	Pd (↑)	1.5 g kg^{-1}	6
Penaeus monodon	14	2-4-6-8 g kg^{-1}	WSSV(↑)	0.4 g kg^{-1}	7
Fenneropenaeus indicus	25	0.1-0.2-0.4 g kg^{-1}	WSSV (↑)	NR	8

Abbreviations: A.M.A.: Antimicrobial activities; Ref.: References; S.dose: Suggested dose; NR: Not recommended; Pd: *Photobacterium damselae* WSSV; White Spot Syndrome Virus; Vp: *Vibrio parahaemolyticus;* YHV:yellowhead virüs; Pa: *Pseudomonas aeruginosa;* SN: silver nanoparticles(↑):increased or improved; (↔):not affect; References:1-Akbary & Aminikhoei, 2018b; 2-Velmurugan et al., 2015; 3-Thanigaivel et al., 2022; 4-Klongklaew et al., (2020); 5-Klongklaev et al., 2021; 6-Akbary & Aminikhoei, 2018a; 7-Manilal et al., 2009; 8-Ponce et al., 2020

Conclusion and future suggestions

Macroalgae species should be diversified in aquaculture in order to increase industrial innovation, sustainability, provide genetic enrichment on the basis of species, increase resistance to disease and counteract the negative effects of climate change.

The importance of macroalgae as a potential replacement protein source in the diet of farmed fish has been well-documented in recent years. Therefore, new studies should be carried out by determining the contents of different macroalgae species in this regard.

Macroalgal PSs play a vital role in the feeding process of fish, as they are effective in the digestive process in the fish gut. Thus, the potential of using PSs in the consumption of hard to digest plant-derived proteins should be investigated.

Ulvan has physicochemical properties and molecular characteristics not found in many other natural polymers. Therefore, it has been suggested that ulvan polysaccharide can be developed with promising prospects for use in many different fields including aquaculture in the future.

In addition to the positive effects of ulvan on growth performance and health, which are the two main priorities of aquaculture, its safety for the environment and human health offers important opportunities. These combined health benefits allow ulvan as a marine biomaterial to be used as a potential feed additive in the aquaculture industry.

On the other hand, several processes such as extraction and physicochemical characterization are required to obtain ulvan as raw material.

Ulvan, a polysaccharide mainly obtained from green marine macroalgae belonging to the genus Ulva, is a natural fiber that can be used as a food component and has numerous benefits as shown in various studies.

It has been proven in both in vitro and in vivo studies that Ulvan has antioxidant, anti-inflammatory, antibacterial, anticancer, antiviral and cytotoxic pharmacological activities.

It has been determined that the solubility, structural properties, quantity and quality of ulvan are affected by extraction and isolation methods. Although it is suggested that 80–90 °C, pH 2–4.5 and 1–3 hours time conditions are required to obtain high productivity, selectivity and low distruption in general, studies should be conducted to determine the optimal extraction of ulvan to be used in aquaculture.

Ulvan has demonstrated many biological activities such as antioxidant, antimicrobial, anti-inflammatory and immunomodulatory activity as well as many other properties.

The mechanism of action of ulvan for biological activities and health benefits should be investigated in future.

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NEW TREND IN FISH DISEASES: QUORUM SENSING, MOLECULES OBSTRUCTION, QUORUM QUENCHING, INTERBACTERIAL COMMUNICATION MESSAGING DESTROY IN BACTERIA WORLD

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1. INTRODUCTION

Proven that bacteria communicate with social behavior through signal molecules, monitor whether reach certain majority and trigger critical gene expressions such as virulence as soon as they reach sufficient majority. Thus, it cannot stimulate host's immune system prematurely, creating successful disease process. Demonstration that bacteria communicate with each other has changed the way we think about world created by bacteria. It can measure density of bacteria through signal molecules that bacteria use in communication, so it can sense number of other bacteria in environment. This interbacterial communication is Quorum Sensing System (QS) (Henke and Bassler, 2004). Bacteria produce series of virulence that contribute to pathogenicity to infect host and cause disease (Bruhn et al., 2005). Virulence is under control of QS in Gram negative (Gram^{-}) bacteria (Jones et al., 1993). Gram-positive (Gram^{+}) and Gram^{-} bacteria are known to communicate with each other by producing small, diffusible *N*-acyl homoserine lactones (*N*-AHLs: AHL) derivative signaling molecules to coordinate virulence. Since QS is used regulate virulence, strategies developed to disrupt this signaling system will likely have many potential applications. Currently, biotechnological researches focused on development of AHL antagonists. The use of such molecules in world of treatment is considered as new treatment approach that will allow reduction of virulence by blocking intercellular communication and thus control of infections.

Claimed that *Streptococcus pneumoniae* acts in coordinated manner using signals. So, described that *Vibrio fischeri* performs coordinated bioluminescence through molecules. Elaborative research carried out related to QS in *V. fischeri* and *Vibrio harveyi*. Bioluminescence bacteria *V. fischeri* was grown liquid cultures in sea, and it was observed that light generation in these cultures occurred only at concentrations where number of bacteria in environment was too high (Greenberg, 1997). This study revealed the main model of QS mechanism in *V. fischeri*, which example model for other QS systems today. In addition, AHLs was found in this study. Subsequently, enzyme, signal receptor and *lux* gene required for signal production were isolated from a single DNA fragment in 1983. In 1990s, homologues of *lux* gene, signal receptor and AHL molecules were discovered (Greenberg, 1997). In 1990s, group of researchers worked on detection of missing genes in *Erwinia carotovora* mutants who could not produce carbapenem antibiotics, and found that could produce this antibiotic into nutrient agar with second group of mutants, while could not produce antibiotics from mutant groups they were working on. Realised that mutants in second group synthesized signal molecule that triggered synthesis of antibiotics in the first group. Interestingly signal molecule seen in mutant bacteria is same as signal molecule used to trigger light generation in *V. fischeri* (Greenberg, 1997). So this state is different aspect of QS. Next researches revealed that *Pseudomonas aeruginosa* also uses QS (Rather et al., 2022). However *P. aeruginosa* was responsible for virulence, not bioluminescence. In research, it was also revealed to production important virulence occur and AHL. With increasing studies on this topic, QS systems initially to be defined one by one in different bacteria. QS responsible for synthesis virulence (e.g. rhamnolipid) and that this system is responsible for production of AHLs has been shown. Fact that virulence that cause disease in bacterial diseases are controlled by QS, researches have focused on inhibition of this system. For this purpose, abundantly plants and synthetic molecules are screened for system inhibition (Pellissier et al., 2021).

This review purposes at describing how bacterial dictionary translates languages AHLs signaling molecule, Autoinducer Peptides (AIP), Autoinducer-2 (AI-2) used by cell to cell communicate; signals of QS which induce various phenotypes (e.g., virulence), cross-talk between species, stopped of QS system and this system stopping strategies have been discussioned.

2. QUORUM SENSING (QS)

Erwin F. Smith said in 1905 that large number of bacteria are stronger than few bacteria, but these few bacteria can overcome obstacles altogether. Years after these words, studies have shown that single-celled bacteria can communicate with each other and respond to changing environment. Proved that bacteria are not a-social, living alone and dying alone isolated alive, but in cohort using complex interbacterial communication systems to survive. Social lifestyle, bacteria communicate with each other through signal molecules, monitor whether reach certain majority and trigger critical gene expressions such as synthesis of virulence when they reach sufficient majoritym(Chu et al., 2014). Due to system all strains coordinate bacterial behavior. Bioluminescence, biofilm (Filik, 2019), conjugation, leaving lag phase and virulence are under management of system (Bruhn et al., 2005).

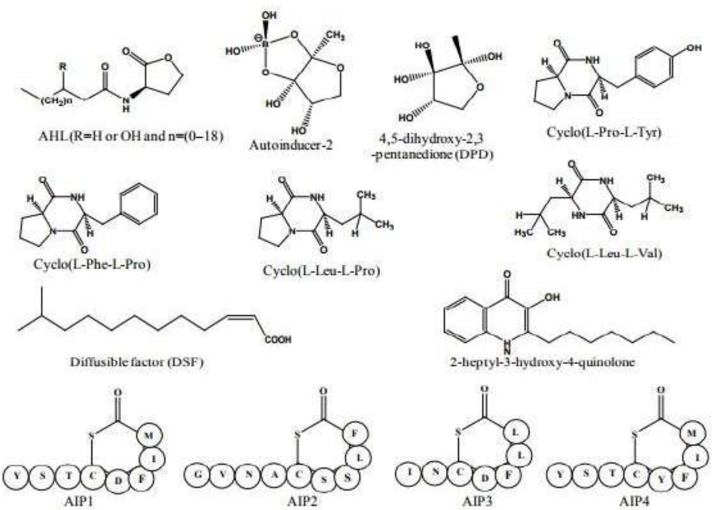

Figure 1. QS molecules: AHL, A-2 and AIP (Lade et al., 2014)

QS molecule accumulates extracellularly and is perceived by specific receptors. Accumulation of molecule elicits planned response when it reaches critical threshold. The cellular response induced by molecule is much broader than the metabolism or detoxification of molecule. While metabolites show first three of these four properties, fourth property is property that molecule must bear (Winzer et al., 2002). Molecules of communication shown in Figure 1. (Raffa et al., 2005).

2.1. CATEGORY OF CELL-TO-CELL COMMUNICATION

2.1.1. LuxI/LuxR type QS communication: AHLs

Gram^{-} use AHL type QS communication. Genes responsible for bioluminescence have been characterized and shown to be controlled by genes (*luxR, luxI, luxC, luxD, luxA, luxB*, and *luxE*) organized in two operons. *luxA* and *luxB* genes encode luciferase. *Lux C*, *D* and *E* genes are involved in synthesis and recovery of aldehyde substrates required in luciferase enzyme synthesis. *LuxI* is gene required in AHL synthesis, while luxR encodes regulator that controls AHL transcription. Providing AHL to LuxI mutants corrects lost function, but AHL cannot be synthesized. On other hand, providing AHL to *luxR* mutants does not improve function and no measurable AHL synthesis can occur. Combination of LuxR protein and AHL causes change in three-dimensional structure of LuxR, its ability to bind to DNA, and production of luciferase by enabling activation of *lux* operon (*luxCDABE*) and transcription of *luxI* gene (Kanojiya et al., 2022).

2.1.2. Autoinducer 2 type QS communication: AI-2

AI-2, which is produced by many Gram$^-$ and Gram$^+$ encoded by *luxS* gene, was first cultured in *Vibrio harveyi* shown in supernatants. *V. harveyi* uses AI-2 molecule for QS purposes in addition to two different QS systems based on AHL. Both AHL and AI-2 systems control bioluminescence genes. They observed that AI-2 has structure of 3(2H)-furanone and is very similar to 4-hydroxy-5-methyl-3(2H)-furnone, but it is not a degradation product (Winzer et al., 2002). While AHL signal produced by LuxM protein is received by LuxN protein, AI-2 signal is transmitted to *LuxQ* protein by binding to *LuxP*, LuxR homologue of LuxS encoded by l*uxS* gene. *LuxN* and *LuxQ* proteins, which are membrane-bound histidine kinases, transmit signal into cell via multi-step phosphorylations (Milton et al., 2001). Signaling pathways carried by *LuxN* and *LuxQ* proteins converge in LuxO protein. LuxO is low cell density phosphorylated state and activates the transcription of a repressor protein that blocks transcription of luxCDABE genes. In high cell density, LuxN and LuxQ dephosphorylate LuxO, and in this case, repressor protein will not be synthesized, so transcription activator LuxR stimulates *luxCDABE* gene expression. *Salmonella typhimurium*, do not transmit AI-2 signal through membrane-bound sensor kinases. Instead, AI-2, which is secreted extracellularly via an ABC transporter (Lsr) controlled by LuxS induced by the lsr operon, takes itself into the cell and transcriptional changes occur in cell (Raffa et al., 2005).

2.1.3. Autoinducer peptides type QS communication: AIP

QS molecules, specifically produced by Gram$^+$ referred to as "autoinducer" peptides (AIP), are produced from large peptides that undergo post-translational modification. Unlike Gram$^-$, AIP is actively secreted by ATP-binding cassette (ABC transporter) system, which is usually found in cell membrane, not by diffusion from inside cell to the outside. Extracellular QS molecules either bind to membrane-bound sensor kinases and cause transcriptional changes in cell through phosphorylation of regulators that control the expression of one or more genes in the cell, or, as in some bacteria, directly enter the cell via oligopeptide permeases and enter intracellular receptors (Raffa et al., 2005). *Staphylococcus aureus* virulence genes, competence (DNA uptake) genes of *Bacillus subtilis* and *Streptococcus pneumoniae*, sporulation in *B.* subtilis, conjugative plasmid transfer in *Enterococcus faecalis*, bacteriocin production in lactic acid bacteria, triggered biofilm in *S. aureus* are controlled by QS molecules. Also biofilms produced bacteria are more sensitive antibiotics in QSI presence (Rasmussen et al., 2005).

3. COMMUNICATION EXAMPLES IN BACTERIAL FISH PATHOGENES

An effective example of QS is that each bacteria *Escherichia coli* can move with other bacteria and construct network of proteins and genes by acting as adjusted molecular clock (Fussenegger, 2010). QS have been studied in fish pathogens *Aeromonas hydrophila* (Swift et al., 1997) and *V. harveyi* (Henke and Bassler, 2004). QS signal molecules have been determined in *Aeromonas salmonicida*, *A. hydrophila*, *Yersinia ruckeri*, *Vibro salmonicida* and *Vibrio vulnificus* (Bruhn et al. 2005). Using *Vibrio anguillarum* hybrid system (Henke and Bassler, 2004). Model studies of QS at high cell population density have also been conducted to determine difference between species in QS studies. It has been observed that *Psedudomonas fluorescens* does not belong to either LuxI or LuxM groups and uses AHL bacterial communication. *P. fluorescens* controls Mupirocin via AHL (Williams, 2007). AHL communicated with LuxRI homolog *AhyRI* in *A. hydrophila* and LuxRI homolog *AsaRI* in *A. salmonicida*. Investigated by crosstalk with mutant *Chromobacterium violaceum* CV026, determined that *Y. ruckeri* had QS. *Y. ruckeri* generates virulence control with QS. *Y. ruckeri*'s QS was cloned from gene library constructed as plasmid carrier and named *yruR*/*yruI* (Temprano et al., 2001).

A. hydrophila, *Y. ruckeri*, *P. fluorescens*, *V. anguillarum* and *V. alginolyticus* bacteria are uses QS. *P. fluorescens*, *V. anguillarum* and *V. alginolyticus* communicated via OdDHL signal molecule while *A. hydrophila* and *Y. ruckeri* via both BHL and OdDHL signal molecules (Nurcan, 2010).

4. QQ MECHANISMS

QQ is control of bacterial communities by disrupting signalling system between bacteria (Odularu et al., 2022). QQ and QS systems are diametrically opposed to each other. QS, which is responsible for virulence that cause bacteria to cause disease in host, has been emphasized among alternative combat options with bacteria (Hentzer and Givskov, 2003).

4.1. Inhibition of synthesis of AHL signal molecule

Majority of bacteria producing AHL signal molecules contain one or more genes, *luxI* homolog in *V. fischeri*. Chain part of AHL is synthesized by S-adenosyl methionine (SAM) and ACP (acyl carrier protein) enables AHL signal molecule to be oriented in accordance with acyl side chain (ASC). Various analogues of SAM such as S-adenosyl homocysteine, sinefungin, S-adenosyl cysteine have been shown to be potential inhibitor candidates on AHL molecule catalyzed by RhlR protein in *P. aeruginosa* (Hentzer and Givskov, 2003). Although SAM synthesis of AHL is specific chemical reaction, SAM play active role in biochemical reactions. For this reason, it has increased hope that SAM analogs will be used as AHL synthesis inhibitor candidates in QS, without affecting eukaryotic enzymes that use SAM as substrate (Tateda et al., 2001).

4.2. Breakdown of AHL signal molecule

Communication between bacteria can also be prevented by reducing active signal molecules in environment. In studies conducted in direction, it has been reported that some bacterial species inhibit AHL. *Bacillus* species catalyzes hydrolysis of AHL signals via enzyme called AiiA. Expression of *aiiA* gene has been found to reduce AHL signals in *Erwinia carotovora* alleviate symptoms of soft rot disease in all plants tested. Moreover, transgenic plants expressing AiiA have been shown susceptible to diseases caused by *E. carotovara* (Dong et al., 2005). In nature, plants and fungi control amount of bacterial population live together symbiotically by disrupting AHL signal communication produced by bacteria. Halogenated furanones, natural substances produced by red seaweed called *Delisea pulchra*, prevent these algae from being colonized by bacteria. It has been shown that these furanones can inhibit virulence in QS management via AHL in bacteria. Main actions mechanism of molecules has been increase degradation of *LuxR* protein. Furanone derivatives show toxic effects. So, reseraches are continuing to obtain new non-toxic derivatives based on basic mechanism action (Manefield et al., 1999).

4.3. Prevention of receiving AHL signal molecule

Another approach focused on stopping QS prevent signal from being detected by bacteria. Inhibition of uptake of AHL achieved by antagonist molecules capable of competing with native AHL signaling molecule for binding to receptor protein. Molecules that compete with AHL are structurally similar to AHL and act like AHL binding site, preventing receptor from being activated. Focus on synthesis of AHL analogue inhibitors are carried out by modification of ASC in different ways. ASC can be modified in different ways, and studies have shown that length of side chain plays an important role in realization of activity. Receptor of AHL is LuxR protein located in cytoplasmic or cytoplasmic surface of membrane, andreceptor for AIP signal is membrane-bound histidine kinases. AI-2 molecule either interacts with LuxR homologue *LuxP*, similar to AHL, or acts by entering cell with Lsr transporter molecule. Based on this point, it has been determined that one of the compounds produced by *D. pulchara* binds to LuxR protein and causes the separation of AHL and thus disrupts mist-style reproduction of *S. liquefaciens* (Raffa et al., 2005; Hentzer and Givskov 2003). Identified molecules with QSI effect by scanning large number of molecules randomly, and most effective of these, 4-nitro-pyridine-N-oxide (4-NPO), expression of genes regulated by QS in *P. aeruginosa* (Rasmussen et al., 2005).

5. QS INHIBITORS

Plants and fungi were screened to determine natural compounds that would have same effect, it was determined that 50 *Penicillium* species were secondary metabolites with QSI activity. Penicillic acid provided decrease at patulin and AHL genes expression controlling by QS in *P. aeruginosa*. In addition, determined that colored many plants have QSI properties (Ramussen et al., 2005a). Vanilla extracts capable of QS inhibiting in *C. violaceum* (Choo et al., 2006). Due to, have been argue that consumption of foods containing vanilla may be beneficial. Gallic acid exerts antibacterial effect on *A. hydrophila* (Lu et al., 2016).

6. QS MIMICS

Recently studies, molecules similar to AHL detected in some plants and algae in Gram$^-$. Abundant researches on this subject have been conduct on halogenated furanones produced by a red sea algae *D. pulchra*. *Delisea* furanones have a similar chemical structure with AHL in Gram$^-$. Furanones specifically inhibit AHL-regulated behavior in variety of bacteria. QS mimics in Delisea function by binding to AHL receptor proteins in bacteria. Thus, provide proteolytic degradation of these receptors. Furanone AHL mimics affect biofilm and virulence in *P. aeruginosa*. Also, molecules change structure of natural bacterial community that develops on algal surface around sea (McDougald et al., 2007).

7. QQ ENZYMES

AHL-Lactonase Enzyme: AHL is member of metallo-β-lactamase superfamily. Found that enzymes in this family have many functions. It has functions such as breaking down bonds such as nitrite oxidase, oxygen reductase, C-O, C-N, C-S, S-O, P-O. QS in Gram$^-$ bacteria consists of two components. Luxl protein that forms AHL synthase and LuxR proteins that function as AHL receptor and transcriptional regulator. Structural characteristics of *luxR* and *luxI* proteins were analyzed. Recently obtained from a *Bacillus* species, AHL lactonase enzyme hydrolyzes the ester bonds in AHLs. This can only be inhibited

QS in Gram$^-$. AHLs show similar structural features with hormones (Dong and Zhang, 2005).

AHL-Acylase Enzyme: Various bacterial species including *Variovorax paradoxus*, *P. aeruginosa* and *Streptomyces* spp. Have been found to have AHL-acylase enzyme. This enzyme performs the degradation of AHL molecules by hydrolysis of amide bond in AHL, production of fatty acids and homoserine in response to lactone (Ramussen et al., 2005).

Paraoxonase Enzyme: Paraoxonase (PON) is ester hydrolase with both arylesterase and paraoxonase activity. PONs (PON1, PON2 and PON3) have important activities (e.g. drug metabolism). QQ enzyme activity was recently described by three laboratories working independently of each other. Purified PON2 is capable of cleaving variety of tested AHL. PON1, PON2 and PON3 expressed found to have AHL degradation activity rapidly. It has also been found that *P. aeruginosa* has hydrolytic activity of purified PON1 in serum against signaling molecule. PON enzymes are effectively break down AHL molecules (Fetzner, 2015).

8. QQ SPECIFIC MOLECULES

Synthetic compounds revealed that C-30 and C-56 act as QSI. GABA effect also controls QS signal molecule level in *Agrobacterium tumefaciens*. Another approach has been diketopiperazines. Diketopiperazines are cyclic dipeptide family compound isolated from supernants in bacterial cultures containing *P. aeruginosa*, *Citrobacter freundii* and *Enterobacter agglomerans*. Diketopiperazines change QS-dependent phenotypes by acting as AHL antagonists in bacteria that communicate with luxR-dependent QS (Kozlowicz et al., 2006). Another approach has been haptens. Recently, idea of using antibody catalysis has gained importance. Within framework of this approach, aimed to catalyze AHL hydrolysis by using small molecules such as haptens and thus prevent QS. Small molecule haptens resembling transition state in reaction must be capable of reacting with antibodies that function as catalysts in reaction (Kapadnis et al., 2009). Researches were initiated with design of suitable transition analogue that hydrolyzes lactone ring in AHL molecule. L-Canavanine effect is another specific molecule in QQ. L-Canavanine is an arginine analogue mostly found in seeds of legitimate plants. This molecule also acts as QSI (Kozlowicz et al., 2006). Pigment is phenotypic property regulated by QS. L-Canavanine inhibits violacein production of *C. violaceum* CV026 in presence of synthetic AHLs. L-Canavanine was isolated from *M. sativa* seeds and effect of its bacterial symbiont, *Sinorhizobium meliloti*, on QS was investigated. There are *Sin* and *Tra* systems in *S. meliloti* strains. *Sin* QS provides regulation of more than 200 genes. Reserches have shown that L-Canavanine inhibits EPS II expression (Rosier and Bais, (2022).

9. QSI AS TREATMENT

Antibiotics, which have therapeutic efficacy in killing or inhibiting bacterial proliferation, can also serve as signal molecules that can reduce expression of virulence (Hemmati, et al., 2020). Some studies have shown that several antibiotics can inhibit virulence in *P. aeruginosa*. The response of *P. aeruginosa* to azithromycin antibiotic was analyzed using microarray method. In addition, phenotype research has shown a link between QS and genes regulated by azithromycin. Several studies have demonstrated that azithromycin has significant anti-QS activity and that azithromycin subinhibitory concentrations (SICs) are able to block many of the regulated genes (LaSarre and Federle 2013). SICs of Tobramycin can block expression of *rhlI* and *rhlR* genes by reducing C4-HSL formation. Previous studies have also confirmed effect of tobramycin as signaling molecule on expression of virulence genes in transcriptional step. Several antibiotics for their ability to interfere with QS. Among antibiotics used, azithromycin showed high levels of QSI activity, followed by ciprofloxacin and ceftazidime, which have strong QSI activities. Piperacillin, spectinomycin, and streptomycin had low or no QSI activity. Also, non-steroidal anti-inflammatory drugs (NSAIDs) such as aspirin, piroxicam, and meloxicam are chemical compounds that can be used as potential inhibitors to control *P. aeruginosa* QS. NSAID drugs can reduce AHL-mediated QS system in *P. aeruginosa* such as *Las*, *Rhl*, and *Pqs*. (De Almeida et al., 2018). In general, some antibiotics and drugs have QSI potentials that can reduce AHL synthesis levels in *P. aeruginosa* (Hemmati et al., 2020).

10. QQ IN BACTERIAL FISH PATHOGENES

Abundant fish pathogens have now acquired Multi Drug Resistance (MDR) (Algammal et al., 2022). For example, Zhu et al. (2020) reported that MDR septicemia caused by *A. hydrophila* has increased exponentially in last decade and has reached alarming rate. Antibiotic resistance and multidrug resistance Hossain et al. (2019), and Sarkodie et al. (2019) and it was emphasized that results were alarming. Recent studies have shown that system inhibition is new and promising option in combating infectious diseases, and QSI researches have gained momentum in last decade. There are many studies that prevent bacteria and investigate its effect on bacteria within scope of QQ in bacterial fish pathogens and are shown in Table 1.

Table 1. Interbacterial communication messaging destroy in bacteria world

Bacteria (Strain)	Blocker	Impact	References
($Gram^{-}$) bacteria	with γ-Valerolactone, 2-Pyrrolidinone, and L-(+)-Prolinol; penicillin	Antagonistic effects and rate of resistance in *E. coli* against the individual antibiotics was reduced	Wang et al., 2016
($Gram^{+}$) bacteria	with γ-Valerolactone, 2-Pyrrolidinone, and L-(+)-Prolinol; penicillin	Antagonistic effects	Wang et al., 2016
A. salmonicida	*N*-(heptylsulfanylacetyl) - L homoserine lactone (HepS-AHL)	10-fold reduction of protease	Rasch et al., 2007
A. hydrophila, *Flavobacterim psychrophilum*, *V. anguillarum*	*Pseudomonas* spp. and *Raoultella planticola*	QS blocking and decrease growth pathogens	Fuente et al., 2015
A. hydrophila	*Bacillus* spp. QSI-1 Vanillin Rosmarinic acid, Vanillic acid, and Gallic acid	Decrease of AHLs, hemolysis and pathogenicity Decrease of AHLs, protease, biofilm Decrease AHL of *A. hydrophila* Virulence control and reduction	Chu et al., 2014 Ponnusamy et al., 2009 Filik, 2020
Edwardsiella tarda	*Tenacibaculum* spp. 20J	Demonstrate a broad spectrum QQ activity Eliminating of AHLs	Romero et al., 2014
Staphylococcus aureus	Gallic asit	Biofilm control and reduction	Borges et al., 2012
Vibrio anguillarum	Furanon C-30	Significant reduction in mortality	Rasch et al., 2004
V. harveyi	An adenosine derivative with P-methoxyphenylpropionamide moiety	Blocking AI-2 based QS Interfering with the signal transmission path	Brackman et al., 2009

11. DISCUSSION AND CONCLUSION

Hundreds of fish pathogens are included in fish diseases doctrine. Consumption of fish as food, fishery activities, zoonosis, fish farming, etc. It is also included in public health doctrine as epizootiologically because this creature source of contamination and source of contamination. From this point of view, prevention of pathogenesis is vital importance for all living things in the World (Filik and Filik, 2022). Antibiotics in bacterial diseases becomes increasingly difficult due to resistance of bacteria as a result of mutations that it develops day by day, and it makes it necessary to develop new strategies in battle against bacteria. Understanding that virulence, which are effective in emergence of disease in pathogenic bacteria, occur with control of discovered QS, has led to intensification of studies on inhibition of this system in battle against pathogenic bacteria. Because bacteria know many antibiotics and develop resistance with different mechanism every day, it is thought new and effective strategy in combating bacterial diseases by suppressing their ability to cause disease instead of killing bacteria. Similarities between signals used by bacteria and artificial neural networks are striking. Based on the finding that bacteria contain many of characteristics of neural network, there may be low level intelligence structure for bacteria (Hellingwerf, 2005). Researchers put bacteria into contact with each other with program loaded on their DNA, and stated that billions of bacteria collectively performed same command. Scientists state that billions of bacteria that can communicate with each other can be managed and directed to certain tasks at same time. They point out that smart biological devices will also be reflected in daily life in future. Cessation of communication between these clever bacteria will largely eliminate their negative effects on fish. QS is complex in attack of bacterial pathogenicity, signal molecules produced by bacterial pathogens are biological markers for follow-up and diagnosis of bacterial infections (Kumari et al., 2008). molecules Detection may be useful at early stage, as a tool for detecting diseases. Nearly only power of microscopic size bacteria its genes. Since system governing expression of QS genes, increasing studies in this field should be investigated in detail, reducing infec-tion power in bacterial world, and can be suggested as alternative method of disease prevention in aquaculture. While resistance of bacteria to antibiotics increases and our strength against bacteria decreases, it is attractive target to prevent communication system between bacteria. Targeting pathogenesis rather than kil-ling bacteria great hope for infectious diseases treatment. QQ has become striking alternative to solve problem of bacterial antibiotic resistance because bacteria control virulence with AHL-mediated QS (Romero et al., 2014).

Surprisingly enough, from large amount of literature that describes identification of QQ activity in organisms and tissue extracts, only a few QQ actors have been finely characterized at molecular level. Only few were also experimentally evaluated with respect to their biological role in organism where they came from, mechanisms of action supporting QQ activity or use as antibacterial treatments under realistic conditions. In line with last point, since their discovery in 1930s, antibiotics have been massively used and proved to be extremely efficient to fight infections. Negative side of, quite likely that QQ components (enzymes, QSIs, antibodies) will not be as efficient under ‘real life’ conditions as antibiotics were and are. On the upside, literature strongly suggests that resistance to QS inhibition may appear, but probably at much lower level than what has been seen for conventional antibiotics, essentially because QQ generated selective pressure only under conditions where QS is essential, whereas antibiotics generate vstrong selective pressure under all environmental (Defoirdt et al., 2004). Multitherapies appear as promising approaches against pathogens for limiting virulence and resistance emergence (Grandclément et al., 2016).

Scientists are beginning to understand complex production and composition processes of biofilms controlled by QS. When patent query on treatment approaches is made on https://patents.google.com/as "quorum sensing inhibitor", it is seen that 1134 patents are included in this subject. However, with respect to QQ strategies, number of problems remain unsolved, such as targeting and delivery of enzymes or molecules, evaluation of cytotoxicity and more globally adverse effect of QQ enzymes and QSIs at population, organism, cellular and subcellular levels. These points, along with above interrogations on possible developement of resistances, are certainly interesting trails for future research on QQ.

QS that adds strength to bacteria, also very effective in pathogenicity. Therefore, it is important to focus on strategies for preventing, cleaving or inhibition of production of QS molecules, inhibition of QS signal acquisition. In this sense, interruption of communication, which is one of disease forces in bacterial world, can be suggested as alternative method of disease prevention. Efforts to obtain antibacterial effects by preventing communication between bacterial cells are seen as promising area for future. In addition, QS molecules early detecting, while there's still chance id est not sick, and stopping brings up concept of early diagnosis in disease and in this case, prophylaxis is aimed to break new ground.

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EFFECTS OF DIFFERENT ORGANIC MATERIAL (ROSE PULP AND SEAWEED) AND NITROGEN APPLICATIONS ON THE FRESH EAR WEIGHT AND KERNEL QUALITY OF SWEET CORN

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Introduction

Sweet corn is a crop of new world origin (Welbaum, 2015) and cultivated plant. Sweet corn (*Zea mays* L var. *saccharata* Strut) is one of several types of maize, which also includes flint corn, dent corn, popcorn, flour corn, and pod-corn but sweet corn differs from other corns. The primary difference is gene expression that determines endosperm carbohydrate content as well as many other genes that affect maize growth (Adamec et al., 2020). Sweet corn was probably originated from a mutation of an ancient Peruvian corn called 'Chuspillo' or 'Chullpi'. There are different varieties of sweet corn that is yellow, white, or bicolored types, with varying maturity dates from early to mid- to late-season. Different varieties have increased sugar content (a sugar enhancer gene, se), super sweet (contain the shrunken sh-2 gene), 'Synergistic' sweet corns (Walker, 2020).

The sweet corn is use in human nutrition that it has contents of minerals phosphorus, magnesium, iron, zinc, vitamins and antioxidants (Keerthi et al., 2017) and industrial products as raw or processed material for canned food. The Sweet corn is favorable for fresh consumption because of its delicious taste, soft, sugary texture. On the other hand, sweet corn is very suitable for crop rotations and early harvested plants can also be used as a green forage crop.

The leader producer country of sweet corn is the USA, other important producers are Nigeria, Mexico, Indonesia etc. (Anonymous, 2020). Although sweet corn has been in the high potential of consumption and production in Turkey, there could not be determined statistical records about the cultivation area and production amount of sweet corn in Turkey. But, cultivated area of sweet corn is estimated by 1-2% of the total corn cultivation area in Turkey (Arslan and Williams, 2015; Stanslous et al., 2020). New high yielding sweet corn varieties may play an important role in the increasing of the production area.

Sweet corn is a real source of food for the human diet. It was observed with higher caloric content and high nutritional value compared to regular corn. Sweet corn contains 10 g oil, 221 g carbohydrates, 3.35 g protein, 1.11 g phosphor, 2.8 g potassium per kg (Cetinkol, 1989). It was reported that sweet corn contained 5–6% sugar, 10–11% starch, 3% water-soluble polysaccharides, and 70% water at optimal market maturity (Walker, 2020).

Conventional farming methods recent years is not acceptable to use the resource management and relying too much on synthetic inputs such as fertilizers and the ecosystem of unstable farming (Malakouti and Homaee, 2005; Roberts, 2008). Bio-fertilizers are microorganisms helping plants to grow by increasing the quantity of nutrients. They are also living microorganisms and increase the supply of important nutrients for productivity of the soil (Namasivayam et al.,

2014) and soil biological activity (Muhammad et al., 2006). The synthetic fertilizers are harmful for soil, because the inorganic fertilizers mainly contain major nutrients NPK in large quantities and they are the reasons of soil health deterioration (Choudhry, 2005).

The most important producers of rose oil in the world are Turkey and Bulgaria. According to data from the 2019, planting area is 38.234 da in Turkey and 16.6 thousand tons of oil roses are produced. Out of this 85.12% of the production is in Isparta (Anonymous, 2019) and about 30 thousand tons of rose pulp are produced annually (Baydar et al., 2020). It has been reported that rose pulp contains an average of 84.2% organic matter, 3.7% nitrogen, 1.99 mg g^{-1} phosphorus, 24 mg g^{-1} potassium and 5 mg g^{-1} (Tosun et al., 2003). It has been suggested that rose pulp is fairly qualified and an economical source of organic fertilizers, the amounts of heavy metals such as Sn, Ni and Pb are below the upper limit values and rose pulp is not a risk to human health and environmental when used as an organic fertilizer (Baydar et al., 2020).

Seaweeds are a known source of plant growth regulators and the use of seaweed extracts as natural regulators have increased crop yield and plant vigor (Rathore et al., 2009). It has been suggested that the use of seaweed extracts for agricultural purposes increases germination, root development, resistance to unsuitable soil conditions and stimulates the uptake of nutrients in the soil (Berlyn and Russo, 1990; Blunden et al., 1991; Hong et al., 1995). *Ascophyllum nodusum* (L.) most widely used in agriculture is seaweed. In addition, *Fucus* spp*.*, *Laminaria* spp., *Sargassum* spp. *and Turbinarina* spp. are also used as natural fertilizers such as *Ascophyllum nodusum* (L.) (Hong et al., 2007).

In this study, it was aimed to reduce the use of chemical fertilizers and to increase the use of organic material and recycling agricultural wastes to production. Therefore, In the current stud the effect of different doses of nitrogen, seaweed and rose pulp on the cob yield and quality in sweet corn was evaluated.

Materials and Methods

The experiments were carried out in 2015 and 2016 growing seasons in Isparta ecological conditions (37° 45' N latitude, 30° 33' E longitude and 1050 m altitude). Monthly climatic data of the research area is shown in Table 1. The long-term mean temperature, total precipitation and mean relative humidity are 18.6 °C, 164.1 mm, and 52.3 % respectively. The vegetative periods (from April to August) in 2015 and 2016 had mean temperatures of 18.0 and 19.8°C, total precipitation of 232.2 and 219.2 mm and mean humidity of 58.3 and 52.2%, respectively. Meteorological data of sweet corn growing seasons were nearly similar compared to long term meteorological data. Especially 2016 was hotter.

Table 1. Some climate data for the growing seasons and long-term (1950-2014) in Isparta*

Years/ Months	Mean temperature (ºC)			Total precipitation (mm)			Relative humidity (%)		
	Long-term	2015	2016	Long-term	2015	2016	Long-term	2015	2016
April	10.8	8.7	13.8	53.1	26.1	47.8	61.3	60.7	52.1
May	15.5	16.1	14.5	54.3	67.5	87.6	57.4	59.8	64.4
June	20.1	17.8	21.6	31.5	92.2	12.7	51.2	67.7	47.7
July	23.5	23.7	24.8	14.5	3.0	25.7	45.4	48.3	44.9
August	23.2	23.5	24.5	10.7	43.4	45.4	46.4	54.8	51.8
Mean/Total	**18.6**	**18.0**	**19.8**	**164.1**	**232.2**	**219.2**	**52.3**	**58.3**	**52.2**

*: Turkish State Meteorological Service

Treatment application and plotting

The research was set up with 3 replications according to complete randomized block design and 9 different applications were established to compare the effects of conventional cultivation (nitrogen fertilizer) and organic materials [rose pulp (*Rosa damascene* Mill.) and seaweed (*Ascophyllum nodosum*) applications] on quality of grain and ear yield of sweet corn. Thus, there were 9 treatment combinations (Table 2) with 18 experimental units. The seeds of Vega F1 sweet corn cultivar were supplied by the Turkish seed company, May Agro Seed Corporation. The research was conducted on the same field for 2 years. There were 4 rows of 4 m in each plot (70 cm between rows and 20 cm distances within rows was maintained). The sowing was done in the first week of May. All of the 100 kg ha^{-1} P_2O_5 and half of the nitrogen fertilizer were applied with sowing and the remaining part of N was given when the plants reached 30-40 cm plant height (Turgut and Balcı, 2002). Rose pulp that had been kept for one year was used in the research was mixed into the soil by using the anchor motor. After the emergence of plants, plots were irrigated equally by the dripping irrigation system. Irrigation water was applied as required to prevent the occurrence of moisture stress in the crop.

Table 2. Applications in research

No	Applications	Amount / method of application
1	**Control**	With sowing 100 kg ha^{-1} P_2O_5
2	**Seaweed application**	With sowing 100 kg ha^{-1} P_2O_5 + 5 kg ha^{-1} solid seaweed application to soil
3	**Seaweed enriched with nitrogen application**	With sowing 100 kg ha^{-1} P_2O_5 + 5 kg ha^{-1} seaweed as solid in soil + 50 kg ha^{-1} N (with sowing 25 kg ha^{-1}, the other half gave when plants reach a plant height of about 30-40 cm).
4	**Solid and liquid seaweed applications**	With sowing 100 kg ha^{-1} P_2O_5 + 5 kg ha^{-1} seaweed as solid in soil + 5 kg ha^{-1} seaweed as liquid in leaf fertilizer (Liquid leaf fertilizer applied with knapsack sprayer when plants reach a plant height of about 30-40 cm).
5	**Rose pulp application pre-sowing**	With sowing 100 kg ha^{-1} P_2O_5+ 40 ton ha^{-1} Rose pulp before 40 days

6	**Rose pulp application with sowing**	With sowing 100 kg ha^{-1} P_2O_5 + 40 ton ha^{-1} Rose pulp with sowing
7	**Rose pulp enriched with nitrogen application**	With sowing 100 kg ha^{-1} P_2O_5 + 40 ton ha^{-1} Rose pulp with sowing + 50 kg ha^{-1} N (with sowing 25 kg ha^{-1}, the other half gave when plants reach a plant height of about 30-40 cm)
8	**Application of 100 kg N ha^{-1}**	With sowing 100 kg ha^{-1} P_2O_5 + 100 kg ha^{-1} N application (50 kg ha^{-1}, the other half gave when plants reach a plant height of about 30-40 cm)
9	**Application of 200 kg N ha^{-1}**	With sowing 100 kg ha^{-1} P_2O_5 + 200 kg ha^{-1} N application (100 kg ha^{-1}, the other half gave when plants reach a plant height of about 30-40 cm)

Data collection

In the experiment, ears from two rows in the center of each plot were harvested manually at the milking stage when the tassels was dried. Observations were made on 15 to 20 ears selected randomly from plants in each plot to measure the ear characters (ear weight (g) husked and huskless, number and weight (g) of kernels on ear) and the chemical analysis (the dry matter (%), protein content (%) and total sugar content of kernels). The ears were divided into the categories for observations: ten ears for measuring the ear characters and remaining ears used for other analysis Fresh husked ears were packed in with plastic bag material and stored in the freezer (-20°C) until they were analyzed and then kernels were removed from sweet corn ear for chemical analysis.

