



# **ICONST LST 2022**

**International Conferences on Science and Technology**

**Life Science and Technology**

**September 7-9, 2022 in Budva, MONTENEGRO**

## **ABSTRACTS & PROCEEDINGS BOOK**

# **ICONST LST 2022**

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### Life Science and Technology

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# ICONST 2022

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Dear Readers;

The fifth of ICONST organizations was held in Budva/Montenegro between 7-9 September 2022 with the theme of '*science for sustainable technology*' again. In recent years, weather changes due to climate change have reached a perceptible level for everyone and have become a major concern. For this reason, scientific studies that transform technological progress into a sustainable one is seen as the only solution for humanity's salvation. Here we ask ourselves "which branch of science is responsible for sustainability?". Sustainability science is an interdisciplinary field of study that covers all basic sciences with social, economic, ecological dimensions. If we consider technology as the practical application of scientific knowledge, the task of scientists under these conditions is to design products that consume less energy, require less raw materials, and last longer.

ICONST organizations organize congresses on sustainability issues of three main fields of study at the same time in order to present different perspectives to scientists. This year, 129 papers from 27 different countries presented by scientists in **ICONST Organizations**.

72 papers from 19 countries presented in our **International Conference on Engineering Science and Technology** organized under ICONST organizations. The total rate of countries excluding Türkiye is 52%. Türkiye is the country with the highest participation with 48%, followed by Poland 7%, Montenegro 5%, India 4%, Italy 4%, Kosovo 4%, Hungary 4%, Slovakia 4%, Afghanistan 2%, Czech Republic 2%, Iran 2%, Algeria 2%, Ethiopia 2%, Central African Republic 2%, Romania 2%, Russia 2%, Serbia 2%, North Macedonia 2% and Moldova 2%.

31 papers from 9 countries presented in our **International Conference on Life Science and Technology** organized under ICONST organizations. The total rate of countries excluding Türkiye is 58%. Türkiye is the country with the highest participation with 42%, followed by Poland 16%, Bulgaria 12%, Slovakia 8%, Philippines 6%, Czech Republic 3%, Tunisia 3%, Algeria 3% and Switzerland 3%.

Finally, 26 papers from 10 countries presented in our **International Conference on Natural Science and Technology** organized under ICONST organizations. The total rate of countries excluding Türkiye is 65%. Türkiye is the country with the highest participation with 35%, followed by Serbia 19%, Slovakia 11.5%, Algeria 8%, India 8%, Croatia 3.8%, Ethiopia 3.8%, Hungary 3.8%, Kosovo 3.8%, South Africa 3.8%.

As ICONST organizations, we will continue to organize organizations with the value you deserve in order to exchange ideas against the greatest threat facing humanity, to inspire each other and to contribute to science. See you at your future events.

ICONST Organizing Committee

# ICONST LST 2022

## International Conferences on Science and Technology

### Life Science and Technology

September 7-9, 2022 in Budva, MONTENEGRO

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## **Artificial underwater reefs and habitats. Concept and organization of biosystems**

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**Plamen Penev Penev<sup>1\*</sup>**

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**Abstract:** Mussels are the most widespread and most desirable inhabitant of the underwater artificial reef. As mussels feed mainly on plankton, they are an important consumer of the super-abundance of microalgae and thus play an important role in water purification. This is especially important for the seas, as large amounts of plankton can suffocate bottom ecosystems. In turn, the over-abundance of microalgae is the result of water pollution as a result of human activity. Thus, in practice, the artificial reef is a solution to deal with the effects of marine pollution.

**Keywords:** Marine solutions, ecosystems.

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## **Effect of resveratrol on the development of diabetes complications**

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**Piotr Bramora<sup>1\*</sup>, Ilona Kaczmarczyk-Sedlak<sup>2</sup>**

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**Abstract:** Diabetes mellitus belongs to the group of metabolic diseases in the course of which chronically elevated blood glucose levels are noted. It is believed that the disease is caused by both genetics and environmental factors. Currently used drugs in the treatment of diabetes do not fully prevent complications such as cardiomyopathy, retinopathy, neuropathy and diabetic nephropathy. Moreover, some patients do not observe to the established treatment regimen due to economic factors and side effects associated with the therapy. Therefore, it is necessary to search for new drugs based on compounds of plant origin that can more effectively inhibit the development of diabetic complications. Resveratrol is one of the phytoalexins that are produced in response to damage or the presence of pathogens. The natural sources of this compound are fruits, vegetables, grains and legumes. Resveratrol has many biological properties valuable for health, such as anticancer, cardioprotective and antioxidant properties. It has been documented on the basis of the found studies that resveratrol normalizes glycemia, improves insulin sensitivity of tissues, and protects pancreatic  $\beta$ -cells against apoptosis. It has also been confirmed that this phytoalexin is a powerful antioxidant that inhibits the excessive production of free radicals and lipid peroxidation. It should be added that resveratrol is a compound of low toxicity. Unfortunately, it is characterized by low bioavailability, so further research should focus on obtaining resveratrol derivatives with greater absorption by the human organism. Due to the promising results of in vitro and in vivo studies, experiments should be continued to fully understand the molecular mechanisms of action, pharmacokinetics, pharmacodynamics and side effects.

**Keywords:** diabetes mellitus, metabolic diseases, resveratrol, insulin sensitivity, apoptosis

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## **Antimicrobial activities of Citrus aurantium and Citrus reticulata essential oils**

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**Nouara Ait Mimoune<sup>1\*</sup>, Ahlam Otmani<sup>2</sup>, Bouchra Benabdi<sup>3</sup>**

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**Abstract:** Essential oils (Eos) are secondary metabolites of plant and complex mixtures of volatile lipophilic constituents. Essential oils and some of their constituents are used in pharmaceutical products for their therapeutic activities but also in agriculture as food preservatives. In this study the chemical composition, antibacterial and antifungal activities of Citrus aurantium and Citrus reticulata essential oils from Algeria were investigated. The essential oils obtained by hydrodistillation of the aerial parts of the two species were analysed by GC/MS. Monoterpene and sesquiterpene were present in high percentages. The GC/MS analysis of C. aurantium Eo revealed the presence of limonene (65.3%),  $\beta$ -pinene (10.45%), and  $\beta$ -caryophyllene (8.45%) representing together 84.2% of the total Eo composition. The Eo from C. reticulata was constituted mainly of  $\beta$ -pinene (22.53%),  $\alpha$ -humulene (20.92%), and linalool (10.96%).

Antibacterial analyses were performed using agar well diffusion method. The bacteria evaluated were Staphylococcus aureus, Escherichia coli, Proteus vulgaris and Pseudomonas aeruginosa. The Gram-positive bacteria Staphylococcus aureus was more sensitive to the tested Eos than the Gram-negative bacteria. Mandarin orange EO had the highest activity against all the tested strains.

Antifungal properties were determined by the poisoned food method using Czapek Yeast Agar (CYA) medium against Aspergillus (Aspergillus flavus, Aspergillus parasiticus, Aspergillus fumigatus, Aspergillus carbonarius, Aspergillus tamaritii) and Penicillium (Penicillium sp.) species. The obtained results showed percentages of inhibition ranging between 3.4% and 73.1%. According to these findings, the tested EOs could be used as a

**Keywords:** Citrus aurantium, Citrus reticulata, GC/MS, antifungal

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## **Fungal diseases of cultivated plants in aquaponic systems – prevention by VIR-NIR spectroscopy monitoring**

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**Ivaylo Sirakov<sup>1\*</sup>, Katya Velichkova<sup>2</sup>, Toncho Dinev<sup>3</sup>, Desislava Slavcheva-Sirakova<sup>4</sup>, Elica Valkova<sup>5</sup>, Milena Tzanova<sup>6</sup>, Dimitar Yorgov<sup>7</sup>, Vasil Atanasov<sup>8</sup>, Stefka Atanassova<sup>9</sup>**

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**Abstract:** The aquaponics is a system where aquaculture and hydroponic are integrated. The plants in aquaponics are cultivated in high humidity environment which benefits the development of fungi pathogens. An important factor in the combat of fungi pathogens in this system is the prompt detection of their appearance which could prevent their spreading. In this respect, various methods of fungi diseases detection could be used as a valuable tool in aquaponics system. The aim of this study was to apply the NIR spectroscopy to test an aquaponically cultivated lettuce (*Lactuca sativa*) infected with different fungi pathogens. The lettuces on third leaf formation were placed in tanks filled up with the water from aquaponics system every second day. The tanks were stored at the Botanical laboratory of the Faculty of Agriculture where appropriate climatic conditions were assured. The plants were infected with different fungi pathogens - *Aspergillus niger* NBIMCC 3252, *Alternaria alternata* NBIMCC 109 and *Fusarium oxysporum* NBIMCC 125. Spectra features of tested plants were obtained nondestructive in 450-1100 nm region using fiber-optic reflectance probe and USB400 spectrometer (OceanOptics, Inc.). Vegetative indices used in remote sensing were calculated using reflectance at different wavelengths. Differences between the reflectance spectra of healthy and infected leaves were obtained. The vegetative indices, most sensitive to the presence of these diseases were identified. The conducted experiment showed that VIR-NIR spectroscopy is a precious tool for detection and prevention of fungi diseases in plants cultivated in aquaponics conditions.

**Keywords:** Aquaponics, Fungi diseases prevention, VIR-NIR spectroscopy, Vegetative indices

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1 Aquaculture, Bulgaria

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## **Management of nutrient supplementation in aquaponics system**

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**Katya Velichkova<sup>1\*</sup>, Ivaylo Sirakov<sup>2</sup>, Desislava Slavcheva-Sirakova<sup>3</sup>, Stefka Stoyanova<sup>4</sup>,  
Mitko Georgiev<sup>5</sup>, Stefka Atanasova<sup>6</sup>**

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**Abstract:** The aim of current study was to retrace the influence of timing application of micro and macro nutrients in pepper cultivated in aquaponics on optical determinate vegetate indexes and their quantity in plants. In experimental aquaponics system three times intervals 1, 3 and 4 hours of application of micro and macro GHE essentials (Oligo Spectrum) elements at concentration 2 ml/l were applied on pepper. Common carp with average weight of 306±1,80 g were cultivated in fish section part of aquaponics system. The continuation of experiment was 60 days. At the end of trial the following parameters were analyzed – final weight of carp, FCR, concentration of micro and macro elements in plants, biomass of plants and length of roots. Spectra features of tested plants were obtained nondestructive in 450-1100 nm region using fiber-optic reflectance probe and USB400 spectrometer (OceanOptics, Inc.). Chemical analyses of micro and macro elements in plants were also analyzed. The current study showed that VIR-NIR spectroscopy could be used for early alert for detection of micro and macro elements deficiency in plants cultivated in aquaponics system.

**Keywords:** Aquaponics, Macro, Micro elements, Spectroscopy

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## **Preliminary investigation of UF resin substitution by bark-residue-based binder**

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Aleksandra Ježo<sup>1</sup>, Grzegorz Kowaluk<sup>2\*</sup>

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**Abstract:** Nowadays, in the wood-based composites industry, aspects such as ecology and joining the current circular economy play a very important role. However, user safety is also very important. Formaldehyde is one of the hazardous substances which, if emitted too high, can harm human health. Unfortunately, binders containing formaldehyde still reign supreme in the wood-based panels' industry. Therefore, this research concerns the possibility of using ground waste bark as a formaldehyde-free and ecological binder in the production of particleboards. The main component of the mass used is suberic acid, which is a colorless, crystalline solid used in the synthesis of drugs and the production of plastics. The particleboards produced as part of the work have been widely characterized, also referred do European standards requirements.

It should be mentioned, that the use of ground bark, and thus the elimination of synthetic adhesives in the production process, allows the reuse of wood raw material, which fits perfectly with the idea of upcycling.

Acknowledgement: These research have been funded by the National Science Centre, Poland under the ForestValue Programme, reg. no. 2021/03/Y/NZ9/00038.

**Keywords:** Particleboard, Glue, Binder, Formaldehyde, UF, Bark

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## **An attempt to upcycle pine tree branches for particleboard production**

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**Anita Wronka<sup>1\*</sup>, Grzegorz Kowaluk<sup>2</sup>**

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**Abstract:** Due to their small diameter, irregular shape and size, and the high bark content, among other reasons, the tree branches are very often not widely used in the wood industry. To obtain as much wood as possible in a short time, in pine forests, the pruning is carried out every few years, removing branches. They are most often used as fuel or bedding, which means that the carbon dioxide they contain reaches the atmosphere faster. In this research, the *Pinus sylvestris* L. branches have been fragmented, and six variants of panels were made with different mass fractions of particles from the branches.

The research shows, that the milling of pine branches produces smaller particles than from regular wood. The amount of dust was also higher in the particles produced from the branch material. The mechanical properties of the panels have been reduced with the increasing amount of pine branch particles. However, for most of the features of the tested panel variants, the minimum requirements of European standards for furniture panels were achieved. Thus, the potential for the higher added value of pine branches, a lengthening of their economic life cycle, and the fact that carbon dioxide remains "bound" for a long time before being released into the atmosphere was highlighted.

**Acknowledgment:** The presented study was completed within the activity of the Student Furniture Scientific Group (Koło Naukowe Meblarstwa). The selected investigations have been funded by the National Science Centre, Poland under the ForestValue Programme, reg. no. 2021/03/Y/NZ9/00038.

**Keywords:** upcycling, particleboard, tree branches, pine, bark

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## **Interdisciplinarity between Trans Humanism and the imagination of INBIC**

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**Amine Elgheryeni<sup>1\*</sup>, Mona Turki<sup>1</sup>**

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**Abstract:** The Trans Humanism puts -as the American association indicates to arrive at such results- on an «interdisciplinary approach» making use of current techniques, such as information technology and genetic engineering, and future technologies such as nanotechnology and artificial intelligence. In short, the NBIC\* rather than studying each of its domains separately and individually it is therefore more useful to approach them together from the angle of their convergences and mainly from the angle of nanotechnologies.

In fact, the latter appear to be cumulative techniques to some extent underlying the other three, as their future applications are expected to lead to significant progress in this area. It is obvious to mention that the term “Nanotechnology” can be used to designate any type of technology, technique or invention taking place at the nanometer scale (the billionth of a meter the atomic and molecular scale) therefore can designate techniques coming from distinct domains but converging by their applications towards what is presented as a frontier the Nano-World. In this direction of thought, our objective is to be able to intervene at the nanometric scale in order to obtain a truly demiurgical power on matter but also on the living

**Keywords:** living, NBIC, Arts, Artificial intelligence, Nano

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## **Recycling potential of lignocellulosic biodegradable layered composites**

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Anita Wronka<sup>1\*</sup>, Grzegorz Kowaluk<sup>2</sup>

---

**Abstract:** Due to the limited resources of wood raw materials, and thus, rising prices and shortage of wood and wood-based materials on the market, intensified interest in the potential of recycling of lignocellulosic composites should be paid. In this research, the attempt has been made towards two different methods of disintegration of produced wood layered composite, bonded with the use of biodegradable, natural origin, renewable resources binders, like polylactic acid (PLA), polycaprolactone (PCL), polyhydroxyalkanoate (PHA), as well as cellulose acetate, and, production of new lignocellulosic-based composites. The disintegration has been conducted by 1) thermal recovery of lignocellulosic layers, and 2) mechanical processing (chipping). The prototypes of the composites made of recovered raw materials have been produced on a laboratory scale, and the basic characteristics of the composites were completed, as well.

The research shows, that there is possible to recycle the raw materials of lignocellulosic layered composites bonded with biopolymers when applying both methods, mentioned above. In the case of thermal recovery, the profitable reduction of biopolymer binder needs has been found to reach the properties of the reference composite. Mechanical disintegration of layered composite lead to producing useful particles, that allow producing particle composite bonded with biopolymer.

**Acknowledgment:** The presented study was completed within the activity of the Student Furniture Scientific Group (Koło Naukowe Meblarstwa). The study has been co-financed by the Polish Ministry of Education and Science from the state budget under the program “Student scientific groups create innovations” (Studenckie koła naukowe tworzą innowacje)—agreement no. SKN/SP/495845/2021.

**Keywords:** composite, plywood, biodegradable, PLA, PCL, PHA, cellulose acetate, recycling, upcycling

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## **The aspects of biodegradation of lignocellulosic layered composites with biopolymer binders**

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**Patrycja Rosa<sup>1</sup>, Anita Wronka<sup>2</sup>, Grzegorz Kowaluk<sup>3\*</sup>**

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**Abstract:** The susceptibility of materials to biodegradation conditions is one of the key factors, that need to be taken into account when new composites are developed. This limits the end-of-life of all materials. The biodegradability scenarios allow excluding biodegradable materials from the waste stream. In this research, the main requirements of ISO 14855 standard have been adopted to estimate the susceptibility to biodegradation of lignocellulosic composite materials, produced with the use of biopolymers as a binder. The aim of this research was the characterization of biodegradability of designed and produced in laboratory conditions, wood layered composites, bonded with the use of biodegradable, natural origin, renewable resources binders, like polylactic acid (PLA), polycaprolactone (PCL), polyhydroxyalkanoate (PHA), as well as cellulose acetate.

According to the conducted research, the aerobic biodegradability and disintegration of tested lignocellulosic layered composites bonded with selected biopolymers have been confirmed. The differences between biodegradability aspects of tested biopolymer binders have been also highlighted. The results show, that the designed composites can positively contribute to the circular economy rules since there are not loading the environment with waste.

**Acknowledgment:** The presented study was completed within the activity of the Student Furniture Scientific Group (Koło Naukowe Meblarstwa). The study has been co-financed by the Polish Ministry of Education and Science from the state budget under the program “Student scientific groups create innovations” (Studenckie koła naukowe tworzą innowacje)—agreement no. SKN/SP/495845/2021, as well as by the Polish National Agency for Academic Exchange, agreement no. PPN/BFR/2020/1/00042/U/00001.

**Keywords:** composite, biodegradation, PLA, PCL, PHA, cellulose acetate, recycling, upcycling

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## **The impact of climate change on food self-sufficiency: a case study of the Slovak**

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**Peter Bielik<sup>1\*</sup>, Dominika Čeryová<sup>2</sup>, Viktória Bend'áková<sup>3</sup>, Patrícia Husárová<sup>4</sup>, Peter Bulla<sup>5</sup>**

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**Abstract:** Agriculture is one of the economic sectors most exposed to the global climate and its effects are likely to be transferred to the intensity, cost, efficiency, and structure of agricultural production. The main goal of the poster is to assess the effects of climate change on agriculture and food self-sufficiency in the Slovak Republic. Slovakia is not self-sufficient in food and is currently below the level of 40 percent. The growth of Slovakia's food self-sufficiency is particularly important in the context of climate change because it is self-sufficient only in grain production. As a result of the EU's focus on biofuels, not a small part of the rapeseed and corn harvest ends up in factories producing mero added to diesel and ethanol added to gasoline. Biogas plants are being built in agriculture, where the main medium is not manure, but biomass from corn. When researching the growth of Slovakia's food self-sufficiency, we must consider the food self-sufficiency of the European Union, which is positive with some exceptions, but the aging of the continent predetermines the EU as a net exporter in the future. In our research we will use the model PΑΣMA, is an economic land use optimization model for agriculture by authors Schmid, E., Sinabell, F. (2007). PΑΣMA model maximizes total gross margins from land used for crop production and livestock breeding in all NUTS regions of Slovakia, including interdependencies between production potential, private consumption, international trade relations and agricultural policies.

**Keywords:** climate changes, PΑΣMA model, self-sufficiency, crop production

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## **Conditions and Challenges of Weaving Culture in Ibaan, Batangas: A Case Study Towards Sustainability**

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**Abstract:** With more than seven thousand islands comprising the Philippines, each community poses a unique and diverse culture manifested in the form of art through work which has become one of the means of livelihood for everyone. One of which is the weaving culture that has been distinctive because of its power to unite people as strong, resilient communities bound by living tradition and colorful textile patterns and motifs. A mixed research design (case study) was applied through the DMAIC approach and RULA/REBA (Rapid Upper Limb Assessment / Rapid Entire Body Assessment) Methods to allow an in-depth, multi-faceted exploration of complex issues in their real-life settings. Based on the results, most process steps are generally done in a seated position, repetitive in nature, and require attention to detail. There has been evidence of musculoskeletal discomfort from upper to lower extremities among the weavers for the past 12 months and a REBA score of 4 to 8 poses medium to high risks. Worker postures vary from leaning to sitting straight while working throughout the day. Awkward postures were also observed. Hence, there were concerns with seat height, seat adjustability, working space, work posture, illumination, and ventilation which contributes to musculoskeletal discomfort experienced by the weavers.

**Keywords:** Social Science, traditional weaving culture, RULA/REBA assessment, musculoskeletal disorder, mixed research

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## **Sustainability of Religious Tourism in Lipa City, Batangas amid Covid-19 Pandemic**

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**Mary Joy O.<sup>1\*</sup>, De Castro Jinky R.<sup>2</sup>, Asugui Alfie V.<sup>3</sup>, Lindo Mila M.<sup>4</sup>, dela Cruz<sup>5</sup>**

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**Abstract:** COVID-19 pandemic has greatly affected many sectors of the economy. The tourism industry has felt the negative effects of the pandemic causing several areas to halt their operation. The researchers opted to conduct a relevant study on the sustainability of religious tourism in Lipa City, Batangas amid the pandemic. The study used descriptive – survey form, using a quantitative approach. The findings included the need to strengthen faith in God, observe health protocols in religious gatherings, provide just and appropriate compensation to workers, and assign personnel to remind tourists to follow the health protocols. Identified challenges are retrofitting of religious sites to accommodate pilgrims and wider parking space to prevent overcrowding. There is significant relationship between social, economic, and environmental dimensions of sustainability. Religious tourism in Lipa City can be sustained amid COVID-19 pandemic. The study highlighted the necessity for religious tourism management to carefully plan religious activities that aim to strengthen people’s faith in God, consider virtual tourism, provide flexible incentives to workers, assign personnel to remind tourists to follow the health protocols, ensure standardized, well-communicated, and firm implementation of

**Keywords:** Sustainability, Religious Tourism, Sustainability Dimensions, COVID-19 Pandemic, Challenges, Action Plan

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## **Hulled and Naked Oat Yield in Conventional and Organic Farming**

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**Petr Konvalina<sup>1\*</sup>, Ivana Capouchová<sup>2</sup>, Václav Dvořáček<sup>3</sup>**

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**Abstract:** Hulled and naked oat is a perspective crop for the organic farming because has low requirements on soil fertility and good competition ability against weeds. The aim of our study was to compare grain yield production of naked and hulled oat in organic and conventional production systems. Small plot trials were conducted in two locations in the Czech Republic for three years (2018-2020). We used four varieties of hulled oat and one variety of naked oat. The average grain yields at the locality in Prague in the organic growing system were lower than in the conventional growing system (organic on average 4.5 t/ha, conventional 5.7 t/ha). In České Budějovice the organic growing system showed similar results (organic 3.0 t/ha, conventional 5.0 t/ha). The gap between organic and conventional growing systems was 30% in yield. Similarly, the number of panicles in the organically grown system per square meter was reduced too. The thousand grain weight reached similar values in the organic and conventional systems on both locations. The lower productivity of organically grown oat was caused by the lower tillering ability of plants. However, in the conventional system, herbicides were applied and the crops were fertilized with nitrogen at a rate of 60 kg of nitrogen per hectare. In the organic system, the nutrient nitrogen was based on nitrogen balance within the crop rotation. Based on our results we can propose both types of oat (hulled and naked) as perspective crops for organic farming. An organic farmer can expect to achieve stable yields which, in less favorable conditions for the production of cereals in the organic system, may be close to the level of conventional yields.

**Acknowledgment:** This study was supported by the project NAZV MZe Czech Republic, No: QK1810102.

**Keywords:** hulled oat, naked oat, organic farming, conventional farming, yield

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## **The Impact of Climate Change on Food Self-Sufficiency: a Case Study of the Slovak Republic**

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Peter Bulla<sup>5</sup>, Stefaniia Belinska<sup>6</sup>**

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**Abstract:** Agriculture is the sector most affected by climate change. About 30 years ago, Slovakia was almost completely food self-sufficient, but currently it is about 37% of food self-sufficiency. In this context, does climate change affect food self-sufficiency, or are there other factors at work? Due to climate change, scientists are looking for ways to increase overall self-sufficiency in agricultural and food production, since Slovakia has a low level of food self-sufficiency compared to other small open economies. And this food self-sufficiency, based on research results, continues to decline relatively. The level of food security is just as low. The truth is that in recent times, agriculture and all food production has been very adversely affected, especially by lack of moisture and weather fluctuations - extreme drought, heavy rains, uneven rainfall, floods, extreme low temperatures, often during the early spring. The aim of the study was to model the opportunity costs of various technologies for growing plants in a selected area in a changing climate. The economic aspects of the combined biophysical and economic data at the model site were also evaluated. The premise of the activity is the creation of a model for the territorial integration of biophysical and economic data on selected plant products. The integrated model framework is used to create an eco-economic model of the impact of plant production. The integrated model combines biophysical and economic data into an agricultural land use optimization model considering different cultivation methods, or under different climate scenarios.

**Keywords:** climate change, food security, food self-sufficiency, economic model of the opportunity costs, optimization

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## **Predicting of the future changes of hawthorn (*Crataegus monogyna* JACQ.) and rosehip (*Rosa canina* L.) in Antalya**

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Serkan Özdemir<sup>1\*</sup>

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**Abstract:** The effects of climate change on ecosystems are becoming more and more dramatic. Especially the changes in the distribution of plant and animal species draw attention. In this study, it was aimed to determine the potential suitable areas of *Crataegus monogyna* JACQ. (*C. monogyna*) and *Rosa canina* L. (*R. canina*) distributed in Antalya, which has a typical Mediterranean climate, and to reveal future changes. These species have a significant commercial use. At the same time, they are consumed as food by wild animals and can be an indicator of the main forest tree species depending on the site. Therefore, in present study, the potential distribution modellings of the mentioned species under current and future climatic conditions were carried out with the MaxEnt method using the climate data downloaded from the CHELSA database. Future climate predictings were performed for three different scenarios (SSP12.6, SSP37.0, SSP58.5) for the period 2071-2100. The mean AUC values of the models acquired for *C. monogyna* and *R. canina* were determined as 0.96 and 0.87, respectively. In the potential distribution maps, the predictive values were grouped according to the 0.5 threshold value and potential suitability maps consisting of two colors were obtained. According to these maps, it was seen that 1158 hectares of potential suitable areas for *C. monogyna* and 7661 hectares for *R. canina* were found in terms of current climatic conditions. However, due to future climatic conditions, it has been predicted that *C. monogyna* has lost almost all of its potential suitable areas and *R. canina* has lost all of it.

**Keywords:** Climate change, hawthorn, maximum entropi, rosehip, species distribution modeling

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## **Habitat Suitability Modelling of Brown Bear (*Ursus arctos*) in Turkey**

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**Ahmet Acarer<sup>1\*</sup>, Ahmet Mert<sup>2</sup>**

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**Abstract:** *Ursus arctos* belonging to the genus *Ursus* of the family Ursidae is the largest terrestrial mammal species in Turkey. In addition to its distribution in the Black Sea and Eastern Anatolia regions in Turkey, it is known that this distribution extends to the Mediterranean region after it was taken under protection in 2003. Although the distribution of Brown bear is not under threat in our country, the risks of habitat isolate or fragmentation still continue. For this reason, habitat suitability modeling methods come into prominence for sustainable management of wild animal species whose habitats are limited to a certain area. Habitat suitability modeling are divided into two as methods that work only present and present-absent data. Maximum entropy which only works with present data, is a frequently preferred method in wildlife studies as it produces reliable models with the least present data. For this reason, the Maximum entropy which gives high reliability and accurate results has been preferred for the habitat suitability modeling of the Brown bear, which is distributed in Turkey. For this purpose, the existing data of the Brown bear were obtained from the master's and doctoral theses made in Turkey. The modeling process was carried out with 47 different variables that could be effective on the target species with the obtained present data. As a result, habitat suitability mapping of Brown bear which has an important place in Turkish tribes from past to present, has been revealed.

**Keywords:** Brown bear, habitat suitability mapping, maximum entropy, wildlife

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## **Nursing Profession: An Approach Related to Healthcare Market Sustainability**

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**Indrit Bimi<sup>1\*</sup>, Daniela Bimi<sup>2</sup>**

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**Abstract:** Nowadays we are facing many problems regarding the healthcare market. In many countries in Europe and worldwide healthcare systems are having some phenomena like workforce crisis, turnover of staff, etc. So the society of one country is losing one of the main components of life, who is taking care of health at different ages, especially in geriatric age. After exploring the PubMed-related “nursing sustainability” we saw that are more than 13.000 articles and papers related this topic. Papers were related to the nursing workforce, education, job satisfaction, turnover, work environment, and equipments, etc. The nursing population needs to meet all the requirements and needs to be effective in their daily routine work. Healthcare settings need to be able to enhance the quality of life and improve the well-being in this population. Nurses need to eat well, regular exercise, and maintain a healthy and balanced state of mind. These can assure quality nursing care and a sustainable work environment for nurses and other healthcare staff.

**Keywords:** nursing sustainability, quality nursing care, work environment

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## **Determining The Level of Knowledge About Hepatitis Virus And Hepatitis Vaccine of Students**

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**Sıddıka Ersoy<sup>1\*</sup>, Şükran Özkahraman Koç<sup>2</sup>, Sultan Palantöken<sup>3</sup>**

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**Abstract:** Studies on hepatitis B in the literature have generally focused on the relationship between stab wounds of high school students and healthcare workers and hepatitis B. Studies on hepatitis B vaccine and virus with university students, which are a very large population, have been limited. In the light of these data, our research was written to determine the level of knowledge of university students about hepatitis vaccine and hepatitis virus. In order to realize the purpose of the descriptive research, a questionnaire study was conducted with the students studying at the Faculty of Health Sciences of Isparta Süleyman Demirel University by face-to-face interview method. It was completed with 443 students who filled out the questionnaire completely.

The sociodemographic characteristics of the group included in the study were examined and their knowledge levels about hepatitis B were compared with their knowledge of the ways of HBV transmission and ways of protection from HBV. Mean age of the participants was  $20.15 \pm 1.022(18-26)$ ; 80.10% (355 people) were women; 68.80% (305 people) are nursing students. The 83.70% of the respondents stated that they received training on Hepatitis B; 51.70% of the respondents stated that they have sufficient information. only 16.90% of the participants said that they knew the symptoms of hepatitis B disease; It was determined that 68.60% said that they knew the transmission ways of hepatitis B disease. Only 225 (50.88%) of the participants said they were fully vaccinated against hepatitis B. The education given to students in the field of health should be restructured

**Keywords:** Hepatitis B, Level of Knowledge, Health

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## **Predicting the potential distribution areas of *Cistus creticus* L. in Acıpayam district**

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**Musa Denizhan Ulsan<sup>1\*</sup>**

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**Abstract:** In recent years, there may be significant changes/decreases in the distribution of species due to reasons such as climate change, grazing pressure, and deforestation. Hence, the species with commercial use are important and their sustainable use comes to the fore. For this reason, it was aimed to determine the potential suitable areas of the *Cistus creticus* L. (*C. creticus*) species, which has important medical use. Distribution modeling of the species was performed using the MaxEnt method with 28 presence data obtained from Acıpayam district. As the climate variable, 19 bioclimatic variables obtained from the WorldClim database were preferred. In addition, 8 topographic variables were also included in the modeling process. Firstly, correlation analysis was applied to eliminate the multicollinearity problem. In this direction, 12 variables were selected and included in the modeling by eliminating the variables with high correlation (>0.80) with each other. As a result of the modeling with the selected variables, the AUC value of the model was determined as 0.95. Finally, it was determined that the *C. creticus* was distributed in a limited area within the study area.

**Keywords:** Indicator plant species, interspecific correlation analysis, principal component analysis, productivity, red pine

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## **Major maize pests and diseases in Pioneer varieties for Varna region**

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**Abstract:** Six maize varieties were studied: R-9241, R-9889, R-8409 R-8812, R-0216, R-0217. Vegetation period showed mid-early duration, positioned at the beginning of FAO 400. Deciduous weeds were widely spread: *Amaranthus retroflexus* and *Sinapis arvensis*. High weeding level was found with wheat weeds *Echinochloa crus-galli* and *Sorghum halepensis*. In our study we also found high weeding level with *Convolvulus arvensis* and *Cirsium arvense*. The studied mid-early Pioneer hybrids for the region of Varna showed an average yield of 1141kg/da. Maize hybrids P-0216 and P-0217 were characterized by the highest grain yield, 1217 kg/da and 1290 kg/da respectively. The studied indicators for the yield elements showed that the average plant height was 312 cm. The research found that the average height of the main ear was 131 cm. Hybrids P-9889 and P-0216 were the lowest, at 124 cm and 128 cm respectively. The weight of 1000 seeds varied from 321.5 g to 390.2 g for hybrid P-0217. The average value of all hybrids on this indicator was 357.2 g. The studied hybrids had been found to have relatively good disease resistance, in particular to corn smut and fusarium. Common rust attack was relatively weak. Hybrids P-0216 and P-0217 showed very good resistance to the studied diseases.