Kernels were dried in an oven at 65 °C and the differences between the fresh and dry weights were used to calculate the dry matter content (Anonymous, 2010). The N content of kernels was determined using the Kjeldahl method (Kacar and Inal, 2010), and the result was multiplied by a factor of 6.25 to calculate the protein content. Total sugar content (%) was analyzed using standard method (Cemeroglu, 1992) and this procedure was done for fresh kernels. The experimental soil had a slightly alkaline (pH 7.9) with 29.48% $CaCO_3$, 72.0 kg ha^{-1} P, 1762.4 kg ha^{-1} K, 0.84% organic matter content, 0.014 dS m^{-1}, total salt content and a clay- loam texture.

Statistical analysis

Analysis of variance (ANOVA) was conducted using SAS Statistical Package Program (SAS, 1998) and the differences among treatments were compared using Duncan’s multiple range test and least significant difference (LSD) tests according to the complete randomized block design. Data was combined over the years and presented as a two-year mean values.

Results

Husked and huskless ear weight (g)

In the study, effect of applications on husked ear weight was found to be significant and husked ear weight was changed between 262.28 and 385.95 g according to applications. According to the two-year means, the highest value was obtained from 200 kg ha^{-1} N application, but difference between all of applications in which nitrogen was added was not found significant (200 kg ha^{-1} N, rose pulp enriched with nitrogen, seaweed enriched with nitrogen). There was no statistically significant difference between control application (262.28 g), seaweed application (292.77 g), solid and liquid seaweed with rose pulp application with sowing (Table 3).

Table 3. Mean values of sweet corn for the husked ear weight (g) and huskless ear weight (g) in different applications.

	Husked ear weight			Huskless ear weight		
Applications/ Years	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Control	291.95 ^{b*}	232.62 d*	**262.28 D***	189.21 e*	133.51 e*	**161.36 E***
Seaweed	294.87 ^{b}	290.67 c	**292.77 CD**	199.07 de	170.17 d	**184.62 DE**
Seaweed enriched with nitrogen	369.44 ^{a}	360.11 b	**364.77 A**	252.15 a	257.23 c	**254.69 BC**
Solid and liquid Seaweed	346.28 a	295.33 c	**320.81 C**	227.75 b-d	184.65 d	**206.20 D**
Rose pulp application pre-sowing	336.53 a	358.17 b	**347.35 B**	240.73 bc	243.73 c	**242.11 C**
Rose pulp application with sowing	310.36 a	343.75 b	**327.06 BC**	191.38 de	218.16 c	**204.77 D**
Rose pulp enriched with nitrogen	349.21 a	371.41 b	**360.31 A**	248.58 ab	262.87c	**255.72 BC**
100 kg ha^{-1} fertilizer with nitrogen	358.89 a	393.59 b	**376.24 A**	258.74 a	291.60 b	**275.17 AB**
200 kg ha^{-1} fertilizer with nitrogen	339.38 a	432.51 a	**385.95 A**	249.19 ab	329.50 a	**289.35 A**
Means	**332.99**	**342.02**		**228.53**	**232.38**	
CV (%)	**5.94**			**7.31**		

*Significant at P<0.01 levels; Means in the same columns followed by the same letter (s) are not significant

Although, effect of years in the study was statistically significant, year x application interaction was significant. Except for control (291.95 g) and seaweed (294.87 g) application, the others were statistically at the same group in the first year (2015). In the second year (2016), the highest value was obtained from 200 kg ha^{-1} application and it was found statistically different from other applications. Husked ear weight varied between 232.62 and 432.51 g in the second year.

The huskless ear yield is shown in Table 3. Applications and year x application interaction are statistically significant. In the study, weight of huskless ear varied between 189.21-258.74 g in the first year and 133.51-329.50 g in the second year. The lowest values in both years were obtained in the control application, the highest values varied by years. Likewise, there was no statistically significant difference between the applications in which nitrogenous fertilizers were added in the first year (Seaweed enriched with N, rose pulp enriched with N, 100 and 200 kg N ha^{-1}), the application of 200 kg ha^{-1} N, compared to the others, was found significantly different in the second year (Table 3). This situation caused year x application interaction to be found important.

When the two-year means are examined, the lowest huskless ear weight value was determined in the control application (161.36 g) and the highest value was determined in application of 200 kg N ha^{-1} (289.35 g). Also, there was no statistically significant difference with application of 200 kg N ha^{-1} with 100 kg N ha^{-1} (275.17 g). It was also determined that huskless ear weight was higher in additional nitrogen applications (Seaweed enriched with N and rose pulp enriched with N).

Weight and number of kernels in ear

Applications are statistically significant on kernels weight in ear of sweet corn. According to the two-year means, kernels weight in ear varied between 109.62 - 170.88 g. The lowest value was determined in the control application and the highest value was determined in the 100 kg ha^{-1} N application. Except for control, seaweed and rose pulp applications pre-sowing in terms of kernel weight in ear, the other applications were statistically at the same group with the application of 100 kg ha^{-1} N (Table 4) in the study. These data showed that the applications affected ear husks and corncob weight more than the kernels weight in the ear.

Applications and years are statistically significant and the means of kernels numbers in ear (Table 4). In the research, kernels number in ear varied between 501.84-692.18 in the first year and 467.0- 697.67 in the second year. As a general mean, in first year kernels number in ear (598.53) was found to be statistically significantly higher than second year. When the two-year mean data were examined, the lowest kernels number in ear was determined in the control (484.42), the highest value (694.92) was determined in the application of 200 kg N ha^{-1}. However, the difference between the value obtained from 200 kg N ha^{-1} application and 100 kg N ha^{-1} was not found to be statistically significant. Again, addition of nitrogenous fertilizers to organic material increased the kernels number in ear.

Table 4. Mean values of sweet corn for the kernel weight (g) and kernels number in ear in different applications.

Applications/ Years	Kernel weight in ear			Kernels number in ear		
	2015	2016	Means	2015	2016	Means
Control	115.47	103.76	**109.62 C***	501.84	467.00	**484.42 E***
Seaweed	135.02	108.21	**121.62 C**	545.73	530.33	**538.03 D**
Seaweed enriched with nitrogen	157.63	151.33	**154.48 AB**	608.01	594.67	**601.34 BC**
Solid and liquid Seaweed	151.82	154.57	**153.19 AB**	563.83	520.67	**542.25 D**
Rose pulp application pre-sowing	133.43	135.53	**134.48 BC**	590.53	573.33	**581.93 BC**
Rose pulp application with sowing	157.25	156.79	**157.02 AB**	591.60	563.00	**577.30 C**
Rose pulp enriched with nitrogen	163.62	164.72	**164.17 A**	609.08	611.30	**610.19 B**
100 kg ha^{-1} Fertilizer with nitrogen	168.47	173.29	**170.88 A**	687.00	691.00	**689.00 A**
200 kg ha^{-1} Fertilizer with nitrogen	170.27	170.10	**170.18 A**	692.18	697.67	**694.92 A**
Means	**150.33**	**146.48**		**598.87 A***	**583.22 B**	
CV (%)	**9.27**			**5.84**		

*Significant at P<0.01 levels; Means in the same columns followed by the same letter (s) are not significant

Dry matter and crude protein contents

In the study, a statistically significant difference was determined between applications in terms of dry matter content. According to two-year means, the dry matter content varied between 25.30-30.50% and the lowest value was found in the control group. There was no statistically significant difference in dry matter content when applying 100 kg N ha^{-1} and 200 kg N ha^{-1} nitrogen. It has been determined that when nitrogen is added to organic matter, the amount of dry matter is higher than other organic matter applications. The dry matter content in years of the experiment are similar (Table 5).

Table 5. Mean values of sweet corn for dry matter content (%) and crude protein content (%) in different applications.

Applications/Years	Dry matter content			Crude protein content		
	2015	2016	Means	2015	2016	Means
Control	25.38	25.21	**25.30 D***	10.30	9.27	**9.78 D***
Seaweed	25.67	25.36	**25.51 D**	11.40	11.90	**11.65 C**
Seaweed enriched with nitrogen	27.44	28.26	**27.85 C**	12.20	14.17	**13.18 AB**
Solid and liquid Seaweed	26.37	25.44	**25.91 D**	12.23	13.23	**12.73 BC**
Rose pulp application pre-sowing	25.00	25.68	**25.34 D**	12.53	12.53	**12.53 BC**
Rose pulp application with sowing	26.26	27.85	**27.06 C**	11.83	12.00	**11.92 BC**
Rose pulp enriched with nitrogen	28.37	29.94	**29.16 B**	13.17	13.20	**13.18 AB**
100 kg ha^{-1} Fertilizer with nitrogen	29.97	30.77	**30.37 A**	13.93	14.63	**14.28 A**
200 kg ha^{-1} Fertilizer with nitrogen	30.07	30.92	**30.50 A**	13.73	14.93	**14.33 A**
Means	**27.28**	**27.94**		**12.37**	**12.87**	
CV (%)	**5.18**			**6.37**		

*Significant at P<0.01 levels; Means in the same columns followed by the same letter (s) are not significant

The table 5 shows that the crude protein in the dry mass is 9.78-14.33% according to two-year mean results. The lowest crude protein content was observed from control applications (9.27 and 10.30%, respectively) in both the years. The highest crude protein content was obtained from the 100 kg ha^{-1} N

(13.93%) in the first year and 200 kg ha^{-1} N (14.93%) in the second year. In the study, there was no statistically significant difference among the nitrogen applications according to two-year mean results. On the other hand, it was found that the effect of different applications on the crude protein content of sweet corn was statistically significant (Table 5).

Total sugar content

The total sugar amount changed from 22.42 - 23.33 mg 100 g^{-1} according to two-year mean results. The differences between applications were found to be not statistically significant. The lowest sugar amount was obtained from control application. The sugar content in all applications in the second year was higher than the first year. High sugar amount might be due to the temperature. Because the mean temperature was higher in the second year (Table 1). The highest total sugar amount was obtained in rose pulp enriched nitrogen, nitrogen enriched seaweed and 100 kg N ha $^{-1}$ applications (Table 6).

Table 6. Mean values of sweet corn for total sugar content (mg 100 g^{-1}) in different applications

Applications/ Years	**Total sugar content**		**Means**
	2015	**2016**	
Control	20.93	23.90	**22.42**
Seaweed	21.63	24.57	**23.10**
Seaweed enriched with nitrogen	21.90	24.77	**23.33**
Solid and liquid Seaweed	21.20	25.00	**23.10**
Rose pulp application pre-sowing	21.00	24.53	**22.77**
Rose pulp application with sowing	20.77	24.10	**22.43**
Rose pulp enriched with nitrogen	21.83	24.83	**23.33**
100 kg ha^{-1} Fertilizer with nitrogen	21.97	24.63	**23.30**
200 kg ha^{-1} Fertilizer with nitrogen	20.80	25.03	**22.92**
Means	**21.34 B***	**24.60 A**	
CV (%)	**2.6**		

* Significant at P<0.01 levels, Means in the same lines followed by the different letter are significant

Discussion

In the research, the effects of applications on all the characters were found to be significant. Nitrogen fertilization caused a significant increase in husked and huskless ear weight. In addition, the husked and huskless ears weight were found to be low in seaweed and rose pulp applications without nitrogen application. The greatest with husk and without husk ear weight were observed for 200 kg N ha^{-1}.

Significant variation in the ear weight was determined in the previous researches. Fresh ear weight can change according to varieties (Sonmez et al., 2004; Stanslous et al., 2020), sowing date (Farsiani et al., 2011; Akgun et al., 2017; Burcu and Akgun, 2018), plant density and nitrojen doses (Turgut, 2000; Grazia et al., 2003; Baht, 2012; Akgun et al., 2017; Sakin and Azapoglu, 2017).

It has been reported that the weight of the husked has a positive relationship with the weight of the huskless, the number of grains in the ear and the length of the ear (Uckesen, 2000). Similar results were found in our study and the weight of the huskless ear was higher in the applications with more husked weight.

In the study conducted by Grazia et al. (2003), on sugar corn, different nitrogen fertilizer doses were applied (N = 0; 100 kg N ha^{-1} and 200 kg N ha^{-1}). Although the highest yield (with husk and without husk yield) was determined in 200 kg application, there was no statistically significant difference with 100 kg application. The effect of nitrogen fertilization in the study was in agreement with our observations.

The lowest values of all the examined characters were determined in the control application. Nitrogen deficiencies reduced biomass production and this reduction is mainly explained by low photosynthetic rate. It will also reduce the dry matter content in aerial organs (Grazia et al., 2003).

Nitrogen applications increased kernel weight and number in ear. The kernel weight and number in ear were found to be lower in the different application of organic materials (2, 4, 5 and 6 applications). Nitrogen deficiency could affect ovule fertilization and the number of endospermatic cells. It reduces the source of assimilates during the filling period (Uhart and Andrade, 1995; Grazia et al., 2003). The number of kernel in ear also varies depending on the environmental conditions and cultivation applications. Relevant studies showed that nitrogen doses significantly affected the number of kernels in ear (Turgut, 2000; Oktem et al., 2004). On the other hand, the number of kernel rows per ear that determined by genetic structure is one of the factors affecting the kernel yield (Farsiani et al., 2011; Stanslous et al., 2020)

In the previously conducted researches, the differences were with husk and without husk ear weight, kernel weight and number in ear of Vega F1 cultivar with husk and without husk ear weight 435.43 g and 301.61 g respectively (Eser, 2014); kernel numbers in ear 639.0 (Eser, 2014) and 539.92 (Atakul, 2011) 263.3 (Bozkurt and Karadogan, 2017); kernel weight in ear 200.26 g (Eser, 2014) and 167.0 g (Atakul, 2011). These data shows that environmental conditions and cultivation applications are effective on ear weight and characters related to ear of the sweet corn cultivar.

Dry matter content and protein ratios were determined in the highest 200 kg N ha^{-1} application in the study. Nitrogen applications increased biomass production and photosynthetic activity. It could also increase other nutrient elements intake. Accordingly, the dry matter and the crude protein contents had increased. In studies on this subject, it has been determined that nitrogen fertilizer application increases the crude protein content significantly. (Altıparmak, 2001;

Akgun and Siyah, 2015). It is reported that sweet corn grain contains 7 to 15% protein rate (More et al., 2017). The similar results were also reported by Sevov (2017), that the grain of sweet corn as absolutely dry matter contained 15% protein, 64% carbohydrates. In this study, the crude protein rate and dry matter content depending on different applications have changed 9.78 to 14.33% and 25.30 to 30.50% respectively. The results in the previous researches were in agreement with our data.

Akgun and Siyah (2015) found that the highest fresh ear yield and seed number in ear were obtained by applying 100 kg N ha^{-1} with *Azotobacter.* Also the highest protein and total sugar contents were obtained by 100 kg N ha^{-1} with and *Mycorrhiza.* It has been suggested by researchers that applying nitrogen with bio-fertilizers can reduce amount of nitrogen fertilizer. This might be the result of the microorganisms that can enhance plant growth by increasing the efficiency of biological fixation and enhance the availability of trace elements by the production of plant growth promoting substances (Gyanershwar et al., 1998).

In the research, the total sugar content was higher in the second year. It is thought to be related to the temperature. Because the mean temperature was higher in the second year. It has been reported that the sweetness gene in the endosperm and environmental factors had significant effect on the sugar content (Szymanek, 2009). The studies on this subject are examined; Can (2014) reported that nitrogen doses do not have a significant effect on the total sugar content, the sugar content decreases depending on the nitrogen dose (Altıparmak, 2001) and Akgun and Siyah (2015) determined that nitrogen had a significant positive effect on the total amount of sugar. Also, Adamec et al. (2020) reported genotype has a significant effect on the total sugars in the grains at the stage of milk maturity. Though, the sweetness is determined not only by genetics, but also by the agronomics practices and how the respective varieties are managed and harvested (Alan et al., 2014). Based on our results, applications had not a significant effect on total sugar content, but positively affected total sugar content.

Isparta, which is an important rose oil producer (85.12% of total production), the use of rose pulp as fertilizer in agriculture is important in prevention of environmental pollution and increasing organic matter in the soil. It has been reported that the organic matter content of rose pulp is 84.2%, total nitrogen 3.7%, total phosphorus 1.99 mg g^{-1}, total potassium 24 mg g^{-1} and magnesium 5 mg g^{-1} (Tosun et al., 2003). The rose pulp significantly increased the moisture retention of the soil and could be as an organic material (Alaboz and Isıldar, 2018). Baydar et al. (2020) reported that rose pulp is high quality and economic source of organic fertilizers. Erdal and Aydemir (2003) found that by applying directly or enriching of rose pulp, plant growth is positively affected. These data on rose pulp support our research results. Rose pulp application enriched with nitrogen increased significantly data in all investigated parameters in sweet corn compared to control and rose pulp applications before and with sowing. Significant increase in the yield of crops due to foliar application of seaweed extracts has been reported in the literature (Rathore et al., 2009).

Conclusion

In the research, effect of traditional fertilizer application and different organic material (rose pulp (*Rosa damascena* Mill.) and seaweed (*Ascophyllum nodosum*)] applications in sweet corn was determined on ear yield and quality properties. It is aimed at reducing the use of chemical fertilizers, increasing the use of organic material in agricultural production.

In the result of the research, husked and huskless ear weight, kernel weight and number in ear, dry matter, crude protein and total sugar contents were effected positively with nitrogen fertilizer and different organic material applications. On the other hand, the husked and huskless ears weight were lower in seaweed and rose pulp applications without nitrogen application. Although the highest ear weight (with husk and without) was determined in 200 kg application, there was no statistically significant difference with 100 kg application.

As a result of the research, it has been determined that rose pulp enriched with nitrogen can be used in sweet corn growing.

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EXTRACTIONS OF POLYSACCHARIDES FROM MARINE BROWN MACROALGAE

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Introduction:

Aquaculture, which is predicted to have an important role in the future of food production sectors, plays an important role in global food security and in eliminating malnutrition (Tamilarasu et al., 2021).

Today, aquaculture comes to the fore at the point where the production of fisheries from hunting has reached the saturation point and the demand for protein that arises with the increasing population is met (FAO, 2022). However, the industry is on the verge of a major crisis due to the over exploitation of existing marine resources and the emergence of deadly infectious diseases in cultural environments (Tamilarasu et al., 2021).

Macroalgae are an important component of global aquaculture. In 2019, macroalgae cultivation contributed a great deal, approximately 28.6% of the 122.58 million tons of world aquaculture production (Figure 1.). (FAO, 2022)

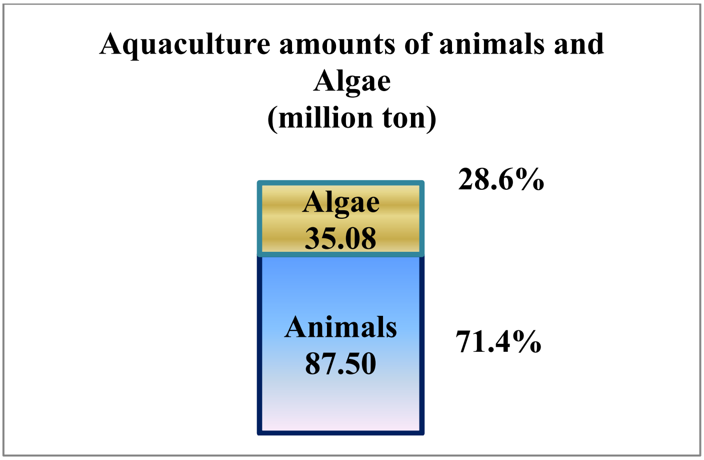

Figure 1. Aquaculture amounts of animals and Algae (million ton) (FAO, 2022)

In the animal group, which constitutes 87.50% of the total aquaculture production as mentioned in Figure 1, finfish have the largest share with 57.46%, followed by Molluscs with 17.74%, Crustacea with 11.23% and other aquatic species with 10.62%, respectively (FAO, 2022).

Macroalgae are classified into three different groups, Green algae (Chlorophyta), brown algae (Ochrophyta) and red algae (Rhodophyta) with reference to thallus colors (Saleh et al., 2020). The brown macroalgae production in the world has reached 16.4 million tons as of 2019, from 13.000 tons with an average annual growth of 10.9% in the last 70 years. This increase in brown macroalgae production was even higher than the 7.9 percent growth recorded in aquaculture overall (Cai et al., 2021).

According to 2019 data, while brown macroalgae constitutes 47.3% of the world macroalgae production in terms of tonnage and 52% economically, red and green macroalgae together make up 52.7% in terms of tonnage and only 48% in terms of economic return (Cai et al., 2021).

Macroalgae contain minerals, polysaccharides, proteins, low lipids, pigments and polyphenols as main components (Jönsson et al., 2020). Macroalgae polysaccharides are divided into cell wall and storage polysaccharides according to their location in macroalgae. Most of the macroalgae polysaccharides are composed of cell wall polysaccharides, with the exception of storage carbohydrates (Şahin, 2021). Polysaccharide-rich macroalgae contain high value-added metabolites such as fucoidan, agar, alginate, carrageenan and ulvan in their cell walls and intracellular structures. Macroalgae are the most important economic and industrial products (Şahin, 2021).

Morever, marine macroalgal polysaccharides are highly promising for next-generation applications in several industries. However, despite the reported comprehensive potential of these polysaccharides, commercial products are scarce on the market (Jönsson et al., 2020). Marine macroalgae are classified into three main groups based on the brown, red and green pigments they contain. Different extraction methods are developed and used to obtain the different polysaccharides contained in each group (Saleh et al., 2020).

In this review, the production/extraction methods of Fucoidan, Alginate, Laminarin polysaccharides obtained from brown-colored algae with wide usage areas and high economic value will be discussed. It is also aimed to contribute to the use of brown macroalgae polysaccharides in different industrial areas by obtaining effective and high quality.

Polysaccharides from marine brown Macroalgae

Brown macroalgae are rich in polysaccharides such as alginate, fucoidan, laminarin and cellulose (Deniaud-Bouet et al., 2017). The most important factors affecting the functional properties of macroalgae polysaccharides are harvest time, algae species, growth medium composition and extraction methods (Mohsen et al., 2007; Wang et al., 2008). While the fucoidan and alginate amounts do not fluctuate greatly during the year, there may be significant fluctuations in the amounts of laminarin due to its energy storage role (Otero et al., 2021)

Traditionally, chemical extraction methods have been widely used to obtain polysaccharide from algae. Recently, innovative methods have been developed to obtain high yields, use low amounts of solvent, work at low temperatures and reduce extraction time (Kadam et al., 2015a; Sosa-Hernandez et al., 2018).

Fucoidans

Generally, fucoidan is present in the cell wall matrix of various brown macroalgae species (Mohsen et al., 2007; Xin et al., 2016). Fucus vesiculosus is a widely known source of fucoidan. Its chemical composition consists of fucose linked sulfate groups, α-(1–3)-l-fucopyranose (Şahin, 2021). In general, the fucose content of fucoidan is 40% of its total monosaccharides. However, in some species this amount can reach up to 80%. Monosaccharides such as mannose, glucose, galactose, xylose and glucuronic acid are also commonly found in fucoidan. The structure of fucoidan is generally quite heterogeneous and may vary according to algae species (Ale et al., 2011; Bittkau et al., 2020; Otero et al., 2021). This feature of fucoidan makes it difficult to purify and identify (Xin et al., 2016). Variation among fucoidans results in differences in molecular weights ranging from 40 kDa to 1600 kDa (Fletcher et al., 2017)

Fucoidan is usually obtained by extraction with water and gradual precipitation with different concentrations of ethanol (Xin et al., 2016). Most of the macroalgae polysaccharides obtained using the acid extraction method are crude fucoidans (Becker and Lowe, 2003). Recently, many modifications of the extraction and purification methodology of fucoidans have been studied (Ale et al., 2011).

Alginates

Alginate, which is an acid molecule by nature, forms the main cell wall and cell matrix of brown macroalgae. Phaeophyceae, Ascophyllum, Ecklonia, Laminaria, Lessonia, Durvillaea, Macrocystis, Turbinaria and Sargassum species are the most important sources of alginate (Kraan, 2012; Otero et al., 2021). Alginate is mainly consist of monomers such as α-(1→4) β-D-mannuronate (M-blocks) and α-L-guluronate (G-blocks) (Cardoso et al., 2016).

Alginate can be classified according to low and high mannuronic acid amounts and high guluronic acid amounts. It has been revealed that young algal thalli tissue has higher mannuronic acid content than older algae thalli (Rabille et al., 2019). Factors such as extraction method, anatomical structure, geographical distribution and seasonal collection affect the ratio of mannuronic acid and guluronic acid of alginate (Ullah et al., 2021).

Alginates are used industrially for their physical properties such as emulsifying, thickening, stabilizing and properties (Skjak-Bræk et al., 2015). During extraction from brown algae, a calcium compound (CaCl2) can be added to the polysaccharide fraction to precipitate the alginate. Laminarin is separated from the alginate fraction by the addition of calcium compound. On the other hand, fucoidan is present in different amounts in both fractions (Rioux et al., 2007).

Alginates are formed when alginic acid reacts with metal ions present such as magnesium, sodium, calcium. While calcium alginates form water-insoluble gels, magnesium and sodium salts transform into water-soluble gels (Domozych, 2019).

Alginate extraction pre-extraction, neutralization and precipitation (calcium or acid) takes place in three stages (Kimica, 2019). Before extraction, the water-insoluble divalent alginate gel or alginic acid gel swells in acidic water. During extraction, sodium-containing compounds are added to convert the divalent alginate to sodium alginate, which is a water-soluble form. The commercial form of alginate is known as sodium alginate. One of the biggest problems encountered in alginate extraction and purification processes is the cytotoxic compounds found in contaminated macroalgae (Hernandez-Carmona et al., 2013).

Aqueous alginate has a high viscosity and dilution should be done before the purification and filtration stages. The yield of alginate extraction is generally higher than fucoidan and laminarin (Jönsson et al., 2020).

Laminarin

Laminarin, which has a linear structure, is a polysaccharide found in the cell plastids of brown macroalgae. Laminarin is in the form of β-(1–3)-d-glucans with β-(1–6)-D-glucosyl branches, with d-mannitol or d-glucose residues at the ends of the polymeric chains (Cui et al., 2021). The ratio of each polymeric structure and chain may change according to species and environmental conditions (Şahin, 2021).

Laminarin is the carbohydrate reserve of brown macroalgae, corresponding to starch in terrestrial plants (Kadam et al., 2015b; Graiff et al., 2016). Laminaria, Saccharina, Ascophyllum and Fucus are known as laminar-rich brown macroalgae (Şahin, 2021). The amount of Laminarin, known as a water-soluble linear polysaccharide, is affected by factors such as algae species, harvest season, temperature, salinity, sea currents, depth and nutrient availability (Quillet, 1958; Chizhov et al., 1998). The levels of laminarin extracted from collected brown algae reach a maximum in autumn and a minimum in winter (Schiener et al., 2015).

Because laminarin forms change in water solubility, its extraction is carried out at increasing temperatures. Unbranched forms tend to be less soluble in water than branched forms (Jönsson et al., 2020). While extracting alginate and fucoidan polysaccharides, laminarin, which is one of the intermediate steps, can also be extracted, and also, the addition of calcium chloride ensures the precipitation of alginate during extraction. Due to its small molecular weight, laminar can be purified by ultrafiltration by separating it from fucoidan (Rioux et al., 2007; Rioux and Turgeon, 2015).

Extraction Techniques of Macroalgae

The most commonly used solvents in the extraction stage are water (Cong et al., 2016;), ethanol (Huang et al., 2016) and acidic solutions (Dinesh et al., 2016).

After the preparation and pretreatment of macroalgae, traditional and innovative techniques are used for extraction. After extraction, the purification processes are commonly used.

Traditional techniques

Soxhlet extraction and Heat assisted extraction (HAE) are the most widely used traditional techniques (Garcia-Vaquero et al., 2020).

Hot water is widely used in the extraction of macroalgae. (Bhardwaj et al., 2020) and also acidic and other solvents (Yaich et al., 2017; Abid et al., 2019). Also, addition of calcium chloride is made to precipitate alginates. (Ammar et al., 2015; Bittkau et al., 2020). Extraction temperature and time may vary from room temperature (RT) to ≥100 °C and from a few hours to 48 hours (Otero et al., 2021).

Soxhlet extraction has higher extraction efficiency than HAE method (Garcia-Vaquero et al., 2020). This method is actually used as a pretreatment to remove untargeted compounds. (Ammar et al., 2015; Bittkau et al., 2020; Abid et al., 2019). The continuous flow of the method drops the extraction duration ranging from 2 to 3 hours (Otero et al., 2021).

Today, it has been determined that traditional techniques have many disadvantages such as the use of solvents with high toxicity, long extraction time, degradation of compounds and high temperatures (Garcia-Vaquero et al., 2020; Gomez et al., 2020). To eliminate these disadvantages, researchers have focused on innovative technologies that increase the efficiency of polysaccharide extraction (Jönsson et al., 2020; Otero et al., 2021).

Innovative techniques

Today, new technologies are used to develop more efficient and more environmentally friendly extraction methods in terms of time, yield and economy by reducing energy consumption. (Kadam et al., 2013; Barba et al., 2015).

Innovative techniques used in polysaccharide extraction are (UAE) ultrasound assisted extraction, (MAE) microwave assisted extraction, (PLE) pressurized liquid extraction and (EAE) enzymatic assisted extraction and (PEF) pulsed electric field extraction (Otero et al., 2021).

Microwave-assisted extraction (MAE)

MAE, a thermal based approach, uses microwaves that leads to break down of the cell walls (Michalak & Chojnacka, 2014; Otero et al., 2021). Compared to Traditional techniques, MAE is an energy-assisted extraction method, increasing extraction efficiency by using less solvent. The most important disadvantage is that it can damage the heat sensitive compounds that emerge during the extraction. (Michalak & Chojnacka, 2014).

MAE can be easily combined with other extraction technologies (Garcia-Vaquero et al., 2017; Dobrincic et al., 2020). It has been reported that MAE extraction parameters have a significant effect on fucoidan monosaccharide composition, degree of sulfation, molecular weight and biological activities (Yuan and Macquarrie, 2015; Dobrincic et al., 2020).

Ultrasound-assisted extraction (UAE)

UAE is a non-thermal extraction technique performed at RT (Ying et al., 2011; Michalak & Chojnacka, 2014; Kadam et al., 2015a,b; Okolie et al., 2019). UAE is based on the use of ultrasound waves above 20 kHz to produce high and low pressure bubbles and zones.The mentioned process could cause structural (molecular weight, monosaccharide compositions, sulfate content) and microstructural modifications in the sulfated material (Dobrincic et al., 2020).

The bubbles that grow and collapse during UAE extraction cause the cell walls to break down. This process increases the interaction between solvent and sample (Otero et al., 2021). Additionally, UAE has been used to break down already extracted polysaccharides. Small molecular weight molecules produced during extraction had more promising properties than those obtained from algae (Sun et al., 2012).

UAE is regarded a proper technique for use on an industrial scale due to the use of economical devices, high automation, high efficiency and speed. Furthermore, this extraction technique leads to the protection of thermolabile compounds as it can work at low temperatures. Therefore, this technique can work together with other extraction techniques such as EAE and MAE (Ibanez et al., 2012; Michalak & Chojnacka, 2014; Cikos et al., 2018; Hanjabam et al., 2019; Alboofetileh et al., 2019a,b; Dobrincic et al., 2020; Wang et al., 2021).

Pressurized liquid extraction (PLE)

PLE is an innovative extraction technique based on the principle of using water and solvents at high temperature and pressure to keep the solvent in a liquid state (Dobrincic et al., 2020; Otero et al., 2021).

Depending on the solvent used during the extraction and different operating conditions, PLE is common called pressurized fluid extraction (PFE), pressurized solvent extraction (PSE), accelerated solvent extraction (ASE), subcritical water extraction (SWE) or hot water extraction (HWE) (Wu, 2017; Jacobsen et al., 2019).

Operating conditions such as temperature, pressure and extraction time used in this technique vary between 50–200 °C, 35–200 bar and 5–25 min, respectively. (Cikos et al., 2018; Khalil et al., 2018; Hierro et al. 2020; Otero et al., 2021). High temperature in the extraction technique ensures that the sample is more soluble and a high dilution rate, while high pressure keeps the solvent below its boiling point (Wu, 2017).

PLE has advantages such as low solvent usage, short extraction time and high productivity (Saravana et al., 2016). On the other hand, the high temperatures used during the extraction cause undesirable reactions, decomposition of the compounds. In addition, industrial-scale application of this extraction technique is still limited, as it is necessary expensive device and large amounts of energy (Jacobsen et al., 2019).

Enzymatic assisted-extraction (EAE)

In the EAE technique, digestive enzymes are used during the cell wall breakdown of macroalgae (Otero et al., 2021). Enzyme assisted extraction is a promising alternative to traditional solvent-based methods due to its high catalytic efficiency, high specificity, mild reactive conditions, higher extraction efficiency, faster extraction rate, lower energy consumption and lower solvent usage (Kulshreshtha et al., 2015; Nadar et al., 2018).

Many enzymes used for polysaccharides extraction include proteases which hydrolyse peptide bonds, such as Alcalase or Flavourzyme, or Viscozyme—a mixture of carbohydrases (glucanase, cellulase, xylanase and hemicellulase) that catalyzes the breakdown of pectin-like substances in the algal cells or Celluclast—able to break down cellulose in algal cells into glucose, cellobiose and longer glucose polymers (Lakmal et al., 2015; Dobrincic et al. 2020).

The most important factors affecting efficiency in EAE technique are solvent enzyme sample rate, pH and temperature (Khalil et al., 2018). Although the EAE technique is environmentally friendly and highly specific, its use on an industrial scale limits its use due to the high cost of commercial enzymes (Garcia-Vaquero et al., 2017; Dobrincic et al., 2020).

Pulse-electric field (PEF)

Toxic solvents are not used in PEF, which is generally known as an environmentally friendly extraction technique. In this technique, intense electricity is applied to break the connections between cell wall polysaccharide molecules. The most parameters used in this extraction are the distance between the electrodes and the density (Polikovsky et al., 2016; Otero et al., 2021). PEF extraction in macroalgae is mostly preferred for the recovery of minerals, polyphenols and proteins (Robin et al., 2018).

Comparison of extraction techniques

Fucoidan amounts obtained from conventional chemical extraction (CE), ultrasound-assisted extraction (UAE), microwave-assisted extraction (MAE),, enzymatic assisted extraction (EAE), pressurized liquid extraction (PLE) and pulse-electric field extraction (PEF) were 1,63-12,2%, 3,51-14,61%, 1,06-20,98%, 1,5-5,58% and 4,99-23,77%, respectively (Je et al., 2009; Rodriguez-Jasso et al., 2011; Yuan and Macquarrie, 2015; Fletcher et al., 2017; Rani et al., 2017; Alboofetileh et al., 2019a,c,d; Hanjabam et al., 2019).

Alginate amounts obtained from conventional chemical extraction (CE), ultrasound-assisted extraction (UAE) and enzymatic assisted extraction (EAE) were 13,47-66,72%, 27-54% and 3,47-23,6%, respectively (Je et al., 2009; Mazumder et al., 2016; Youssouf et al., 2017; Borazjani et al., 2017; Abid et al., 2019).

Laminarin amounts obtained from conventional chemical extraction (CE), ultrasound-assisted extraction (UAE) and enzymatic assisted extraction (EAE) were 6-20%, 5,29-6,24% and 3,2%, respectively (Deville et al.,2004; Je et al., 2009; Kadam et al., 2015c).

The steps involved in the traditional algal polysaccharide extraction procedure are as follows (**Figure 2**).

1 Pre-treatment for extraction: washing and drying of algae

2-4 Preparation for extraction: grinding algae into flour

5-7 Wetting algae flour with the addition of solvent for extraction

8-9 Separation of algae flour from polysaccharide solution by filtration

10-11 Obtaining the polysaccharide by precipitation

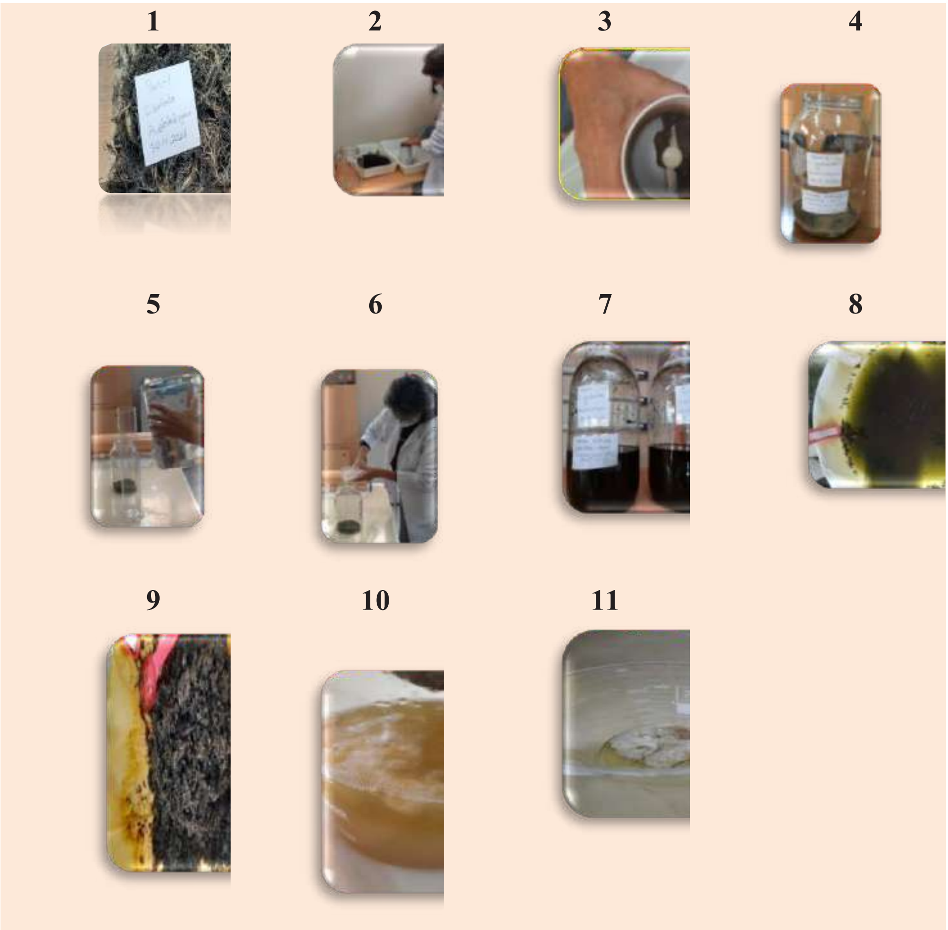

Figure 2. Traditional algal polysaccharide extraction

Conclussion and Future Perspective

In addition to their use as functional feed additives in aquaculture, polysaccharides/polymers have a wide range of uses, from advanced technologies such as tissue engineering to the food industry, such as simple ice cream making. They are important macro-molecular structures with high bioactivity, physical and chemical properties that can be modified according to their areas of use, and effective processing properties. Both academic and industrial studies suggest that polysaccharides are the most important raw material in the perspective of the Hybrid World. The importance and economic value of polysaccharides, especially obtained from macroalgae, are being understood day by day and they are starting to take their deserved place with their wide use in the industry. However, when existing extraction methods are examined at the point of obtaining polysaccharides suitable for usage areas, high energy consumption, low productivity, low quality, ineffective extraction time, uneconomical extraction process and environmental damage can be counted as the leading problems to be solved.

On the other hand, preserving the biological, physical and chemical characterizations of the polysaccharide are important criteria in determining the extraction method. It is suggested that the determination of economical and effective extraction methods by modifying traditional and innovative methods according to the usage areas of the polysaccharide will increase the industrial use of algal polysaccharides and, in parallel, their economic value.