**Keywords:** maize, varieties, economic qualities, diseases

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### **1. Introduction**

Corn is the third most popular crop in the world in terms of area occupied after wheat and rice. The United States are the leader in corn production /about 1/3 of worldwide corn production/, followed by China, Brazil, Argentina, Ukraine, India, Mexico, South Africa, Russia, Canada and others. In the recent years in our country sunflower crop has replaced corn crop in terms of crop area. In 2019, the harvested corn areas were 5.609.110 da, and the average yields were 711 kg/da. This is the crop with the highest productive potential in the cereals group (OECD-FAO, 2020).

It is grown mainly for grain, but also in large areas for livestock feed. Corn kernel is characterized by high caloric content /1 kg grain equals 1.34 feed units/, but is low in protein and essential amino acids lysine and tryptophan. It is used mainly for feed - as a basic raw material for combined concentrated feed production, but also as a raw material for starch, glucose, sugar, spirits, semolina, vegetable oil and alcohol (Glogova, 2007).

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Maize has a high weed sensitivity in the early stages of its development, especially in cases where the emergence of the plant is delayed due to adverse conditions. It has been experimentally proven that if there is severe corn weeding, seed yield can be reduced to 77-91%. We can reduce losses caused by weeds by their timely removal. Maize crops have wide rows, which are a prerequisite for a large number of weeds in the open space. Due to their adaptability in eco agri-cultural environment, they grow and develop faster, strongly competing corn plants. Massive distribution of perennial rhizomatous and rhizomatous weeds on arable land creates serious problems in maize cultivation (Ilchovska, 2004., Ilchovska, 2007). Annual weed reports are very important in order to develop effective weed control measures. Systematic survey data on an area makes it possible to predict any change in the weed composition (Tonev, 2000., Tonev, 2000).

It is known that some agro-technical factors in combination with the yearly meteorological conditions affect both the productivity of a crop rotation and the productivity of the crops included (Tsvetanova et al. 1996., Yordanov, 2004). Mineral fertilization has a positive effect on the maize yield structural elements, and tillage systems have almost no effect on them. Structural elements analysis of different maize varieties yields are the basis of research by authors (Hristov and Petrov, 2006, Nankov, 2006). Maize plants productivity is determined by the number of cobs and a number of parameters (size, weight, number of rows, seeds, weight per 1000 grains) (Dimitrov and Dochev, 2015).

The aim of the present study is to establish the productive potential of maize hybrids and some major pests for Varna region.

## **Material and methods**

2020-2021 climatic factors were very favorable for corn growth. The average precipitation amount for the vegetation period was 312 l/m<sup>2</sup>. Only in June, during the two years of testing, the average rainfall was 206 mm/m<sup>2</sup>. The main focus was on the grain yield structural elements and detection of maize diseases. Herbicide Team was used for maize weed control technology, at a dose of 250 ml/da. The herbicide was introduced in crop phase 3-5 corn leaf, which allowed us to take into account the weed composition. Weed species composition determination was done by a route method - using meters diagonally across the field. 5 meters of each variety were reported in detail (Tonev, 2000). For checking disease attacks, the middle six rows of the experimental area were surveyed, taking into account the disease attack per 100 plants. We presented graphically the infested plants by the observed diseases (Bobev, 2002., Bobev, 2009., Hristov, A, 1976., Nakov et al. 1999., Shindrova, 2012).

## **Results and discussion**

Corn crop set its productivity potential relatively early. Weed existence in those phases greatly reduced yields. Corn weeding was from the group of early weed species *Sinapis arvensis*, *Polygonum convolvulus*), etc.; late spring species *Amaranthus retroflexus*, *Setaria sp.*, *Chenopodium album*, *Datura stramonium*, *Solanum nigrum*, *Poligonum aviculare*, *Poligonum lapathifolium*, *Xanthium strumarium*, *Echinochloa crus-galli*, etc. There was massive spread of rhizomatous and root-shoot weeds - *Sorghum halepensis*, *Convolvulus arvensis*, *Cirsium arvense*, *Sonchus arvensis*. The reasons for that were different: misuse of agricultural technology - use of cutters and disc tools for treating rhizome weeds, improper crop rotation, improper herbicide application, mistimed treatment, inaccurate doses, etc. The perennial weed

species *Sorghum halepensis*, *Convolvulus arvensis*, etc. were greatly multiplied with monocultural corn cultivation.

Table 1 presents the data from the weeding survey on the studied areas. Crop examination showed that the strongest weeding was with deciduous weeds *Amaranthus retroflexus* and *Sinapis arvensis*. Very strong weeding was found with *Echinochloa crus-galli* and *Sorghum halepensis*. Our survey also found significant weeding with *Convolvulus arvensis* and *Cirsium arvense*. The use of Team herbicide at a dose of 250 ml/da was correctly assessed, mainly due to the significant presence of *Sorghum halepensis* weeds.

Table 1. Weed composition in maize

Weed species	Weeding	Weed species	Weeding
Amaranth ( <i>Amaranthus retroflexus</i> L.)	++++	Field mustard ( <i>Sinapis arvensis</i> L.)	++++
Chicken millet ( <i>Echinochloa crus-galli</i> L.)	+++++	Johnsongrass ( <i>Sorghum halepensis</i> L.)	++++
Field bindweed ( <i>Convolvulus arvensis</i> L.)	+++	Canada thistle ( <i>Cirsium arvense</i> L.)	+++
Cocklebur ( <i>Xanthium strumarium</i> L.)	+	Field poppy ( <i>Papaver rhoeas</i> L.)	+
Polish cellar ( <i>Anthemis arvensis</i> L.)	+	Nightshade black ( <i>Solanum nigrum</i> L.)	+
Lambsquarters ( <i>Chenopodium album</i> L.)	++	Wolf apple ( <i>Aristolochia clematitis</i> L.)	+
Corn - cleavers ( <i>Galium tricorne</i> L.)	+	Couch-grass ( <i>Cynodon dactylon</i> L.)	+
Wild buckwheat ( <i>Polygonum convolvulus</i> L.)	+	Field sowthistle ( <i>Sonchus arvensis</i> L.)	+

0% no weeding  
 0 - 25% low weeding +  
 26 - 50% average weeding ++  
 51 - 75% strong weeding +++  
 76 - 100% very strong weeding ++++

Figure 1 presents the data on the average yields obtained from the studied hybrids. Maize hybrids P-0216 and P-0217 occupied the first and the second place with 1217 kg/da and 1290 kg/da, respectively. A relatively lower value (1208 kg/da) was obtained for P-9241 hybrid. The average grain yield for the group of the studied hybrids was 1141 kg/da.

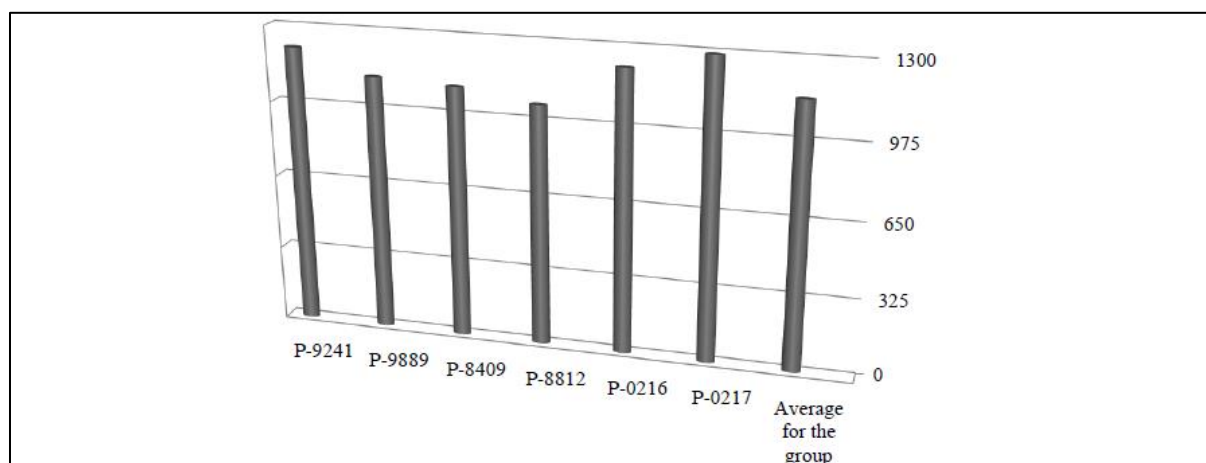


Figure 1. Average maize yields, kg/da



In the present study, we challenged ourselves to trace some of the grain yield elements in corn. The study of plant height is shown in Figure 2. The average plant height for the studied hybrids was 312 cm. P-0217 variety (340 cm) had the highest plants in the trial representative. P-8812 hybrid (335 cm) had a similar value.

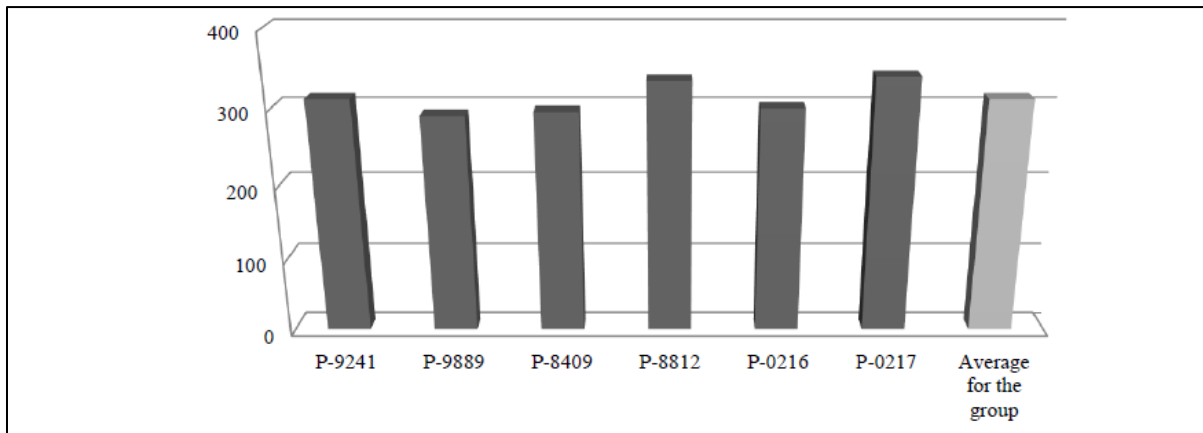


Figure 2. Maize plants height, cm

The height of the main ear is a functional indicator and strongly depends on the climatic conditions and the hybrid genotype. In practice, varieties with lower set cobs are preferred. The research found that the average height of the main ear was 92 cm. Hybrids P-0217 and P-0216 had their reproductive organs the lowest at 89 cm and 85 cm respectively.

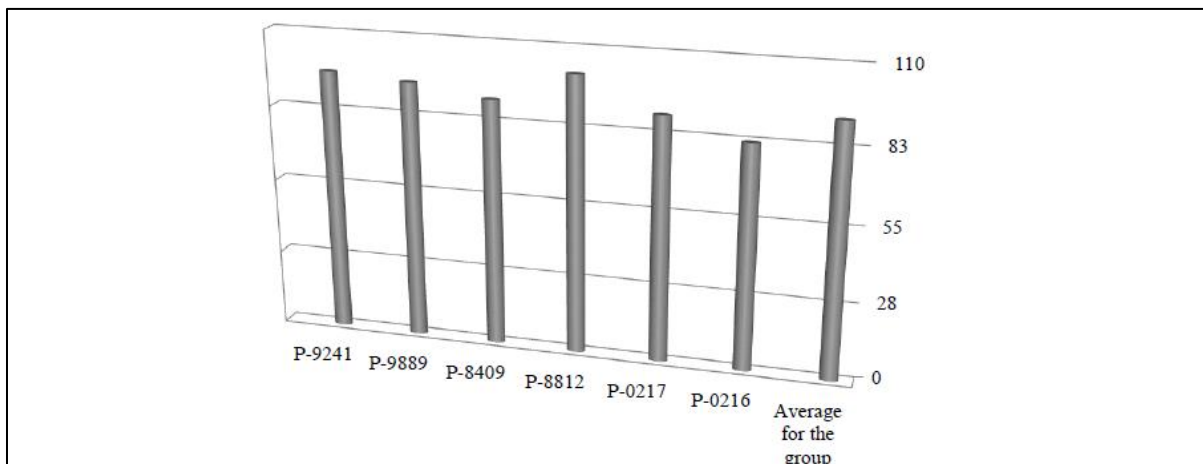


Figure 3. Height of the main ear, cm

Seed number in a row is usually a genetic trait, as well as the rows in a cob. When we counted the seeds in one cob's row we found out that, on average, for all hybrids in the group, there were 32.7 pieces (Fig. 4). The largest number of seeds was reported for hybrid P-9241 (37 grains); a similar result showed hybrid P-0217 (36 grains).

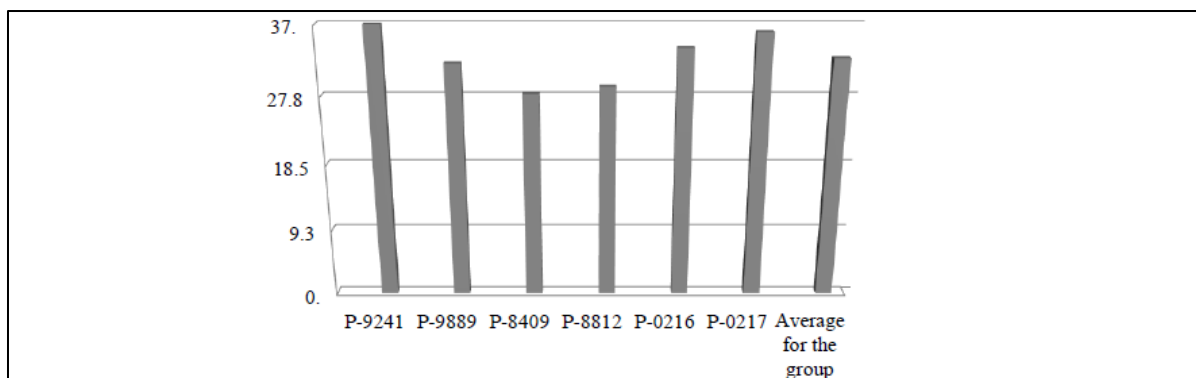


Figure 4. Number of seeds in a cob's row

According to some authors (Dimitrov and Dochev, 2015., Yordanov, 2004), the number of rows in dent corn (*ssp. indentata*) varied from 14 to 20 and more per cob. A review of the data in Figure 5 shows that there were significant differences in the number of rows in a cob. For example, hybrids P-9889 and P-0217 had on average 14, while in hybrid P - 8409 it reached 18. In general, the average number of rows in a cob in the tested group hybrids was 16.

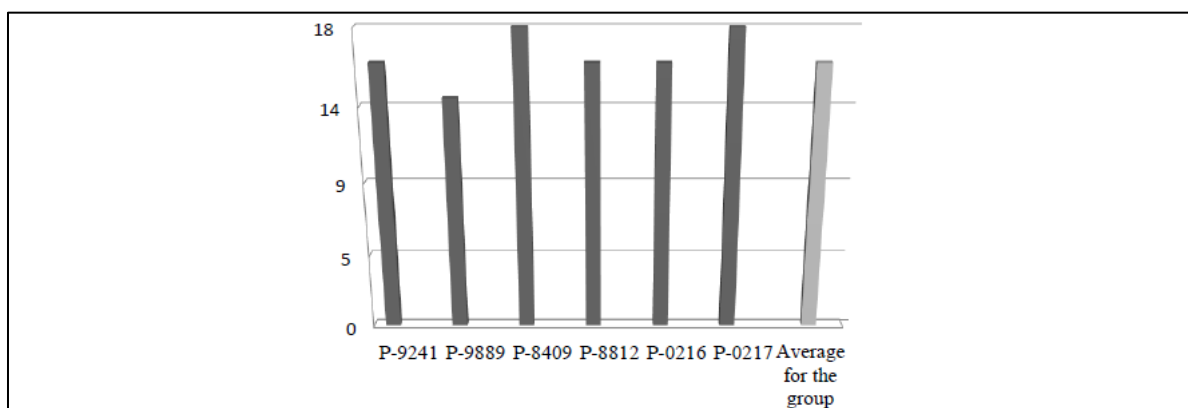


Figure 5. Number of rows in a cob

Corn spindle makes up about 18% of the grain cob and is rich in crude fiber - 30-33% (Figure 6). Corn spindles are superior in nutritional value compared to corn stalks. Our observation found that the average weight of a corn spindle reached 159.2 g. The lowest weight of corn spindle showed hybrids P-9889 and P-8409, 142.3 and 146.8 g respectively.