Considering the results obtained, innovative polysaccharide extraction methods are a promising alternative to traditional polysaccharide extractions in which toxic solvents are used extensively. It is recommended to work on operating conditions (solvent, temperature, time, etc.) of innovative extraction methods in the future.

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QUALITY CONCEPT FOR FOOTBALL TURF

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Introduction

The importance of sports, especially football, in societies is increasing today. A survey conducted by FIFA published in 2001 shows that over 240 million people from more than 200 countries regularly play football (Bey, 2014). Football is also Turkey's most preferred sports branch, with its amateur, professional, licensed, and unlicensed athletes. On the other hand, it attracts more and more attention from viewers, and new football stadiums are constantly being built (TFF, 2022). In addition, the share of football tourism in the tourism sector of Turkey is gradually increasing. Antalya is in first place in terms of football tourism today. Every year, many professional football teams from Russia, Ukraine, Romania, and others, especially from European countries, prefer our country for the half-time football camp (Anonymous, 2022). For this reason, the number of football facilities has rapidly increased to meet this demand in recent years.

A football pitch (also known as a football field) is the playing surface for association football. The quality of the pitches is one of the two most important factors for football clubs in choosing a half-time or pre-season camp (Icoz et al., 2009). For these facilities to serve the football tourism sector and international platforms, they should be built in line with FIFA standards. Furthermore, maintenance-management practices should be continued in line with recommendations based on scientific research results. It is necessary to have high-quality turf pitches for the athletes to perform at a high level and minimize the risk of injury, considering the high transfer fees of professional football players (Tosun Arslan, 2014).

For players, coaches, and fans in the stadium and on television, the focal point of a football pitch is the turf where the game is played. Therefore, the high quality of turfgrass pitches is one of the primary conditions of the football game and should be given priority (Pessarakli, 2007; FIFA, 2011; Puhalla et al., 2020). For this reason, when establishing a football pitch, it is necessary to work with people who are experts in the establishment and maintenance of turfgrass fields from the first stages. From the suitable infrastructure materials to the species/cultivars of turfgrass to be grown, the essential decisions regarding the field must be carefully taken to ensure the best players' performance and prevent unnecessary falls and injuries (FIFA, 2011; UEFA, 2018).

Definition of Football and General Features of Football Pitches

The word football, written as “fussball” in German and “football” in English, combines the words foot and ball. Although almost every body part can be used except for the hands and arms, it is generally played with the feet (Yakich, 2022). It is based on passing a particular ball made of spherical leather between two teams of eleven players, one of whom is a goalkeeper, between the opponent's goalposts without using hands and arms (Bey, 2014).

Football is a game with an aerobic basis, combining short-term anaerobic movements for 90 minutes and ball skill. It is in a game structure in which approximately 1.000 different movements differ from each other, and the movements can change rapidly one after the other. Speed, one of the essential features of being able to enter a suitable position on a narrow field or reduce players, especially in one-on-one fights, has gained importance in today's football understanding (Lindquist and Bangsbo, 1991).

For football fields, the dimensions can vary between a minimum of 90 meters in length and a maximum of 120 meters and a minimum of 45 meters in width and a maximum of 90 meters (Figure 1). The pitches have two goalposts 7.32 meters wide and 2.44 meters high (FIFA, 2011; UEFA, 2018). As it is known, the aim is to pass the ball through these goalposts. In football fields where high-level professional matches or international matches are played, the standard dimensions of the turf pitch are determined as 68x105 m (FIFA, 2011). These dimensions are mandatory for final matches of FIFA World Cup matches (FIFA World Cup™) and FIFA confederations championships (e.g., UEFA Champions League). These dimensions are recommended especially for the playing fields of newly built stadiums. In addition, the playing field must be determined with precise lines (Puhalla et al., 2020).

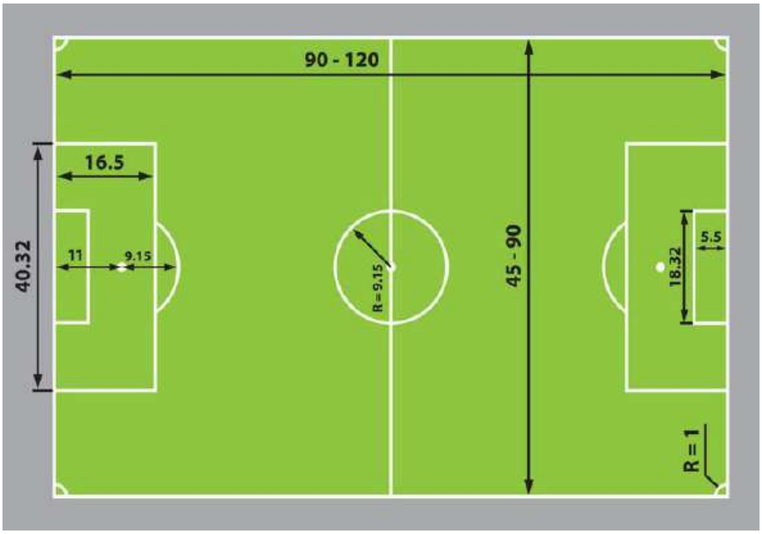

Figure 1. Dimensions of standard football pitches

Football pitches are classified into two groups according to the characteristics of the ground: natural turfgrass pitches and artificial turf pitches. In recent years, the use of hybrid pitches has also become widespread. Regarding football players and the game, natural turfgrass pitches are preferred over artificial grass pitches (Emmons and Rossi, 2015). Turf both creates a visually aesthetic appearance and absorbs the sun's rays, reducing the effects of the sun's rays on the eyes. On the other hand, football pitches create a soft ground and an area that can be moved more safely for players (Orchard, 2002; Chivers, 2008).

Football pitches are one of the most difficult areas to maintain among natural turfgrass pitches (Puhalla et al., 2020). These difficulties are climatic conditions, excessive wear and compression of the turfgrass because of playing many matches on the same ground, and high costs for maintenance (Pessarakli, 2007). In most countries, the football season is in the autumn-winter period when grass species slow and/or stop active growth and development. The main problem is the sustainability of the turfgrass quality in these heavily used pitches, especially in the winter period (Puhalla et al., 2020). Keeping and protecting the grass ground in winter conditions is complicated and costly. In addition, uneven or unstable ground can hinder the players' performance. These problems are minimized in football pitches that are established and well-managed with a suitable infrastructure system and correct turfgrass species and cultivars in line with the standards (Emmons and Rossi, 2015).

Turf Quality Concept for Football Pitches

Turfgrass is a description given to a very small group of grasses with a unique combination of plant morphology (form) and adaptation to a defined set of cultural practices (Beard, 1973). Botanists have cataloged over 10.000 species of grasses worldwide (Kraehmer, 2019). Within that classification, there are primarily 12 grass species that fall under the turfgrass label. Out of that number, only six grass species are recognized for sports turf application. This elite group of sports turf must possess three turfgrass criteria. The sports turf species must have excellent traffic tolerance, rapid recovery from divoting and injury, and high tensile or sod strength. Sometimes, a combination of turfgrass species is used to obtain all or most of these features (Christians et al., 2016; Puhalla et al., 2020).

Out of the 12 kinds of grass commonly used as turfgrasses, the six species used in sports turf management are cool-season turfgrass species perennial ryegrass (*Lolium perenne*), Kentucky bluegrass (*Poa pratensis*), red fescue (*Festuca rubra*) and tall fescue (*Festuca arundinacea*); and warm-season turfgrass species bermudagrass (*Cynodon dactylon*) and seashore paspalum (*Paspalum vaginatum*). In addition, two other warm-season turfgrass species, buffalograss (*Buchloe dactyloides*) and zoysiagrass (*Zoysia japonica*), are sometimes used for sports turf but infrequently (Beard, 1973; Avcioğlu, 2014; Puhalla et al., 2020).

The most preferred turfgrass species for football pitches established in cool climate zones are mostly these six species or their mixtures (Beard, 1973; Avcioğlu, 2014). Perennial ryegrass has a speedy germination and growth rate. It provides the desired turf surface until Kentucky bluegrass and Fescue species, which have slower germination rates, germinate in the pitch (Pessarakli, 2007; Turgeon, 2011; Emmons and Rossi, 2015). Kentucky bluegrass, which has excellent self-renewal ability with its vigorous rhizomes, can tolerate mechanical stress quite well (Aldous and Chivers, 2002; Reyneri and Bruno, 2004). In recent years, newly developed tall fescue cultivars have also found the opportunity to be used in football pitches (Grossi et al., 2004). On the other hand, perennial ryegrass is the most preferred cool-season turfgrass species for rapidly repairing damaged parts in both winter overseeding and football pitches due to its rapid germination and facility feature (Turgeon, 2011; Fontanier and Steinke, 2017).

The most used turfgrass species in football pitches established in warm climate regions are hybrid bermudagrass (*Cynodon dactylon* x *Cynodon transvaalensis*) or common bermudagrass (*Cynodon dactylon*) species and cultivars (Pessarakli, 2007; Lulli et al., 2014). These species are preferred because of their resistance to pressing and crushing, their short height mowing and thus their positive contribution to ball response and their ability to provide a surface at the desired speed (Beard, 1973; Kir et al., 2019; Puhalla et al., 2020). In addition, certain seashore paspalum (*Paspalum vaginatum*) cultivars or other warm-season turfgrass species are suitable for use on athletic fields in place of the “Tifway” hybrid bermudagrass (Brosnan and Deputy, 2009). However, warm-season turfgrasses must be overseeded with cool-season turfgrass in the fall to provide green color and maintain suitable playing surfaces by preventing wear on the dormant warm-season turfgrass throughout the winter months (Watschke and Schmidt, 1992; Horgan and Yelverton, 2001). To prevent the appearance of winter dormancy in football pitches established with bermudagrass turf, they are necessary to overseed, especially with perennial ryegrass, in the autumn season (Turgeon, 2011; Christians et al., 2016). Thus, in winter, dormant bermudagrass provides ground resistance and a visually desirable surface, while perennial ryegrass in active growth tolerates low temperatures and mechanical stress, allowing football to be played and maintaining the green appearance (Beard, 1973; Foy, 1998; Stewart, 2004; Avcioglu, 2014).

Fans often evaluate the quality of the football pitch by looking at the overall appearance (visual turf quality) of the field (Puhalla et al., 2020). Football players, clubs, and federations have different interests and concerns about the quality of football pitches (Cereti et al., 2004). The quality of a football pitch is primarily the turf, determined by its effects on player safety, performance, and ball response (Puhalla et al., 2020). In a good way of revealing the desired features in the football game, in one condition, it is good pitch conditions. In other words, excellent and stable pitch conditions are needed to make runs and stop quickly, effective ball control, passing and similar movements. A pitch ground other than these criteria is always an obstacle to full performance (Wesson, 2019). In football, players benefit from important physical movements unique to this game, such as rapid starts and stops and frequent and sudden changes in direction during the game (Puhalla et al., 2020). For these reasons, the safety of the player, his/her performance, and the ball's response depending on the pitch surface's hardness, evenness, and homogeneity (Miller, 2004). High safety and homogeneous pitch conditions covered with quality turf are essential for sudden and fast runs and stops and effective over-controls, passes, and similar movements (Baker, 2004; Reicher et al., 1999). Especially in the winter, the ratio of the area covered with turfgrass, especially the penalty area and the midfield, decreases due to intense use and crushing. As a result, the bare soil surface increases, the density of weeds increases in these areas emptied from the turfgrass, and the pitch surface loses its homogeneity and becomes rough and uneven (Emmons and Rossi, 2015; Cereti et al., 2004). As a result, the game quality decreases, and the players' risk of injury increases (Baker and Canaway, 1991).

The equipment used at every football stage significantly influences how the game is played, and its quality. For example, the ball has a specific particular shape, structure, weight, and pressure that affect the outcome of play. A football match ball (FIFA approved) in accordance with the standards must be size 5 and inflated to 0.9 bar (Bey, 2014; FIFA, 2015). On the other hand, the playing ground also affects the nature of the game. The ball's reaction on the turf pitch is also significant in football. Players need a smooth, uniform turf surface that allows the ball to roll directly and decisively to pass and shoot flawlessly. (Puhalla et al., 2020). A pitch with a bumpy, rough, and occasionally bare surface without turfgrass causes the ball to bounce and roll unevenly and unpredictably. Thus, it negatively affects the game by affecting the speed of the ball rolling (Baker and Canaway, 1993). For all these reasons, the bad ground always prevents full performance from occurring and causes injuries that put the safety of the players at risk. Each time the football player hits the ball with one foot, his/her body takes a position on the other foot, and in order to achieve this balance, the ground on which he/she stands must be smooth and solid (Puhalla et al., 2020). Player injuries mostly occur in low-quality pitch conditions, mainly in shooting and running training (Orchard, 2002).

Hard grounds can increase the severity of the fall and thus the risk of injury if players fall. On the other hand, wet, muddy, and lose surfaces can cause faster fatigue in the foot muscles of the player and cause cramps (Orchard, 2002; Saunders et al., 2011; Orchard et al., 2013; Puhalla et al., 2020). In addition to the entire pitch being covered with grass, the adequate drainage of rain and irrigation water falling on the surface directly affects the player's safety. For example, an overly cramped football pitch with sparse turfgrass and bare soil forces players to grapple with mud, especially on a rainy day, increasing the risk of injury from the ground. Therefore, professional and effective maintenance practices are essential to maintain turfgrass quality and to play football at the desired level (Pessarakli, 2007; FIFA, 2011).

Mowing height directly affects game quality. A short-cut turf surface exerts less friction on the ball passing over it and allows it to roll in the desired direction without bouncing. For this reason, in sports where the ball's response is significant, such as football, it is essential to mow the turf pitch short and properly (McNitt et al., 2004; Grossi et al., 2004; Salman et al., 2019; Puhalla et al., 2020). First, the pitch should be established with turfgrass species and cultivars that will allow short mowing, tolerate heavy traffic, renew itself quickly, and are suitable for environmental conditions (Beard, 1973; Turgeon, 2011; FIFA, 2011; Christians et al., 2016). In addition, even the mowing patterns applied on the turf pitch (Figure 2) and the color contrasts obtained are essential aesthetic factors that affect the general appearance (Pessarakli, 2007). Therefore, all turfgrass-covered pitches with creative mowing patterns are the pitches that receive the most attention and appreciation (Demiroglu Topcu and Ozkan, 2018).

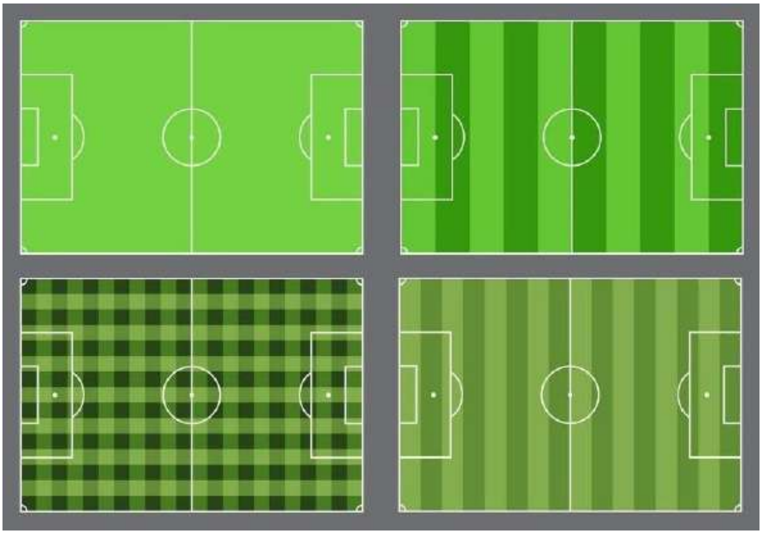

Figure 2. Some mowing patterns commonly used on football pitches

Establishing an effective underground and/or surface drainage system that allows playing in rainy and extremely wet conditions and does not allow water to accumulate on the surface is one of the most critical issues in the construction of football pitches (Connellan, 2013; Puhalla et al., 2020). Because football pitches are used most intensively, especially in the winter season when the rainfall is the highest, after the pitch is established, the maintenance operations to be applied also should aim to protect or make these drainage features of the pitch more effective (Evabs, 1994; Stewart, 2004). Football pitches with poor drainage remain wet for a long time after rain and irrigation (Stier et al., 2020). For this reason, a wet pitch prevents the game from being played at the desired quality and creates a risk for the players by causing unnecessary slips and falls (Puhalla et al., 2020).

Playability Criteria on Football Pitches

Football pitches and related facilities should be designed and built to meet two fundamental requirements. These requirements are a pitch large enough to allow football to be played according to official rules and regulations and a surface allowing players to play safely at high performance. Pitch conditions must allow players to compete with confidence. Also, since many football pitches are also used for non-sport activities, the surface must be durable enough to withstand the stresses associated with these non-sport functions. Each of these essential aspects mainly depends on three properties of the turf surface: traction, hardness, and evenness (Puhalla et al., 2020).

Traction is critical for football players to reach high speeds, make rapid changes in their movements, and especially for sudden stop activities. In addition to reducing the ability of football players to avoid or control collisions, poor traction can lead to muscle pulls or other injuries. Hardness can allow football players to perform at maximum speed but can also affect their ability to cut sharply and increase injury from falls and tackles. Evenness and hardness are significant factors affecting ball response, including the height and direction of bounce, as well as the trueness and speed of the roll. In football, predictable ball response is necessary to support the desired level of competition (Puhalla et al., 2020).

Football stadiums have developed to meet performance and financial requirements over the years (Figure 3). In addition, some disputes arose with the widespread use of artificial fields in the football industry. In this case, it has directed researchers to determine the performance characteristics of football pitch types with biomechanical studies. Therefore, some ball/surface and player/surface traits have been investigated by researchers. The most investigated of these traits are ball rebound, ball roll, shock absorption/force reduction and vertical deformation.

Figure 3. Ataturk Olympic Stadium in Turkey (Anonymous, 2016)

The ball rebound trait plays an essential role in the players' possession of the ball during the match. Therefore, it is desired to be within specific limit ranges and is determined as a percentage (%) of the drop height of the ball in the British system (Baker and Canaway, 1993). However, other countries have accepted different international borders (FIFA, 2005). These standards determine the highest point (60-85 cm range for natural turf) the ball can rise after bouncing. Weakness of turf cover, rainfall or irrigation, and mowing height are the essential parameters affecting this trait (Canaway, 1984; Orchard, 2002; Grossi et al., 2004; Saunders et al., 2011; Avcioglu et al., 2013; Kir et al., 2014). In addition, different turfgrass species generate surfaces with different ball rebound values (Orchard et al., 2005; Chivers, 2008; Lulli et al., 2014).

Ball roll trait is the function of rolling and rolling resistance which is regarded as force acting at the point of contact between the ball and turf surface whose direction is the inverse of the direction of movement. For this reason, it causes the ball to slow down while moving along the surface and is generally expressed indirectly in terms of the distance rolling by the ball (Baker and Bell, 1986). The ball roll must be within certain limits because of the game's speed and the players' domination of the ball while playing on turfgrass (Baker and Canaway, 1993). Initially, these limits were identified as 4-14 m in the United Kingdom. Afterward, the 4-10 m ball roll distance was accepted as a standard according to FIFA (FIFA, 2005). Soil dryness and turf cover weakness or vegetation deprivation, moisture condition of the soil, and especially the mowing height are the most critical factors affecting the ball roll distance (Orchard, 2002; Grossi et al., 2004; Miller, 2004).

Shock absorption trait is also described as the "force reduction or surface hardness" of the turf surface. It is defined as a measure of the ability of the turf surface to absorb a part of the force on it, which is related to its softness or hardness (Rogers III, 1988). High values (%) mean soft surface. Therefore, the force reduction value of turf is desired to be at the level of 60-70% in a natural turf football pitch. The acceptable lower limit of this value is reduced by up to 55% on relatively low-quality turf surfaces (Brosnan et al., 2009). In addition, there is a significant relationship between surface hardness and the game's speed. Faster speeds occur on hard grounds (Norton et al., 2001; Otago et al., 2007). As a result, shock absorption values may affect football players' safety, increasing the risk of injury (Orchard et al., 2005).

Vertical deformation trait that varies within certain limits is desired on football pitches. Because an unsafe movement environment occurs on the undeformed ground, which also disturbs the football player due to hardness and slippages, for this reason, players feel obligated to keep them self safe by shortening their steps and decreasing their running speed on surfaces like this (Orchard, 2002). According to FIFA standards, the 4-8 mm vertical deformation range is considered optimal for high quality pitches. On the other hand, the 9 mm vertical deformation is the upper limit on sports surfaces. In addition, surfaces with deformation values of 10 mm and above are hazardous (Baker and Canaway, 1993; FIFA, 2005).

Finally, it should be remembered that ideal playing quality values are obtained in football pitches consisting of turfgrass types that can adapt to the ecology and form a good turf cover (Grossi et al., 2004). Afterward, the most important way to increase and protect player safety and game quality on football pitches is the timely and accurate implementation of maintenance operations (Puhalla et al., 2020). The main maintenance operations on football pitches are mowing, irrigation, fertilization, aerification, topdressing, rolling, overseeding, and painting if necessary. These maintenance works and how often they are applied vary according to the selected turfgrass species, climatic conditions, soil structure, and the pitch's intensity of use (Beard, 1973; Pessarakli, 2007; Turgeon, 2011; FIFA, 2011; Avcioglu, 2014; Christians et al., 2016).

Conclusion

The football industry is constantly evolving today to meet performance and financial needs. Investments in football pitches are increasing at the same rate. On the other hand, professional football players are expected to perform at a high level considering their high transfer fees. This is only possible by minimizing the risk of injury in pitches. Therefore, the high-quality of natural turf pitches is one of the primary conditions of the football game and should be given priority. Football pitches should be examined regularly regarding game features, and maintenance practices should be carried out without interruption.

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USES OF SOME SALVIA TAXA AND MAIN COMPONENTS OF ESSENTIAL OIL IN TURKEY FLORA

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INTRODUCTION

Most of the Lamiaceae family members are of great importance in fields such as medicine, food, cosmetics, and perfumery, as they are rich in essential oils, aromatic oils, and similar secondary metabolites. *Salvia* species, which are a member of this family, are used both in herbal treatment and in cuisine for different purposes in the world and in Turkey. At the same time, some species are cultivated (Dweck, 2000; Baydar 2013).

It is known that the genus Salvia, one of the largest members of the Lamiaceae family, has about 1000 species worldwide. In the flora of Turkey, the genus *Salvia* is represented by 114 species, 58 of which are endemic. In the Central Anatolia region of Turkey, there are 43 species belonging to the genus Salvia (Güner et al., 2012, Tübives, 2022). There are most fragrant, mostly perennial species, as well as a biennial and annual species. Its flowers are white, yellow, pink, blue, or purple, with two lips. The genus *Salvia* is distributed in both hemispheres, especially in the tropics and subtropics, around the Mediterranean and Central Europe, and in Mediterranean countries, it is distributed from sea level to 1500 m (Dweck 2000; Arslan et al., 2015).

Essential oil is a volatile complex mixture in which many different chemical compounds, whether solid or liquid, dissolve in each other and form a homogeneous solution. The plant secondary metabolites such as essential oils, alkaloids, glycosides, saponins, balms, waxes, resins, etc. are the most basic products of food, cosmetics, paint, medicine, etc. industries directly or indirectly. Salvia species are especially rich in terpenoid components. Apart from these, they contain flavonoids, essential oils, and phenolic compounds (Mammadov, 2014).

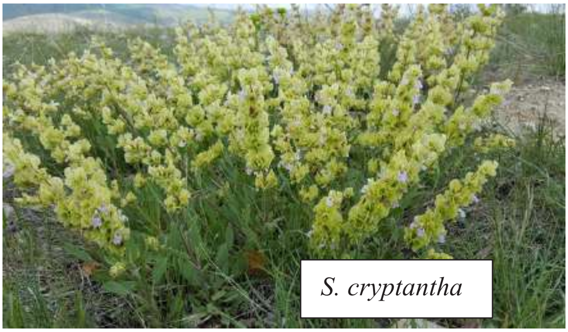
Essential oils of *Salvia* species are known as essential oils with very strong antiseptic and antibiotic effects. The usage areas of essential oils emerge as a result of the main component of these complex solutions and the effect of other components. For this reason, knowing the main component of essential oils also determines the usage area. Within the scope of this study, the usage areas of the major constituents of the essential oils determined by GC/MS of the *Salvia* taxa in the Yozgat/Turkey Flora were evaluated with the literature data.

MATERIAL AND METHOD

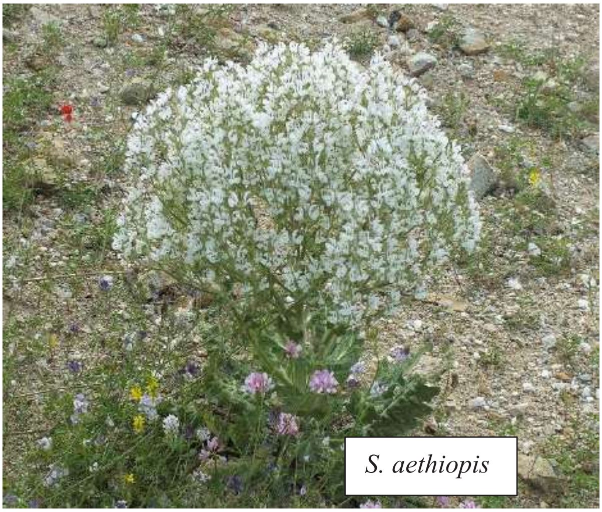
For the data used in this study, 10 *Salvia* taxa registered in Yozgat/Turkey Flora were collected from their natural habitat during flowering periods (Table 1, Figure 1).

Table 1. *Salvia* taxon

Taxon	Endemic
S. freyniana Bornm. ex Freyn	+
S. cryptantha Montbret & Aucher ex Benth.	+
S. sclarea L.	
S. aethiopis L.	
S. russellii Benth.	
S. verticillata L. subsp. *amasiaca* (Freyn & Bornm.)	
S. hypargeia Fisch. & C.A. May.	+
S. virgata Jacq.,	
S. candidissima Vahl. subsp. *occidentalis* Hedge	
S. cyanescens Boiss. & Balansa	+




S. sclarea


S. aethiopis


S. russellii

S. verticillata subsp. *amasiaca*

S. hypargeia

S. cyanescens

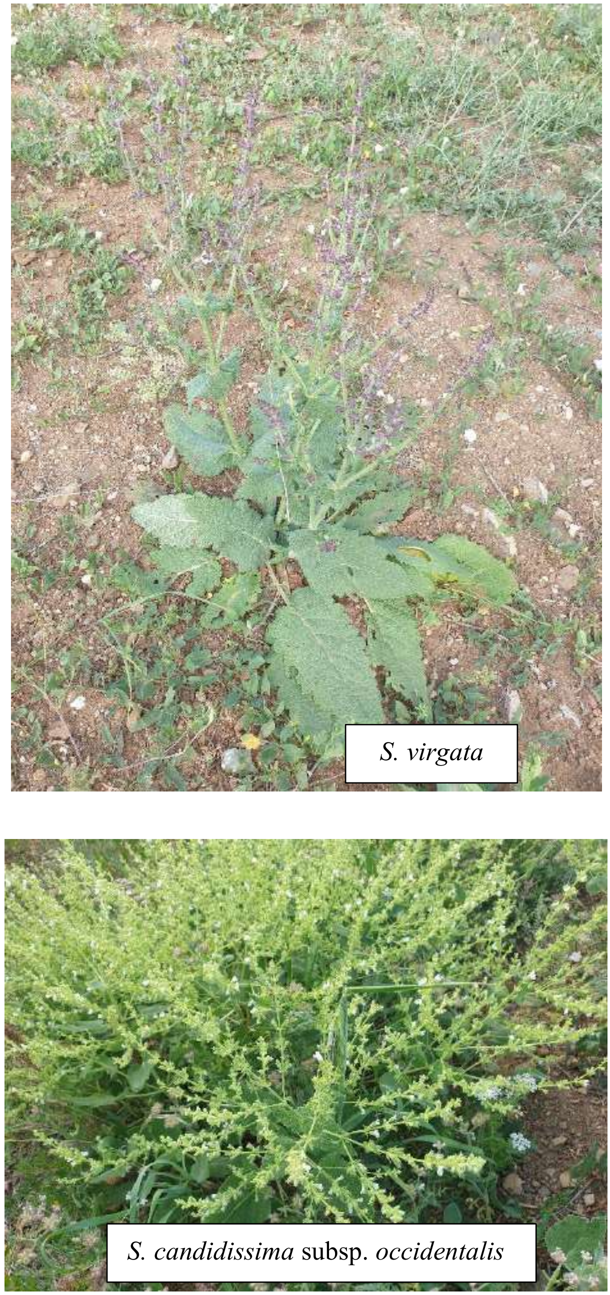


Figure 1. Images of *Salvia* taxa in the natural area

Essential Oil Determination and Component Analysis

The flowering aerial parts (herbage) of the plants obtained from the natural area were dried in the shade and an average of 50 g plant samples were subjected to water distillation for 3 hours using the Clevenger device. The chemical composition of the essential oils obtained was determined by GC/MS (Gas Chromatography/Mass Spectrometry). The usage areas of the main component(s) of essential oils have been evaluated with literature data.

DISCUSSION AND CONCLUSION

It was collected from the natural area during the flowering period of 13 *Salvia* taxa, 6 of which are endemic, in the Yozgat/Turkey. In the studies carried out, essential oil could not be obtained from *S. ceratophylla* L., *S. ekmiana* Celep & Doğan, and *S. yosgadensis* Freyn & Bornm. species. However, a sufficient amount of essential oil could not be obtained from these species for component analysis. The main components (5% and above) with the highest value among the chemical compositions of essential oils obtained from other taxa are presented in Table 2.

Table 2. Main components detected in essential oils of Salvia taxa

Taxa	Main components of essential oils
S. freyniana Bornm. ex Freyn	Spathulenol, Caryophyllene oxide, Valeranone, β-Guaiene, β-Farnesene
S. cryptantha Montbret & Aucher ex Benth.	Caryophyllene, Caryophyllene oxide, Spathulenol, β-copaene,1-Borneol, α-Humulene, Germacrene-D, Valeranone, α-Cadinol, Carotol, tau.-Cadinol, Humulene, Ledene oxide, Hexahydrofarnesyl acetone
S. sclarea L.	Spathulenol, Caryophyllene oxide, Linalyl 2-methylpropanoate, Sclareoloxide, geranyl-p-cymene , Sclareol, β-Eudesmol
S. aethiopis L.	α-Copaene, Isolongifolene, Caryophyllene oxide, Aromadendrene, α-Humulene epoxide, Isoaromadendrene epoxide, γ-Muurolene, β-copaene, Hexahydrofarnesyl acetone
S. russellii Benth.	Hexahydrofarnesyl acetone, Spathulenol, β-Guaiene, Caryophyllene oxide, Ledene oxide
S. verticillata L. subsp. *amasiaca* (Freyn & Bornm.)	Spathulenol, Caryophyllene oxide, β-Guaiene, Caryophyllene, Ledene oxide
S. hypargeia Fisch. & C.A. Mey.	6-epi-shyobunol, β-Guaiene, α-acorenol, Linalyl acetate, Spathulenol, Caryophyllene oxide, α-Eudesmol, 2-Pentadecanone, Phytol, Sclareol, Pentacosane, γ-Elemene, Ledene oxide, Hexahydrofarnesyl acetone
S. virgata Jacq.,	Pentacosane, Phytol, Caryophyllene oxide, Spathulenol

S. candidissima Vahl. subsp. *occidentalis* Hedge	Spathulenol, Caryophyllene oxide, γ-Himachalene, Ledene oxide
S. cyanescens Boiss. & Balansa	Spathulenol, Ledene oxide, Caryophyllene oxide,

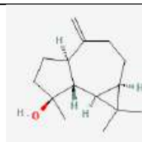
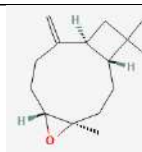
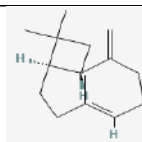
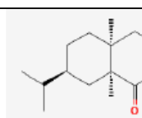
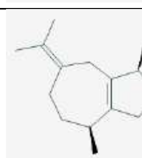
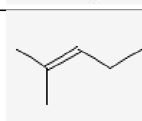
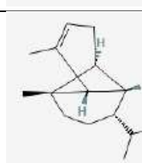
Intensive research has been carried out on the essential oil composition of many *Salvia* taxa. In some studies, the main components of essential oil were β-caryophyllene, α-copaene, germacrene-D, β-cubene, spathulenol, δ-cadinene and α-humulene in *S. aethiopis* (Morteza-Semnani et al.,2005); linalyl acetate, linalool, germacrene-D, α-terpineol, caryophyllene oxide, sclareol, spathulenol, 1H-naphto (2,1,6) pyran and β-caryophyllene in *S. sclarea,* (Sharopv and Setzar 2012; Yüce et al. ,2014); camphor, 1,8-cineole, borneol, viridifloral, valencene, eucalyptol and β-pinene in *S. cryptantha* (Akın et al., 2010; İpek et al., 2012); α-pinene, β-pinene, pulegone, and ylangene in *S. hypargeia* (Ataş et al., 2011); germacrene-D in *S. verticillata* L. subsp. *amasiaca* (Kunduhoğlu, 2011); β-caryophyllene, caryophyllene oxide, sabinene, 1-octen-3-ol, α-thujene, α-pinene, β-mycene and limonene in *S. virgata* (Alizadehi, 2013; Özdek and Fakir, 2019); sabinene, β-myrcene, linalool, γ-terpinene and α-thujene *S. candidissima* Vahl. subsp. *occidentalis* (Özdek and Fakir, 2019).

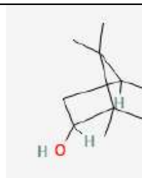
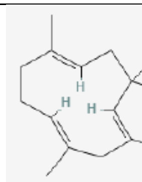
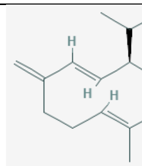
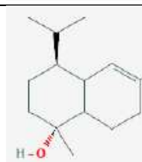
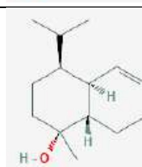
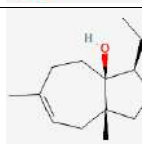
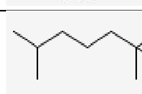
There is a wide variation among the *Salvia* taxa in terms of both the amount of essential oil and chemical components. The genetic structure of the plant and various environmental factors (such as temperature, precipitation, duration and intensity of light, altitude, direction, drought, salinity, soil structure, and plant nutrients) are effective in this situation (Rajabi et al., 2014). On the other hand, it has been reported that morphogenetic, ontogenetic, and diurnal variability also change the essential oil composition (Baydar, 2013). Secondary metabolites are generally more synthesized when plants are stressed. Because plants benefit from secondary metabolites to resist biotic and abiotic stress factors. For example, the essential oil ratios of medicinal and aromatic plants grown in hot and arid regions are higher than those grown in cool and rainy regions (Baydar, 2013; Mammadoz, 2014).

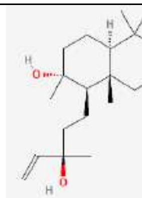
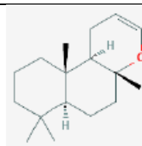
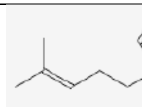
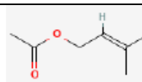
Salvia taxa are used in herbal treatment in the world and in our country, and they contain essential oil with a very strong antiseptic and antibiotic effect. For this reason, it is an additive of drugs made especially for throat infections, tooth inflammation, and mouth sores. It is a natural antibiotic due to effective substances such as cineol in the essential oil (Baydar, 2013; Seçkin 2014). In general, *Salvia* species have been observed to exhibit a wide range of biological effects (antibacterial, antifungal, antiviral, antiseptic, analgesic, antioxidant, astringent, antispasmodic, hallucinogenic, central nervous system depressant, antisudorific, emmenagogue, antidiabetic, anticancer, tuberculostatic, cardio-vascular and insecticide, etc.) (Karamanos, 2000).

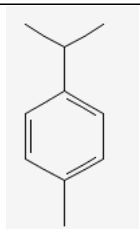
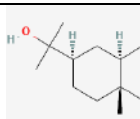
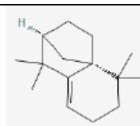
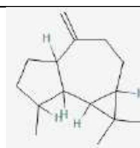
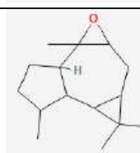
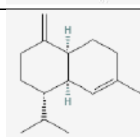
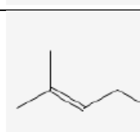
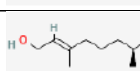
The biological activity and uses of the main components of the essential oils obtained from the *Salvia* taxa evaluated in the studies are presented in Table 3.

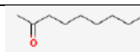
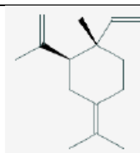
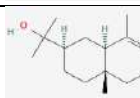
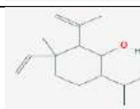
Table 3. Biological activity and uses of the main components of essential oils[1]

Components	**Molecule Structure**	**Molecule Formula**	**Biological Activity**	**Uses**
Spathulenol		$C_{15}H_{24}O$	Cytotoxicity	
Caryophyllene oxide		$C_{15}H_{24}O$	Antispasmodic Cytotoxicity Insecticidal	Cleaning products and home care-air fresheners Sweetener Used as fragrance and flavoring agent
Caryophyllene		$C_{15}H_{24}$	Agonist Antiviral Anti-tripanozomal Antimicrobial Nematicide Insecticidal	Food additives - Sweeteners Cleaning products and home care - air freshener - bathroom cleaner
Valeranone		$C_{15}H_{26}O$		
β-Guaiene				
Farnesene		$C_{15}H_{24}$		Food additives - Sweeteners Perfume
Copaene		$C_{15}H_{24}$		

Borneol		$C_{10}H_{18}O$	Antifungal	It is used in the production of esters. in perfumery and incense and as a food flavoring agent Cleaning and personal care products
Humulene		$C_{15}H_{24}$	Cytotoxicity Antimicrobial Antituberculosis Antimalarial	
Germacrene-D		$C_{15}H_{24}$	Antibacterial Anti-inflammatory	
Cadinol		$C_{15}H_{26}O$		
tau.-Cadinol		$C_{15}H_{26}O$		
Carotol		$C_{15}H_{26}O$		
Ledene oxide		$C_{15}H_{24}O$		
Hexahydrofarnesyl acetone		$C_{18}H_{36}O$		Sweetener Smell Fragrance component

Sclareol		$C_{20}H_{36}O_2$	Cytotoxicity Antibacterial Anti-Inflammatory Antiplasmodial	Food additives - Sweeteners Smell Fragrance component Perfume
Sclareol oxide		$C_{18}H_{30}O$		
Linalyl 2-methylpropanoate Syn: Linalyl isobutyrate		$C_{14}H_{24}O_2$	Cytotoxicity Acetylcholinesterase (Ache)	Food additives - Sweeteners Smell Fragrance component Perfume
Geranyl acetate		$C_{12}H_{20}O_2$	Cytotoxicity Agonist Activity Acetylcholinesterase (Ache)	Cleaning products and home care--air freshener -- bathroom-bathroom cleaner --washing powder Sweetener Smell Personal care - Fragrances, colognes and perfumes Personal care - make-up and related - lip color Colored lip products excluding glosses Pesticides - insect repellent Various products to repel insects, including citronella type waxes (excluding products to be applied to the skin)

p-cymene		$C_{10}H_{14}$	Nematocidal Antioxidant Insecticidal Repellant Antimicrobial Nematicidal Anticonvulsant Sedative	Cleaning products and home care - air freshener - bathroom cleaner Sweetener--Odor
β-Eudesmol		$C_{15}H_{26}O$	Agonist Cytotoxicity Antihepatotoxic Insecticidal Antifungal Antitumor	
Isolongifolene		$C_{15}H_{24}$	Cytotoxicity	Cleaning products and home care - air freshener (Domestic air fresheners, including scented candles) Sweetener Smell Perfume
Aromadendrene		$C_{15}H_{24}$		
Isoaromadendrene epoxide		$C_{15}H_{24}O$		
γ-Muurolene (gama)		$C_{15}H_{24}$		
Linalyl acetate		$C_{12}H_{20}O_2$		
Phytol		$C_{20}H_{40}O$	Anti-Inflammatory Antiproliferative	Plasticizer Sweetener Smell Perfume

			Cytotoxicity Vasodilator Analgesic Antimicrobial Antimycobacterial	Emollient and conditioner
Pentacosane		$C_{25}H_{52}$	Anticancer	They are mainly used in applications where isoalkanes are not acceptable for biological reasons, eg for detergent or protein production.
2-Pentadecanone		$C_{15}H_{30}O$	Hypocholesterolemic Agonist	Sweetener Smell
γ-Elemene		$C_{15}H_{24}$		
α-Eudesmol		$C_{15}H_{26}O$		
6-epi-shyobunol		$C_{15}H_{26}O$		

[1]PumChem, 2022

Within the scope of the studies, we have carried out, 10 *Salvia* taxa, four of which are endemic, have been identified in the Flora of Yozgat/Turkey. It was determined that *Salvia* taxa, which were examined in the flora of Yozgat/Turkey, exhibited significant biological activity. As a result of the research, it was determined with the literature data that the main components determined in the essential oils of the taxa are important areas of use. It is important to focus on efforts to bring economically important taxa (such as *S. sclarea*) into the economy.

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CESTODE PARASITES OF SOME MARINE FISHES FROM TURKISH COAST OF THE BLACK SEA

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INTRODUCTION

Cestoda is a class of parasitic flatworms of phylum Platyhelminthes. The class includes two subclasses, Cestodaria and Eucestoda. Adult cestodes are known as tapeworms and they are parasites by complex life cycle, which develop in distinct hosts. Typically the adults live in the digestive tracts of all groups of vertebrates (usually in the intestine), while the larvae (metacestodes) often live in the different organs and body cavity of animals, either vertebrates or invertebrates (Scholz et al., 2021).

CESTODE CHARACTERISTICS

Morphological Features

Cestodes typically have an elongated, bilaterally symmetrical, usually rather dorsoventrally flattened in shape and made up of many segments. The segments as called proglottids. A few cestodes have unsegmented bodies of moderate length and are referred to as monozoic, segmented cestodes being polyzoic (Anonymous, 2022a). The body of a typical adult cestode consists of three parts: the head, the neck, and the trunk (Figure 1).

The head is referred to as scolex. Cestodes has various attachment organelles such as bothridia, muscular suckers, rostellum, hooks or tentacles that aid them in attacthing to the intestine of their host with species-specific shapes and numbers. Some cestode groups possess scolex that bear weakly muscular elements called bothria (Caira et al., 1999).

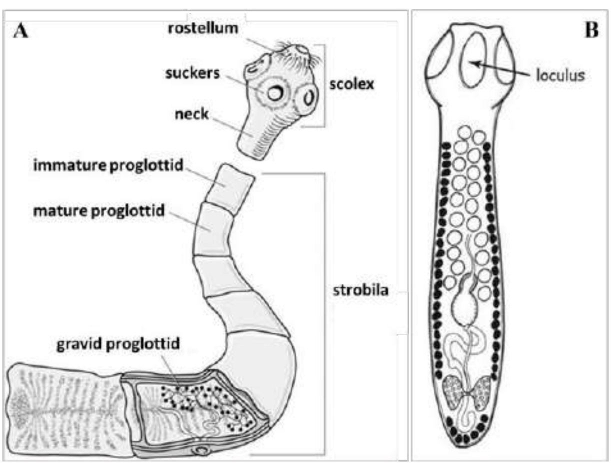

Figure 1. General cestoda morphology. **A.** Polyzoic cestoda, **B.** Monozoic cestoda (Anonymous, 2022b; 2022c)

Some cestode groups possess scolex that four spherical muscle suckers or bothridia, apical muscle sucker, apically located rostellum, often armed with hooks, four reversible tentacles with hooks (Caira & Jensen, 2017). Some cestode species have frilly or leafy scales and may have other structures to aid in attachment (Figure 2).

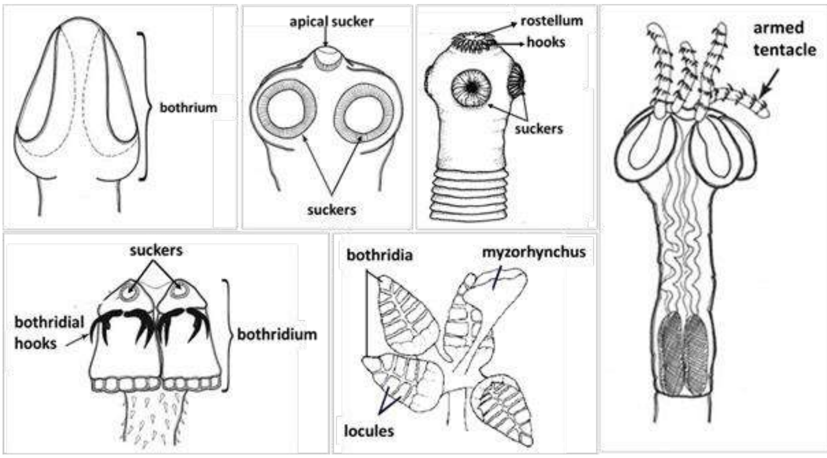

Figure 2. Scolex morphology of monozoic and polyzoic cestodes (Anonymous, 2022c)

The neck is just behind the scolex. It is the narrowest part of the body that contains germination tissue from which immature segments called proglottids are produced. The trunk is called strobila and it consist of proglottids that consecutively contain by stages immature, mature and gravid proglottides. Each individual proglottid contains both male and female gonads, and these proglottids are capable of self-fertilization (Scholz & Kuchta, 2017).

Morphology and strobilar anatomy of scolex, particularly the genital system's structure, are very important for classification of and identification of tapeworms (Caira & Jensen, 2017; Khalil et al., 1994).

Cestodes have primitive excretory system and nervous system. They haven't eye spots or light-sensitive structures. Moreover, they also lack mouths, gastrovascular cavities, or other digestive organs. Its feeding function is performed by the tegument, which contains unique, hair-like or cilia-like structures called microtriches (singular microtrix) that are about 1 to 2 micrometres in length and vary in shape, on the parasite's outer surface (Figure 3A) (Chervy, 2009). They absorb nutrients through their tegument directly from the host's digestive tract. The tegument is highly folded, which increases the surface area available for absorption.

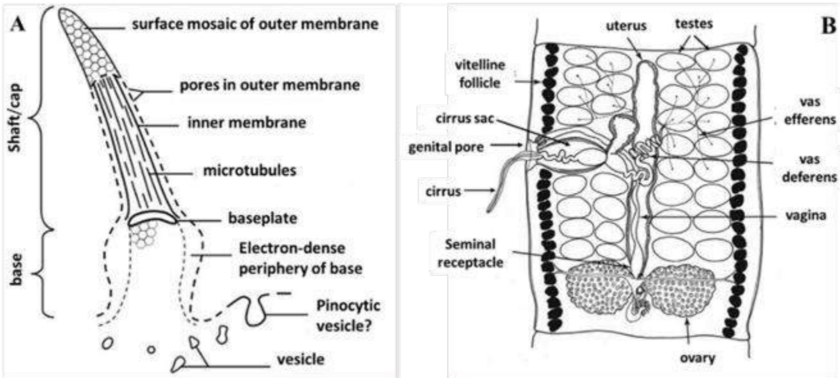

Figure 3A. Ultrastructure of a microtrix (Anonymous, 2022d), **B.** Mature proglottid showing reproductive organs (Anonymous, 2022c)

They are hermaphrodites, that is possess both male and female reproductive systems in each proglottids. The male reproductive system consist of one or more testes, cirrus, vas deferens, and seminal vesicles, while the female reproductive system consist of a single lobed or unlobed ovary with the connecting oviduct and uterus. Genital pore which is a common external opening for both male and female reproductive systems, is situated at the surface opening of the cup shaped atrium (Figure 3B). In the most cestodes, the strobila is polyzoic, that is, it consist a succession of many proglottids. Each proglottid includes one, rarely more sets of male and female reproductive organs. However, some fish cestodes are monozoic, containing just a single set of genital organs (Scholz & Kuchta, 2017).

Life cycle

All cestodes life cycle include 3 stages - eggs, larvae, and adults. Adults present the intestines of definitive or final hosts. Eggs laid by adult cestodes in the intestines of definitive or final hosts are excreted with feces into the environment. The eggs are ingested by an intermediate host and enter the circulation of the intermediate host, and which develop encyst in the musculature or other organs, hatch into larvae. When the definitive or final host eats the intermediate host to be raw or undercooked, ingested encysts released to the in intestine and encycts hatch thus into adult cestodes, thus restarting the cycle. Generally in aquatic ecosystem, the first intermediate host is a copepods, the second intermediate host (sometimes final host) is a fish and the final host is a fish-eating bird, mammal or other fish. Fish can harbour two stages of the life cycle of cestodes: adults which placed in the intestinal tract and metacestodes, which are usually located in the body cavity, in the internal organs or in muscles (Hoole, 1994).

Diversity

Cestode parasites are foun widespread throughout the world. They occur in almost all terrestrial, marine, brackish, and freshwater habitats where vertebrate animals live.

To date, approximately 5000 species of cestodes, taxonomically classified into 19 orders, have been reported as parasites in all vertebrate groups, including humans (Table 1).

As seen in Table 1, about 1000 species of these cestodes have been reported in Chondrichthyan (Elasmobranchs) and about 500 species in Teleost fishes (Caira & Jensen, 2017; Scholz & Kuchta, 2017).

When the cestode faunas of elasmobranch and teleosts are compared; nine orders and 1.034 species have been reported in elasmobranchs, while seven orders and only 465 cestode species have been reported in the teleost fish (Table 1). Also, only three of the seven orders parasitizing bony fish contain more than 50 species, while seven of the nine orders parasitizing elasmobranchs have much more than 50 species (Table 1).

Table 1. Number of valid genera and species in the class Cestoda according to Caira et al., (2017). (Major host groups listed in order of decreasing cestode diversity; minor host groups enclosed in parentheses).

Cestode order	Major Vertebrate Host Group	Genera	Species
Amphilinidea	Bony Fishes, Turtles	6	8
Bothriocephalidea	Bony Fishes	48	132
Caryophyllidea	Bony Fishes	42	122
Cathetocephalidea	Elasmobranchs	3	6
Cyclophyllidea	Birds, Mammals, Lizards & Snakes, (Amphibians)	437	3034
Diphyllidea	Elasmobranchs	6	59
Diphyllobothriidea	Mammals	18	70
Gyrocotylidea	Holocephalans	1	10
Haplobothriidea	Bony Fishes	1	2
Lecanicephalidea	Elasmobranchs	29	90
Litobothriidea	Elasmobranchs	1	9
Nippotaeniidea	Bony Fishes	1	6
Onchoproteocephalidea	Bony Fishes, Lizards & Snakes, Amphibians, (Turtles) And (Mammal)	68	316
	Elasmobranchs	11	246
Phyllobothriidea	Elasmobranchs, (Holocephalans)	24	69
Rhinebothriidea	Elasmobranchs	26	164
Spathebothriidea	Bony Fishes	5	6
Tetrabothriidea	Birds, Mammals	6	70
Tetraphyllidea	Elasmobranchs	25	104
Trypanorhyncha	Elasmobranchs	81	315
Total		833	4810

Comprehensive data have been published on the cestoda parasites in the Black Sea basin, especially on the coasts and estuaries of the Northern Black Sea (Kornyushin & Polyakova, 2012; Pogorel'tseva, 1960; Polyakova et al., 2017; Polyakova 2020; Vasileva et al., 2002), but there are few studies on the coasts of the Southern Black Sea (Güneydağ et al., 2017; Özer et al., 2014; Özer et al., 2016; Tepe et al., 2014). The aim of this research is to examine the current status of cestoda parasites in marine fishes living in the Black Sea coasts of Turkey, based on original data.

EXAMINED FISH SPECIES

This research was performed in the Sinop coasts of the Black Sea. Fish samples were collected from commercial fishing vessels between June 2015 to May 2017 and brought to the Parasitology Research Laboratory of the Faculty of Fisheries of Sinop University. They were dissected to for cestode parasites using conventional methods under the dissecting microscope. A total of 1956 specimens belonging to 34 fish species, 32 Teleostean and 2 Chondrichthyan, were examined. The body cavity, visceral organs and the contents of the intestines of fish were investigated. Cestodes were recovered either studied fresh or frozen fish samples. Relaxation, fixation, staining and mounting of the collected cestoda parasites were carried out according to Pritchard & Kruse (1982). Cestode larvae were flattened between a slide and a coverslip. The infection prevalence (%) and mean intensity values were calculated according to Bush et al., 1997.

DETERMINED CESTODE SPECIES

In the present study, 19 of 34 fish species examined were determined to be infected with cestode parasites and a total of 9 cestode parasites were identified (Table 2). Among them 3 species, *Scolex pleuronectis, Bothriocephalus scorpii* and *Progrillotia dasyatitis* were detected only on Teleost fish. On the other hand, 5 species of cestodes, *Tetrarhynchobothrium tenuicolle, Echeneibothrium variabile, Acanthobothrium coronatum, Yamaguticestus squali* and *Bothriocephalus* sp. were founded on Chondrichthyan fish. *Grillotia (Grillotia) erinaceus* was detected both Teleost and Chondrichthyan fishes. The infection prevalence (%) and mean intensity values were determined for each cestode species on respective hosts.

Table 2. List of identified cestode species detected in marine fishes from Turkish coast of the Black Sea

Order and species	stages
Order: Tetraphyllidea	
Scolex pleuronectis Müller, 1788	larva
Order: Trypanorhyncha	
Progrillatia dasyatitis Neveridge, Neifar & Euzet, 2004	larva
Grillotia (Grillotia) erinaceus (van Beneden, 1858) Guiart, 1927	larva
Tetrarhynchobothrium tenuicolle Diesing, 1850	adult
Order: Rhinebothriidea	
Echeneibothrium variabile van Beneden, 1850	adult
Order: Onchoproteocephalidea	
Acanthobothrium coronatum (Rudolphi, 1819) Blanchard, 1848	adult
Order: Phyllobothriidea	
Yamaguticestus squali (Yamaguti, 1952) Caira, Bueno & Jensen, 2021	adult
Order: Bothriocephalidea	
Bothriocephalus scorpii (Müller, 1776) Cooper, 1917	adult
Bothriocephalus sp.	adult

TETRAPHYLLIDEA

Scolex pleuronectis Müller, 1788

Subclass: Eucestoda
Family: Tetraphyllidea *incertae sedis*
Genus: *Scolex*
Species: *Scolex pleuronectis* (status: unaccepted - larval name)

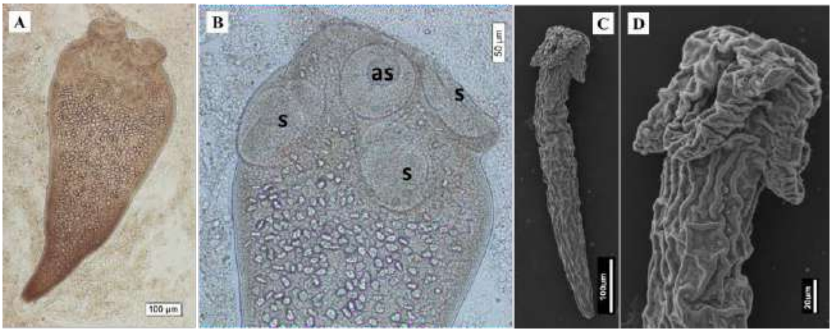

Figure 4. Light micrographs (LM) and Scanning electron micrographs (SEM) of *Scolex pleuronectis* Müller, 1788 (plerocercoids). **A.** total view (LM), **B.** scolex (LM), **C.** total view (SEM), **D.** scolex (SEM), **as**: apical sucker, **s**: sucker

The genus *Scolex* is used as a collective group named for plerocercoids of unknown generic affinity. Since Tetraphyllidea larvae in the plerocercoid stage display different morphological types, it is very difficult to morphologically identify the species of these larvae. Therefore, these plerocercoids are named *Scolex pleuronectis* Müeller, 1788, which was proposed as a common name by Chambers et al. (2000).

Scolex pleuronectis was the most common cestode species infected 17 different teleost fish species (Table 3). The larval specimens of this parasite was detected in the examined fish species, but its adult specimens was not found. The highest mean intensity value was determined in *O. rochei*, the lowest prevalence value was determined in *T. trachurus* (Table 3).

Table 3. Prevalance (%), mean intensity (MI) values of *S. pleuronectis* (plerocercoid) in some marine from Sinop coasts of the Black Sea

Hosts	N	P (%)	M.I. ± SD	Min-Max
Zosterisessor ophicephalus	6	100.0	43.66 ± 14.94	5-98
Ophidion rochei	13	92.3	124.00 ± 34.78	4-418
Arnoglossus laterna	22	81.8	85.72 ± 50.71	23-223
Mesogobius bathriocephalus	122	72.1	43.81 ± 49.04	1-266
Gobius niger	80	67.5	31.14 ± 21.02	1-211
Platichthys flesus	4	50.0	32.00 ± 7.07	27-37
Chelidonichthys lucerna	10	40.0	41.75 ± 21.09	21-71
Gobius cruentatus	5	40.0	8.50 ± 10.61	1-16
Gaidropsarus mediterraneus	99	36.4	29.81 ± 8.31	1-244
Merlangius merlangus	13	23.1	1.00 ± 0.00	1
Spicara flexuosum	90	17.2	5.00 ± 7.98	1-34
Trachinus draco	27	11.1	9.00 ± 7.00	1-14
Neogobius melanostomus	170	8.3	3.00 ± 2.80	1-10
Scorpaena porcus	173	6.0	3.93 ± 2.44	1-12
Solea solea	140	5.7	18.62 ± 23.86	1-50
Mullus barbatus	29	3.5	1.00 ± 0.00	1
Trachurus trachurus	147	1.4	1.50 ± 0.50	1-2

(N: examined fish number, SD: Standard deviation)

Scolex pleuronectis was previously reported in *Merlangius merlangus*, *Ophidion rochei*, *Sarda sarda*, and *Trachurus mediterraneus* by Dimitrov (1989); in *Liza aurata*, *L. saliens* and *Mugil cephalus* by Dmitrieva & Gaevskaya (2001); in *Belone belone* and *T. mediterranneus* by Polyakova (2009); in *S. porcus*, *M. barbatus*, *T. mediterraneus, Symphodus ocellatus, G. mediterraneus, Atherina hepsetus, Gobius niger, Gobius bucchichi, N. melanostomus*, *Ponticola eurycephalus, Aidablennius sphynx* and *Spicara smaris* by Polyakova (2020) in the northern coasts of Black Sea. In addition, several marine fish in the Turkish coast of the Black Sea have been reported by various authors (Table 4).

The presence of *S. pleuronectis* in *Chelidonichthys lucerna*, *Trachinus draco* and *Scorpaena porcus* is reported for the first time in the Turkish coasts of the Black Sea. Thus, the intermediate host list of *S. pleuronectis* has expanded by the addition of *Chelidonichthys lucerna*, *Trachinus draco*.

Table 4. Infection parameters of *S. pleuronectis* (plerocercoid) reported in host fish species from the Turkish coast of the Black Sea.

Host	P (%)	Intensity	References
Merlangius merlangus	3.2 25.0	1.0 17.5	Özer et al., 2015
Gaidropsarus mediterraneus	12.5	2.0 ± 0.0	Güneydağ et al., 2017
Trachurus trachurus	4.76	1.0 ± 0.0	Güneydağ et al., 2017
Spicara flexuosa	20.0	6.8 ± 3.2	Güneydağ et al., 2017
Zosterisessor ophicephalus	20.0	4.0 ± 0.0	Güneydağ et al., 2017
	100.0	43.66 ± 36.61	Öztürk & Güven 2021
Neogobius melanostomus	1.44	55.0 ± 0.0	Güneydağ et al., 2017
	8.3	3.00 ± 2.80	Öztürk & Güven 2021
Ophidion rochei	33.0	1.0	Tepe et al., 2014
Mullus barbatus ponticus	2.12	1.57 ± 0.30	Öztürk & Yeşil 2018
Solea solea	5.71	18.62	Güven & Öztürk 2019
Arnoglossus laterna	81.82	85.72	Güven & Öztürk 2019
Mesogobius bathriocephalus	72.1	43.81 ± 49.04	Öztürk & Güven 2021
Gobius niger	67.5	31.14 ± 36.17	Öztürk & Güven 2021
Gobius cruentatus	40.0	8.50 ± 10.61	Öztürk & Güven 2021

Scolex pleuronectis plerocercoid that found previously in this region, were also found in the same or different fish hosts in this study (Table 3 and Table 4).

TRYPANORHYNCHA

Cestodes of order Trypanorhyncha Dising, 1863 are among the most common parasites of marine fishes (Palm, 2004). These parasites are characterized by a scolex with two or four bothria and a tentacular apparatus comprised of four retractable tentacles (Rohde, 2005). They have a complex life cycle and use elasmobranch fish as a final host, small crustaceans as first host and teleosts or other invertebrates such as cephalopods as second intermediate hosts (Palm et al., 1997). In general, they use two intermediate host for the life cycle, but in some cases, only a single intermediate host is adequent. Alternatively, in some species, paratenic hosts may harbor the plerocerci until a final host is available (Rohde, 2005).

In the present study, 3 cestode species belonging to Progrillotiidae, Lacistorhynchidae and Echeneibothriidae families of Trypanorhyncha order were identified.

***Progrillotia dasyatidis* Beveridge, Neifar & Euzet, 2004**

Family: Progrillotiidae
Genus: *Progrillotia*
Species: *Progrillotia dasyatidis*
Original name: *Progrillotia dasyatidis* Beveridge, Neifar & Euzet, 2004

In this study, *Progrillotia dasyatis* (Figure 5) was detected in 10 of 34 fish species examined (Table 5).

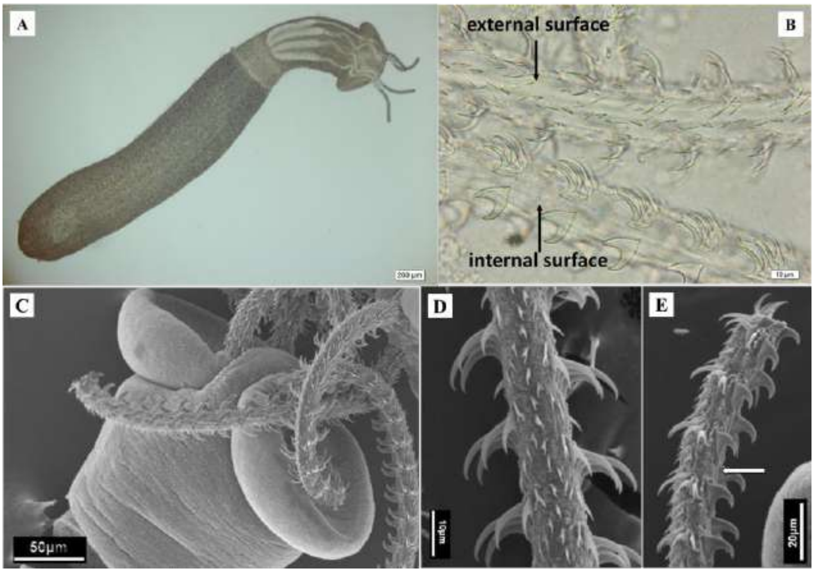

Figure 5. Light micrographs (LM) and Scanning electron micrographs (SEM) *Progrillotia dasyatidis* Beveridge, Neifar & Euzet, 2004 (Larva). **A.** Total view of plerocerci (LM), **B.** tentacles (LM), **C.** botria and tentacles (SEM), **D.** external tentacle surface (SEM), **E.** internal tentacle surface (SEM)

Progrillotia Dollfus, 1946 is the only genus of the family Progrillotiidae Palm, 2004. It consists of three species parasitic in rays as adults: *P. pastinacae, P. louiseuzeti* and *P. dasyatidis* (Beveridge et al., 2004, 2017; Marques et al., 2005; Palm, 2004;). Larvae have been recorded in marine demersal and pelagic teleosts from coastal Atlantic waters as well as from the Black Sea, Marmara Sea and the Persian Gulf (Al-Niaeem et al., 2014; Çelik & Oğuz, 2021; Marques et al., 2005; Oguz & Bray, 2008; Özer & Öztürk, 2017; Palm, 2004; Polyakova et al., 2014, 2017;).

Tablo 5. Prevalance (P), mean intensity (MI) values of *P. dasyatitis* in some marine from Sinop coasts of the Black Sea

Hosts	N	P (%)	M.I. ± SD	Min-Max

Mesogobius bathriocephalus	122	91.80	21.90 ± 19.05	1-127
Arnoglossus laterna	22	77.27	15.65 ± 10.79	5-37
Ophidion rochei	13	76.92	6.20 ± 7.16	1-15
Zosteriosessor ophicephalus	6	66.67	5.25 ± 6.65	1-15
Gaidropsarus mediterraneus	99	49.50	13.96 ± 15.79	1-85
Gobius niger	80	42.50	1.50 ± 0.76	1-4
Mullus barbatus	29	24.14	7.00 ± 4.16	1-10
Solea solea	140	6.43	5.44 ± 10.88	1-34
Scorpaena porcus	173	4.62	1.13 ± 0.35	1-2
Neogobius melanostomus	170	1.2	1.0 ± 0.0	1

The highest mean intensity and prevalence values were determined in *M. bathriocephalus*, the lowest mean intensity and prevalence values were in *N. melanostomus* (Table 6).

Table 6. Infection prevalence and intensity values of *P. dasyatidis* reported in host fish species from the Turkish coast of the Black Sea.

Host	**P (%)**	**Intensity**	**References**
Uranoscopus scaber	4.0	4.5	Tepe et al., 2014
Mullus barbatus	18.0	3.3	Tepe et al., 2014
	38.8	3.3	Öztürk & Yeşil, 2018
Mullus surmuletus	17.0	2.0	Çelik & Oğuz, 2021
Chelidonichthys lucerne	100.0	2.0	Çelik & Oğuz, 2021
Scorpaena porcus	4.3	1.0	Çelik & Oğuz, 2021
Gaidropsarus mediterraneus	33.0	1.5	Tepe et al., 2014
Ophidion rochei	67.0	20.5	Tepe et al., 2014
Gobius niger	44.0	4.0	Tepe et al., 2014
	34.4	2.6	Çelik & Oğuz, 2021
	42.50	1.5	Öztürk & Güven 2021
N. melanostomus	1.2	1.0	Öztürk & Güven 2021
M. bathriocephalus	91.8	21.9	Öztürk & Güven 2021
Z. ophicephalus	66.7	5.25	Öztürk & Güven 2021

In the Black Sea, *P. dasyatidis* has been recorded from *D. pastinaca* and *R. clavata* (Polyakova et al., 2017) as well as from several demersal and pelagic teleost fishes (Çelik & Oğuz, 2021; Kornyychuk et al., 2016a, b; Öztürk & Yesil, 2018; Polyakova et al., 2014; Polyakova, 2020; Tepe et al., 2014; 2022).

Progrillotia dasyatitis plerocerci is the first time recorded in *Solea solea* and *A. laterna* from Turkish coasts of the Black Sea with this study.

Grillotia (Grillotia) erinaceus **(van Beneden, 1858) Guiart, 1927**

Family: Lacistorhynchidae
Subfamily: Grillotiinae
Genus: *Grillotia*

Subgenus: *Grillotia (Grillotia)*

Species: *Grillotia (Grillotia) erinaceus*

Original name: *Tetrarhynchus erinaceus* van Beneden, 1858

Alternate representation: *Grillotia erinaceus* (van Beneden, 1858) Guiart, 1927

Synonymised names: *Anthocephalus granulum* Rudolphi, 1819, *Grillotia pseuderinaceus* Dollfus, 1969, *Grillotia recurvispinis* Dollfus, 1969, *Heterotetrarhynchus erinaceus* (van Beneden, 1858) Pintner, 1929, *Rhynchobothrium imparispine* Linton, 1897, *Tetrarhynchus erinaceus* van Beneden, 1858

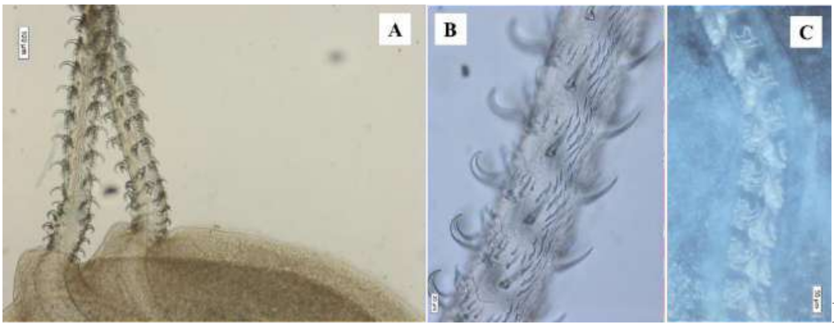

Figure 6. *Grillotia (Grillotia) erinaceus* (van Beneden, 1858) Guiart, 1927. **A.** botrial surface and tentacles, **B.** tenctacle surface, **C.** hooks inside tentacle tube

Species of the cestode genus *Grillotia* Guiart, 1927 are among the most commonly encountered trypanorhynch cestodes, either as the adult in elasmobranchs or as the larval stage in teleosts.

In the study, while *G. erinaceus* plerocercoids (Figure 6) were detected in teleost fish, *P. flesus* and *M. merlangus*, adult individuals of the parasite were detected in *R. clavata*.

The plerocercoids were obtained from the wall of the anterior oesophagus, stomach and pyloric caeca of teleost fishes, *Platichthys flesus and Merlangius merlangus* and adults were collected from the intestine of elasmobranch thornback rays, *Raja clavata.* The highest mean intensity value was determined in *R. clavata* (Table 7).

Tablo 7. Prevalance (P), mean intensity (MI) values of *G. erinaceus* in some marine from Sinop coasts of the Black Sea

Hosts	N	P (%)	M.I. ± SD	Min-Max
Platichthys flesus	4	25.00	6.00 ± 0.00	6
Merlangius merlangus	13	23.08	1.00 ± 0.00	1-1
Raja clavata	20	10.00	18.15 ± 4.95	13-39

To date, adults of this species have been reported in 24 elasmobranch species and plerocercoids in 62 teleost fish species (Menoret & Ivanov, 2012). *Grillotia erinaceus* was previously reported in *Odontogadus merlangus euxinus*, *Spicara smaris*, and *Trachurus mediterraneus* by Dimitrov (1989); in *Merlangius merlangus euxinus* by Polyakova (2009); in *M. merlangus* and *R. clavata* by Özer et al. (2020); in *R. clavata* by Polyakova (2020) in the Black Sea. The present study is the first to report on presence *G. erinaceus* plerocercoid in *P. flesus* from this geographic locality.

Tetrarhynchobothrium tenuicolle **Diesing, 1850**

Family: Eutetrarhynchidae
Genus: *Tetrarhynchobothrium*
Species: *Tetrarhynchobothrium tenuicolle*
Original name: *Tetrarhynchobothrium tenuicolle* Diesing, 1850

The trypanorhynch genus *Tetrarhynchobothrium* currently comprises 5 marine species, namely *T. australe, T. rossii, T. striatum, T. tenuicolle* and *T. unionifactor*.

In the present study, *T. tenuicolle* was found in the intestine of elasmobranch thornback rays, *Raja clavata* and picked dogfish, *Squalus acanthias*. The prevalence and mean intensity values were determined in 23.08% and 1.0 ± 0.00 for *R. clavata,* and 20% and 3.00 ± 0.00 for *S. acanthias*, respectively.

Scolex with two bothridia and four rectactile tentacles armed with spiral rows of hooks and all hooks are of the same size (Figure 7).

Figure 7. *Tetrarhynchobothrium tenuicolle* Diesing, 1850. **A-B.** scolex, **C**. tentacle, **D.** proglottid

Tetrarhynchobothrium tenuicolle has been recorded from *D. pastinaca* and *R. clavata* (Polyakova et al., 2017) in the Black Sea. However, this cestode was not detected again in later studies related with fish cestodes of the Karadag nature reserve and adjacent water areas of the Black Sea (Polyakova, 2020). Akmırza

(2013) recorded *T. tenuicolle* from *Squalus acanthias* from the North Aegean Sea, Türkiye. Until now, no records *T. tenuicollis* from Turkish coasts of the Black Sea have been published. This study is the first report of *T. tenuicollis* in *S. acanthias* and *R. clavata* off the Turkish coast of the Black Sea.

RHINEBOTHRIIDEA

***Echeneibothrium variabile* Van Beneden, 1850**

Family: Echeneibothriidae
Genus: *Echeneibothrium*
Species: *Echeneibothrium variabile*
Original name*: Echeneibothrium variabile* Van Beneden, 1850

Adult members of *Echeneibothrium* have a scolex with a myzorhynchus and quadruple stems with multiple possible locules on their distal surfaces (Figure 8), but they have not accessory sucker. Neck is present. Testes is expend longitudinally in intervascular field. The ovary is located at the posterior end of the proglottids.

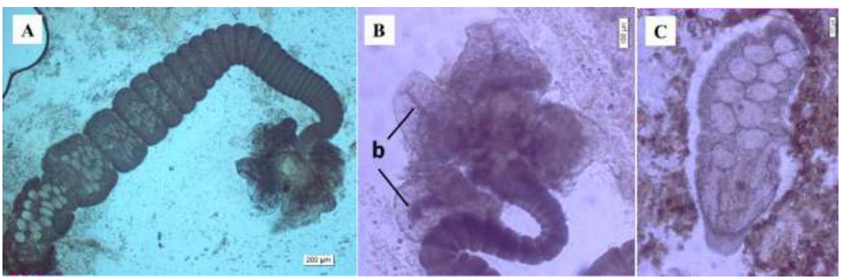

Figure 8. *Echeneibothrium variabile* Van Beneden 1850. **A.** adult specimen, **B.** scolex, **C.** mature proglottid. **b:** bothria

Echeneibothrium is one cestode genus among the 26 genera belonging to the order Rhinebothriidea (Boudaya et al., 2020; Coleman et al., 2019; Franzese & Ivanov, 2020; Ruhnke et al., 2017). They have a high degree of specificity for their definitive host.

Echeneibothrium variabile has been reported from *R. clavata* by Polyakova et al. (2017) and Polyakova (2020) in the Black Sea. Similarly, in this study, *E. variabile* was found in the intestine of *R. clavata* (Chondrichthyes: Elasmobranchii). The prevalence and mean intensity values were determined in 50.0% and 16.00±13.41, respectively.

ONCHOPROTEOCEPHALIDEA

***Acanthobothrium coronatum* (Rudolphi, 1819) Blanchard, 1848**

Family: Onchobothriidae
Genus: *Acanthobothrium*
Species: *Acanthobothrium coronatum*
Original name: *Bothriocephalus coronatus* Rudolphi, 1819
Synonymised names: *Bothriocephalus coronatus* Rudolphi, 1819, *Calliobothrium coronatum* (Rudolphi, 1819) Diesing, 1863

Scolex with four bothridia, each divided into three loculi by two transverse septa. In front of each bothridia one pair of symmetrically forked hooks (Figure 9).

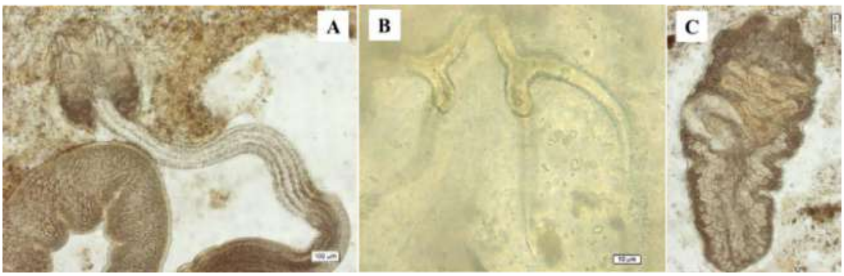

Figure 9. *Acanthobothrium coronatum* (Rudolphi, 1819) Blanchard, 1848. **A.** adult specimen, **B.** bothrial hooks, **C.** mature proglottid.

In the present study, adult specimens of *A. coronatum* was found in the intestine of elasmobranch thornback rays, *Raja clavata* and picked dogfish, *Squalus acanthias.* The prevalence and mean intensity values were determined in 60.0% and 2.50 ± 2.38 for *R. clavata,* and 80.0% and 17.08 ± 3.49 for *S. acanthias*, respectively.

Acanthobothrium is the most particular genus of onchoproteocephalidean cestodes, contain than more 208 valid species parasitizing the intestine of elasmobranch fishes as adults. Previously, a total of 3 species belonging to this genus, one of which is endemic *A. pontica*, and the others are *A. coronatum* and *A. dujardini*, were reported at species level in the Black Sea. Later, Polyakova (2020) investigated the fauna of fish cestodes of the adjacent water areas of the Black Sea and stated that these cestodes were not found in the research area, and 5 different species (such as sp1, sp2...) belonging to the genus *Acanthobotrium*, different from these species, were identified in *R. clavata* and *D. pastinaca*.

PHYLLOBOTHRIIDEA

***Yamaguticestus squali* (Yamaguti, 1952) Caira, Bueno & Jensen, 2021**

Family: Phyllobothriidae
Genus: *Yamaguticestus*

Species: *Yamaguticestus squali*
Original name: *Phyllobothrium squali* Yamaguti, 1952
Synonymised names: *Crossobothrium squali* (Yamaguti, 1952) Williams, 1968, *Phyllobothrium squali* Yamaguti, 1952

Morphologically scolex include four bothridia. Bothridia is shaped round or oval with single apical sucker, undivided loculus and its cephalic peduncle and myzorhynchus is lacking. The neck is present and evident (Figure 10).

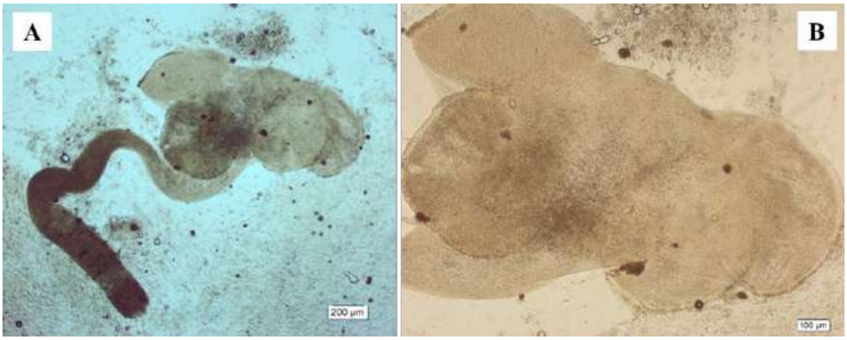

Figure 10. *Yamaguticestus squali* (Yamaguti, 1952) Caira, Bueno & Jensen, 2021. **A.** immature specimen, **B.** scolex.

The present study is the first to report on presence immature *Y. squali* in *S. acanthias* from Turkish coasts of the Black Sea. The prevalence and mean intensity values were determined in 40.0% and 1.50 ± 0.50 respectively.

Yamaguticestus squali was originally described by Yamaguti (1952) as *Phyllodistomum squali* from the Pacific spiny dogfish (*Squalus suckleyi*) off the eastern coast of Japan. Vasileva et al. (2002) subsequently provided a thorough redescription of this species based on examination of specimens from the *Squalus acanthias* off the Bulgarian Black Sea coast. It was transferred from genus *Phyllodistomum* to new established genus, *Yamaguticestus* using molecular sequence data by Caira et al. (2021).

BOTHRIOCEPHALIDEA

In the present study, 2 cestode species belonging to Bothriocephalidae family of Bothriocephalidea order were identified.

***Bothriocephalus scorpii* (Müller, 1776) Cooper, 1917**

Order: Bothriocephalidea
Family: Bothriocephalidae
Genus: *Bothriocephalus*
Species: *Bothriocephalus scorpii*

Original name: *Taenia scorpii* Müller, 1776

Synonymised names: *Bothriocephalus bipunctatus* (Zeder, 1800), *Bothriocephalus punctatus* (Rudolphi, 1802), *Bothriocephalus rhombi* Mola, 1928, *Taenia scorpii* Müller, 1776

In the present study, adult specimens of *B. scorpii* (Figure 11) was found in the intestine *Scorpaena porcus* in 4.05% with mean intensity 1.29 values.