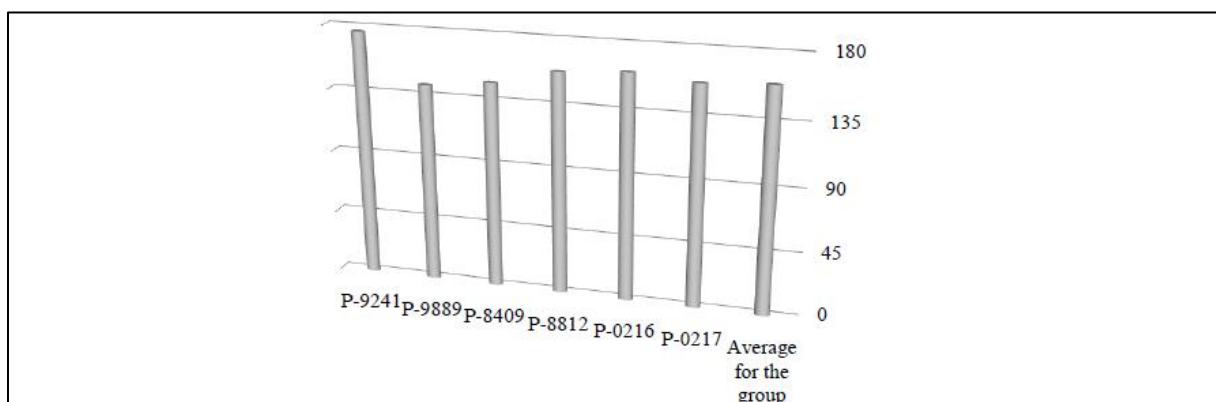


Figure 6. Corn spindle weight, g

Practically, the absolute seed weight indicator is presented in grams per 1000 pieces of air-dried seeds. It is used to specify the sowing rate and varies according to the biological characteristics of the agricultural crop, variety, agro-technical and meteorological factors, soil conditions, etc. (Ordish and Hyams, 2014).

Figure 7 presents the results obtained from this indicator measurement.

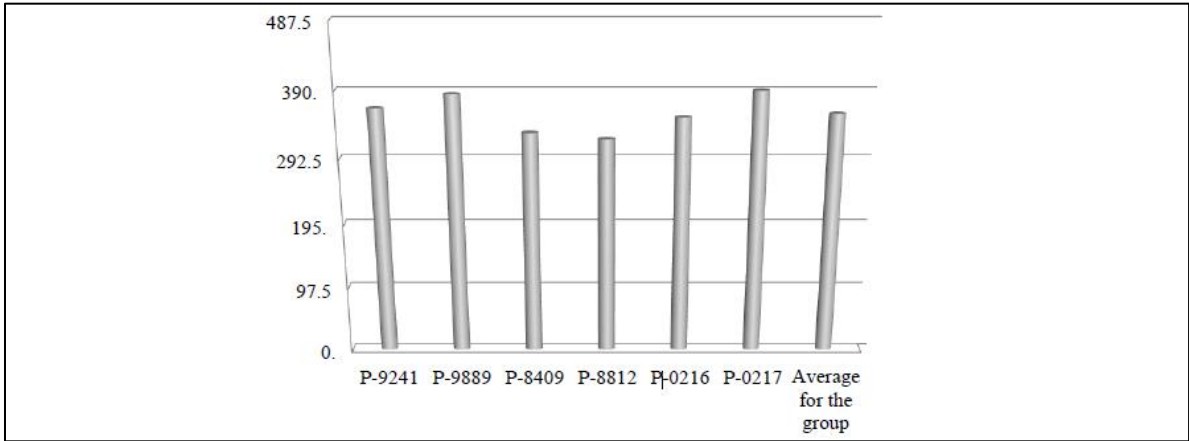


Figure 7. Weight per 1000 seeds, g

The highest absolute weight of seeds was found in hybrids P-9889 and P-0217 (385.0 - 390.2 g). P-8812 and P-8409 (321.0 - 330.0 g) had relatively low indicator values. We could consider that the average value of the studied hybrids on this indicator was 357.2 g.

Root and stem rot is a widespread disease in our country (Nakov et al. 1999, Shindrova, 2012). It manifests itself after the plant sheds its blossoms and moves to milk maturity. This disease causes the plants to be plucked easily, the roots are dead and are red or pink in color. The rot covers several stalk internodes, which are soft and straw-brown in color. The cobs of diseased plants are drooping, the grains are small, malnourished and poorly adhered to each other.

Data review in Figure 8 shows that the most affected plants by stem rot were the ones of hybrid P-9241 (14.2%). Stronger attack was observed in hybrids P-9889 and P-8812. The attack of stem rot reached 8.4% for the group on average.

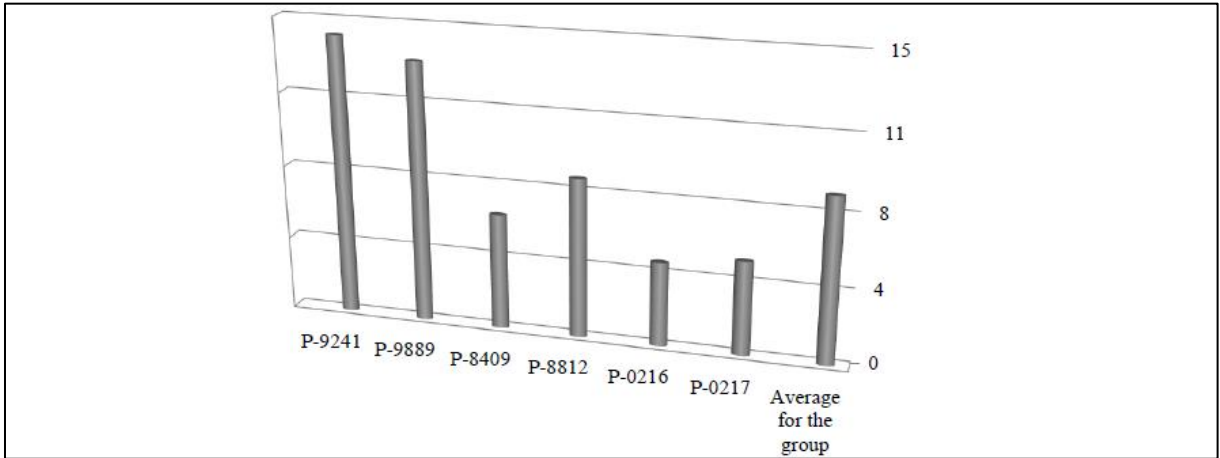


Figure 8. Stem rot attack, %

This disease is widespread in the world. Until recently, its distribution in our country was more limited. Nowadays, especially on irrigated areas and higher density crops, the disease damage has increased. It affects mainly the leaves. The first signs are the appearance of elongated gray-green spots. Lower leaves are attacked in the beginning. After that it spreads and covers the entire leaf mass.

Figure 9 shows the leaf blight attack. After the two reports we found out that the average attack number was 6.4%. Relatively stronger disease attack was reported for hybrid P-8812 (10.1%). Weaker disease damage was reported for hybrids P-9889 and P-8409, 4.8% and 5.1%, respectively. Good disease resistance showed hybrid P-0217 - less than 3%.

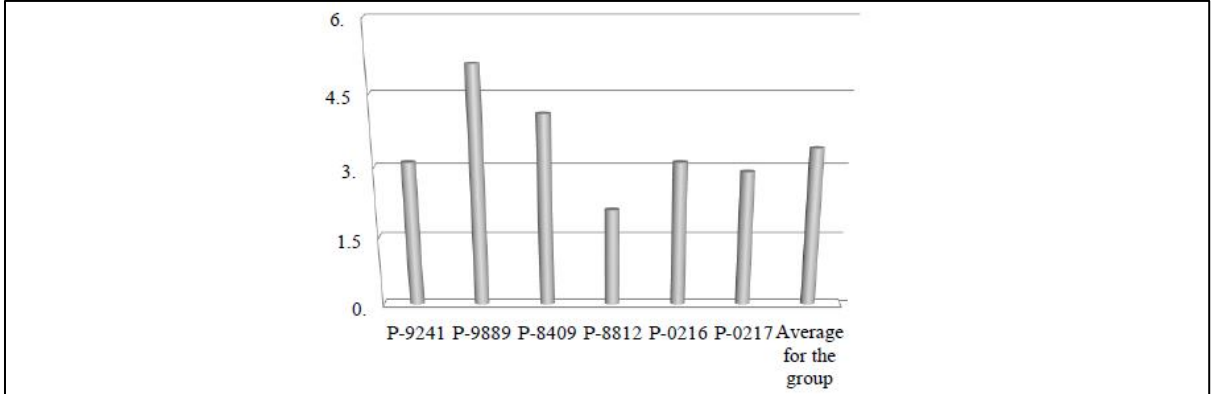


Figure 9. Leaf blight attack,%

This disease is still found nowadays, having less economic importance since the selected hybrids are characterized by higher resistance (Figure 10).

Maize varieties show a relatively good resistance to common fungal disease corn smut (3.4% on average for the group). A stronger attack was reported for hybrids P-0216 and P-0217 (2.1%, 3.1%).

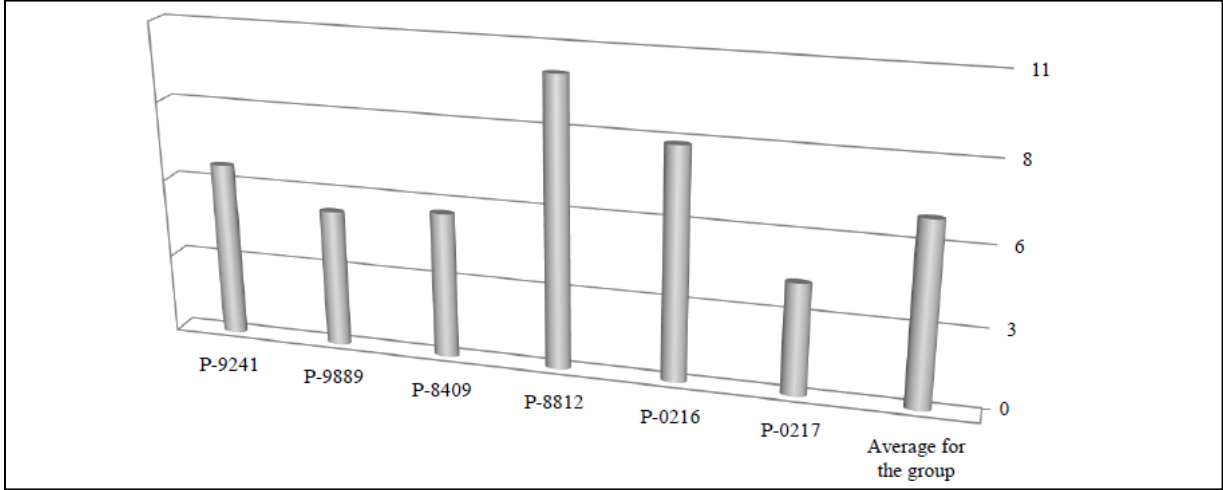


Figure 10. Corn smut attack, %

Figure 11 presents the results for Fusarium infestation during maize ripening. We observed partially damaged tassels as well as cob rot. The presented data in the Fusarium infestation chart shows that most hybrids have good disease resistance. Hybrids P-0217, P-0216 (3.6%, 4.1%) show very good resistance. A strong attack of fusarium at the end of the growing season was reported for hybrids P-8409 (10.1% ) and P-8812 (9.8%).

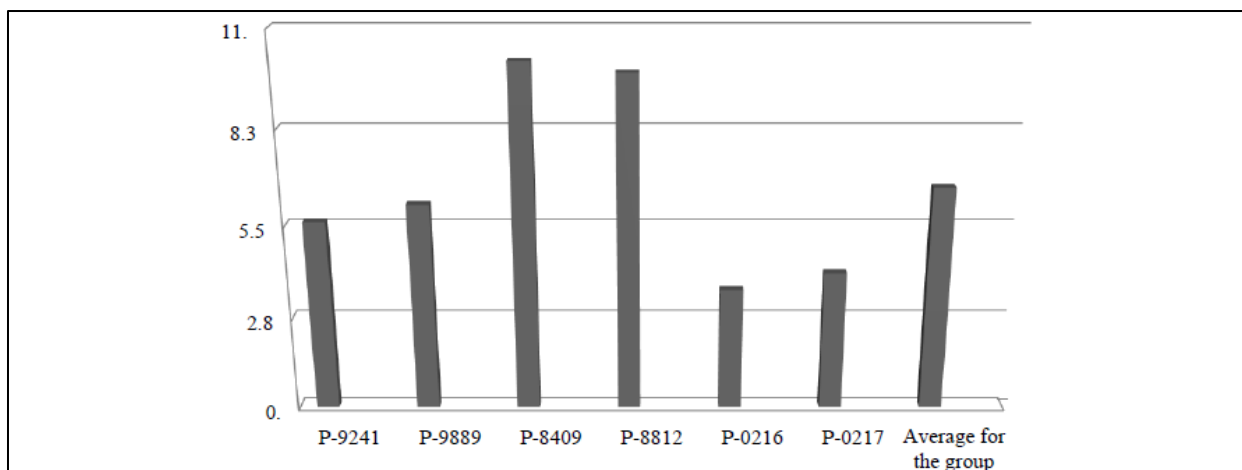


Figure 11. Fusarium attack,%

Our survey on common rust attack in maize (Figure 12) shows that on average 8.1% of the plants in the group were affected to a different degree. Very weak attack was reported for hybrids P-8812 (4.1%) and P-02017 (4.3%). Strong attack was found for hybrids P-9889 and P-8409 (12.1%,14.2%).

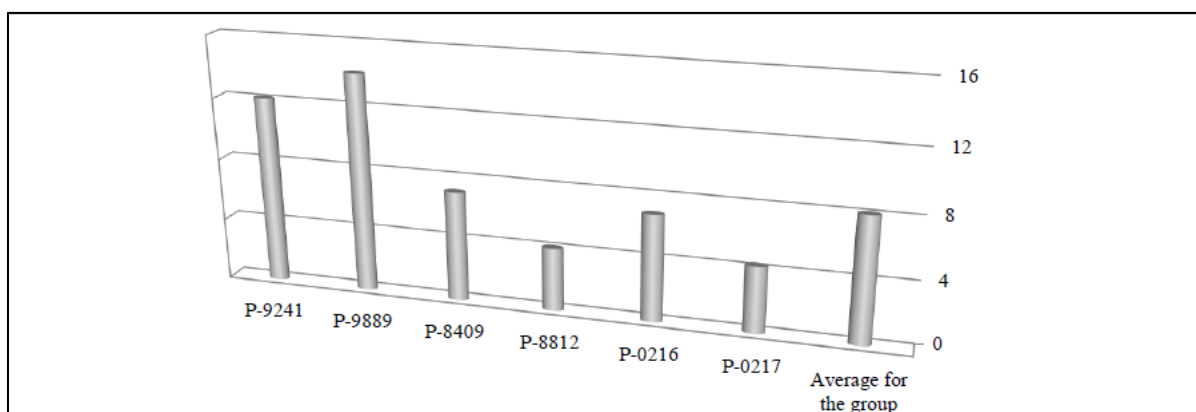


Figure 12. Maize common rust attack, %

## Conclusions

Strong weeding was found with deciduous weeds - *Amaranthus retroflexus* and *Sinapis arvensis*. Very strong weeding was found with wheat weeds: *Echinochloa crus-galli* and *Sorghum halepensis*. Our study also found significant weeding with *Convolvulus arvensis* and *Cirsium arvense*.

The studied Pioneer varieties from the group of mid-early hybrids for the region of Varna show an average yield of 1141kg/da. Maize hybrids P-0216 and P-0217 have the highest grain yields of 1217 kg/da and 1290 kg/da, respectively.

Indicators characterizing the yield elements show that the average height of plants is 312 cm. The conducted research found out that the average height of the main ear is 131 cm. Hybrids P-9889 and P-0216 are the lowest at 124 cm and 128 cm, respectively. The number of seeds in a row and the number of rows in a cob, as genetically determined traits, show differences. The

average number of seeds in a row in the studied hybrids is 32.7. The largest number of seeds in a row was found in hybrid P-9241 (37 pieces).

There were significant differences regarding the number of rows in a cob. In hybrids P-9889 and P-0217 the average number of rows was 14, while in hybrid P-8409 their number reached 18. In total, for the group, the cob rows in the tested hybrids were 16, on average.