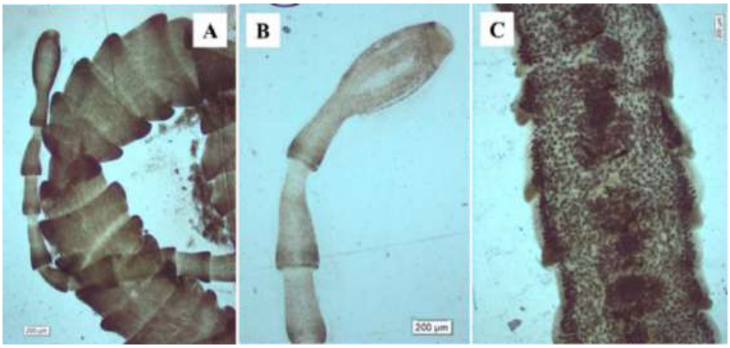

Figure 11. *Bothriocephalus scorpii* (Müller, 1776) Cooper, 1917. **A.** adult specimen, **B.** scolex, **C.** mature proglottids

This cestode is a common species and to date, it is reported from more than 50 genera of marine fish from families and orders that are not related phylogenetically (Polyakova, 2020). *Bothriocephalus scorpii* has been recorded from *Psetta maxima* (Özer & Olguner, 2013*)*, and *Scorpaena porcus* (Polyakova, 2020) in the Black Sea.

Another species of this genus, *Bothriocephalus* sp. is detected in *R. clavata* (Figure 12). 20 specimens of *R. clavata* were examined and a prevalence of 10%, with mean intensity of 4.5 worms per individual host were detected.

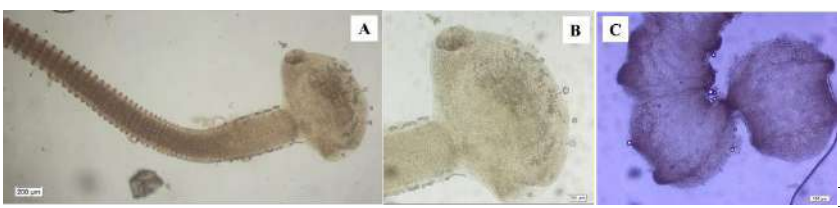

Figure 12. *Bothriocephalus* sp. **A.** anterior body. **B.** scolex, **C.** proglottids

CONCLUSION

Cestode parasites were detected in 19 of 34 fish species in the area studied. The greatest cestode species richness (5 species) was identified in *Raja clavata.*

As a result of the investigation of the cestode parasites of some marine fishes from Turkish coast of the Black Sea, it is recorded 9 cestode parasites belongin to the representatives of 6 orders including Tetraphyllidea, Trypanorhyncha, Rhinebothriidea, Onchoproteocephalidea, Phyllobothriidea and Bothriocephalidea (Table 2).

The present study on parasitic cestode yielded new data, *Tetrarhynchobothrium tenuicolle*, *Acanthobothrium coronatum*, and *Yamaguticestus squali* were detected for the first time in the Turkish Black Sea coast.

Moreover, *Scolex pleuronectis* in *Chelidonichthys lucerna*, *Trachinus draco* and *Scorpaena porcus*; *Progrillotia dasyatitis* in *Solea solea* and *Arnoglossus laterna*; *Grillotia (Grillotia) erinaceus* in *P. flesus*, are reported for the first time in the Turkish coasts of the Black Sea.

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SOIL-PLANT-WATER RELATIONS IN CITRUS

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Introduction

Citrus fruits are trees of regions with mild winters. Sufficiently suitable temperature is effective for long-lasting and profitable citrus agriculture in these regions. For this reason, the Mediterranean and Aegean Regions have the necessary ecological conditions for the production of citrus fruits, which can be produced in limited regions of the world, in our country. Citrus production is an important agricultural branch that develops rapidly in these regions and contributes to the country's economy (Eylen and Tok 1988). The Mediterranean Region has the potential to increase Turkey's total citrus production 4 times Studies conducted in the world and in our country; reveals that one of the plant groups with the highest amount of water consumption is citrus fruits.

Citrus plants need precipitation or an adequate water source as irrigation water throughout the year, as they remain constantly green. The water requirement varies widely and the needed water is applied with various irrigation methods. The annual water requirement of citrus fruits varies between 900-1200 mm depending on the soil, climate and physiological condition of the trees (Doorenboss and Kassam 1979). According to studies conducted in our country, annual water consumption values in citrus fruits vary between 888-977 mm(Anonymous, 1982) . Citrus fruits have a fringe root system, some of the water they benefit from is 1 m. from deep water. The annual water requirement of citrus fruits is between 800-1200 mm in Turkey.

Some of this amount is provided by precipitation. Depending on the climate in the Mediterranean region, irrigation is carried out between 15 May and 15 October. Initially, the irrigation interval is between 25-30 days, while in summer it is watered every 15-20 days. Although it varies according to the soil structure; 8-12 liters in seedlings; 40–60 liters on medium-sized trees; 100-200 liters of water should be given in fully developed trees. According to the irrigation methods; 600–750 mm for flood(surge) irrigation; 500-600 mm as sprinkler irrigation; 300–400 mm of annual water should be given as drip irrigation. In a study conducted in Çukurova conditions, according to A-class steam pot evaporation by drip irrigation method on mandarin trees; about 300-310 mm of irrigation water was applied by the researchers (Kırda et al., 2007).

According to the estimates of the United Nations Population Fund, the world population reached 6 billion 908.7 million people in 2010 and approximately 8 billion people in 2020 , with an increase of 79 million people, approximately as the population of Turkey, compared to the previous year. The world population will reach 9 billion 150 million in 2050 (UNFPA, 2020).

Factors such as the expansion of the demand for water due to rapid population growth and industrial developments, worsening of water quality, environmental pollution and possible climate changes have led to a decrease in water resources allocated for irrigation in recent years (Hanks, 1983).

The main purpose of irrigation programs is to ensure that the amount of moisture in the soil is irrigated before it decreases to the critical moisture level determined for fruit trees.For the irrigation program, first of all, the degree of drought resistance of the rootstocks used in citrus cultivation should be known. At the same time, it should be known that root systems and development (effective root depth, etc.) of rootstocks with different canopy widths are also different. Since crop production occurs as a result of events that occur as a cycle between plant-soil-climatic conditions, techniques based on monitoring these factors can be used in determining the irrigation schedule. Plant-based monitoring methods for determining irrigation time; appearance, leaf water potential measurements, leaf temperature measurements, tree trunk and fruit diameter monitoring and stomatal resistance measurements.

Soil Requirements of Citrus

As with other plants, the soil requirements of citrus fruits are determined by (1) the structure of the soil (clay, loam, sand); (2) soil structure (permeable, moderately permeable, slowly permeable) and (3) soil profile depth. Because these properties affect the soil's (a) water holding capacity, (b) water intake (infiltration) rate, (c) permeability, (d) plant nutrients content and (e) soil aeration. For these reasons, the basic soil properties suitable for citrus fruits are; deep-profile, well-drained, sandy, sandy-loam, loam and clay-loam soils that do not contain a high percentage of clay. The most suitable among these are sandy-loam soils (Çevik, 2002).

Factors Affecting Water Consumption in Citrus Fruits

In citrus, as in other plants, water consumption factors vary widely.

These are soil characteristics, effective root depth, ground water height, variety, age and yield capacity and the type of rootstock. It is also necessary to add climatological factors such as effective wind direction and speed, relative humidity of the atmosphere, fog, cloudiness, sunshine and temperature (Özbek, 1967).

Root development in citrus fruits is related to the characteristics of the soil profile and may vary with the amount of water given to the soil. According to researchers, citrus fruits have a very superficial root system. In deep profile soils, the effective root depth is in the 0-90 cm layer. However, the root system completely reaches up to 150 cm. The amount of water used along the soil profile also strengthens the opinion that the effective root depth is between 0-90 cm. In citrus fruits, 85-90% of the total water supplied to the entire depth of the root zone is used by the effective root depth located in the soil profile of approximately 0-90 cm, and the remaining 10-15% is used by the deeper roots. This situation is clearly seen in Figures 1 and 2 (Berkmen, 1996). According to the results obtained from this information, the majority of the water consumed by citrus fruits is obtained from the layers of the soil at a depth of 0-90 cm (Yaron et al., 1973). However, some researchers have stated that the effective root depth can go down to 1.20 m (Kekeç.2006). Fine textured soils; Since their water holding capacity is high and the movement of water in the soil profile is slow during irrigation, they cause water to remain in the root zone for a longer time. Too much water in the root zone affects the root system more negatively than the lack of water.

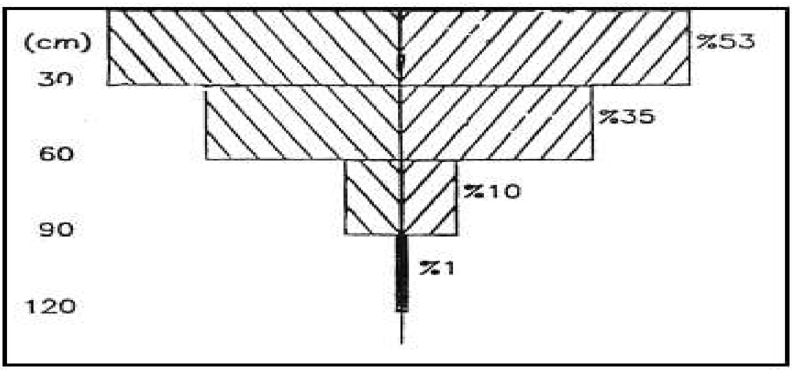

Figure 1. The percentage of water taken up by roots in different soil layers (%) in orange (Washington Navel)

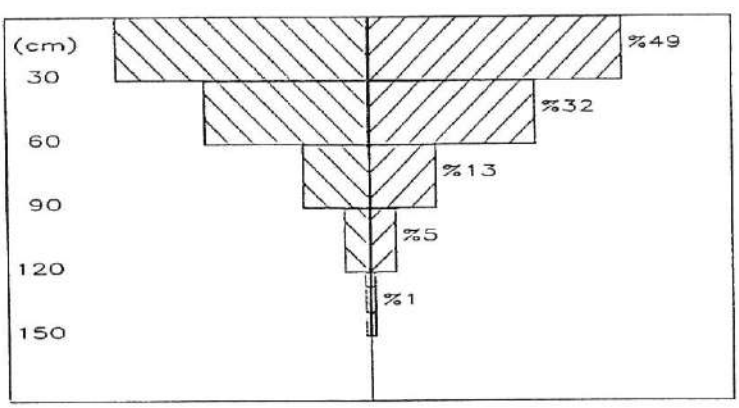

Figure 2. The proportions of water taken up by roots in different soil layers in lemons (%).

Irrigation in citrus, as in other irrigated plants, is the artificial supply of plant water requirement, which cannot be met by natural means, to the soil by artificial. Irrigation water is effective on root and stem development and fruit yield of the plant. It also has an effect on the microclimate of the citrus orchard. However, irrigation must be done consciously. For example; If a good irrigation application is not made under optimal soil conditions, the expected yield cannot be obtained. On the other hand, high yields can be obtained with a suitable irrigation method in many citrus orchards established in shallow and coarse or fine textured soil conditions.

Citrus cultivation is carried out in a wide area on the earth in tropical, subtropical and even semi-arid climate regions.

Citrus trees, which are constantly green and evergreen, require sufficient water in the soil provided by precipitation or irrigation throughout the year. Of course, there are yield and quality differences in citrus fruits grown in irrigated and non-irrigated conditions. Because under irrigated conditions, lack of water prevents development. Irrigation after a relatively long period without water may stabilize growth somewhat, although some fruits remain smaller compared to those grown under irrigated conditions. In addition, sudden flower and fruit drop or untimely flowering may occur due to the deterioration of the physiological water balance. Many researchers have investigated the relationship between water shortage and fruit number and yield in citrus fruits. Shalvent et al (1979), citrus fruits, flowering and fruit formation periods are very sensitive to water, the water shortage in these periods, flower and fruit shedding; then, it stated that it will cause changes in fruit number and yield. Similarly, Gonzalez and Castel (2000), in their study, determined that water restriction had a significant effect on the decrease in the number of fruits and the amount of yield at harvest in different growth periods. Perez et al. (2008), in a study they conducted with orange trees, stated that limited irrigation during the first fruit formation and harvest period reduced the number of fruits and yield. Perez et al. (2014), in their study with Star Ruby graphefruit trees, stated that water restriction applied in different growth periods of the tree caused small fruits and thus a decrease in yield. The most critical periods of fruit fall in citrus are spring and first summer months. In citrus fruits that cannot get enough water during these periods, the leaves, with their stronger osmotic structures, take water from the fruits and cause them to fall. Therefore, balanced water application is important in preventing excessive flower and fruit drop. In citrus, the leaves fall when arid conditions are continuous, but the fact that the fin between the petiole and the palm remains on the branch is considered the most obvious indicator of thirst in these trees. This symptom is also seen in frost damage due to its similar physiological effect.

Effects of Irrigation on Citrus Trees

Irrigation practices have various effects, first on vegetative growth and then on fruits, in the Mediterranean and Aegean regions, which do not receive sufficient rainfall during the summer months.

Irrigation in citrus fruits has various effects first on vegetative growth and then on fruits in the Mediterranean and Aegean regions, which do not receive sufficient rainfall in summer.

Vegetative growth; while affecting the development of shoots, tree canopy and trunk growth and root growth. The effects on fruits are; bud formation and development, fruit formation, fruit cracking, pre-harvest casting, fruit yield and fruit quality (size, shape, color, taste, durability) (Hagan et al., 1967; Özbek, 1969).

Disadvantages of Overwatering Citrus

Citrus fruits are one of the indispensable products of tropical and subtropical climates. The water requirement varies widely and the required water is applied with various irrigation methods. Irrigation methods such as uncontrolled pot pans or surge irragation often cause the producer to use more irrigation water than necessary. Thus, water shortage arises during periods when water is very needed. In addition, the negative effects of excessive use of water also occur. In addition to the emergence of many diseases in the plant, problems such as salinity and sodium in the soil are seen. In addition, many problems arise from the way water is applied. The producer gives the water by ponding it near the plant body. This situation is harmful to the soil and the plant, and the irrigation efficiency decreases as a result of excessive water use.

As in other fruit trees, it is essential to apply balanced water in citrus fruits, depending on climate and soil conditions. Unconsciously excessive irrigations cause regression in the development of trees by causing the ground water to rise, the air spaces in the soil being filled with water and the roots not getting oxygen, the rising ground water to melt the salt in the lower layers and rise to the root zone, due to the root zone remaining moist for a long time, causing the development of pathogenic fungi and bacteria transmitted from the soil, It causes a decrease in yield and deterioration in quality. (Cevik, 2002).

Producers in Turkey have been looking for different ways to increase productivity and reduce production inputs. For this purpose, pressurized irrigation systems, which save water and energy, minimize water losses, do not pollute the environment, increase the amount and quality of the product, in order to achieve the expected benefit from irrigation, especially by expanding the drip irrigation system and planning the right irrigation time, effective use of water resources and water savings. can be provided (Bozkurt Çolak, 2014).

Drip Irrigation Method

Drip irrigation; It is a modern irrigation technique that provides advantages such as water and energy savings, less labor requirement, increased efficiency and quality, application of fertilizer together with irrigation water (fertigation). The necessity to use water and fertilizer at the highest level has brought the drip irrigation system and fertilizer applications (fertigation) with this method to the fore. The fact that water application efficiencies reach 90-95% in drip irrigation systems and increase the water use efficiency of plants reveals the necessity of considering it as one of the basic conditions for sustainable agriculture (Bozkurt Çolak, 2014).

Fertigation method in drip irrigation method can be provided with different tools and equipment. Equipment such as injection pump, venturi and by-pass systems are used in fertigation method. Today, with the advancement of technology, it is possible to provide irrigation water and fertilizer together in a fully automated way, and this situation can provide great convenience to producers. The general view of the fertigation method is given in Figure 3.

Figure 3. General view of the fertigation method

In the drip irrigation method, the laterals should be placed at a certain distance from the trunk to avoid limiting the root development of citrus trees.

Considering that root development is more intense on the side where the lateral passes, the producers' use of systems that can give water to both sides of the tree or lateral designs will provide a more uniform root distribution and the trees will be less affected by physical damage caused by strong winds thanks to the stronger root structure that develops.(Kekeç, 2006) .

Practically; The distance from the trunk to the crown projection is divided into three and laterals are placed between the 2nd and 3rd parts from the trunk. Since the capillary roots, which take water and plant nutrients in citrus trees, are concentrated towards the outer parts of the root zone, placing the laterals close to the crown projection increases irrigation efficiency (Küçükyumuk, 2011).

Drip Irrigation-Evapotranspiration (ET) Relationships and Calculation of Irrigation Water Requirement for Citrus

Plant water consumption (evapotranspiration) is defined as the amount of water lost by plants by "transpiration" and a part by "evaporation" (evaporation) from the soil surface where the plant is located. Plants irrigated by drip irrigation grow and thrive under “potential transpiration” conditions. The basic principle in drip irrigation is to apply irrigation water at small flow rates and at frequent intervals.

In addition, only a part of the total area is irrigated. Therefore, evaporation loss from the soil surface is almost eliminated. In these circumstances, only one situation arises.

Even if there is little evaporation from the soil surface, the plant root zone is constantly at field capacity. In these conditions, the element of "evaporation" in the term "potential evapotranspiration" almost disappears. Thus, it is accepted that the water passing into the atmosphere is only "transpiration" (Goldberg, 1974).

Potential transpiration values;

(1) The value of potential transpiration (Tp) is smaller ($Tp < ETp$) than potential evapotranspiration (ETp) in all cases.

(2) Since potential transpiration is entirely dependent on the transpiration abilities of plants, there may be some variation between plants in the passage of water into the atmosphere.

3) Under drip irrigation conditions, plants thrive in an environment where the soil is constantly watering at or near field capacity. In this case, plant roots can take water from the soil at a certain level and continuously without being subjected to almost any stress. As a result, equality; It is expressed as Tp =

Epan* Kp. Epan in this equation; It refers to the evaporation (mm) from the Class A evaporation pan (Class-A-Pan). Figure 4.

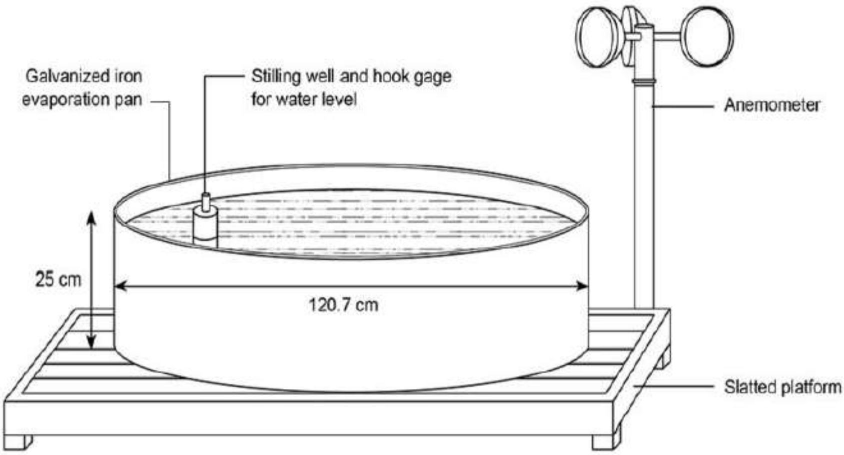

Figure 4. A-Class evaporation pan (Class-A-Pan).

However, due to the differences in climatic conditions; For example, in regions such as the Harran Plain where the temperature is higher and the relative humidity is low, this coefficient can reach high levels such as Kp=1.1-1.3. In Cukurova conditions, Kp= 1.00 was determined in a study on Kütdiken Lemon, which is a citrus fruit.

This general formula was developed by Jobling (Jobling, 1974), by adding the plant factor (f1), soil infiltration factor (f2), the factor related to the area covered by the plant (f3) and the area to be irrigated (A) to the formula, adding the daily or 2 -5 days water requirements (IR) can be calculated. However, the f3 factor is calculated using the formula f3=GC+1/2 (1-GC).

In this formula, GC is the ratio of the land surface area covered by vegetation to the total land area. It is determined according to the total crown projection area of the plants, according to the crown and root development only in orchards. When the orchards are old, it is recommended to take the GC value of 0.40 or at most 0.50. This equation can be used not only for daily irrigations, but also for different applications with the selected irrigation interval. The plant factors in the formula are shown in Table 1, and the infiltration factors according to soil textures are shown in Table 2.

Table 1. Plant Factors.

Plant Type	f1 Factor
Citrus	1.00
Cotton	1.00
Potatoes	1.15
Tomatoes	1.20
Vegetables	1.20

Table 2. Infiltration Factors According to Soil Structures.

Soil Structure	f 2 Factor
Coarse-sand	1.15
Annual	1.10
Plate	1.05
Loam and clay	1.00

The Mediterranean region has an important place in Turkey's fruit and vegetable production. Especially citrus fruits have a large share in this production and irrigation is one of the important factors in this increase in production. In this study, related to irrigation of citrus; It has been tried to give detailed information about soil demands, the factors affecting water consumption in citrus fruits, the effects of irrigation on citrus trees, drip irrigation method and evopatranspiration (ET) relations and calculation of irrigation water requirement in citrus fruits.

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PRECISION APPLIED AGRICULTURAL TECHNOLOGIES AND ITS USE IN IRRIGATION OF ORCHARDS.

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1. Introductıon

The agricultural system consists of a complex interaction of seeds, water, soil, fertilizer and pest control in agriculture. Making the best use of resources is essential to the sustainability of this complex system. Due to the lack of supply/demand due to the increasing population, the unscientific overuse of agricultural resources leads to their deterioration and consequently to a decrease in crop yield (Mondal and Tiwari, 2007). In addition, the uncertainty of climatic conditions also plays an important role in this complex system. Agricultural systems are naturally also characterized by the variability of place and time of cultivation, which maximizes yield with minimum input. In this case, the technologies used on the farms need to be constantly updated to achieve the stated objectives.

Agriculture plays a vital role in the economies of all developed or developing nations. Agriculture is also a source of livelihood for the population, which produces food and important raw materials. In addition, agriculture provides very important opportunities in the provision of job opportunities. It is accepted that agricultural growth is necessary for the development and transformation of the country from the traditional economy to the modern economy. For this reason, it is necessary to give more space to science and technology for high yields and agricultural development.

In fact, modern agriculture has been in change since ancient times. For example, in the last ten years, another concept, "Precision Farming" has been introduced and is still widely discussed in many circles.

Precision agriculture is the use of the developing technologies of the information age by integrating them in agricultural production.

Technologies used in the application stages of precision agriculture;

Global Positioning System (GPS),

Variable Rate Technologies (VRT),

Geographic Information Systems (GIS),

Remote Sensing Technologies (UAT),

Yield Mapping Systems (VHS), It covers many information communication technologies such as automated and controlled field traffic technologies, and electronic measurement and control systems.

The latest technological developments in precision agriculture (HT);

a) Especially the use of unmanned aerial vehicles (UAV) with sensing and imaging platforms for agricultural purposes,

b) Remote sensing with optical and radar satellite technologies,

c) Applications with smart sensors,

d) Computer software for tablets or handheld computers,

e) Portable terrain computers,

f) Wireless data transfer and communication systems,

g) Data transmission from vehicle to vehicle,

h) Self-propelled vehicles and platforms,

i) Robots,

j) Smart machines,

k) ISO-Bus systems in tractors and equipment compatible with them (Türker et al, 2015).

The term precision agriculture is defined as the application of many technologies and principles together, as well as the management of spatial and temporal variables associated with all elements of agricultural production. With another definition, Precision Agriculture is a very special agricultural system that contributes to sustainable agricultural concepts. On the other hand, precision agriculture is defined as an innovative, integrative and internationally standardized approach (Schellberg et al., 2008).

Precision Agriculture also has objectives such as increasing the efficiency of the resources used and reducing the uncertainties that arise in monitoring the response of farms to variations in location and time. In addition, the expected high yield cannot be obtained in traditional agriculture, since applications such as irrigation, fertilization and chemical use are carried out in a large orchard without considering soil characteristics and plant growth variability. This situation led to the introduction of the term and practice of Precision Agriculture: Precision Agriculture is defined as the application of appropriate amounts of seeds, fertilizers, irrigation water and chemicals in order to provide the highest yield against a given input or to optimize agricultural inputs, which takes into account the variability in soil fertility and plant growth.

This term has been used very frequently in recent years and is especially applied in herbal agricultural activities. In Precision Agriculture technique, there is an agricultural system based on knowledge and technology, and in this system, each step is carefully monitored to ensure the highest agricultural yield with the least environmental impact. Thus, it is tried to improve agricultural processes. Precision Agriculture covers issues such as correcting planting criteria, adjusting fertilizer doses, applying special irrigation water to cultivation areas, and pesticide application for diseases and pests (Adams et al., 2000). Irrigation is the most basic element of precision agriculture in terms of determining the water need correctly and reducing water losses. For this reason, sensitive irrigation has emerged within the concept of Precision Agriculture. Water plays a very important role in assimilation and plant nutrition. Today, the development of nations is closely related to agricultural water management. About 40-70% of water resources in developing countries are used in agriculture. In Turkey, approximately 50% of our total water resources are used; 70% of this is consumed in agriculture, 20% in cities and 10% in industry. Providing irrigation water for agricultural activities in the near future is the most challenging thing on a global scale.

Precision irrigation is a new concept used in irrigation engineering worldwide. This term includes items such as the precise and correct application of water to meet the specific water requirements of plants or to minimize environmental impact. Generally, the sustainable management of water resources includes the accepted precision irrigation and the application of water to the plant at the right time, in the right amount, in the right place and in the right way. In this way, water use efficiency is increased by reducing energy costs in irrigation, and it helps to manage the observed variability in agricultural areas in ensuring the equal distribution of irrigation water to the land in order to obtain high vegetative yields. (Shah and Das, 2012).

Precision irrigation has the capacity to increase both water use efficiency and economic efficiency. For example, precision irrigation (drip and sprinkler) can increase application efficiency by 80-90% compared to 40-45% for surface irrigation. Generally speaking, two important benefits of precision irrigation are mentioned:

a) Irrigation water increase and

b) Yield and profit.

The main purpose of precision irrigation is to apply optimum irrigation water to the entire area. Thus, a significant increase in irrigation water has been reported by many researchers (Evans and Sadler, 2008). A necessary or essential element of precision irrigation is the application of specific or varying amounts of irrigation water to the ground. It has been reported that by applying different amounts of irrigation water to different parts of the orchard, irrigation water is increased by 10-15% compared to traditional irrigation practices. (Hedley and Yule 2009).

In an orchard consisting of almost homogeneously developed trees, it is assumed that all trees have the same plant water consumption rate. However, if the tree leaf area varies with the location of the tree, this may be a bad assumption; as a result, some trees may use more or less water than necessary, resulting in yield loss. The variability of leaf area with respect to tree location has been reported for some citrus trees (Pereira and Villa Nova, 2009). From a practical point of view, an irrigation program should definitely take into account the site-related variability of plants and soils within the orchard (Fernandez et al., 2008; Pereira and Villa Nova, 2009).On the other hand, it has been explained by many researchers that the efficiency and profitability of irrigation increased significantly compared to conventional irrigation, taking into account the variability of the location of the orchard or field. For example, King et al. (2006) in the potato plant, Booker et al. (2006) and Bronson et al. (2006), on the other hand, stated that much higher yields were obtained compared to traditional irrigation practices in their studies on cotton plants. Precision irrigation requires knowing both the water use of each fruit tree and its location in the orchard. Knowing the daily water consumption of the fruit tree is used to develop a sensitive irrigation program in orchards. Likewise, it is aimed to reduce the leaching of water and plant nutrients below the root zone to avoid any potential water stress, and this is essential for improving irrigation management (Cohen, 1991; Pereira and Villa Nova, 2009). The amount and time of irrigation water to be applied is determined using the water balance of the soil around each tree. Soil water absorption capacity is dependent on the physical properties of the soil, and spatial variations are common in many commercial orchards.

Irrigation is a vital agricultural application in fruit-producing regions of the world, especially in arid and semi-arid climates. For example, in the Mediterranean Region, where citrus is widely grown, summers are hot and dry; For this reason, irrigation is essential for obtaining higher and better quality products. One of the important problems in irrigated orchards is the lack of viable solutions to find the amount and frequency of irrigation water (Kanber et al., 1999; Assaf et al., 1982).

Lack of irrigation water can reduce growth, yield and quality due to water stress. On the other hand, excessive irrigation can increase nutrient leaching, water ponding problems, disease and pest formation, environmental problems such as soil and water salinity, and associated maintenance and repair costs of irrigation systems. Programmed irrigation in orchards can increase water conservation, reduce production costs, and increase tree growth and yield. The irrigation programs is particularly important as net income is normally higher for fruit crops than for other crops (Fereres, 1997; Pereira and Villa Nova, 2009; Al-Yahyai, 2012). However, in the cultivation of fruit trees, producers have to overcome seasonal and terrestrial variability in soil and microclimate that affect plant growth. Furthermore, producers face high levels of uncertainty in yield and quality in 8-30 year old orchards due to recent climate change. The impact of irrigation and fertilization programs in orchards is very important in relation to predictable and sustainable yields. Optimizing irrigation programs requires reliable data and information. From an engineering point of view, a conceptual basis for deciding an irrigation program is also; yield and quality are considered as an interconnected feedback.

Many techniques are used to determine the water requirements of fruit trees. They have both advantages and limitations. For a long time, direct or indirect measurements of soil, water and climate have been used to estimate the irrigation water requirements of trees. However, these measurements are more suitable for herbaceous plants rather than trees due to the different anatomical and morphological structures of fruit trees and their compatibility with soil water levels (Al-Yahyai, 2012).

Although climate- and soil-based methods provide data on the estimation of irrigation water amount and time, these methods do not take into account the differences between fruit tree species and varieties, developmental periods, or the response to soil water deficiency. The lowest soil water level that does not cause a reduction in fruit quantity or quality varies between different tree species, rootstock varieties, soil and seasons (Jones, 2004). Tree water use is particularly dependent on weather conditions, leaf area forming an effective plant water consumption surface, and tree growth (Pereira and Villa Nova, 2009). Leaf water potential measurements are used most frequently among many physiological variables as a tree water status indicator (Hsiao, 1990, Al-Yahyai et al., 2005).

It is often beneficial to use both soil and plant factors for the irrigation program. This approach includes soil analyzes to determine soil properties and factors such as plant type, cover width, rooting depth and width, plant density, and leaf water potential. Physiological formations in fruit trees, such as water potential and gas exchange, are very sensitive to changes in soil water content (Al-Yahyai et al., 2005; Naor and Cohen, 2003). The physiological variables mentioned, growth and fruit set should be correlated with the soil water content, which determines the appropriate amount of water supplied to the orchard.

If the water loss from the leaves is more than the amount of water taken from the soil, water tension occurs in the plant (Currier, 1967). As a result of the decrease in the water level in the plant, many physiological formations such as leaf growth and other plant functions are affected. Many plants are very sensitive to water deficiency and yields can be negatively affected by even a very short-term lack of water (Hsiao et al., 1976).

Leaf water potential is widely used to characterize plant water status (Hsiao, 1990). Leaf water potential is a very accurate indicator of plant water status for estimating the effects of water shortage on plant yield, and small changes in the proportional amount of water in leaf cells are consistent with large changes in leaf water potential (Kramer and Boyer, 1995).

Although the daily variation of the leaf water potential makes it difficult to determine its correct measurement time, the leaf water potential on a sunny day is partially constant for a few hours at noon and reaches minimum values (Kramer and Boyer, 1995). In many fruit tree cultivars, some researchers argue that petiole water potential is more convincing than leaf water potential as an indicator of plant water level. However, there is a large amount of scientific data that contradicts this approach.

Providing guaranteed fresh fruit and vegetable production for the growing population and economic welfare of the producer for the reasons explained above is one of the main priority objectives in global change. In the cultivation of fruit trees, the producer has to know and overcome the seasonal differences and the special local variations in soil and micro-climate that affect plant growth. In addition, the producer faces enormous uncertainties in terms of sustainable yield and required quality due to climate changes. In this respect, special attention should be paid to the amount and distribution of precipitation and cloud development.

The effect of the water supplied to the plant for the quantity and quality of the harvested product is very important and fundamental. There is a need for reliable data about the plant as well as the harvested product in order to support the decision mechanism regarding water and plant nutrients and amounts applied together with water in the formation of the product. For example, automation in garden irrigation can be economical in many countries and europe. The main question here is how to overcome variability in water supply, which means, from an engineering point of view, how to arrive at a basic system for deciding the irrigation regime, taking into account the quality and quantity of the crop. In order to reach this system, first of all, it is necessary to know in detail the soil properties in which each tree grows in the orchard. In addition, trees in the same garden have very different water and fertilizer demands, which are controlled by the soil properties on which they live and the microclimate around them. Therefore, to obtain agricultural product-based plant data in relation to the effect of irrigation in order to determine the fertilizer and water needs of the products in both orchards and cultivated areas and to observe the effects of missing or excess plant nutrients; Precision agriculture and precision irrigation encompass highly beneficial practices for sustainable agricultural production in order to contribute to the creation of a unified approach to and control them.

Conclusıon

Unlike traditional practices, precision agriculture is an agricultural practice that divides the field into subgroups and provides each subgroup with as much input as it needs, in order to realize a sustainable agricultural production. With this aspect of precision agriculture, the efficiency of the inputs is increased, the cost is reduced, a homogeneous yield and most importantly an environmentally friendly agriculture is provided. Therefore, it is important to support research, publication and infrastructure studies on precision agriculture in all sensitive countries, including Turkey. These applications, which are very important especially for the protection of natural resources, also contribute to the reduction of product losses in production, harvest and post-harvest processes.

For this reason, although studies are carried out at the research level, it is necessary to make its use, which is not widespread at the producer level, widespread. It can be said that faster and more reliable data can be obtained in a short time with the technologies used in precision agriculture and irrigation, and a database describing production areas will be created, as stated by the researchers, in many studies where components of precision agriculture technology such as remote sensing and GIS are used in different application areas of irrigation.

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INTERNET OF THINGS (IOT) AND AGRICULTURAL APPLICATIONS

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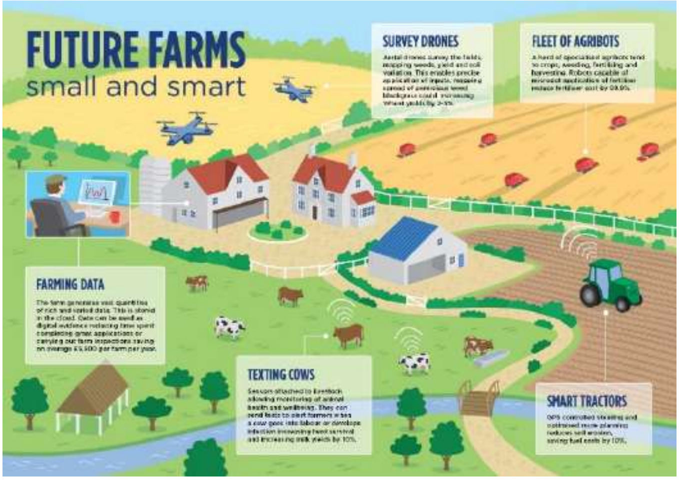
Internet of Things (IoT) and Agricultural Applications

The term Internet of Things (IoT) first came to the fore in 1991 with a camera system designed by 15 academics working at Cambridge University to observe the coffee machine. Images of this coffee machine were transmitted to the computer at certain periodic intervals. Although the system was not connected to the internet, the transactions continued online, and real-time communication was achieved. Due to these features offered to the user, the method mentioned above is considered the first application of the Internet of Things (Suresh, 2014).

Kevin Ashton first used the concept of the Internet of Things (IoT) in 1999 in a presentation he prepared for a company called Procter & Gamble. In the following years, smart devices, mobile phones, and thousands of devices connected to the internet have been developed thanks to the developing technology with increasing momentum. All technological or electronic devices (objects) produced are now addressable and usable in the network environment. As a result, IoT is a system that controls or regulates physical objects to see, perceive data, think, make decisions, share data and communicate with each other (Al-Fuqaha et al., 2015).

In modern agriculture, IoT technologies generally collect real-time information such as temperature, humidity, wind, weather, rain, soil moisture, electrical conductivity, pH value, and soil nitrogen value. Smart agriculture is defined as the interactive operation of many technologies for agricultural purposes (Jannat and Islam, 2017). With the IoT, the workload in smart agricultural technologies is alleviated, while at the same time, productivity and quality can be increased in the product. As a result, many processes can be performed in IoT-based agricultural applications. Below is a visual of a modern agricultural business and IoT applications.



Şekil 1. internet of things and agriculture (Geospatial World, 2022)

Real-time weather forecast data is used with the necessity of an advanced irrigation management system to control water use in today's agricultural activities (Ray, 2017). In light of the data obtained from humidity sensors placed in farm areas with Wi-Fi connections, water usage can also be managed, and thus water savings can be achieved. This approach, which was also suggested in this thesis, was used; therefore, the user or farmer was allowed to control the control process from home or anywhere in the world (Ray, 2017).

Controlled use of pesticides and fertilizers helps to improve planting quality and minimize the cost of farming. The probability of damage to the product for controlled use can be estimated by collecting the necessary data with the IoT infrastructure (Ray, 2017).

Water quality can be monitored with sensor nodes with wireless communication. For example, IoT monitors water quality in real-time in studies conducted for this purpose. Thus physical and chemical parameters of water, such as temperature, pH, turbidity, conductivity, and dissolved oxygen, can be measured (Paventhan, 2012).

Innovative greenhouse applications can be developed with IoT technology. In addition, greenhouse gases can directly affect agricultural areas as they increase the climate temperature. Thus, the product quality can be increased by monitoring the greenhouse gas (Ray, 2017).

It can be said that modern agriculture has replaced traditional agriculture with new techniques, concepts and ways of developing technology. This new farming system is called Precision Agriculture (PAPrecision Agriculture). In addition, knowledge-based tools and technologies can be used for agricultural processes, with every sensitive action taken to ensure greater crop productivity (Nabi and Jamwal, 2017).

Precision agriculture is based on detecting the necessary data and deciding on the final process after intensive monitoring of the environmental conditions, and processing the obtained data in the computer environment to control the agricultural machinery in this direction (Roy and Bandyopadhyay, 2013). In this context, it can be said that the wireless sensor network is an ideal method for monitoring environmental conditions affecting agricultural applications. Precision agriculture-based system design principles are increasingly used in commercial projects that produce solutions for the products that are followed, providing water supply for irrigation, fertilizer management, pest control and solutions for automatic harvesting. Such systems can reduce costs with automation and cost savings. Another critical benefit of precision farming to farmers is its ability to prevent hazardous events and proactively monitor crops and local environmental conditions. The effectiveness of precision farming is based on the real-time analysis of accurate measurement sets (Dong, 2013).

As irrigation techniques in Turkey, two main irrigation methods are applied: surface and pressurized. Surface irrigation is divided into four sub-headings: regular flood irrigation, pan irrigation, prolonged pan irrigation and furrow irrigation. However, it is known that the most common use belongs to the standard release irrigation method, the only advantage of which is its low cost. The pressurized irrigation method, known as irrigation only with the sprinkler system in our country until a few years ago, also includes drip irrigation systems, which have recently become widespread (Karasekreter, 2011). Regardless of the type of plant, irrigation made in the light of traditional knowledge, not as much as it needs, can cause excessive irrigation. As a result, with excessive irrigation, the surface water level may increase, causing an increase in the salinity of the soil, which may adversely affect the product quality and yield. Although it is thought that this problem can be prevented with the experience of the person who irrigates, it is believed that the most efficient way can be solved by adding an intelligent system to be designed with expert knowledge and experience (Karasekreter, 2011).

Yenikaya et al. A study was carried out in 2022 to manage the moisture and Ph data obtained from the soil, to control the opening and closing of the valves, and to measure the liquid level in the reservoir to measure this data over the internet. As a result of this study, Arduino Uno was used to optimize the fertilization values. As a result of this study, it managed to keep the valves and fertilization system under control in light of the incoming data.

Blank et al. (2013) conducted experimental studies on a widespread dynamic network that provides independent data sharing from manufacturers in the future precision agriculture, wheat and forage crops production within the scope of the iGreen project they carried out in Germany.

Gawali and Gajbhiye (2014) developed an embedded web server for agricultural applications with an ARM7 processor and ENC28J60 ethernet chip. Researchers stated that most internet applications work on a client/server basis; They said that it is more appropriate to use embedded web servers instead of PC servers, considering the volume, cost and energy usage.

In their published article, Patil and Malviya (2014) developed a system that controls the agricultural irrigation application with a short message using an ARM-based processor and GSM modem support.

Pesonen et al. (2014) developed a multi-layered service business platform based on internet technologies to increase the efficiency of crop production in future agriculture within the scope of the Cropinfra project they carried out in Finland. The four-layer work platform consists of sub-services such as sensors in tools and machines, data collection and machine control, data storage, and external services that do weather and disease forecasting.

In their article, Dlodlo and Kalezhi (2015) discuss the advantages and solutions provided by the internet of things technology in the fields of plant production, water management, plant and animal diseases, weather forecasting, wildlife management, market identification and rural finance in ensuring sustainable rural development in South Africa and Zambia. They have researched.

Gayatri et al. (2015) investigated IoT and cloud computing technologies for smart agricultural production in India.

Guo and Zhong (2015) applied IoT technology to sensitive irrigation, fertilization and air conditioning systems for more efficient production in greenhouses.

Srbinaovska et al. (2015) proposed a wireless sensor network architecture to reduce management costs by monitoring greenhouse vegetable production and environmental data. They designed a practical and cost-effective data monitoring system based on a wireless sensor network technology to monitor key environmental parameters such as temperature, humidity and light.

Vijayakumar and Ramya (2015) stated in their article that water quality should be monitored in real-time to ensure the safe distribution of drinking water. They noted that the system they designed and developed to measure drinking water quality is a low-cost Internet of Things application. In the study, they argued that the Raspberry Pi mini-computer to which the sensors are connected is low-cost, efficient and sufficient for the processing, analysis, sending to the cloud server and monitoring of the collected data.

Vujovic and Maskimovic (2015) used the Raspberry Pi single-board computer as an inexpensive, fully customizable and programmable Internet of Things node in home automation in their published article.

Zaceping and Kviess (2015) conducted studies on real-time bee colony temperature monitoring system architectures that can be used in precision beekeeping in their published article.

Sarangi et al. (2016) developed a system for disease diagnosis through an automated plant disease advisory service based on internet technologies using the wireless sensor information archive (Wisekar) in India.

Türker et al. (2016) developed a prototype system for measuring temperature changes in the greenhouse, transferring them to the Web environment and monitoring them wirelessly, using the Internet of Things technology. The system consists of Raspberry Pi, a Wi-Fi adapter and 2 DS18B20 temperature sensors. The system has been tested by saving the air, soil and water temperature data measured in the greenhouse to the database in the Web environment.

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FACTORS EFFECTING CAPITALIZATION RATES: A CASE STUDY ON IRAN-TURKEY-EUROPE NATURAL GAS PIPELINE ROUTE IN TURKEY

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Introduction

Because of the struggle between Russia and the West especially over Ukraine, Russia's energy monopoly weakens in the European market. The main reason of this, Europe has remained to reconsider compulsorily its gas options and still obvious as its weak aspect about energy dependency to Moscow. Iran's role in supplying gas to European markets comes out a new dynamic which is bringing alternative energy options for European. Iran has the world's second largest natural gas reserves after Russia according to old estimates (www.naturalgaseurope.com). But BP's recent statistics at the end of 2013 however, indicates that Iran has taken first order with 18.2% (33.8 trillion cubic m) of total reserves and follows the Russia with 16.8% (31.3 trillion cubic m) (BP, 2016). Since 2010 international sanctions have targeted Iran's energy sector, as the result of this the Iran's technical and financial capacity were limited to deliver gas to international markets and hindered largely the development of its energy sector's infrastructure. But after the sanctions relief resulting from the November 2013 interim agreement to curb its nuclear activity, Iran strives to bring more foreign companies into its energy sector. Gradually lifted international sanctions against Iran, this situation would increase the significance of the Turkish route (CCEE, 2014).

There are several options for delivering gas from Iran to world markets. Going through Turkey is considered by top Iranian officials to be the most cost-effective route. Back in November 2008, notably, an agreement was signed between the Turkish and Iranian energy ministries to develop three blocks of Iran's giant South Pars gas field and pipeline, which crosses Turkish territory to deliver Iranian gas to Europe. But due to the international sanctions and concerns in the US that Iran could use the revenues to develop non-peaceful nuclear capacities, the development of the project has been halted. The tender has been given to a Turkish company; a project developer called Turang Transit Tasimacilik (which is a subsidiary of a minor Turkish petroleum trading company called Som Overseas Petroleum). In June 2013, the Turkish Cabinet approved the urgent expropriation of land along the proposed route of the pipeline. According to the project's developer, the total length of the Iran-Turkey-Europe (ITE) pipeline will be about 5,000 kilometers, approximately 1769 km of which will run from Iran to Turkey's İpsala/Edirne border with Greece, and from here on to Germany (CCEE, 2014) (Figure 1).

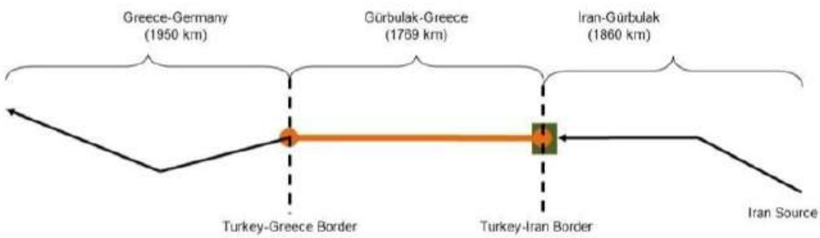

Figure 1: Iran-Turkey-Europe Natural Gas Pipeline Route

For the transit pass of Iran natural gas over Turkey, "Memorandum of Understanding" was signed on the date of 17 November 2008 between The Ministry of Energy and Natural Resources of Turkish Republic and The Ministry of Oil of Islamic Republic of Iran. The diameter of the project is 56 inch and its pressure is 92 bars. Project's service life is predicted as 40 years (ITE, 2016).

Turkey part of ITE Natural Gas Pipeline Project is starting from Turkey-Iran border, and is following those provinces Ağrı, Erzurum, Erzincan, Gümüşhane, Sivas, Yozgat, Kırşehir, Kırıkkale, Ankara, Eskişehir, Bilecik, Kütahya, Bursa, Balıkesir, Çanakkale, Tekirdağ, to İpsala/Edirne Greece border (Figure 2).

Figure 2: The provinces on ITE Natural Gas Pipeline Route in Turkey

The purpose of this study to analyze the factors affecting the capitalization rate in dry and irrigated farmland, by using the data collected through ITE Natural Gas Pipeline Project in Turkey. A similar study has not been conducted on the analysis of factors affecting the rate of capitalization in agricultural land in the world. However, a number of studies have been conducted on factors affecting the rate of capitalization in buildings (Froland, 1987; Evans, 1990; Williams, 1990; Ambrose and Nourse, 1993; Sivitanidou and Sivitanides, 1999; Sivitanides et al., 2001; Frew and Jud, 2003; Bleich and Donald, 2003; Ching, 2004; Hendershott and MacGregor, 2005; Shilling and Sing, 2007; Plazzi et al., 2008; Bayramoglu and Gundogmus, 2008; Chervachidze et al., 2009). In these studies, it has been observed that the factors affecting the rate of capitalization mainly include variables such as location, city center and main road distance. In our study, similar variables were tried to be taken into account.

Materials and Methods

Data collection

The basis material of the research is consisting of data obtained from field surveys and measurements made on the terrain in the 61 numbers of villages of Ağrı, Erzurum, Erzincan, Gümüşhane, Sivas, Yozgat, Kırşehir, Kırıkkale, Ankara, Eskişehir, Bilecik, Kütahya, Bursa, Balıkesir, Çanakkale, Tekirdağ and Edirne provinces. The vast majority of the data used in this study consists of primary data collected by a survey made with the buyers/sellers of farmlands in the villages. In addition to this, secondary data is related to the subject obtained from public and private organizations used in the study. At the same time, it is benefited from scientific research and investigations made in the field of agricultural product costs and in particular valuation.

Questionnaires are generated which could allow to determine the capitalization rates and net incomes, and these forms are filled upon mutual consultation with people who actually purchase and sale land. Financial data of the last realised production period (2015) and product pattern and physical data concerning an average rotation period were collected from the buyers/sellers with the survey forms. Surveys were applied in the period January-August 2015 with people who actually buy or sell dry and irrigated farmland.

The real purchase-sale values of farmlands, land and buildings (occuring without any intervention between the parties) in the land registers in Turkey are usually shown lower due to the taken tax during the purchase-sales. Under these conditions, the land title records in the determination of the real sales values of the farmland usually do not bear the characteristic of being the trusted source. At the same time the plots (parcels) are determined which actually have been purchased/sold from January 2013 to August 2015 from the records of Directorates of Land Registry on the route. The average sales value of farmland has been found in the investment area for which a certain level of annuity can be given by evaluating the collected farmland sales prices. So the capitalization rate is determined as close as possible to the reality by dividing the sales value of the determined value into previously calculated annuity (net operating incomes).

In villages of the research where field works are carried out are physical and financial datas collected related to common rotating system, average product yields, prices received by farmers and production costs by the survey applied to landowners of the agricultural land whose buying-selling prices are known. Gross product values of dry or irrigated farmlands, are based on production activities from which they obtained. In the same way the production costs according to the production activities of farmlands are determined by the physical and monetary values. The values per unit land (parcel) is determined by dividing the gross product value provided from all activities and production costs total in the parcel area. The calculated net income per unit area will be as the difference between gross product value and production cost (Kıral et al., 1999).

Adequate and reliable data supply is the most important problem in the determination of capitalization rate according to market approach. For determining the value of the real estate according to income capitalization method in valuation is primarily determined the annual average net income (rent) (**R**) of the farmland and the applicable capitalization rate (**r**) in the region. In the next stage is the farmland value found **(V)** by dividing the annual average net income of parcel with the capitalization rate **(r)**. According to this the following equation (1) can be stated (Murray et al., 1983; Rehber 1999; Mülayim, 2001):

$$V = \frac{R_1}{(1+r)^1} + \frac{R_2}{(1+r)^2} + \frac{R_3}{(1+r)^3} + \ldots + \frac{R_n}{(1+r)^n} \quad (1)$$

Income concept used for appreciation of farmland values, refers to the net income of the farmland, net land rent or the annuity of the land. As farmlands out of usual conditions, usually bring in an average fixed net income or an annuity ($R_1 = R_2 = R_3 = \ldots\ldots\ldots = R_n$), when it is accepted that the farmland can be used for the production in the endless year (n), when above series are simplified according to the sum of geometric series, the following equation (2) is obtained:

$$Market\ Value\ (V) = \frac{The\ Annual\ Net\ Income\ of\ Farmland\ (Annuity)(R)}{Market\ Capitalization\ Rate\ (r)}$$

(2)

With the capitalization formula given in equation (2) both the value of the real estate is determined as well as the capitalization rate is found by making use of the (r = R/V) relation between the net income of the real estates and market price. Two factors are required for the capitalization which is the process for the estimation of the value of the goods based on the annual net income. These are; the estimated annual net income and the capitalization rate. The capitalization process is usually expressed with equation (2) (Murray et al., 1983).

When the basic capitalization formula in equation (2) is rearranged, it comes out that the capitalization rate is the ratio of annual net income. The current relationship (∑R/∑V) between the net rental incomes of farmlands whose similar and real buying and selling values are known in the villages where field surveys are carried out in this research (∑R) and the real sales values of the lands (∑V), will give the capitalization rate. For this purpose, it is necessary to know sales prices of the very new and similar farmlands. After the calculation of annual average net incomes of the sales prices known farmlands (R_1, R_2, R_3,…..R_n), the capitalization rate can be determined with r = ΣR / ΣV formulae (Murray et al., 1983; Rehber, 1999; Mülayim, 2001):

$$r = \frac{R_1+R_2+R_3+\cdots+R_n}{V_1+V_2+V_3+\cdots+V_n} = \frac{\sum_{i=1}^{n} R}{\sum_{i=1}^{n} V} \qquad (3)$$

Basic formulas used for calculating net incomes by taking operation saving forms of the farmlands into account are given below. As operation by land owners is common of farmland in the examined expropriation area, the annual average net income (annuity) of this kind operated farmlands is found by using the formula in equation (4) (Mülayim, 2001):

$$R = GPV - (C + O_r + A_e + L_c + T) \qquad (4)$$

In equation (4) mentioned R: average annual net income of the farmland (annuity), GPV: gross product value, C: costs of production tools and services provided outside the enterprise, insurance, repairs and maintenance expenses, O_r : operating capital (varying costs) interest, A_e : general administrative expenses, L_c : paid basis human labor and T: if applicable enterprise-related property taxes are indicated.

The annuity of farmland will be as the difference between average gross production value of farmland calculated according to commonly applied rotating system and the production costs except the lease if parcel integrity is based instead of agricultural enterprise integrity in especially valuation principles of the expropriation legislation and generally studied at the parcel level in expropriation works (Equation 5).

$$R = [GPV - Total\ Production\ Costs\ except\ farmland\ leasing\ cost] \quad (5)$$

The model

The rate of capitalization represents all elements that influence the value of land, other than the net income of farmland (Burt, 1986). Hence, a reverse relationship is expected between the farmland value and the rate of capitalization. Here, it is important to identify the factors affecting the rate of capitalization. Among the factors affecting the rate of capitalization are variables such as distance to the village settlement, distance to the main road, distance to the nearest province / county center, distance to nearest metropol city, altitude, health center in the village where farmland parcel is located, availability of water network and sewage system were taken into consideration and tried to be explained by different (OLS, Robust, log-log, lin-log) regression models. The variables discussed in the models are shown below:

$$CR_i = \propto + \beta_1 DV + \beta_2 MR + \beta_3 DC + \beta_4 DP + \beta_5 DM + \beta_6 AL + \beta_7 FV + \beta_8 HC + \beta_9 DWN + \beta_{10} SS \quad (6)$$

Where **CR:** capitalization rate calculated (%); **DV:** Distance to the village settlement (km); **MR:** Distance to the nearest main (asphalt) road (km); **DC:** Distance to the nearest county (km); **DP:** Distance to the nearest province (km); **DM:** Distance to the nearest metropol city (km); **AL:**altitude; **FV:** farmland value ($ ha^{-1}); **HC:** Dummy for existence of primary health clinic in the village; **DWN:** Dummy for existence of drinking water network in the village; **SS:** Dummy for existence of sewage system in the village.

Variable	Dry Farmlands (n=799)			Irrigated Farmland (n=599)		
	Mean	**Std. Dev.**	**Min / Max**	**Mean**	**Std. Dev.**	**Min / Max**
Capitalization Rate (%)	0.06	0.01	0.02 -0.08	0.05	0.01	0.02-0.07
Distance to the village settlement (km)	2.44	1.67	0.05 - 1.00	1.55	1.27	0.05 - 7.00
Distance to the nearest main road (km)	1.39	1.54	0 - 15.00	1.17	1.37	0.05 - 10.00
Distance to the nearest county (km)	18.93	11.55	0 - 83.00	15.88	10.48	0 - 50.00
Distance to the nearest province (km)	69.69	37.15	0 - 180.00	67.98	40.65	1 - 179.00
Distance to the nearest metropol city (km)	107.05	69.86	10.00 - 316.00	110.54	73.59	1 - 310.00
Altitude (m)	981.92	522.32	4.00 - 2,064.00	1,063.33	658.05	3- 2,470.00
Farmland Value ($/ha^{-1})	1,853.26	2,327.50	300.00 - 20,000.00	3,037.09	2,678.60	700.00 – 25,000.00
Dummy (Primary heath clinic)	0.22	0.41	0 - 1.00	0.26	0.44	0 - 1.00
Dummy (Drinking water network)	0.86	0.34	0 - 1.00	0.82	0.38	0 - 1.00
Dummy (Sewage system)	0.59	0.49	0 - 1.00	0.64	0.48	0 - 1.00

Table 1. Descriptive statistics for dry and irrigated farmlands

The basic descriptive statistics are shown in Table 1. CR is calculated annual return (usd) from the crop sales grown up in farmland divided by the selling price of the parcel (usd). The data consist of 599 irrigated farmland sales and 799 dry farmland sales of different villages in Turkey. The data used in this study are taken from the expropriation study of ITE (Iran-Turkey-Europe) natural gas pipeline taking part in the 17 cities in the middle, east and west part of the Turkey in 2013-2015.

The selling prices of parcels range from 300 \$ ha^{-1} to 20,000 \$ ha^{-1} for dry farmlands and range from 700 \$ ha^{-1} to 25,000 \$ ha^{-1} for the irrigated farmlands. The capitalization rate of parcels changes between 0.02% and 0.08 % for dry farmlands and between 0.02% and 0.07% for the irrigated farmlands. Distance to the nearest metropol city, province, county, village and main road are measured in kilometers. Each parcel has been determined to be located within the considered locations and the "parcel query" service on the website of the General Directorate of Land Registry and Cadastre has been utilized.

In the scope of multi-choice models, some dependent variables show sequential feature as structures. In the analysis of such variable, it may be used ordered choice models. A simple ordered model and the probabilities that observation *i* will select alternative *j* is (Ozer, 2004) :

$$P_{ij} = P(Y = j) = p(\alpha_{j-1} < y_i^* \leq \alpha_j) = F(\alpha_j - X_i' \beta) - F(\alpha_{j-1} - X_i' \beta)$$

$j = 0, 1 \ldots j$ (7)

$\alpha_0 = -\infty \quad \alpha_{j-1} \leq \mu_j \qquad \alpha_j = +\infty$

Here, α's are unknown and constants to estimate accordingly. We can get the below equation (8), if an index model is composed for a single latent variable y* (which is unobservable and continuous random variable and, it may be only known when it crosses thresholds).

$$y_i^* = X_i' \beta + u_i$$

(8)

(Here, u_i a random variable with normally distributed and with 0 (zero) mean, 1 variance.)

$y_i = j$ Only if $\alpha_{j-1} < y_i^* \leq \alpha_j$ $(j = 0, 1 \ldots j)$

(9)

As this rule, it is determined the values of Y. Because of this, even if Y* can not be observed, variables determined accordingly can be stated in equation 10 (Ozer 2004):

$$
\begin{aligned}
Y &= 0 && y_i^* \leq 0 \\
&= 1 && 0 < y_i^* \leq \alpha_1 \\
&= 2 && \alpha_1 < y_i^* \leq \alpha_2 \\
&\ \ \dots && \\
&= J && \alpha_{j-1} \leq y_i^*
\end{aligned}
\qquad (10)
$$

For the ordered logit, F is the logistic cumulative distributed function (CDF) which can be shown as in equation 11:

$$F(z) = e^z/(1 + e^z) \qquad (11)$$

For ordered probit, F is the standard normal cdf. The ordered logit/probit model with j alternatives will have one set of coefficients with (j-1) intercepts. You can recognize an ordered choice model by the multiple intercepts. The ordered logit/probit model with j alternatives will have j sets of marginal effects.

If the coefficients are interpreted, the sign of parameters shows whether the latent variable y* increases with the regressor. The magnitude of the coefficients will be different by a scale factor between the probit and logit models (Katchova, 2013). The marginal effect of an increase in a regressor X_r on the probability of selecting alternative j is shown in equation 12:

$$\frac{\partial P_{ij}}{\partial X_{ri}} = \left\{F'\left(\alpha_{j-1} - X'_{i\,i}\beta\right) - F'(\alpha_j - X'_i\beta)\right\}\beta_r$$

(12)

The marginal effects of each variable on the different alternatives sum up to zero. The marginal effect can be interpreted as each unit increase in the independent variable increases/decreases the probability of selecting alternative j by the marginal effect expressed as a percent (Katchova, 2013).

Model Estimation

Model results for dry farmlands

The estimated coefficients for the regression model are shown in Table 2. The R^2 values indicate that the model has a middle general fit. As the results of estimations; the capitalization rate (CR) that is dependent variable is affected from the distance to the village settlement (DV) variable with the negative relationship as different models. But its coefficient is only significant at with logged models. For only this model, if DV increases amount of 1%; in the log-log model, CR decreases of 0.01295% and in the lin-log model, CR decreases of 0.00064%.

Dependent: Capitalization Rate	**OLS**	**Robust**	**The Log-Log Model**	**Lin-Log Model**
Distance to the village settlement	---	---	-0.01295[c]	-0.00064[c]
Distance to the nearest main road	0.00044[b]	0.00047[a]	0.01677[a]	0.00082[a]
Distance to the nearest county	---	---	---	---
Distance to the nearest province	---	---	---	---
Distance to the nearest metropol city	0.00002[a]	0.00002[a]	0.02979[a]	0.00207[a]
Altitude	3.03e-06[a]	3.01e-06[a]	-0.01546[a]	---
Farmland Value ($\$/ha^{-1}$)	-2.56e-06[a]	-2.56e-06[a]	-0.17460[a]	-0.00819[a]
Dummy (Primary health clinic)	-0.00171[a]	-0.00127[c]	-0.0318893[a]	-0.0014033[a]
Dummy (Drinking water network)	0.00266[a]	0.0028169[a]	0.0404908[a]	0.0021184[a]
Dummy (Sewage system)	---	---	---	---
_cons	0.0533883[a]	0.0532467[a]	-1.683003[a]	0.1054678 [a]
F Stat	F(6, 792) = 122.96[a]	F(6,792) = 111.29[a]	F(7,782) = 116.55[a]	F(6, 783) = 115.04[a]
R-squared/Adj. R-squared	0.48/0.47		0.51/0.50	0.46/0.46
Root MSE =	0.00737		0.13789	0.00745

[a] *Indicates significance at 1% level.*
[b] *Indicates significance at 5% level.*
[c] *Indicates significance at 10% level.*

Table 2.Ampirical results of models for dry farmlands

The capitalization rate (CR) that is dependent variable is affected from the distance to the nearest main road (MR) variable with the positive relationship as different models. The value of farmland close to the main road is higher.

Therefore, as the distance from the main road increases, the increase in the rate of capitalization is expected to be appropriate. If the distance to the nearest main road variable increases 10 km; for OLS model, CR increases of 0.0044 units and for the robust model, CR increases of 0.0047 units. If MR increases amount of 1%; for log-log model, CR increase of 0.01677% and for lin-log model, CR increase of 0.00082%.

The capitalization rate (CR) hasn't got generally significant coefficients of the relationship with the distance to the nearest county (DC) variable. This is an indication of the fact that the districts can not be enough attraction centers than the metropolitan cities.

It can not be told that the capitalization rate (CR) is affected from the distance to the nearest province (DP) variable. For only initial logged model (before removing unsignificant variables) CR is related to DP with the negative relationship.

The capitalization rate (CR) is affected from the distance to the nearest metropol city (DM) variable as positively but very small as the other variables for all models. This is an expected situation that as you get closer to a larger metropolitan city, the rate of capitalization falls. If DM increases 10 km; CR increases of 0.0002% for OLS model and of 0.0002% for the robust model. If DM increases amount of 1%; CR increases of 0.02979% for log-log model and of 0.00207% for lin-log model.

The capitalization rate (CR) is affected from the altitude (AL) variable with the positive relationship as linear models but with the negative relationship as with logged models. It is expected that the rate of capitalization will increase relatively as the altitude increases. If AL increases 10 m; CR increases of very little (3.03e-06) as the OLS model and of very little (3.01e-06) as the robust model. If AL increases amount of 1%; CR decrease of 0.01546% for log-log model, but its coefficient is insignificant for lin-log model.

The capitalization rate (CR) is affected from the farmland value (FV) variable with the negative relationship generally as different models. If FV increases \$10, CR decreases very little (2.56e-05) for OLS model and same results for the robust model. If FV increases amount of 1%; CR decrease of 0.1746% for log-log model and of 0.00819% for lin-log model.

The capitalization rate (CR) is generally affected from existence of primary health clinic (HC) dummy variable with the negative relationship as different models. If there is a primary health clinic in the village of farmland; CR decreases 0.00171% for OLS model and 0.00127% for the robust model.

The capitalization rate (CR) is generally affected from existence of drinking water network (DWN) variable with the positive relationship generally as different models. If there is a drinking water network in the village; CR is increases 0.00266% for OLS model and 0.00281% for the robust model.

The capitalization rate (CR) hasn't got generally significant coefficients of the relationship with the existence of sewage system variable. We study the factors influencing the capitalization rate (seperated 3 categories that are low, medium, upper) which is dependent variable (Table 3).

Ordered Capitalization Rate	Original Capitalization Rate	Frequency	Percent	Cumulative
1: Low	0.020 -0.053	255	32	32
2: Medium	0.053 - 0.063	313	39	71
3: Upper	0.063 - 0.080	231	29	100
TOTAL	0.020 -0.080	799	100	

Table 3. Classification of capitalization rates for logit model for dry farmlands

We have got 799 observations collected from dry farmlands. If the capitalization rate (CR) is from 0.020 to 0.053, we coded it as 1 (low) for the first 255 observations or 32%; if CRis greater than 0.053 to 0.063, we coded as 2 (medium) for the second 313 observations or 39%; if CRis greater than 0.062, we coded as 3 (upper) the third 231 observations or 29%.

In Table 4, there will be one set of coefficients with two intercepts, and there will be three sets of marginal effects, one for each category. Coefficient interpretation for the ordered logit model, the capitalization rate (CR) is better (from low to medium to upper) with higher distance to nearest main road, distance to nearest province, distance to nearest metropol city, altitude, farmland value, existence of drinking water network. And the CR is better with lower the value per hectars. The threshold/ intercept parameters are significantly different from each other so the three categories should not be combined into one.

Dependent Variable: Ordered Cap. Rate	Ordered Logit Coef.s	Means For Marginal Effects	Marginal Effects in Group I (dy/dx)	Marginal Effects in Group II (dy/dx)	Marginal Effects in Group III (dy/dx)
Distance to the village settlement	-0.02676 (0.572)	2.4419	0.00588 (0.573)	-0.00163 (0.578)	-0.00425 (0.572)
Distance to the nearest main road	0.1062687 (0.057)	1.3909	-0.02335 (0.057)	0.00647 (0.079)	0.01688 (0.059)
Distance to the nearest county	-0.0027715 (0.657)	18.9311	0.00060 (0.657)	-0.00016 (0.658)	-0.00044 (0.657)
Distance to the nearest province	0.0053369 (0.027)	69.6921	-0.00117 (0.028)	0.00032 (0.059)	0.00084 (0.027)
Distance to the nearest metropol city	0.0041002 (0.001)	107.0551	-0.00090 (0.001)	0.00024 (0.007)	0.00065 (0.001)
Altitude	0.0005506 (0.003)	981.9212	-0.00012 (0.002)	0.00003 (0.006)	0.00008 (0.004)
Farmland Value ($/ha^{-1})	-0.0008233 (0.000)	1853.2650	0.00018 (0.000)	-0.00005 (0.002)	-0.00013 (0.000)
Dummy (Primary health clinic)	-0.235719 (0.220)	0.2265	0.05180 (0.220)	-0.01435 (0.242)	-0.03744 (0.220)
Dummy (Drinking water network)	0.5836251 (0.007)	0.8598	-0.12825 (0.007)	0.03554 (0.026)	0.09271 (0.007)
Dummy (Sewage system)	0.1087652 (0.476)	0.5969	-0.02390 (0.477)	0.00662 (0.487)	0.01727 (0.475)

Cut1		-0.3568113
Cut2		1.767316
Log likelihood =		-729.30991
Pseudo R2 =		0.1629
Number of obs =	799	LR chi2(10) = 283.83
Prob> chi2		= 0.0000

[The values in the brackets (under the statistics) are the prob values.]

Table 4. Results for ordered logit model for dry farmlands

The logit ordered model coefficients differ by a scale factor and therefore we cannot interpret the magnitude of the coefficients (Katchova, 2013). Marginal effects got from ordered logit model can be interpreted only for significant variables that: one unit increase in distance to the nearest main road is associated with being 2.33% less likely to be in the low capitalization rate (CR) status, 0.64% more likely to be in medium CR status, and 1.68% more likely to be in upper CR status.

If the increase with one km in distance to the nearest province will become, it is associated with being 0.11% less likely to be in the low capitalization rate (CR) status, 0.03% more likely to be in medium CR status, and 0.08% more likely to be in upper CR status.

One km increase in distance to the nearest metropol city is associated with being 0.09% less likely to be in the low capitalization rate (CR) status, 0.02% more likely to be in medium CR status, and 0.06% more likely to be in upper CR status.

If the altitude go up one meter, this will able to cause 0.01% less likely to be in the low capitalization rate (CR) status, 0.003% more likely to be in medium CR status, and 0.008% more likely to be in upper CR status.

In case that the farmland value increases one unit ($/ha-1), it is associated with being 0.01% more likely to be in the low capitalization rate (CR) status, 0.005% less likely to be in medium CR status, and 0.01% less likely to be in upper CR status.

If there is a drinking water network in the village where farmland is located; in this manner it is waited to see 12.82% less likely to be in the low capitalization rate (CR) status, 3.55% more likely to be in medium CR status, and 9.27% more likely to be in upper CR status.

The marginal effects sum up to zero. The marginal effects and the all results for the probit model (not reported here) are similar to those of the logit model.

Model results for irrigated farmlands

As the results of estimations; the capitalization rate (CR) that is dependent variable is affected from the distance to the village settlement with the negative relationship as different models. But its coefficient is only significant at with logged models. For only this model, if the distance to village settlement (DV) variable increases amount of 1%; in the log-log model, CR decreases of 1.23% and in the lin-log model, CR decreases of 0.13% (Table 5).

Dependent: Capitalization Rate	**OLS**	**Robust**	**Log-Log Model**	**Lin-Log Mo**
Distance to the village settlement	---	---	-0.01235 [a]	-0.00131 [a]
Distance to the nearest main road	0.00099 [a]	0.05177 [a]	0.01177 [a]	0.00134 [a]
Distance to the nearest county	-0.00007 [a]	-0.00440 [c]	-0.02596 [a]	-0.00312 [a]
Distance to the nearest province	---	---	---	---
Distance to the nearest metropol city	0.00002 [a]	0.00185 [a]	0.01778 [a]	0.00291 [a]
Altitude	3.02e-06 [a]	0.00037 [a]	---	0.00117 [b]
Farmland Value ($/ha^{-1})	-1.74e-06 [a]	-0.00011 [a]	-0.20121 [a]	-0.02217 [a]
Dummy (Primary health clinic)	-0.00298 [a]	-0.22327 [a]	-0.02027 [a]	-0.00226 [a]
Dummy (Drinking water network)	0.00228 [a]	0.21285 [a]	0.01516 [a]	0.00173 [a]
Dummy (Sewage system)	---	---	---	---
_cons	0.05259[a]	1.67076[a]	-0.60274[a]	0.12320[a]
F Stat	F(7, 591)= 89.16[a]	F(7, 591)=54.88[a]	F(7, 563) = 129.49[a]	F(8, 562)=1(
R-squared / Adj. R-squared	0.51/0.50		0.62/0.61	0.59/0.59
Root MSE =	0.00641		0.04857	0.00592

[a] *Indicates significance at 1% level.*

[b] *Indicates significance at 5% level.*

[c] *Indicates significance at 10% level.*

Table 5.Ampirical results of models for irrigated farmlands

The capitalization rate (CR) that is dependent variable is affected from the distance to nearest main road (MR) variable with the positive relationship as different models. If MR increases 10 km; CR increase of 0.0099 units for OLS model, and increase of 0.5177 units for the robust model. If MR increases amount of 1%for the log-log model, CR increase of 0.01% and, increase of 0.001% for the lin-log model.

The capitalization rate is affected from the distance to the nearest county (DC) variable with negatively. If the distance to the nearest county increases 10 km; for OLS model, capitalization rate (CR) decreases of 0.0007units and for the robust model CR decrease of 0.044 units. If the distance of county increases amount of %1; CR decrease of 0.02% for the log-log model and decrease of 0.003% for the lin-log model.

The capitalization rate (CR) hasn't got generally significant coefficients of the relationship with the distance to the nearest province (DP) variable. The capitalization rate (CR) is affected from the distance to the nearest metropol city (DM) variable with the positive relationship as different models. If DM increases 10 km; CR increases of 0.0002 units as the OLS model and increase of 0.0185 units as the robust model. If DM increases amount of 1%; CR increases of 0.01 as the log-log model and increase of 0.002% as the lin-log model.

The capitalization rate (CR) is affected from the altitude with the positive relationship as different models. If the altitude increases 10 m; CR increases very little (3.02e-05) as the OLS model and increase of 0.0037 as the robust model. If the altitude increases amount of %1; its coefficient is insignificant as the log-log model and CR increase of 0.001% as the lin-log model.

The capitalization rate (CR) is affected from the farmland value (FV) variable with the negative relationship as different models. If FV increases $10; CR decreases very little (1.74e-05) as the OLS model and increase of

0.0011 as the robust model. If FV increases amount of 1%; CR decreases of 0.20% as the log-log model and CR decreases of 0.02% as the lin-log model.

The capitalization rate (CR) is generally affected from existence of primary health clinic (HC) dummy variable with the negative relationship as different models. If the village where the parcel is attached has primary health clinic; CR is less 0.00298 units as the OLS model and 0.22327 units as the robust model.

The capitalization rate (CR) is generally affected from existence of drinking water network (DWN) dummy variable with the positive relationship as different models. If the village where the parcel is attached has a drinking water network; CR is less 0.00228 units as the OLS model and 0.21285 units as the robust model.

The capitalization rate (CR) hasn't got generally significant coefficients of the relationship with the existence of sewage system.

Ordered Capitalization Rate	Original Capitalization Rate	Frequency	Percent	Cumulative
1: Low	0.0205 - 0.0490	172	29	29
2: Medium	0.0490 - 0.0580	246	41	70
3: Upper	0.0580 - 0.0796	181	30	100
TOTAL	0.0205 - 0.0796	599	100	

Table 6. Classification of capitalization rates for logit model for irrigated farmlands

The classificiation of capitalization rates are shown in Table 6. If the capitalization rate (CR) is less than 0.049 we coded it as 1 (low) for the first 172 numbers of observations or 29 percent; if CR is greater than 0.049 to 0.058, we coded as 2 (medium) for the second 246 numbers of observations or 41%; if CR is greater than 0.058, we coded as 3 (upper) the third 181 numbers of observations or 30%.

The results for ordered logit model on irrigated farmlands were shown in Table 7. Coefficient interpretation for the ordered logit model is that; the capitalization rate (CR) is better (from low to medium and to upper) with higher distance to the nearest main road, distance to the nearest metropol city, altitude, farmland value, existence of drinking water network. And the CR is better with lower distance to the nearest county and existence of health clinic in the village. The threshold/ intercept parameters are significantly different from each other so the three categories should not be combined into one.

Dependent Variable: Ordered Cap. Rate	Ordered Logit Coefficients	Means For Marginal Effects	Marginal Effects inGroup I (dy/dx)	Marginal Effects in Group II (dy/dx)	Marginal Effects in Group III (dy/dx)
Distance to the village settlement	-0.07323 (0.351)	1.5595	0.01300 (0.352)	-0.00289 (0.390)	-0.01010 (0.352)
Distance to the nearest main road	0.21360 (0.004)	1.1790	-0.03793 (0.004)	0.00844 (0.072)	0.02948 (0.005)
Distance to the nearest county	-0.02236 (0.014)	15.8848	0.00397 (0.015)	-0.00088 (0.104)	-0.00308 (0.014)
Distance to the nearest province	0.00308 (0.265)	67.9816	-0.00054 (0.266)	0.00012 (0.326)	0.00042 (0.264)
Distance to the nearest metropol city	0.00570 (0.000)	110.5492	-0.00101 (0.000)	0.00022 (0.047)	0.00078 (0.000)
Altitude	0.00072 (0.000)	1063.3370	-0.00012 (0.000)	0.00002 (0.037)	0.00010 (0.000)
Farmland Value ($/ha^{-1})	-0.00084 (0.000)	3037.0960	0.00015 (0.000)	-0.00003 (0.040)	-0.00011 (0.000)
Dummy (Prmary health clinic)	-0.66309 (0.003)	0.2671	0.11775 (0.003)	-0.02622 (0.074)	-0.09152 (0.004)
Dummy (Drinking water network)	0.73111 (0.004)	0.8230	-0.12983 (0.004)	0.02891 (0.077)	0.10091 (0.004)
Dummy (Sewage system)	-0.31650 (0.123)	0.6410	0.05620 (0.122)	-0.01251 (0.195)	-0.04368 (0.126)
Cut1	-2.1520				
Cut2	0.66997				
Log likelihood =	-464.91475				
Pseudo R2 =	0.2849				
Number of obs=599	LR $chi^2(10)$ = 370.48				
Prob> chi^2 =	0.0000				

[The values in the brackets (under the statistics) are the prob values.]

Table 7. Results for ordered logit model for irrigated farmlands

The logit ordered model coefficients differ by a scale factor and therefore we cannot interpret the magnitude of the coefficients (Katchova, 2013). Marginal effects got from ordered logit model can be interpreted only for significant variables that; one unit increase in distance to the nearest main road is associated with being 3.79% less likely to be in the low capitalization rate (CR) status, 0.84% more likely to be in medium CR status, and 2.94% more likely to be in upper CR status.

If the variable of distance to the nearest county will increase one km, it will able to cause 0.39% more likely to be in the low capitalization rate (CR) status, 0.08% less likely to be in medium CR status, and 0.30% less likely to be in upper CR status.

One km increase in distance to the nearest metropol city is associated with being 0.10% less likely to be in the low capitalization rate (CR) status, 0.02% more likely to be in medium CR status, and 0.07% more likely to be in upper CR status.

In case that the altitude increases one meter, it is waited with 0.01% less likely to be in the low capitalization rate (CR) status, 0.002% more likely to be in medium CR status, and 0.01% more likely to be in upper CR status.

If it is met the increase with one US dollar in the farmland value; in this manner it is available 0.01% more likely to be in the low capitalization rate (CR) status, 0.003% less likely to be in medium CR status, and 0.01% less likely to be in upper CR status.

If there is a primary health clinic in the village where farmland is located in that case it is associated with being 11.77% more likely to be in the low capitalization rate (CR) status, 2.62% less likely to be in medium CR status, and 9.15% less likely to be in upper CR status.

And if there is a drinking water network in the village where farmland is located, it is possible to see 12.98% less likely to be in the low capitalization rate (CR) status, 2.89% more likely to be in medium CR status, and 10.09% more likely to be in upper CR status.

The marginal effects sum up to zero. The marginal effects and the all results for the probit model (not reported here) are similar to those of the logit model.

Discussion

In a study of this scope has not been done before in Turkey. Also, statistics relating to real farmland prices are not regulated in Turkey. The fact that the land buyers and landlords are forced to pay for land title in this case because the title deed is lower than the actual value of the buy/sell value affects the collect the real farmland prices in Turkey. For this reason, it is possible to carry out such a study thanks to the data gathered within the scope of an international project with a total of 17 provinces.

In model predictions made for dry and irrigated farmlands, similar variables are generally seen to give meaningful results. When the ordered logit model estimates for both dry and irrigated farmlands are evaluated together, significant variables affecting the rate of capitalization were determined such as distance to the nearest main road, distance to the nearest metropol city, altitude, farmland value and drinking water network existence in the village (dummy). This is a sign that metropolitan cities are a center of attraction and also positively affect the farmland prices around them. As a matter of fact, this has been explained by gravity models (Bayramoglu and Gundogmus, 2008). On the other hand, the fact that a parcel is close to the main asphalt road presents itself as an element that obviously increases its value. Increasing the amount of asphalt roads in the country can cause the values of farmland to increase. Especially since the beginning of the 2000s the last 15 years, Turkey is known to be increased by 120% in the amount of asphalt concrete road (Çelik 2014).

Because of the lower unit price of farmland in high altitude regions, it is natural that the rates of capitalization are high. As a matter of fact, in regression models both dry and irrigated farmlands have yielded meaningful results in terms of altitude variable.

On the other hand, in the village where the farmland parcel is located, the presence of the primary health clinic was identified in all regression models that had an effect that reduced the rate of capitalization. It is possible to say that importance of human health is influential on farmland values and capitalization rates from here. The primary health clinics also established relatively large and often crowded villages in Turkey. From here it is expected that the rates of capitalization will be relatively lower in the more crowded settlements.