The weight of 1000 seeds varied from 321.5g to 390.2 g for hybrid P-0217. This indicator average value obtained for all hybrids was 357.2 g.

The studied hybrids were reported to have relatively good disease resistance, in particular to corn smut and fusarium. Common rust attack was relatively weak. Hybrids P-0216 and P-0217 showed very good resistance to the studied diseases.

### **Acknowledgments**

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### **References**

Dimitrov, S., Dochev, Ch., (2015) Comparative testing of American maize hybrids for VCU, Digital book of proceeding International Conference Dedicated to the International year of soils and the 140-th anniversary from the birth of Nicola Pushkarov, Published by ISSAPP "Nicola Pushkarov" ISBN: 978-619-90560-0-4, 121-125.

OECD-FAO Agricultural Outlook 2020-2029, (2020) [fao.org](http://fao.org/) /3/ Cereals.pdf, 125-126

Bobev, S., (2002). Handbook of diseases of agricultural crops. *Plovdiv. Ed. Agroeco*, pp. 560.

Bobev, S., (2009). Directory of Crop Diseases. *Plovdiv. Agroeco*, ed. 2, pp 720.

Glogova, L., (2007). Analysis of the structural elements of the yield of experimental maize hybrids. *Sat International Scientific Conference, St. Zagora, vol. I, Crop production*, 345-348.

Hristov, A., 1976. Special phytopathology. *State Publishing House for Agricultural Literature*

Hristov, I., Petrov, P., (2006). Productivity of five-field crop rotation depending on the system of tillage and fertilization. *Sat scientific reports from the VI scientific and technical conference "Ecology and Health", Plovdiv*, 73-78.

Ilchovska, M., (2004). Technological evaluation of modern maize hybrids. *Plant Sciences*, 4, 291-294.

Ilchovska, M., (2007). Comparative study of experimental maize hybrids. *Sat International Initial Conference, St. Zagora, vol. I, Crop production*, 388-392.

Nakov, B., Karov, S., Popov, A., Neshev, G., (1999). Special phytopatology, *Publisher PSSA, Sofia*, pp. 325, ISBN 954-14-0043-4.

Nankov, M., (2006). Influence of the methods of soil cultivation and mineral fertilization on the productive and quality indicators of corn for grain grown as a monoculture. *Sat International Symposium "Ecology - Sustainable Development"*, Vratsa, 14-19.

Ordish, G., Hyams, E., (2014). The last of the Incas: the rise and fall of an American empire. *New York, Barnes & Noble*, ISBN 0-88029-595-3. pp. 26.

Shindrova P., (2012). Textbook on phytopathology, *Dobrich, Ed. K. Preslavski University of Shumen*.

Tonev, T., (2000). Color atlas of weeds. *Ed. AU - Plovdiv*.

Tonev, T., (2000). Guide for integrated weed control and agricultural culture. *Ed. AU - Plovdiv*.

Tsvetanova, K., Stamboliev, M., Georgiev, D., (1996). Productivity of maize grown on carbonate chernozem in four-field crop rotation. *Plant Sciences*, 3, 11-14.

Yordanov, G. (2004). Analysis of grain yield from early maize hybrids. *Sat International Scientific Conference, St. Zagora, vol. II, Crop production*, 108-110.

## **Municipal solid waste landfills and their impact on air quality: A Review**

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**Tuğçe Pekdoğan<sup>1\*</sup>**

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**Abstract:** In the past years, the National Waste Management Action Plan has been prepared within the framework of the sustainability principle. However, new sanitary landfills are also in need with the increase in waste. Even if measures are taken for landfills, it is likely to adversely affect public health, as they create a source of various air pollutants such as chemicals, odor, and volatile organic compounds, as well as their positive role in contributing to sustainable strategic steps. Therefore, landfills and disposal sites can cause emotional and physical discomfort to the topographic profile of the area, the management of neighboring lands, and the population in nearby settlements. This study provides an overview of the microbial diversity reported in air samples collected from various landfills worldwide. This article also discusses techniques for sampling bioaerosol concentrations, bioaerosol exposure and potential health effects.

**Keywords:** Solid waste landfill, Air quality, Bioaerosol sampling

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### **1. Introduction**

The most common method of providing indoor air quality is using cleaner outdoor air. The pollutant concentration can be reduced by giving the outside air with a lower pollutant concentration to the indoor environment, and the desired suitable conditions can be provided. However, the pollutant concentration of the outside air is also important (iskid, 2022). Health can be affected by indoor air quality, which results from indoor and outdoor pollutants, thermal comfort, and sensory loads (smell, freshness) (Council and others, 2007). According to Yeang, there are several criteria required to ensure indoor air quality (Yeang, 2006); Maintaining a minimum concentration of oxygen, providing sufficient outside air, limiting the concentration of pollutants such as CO<sub>2</sub>, humidity and cigarette smoke, removing or controlling the release of pollutants, toxic gases and dust, keeping the temperature and humidity at a comfortable level, emitted by users, lighting and machinery to remove or control heat and humidity and to reduce the number of harmful microorganisms and bacteria. Monitoring common indoor pollutants will help us reduce the risk of indoor health concerns (EPA, 2019). Therefore, continuous ventilation of the used areas is essential to provide adequate indoor air quality (IAQ).

Sick Building Syndrome (SBS) is frequently seen in buildings with insufficient air circulation and ventilation. Mentеше et al. (Mentese *et al.*, 2020) collected CO<sub>2</sub>, VOCs, temperature and

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relative humidity data for one year from 121 houses in Çanakkale province. As a result of this study, SBS symptoms vary seasonally, and some diseases occur frequently. The frequency of SBS symptoms calculated by IAQ parameters and personal factors are interrelated. Ma et al. (Ma *et al.*, 2021) proposed an analytical model and IAQ variables related to thermal comfort and health. In summary, parameters such as outdoor/indoor temperature, wind speed, outdoor/indoor relative humidity, physical characteristics of the room, natural/mechanical ventilation, number of people and air exchange rate are the factors affecting health, IAQ and thermal comfort.

The National Waste Management and Action Plan have been prepared within the principal sustainability framework in the past years. However, new sanitary landfills are also in need with the increase in waste. The selection of these alternative landfills is very important (Unal *et al.*, 2020).

Even if sanitary landfills are well protected, they are likely to adversely affect public health, as they create a source of various air pollutants such as chemicals, odor, and volatile organic compounds, as well as their positive role in contributing to sustainable strategic steps (Frączek and Ropek, 2011). Therefore, landfills and disposal sites can cause emotional and physical discomfort for the topographic profile of the area, the management of neighboring lands, as well as for the population in nearby settlements (Aatamila *et al.*, 2011; Heaney *et al.*, 2011).

The primary source of bioaerosol in landfills is accumulated organic waste. Some elements of municipal solid waste may contain enteric pathogenic bacteria. The wastes in the settlements include rotten food wastes, packaging materials, etc., containing many bacteria (Pahren, 1987). These wastes become bacterial and fungal bioaerosols during collection, transportation, and disposal (composting, bio mechanization, incineration, pyrolysis, gasification) during landfilling in these areas (Kalwasińska *et al.*, 2014). In addition, many studies have reported higher bioaerosol concentrations, especially in spring and summer, as high temperature and relative humidity provide a suitable environment for microbes to survive and multiply. In these areas, bioaerosols are in respirable sizes. Therefore, it can cause chronic lung disorders (Nair, 2021). (Ithnin *et al.*, 2013) conducted a study on the effects on air quality and respiratory health of students at the school near the old landfill, and as a result, a high lead concentration was encountered in the old waste disposal site. In addition, respiratory symptoms were observed among students at the school near the old landfill.

This study provides an overview of techniques for extracting energy from waste, integrated solid waste management, air pollution, and the microbial diversity reported in air samples collected from various landfills worldwide. This article also discusses techniques for sampling bioaerosol concentrations, bioaerosol exposure and potential health effects.

## **2. Material and Method**

### **2.1. Solid Waste and Its Properties**

Solid waste results from increasing human activities with rapid urbanization, increasing living standards and changing consumer needs. Waste is generated during industrial processes and corporate and development activities. According to the United Nations Environment Program (UNEP), waste is substances the owner does not want, does not need, does not use, and needs to be purified and removed. Solid wastes: They are divided into biodegradable and nonbiodegradable. Wastes, according to their composition and properties of the materials they

contain, decomposable organic matter such as vegetables, fruits, food supplies etc., are biodegradable wastes (Unal *et al.*, 2020). According to the sources; household, hazardous, medical, electronic waste, packaging waste, waste batteries and accumulators, waste oils, end-of-life tires, and vehicles (Table 1).

Table 1. Municipal Solid Waste and Component Type

MSW	Component Type
Kitchen waste	Food waste
	Agro-food residues
	Coffee residues and waste tea leaves
Plastic and rubber	Low-density polyethylene
	High-density polyethylene
	Polypropylene
	Polyethylene terephthalate
	Polyethylene
	Polycarbonate
	Polyvinyl chloride
	Polystyrene
Clear wrap; zip-lock bags; rubber bands	
Metal	Food packaging cans, cans, aluminum foil
Electronic waste	Dead batteries
	Electronic devices
Miscellaneous	Ceramics
	Discarded clothes
	Biomedical wastes
	Pharmaceuticals
	Diapers; sanitary napkins; contraception
	Pet litter
	Leather and textiles
Inert materials	Broken and discarded furniture
	Construction, demolition, and renovation wastes

In general, the amount of solid waste is directly proportional to the economic development and urbanization rate. Globally, the amounts of waste are increasing rapidly. Like urbanization rates and increases in GDP, solid waste growth rates appear to be increasing rapidly in China, other parts of East Asia, and parts of Eastern Europe and the Middle East and Pacific Region (AlFakih *et al.*, 2019). There is a strong relationship between urban solid waste generation rates and greenhouse gas emissions. The increase in solid waste, greenhouse gas emissions and ozone-depleting substances result from pollution and urbanization. According to a study in 2016 waste management statistics, waste generation in urban areas is twice as much as in rural areas (Statista, 2019). Most landfills are open dumps and pose serious environmental and social threats (Pulimeno *et al.*, 2020). Figure 1 shows the percentages of global municipal solid waste generation in selected countries in 2018. While the production is mostly seen in China and India, Turkey is at the top with 1.5% (Statista, 2019).

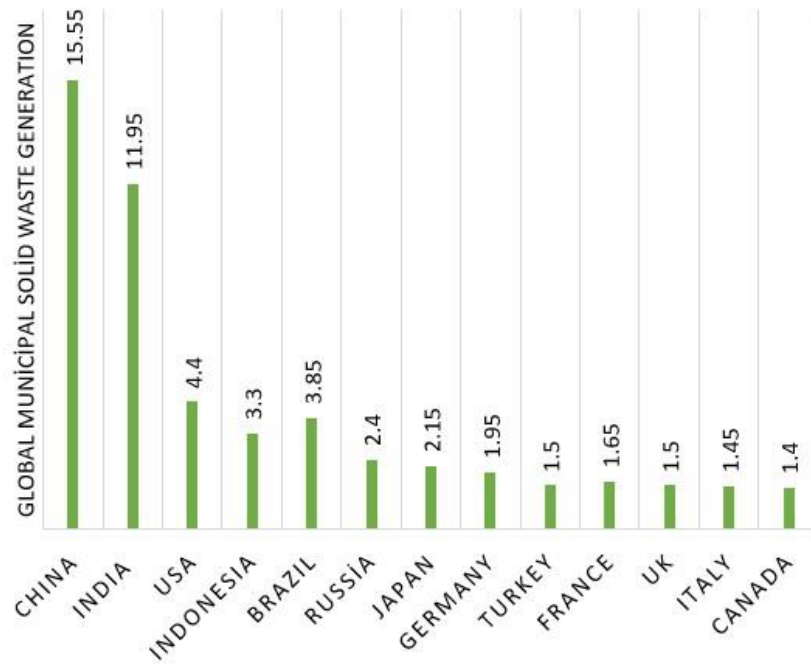


Figure 1. Global municipal solid waste generation (Statista, 2019)

Solid waste management is almost always the responsibility of local governments. For this reason, solid waste management by local governments should be done most appropriately in terms of economic, social, and environmental aspects.

## 2.2. Solid Waste Management Strategies

Solid waste and the problems associated with its management have been the focus of significant environmental attention in the last quarter of the 20th century, as communities around the world began to recognize the hazards posed by waste management (Unal *et al.*, 2020). Municipal planners should manage solid waste as holistically as possible. Various techniques are used for waste management. These techniques include recycling, composting, anaerobic digestion and incineration, thermo-chemical waste-energy technologies such as gasification and pyrolysis, and final waste disposal such as storage (Bundhoo, 2018). Integrated solid waste management; consists of prevention, reduction, recycle and reuse, recover, and landfill disposal steps (Figure 2) (Lumen, 2022).

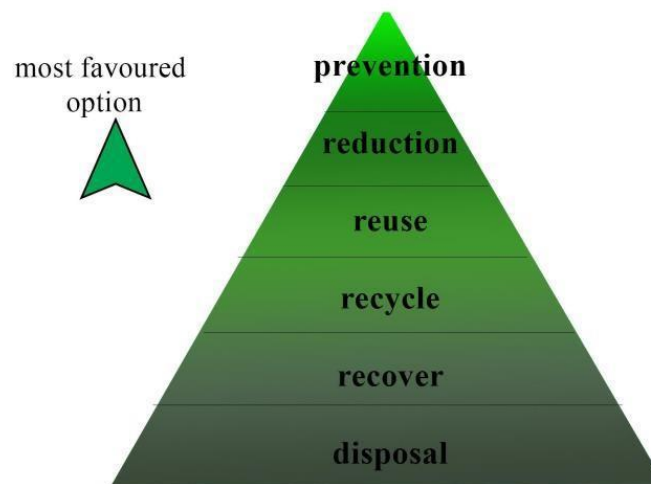


Figure 2. Solid waste management strategies

**Waste Prevention:** Ideal waste management is to prevent waste generation in the first place. Therefore, waste prevention is the main objective of all waste management strategies. The first step is to prevent waste generation, such as extending the useful life of products or reusing them, reducing the amount of waste and its toxic properties, and minimizing the effects of waste on human and environmental health. Numerous technologies can be applied throughout the production, use or post-use parts of product life cycles to eliminate waste and thus reduce or prevent pollution.

**Waste Reduction:** It covers using fewer resources/raw materials in product designs and manufacturing and reducing unnecessary consumption. In most cases, waste cannot be eliminated from various processes. Before an event occurs, steps can be taken to reduce the amount and toxicity of event-related waste.

**Reuse:** It is the whole of the processes in which any product or non-waste components are produced/used for the same purpose following the way it was designed. Reuse refers to materials that can be reused in their original form. These items are not usually removed from the field.

**Recycle** is the process of converting waste products into various products, materials, or substances. Recycling means recovering useful materials such as glass, paper, plastic, wood, and metals from the waste stream to be incorporated into manufacturing new products.

**Recovery** is the process of making the wastes ready to replace the materials used in the production/consumption processes or the recovery of fuel, heat and electrical energy by oxygen-free digestion and thermal methods. Most discarded materials can be used and processed other than destroyed.

**Disposal** is the storage of non-recoverable and non-recyclable wastes with specified technical methods. This stage includes all of the incineration and/or landfill processes to gain energy to contribute to the economy by making it harmless in terms of the environment and human health after the collection, transportation and recycling of the solid wastes temporarily accumulated at the source.

### 2.3. Techniques of Obtaining Energy from Waste

It is an additional renewable energy source to reduce its dependence on fossil fuels. Fossil fuels are still used to generate electricity. Waste can be an attractive fuel alternative to fossil fuels all over the world. Many methods can process solid waste, including incineration, landfill gas production, recycling, and thermal and biological processing. Incineration is a method of disposal where solid wastes are burned at high temperatures so that they are reduced to ash or other by-products such as fumes or 25% by volume. In this way, the volume of solid waste becomes very small. However, it should be noted that continuing environmental pollution caused by the incineration process continues to harm the environment (Unal *et al.*, 2020). Landfill gas production can be considered a process that creates energy from solid waste. It takes place when decomposition takes place under anaerobic conditions. In landfill gas production processes, there are two main types: methane generation and carbon dioxide generation. Methane is used for energy and electricity generation, while carbon dioxide can be used for different purposes, such as sterilization or freezing food products (Unal *et al.*, 2020). Recycling converts solid wastes into new materials or products with different properties than the original (Unal *et al.*, 2020). Thermal processing involves heating (above 550 °C) of certain types of materials resulting in a change of physical or chemical properties (e.g., melting). Biological processing uses organic matter (e.g., heat) to obtain a product with different physical or chemical properties; it usually proceeds under aerobic conditions (e.g., composting) (EPA, 2019).