According to the model results, the existence of the water network in the village where the farmland parcel is located affects the rate of capitalization positively. But expectation is exactly the opposite. In villages where there is no drinking water network, each househols has its own well, or because it has abundant water resources, an unexpected situation has emerged.

In this study, the factors effecting capitalization rates of farmlands in Turkey were studied to determine in the case of Iran-Turkey-Europe Natural Gas Pipeline Project. A topic for future research would be establishing a model which takes into account other measurable variables that are not considered in this study. Also another important issue arising here is the necessity of the establishment of the infrastructure of statistical data on the actual price of farmlands in Turkey.

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HATCHERY-BASED ARTIFICIAL PRODUCTION OF FRESHWATER CRAYFISH

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INTRODUCTION

Crayfish are known as one of the ecologically important and largest benthic invertebrates in the freshwaters. Besides, it is also one of the most popular human food in many regions of the world. In this concept, crayfish meat is a good source of protein, which contains about 16-18% protein, and is a low-calorie food (Öksüz, & Mazlum, 2016). They are also rich in terms of vitamin B, sodium, potassium, calcium, and magnesium (Goddard, 1988).

Many studies showed that crayfish species can alter the benthic fauna structure in the freshwaters, show a significant effect on the environment, demonstrate various ecological strategies, and have life spans reaching up to 20 years. They have also important roles both as prey and predator, and also form a significant part of energy sources in the aquatic food web (Lehmann et al., 2021; Leonard et al., 2001).

However, native crayfish stocks have been declining in many countries worldwide due to diseases, climatic changes, and human activities in nature. Thus, there is considerable interest in the hatchery-based artificial production of crayfish in various areas of the world owing to their high nutritional properties in recent years.

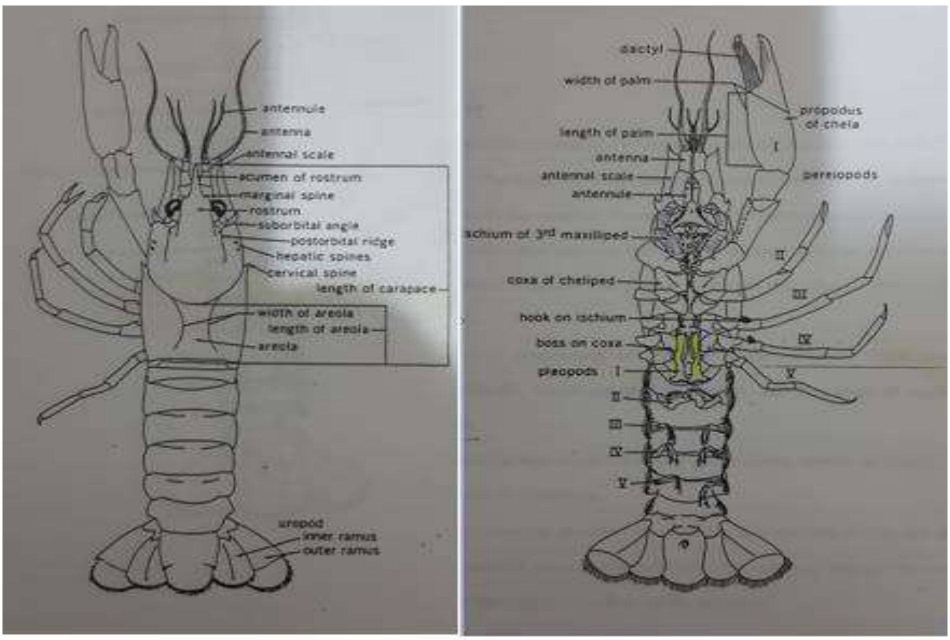
However, despite the demand for crayfish species, the large-scale artificial crayfish culture industry hasn't been able to develop as required due to mainly reproductive matters. Thus, the development of the artificial culture of crayfish primarily depends on solving of reproduction-related issues, which form the backbone of its artificial production.

SYSTEMATIC AND DISTRIBUTION OF CRAYFISH IN THE WORLD

Freshwater crayfish belong to the *Arthropoda* phylum, *Crustacea* class, and *Decapoda* order. The crayfish comprise a diverse group of benthic fauna which play important roles in the maintenance of ecology including three families such as *Astacidae*, *Cambaridae*, and *Parastacidae*. The crayfish species are able to live on almost all continents except Africa and Antarctica (Hobbs, 1989; Crandall, & Buhay, 2008). While, the *Astacidae* family is found in Europe, North America, and Western Asia (Taylor, 2002), the *Cambaridae* family is found in far east Asia, Japan, and North America (Hobbs, 1989). However, the *Parastacidae* family is found in Australia, South America, New Guinea, Madagascar, and New Zealand and (Hobbs, 1989).

PHYSICAL AND BIOLOGICAL PROPERTIES OF CRAYFISH

The body of crayfish is divided into three sections such as head, cephalothorax, and abdomen. The cephalothorax section of the body extends from the head to the abdomen, which consists of segments and a fan-like tail. (Figure 1). The whole body of the crayfish is covered with a protective shield. In crayfish, growing is depends on the shedding of this shield periodically. Besides, this shield is used both to protect the crayfish from predators and provide a skeleton for the body.



(a) (b)

Figure 1. Dorsal (a) and ventral (b) view of generalized crayfish (from Hobbs 1989).

Crayfish are found globally with a broad range of tolerance to environmental conditions. Crayfish can live in different ecological habitats. Crayfish can be found abundantly and dominantly among all invertebrates. Some of these species can breed in cold waters with plenty of oxygen, such as lakes and rivers, while other species can live in warm water environments that are poor in terms of dissolved oxygen. Additionally, some species are well adapted to live in brackish waters.

Crayfish feed on other invertebrates, macrophytes, algae, and detritus and have important roles in the freshwater food chain. Crayfish also display a cannibalistic trait and have a selective diet that consumes certain invertebrates and macrophytes. When they are abundant, they make significant contributions to the food chain and species diversity, either as a direct consumer or as consumable creatures. Most predators feed on crayfish, and therefore, crayfish are a significant energy source for organisms higher up in the food chain. However, larger crayfish can protect themselves from aquatic predators. Because crayfish hide in aquatic plants and sheltered areas, the pressure of predators other than fish on crayfish is lower (Mazlum et al., 2017).

SEXUAL MATURITY

Sexual maturity in crayfish differs depending on the species in terms of age and size. Besides, some factors such as water quality, food supply, water temperature, and crayfish density can affect this property (Westman et al., 1995; Berber, & Mazlum, 2009).

Sexual maturity is an important parameter in the implementation of life cycle and management plans for the conservation of crustacean species (Hartnoll, 1985; Pinheiro, & Fransozo, 1998; Mazlum, & Eversole, 2004). The best way to determine sexual maturity in female crayfish estimation is the ovigerous stage (Grandjean et al., 1997). On the other hand, in male crayfish, sexual maturity can be estimated by changing of morphological characteristics such as the increase in the chelae size (Lowery, 1988; Mazlum, 2021). Male crayfish reach sexual maturity nearly one year before females depending on species and climatic conditions (Streissl, & Hödl, 2002).

Figure 2. Sperm ducts in male individuals (from Uzunmehmetoğlu, 2011).

During the mating period, sexually mature males actively search for their female partners (Buric et al., 2009). This seeking behaviour activity is controlled hormonally by stimulants such as water temperature and photoperiod (Reynolds, 2002). During this period, egg laying of the females from the oviduct is stimulated by some factors such as a decline in water temperature or the creation of short daylight (Skurdal, & Taugbol, 2002). The mating period between copulation and ovulation changes from days to weeks (Vogt, 2002) or to several months (Buric et al., 2013).

Figure 3. Fertilized eggs attached to pleopods of female crayfish (from Mazlum, & Yılmaz, 2012).

STRUCTURE OF THE REPRODUCTIVE ORGANS

Commonly, crayfish are gonochoric animals where individuals have separate sex such as male or female, and have external fertilization (Hamr, 2002). In crayfish, the gonads, either testis or ovary, are found dorsally in the thorax between the floor of the pericardial sinus and the hindgut. Gonad's size and appearance are linked with the reproductive conditions and ages of the crayfish. In mating season, the internal reproductive organs of the crayfish enlarge. In case of male crayfish, the *vas deferens* becomes milky white colour (Figure 2) because of sperm production while in females the ovary becomes full of eggs and their colour can be yellowish brown or dark blue (Figure 3) (Duris et al., 2015).

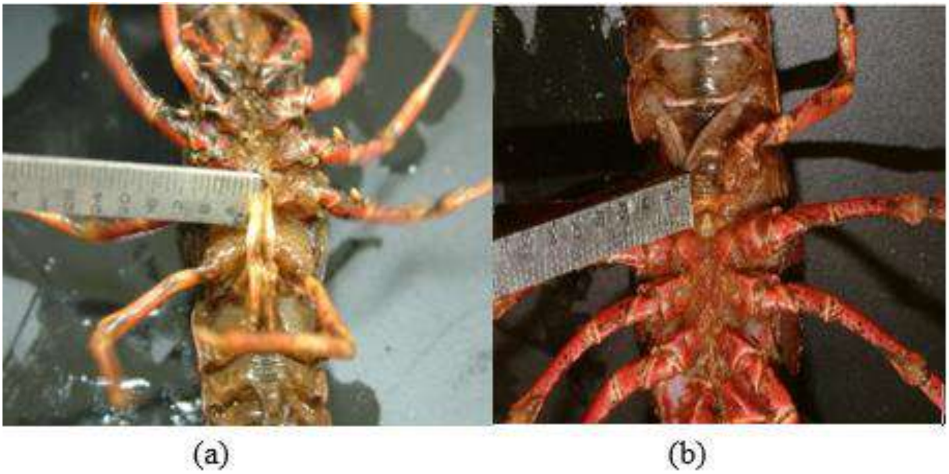


Figure 4. Male form I gonopod (a) and Female with annulus ventralis (b) (from Mazlum, & Yılmaz, 2012).

Male crayfish can be distinguished by the two pairs of gonopods, which are the first two pairs of pleopods (Figure 3). These are projecting forward between the bases of the legs. The testis is covered by a connective tissue cortex and its structure is composed of seminiferous tubules. As in other animals, the spermatids and spermatocytes improve gradually from spermatogonia (Duris et al., 2015). Non-motile spermatozoa of crayfish (Kouba et al., 2015) are produced in the testis and finally moved to the *vas deferens*, which its function is to transfer of sperm cells from male to female during copulation. Here, spermatozoa are packed into the spermatophore and is surrounded by the spermatophore wall (Dudenhausen, & Talbot, 1983; Niksirat et al., 2014a).

In females, the structure of the ovary is trilobed and it has one straight toward the oviduct on each side of the body. The oviduct is opened to the outside on the bases of the third pereopods (Figure 4). The oogenesis occurs in the ovaries, which realizes producing of eggs.

REPRODUCTION IN NATURE

As known, aquatic animals mostly perform external fertilization in aquatic environments. In this regard, there are various reproductive strategies performed by aquatic animals differing from strict gonochorism to hermaphrodism, from mass spawning to parental care, and from oviparity to viviparity to ensure their offspring's survival (Bozkurt, & Bucak, 2022).

In case of crayfish, their reproductive activity has an annual cycle (Berber, & Mazlum, 2009). In this respect, decreases in water temperature and sunlight determine the beginning of sexual activity in September-October. (Wetzel, 2002; Buric et al., 2015). During the mating season, the female lies back and excretes glair from glands, which are located on the abdomen surface of the body (Figure 5). This high-viscosity excretion protects sperm cells from being washed away during fertilization. Additionally, these excretions dissolve the spermatophore wall and disperse spermatozoa during the ventral abdomen in a few hours before the egg releasing for fertilization. Following fertilization, the females form a chamber by curling their abdomen to hide the spermatozoa and eggs that float in the glair secretions (Niksirat et al., 2014b).

Figure 5. Mating of crayfish in nature (from Mazlum, & Yılmaz, 2012).

In crayfish, sperm are ejaculated in the form of spermatophores containing spermatozoa and other nutrients for females. The spermatophores stay on the body of females until fertilization begins (Niksirat et al., 2014b; Niksirat, & Kouba, 2016). Following mating, eggs remain as attached to the maternal pleopods for 4-10 months till hatching (Niksirat et al., 2015), which varies according to water temperature and the species (Reynolds, 2002).

FACTORS AFFECTING REPRODUCTION EFFICIENCY

There are some biological (male/female size, gamete quality, food supply, and hormones) and environmental (water temperature, stocking, sex ratio, annual life cycle, and photoperiod) factors that affect the reproductive efficiency of crayfish.

Male/Female Size

In crayfish, females determine mate selection, and the size of the male acts an important role in the female's mate selection. Mostly, female crayfish prefer to mate with larger males than themselves (Robertson, & Butler, 2013; Jinbo et al., 2017). In fact, large male crayfish have more spermatozoa stores and they can able to refill their spermatozoa stores more quickly than smaller ones (MacDiarmid, & Butler, 1999; Kendall et al., 2001). Resultingly, larger males can able to produce a higher proportion of sperm cells compared to small ones as well (Alfaro, 1993). In reality, male crayfish can adjust their spermatozoa ejaculate according to female size. In this regard, males ejaculate larger sperm cells in the case of mating with larger females and act with higher reproductive success compared to small crayfish (Rubolini et al., 2006).

However, in the case of not availability of large males, females mate with smaller ones, which may decrease fertilization success (Robertson, & Butler, 2013) most probably due to the availability of insufficient sperm cells to fertilize all eggs (MacDiarmid, & Butler, 1999; Kendall et al., 2002; Sato et al., 2006).

Gamete Quality

Sperm quality is an important factor affecting the reproduction success of male fish (Tekin et al., 2003; Bozkurt, 2006) and crustaceans as well (Harlıoğlu, & Farhadi, 2017). In this concept, spermatozoon motility is thought as one of the most important factors to evaluate sperm quality in aquatic animals (Akçay et al., 2004; Bozkurt, 2008; Hatef et al., 2009; Bozkurt, & Bucak, 2022). Since crayfish spermatozoon is immotile (Kouba et al., 2015; Yazicioglu et al., 2016), the analysis of spermatozoon quality depends on different variables such as acrosome reaction, spermatozoa count, spermatophore size, spermatozoa viability, and energy content of sperm cells (Harlıoğlu et al., 2018a).

Extraction of sperm cells is provided by the incubation of spermatophores, which are provided from the ductus deferens in a physiological solution in crayfish and other crustaceans as well (Van Harreveld, 1936). Following this step, the physiological solution in a hematocytometer is examined microscopically under a light microscope and is recorded as the number of spermatozoa/ductus deferens (Bugnot, & Lopez Greco, 2009; Harlıoğlu et al., 2018a).

The motility of sperm cells and fertilization are two commonly used methods to determine the reproduction efficiency of male animals with flagellate spermatozoa (Hatef et al., 2009; Bozkurt et al., 2011). On the other hand, crayfish sperm cells are aflagellate and immotile (Kouba et al., 2015; Yazicioglu et al., 2016). Furthermore, the sperm cells are covered by a spermatophore, which provides a kind of protective wall during sperm cells remain in the vas deference of the male or post-mating storage period on the female body (Jamieson, & Tudge, 2000; Niksirat, & Kouba, 2016). This structure differs from fish and mammals, in which sperm cells are immersed in seminal plasma.

Food Supply

Food supply plays an important role to increase reproductive success in all animals. The energy and protein components of diets are the major nutrients involved in the greatest amounts and must be the top priority in order to optimize growth in juvenile crayfish and reproduction in ovigerous female crayfish. Moreover, the minerals and vitamins also can't be ignored and should be balanced in the diets of crayfish (Nascimento et al., 1991). Additionally, the plants in the ponds (Figure 6) form a vertical structure that allows the crayfish to hide and the food organisms to hold on. Because these structures facilitate entry into the water column from the surface, thus crowding, and increasing growth (McClain, 1997).

Figure 6. A view from the crayfish ponds cultivated with plants as food and shelter (from Mazlum, & Yılmaz, 2012).

Hormones

There are many hormones playing important roles to control gonad maturation in crustacean species, including crayfish. In female crustaceans, gonad maturation is regulated by GIH, which is synthesized and excreted from the X-organ-sinus gland (XO-SG) complex of the eye stem and gonad-stimulating complex. In addition, methyl farnesoate and ecdysteroids excreted by mandibular and Y organs play important roles in the regulation of female reproduction in crayfish (Chang et al., 2001).

Water Temperature

Water temperature has important effects on the regulation of cold-blooded aquatic animal's body temperature. In this regard, main biological activities such as growth, behavior (Wittmann, & Pörtner, 2013), immune response (Jiravanichpaisal et al., 2004), moulting (Hammond et al., 2006; Mazlum, 2007a), and reproduction (Tropea et al., 2010; Yazicioglu et al., 2018) are controlled by water temperature in aquatic animals. Additionally, it is clear that water temperature has rather effective on ovarian development, spawning rate (Tropea et al., 2010), sperm production (Bugnot, & López Greco, 2009), and mating time (Yazicioglu et al., 2018) in crayfish species.

Stocking density

Stocking density had a great effect on crayfish production (Mazlum, 2007b). The most important reason for that is the overcrowding at higher stocking densities causing additional stress to the crayfish. Crowding, ie the number of individuals per tank can stress crayfish in two ways such as insufficient space, and poor water quality (Schreck et al., 1997). While water quality parameters such as temperature, pH, dissolved oxygen, and ammonia can affect the physiological state of crayfish, at the same time, violations of behavioral requirements for space can affect growth or impair nutrition by reducing the efficiency of food intake and reproduction activity as well (Olivera et al., 2008). Recommended stocking rates vary depending on the amount of crayfish available and the vegetation around the pond. Thus, it can be recommended that 45-56 kg/ha is enough for areas where natural stock is low and sufficiently sheltered (Mazlum, 2007).

Annual Life Cycle

As mentioned before, crayfish have an annual reproductive cycle and it is affected by environmental factors mainly by water temperature and sunlight (photoperiod) (Farhadi, & Jensen, 2016). For instance, it is known that the narrow-clawed crayfish has a broad reproductive season, about 6 months, from autumn to winter (Skurdal, & Taugbol, 2002; Kozak et al., 2015). In case of astacid crayfish, mating activity occurs between September and January (Niksirat et al., 2015; Harlıoğlu et al., 2017).

HATCHERY TECHNIQUES IN CRAYFISH HATCHERIES

Artificial Insemination of Eggs

Reproduction technologies used in farm animals such as artificial insemination is another beneficial approach for the improvement of crayfish culture. On the other hand, in spite of there being some information on applications of artificial insemination technique in other crustaceans such as shrimp and prawn species, there is almost no information for crayfish species (Farhadi, & Harlıoğlu, 2019).

In this regard, as known, the successful collection of the male gametes is the first step for artificial reproduction in all animal species. In order to achieve this, it is necessary to separate spermatozoa from spermatophores and suspend individual cells. On the other hand, sperm cells are concentrated inside a package, which is known as spermatophores, and therefore it is not possible to collect the spermatophores by pressing the abdomen in male crayfish (Niksirat et al., 2016).

Thus, there are two main techniques have been used to solve this problem. The first one is the extrusion of spermatophores by electrical stimulation (Niksirat et al., 2015). Another technique is the extrusion of spermatophores by male dissection. However, the viability of spermatozoa following using these extrusion techniques is not clear. Moreover, it has been known that sperm cells are not able to move due to their unusual morphology (Kouba et al., 2015). Thus, their viability could not be determined using motility parameters under the microscope as it is done in fish (Hatef et al., 2009). Thus, there is a need for an effective technique to evaluate sperm cell viability and motility.

Artificial Incubation of Eggs

Regarding production problems in crayfish, artificial incubation technology can be used as an alternative solution. Additionally, it also allows closer control of ambient conditions, such as the prevalence of predators, water quality, and diseases. Furthermore, it requires less energy, space, and labor. In this way, it allows for the production of animals free from aphanomycosis (Jose et al., 1999; Evans, & Edgerton, 2002).

Various incubators have been developed for the incubation of crayfish eggs and have attracted many scientists in many countries recently (Jones, & Valverde, 2020). In this way, developments in artificial incubation production techniques improve artificial reproduction success day by day in aquaculture conditions.

CONCLUSION

It can be concluded that knowledge on factors affecting crayfish reproductive efficiency is limited and there are still information gaps regarding knowledge on the factors affecting male crayfish reproductive efficiency is less than females. It is assumed that this review will fill the gap of knowledge on artificial production and contribute to the development of the crayfish aquaculture industry.

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SOILLESS FARMING:
THE FUTURE OF FOOD AND FEED PRODUCTION

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Introduction

The agricultural sector, which aims to produce the highest quality yields at the lowest possible cost, is a sector aiming mainly for efficiency. The global population is estimated to approximately reach 10 billion people by 2050 and 66% of this population will inhabit urban areas (Ghorbel et al, 2021). As the world's population grows rapidly, the need for food and feed for livestock is eventually increasing. However, the world is full of unproductive soils, and often, climate change also results in adverse meteorological conditions for agricultural production. Therefore, it is challenging to provide big-quantity and high-quality crops using conventional farming (growing plants in soil). That's why soilless agriculture is used in order to help minimize farming costs and to develop crops in uncultivated areas. In traditional agriculture plants, despite consuming more space and water, it still absorbs minimum amounts of nutrients and depends solely on meteorological conditions (Grigas et al, 2019). One of the measures to overcome these limitations is the use of hydroponic systems. Hydroponics is a method of growing plants without using soil. Instead, this method uses water or a mineral nutrient solution that allows nutrient uptake more efficiently than using soil. A German botanist named Julius von Sachs, succeeded in 1860 to grow plants to maturity without soil using only a nutritional solution. Also, in early 1930, Professor William Gerrick created the term hydroponics to describe the fact of growing plants with roots suspended in water and nutritive solution. Finally in 1940, researchers in Purdue University established the hydroponic feeding system. Hydroponics gardens were established in Arizona, Abu Dhabi, Belgium, California, Denmark, Germany, Holland, Iran, Italy, Japan, and Russia throughout the 1960s and 1970s (Sardare et Admane, 2013). Due to fast growing industrialization and urbanization, there is not only a lack of cultivable land, but the conventional farming techniques are no longer environment friendly. Nowadays, soilless agriculture can be successfully regarded as an alternative option for cultivating nutritious healthy vegetables and crops (Sharma et al, 2018). Thus, hydroponics allows people to grow food and forage in areas where conventional agriculture is simply difficult to establish, such as extreme climate areas, densely populated urban areas, costly cultivated land. This farming method allows people in these areas to expand their food production and to feed their livestock the locally grown produce (Grigas et al, 2019). Livestock production in most regions is also limited due to poor production and pricey imported green fodder. Today, land scarcity presents an important limit towards forage production for animals, especially sheep, goats and cattle. Unlike monogastric mammals, ruminants cannot solely depend on cereal grains. That's why alternative technologies, such as hydroponics, are regarded as vital to face these issues. The use of this technology can help improve the long-term economic development of the livestock industry (Masud et Bhowmik, 2018). Hydroponic fodder can also improve the performance of the animals (Girma et Gebremariam, 2018) by providing their nutrient needs (Munson, 2021). Hydroponic fodder is an alternative solution to provide the sustainability of quality forage for ruminants. Hydroponics can include several crops such as maize, wheat and barley, the fodder can be produced in a short duration (6-10 days) and all year around. The hydroponics fodder presents various benefits for animal health. It is rich in protein, vitamins, fiber, and minerals (Girma et Gebremariam, 2018). Feeding hydroponically produced fodder enhances the digestibility of the ration's nutrients, which help improve the milk production (Hassen et Dawid, 2022). Hydroponic fodder production is an economic solution particularly where the conventional production of green fodder is limited or unavailable. This technology put forward a solution to address the shortage of forage production caused by the scarcity of green feed in dry seasons and urban areas (Ndaru et al, 2020). Actually it is one of the important agricultural techniques used nowadays in different countries where Hydroponics fodder production is regarded as an effective alternative technology for sustainable livestock production (Ramteke et al, 2019). The fact that hydroponics has been used for food production since ancient times has led to the relatively recent development of hydroponics for feed production and the potential of hydroponics equipment for feed has not yet been sufficiently revealed.

The objective of this study is to give an overview about the technology of hydroponic production (six types of hydroponic systems based on plant nutrient supply technology), to review the advantages and disadvantages of hydroponic fodder production systems and its hi-tech or low-cost applications. Also this work aims to emphasize the importance of soilless agriculture in the food sector which has led to the Hydroponic system being commonly used in the feed sector. That is why it is also important to explain hydroponic fodder production process, nutritious value and effects on livestock production and productivity to help expand its use by farmers.

Concept of Hydroponic Systems

Soilless systems present a significant alternative to soil cultivation in case of soil and/or water issues, and some of the most important problems are salinization and water shortage (Olympios, 1999). The three main soilless systems are liquid hydroponics, solid media culture and aeroponics.

Hydroponics (Fig. 1) can further be divided into open and closed systems. The open system doesn't provide the recycling of the excess of nutrient solution, however in closed systems, the surplus flow of nutrients coming from the roots is collected and recycled back to the system (Fig. 4).

Solid media culture systems (Fig. 2) can also be separated to open or closed systems, several substrates can be used for plant anchorage (i.e. coconut coir, vermiculite, perlite), as long as characterized by water/air holding capacity and easy drainage.

Aeroponics (Fig. 3) enables the maximum utilization of space by growing plants with roots suspended in air sprayed every 2–3 minutes, plants get nutrients and water from the solution film that adheres on roots (Hussain e tal, 2014).

This diversity of techniques makes soilless culture adaptable to every situation, with a great applicable potential to provide food in areas characterized by soil and water availability issues (Sheikh, 2006).

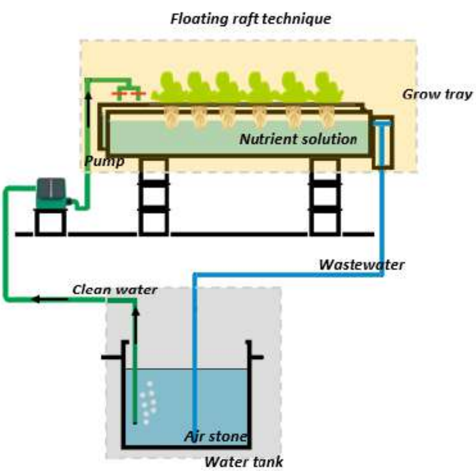


Fig. 1. Scheme of the Hydroponics system. system.

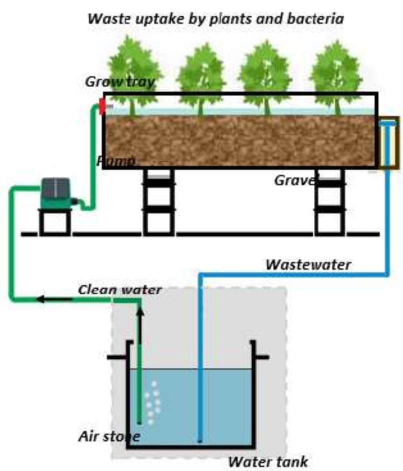
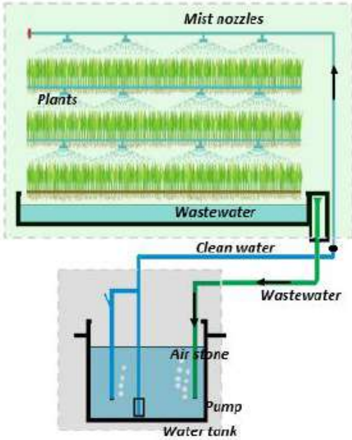


Fig. 2. Scheme of the Solid media culture system

(Ghorbel et al, 2021)



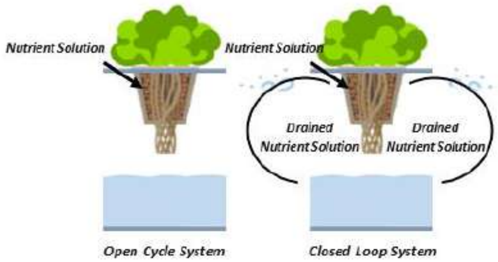


Fig. 3. Scheme of the Aeroponics system.

Fig. 4. Scheme of open cycle and closed loop systems.

(Ghorbel et al, 2021)

Hydroponic Systems Designs and Technologies

There are a total of six types of hydroponics system setups, these systems are based on the flow, nutrient solutions, application of electricity and disposition of plants.

Wicking System

The wick system is a hydroponic system that doesn't need electricity to work so it is regarded as relatively easy to install. In this system the roots of plants are connected to the irrigation solution by the wick which is a special absorbent material such as nylon rope, wool strip, polyethene strip (Fig 5). The wick will gradually deliver the nutrient solution to the plant. An air pump is maybe needed in this type of system (Akkenapally et Lekkala, 2021). This system may not be very suitable for forage production due to less efficient seedling (Grigas et al, 2019).

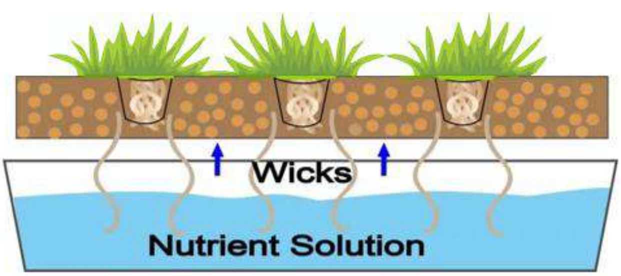


Fig 5. Wick system.

Deep Water Culture (DWC)

DWC system is one of the most basic and common systems in hydroponics. In this system, the plant roots are immersed in a reservoir full of irrigation solution (Fig 6). The roots being in direct contact with the nutrient solution there is no need for a water pump, but an air pump is necessary for the oxygen (Ghorbel et al, 2021). Water culture systems allow the roots to have a large space therefore a larger contact with the nutrient solution and more absorbed nutrients. Being one of the easiest systems it is a good choice for beginners. This system lacks the inadequacy for efficient feed production. It is not adequate for seed growing (Grigas et al, 2019).

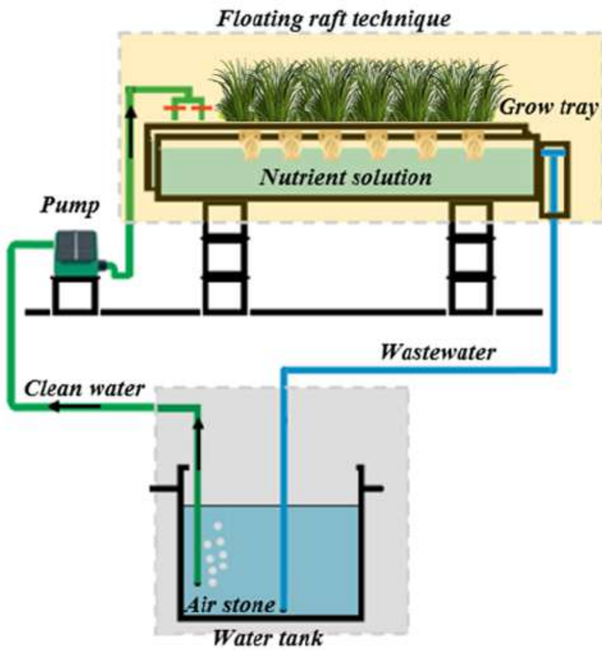


Fig 6. Deep Water Culture system.(Ghorbel et al, 2022a)

Drip System

A drip hydroponic system is based on transporting the nutrient solution inside a tube and dripping it above the plant and roots (Fig7). The drip system is very good at monitoring the quantity of water dripped to each plant. These systems can be either circulating or non-circulating. In the circulating system the water is recycled into the reservoir and reused. In the non-circulating system, the nutrient solution is single-used and not recycled. These systems. The main advantage of this system is the use of less water, but it can be prone to clogs. It is very adequate for outdoor gardens but can easily become clogged and it is an inefficient system for forage production.

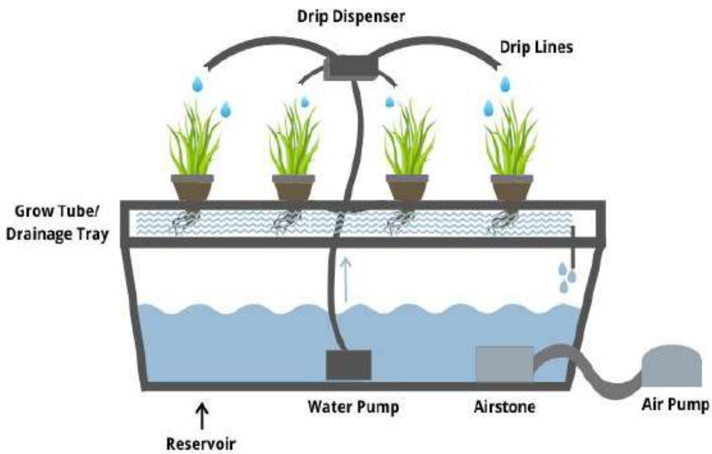


Fig7. Drip system. (Ghorbel et al, 2022a)

Aeroponics

Aeroponics is a system where the plant's roots are suspended in air and sprayed directly by the nutritional solution with static sprinklers (nozzle, aerosol or misting spray). Aeroponics is a great system to economize water. Mist nozzles can spray the nutrient continuously or intermittently. The suspended root system is also very good for absorbing more oxygen (Fig 8). The aeroponic technique is specifically aimed for smaller horticultural species and has not yet been widely used. It significantly increases the relative humidity of the room, which increases the risk of molds (Grigas et al, 2019). Using this system for growing large quantities of feed would be quite challenging but manageable under controlled environmental conditions.

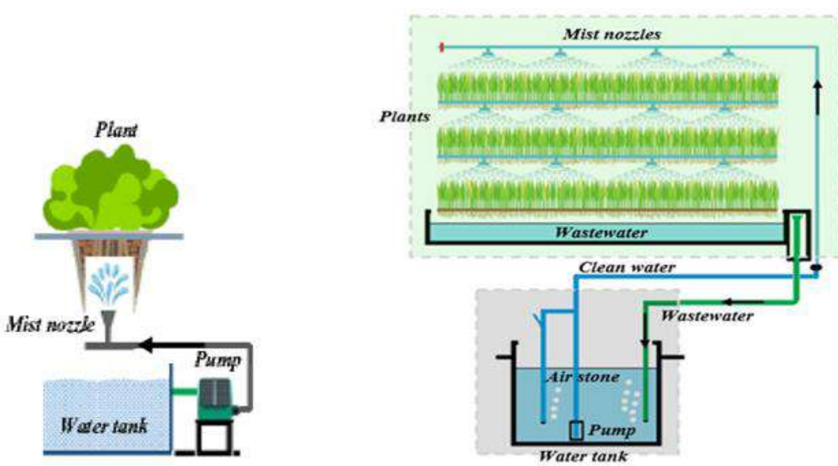


Fig 8. Aeroponic system .(Ghorbel et al, 2021)

An Ebb and Flow System

Ebb and flow system or as is also called flood and drain system is one of the hydroponics systems. In this system the plant roots sit directly on a tray that floods in the nutrient reservoir water. The nutrient solution floods for some period then with a precise interval drains back to a lower reservoir. The flooding interval can be controlled by a timer (Fig 9). Ebb and flow hydroponics system is specific for plants that flourish under a period of excess nutrients followed by a period of dryness (Kumar et al, 2021). During the dry intervals, the plant roots will grow searching for nutrients thus the fast plant growth. This system is rarely used in forage production for being ineffective (Grigas et al, 2019).

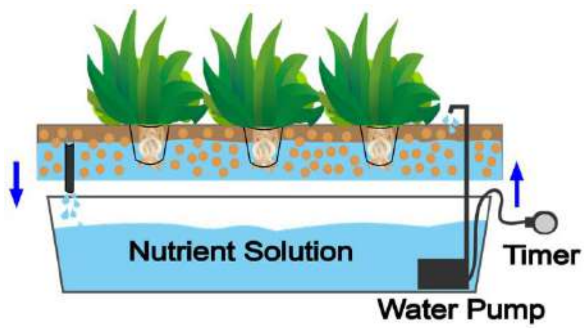


Fig 9. Ebb and Flow system. (Ghorbel et al, 2022a)

Nutrient Film Technique NFT

The NFT technique is often used and can be considered the classic hydroponic cultivation system; in this type of system the nutrient solution flows along and circulates in tubes with a 1–2 cm layer of water (Ghorbel et al, 2021) (Fig. 10). This technique is mainly used to increase the oxygen level and decrease the amount of water used. The NFT system is based on suspending the plants in a row with a slight tilt. This tilt is necessary to move the water by gravity through the tips of the roots. The roots being entirely exposed to air and only the tips immersed in nutrient solution help increase the amount of oxygen adsorbed by plants. The NFT hydroponic system can be effective in forage growing but due to the tilted growing tray can cause the germinated seeds to flow downwards with the irrigation solution (Grigas et al, 2019).

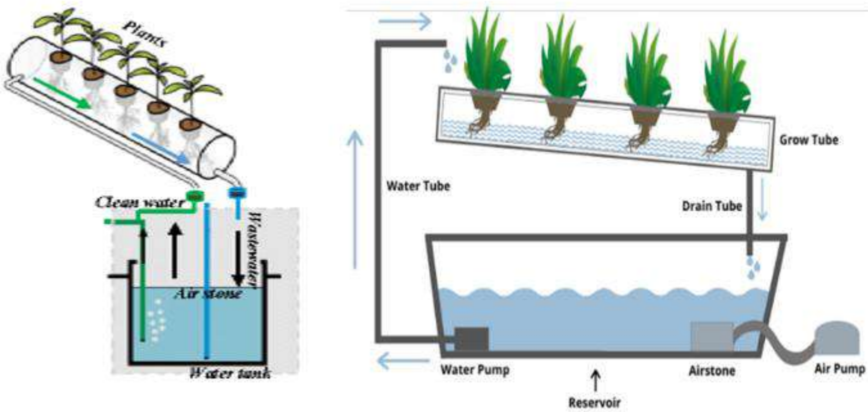


Fig10. Illustrations of the NFT system. (Ghorbel et al, 2022a)

These are the basic six hydroponics systems used until now. Hybrid systems can be also created using a combination of any of the above six techniques. A mix between Aeroponics and NFT technique can be a great hybrid system for green fodder production. Some other interesting alternatives may be also present in literature such as aquaponics and fogponics.

Land for Hydroponic Systems

Hydroponic technology is used in harsh climates such as deserts, poor soiled areas or in urban areas where agriculture lands are pricey. It is also suited to semi-arid, arid, and drought prone regions, areas with chronic water shortages or areas where irrigation, fencing and land preparation resources are limited. It is also used in mining and coastal regions where soil is rocky and infertile. Limited crops due to stray cattle or wild animals, costly labor and high rate of educated unemployed youths can also be the main reasons to favor hydroponic technology.

Nutrient Solution Management

Essential Nutrients

In hydroponics, plants are grown outside the soil so required nutrients must be delivered directly through the watering solution to enhance the growth of the plants.

Nitrogen ***(N):*** Nitrogen is primordial for plants because it allows the production of amino acids consequently proteins, enzymes and chlorophyll. Nitrate and ammonium are the main nitrogen forms used in fertilization. Nitrate is quickly absorbed by the roots; and can be accumulated inside the plant without toxic effects. However, ammonium can be absorbed only in low quantities and at high quantities can cause toxicity (Sonneveld et Voogt, 2009).

***Phosphorus** (P):* Phosphorus stimulates root growth, the rapid development of buds and quantity of flowers. Absorption of P is very easy and its accumulation presents no damage to the plant. Phosphorus's main role is to help the formation of high-energy compounds necessary for plant metabolism (Bot et al, 1998).

***Potassium** (K):* Potassium is a fundamental component for cell division and extension, protein synthesis, enzyme activation and photosynthesis. It actually transports other elements and carbohydrates between the intra and extracellular environment, playing a major role in keeping an equilibrated osmotic potential of the cell and a regulated stomatal opening (Wang et al, 2013).

***Calcium** (Ca):* Calcium is needed for cell wall formation, cell division, cell extension and membranepermeability.ca helps raise the plant's resistance barrier against fungal and bacterial infections (Lui et al, 2014). The absorption is very closely controlled by the water flow between roots and aerial parts.

***Magnesium** (Mg):* Magnesium is involved in the constitution of chlorophyll molecules. Its immobilization occurs at pH below 5.5 and it is always in competition with K and Ca. The observed yellow color between leaf veins and internal chlorosis of the basal leaves may indicate Mg deficiency (Sonneveld et Voogt, 2009).

***Sulphur** (S):* Sulphur is required by the plant in quantities comparable to those of phosphorus, and for better absorption, its ratio with nitrogen must be 1:10 (Muneer et al, 2014).

***Iron** (Fe):* Iron is a very important micro-nutrients for the plant because it has a key role in some major biological processes like photosynthesis (Briat et al, 2015). The optimal ratio of Fe–Mn is generally around 2:1 (Heuvelink et Kierkels, 2016).

***Chlorine** (Cl):* Chlorine has been recently considered a micro-nutrient, even if its content in plants (0.2–2.0% dw) is quite high. It is easily absorbed and very mobile within the plants. It is involved in the photosynthetic process and the regulation of the stomata opening.

***Sodium** (Na):* Sodium, it can be toxic if absorbed in big quantities it can enter in antagonist activity and minimize the absorption of other ions. Similar to Cl, it is very important to monitor the concentration of Na in the nutrient solution (Sonneveld et Voogt, 2009).

***Manganese** (Mn):* Manganese get involved in the formation of many coenzymes, the extension of root cells and their resistance to pathogens. Its availability is controlled by the pH of the nutrient solution and by competition with other nutrients (Uchida, 2000).

Boron ***(B):*** Boron is essential for fruit setting and seed development. Its absorption methods are similar to Ca that's why they are always in competition. The optimal pH of the nutrient solution should be between 4.5 and 5.5 (Rooney et al, 2006).

Zinc ***(Zn):*** Zinc takes an important role in some enzymatic reactions. PH and P content in the nutrient solution can strongly affect Its absorption (Gibson, 2007).

Copper ***(Cu):*** Copper is mainly implicated in respiratory and photosynthetic processes. pH values above 6.5 can negatively affect its absorption, whilst pH values lower than 5.5 may result in toxic effects (Gibson, 2007)..

Molybdenum ***(Mo):*** Molybdenum is primordial in protein synthesis and in nitrogen metabolism. Contrary to other micronutrients, its availability is optimal at neutral pH values. Symptoms of deficiency show as chlorosis and necrosis along the main rib of old leaves, whilst the young leaves appear deformed (Gibson, 2007).

Water Quality and Nutrients

Supplied water's quality is enormously important in hydroponic and AP systems. For long-term recirculation, the chemical composition of nutrient solution can deteriorate; that's why it should be frequently monitored and analyzed not only to avoid a deficiency in nutrient supply but also to avoid the accumulation of some toxic elements. De Kreij et al. (1999) made an overview about the chemical needs for water quality in hydroponic systems. For example, if rainwater is used as a watering solution, major attention has to be made for the amount of Zn, especially when water collected from untreated gutters. For the case of tap water, Na, Ca, Mg, SO4 and HCO3 amounts may appear to be problematic. Furthermore, some water sources such as surface and borehole water can be used and that can cause some issues because it may contain amounts of Na, Cl, K, Ca, Mg, SO4 and Fe and also microelements such as Mn, Zn, B and Cu. It should be taken into consideration that all valves and pipes should be preferably made of synthetic materials such as PVC and PE, and are free from Ni or Cu parts.

Disinfection of Nutrient Solution

To minimize the risk of spreading soil-borne pathogens, disinfection of the circulating nutrient solution is required (Postma et al, 2008). Heat treatment (Runia et al, 1988) was the first method used. Van Os (Van Os EA, 2009) made an overview for the most important methods. Recirculating the nutrient solution opens possibilities to save on water and fertilizers (Reddy, 1988). But also offer some disadvantages such as an increased risk of root-borne pathogens propagation through all the system. To reduce this kind of risk, the nutrient solution must be controlled and treated before reuse.

Advantages Of Hydroponic Production Technology

Minimum Water Use

Hydroponic system minimizes wasting water wastage due to the direct application of contact water-roots. The water is usually recycled and used several times. The research findings concluded that the hydroponic system would use only up to 2-5% of water used in conventional fodder growing (Naik et al, 2014). It has been reported that only 1.5 - 2 liters of water is enough for 1 kg hydroponic fodder production compared to 73, 85, and 160 liters of water to produce 1 kg green fodder of barley, alfalfa, and Rhodes grass in field conditions respectively (Jemimah et al, 2015).

Minimum Land Use

Hydroponic systems require much less space, and it is perfect for urban agriculture with restricted yard space. Using hydroponics technology, up to 1000 kg maize fodder can be produced daily from 45-50 m2 area which is equivalent to 25 acres of cultivable land in conventional fodder production (Jemimah et al, 2015) (Naik et Singh, 2013). It is an easy system to be established indoors which can help in land preservation. Practically, one square meter area can produce a daily sufficient amount of fodder for two cows which can increase milk yield by 13% (Yvonne, 2016).

Minimum Growth Period

Hydroponic technology takes only 8 days to develop from seed to fodder where it took at least 45 days for a conventional fodder to grow.

High and Continuous Yield

Fodder production technology is based on minimizing the distance between water-roots which means bringing the nutrients directly to the plants without developing large root systems which can accelerate the growing period by 25%. Actually, 1kg of seed yields 8-10 kg green fodder in 7-8 days (FAO, 2015). So, the hydroponics fodder yields on a fresh basis 5-6 times more than conventional grown forage (Naik et al, 2014). Fodder can be produced around the year despite the changes in monsoon, land availability, natural calamities, and labor shortage. This consistency can ensure promising milk production and better quality of meat and other animal produce. Hydroponic fodder production can be the way leading to sustainable agriculture and livestock production (Maxwell, 2013).

Rich In Essential Nutrients

Compared to the un-sprouted seed, the hydroponic fodder is rich, on DM basis, in crude protein, neutral detergent fiber, acid detergent fiber and Calcium, but less rich in organic matter and non-fibrous carbohydrates (Metha et Sharma, 2016). Hydroponic fodder is a great source of vitamin A, vitamin E, vitamin C, thiamin, riboflavin, niacin, biotin, free folic acid, antioxidants like β-carotene and minerals. Also, hydroponic fodder contains good amounts of bioactive enzymes, essential fatty acids, chlorophyll, and minerals which directly affect fodder growth and improves the performance of livestock (Grigas et al, 2019) (Naik et al, 2015).

Reduced Carbon Footprints

Hydroponic is more environmentally friendly compared to traditional agriculture when it comes to the use of inorganic chemicals. This condenses GHGs emissions and lessens considerable global warming. Hydroponic systems based in urban areas can help minimize transport used fuel and carbon emissions in turn (Newella et al, 2021).

Minimum Pesticides, Insecticides, and Herbicides Use

Traditional agriculture is based on the use of herbicides, fungicides and/or insecticides to achieve higher production. Hydroponic fodder technology aims to grow fodder in a controlled environment soilless to avoid soil borne disease resulting in minimizing pesticides, insecticides, and herbicides use. The susceptibility of any infection can easily be ruled out with specific compounds in hydroponically grown fodder.

Impact on Livestock

Hydroponic fodders are highly digestible, palatable, and nutritious. They are highly succulent, and animal can intake 1-1.5% of their body weight (Starova, 2016) or 15-25, 1.5-2, 0.25 - 2 and 0.1 - 0.2 kg/animal/day in large ruminants, small ruminants, adult pigs, and rabbits respectively (Jemimah et al, 2015) (Naik et Singh, 2013).

Studies proved an increase in the digestibility of nutrients in lactating cows when fed hydroponic fodder compared to cows fed Napier bajra (NB-21) green fodder (Reddy et al, 1988). The daily milk yield of animals fed a total mixed ration containing hydroponic maize or barley fodder showed an increase of 8.0-

14.0% compared to animal fed conventional green fodder (Jemimah et al, 2015) (Yvonne, 2016). The hydroponic fodder tunes longer lactation period, improves fat percentage and general herd health as well as reduces the cost of veterinary intervention (Naik et al, 2015). Poultry animals fed on hydroponic fodder showed faster weight gain, good quality carcass, lower feed cost per kg of weight gain and improved health and production potentials (Jemimah et al, 2015).

Minimum Labor

Minimum manpower is needed to produce hydroponic fodder. It is a soilless agriculture technology so there is no soil preparation, constant weed removal, fencing, and post-harvest labor requirement (Bekuma, 2019). Actually, one person can be sufficient to produce around 600 kg of fodder hydroponically.

Low Cost

Materials used for the system can be low cost and locally provided. The operational systems like irrigation, cooling, and lighting are controlled and can be maintained at a low cost (Al-Kodmany, 2018).

Limits of Hydroponic Fodder Production Technology

Although hydroponic farming is an advantageous technique which is appreciated by most farmers it has some significant limitations.

Technical Knowledge

This type of hydroponic technology may not require major labor input, but few needed manpower must be efficient and skilled. Especially when it concerns monitoring and handling the controlled environment parameters inside the green house.

High Initial Cost

A relatively large initial investment is a basic requirement for commercial-scale farming. The major restriction faced by farmers is the high initial capital investment. The production trays, seeds, equipment and the construction of production-units present the main costs in need of investment (Uddin et Dhar, 2018).

Availability And Price Of Seed :

Availability of seed presents one of the major limitations for farmers. The unavailability of seeds in the market increased its cost which in return can greatly affect the cost of hydroponic fodder as seed costs present up to 90 % of initial cost (Uddin et Dhar,2018).

Dry Matter Loss

Hydroponic fodder is susceptible to be highly perishable in Hot climate and a lack of oxygen if it is not properly stored.

Higher Risk of Fungus and Microbial Infections

Hydroponic fodder is too sensitive to room temperature and humidity, which is the major threat for fodder production technology. Failure to control temperature and humidity could cause mold, fungi and bacteria. Mold affected fodder fed to livestock, would be the cause of digestion problems that can finish by death in extreme cases (Uddin et Dhar,2018).

Waterborne diseases

Sharing the same nutrient solution can be the cause to water borne diseases to spread from plant to another. Hydroponic fodder can be often infected by Aspergillus clavatus. This fungus and its toxins can have negative effects on animal health such as hypersensitivity, dragging of hind legs, clonic convulsions, tremors, decreased milk yield and possibly death (Akkenapally et Lekkala, 2021).

High-Tech cost:

The necessity of Lighting and energy supplies are very important to run the system in a safe environment (Sharma et al, 2018). That's why, maintaining the EC, pH, and optimum concentration of the nutritional solution is very crucial. Environmental conditions inside hydroponic greenhouses such as temperature, light intensity, carbon dioxide concentration, and humidity must be frequently checked with a climate control monitor system (Fao et al, 2021).

Importance of Hydroponic in Food Production

Water scarcity, pollution and nutrient deficient soils present a major challenge worldwide and these are likely to deteriorate with increasing global populations particularly, in urban areas. For a healthy population, this growth in population will be the reason behind a rising demand for fresh products, but this produce will be often exposed to travel a long way to reach the consumer, not only losing quality and nutrition along the way, but also requiring a significant fossil fuel cost for transportation and storage. Adding to this the required packaging and preservatives, which always have negative effects on the environment. Soilless systems present a significant alternative to soil cultivation in case of soil and/or water issues, and some of the most important problems are salinization and water shortage (Olympios, 1999). A number of crops can be grown commercially in hydroponics, principally vegetables and fruits. Such as Fragaria ananassa (Strawberry), Lactuca sativa (Lettuce), Lycopersicon esculentum (Tomato), Phaseolus vulgaris (Green bean), Beta vulgaris (Beet), Cucumis sativus (Cucumbers), Cucumis melo (Melons), Allium cepa (Onion) and many others (Hussain et al, 2014). Accordingly, hydroponics can play a major role in providing essential dietary fiber, minerals and vitamins (FAO, 2003). Even more, it could help in fulfilling the recommended minimum intake of fruits and vegetables per person. Actually, some types of food which are nowadays under-consumed worldwide, due to cultural lack in their cultivation and use, or due to absence of appropriate environmental requirements. Thus, hydroponics systems can enhance crop diversification and consumption attitude.

Crops

A variety of crops can be planted on commercial level in hydroponic, principally fruits and vegetables.

Tomato crop : Always a favorite of gardeners, tomatoes are a popular hydroponic crop. But for its culture proper support is critical, because the plants will get heavy as fruit begins to develop. Tomatoes require heat and high light levels to grow vigorously and produce fruit (Sgherri, 2007).

Lettuce: Lettuce is a popular crop which can grow perfectly well in almost any gardening system, whether hydroponic, aquaponic, or traditional soil gardens. It takes up relatively little space, has a short (5-6 weeks from transplant or 9-11 weeks from seed) growing cycle, and has always high market demand (Atzori, 2016).

Strawberries: Strawberries are one of the most popular grown crops, it is best if it is planted as rootstock rather than seed. Vegetative growth (runners) tends to be much faster than sexual reproduction (seeds), so you can cut the time from planting to production by months or years by using rootstock. Strawberries are vulnerable to pests and diseases that’s why soilless culture is a great alternative.

Radishes: Radishes are one of the easiest vegetables to grow either in soil or hydroponics. It’s better grown from seeds, and it will show seedlings within 3 – 7 days. Cool temperatures and minimum light will stimulate radishes’ growth which as vegetables will make a good flavoring mix with other vegetables.

Cucumbers: Cucumbers are a common grown vegetable planted at home or in commercial greenhouses. If given sufficient needed conditions it is characterized by rapid growth hence high yields. There are several types and sizes of cucumbers, including the thick-skinned American slicers, long thin-skinned seedless European, and the smooth-skinned Lebanese cucumbers. All can grow well in Hydroponics.

Peppers: Peppers are similar to tomatoes concerning hydroponic growing conditions; it both needs warm temperature and great amounts of lights. Recommended varieties for hydroponically growing are Jalapeno, Habanero for hot peppers; Mazurka, Cubico, Nairobi, Fellini for sweet peppers.

Costs and Benefits of Hydroponics

Unlike conventional farming, the hydroponic system offers quite important benefits. As well as the societal benefits of 'greening' urban areas and improving public spaces, hydroponic farming presents also the ability to move farming closer to population and to improve resource usage and growth efficiency (Westphal, 2003). A study about the yield and resource usage of lettuce farmers in Arizona showed that a hydroponic farming system can decrease water usage by 13 ± 2.7 times and increase yield production by 11 ± 1.7 times compared to conventional agricultural systems (Barbosa et al, 2015). Over an equal area, the water consumption for both methods was roughly comparable, but using hydroponic farming, characterized by vertical growing beds and fewer harvest cycles, resulted in raising yield and more efficiency. Being closer to the urban population has reduced transport and CO2 emission but these savings are difficult to calculate precisely as it varies greatly from city to city depending on transport links, transport type, amount of imported food, and food consumption culture. Several estimations have been made, however. A study in Seoul, South Korea, for example, mentioned that if urban farming was set up in a 51.15 km2 area around Seoul, it can decrease CO2 emissions by 11.67 million kg annually, which is the equivalent CO2 emissions of 1155 people each year (Lee et al, 2015). The major costs of installing and operating a small indoor hydroponic farm can be limited to water consumables (nutrients and grow plugs) and electricity costs (water pump, cooling, air flow and lighting).

Importance of Hydroponic in Feed Production

Feeds and animal nutrition presents a major sector in providing food security. However, there is a large gap between feed supply and demand (Akkenapally et Lekkala , 2021). This gap can be attributed basically to climatic changes, urbanization and increase in meat demand. Nowadays, especially after the covid-19 pandemic, there is a crucial problem in supplying fresh green feed to remote and urban regions. The main problems of feed scarcity emanate from land scarcity; actually, rapid urbanization is the major cause behind the decrease in land meant for grazing and fodder cultivation. With Water, labor shortage and elevated cost of fertilizers the farmer leans to cultivate commercial food crops over green fodder (Shit, 2019). Nevertheless, producing green fodder to meet the current demand has become a greatest challenge among livestock farmers. In fact, green fodder is very important for the productive and reproductive performance of animals. Feeding green fodder can improve livestock products (Moorby et Fraser, 2021). Hydroponics is currently an emerging alternative technology for growing fodder in farms, it is also a solution facing all the limits and challenges raised by traditional fodder cultivation (Shit, 2019).

Hydroponic Fodder's History

The concept of hydroponic fodder culture dates to 1800, the era of Hanging Gardens of Babylon, when dairy cows were fed sprouted grains during winter to maintain milk production and improve fertility (Shit, 2019). The word hydroponic is derived from two Greek words, hydro and ponics, which mean respectively water and functioning. It is an eco-friendly alternative technology for landless farmers to produce fodder without soil. It requires only a limited amount of time for the fodder to grow and can mature under controlled environmental conditions inside the greenhouse. Greenhouse provides a growing habitat with totally or partially controlled environmental conditions (Shamshiri et al, 2018). Hydroponic fodder culture may be based on growing forage without soil, but it definitely needs water; nutrient-rich solutions can be used but generally tap water is sufficient. Fodders such as maize, barley, oats, sorghum, rye, alfalfa, horse gram, ragi, bajra, jowar and triticale can be produced by hydroponic technology (Jemimah et al, 2015) The final product is a mat of 20-30 cm height made of roots, seeds, and sprouts, it is highly palatable, digestible, and nutritious for animals. This is a great alternative technology to be used where conventional green forage production is limited especially with low-cost materials (Prafulla et al, 2015).

Principle Of Hydroponic Fodder Production Technology

Hydroponics is a method used to grow cereal grains providing sufficient moisture and nutrients without soil or solid medium. Germination will end with a product of 20-30 cm long forage green shoot and interwoven roots within 7-10 days. Fodder production can include different cereal grains that undergo various chemical and structural changes during the growing process. Such as enzyme activation, which is a necessary step to hydrolyze nutrients to much simpler forms. Grain variety, quality, nutrient supply, pH, water quality, soaking time etc are important factors that affect the quantity and quality of sprouted fodder (Shit, 2019). Water, nutrients, and sunlight are the most needed elements for plants to flourish. Hydroponics is a direct method to provide the required nutrients for plants to grow without soil and under controlled environmental elements. This technology has been proved successful using various crops such as Maize, Sorghum, Barley, and Oats and resulted in high-quality, nutritious and palatable green fodder for dairy animals (Swain et Sahoo, 2020).

Importance Of Hydroponic Fodder

Adapted To Extreme Climate

Hydroponic technology is usually suited to difficult climates like deserts, areas with poor soil or urban areas where high land costs discouraged traditional agriculture. It is probably best used in semi-arid, arid, and drought prone regions, areas with chronic water shortages or where irrigation, fencing and land preparation resources are limited. Green fodder production by this technology is a boon for farmers from mining and coastal belt whose soil is rocky and infertile (Shit, 2019).

Minimum Land Use

Hydroponics avoids problems presented in conventional fodder production. Hydroponics is a vertical growing system that uses small pieces of land to produce a large volume of fodder in fraction of the area needed by conventional fodder production. Different reviews indicated that around 600 kg of maize fodder per day is produced in 50 square meters of area (Kumar, 2019). However, to produce the same amount of fodder in the conventional production method, 1ha of land is required (Hassen et Dawid, 2022).

Minimum Water Requirement

There is less water use when producing fodder hydroponically because water gets recycled. Actually, 1kg of hydroponic maize fodder is produced in 7 days with 1.5 liters (if water is reused) or 3 liters (if water is not reused). The non-recycled water can be exploited in irrigating the land outside the greenhouse (Shit, 2019).

Minimum Labor

Minimum manpower is needed to produce hydroponic fodder. It is a soilless agriculture technology so there is no soil preparation, constant weed removal, fencing, and post-harvest labor requirement (Bekuma, 2019). Actually one person can be sufficient to produce around 600 kg of fodder hydroponically.

All Year Supply

Hydroponic technology can provide green fodder round the year. Constant supply can be provided despite climate elements such as rain, storm, sunshine, or drought (Barrow, 2016). In addition, the nutritive value of hydroponic fodder can be enhanced by additional growth promoters, nutrients… which will have a positive effect on milk quality for dairy animals.

Minimum Fodder Loss

Hydroponically produced green fodder is given to animals as a mat to be eaten wholly so there will be no feeding losses compared to wastages of chopped traditional grasses during feed intake (Naik et Singh, 2013).

Higher Yield:

Hydroponic fodder production aims for high growth with no compulsive need for nutrients. The lack of soil nutrient loss spares crop rotation (Hassen et Dawid, 2022). The hydroponic fodder has a high moisture content, minimum weeds and dust due to sterile media.

Low Cost

Materials used for the system can be low cost and locally provided. The operational systems like irrigation, cooling, and lighting are controlled and can be maintained at a low cost (Al-Kodmany, 2018).

Effect On Livestock

This feed is highly palatable and nutritious which can make it conducive for almost all livestock. Hydroponic feed is a natural product that can be produced without hormone, growth promoter, or chemical fertilizer. It can also be free of pesticide, fungicide, dust, or any toxic contaminating livestock products. Providing green fodder to milk animals can replace, if not totally but partially the concentrate feed which can help lead to an economically viable milk-producing industry (Zhang et al,18).

Fodder Crops for Hydroponic System

Various sorts of grain crops ; oats, ragi, bajra, wheat, sorghum, barley, Alfa-Alfa, cowpea and maize can be employed for soilless farming. However, the crop preference depends on the seed availability and agro climatic conditions. The grain used for soilless culture ought to be sound, perfect, and flawless. Maize and barley can be the best choice for hydroponics, owing to their high biomass production, faster growth rate, cheaper and easy availability of the seed (Naik et al, 2015). According to (Heins et al, 2015), amongst all the hydroponic fodders such as oats, rye, triticale and wheat, the sprouted barley has the highest forage quality. The 6th day is harvesting day for barley seed sprouts as it presents the highest nutrient and biomass yield. Besides cereals, some leafy vegetables such as spinach and coriander can also be grown hydroponically (Akkenapally et Lekkala , 2021).

Environmental Factors for Hydroponic System

The environmental factors are important for optimization of the hydroponic fodder growth and production. The standard level of environmental cues such as temperature (19 to 22ºC), humidity (average 60%), light intensity (2000 lux), length (12-16 h) and aeration for 3 minutes at every 2 h interval should be maintained (Starova, 2016). The electricity requirement to produce hydroponic fodder is much lower than for traditional fodder production.

Hydroponic Fodder Production

Seed Storage and Preparation

In the hydroponic fodder production system, the seed cost contributes 85-90% of the total cost of production (Jemimah et al, 2015) (Naik et al, 2014). It includes procuring clean, sound, intact, untreated, viable seeds/grains of high quality (Naik et al, 2015). Seeds must be dried directly under sunlight one day prior to seed washing.

Seed Cleaning

The seeds must be washed firstly for 5 minutes thoroughly with tap water till all dirt and poor-quality seeds are removed. Next, seeds should be soaked in 0.1-1.5% bleach solution (sodium hypochlorite) or 1-2% hydrogen peroxide solution for 30-60 minutes (Jemimah et al, 2015) (Starova, 2016). Then, the cleaning solution is drained off and seeds are then washed in tap water.

Seed Soaking

The seeds are soaked in fresh aerated water for different periods: 4 h (Naik et al, 2014), 8 h (Starova, 2016), 12-16 h or overnight (Brownin, 2017), 24 h (Reddy, 2014). depending on the hardness of the seed coat. Temperature of the water or solution used for soaking also affects the germination rate. So the optimum temperature at soaking is 23ºC.

Germination of Seed

After soaking, the seeds are spread at up to 1 cm depth in plastic or light weighted metallic trays with holes to facilitate drainage of wastewater/nutrient solution, which can be collected in a tank and recycled. The seed rate (quantity of seeds loaded per unit surface area) changes depending on the type of seeds and can also affect the yield of the fodder. The recommended seeding rate for production of hydroponic barley, wheat or sorghum fodder is 4-6 kg/ m2 (Starova, 2016) and for maize 6.4-7.6 kg/m2 (Naik et al, 2014) (Naik et al, 2013) (Naik et al, 2017).

Loading Seeds in Trays and Racking

A specially constructed frame made to hold plastic trays in which 1-1.25 kg of seed can be placed to produce about 5.5-7.5 kg of green fodder. The seed trays must be clean and free from any dust / dirt. After germination of seeds, trays are transferred and put in the sprouting section (height between two rows must be around 5 inches). Finally, trays should be distributed evenly on both sides of the alley for even sunlight.

Shifting Trays and Harvesting

The irrigation of germinated seeds can be with fresh tap water or nutrient solution. Hydroponic trays should be protected from direct sunlight, strong wind, and heavy rain. During the growing process, the seeds should be kept moist by drip or spray irrigation but not saturated with water. Trays must be shifted to the next level daily so that it moves one step ahead in the growth cycle. If the left side tray shows more growth, the trays must be rotated to the right and vice-versa. On the 9th day, the fodder mat is harvested from the tray and can be fed to the livestock. The trays are washed with a cleaning solution before reusing it for the next cycle.

Health Hazards of Infected Hydroponic Fodder

Hydroponic fodder can be heavily infested with Aspergillus clavatus and can cause a lot of health problems in case it's fed to livestock. Animals may show posterior ataxia, knuckling of fetlocks, dragging of hind legs, high stepping in the hind limbs, stiff gait, tremors, progressive paresis, hypersensitivity, recumbency, clonic convulsions, decreased milk yield and death possibilities (Shit, 2019).

Nutritive Value of Hydroponic Fodder

The hydroponics fodder presents various benefits for animal health. It contains high levels of protein, vitamins, fiber, and minerals (Girma et Gebremariam, 2018). The nutrient quality of hydroponic fodder is better than common non-leguminous fodders in terms of crude protein (CP), organic matter, ether extract (EE) and nitrogen free extract (NFE). Conventional fodders can be less nutritious than hydroponic fodders (Girma et Gebremariam, 2018). During sprouting there will be a nutrient enrichment, crude protein, ether extract, and nitrogen free extract content will increase but crude fiber, total ash, and insoluble ash will be decreasing. Sprouting can also result in 7- 47**%** loss in dry matter (DM) from the original seed in the period of 6-7 days mainly due to respiration during the sprouting process (Shit, 2019). Seed soaking activates enzymes that convert starch stored in endosperm to a simple sugar which produces energy leading to loss of DM with a shift from starch in the seed to fiber and pectin in the roots and green shoots. The sprouts are the most enzyme rich parts and maintain the highest level from germination to seven days of age. They are rich with antioxidants, especially β-carotene. With the decreasing starch content, both organic matter and dry matter content also decrease. Sprouting catabolizes starch into the plant's soluble sugar (Halo et al, 2020). However, ether extract of hydroponic fodder increases due to the increment of structural lipids and chlorophyll as the plant grows. The development of structural carbohydrates increases the concentration of crude fiber (CF), neutral detergent fiber (NDF), acid detergent fiber (ADF) and linoleic acid but decreases nitrogen free extract (NFE). Sprouting process also increases total ash content associated with the decrease of organic matter. Starting from day four of the process, the growing roots will enhance the mineral uptake which enriches the mineral content of the sprout especially if a nutritious solution was used in place of tap water (Dung et al, 2010). However, the gross energy, metabolizable energy, and total digestible nutrient content decrease during sprouting. This is due to energy uptake during respiration of the plant. Besides, the absorption of nitrates facilitates the metabolism of nitrogenous compounds and thus increases the C.P. levels. The use of nutrient solution in place of tap water enhances the C.P. content of the hydroponics fodder and ash content of the sprouts which may be due to the absorption of nitrogenous compounds and minerals by the roots (Brown et al, 2018).

Hydroponics Fodder Feeding Value

Hydroponics fodder is tasty, animals will consume the seed alongside the roots and the shoots which will result in no nutrient waste. Animals sometimes can eat the green part and leave the roots, that's why it is better if the hydroponics fodder is mixed with the other roughage components of the ration (Naik et al, 2014) (vanilla, 2018). The improvement of indigestibility of feed is evident when hydroponic fodder is added in dairy cows' ration. Dairy animals can be fed 25 kg/day based on their physiological status with lower amounts of concentrate and roughage (Prafulla et al, 2015).

Digestibility/Degradability

The digestibility of the sprouts is higher compared to the grains, shoot and root sprouts, but shoots can also have good digestibility (Naik et al, 2014). The increase in the digestibility of dry matter, organic matter, crude protein, and crude fiber in maize might be due to the tenderness of the fodder at an early age (reddy, 1988). Banakar (Akkenapally et Lekkala , 2021) reported that the inclusion of sprouted barley with rice straw and Tamarix Mannifera improved the digestibility of DM, OM, CP, CF, NDF and ADF which may be due to the existence of bioactive catalysts that stimulates the digestion and absorption of the nutrients. In the rumen, the sprouts had shown better digestibility than the cracked grain. However, compared to the digestibility of roots and sprouts, shoots degrade faster, that's why ruminants prefer leafy materials (Dung et al, 2010). The digestibility of hydroponics fodder's nutrient is comparable to highly digestible legumes such as clovers. Even with the loss in the dry matter content of sprouted barley fodder, their digestibility is still advantageous.

Energy

Both hydroponic sprouts and processed grains are regarded as nutritious and digestible feeds. Grain sprouting catabolizes the starch to sugar. On a dry matter basis, sprouts show less energy value compared to the grains with gross energy loss (Farghaly, 2019).

Protein

Protein is a critical element that animal performance highly depends on, thus there is a major need to identify and enhance protein value in hydroponic fodder. Sprouts manifest a higher concentration in crude protein, ash, and other minerals except potassium than grains. The increase in dry crude protein content is mainly due to decrease in dry matter content especially carbohydrates. In addition, nutrient absorption also enhances nitrogenous compound's metabolism which can increase crude protein content. Using nutrient solutions instead of tap water can also improve the crude protein level of the hydroponic fodder (Dung et al, 2010) (Naik et al, 2017).

Vitamins

Hydroponic fodder is especially rich in vitamin C and E. Sprouting process can enhance the vitamin content of the grain. However, the increase in individual vitamin content is not significant enough to meet the nutritional requirements of grain-based diets (Shit, 2019).

Minerals

In hydroponic fodder, growing roots improve mineral uptake, which increases ash and protein contents starting from day four. Absorption also facilitates nitrogenous compounds metabolism and so increases crude protein content (Girma et Gebremariam, 2018). The natural water used to irrigate the hydroponic fodder can easily affect the mineral content of the fodder. However, chelating sprouting makes minerals more available (Naik et al, 2012).

Anti-Nutritional Factor

During germination enzymes can also eliminate other potentially toxic chemicals. Phytic acid is found in the seed coat and germ of plant seeds. The principal impact of phytic acid is that it has an antagonist activity with some minerals. In fact, phytate can join some minerals such as calcium and iron to compose insoluble compounds. Phytic acid levels are reduced during seed sprouting (Xia et al, 2020) (Girma et Gebremariam, 2018). Sprouts have a hundred times more enzymes than fruits; the digestive enzymes in sprouts act as biological catalysts, controlling the digestion of protein, fat and carbohydrates. Enzyme activity defines the amount and therefore the physiological action of vitamins, minerals, and trace elements (Almuhayawi et al, 2021). Sprouts enzyme activity is at its peak between germination and seven days. Because of the inhibitors, enzymes are still active when cereal grains are not germinated. Seed degradation is prevented for years using these inhibitors (Naik et al, 2012).

Effect Of Hydroponic Feed on Livestock Productivity

Milk Production

The milk yield significantly increases when hydroponics fodder is fed, maybe because of enhanced nutritional digestibility (Naik et al, 2014). Hydroponics can aid in the improvement in the quality and amount of milk. Several studies have shown an increase in milk yield and concluded that the increased yield was due to high protein content in the fodder. Studies on improvement of milk production through hydroponic fodder feeding shows improvement than animals fed cereal grains, hay or silage. Hydroponic fodder increases milk yield by 3.9% (Heins et al, 2015), 7.8%, 10.07% (Reddy, 1988), 12.5% and 13.73% (Naik et al, 2013). due to feeding of hydroponic fodders to lactating cows. Also (Abd Rahim et al, 2015) observed a slight improvement in milk protein and milk fat in dairy goats but were not significant in sheep. Canadian dairy farmers reported that feeding of hydroponic fodder increases feed intake of their cows and improves milk yield by 3.6 kg per day over the lactation period. Moreover, farmers from South Africa reported a drop of 3.6 liters of milk after decreasing 6.8 kg of the daily fed hydroponic amount (Shit, 2019). The feedback from the farmers of the Satara district of Maharashtra revealed an increase in the milk yield by 0.5 - 2.5 liters per animal per day and net profit of 0.5 dollar per animal per day due to feeding of hydroponics fodder to their dairy animals (Bakshi et al, 2017).

Meat Production

Hydroponic fodder enhances the body weight gain of lambs which may be due to the high content of bioactive enzymes and ingredients that boost livestock performances (Naik et Singh, 2013). Also, increasing body weight can indicate a good ruminal microbial activity and improved nutrient digestibility. beef cattle fed maize hydroponic fodder, can reach an average increase of 200 g in body weight. Similarly, 8% improvement in body weight gain is reported in birds and other animals. Better body weight gain was recorded in cross breed calves, Awassi lambs and goat fed hydroponic maize and barley fodder respectively (Shit, 2019) (Hassen et Dawid, 2022).

Overall Performance

Hydroponics fodder has more potential health benefits. Sprouts are the most enzyme rich food and the period of peak enzyme activity lies between germination and 7-8 days of age. They are a rich source of natural antioxidants i.e. â-carotene, vitamin - C, E and related trace minerals like selenium and Zn. Feeding of the sprouted grains improves the animals' productivity by developing a stronger immune system due to neutralization of the acidic condition by supplementation of alkaline digestive enzymes through sprouted grains. Sprouted grains are good sources of pigments containing chlorophyll, xanthophylls, grass juice and protein sparing factors which improves the production and reproductive performance of the livestock. Besides this, helping in the elimination of the anti-nutritional factors such as phytic acid, oxalic acid and other toxicants of the fodder (Shit, 2019).

Hydroponic fodder production applications

Low-Cost Shed-Net System

Hydroponic fodder production can be one of the low-cost technologies to increase green fodder production by vertical farming. A low-cost hydroponic fodder unit may be designed in an area of 10 m2 with metal sheet as roofing material with shade net on all the sides to produce hydroponic fodder. The unit consists of a four-tier system with iron angles for holding 48 plastic trays, each of dimension 60×40×8 cm and holding capacity of 1.25 kg maize seed. Fodders can be cultivated in plastic trays for 9–10 days and irrigated manually or via sprinklers with tap water six times a day (Fig 11). The biomass yield recorded after nine days was found to be higher (4.16 kg) in 300 g/cm2 compared to other seed rates.

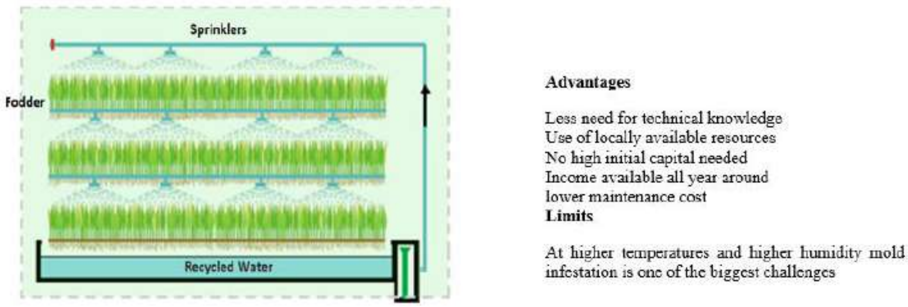


Fig 11. İnterior Concept of Low-Cost hydroponic fodder unit. (Ghorbel et al, 2022b)

70% shade net as roof material yielded the maximum biomass of 3.50 kg of hydroponic fodder /kg of maize seed compared to concrete, thatched or asbestos roof.

Low-cost shed-net hydroponic fodder production system helped improve farmer income ; when fodder was produced in low-cost hydroponic system, the feed cost/kg milk was reduced by 25-30% (Naik et Singh, 2013) and net profit was improved by 0.05 US $ /kg especially when seeds were home-grown or locally purchased (Halo et al, 2020).

High-Cost Hi-Tech System

These are highly sophisticated, fully automated fodder production systems (Fig 12). The environment inside this units is fully controlled, that's why it is immune to natural weather variations. For optimum growth of fodder, the environmental factors are temperature (19-22 ºC), humidity (40-80%), light (2000 lux in intensity) between 12-16 h and aeration for 3 minutes after every 2 h. The required water, light, temperature, humidity, and aeration are totally monitored by sensors. The water used is automatically recycled. The electricity requirement to produce hydroponic fodder is much lower than for traditional fodder production. In this high-tech hydroponic system, a constant monitoring is required for the composition and pH of the nutritional solution, the roots of fodder should also be controlled to prevent any mold.

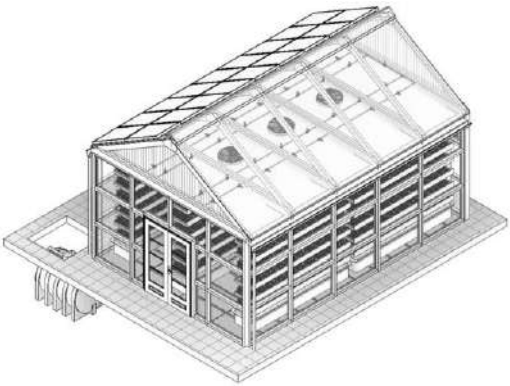


Fig 12. Concept of Hi-Tech hydroponic fodder unit (Ghorbel et el, 2022b).

Conclusion

Soilless agriculture is potentially one of the alternatives that can completely change the landscape of the food sector, making a significant difference for the world. One of the most important benefits a hydroponic system can provide is efficient water use to grow the same product compared to traditional agriculture. The water in a hydroponic system is re-circulated and has minimal losses, whereas water in typical farming practices suffers from evaporation and leakage into the soil. Since agricultural water consumption is a major contributor to the draining of the world's freshwater sources, hydroponics provides a way to grow food and minimize water usage. Another noteworthy benefit of hydroponics is nutrient efficiency. Nutrients when operated in an enclosed system, are protected from losses caused by leakage into the ground or runoff water as with field systems. This closed system aims to decrease the pollution of lakes and rivers, to enhance better water quality compared to land used for agriculture. Lastly, hydroponic systems can also be much more space efficient than typical farming methods and help grow plants in large cities lacking outside agricultural fields. As the global population continues to increase, there is more pressure on agricultural production methods to increase food production. Since there is often limited space available and open land farming methods can endanger surrounding water systems, hydroponics is a potential solution to food insecurity as well as water scarcity. Hydroponic technology is also an agro-technology that can be put to practice locally with low-cost materials to provide nutritious, palatable, and digestible fodder for livestock. Certainly, this technology is less competitive than traditional fodder production in areas that don't lack quality green fodder, but it always stays as a smart alternative technology against land scarcity and hindering climate changes in different agro-climatic regions in the world. Nowadays several countries are practicing it for their sustainable livestock production. Because of greater palatability and digestibility, hydroponic fodders become more lucrative and useful over conventional feeding of cereal grains and concentrate mixture. Actually hydroponic technology, despite having as many advantages as limits, is still a promising alternative for modern agriculture. The hydroponic technology worldwide is estimated to evaluate dramatically in the near future.

The low-cost and high-cost applications of hydroponic technology are still debatable and having a decisive choice between the two systems depends on various parameters such as climate and economic situation of every area. Fully automated commercial hydroponic systems can demand high initial investment, qualified labor and high energy cost to maintain the desired environmental condition inside the green house which can add enormously to the net cost of hydroponic fodder production. Conversely, in case of an acute shortage of fodder and water, a major increase in fuel costs or an extreme seasonal variation of fodder prices, low-cost hydroponic systems have been achieved using locally available infrastructure. Under such situations the employment cost of the hydroponic system will be an advantage and it would become the best alternative for sustainable livestock production.That's why, it is vital to try to incorporate low-cost hydroponic structures that minimize dependence on human labor and reduce set-up and processing costs in order to encourage commercial hydroponic farms. Hydroponic farming can yield high quality, efficiently produced feeds for urban and rural farms with the right nutrient solutions, temperatures, and other environmental parameters. This can pave the way to much needed work to expand the use of the Hydronic technology. In the future, the goal is to standardize the methods, additions, and results of hydroponic fodder production technology for small-scale farmers. To ensure consumer confidence, hydroponic feed must be as safe and healthy as conventional alternatives.

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