Burning, gasification, pyrolysis, combustion, and incineration are thermal technologies used to generate energy from waste. These processes take place at high temperatures. The waste passes through a burner, boiler, or furnace to generate heat and power. Heat recovery systems such as heat exchangers or steam turbines capture the generated energy. Incineration and open burning are destructive methods used to generate energy from waste (Dolla and Laishram, 2021). In incineration, both organic and inorganic waste is burned together. Only organic waste is burnt in open burning, and no technology or precautions are taken to protect the environment or the people in the vicinity of the burning. Conversely, although precautions may be taken in combustion and incineration, the waste is destroyed and diminished to fractional amounts.

Combustion, also known as COMB (Combined Heat and Power) burning (Olabi *et al.*, 2020), is used to burn both household and industrial waste. In this process, household waste is separated into combustible and non-combustible waste. Non-combustible waste such as plastic, glass, metals, batteries, and sand are sent for shredding, grinding, or crushing. Combustible waste is collected in heaps to be burnt using boilers, furnaces, or burners. The heated waste gas generates electricity and heat, and the residual ashes are sent to the landfill. Each ton of waste burnt using this technology produces a one-kilowatt hour of electricity. Comb-burning technology is inexpensive, and it reduces the volume of waste by around 90%.

Gasification is a high-temperature process used to convert waste into gas. In this process, organic waste such as park plastics, tires, wood, refuse bags, cardboard and paper are synthesized into a gas called synthesis gas or syngas (Czajczyńska *et al.*, 2017). In addition to waste, bio-coal is added to the process to ensure that metals present in the waste do not corrode the equipment. Around two tons of waste need to be gasified to produce a one-megawatt hour of electricity. Although gasification technology is noted for its ability to convert even the most unmanageable waste into energy, precautions must be taken to ensure that the process does not release harmful gasses such as carbon monoxide or nitrogen dioxide.

## 2.4. Environmental impacts of Solid Waste landfills

The main purpose of landfill gas management in solid waste landfills is to minimize the negative effects of the gas formed in the landfill area on the environment and human health. Apart from this, it is to ensure that landfill gas is used in energy recovery by eliminating the explosion of methane gas and the risk of slipping the stored waste. It is expected that solid waste storage will also decrease greenhouse gas emissions. Environmental monitoring of all potential sources of pollution from different waste management options is constantly carried out all over the world; therefore, much is known about the types and amount of substances that originate from them (Rushton, 2003).

A mixture of volatile organic compounds (VOC) and other gasses, such as mainly methane and carbon dioxide, as well as low concentrations of hydrogen sulfide and mercury vapor, is emitted from landfills (Powell *et al.*, 2006). In addition to gasses emitted from landfills, landfill investigations should examine metals, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), and chlorinated hydrocarbons, pesticides, dioxins, asbestos, pharmaceuticals and pathogens (Białowiec, 2011).

Waste incineration also produces many pollutants from the combustion of sewage sludge, chemical, clinical and municipal wastes, which can be grouped into particulates and gasses, metals and organic compounds (Charles Humfrey, Mark Taylor, 1997). The pollutants of cadmium, mercury, arsenic, chromium, nickel, dioxins, PCBs, PAHs, PM10 and SO<sub>2</sub> are considered to have the greatest potential impact on human health based on environmental persistence, bioaccumulation and amount emitted and/or natural toxicity (Charles Humfrey, Mark Taylor, 1997). Besides these emitted gasses and particulates, less easily measurable hazards affecting the population near a waste disposal site include odors, litter, noise, heavy traffic, flies, and birds (Reinhart, 2007). In this respect, monitoring and control activities are important in protecting water resources and environmental health after the active storage areas, and the fields are closed.

## 2.5. Microbial Diversity and Sampling Methods

Microbial diversity in municipal solid waste is important in determining bioaerosol concentrations and exposure. There are a variety of sampling techniques that can be used to obtain accurate measurements of bioaerosol concentrations. Bioaerosols can be collected using passive or active sampling systems with active samplers containing a mechanical component (Haig *et al.*, 2016). Measuring the microbial load as CFU/m<sup>3</sup> with test devices (active air sampling) and counting the microorganisms falling on the medium plates (passive air sampling). Passive air sampling is easy, cheap and accessible compared to active air sampling (Alçay and Yalçın, 2015). In addition, according to Murthy's study, passive sampling shows that the passive sampler gives results very close to the active sampler and that the passive sampler is sensitive to smaller emissions (Murthy and McFarland, 1993).

Some of the most common techniques for microbial diversity include:

- Air samplers: Air samplers collect particles from the air and then analyze them for microbial content.
- Surface samplers: Surface samplers collect particles from surfaces such as floors, walls, and countertops.

- Waste samplers: Waste samplers are used to collect particles from solid waste materials.

Due to the different responses of each type of pathogen to environmental conditions and sampling devices, the researcher must determine the bio efficiency of the selected sampler and the pathogen under investigation under laboratory conditions.

## **2.6. Public Health Effects of Solid Waste Sites**

Solid waste management is necessary to protect public health. Public health concerns have been the foundation of solid waste management programs in many countries. Solid waste not collected and disposed of properly can become a breeding ground for insects, vermin and scavengers and cause airborne and waterborne diseases. Research by UN-Habitat shows that diarrhea cases are twice as high in areas where waste is not collected frequently, and acute respiratory infections are six times more common in areas where waste is collected (UNHabitat, 2009).

In addition, several factors should be considered that will affect public health and air quality. For example, landfill fires are unexpectedly common worldwide (Chavan *et al.*, 2019). While it causes public health problems due to fires, it also causes financial damage (Chavan *et al.*, 2019). These fires can cause significant damage to the atmosphere, groundwater, and soil. Risk factors may vary depending on the type of burning waste. Hydrocarbons, chlorinated materials, and pesticides generate various toxic gasses under such conditions, including dioxins/furans, polynuclear aromatic hydrocarbons, particulate matter (PM) and other harmful compounds. The smoke generated during the landfill fire may also contain dangerous toxic gasses such as CO, H<sub>2</sub>S, CH<sub>4</sub>, and carcinogenic substances such as dioxins (Vaverková, 2019).

In addition, the emitted foul odors and smoke may endanger human health while disturbing the residents (Rovira *et al.*, 2018).

## **3. Results and Recommendations**

This study provides an overview of waste-to-energy techniques, integrated solid waste management, air pollution, and the microbial diversity reported in air samples collected from various landfills worldwide. This article also discussed techniques for sampling bioaerosol concentrations, bioaerosol exposure and potential health effects. When we look at the literature, landfill, which has many negative and positive effects, has been one of the most preferred methods for the disposal of municipal solid wastes. In addition to the lack of space for new landfills in high metropolitan cities, waste-to-energy conversion methods are applied to recycle solid wastes.

Negative aspects of these practices can be ruled out with strict control. A municipal management system should be implemented for the collection and disposal of solid wastes. In these disposal facilities established for energy production, control should be increased according to the type of waste materials used. Controlled disposal of all wastes should be ensured. To protect the air, water and soil, and to make them better quality and cleaner, the private sector, especially the public institutions, should fulfill their duties. In addition, important duties fall on the relevant authorities when deciding on the location selection of the facilities planned to be built in terms of public health.

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## References

Aatamila, M., Verkasalo, P.K., Korhonen, M.J., Suominen, A.L., Hirvonen, M.R., Viluksela, M.K. and Nevalainen, A. (2011), "Odour annoyance and physical symptoms among residents living near waste treatment centres", *Environmental Research*, available at:<https://doi.org/10.1016/j.envres.2010.11.008>.

Al-Fakih, A., Mohammed, B.S., Liew, M.S. and Nikbakht, E. (2019), "Incorporation of waste materials in the manufacture of masonry bricks: An update review", *Journal of Building Engineering*, available at:<https://doi.org/10.1016/j.jobbe.2018.09.023>.

Alçay, A.Ü. and Yalçın, S. (2015), "Bioaerosols in indoor air and microbiological air quality measurement methods", *Anadolu Bil Meslek Yüksekokulu Dergisi*, No. 37, pp. 17–30.

Białowiec, A. (2011), "Hazardous Emissions from Municipal Solid Waste Landfills", *Contemporary Problems of Management and Environmental Protection*, No. 9, 2011.

Bundhoo, Z.M.A. (2018), "Solid waste management in least developed countries: current status and challenges faced", *Journal of Material Cycles and Waste Management*, available at:<https://doi.org/10.1007/s10163-018-0728-3>.

Charles Humfrey, Mark Taylor, K.A. (1997), *Health Effects of the Combustion Products*.

Chavan, D., Lakshmikanthan, P., Mondal, P., Kumar, S. and Kumar, R. (2019), "Determination of ignition temperature of municipal solid waste for understanding surface and sub-surface landfill fire", *Waste Management*, available at:<https://doi.org/10.1016/j.wasman.2019.08.002>.

Council, N.R. and others. (2007), *Green Schools: Attributes for Health and Learning*, National Academies Press.

Czajczyńska, D., Anguilano, L., Ghazal, H., Krzyżyńska, R., Reynolds, A.J., Spencer, N. and Jouhara, H. (2017), "Potential of pyrolysis processes in the waste management sector", *Thermal Science and Engineering Progress*, available at:<https://doi.org/10.1016/j.tsep.2017.06.003>.

Dolla, T. and Laishram, B. (2021), "Effect of energy from waste technologies on the risk profile of public-private partnership waste treatment projects of India", *Journal of Cleaner Production*, available at:<https://doi.org/10.1016/j.jclepro.2020.124726>.

EPA. (2019), "Quality Assurance Document Quality Assurance Project Plan for the PM Performance Evaluation", *Performance Evaluation*.

Frączek, K. and Ropek, D. (2011), "Municipal waste dumps as the microbiological threat to the natural environment", *Ecological Chemistry and Engineering S*.



Haig, C.W., Mackay, W.G., Walker, J.T. and Williams, C. (2016), "Bioaerosol sampling: Sampling mechanisms, bioefficiency and field studies", *Journal of Hospital Infection*, available at:<https://doi.org/10.1016/j.jhin.2016.03.017>.

Heaney, C.D., Wing, S., Campbell, R.L., Caldwell, D., Hopkins, B., Richardson, D. and Yeatts, K. (2011), "Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill", *Environmental Research*, available at:<https://doi.org/10.1016/j.envres.2011.05.021>.

Iskid. (2022), "How is Indoor Air Quality Provided?", available at: <https://iskid.org.tr/ichavakalitesi/ichava-kalitesi/ic-hava-kalitesi-nedir/ic-hava-kalitesinasil-saglanir/>.

Ithnin, A., Rahman, M.S.A., Awang, N., Yusuf, N.M., Abdullah, R. and Ariffin, F.D. (2013), "Study on air quality in school located near the former landfill site and its influences on student's respiratory health", *Middle East Journal of Scientific Research*, available at:<https://doi.org/10.5829/idosi.mejsr.2013.14.3.71237>.

Kalwasińska, A., Burkowska, A. and Swiontek Brzezinska, M. (2014), "Exposure of workers of municipal landfill site to bacterial and fungal aerosol", *Clean - Soil, Air, Water*, available at:<https://doi.org/10.1002/clen.201300385>.

Lumen. (2022), "Waste Management Strategies", available at: <https://courses.lumenlearning.com/suny-monroe-environmentalbiology/chapter/15-2waste-management-strategies/>.

Ma, N., Aviv, D., Guo, H. and Braham, W.W. (2021), "Measuring the right factors: A review of variables and models for thermal comfort and indoor air quality", *Renewable and Sustainable Energy Reviews*, Elsevier Ltd, Vol. 135 No. March 2020, p. 110436.

Mentese, S., Mirici, N.A., Elbir, T., Palaz, E., Mumcuoğlu, D.T., Cotuker, O., Bakar, C., *et al.* (2020), "A long-term multi-parametric monitoring study: Indoor air quality (IAQ) and the sources of the pollutants, prevalence of sick building syndrome (SBS) symptoms, and respiratory health indicators", *Atmospheric Pollution Research*, Elsevier, Vol. 11 No. 12, pp. 2270–2281.

Murthy, P.N. and McFarland, A.R. (1993), "An advanced air sampling technique for hazardous waste sites", *Waste Management*, available at:[https://doi.org/10.1016/0956053X\(93\)90075-8](https://doi.org/10.1016/0956053X(93)90075-8).

Nair, A.T. (2021), "Bioaerosols in the landfill environment: an overview of microbial diversity and potential health hazards", *Aerobiologia*, available at:<https://doi.org/10.1007/s10453021-09693-9>.

Olabi, A.G., Wilberforce, T., Sayed, E.T., Elsaid, K. and Abdelkareem, M.A. (2020), "Prospects of fuel cell combined heat and power systems", *Energies*, available at:<https://doi.org/10.3390/en13164104>.

Pahren, H. (1987), "Microorganisms in municipal solid waste and public health implications", *Critical Reviews in Environmental Control*, available at:<https://doi.org/10.1080/10643388709388334>.

Powell, J., Jain, P., Kim, H., Townsend, T. and Reinhart, D. (2006), "Changes in landfill gas quality as a result of controlled air injection", *Environmental Science and Technology*, available at:<https://doi.org/10.1021/es051114j>.

Pulimeno, M., Piscitelli, P., Colazzo, S., Colao, A. and Miani, A. (2020), "Indoor air quality at school and students' performance: Recommendations of the UNESCO Chair on Health Education and Sustainable Development & the Italian Society of Environmental Medicine (SIMA)", *Health Promotion Perspectives*, available at:<https://doi.org/10.34172/hpp.2020.29>.

Reinhart, D.R. (2007), *Urban Infilling Impacts on Florida's Solid Waste Facilities*.

Rovira, J., Domínguez-Morueco, N., Nadal, M., Schuhmacher, M. and Domingo, J.L. (2018), "Temporal trend in the levels of polycyclic aromatic hydrocarbons emitted in a big tire landfill fire in Spain: Risk assessment for human health", *Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering*, available at:<https://doi.org/10.1080/10934529.2017.1387023>.

Rushton, L. (2003), "Health hazards and waste management", *British Medical Bulletin*, available at:<https://doi.org/10.1093/bmb/ldg034>.

Statista. (2019), "Statista - The Statistics Portal for Market Data, Market Research and Market Studies", *Statista*.

TUIK. (2021), "Waste statistics, 2020", available at: [https://data.tuik.gov.tr/Bulten/Index?p=Atik-Istatistikleri-2020-37198#:~:text=Atik bertaraf ve geri kazanım tesislerinde işlenen 127%2C4 milyon,m3 olarak tespit edildi](https://data.tuik.gov.tr/Bulten/Index?p=Atik-Istatistikleri-2020-37198#:~:text=Atik%20bertaraf%20ve%20geri%20kazanım%20tesislerinde%20işlenen%20127%2C4%20milyon,m3%20olarak%20tespit%20edildi.).

UN-Habitat. (2009), "Governing Council of the United Nations Human Settlements Programme".

Unal, M., Cilek, A. and Guner, E.D. (2020), "Implementation of fuzzy, Simos and strengths, weaknesses, opportunities and threats analysis for municipal solid waste landfill site selection: Adana City case study", *Waste Management and Research*, available at:<https://doi.org/10.1177/0734242X19893111>.

Vaverková, M.D. (2019), "Landfill impacts on the environment— review", *Geosciences (Switzerland)*, available at:<https://doi.org/10.3390/geosciences9100431>.

Yeang, K. (2006), "Ecodesign: A manual for ecological design", Wiley-Academy London, UK.

## **Bio-economic modelling of cropping patterns in farm conditions**

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**Abstract:** The ultimate challenges faced by farmers these decades are related to adoption of their farm management to climate changes on the one hand and the consequences of new policies on the other hand. There is an urge to adjust farm systems toward sustainable solutions which would lead to green agriculture, reduction of anthropogenic greenhouse gas emissions, soil protection etc... Bio-economic modelling is widely used for the purpose of assessment of the impact of policy changes. But it is also a useful tool for evaluation of different management systems which can help farmers to control and anticipate the economic and production development of different systems.

Paper presents the results of bio-economic modelling of different cropping mixes on the farm level for the purpose of evaluation of profitability of crop production with respect to agronomic conditions. We used the linear programming for creating the model integrating economic with environmental data on crop production on the sample farm. Economic data were averaged for 9 selected crops for the period 2010-2020 and combine with environmental data on soil, precipitation, and water-use efficiency (WUEF). The interrelations between the data were studied as well, resulting into showing the determinant relationship between crop yields, cropping mixes used and WUEF.

Results suggest that farmers need to meet agronomic demands, policy requirements and satisfy the economic needs of management. With these 3 terms in mind, the production choice is given by the most profitable crop (maize and oil crops in this specific case). Environmental constraints of the model enabled us to set soil protection standards. Thus, bioeconomic modelling is a great tool for farmers as well as for policy makers to assess the consequences of their production/regulatory choices.

**Keywords:** management system, crop yield, production choice, profit, linear programming

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### **1. Introduction**

Agriculture is critical for human welfare and economic growth. That applies to both developed and developing world. However, it has a particular significance in countries where people still live in extreme poverty with subsistence agriculture as their main source of food and income (Toenniessen, G., Adesina, A., DeVries, J. 2008). Due to the continuous increase in the world

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population, the demand for food increases. Consequently, forests and arable lands are changing into urban landscapes. In the context of shrinking arable land area, highly efficient and advanced technologies need to meet a growing world population's food demands. At present, people can easily see the development of advanced approaches to enhance crop yield and improve other agriculture measures.(Khan, N., Ray, R. L., Sargani, G. R., Ihtisham, M., Khayyam, M., & Ismail, S. ,2021). In the next few years, an innovative or knowledge-based economy, which consider the production and use of knowledge and innovation as a source of wealth and competitive advantage will replace the traditional economy. This movement affects all sectors, and agriculture is no exception to this rule. Considering changes occurred in the economy over the past decades, agricultural productivism will no longer be responsive, and its change is inevitable. (Tohidyan Far, S., Rezaei-Moghaddam, K., 2019). As research and farming communities became aware of the need to balance productivity with environmental and social outcomes, the concept of sustainable agriculture was increasingly promoted. Garibaldi et al. (2017) describe agricultural sustainability as a concept which considers the economic, environmental, and social aspects of farming, while also promoting the resilience and persistence of productive farming landscapes.

Agriculture is a source and a cause of the problem, agricultural ecosystems can be a sink of atmospheric carbon dioxide (CO<sub>2</sub>) and reduce greenhouse gas (GHGs) emissions through the adoption of sustainable land management options. Climate change induced great challenges are related with actual and projected warmer and wetter conditions, as well as extreme weather events in Europe, in particular in Northern Europe.( Wirehn L., 2018). These challenges require the implementation of adaptation measures that would change current farming practices and make agriculture more resilient to the adverse effects and risks posed by climate change. Current practices of crop farms oriented to the intensification of agricultural production have caused: (i) increasing cropping of monocultures and application of agrochemicals (i.e. pesticides, mineral fertilizers); (ii) reduction of biodiversity (i.e. agricultural, wild and soil); (iii) decline of soil quality and fertility; etc.( Melece L., Shena I.,2018). The 3 major GHGs affected by most agricultural activities are carbon dioxide, methane and nitrous oxide (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, respectively). GHGs can be mitigated by sequestering carbon or reducing ongoing losses in the soil, by reducing N<sub>2</sub>O emissions, by reducing CH<sub>4</sub> emissions or increasing CH<sub>4</sub> uptake in the system. Often, a management practice affects more than one gas, by more than one mechanism and sometimes in opposite ways, so the net benefits depend on the combined effects on all gases (Robertson, G.P., and Grace, P.R. 2004). A few systematic analyses on the impact of management practices on GHGs and soil organic carbon (SOC) change for croplands and grasslands of China (Rui, W. and Zhang, W., 2010) have been conducted, but all of the studies estimated the impact on either SOC change or GHGs.

Increased risk due to global warming has already become embedded in agricultural decision making in whole world and uncertainties are projected to increase even further. Bio-economic farm models (BEFM) are tools to evaluate ex-post or to assess ex-ante the impact of policy and technology change on agriculture, economics and environment( Janssen and Van Ittersum, 2007). Recently, various BEFMs have been developed, often for one purpose or location, but hardly any of these models are re-used later for other purposes or locations. (Janssen, S., Louhichi, K., Kanellopoulos, A. et al., 2010). BEFM have been frequently proposed by research as tool to assess agricultural emissions to the environment (Falconer and Hodge 2001) and effects of agriculture on landscape and biodiversity (Schuler, J. and Kachele, H., 2003). BEFM is defined as a model that links farms' resource management decisions to current and alternative production possibilities describing input-output relationships and associated externalities. To

address agro-environmental sustainability, numerous modeling frameworks are proposed in the literature. They include Cost–Benefit (Dreschler, M. and Watzold, F., 2001; Rashford, B.S., et al., 2008) and Cost– Effectiveness (Holzkamper, A. and Seppelt, R., 2007) approaches. Therefore the aim of the paper is to present the results of bio-economic modelling of different cropping mixes on the farm level for the purpose of evaluation of profitability of crop production with respect to agronomic conditions. We used the linear programming for creating the model integrating economic with environmental data on crop production on the sample farm.

## 2. Material and Method

In order to perform bio-economic modeling exercise, we used the linear programming for creating the model integrating economic with environmental data on crop production on the sample farm.

Sample farm is located in western Slovakia in Kolíňany and it is located on the western lowland (Danube plain). In terms of the area of agricultural land, it represents the conditions of a medium-sized agricultural enterprise in Slovakia, it also creates conditions and possibilities for modeling the technological-economic processes of private farm management, as its owner is Slovak university of Agriculture in Nitra. In crop production, it focuses on the cultivation of crops with a higher added value, such as food wheat, malting barley, pumpkin and the seed production - corn, soybeans, cereals, and cultivation of canola, soybeans and fodder crops.

Table 1: Summary statistics on main crop data

<i>Profit</i>		<i>Yield</i>		<i>Seed</i>		<i>Fert</i>		<i>CHP</i>	
<i>Mean</i>	19,17	<i>Mean</i>	16,76	<i>Mean</i>	136,13	<i>Mean</i>	226,47	<i>Mean</i>	140,89
<i>Standard Error</i>	146,12	<i>Standard Error</i>	6,65	<i>Standard Error</i>	31,73	<i>Standard Error</i>	55,27	<i>Standard Error</i>	36,46
<i>Median</i>	49,34	<i>Median</i>	6,20	<i>Median</i>	115,23	<i>Median</i>	162,01	<i>Median</i>	93,87
<i>Standard Deviation</i>	438,37	<i>Standard Deviation</i>	19,95	<i>Standard Deviation</i>	95,19	<i>Standard Deviation</i>	165,82	<i>Standard Deviation</i>	109,39
<i>Sample Variance</i>	192169,68	<i>Sample Variance</i>	398,20	<i>Sample Variance</i>	9060,34	<i>Sample Variance</i>	27497,48	<i>Sample Variance</i>	11965,71
<i>Range</i>	1598,89	<i>Range</i>	56,04	<i>Range</i>	336,33	<i>Range</i>	458,65	<i>Range</i>	294,63
<i>Minimum</i>	-811,08	<i>Minimum</i>	0,37	<i>Minimum</i>	26,75	<i>Minimum</i>	100,58	<i>Minimum</i>	13,78
<i>Maximum</i>	787,81	<i>Maximum</i>	56,41	<i>Maximum</i>	363,08	<i>Maximum</i>	559,22	<i>Maximum</i>	308,42
<i>Machines</i>		<i>Labour</i>		<i>WUEF</i>		<i>Precip</i>			
<i>Mean</i>	108,19	<i>Mean</i>	36,46	<i>Mean</i>	10,82	<i>Mean</i>	430,54		
<i>Standard Error</i>	23,29	<i>Standard Error</i>	14,63	<i>Standard Error</i>	2,40	<i>Standard Error</i>	43,10		
<i>Median</i>	79,50	<i>Median</i>	18,87	<i>Median</i>	10,56	<i>Median</i>	378,36		
<i>Standard Deviation</i>	69,88	<i>Standard Deviation</i>	43,90	<i>Standard Deviation</i>	7,20	<i>Standard Deviation</i>	129,31		
<i>Sample Variance</i>	4883,20	<i>Sample Variance</i>	1927,32	<i>Sample Variance</i>	51,85	<i>Sample Variance</i>	16720,39		
<i>Range</i>	196,08	<i>Range</i>	141,85	<i>Range</i>	23,86	<i>Range</i>	367,19		
<i>Minimum</i>	29,90	<i>Minimum</i>	6,73	<i>Minimum</i>	2,45	<i>Minimum</i>	216,91		
<i>Maximum</i>	225,98	<i>Maximum</i>	148,58	<i>Maximum</i>	26,31	<i>Maximum</i>	584,10		

Source: own processing, based on economic dataset of sample farm

The nine selected crops were whet (WHE), barley (BAR), grain maize (MAIG), seed maize (MAIS), rapeseed (RAP), sugarbeet (SUGA), green maize (GMA), alfa (ALFA), pumpkin (PUM). Economic data for the period 2010-2020 were provided by economic department of sample farm.

Environmental data were derived from National Agriculture and Food Centre (NPPC) of Slovakia – Soil Science and Conservation Research Institute (SSCRI), Slovak hydrometeorological institute (SHMI) and the EPIC Slovakia database presented in Svetlanska et.al., 2017. The environmental data comprises WUEF, precipitation (Precip), management systems in terms of nitrogen fertilizer input. In terms of nitrogen input we take into consideration the management system with high nitrogen input without use of irrigation (NHR), which reflects the common reality of Slovak farm.

The cropping mixes are derived:

M1- according to agronomic condition and historically observed shares of crops,

M2 – according to profitability of crops,

M3 – alternative mix presenting even distribution of crops.

Table 2 Derived alternative crop shares

	M1	M2	M3
WHE	0,223	0,150	0,111
BAR	0,162	0,050	0,111
MAIG	0,051	0,040	0,111
MAIS	0,063	0,100	0,111
RAP	0,120	0,200	0,111
SUGA	0,046	0,070	0,111
GMA	0,085	0,100	0,111
ALFA	0,103	0,120	0,111
PUM	0,148	0,170	0,111

Source: own processing

Linear programming form:

$$\text{Max } Z = \sum_{a,c} \pi_{a,c,p} * x_{a,c}$$

s.t.

$$\sum_c b_{a,c,L} * x_{a,c} \leq E_a$$

If we want to prevent overspecialization it is necessary to include 2 balance equations:

$$\sum_m M_{a,c,m} * \theta_{a,m} \leq Land_{a,c}$$

$$\sum_c Land_{a,c} \leq \sum_m (\theta_{a,m} \sum_c M_{a,c,m})$$

Where:

a- area

c- crops

P – profit

E – land endowment

b - constant

x,θ – decision variables

m – crop mixes

### 3. Results

Current situation in agriculture of Slovakia is mostly affected by the process of intensification and specialization but also marginalization. Agriculture of Slovakia still struggles with remains of the former regime. In the period before the transformation, the intensification of production led to excessive use of fertilizers leading to environmental pressures especially in terms of soil. The utilized agricultural land (UAL) is divided into arable land, land devoted to permanent crops, other area and permanent meadows and pastures. More than 39% of total area of the Slovakia was covered by UAL in 2014. UAL has a downward trend, which is environmentally negative phenomenon especially when it comes to set-aside areas of UAL and subsequent re-classification it into built-up areas, what is a case of Slovakia. Loss of the UAL land in recent years is approximately 1000 ha of agricultural land per year according to Soil Service (Svetlanská et al., 2017).

Most of the agricultural activity is allocated in the Slovakia's lowlands. This is due to the structure of agricultural soil. The productive types of soils are concentrated in the southern, south-west and western part of Slovakia, with lower altitude. The southern part of Slovakia has also the highest concentration of chernozems and mollic fluvisols, which are the most fertile types of soils.

The development of yields of selected years over the observed period is presented in Figure 1. These levels are obtained under the management system NHR and reflect the condition on typical Slovak farm. Crops with highest yields are grain maize and wheat among the cereals, sugarbeet, green maize and alfa among the fodder and industrial crops. However, the rapeseed, seed maize and pumpkin are of great importance in terms of their high price, therefore economic importance.

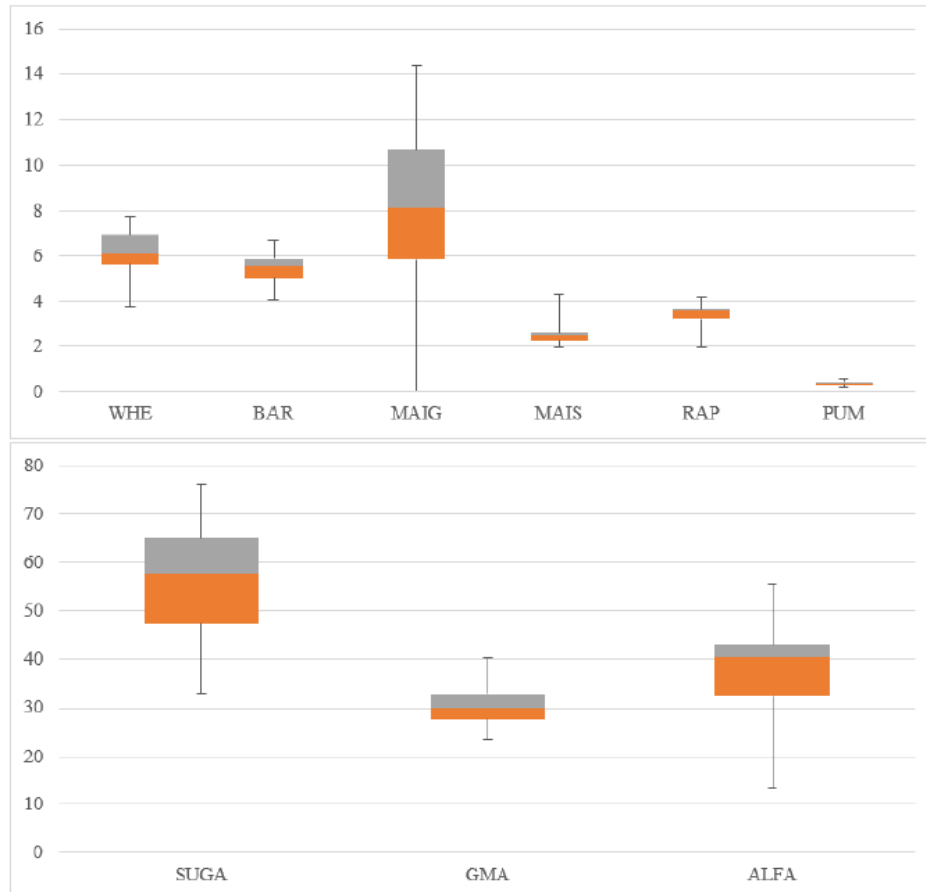


Figure1 Selected crops' yields on the sample farm over the period 2010-2020 Source: own processing

Crop yield is determined by the type of soil, management system given by production choices but also by the level of precipitations and related yield efficiency indicator WUEF.

Table 3 WUEF indicator for selected crops

<b>Crop</b>	<b>WUEF</b>
WHE	8,7
BAR	10,94
MAIG	16,35
MAIS	2,45
RAP	2,89
SUGA	10,86
GMA	26,31
ALFA	8,90
PUM	10,56

Source: own processing

Table 3 presents the WUEF for all selected crops. Crops generating the highest yields are also crops with high WUEF. It demonstrates the kilograms of grain produced from mm of water (applied or rained).



### 3.1. Management system in terms of fertilizer input

Net returns of crop production, together with suitable production choices in form of management practices are important from the point of economic optimization. On the other hand each of management practices influences the soil fertility. To see the impact we compare the nutrient input of typical management system – high fertilizers load (NHR) with requirements of crop’s yields. We consider the nitrogen input (FTN) with nitrogen taken from soil together with the crop’s yield (YLN).

For most of the crops the highest net returns are achieved under the NHR. NHR represents the management with highest nitrogen input. It varies from 80 kg/ha in case of alfa to 120 kg/ha in case of barley, green maize, wheat and 200 kg/ha in case of maize, rapeseed and sugar beet. These nutrient inputs are the best reflection of reality in terms of crops management practices in Slovakia.

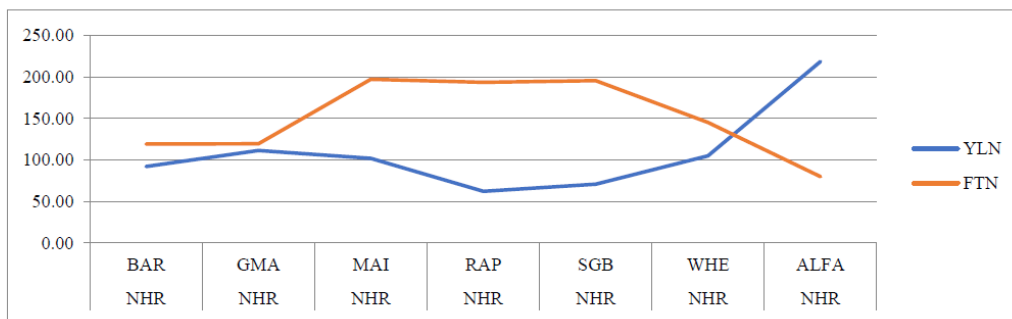


Figure 2 Comparison of FTN and YLN for selected crops\*

Source: own processing

\*data for pumpkin was not available

From the figure, it is obvious that FTN prevails over the YLN in case of barley, green maize, maize (grain and seed), rapeseed, sugarbeet. It seems that in case of wheat the FTN is on the same level as YLN, meaning the nitrogen input is appropriate.

The high nitrogen input may appear as the potential environmental pressure especially from the point of leakages of nitrogen to groundwater. Management system characterized by heavy nitrogen loads, might lead to the over fertilized soil is, with the aim to achieve the highest possible hectare crop yields. However, this also leads to the soil organic carbon losses. Carbon sequestration in agriculture should be seen as an essential element of sustainable agriculture and as a tool to combat climate change. Agricultural carbon sequestration need to be part of a policy-making decision.

### 3.2 Linear programming – sample farm

For the whole farm representation, we employ linear optimization maximizing profit, choosing the most profitable mix of crops.

Employing the balance equations resulted into selection of optimal cropping pattern. Table 3 shows that the optimal mix of crops, maximizing the profit is M1.

Marginal cost in table 4 represents, how would the profit change, if we decided to move any hectare toward the different crop mix. Table 5 represents allocation of crops for M1.

Table 4 Selection of optimal crop mix

	ha per Mix	Marginal cost
<b>M1</b>	1651,44	x
<b>M2</b>	x	-80,26
<b>M3</b>	x	-17,9

Source: own processing

Table 4 Alternative management systems

	ha per Mix	Marginal cost
<b>NHR</b>	1651,44	x
<b>NMR</b>	x	-382,99

Source: own processing

Table 5 Crop shares in hectares

Crop	ha
WHE	367,87
BAR	266,97
MAIG	83,61
MAIS	104,03
RAP	198,08
SUGA	75,82
GMA	139,66
ALFA	170,78
PUM	244,61

Source: own processing

Table 6 provides the summary of optimization on the farm level and shows the levels of all variables considered. Applied M1 as for the crop mix the farm would generate the profit 61 217.70€, on the arable land 1651.40 hectares. The level of cost spend on seed (S) in this case would be 19 7691€, fertilizers (F) would cost 369 186.3 €, chemical protection (CHP) 199 260€, cost of machinery (M) would be 144 689,7 € and the labour expense (L) would be 49 748.4 €. SP in table 6 denotes shadow price and it tells us how much arable land should be added in order to generate one more € of profit (37.10 hectares in this case).

Table 6 Summary result of optimization in farm level

	Profit/€	Land/ha	S/€	F/€	CHP/€	M/€	L/€	SP
<b>Farm</b>	61217,70	1651,40	197691,00	369186,30	199260,00	144869,70	49748,40	37,10

Source: own processing

In case we wanted to add reduced fertilizer level, holding all other conditions constant, the marginal cost of extra unit of land managed by reduced nutrient input (NMR) level would lead to profit decrease by 383 € per hectare (shown in table 4). Therefore, the policy premium for decreased fertilizers levels should be at least equal to marginal cost in order to stimulate farmers to move toward soil protecting management systems.

#### 4. Discussion and Conclusions

The constructed integration model facilitated the optimal agricultural land allocation on the sample farm among 9 selected crops. We observed the level of WUEF as the environmental indicator as well as the comparison between FTN and YLN as the indicator of soil exploitation. As the sample farm is allocated in the western lowland (Danube plain), it has the most suitable condition for the cultivation of crops with a higher added value. For all the crops on the sample farm, the highest net returns are achieved under the production choice characterized as NHR, representing the management with highest nitrogen input. Results represented the way to distribute the land among different crop respecting the agronomical requirements of crop production and aiming the profit maximization at the same time. Similar results were obtained in the study carried by Bullová et al. (2020), which proves that the optimal cropping pattern has to represent agronomic requirements and it is influenced by the production area given by the soil type. Also in the earlier work (Svetlanská et al., 2017) authors stress the importance of

production choice, claiming that high nitrogen input and irrigation represent conventional way of managing the crop production, which might lead to environmental pressures in terms of depletion of water resources and soil degradations. Investments into the improved technology might motivate the farmers to shift toward lower input, sustainable management practices, which still ensure the high economic returns from crop production. Similarly, many authors (Chalinor et al. 2014; Frank et al. 2014) came to the conclusion that environmental decay caused by crop production can be reduced by adjusting management practices and increased incentives from policy makers in form of supporting sustainable management of land use.

According to our results, in case we wanted to shift toward reduced level of fertilizer on the sample farm, the marginal cost of extra unit of land managed by reduced nutrient input (NMR) level would lead to profit decrease by 383 € per hectare. Therefore, we suggest, the policy premium for decreased fertilizers levels should be at least equal to marginal cost in order to stimulate farmers to move toward soil protecting management systems.

However, forming the farm decisions on the suitable cropping mix and respective production choice involves certain level of uncertainty. For the direction of future research, it would be appropriate to assess the risk and uncertainty in the optimization.

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### **References**

- Bullová T., Bielik P., Adamičková I., Urbánová M., Čeryová D. (2020) Linear programming for land allocation – example of selected crops in Slovakia. In International Scientific Days 2020. Gödöllő : Szent István University, pp. 263-270.
- Dreschler, M., Watzold, F., (2001). The importance of economic costs in the development of guidelines for spatial conservation management. *Biological Conservation* 97, pp. 51–59
- Chalinot A., Watson J., Lobell D., Howden S., Smith D., Chhetri N. (2014). A meta analysis of crop yield under climate change and adaptation. *Nature Climate Change*, 4, No. 4, pp. 287-291.
- Rashford, B.S., Dugger, B., Adams, R.M., (2008). Application of a bioeconomic production model to improve wildlife management. *The Journal of Wildlife Management* 72 (2), pp. 510–517.
- Falconer, K., Hodge, I., (2001). Pesticide taxation and multi-objective policy-making: farm modelling to evaluate profit/environment trade-offs. *Ecological Economics* 36: pp. 263–279.
- Frank S., Wittzke H. P., Zimmermann A., Havlík P., Ciaian P. (2014) Climate change impacts on European agriculture: A multi model perspective. Paper prepared for presentation at the EAAE 2014 Congress „Agri-Food and Rural Innovations for Healthier Societies“. August 2014, Ljubljana, Slovenia

- Holzhammer, A., Seppelt, R., (2007). Evaluating cost-effectiveness of conservation management actions in an agricultural landscape on a regional scale. *Biological Conservation* 136, pp. 117–127.
- Janssen, S. and Van Ittersum, M.K. (2007) Assessing farm innovations and responses to policies: A review of bioeconomic farm models. *Agricultural Systems*, 94, 622-636.
- Janssen, S., Louhichi, K., Kanellopoulos, A. *et al.* (2010). A Generic Bio-Economic Farm Model for Environmental and Economic Assessment of Agricultural Systems. *Environmental Management* 46, pp. 862–877
- Khan, N., Ray, R. L., Sargani, G. R., Ihtisham, M., Khayyam, M., & Ismail, S. (2021). Current Progress and Future Prospects of Agriculture Technology: Gateway to Sustainable Agriculture. *Sustainability*, 13(9), 4883. MDPI AG
- Garibaldi, L.A., Gemmill-Herren, R., D'Annolfo, R., Graeub, B.E., Cunningham, S.A., Breeze, T.D. (2017). Farming approaches for greater biodiversity, livelihoods, and food security, *Trends Ecol. Evol. (Amst.)*, 32 (1), pp. 68-80
- Melece L., Shena I. (2018) Farm size and farming method's impact on ecosystem services: Latvia's case. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management*, vol. 18(5.1), pp. 393-400
- Robertson, G.P., Grace, P.R. (2004). Greenhouse gas fluxes in tropical and temperate agriculture: the need for a full-cost accounting of global warming potentials. *Environ. Dev. Sustain.*, 6 , pp. 51-63
- Rui, W., Zhang, W. (2010). Effect size and duration of recommended management practices on carbon sequestration in paddy field in Yangtze Delta Plain of China: a meta-analysis. *Agric. Ecosyst. Environ.*, 135, pp. 199-205
- Schuler J, Kachele H (2003) Modelling on-farm costs of soil conservation policies with MODAM. *Environmental Science & Policy* 6:51–55
- Svetlanská, T. Turčeková N., Adamičková I., Skalský R. Food security facets: case of Slovakia regions. *Journal of security and sustainability issues*. 7, 2 (2017), pp. 311-320.
- Tohidyan Far, S., Rezaei-Moghaddam, K. (2019). Multifunctional agriculture: an approach for entrepreneurship development of agricultural sector. *J Glob Entrepr Res* 9, 23
- Toenniessen, G., A. Adesina, & DeVries, J. (2008). Building an alliance for a Green Revolution in Africa. In S. Kaler & O. Rennert (Eds), *Reducing the Impact of Poverty on Health and Human Development: Scientific Approaches*, Oxford: Blackwell Publishing.
- Wirehn L.(2018). Nordic agriculture under climate change: A systematic review of challenges, opportunities and adaptation strategies for crop production. *Land Use Policy*, vol. 77, pp. 63-74.

## ***Xerocomellus redeuilhii* (Boletaceae: Agaricomycetes): New locality record from Western Turkey**

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Oğuzhan Kaygusuz<sup>1\*</sup>

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**Abstract:** The new locality record for *Xerocomellus redeuilhii* from Aydın Province in the Aegean Region was presented in the current study. *X. redeuilhii* was described in detail, and the first nrITS sequences from Turkey were presented, together with macroscopic and microscopic photographs of the species.

**Keywords:** nrITS, molecular systematics, phylogeny, taxonomy, distribution.

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### **1. Introduction**

*Xerocomellus* Šutara, typified by *Xerocomellus chrysenteron* (Bull.) Šutara, is a small genus in the family Boletaceae Chevall. with nearly 25 species distributed worldwide (Frank et al. 2020, Farid et al. 2021, Garza-Ocañas et al. 2022). The genus is characterized by boletoid, hypogeous to secotioid basidiomata, a relatively small fruit body, sometimes cracked pileus, and smooth to ornamented basidiospores (Peintner et al. 2003, Šutara 2008, Smith et al. 2018, Frank et al. 2020, Garza-Ocañas et al. 2022). The members of this genus form mycorrhizal associations with coniferous and deciduous trees (Šutara 2008, Rinaldi et al. 2008, Wu et al. 2016, Frank et al. 2020, Garza-Ocañas et al. 2022).

While doing the survey on the basidiomycetes in the Mediterranean Region of Turkey, some remarkable samples have been collected. One of them was identified as *Xerocomellus redeuilhii* A.F.S. Taylor, U. Eberh., Simonini, Gelardi & Vizzini. In this study, a new locality record for this species previously known only from Osmaniye Province, was presented with morphological and molecular data.

### **2. Materials and Methods**

#### **2.1. Sample collection and morphological studies**

In order to specify the distribution of mushrooms in Turkey, regular surveys were carried out during the autumn season. The location of collection, habitat characteristics, and fruiting characteristics of the mushrooms were recorded and photographed. The samples were dried at about 40°C. The Mycobank (<https://www.mycobank.org>) and Index Fungorum (<http://www.indexfungorum.org>) databases were used to determine the taxonomic designation

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and name of the species. A Leica DM750 microscope (Wetzlar, Germany) was used for measurements and taking pictures.

## 2.2. Phylogenetic analysis

Genomic DNA was extracted from dry materials using the ZR Fungal/Bacterial DNA MiniPrep kit (Irvine, California). DNA isolation and PCR amplification followed the protocols described in Kaygusuz et al. (2019). The nuclear rDNA's Internal Transcribed Spacer region was amplified using the primers ITS1-F (Gardes & Bruns 1993) and ITS4 (White et al. 1990). Raw data was checked and assembled using BioEdit 7.0.5. (Hall 1999).

For the phylogenetic analysis, nrITS sequences of *Xerocomellus* were selected based on Frank et al. (2020) and the highest similarity rate according to BLAST online tool. A Maximum Likelihood (ML) analysis was performed by RaxmlGUI 1.5b1 using 1000 replicates (Stamatakis et al. 2004).

## 3. Results

### 3.1. Phylogeny

In this study, two new sequences were generated from *Xerocomellus* specimens and the remaining 32 sequences were retrieved from GenBank database. In the phylogenetic tree, based on nrITS (Figure 1), two collections of *Xerocomellus redeuilhii* from Turkey were clustered together with nine sequences from GenBank in a distinct monophyletic branch with high statistical support (100%, Figure 1).

### 3.2. Taxonomy

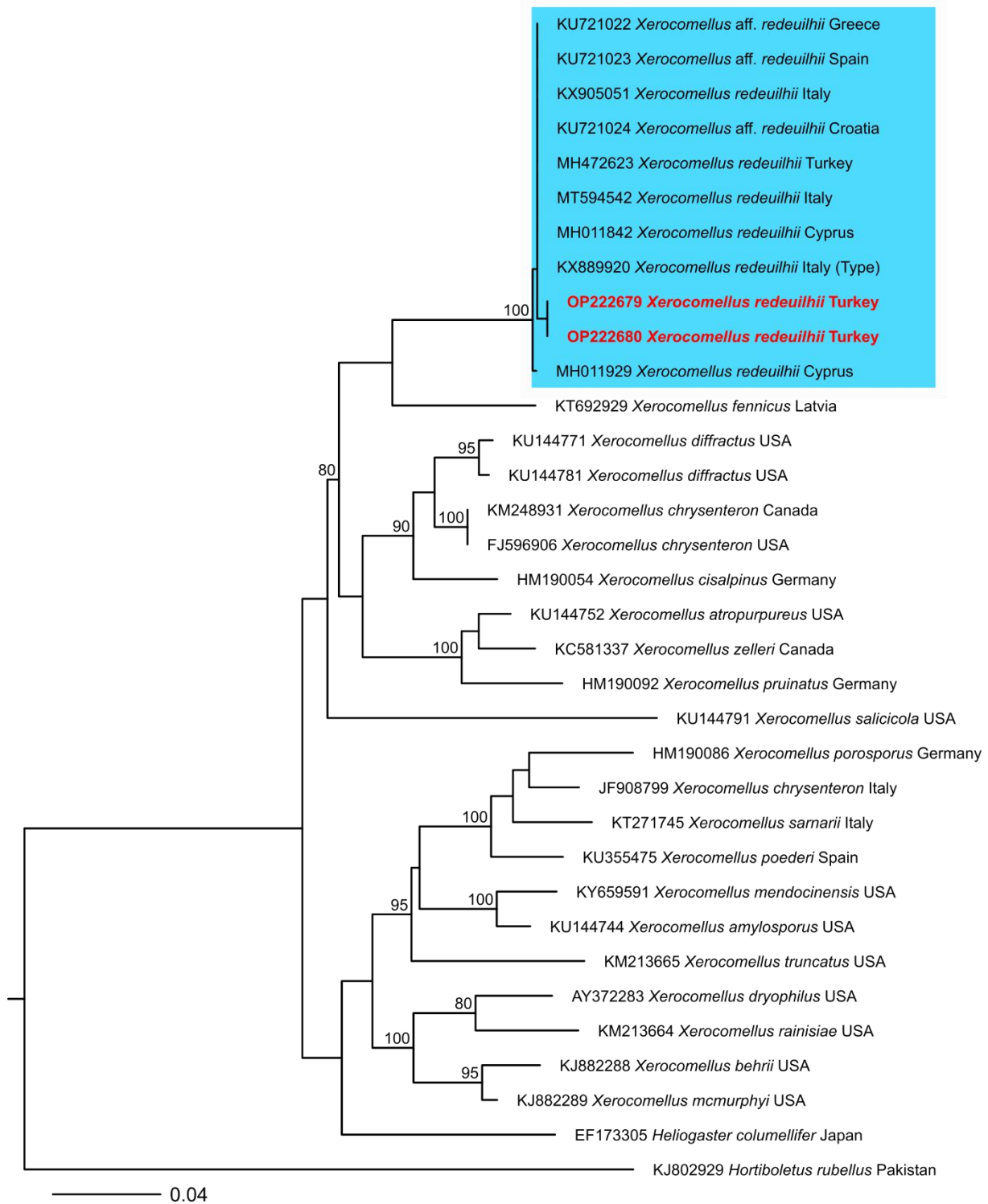
*Xerocomellus redeuilhii* A.F.S. Taylor, U. Eberh., Simonini, Gelardi & Vizzini, in Simonini, Gelardi & Vizzini, Riv. Micol. 59(2): 125 (2016) Figures 2–3

Description. Pileus 15–18 mm in diam, convex when young, becoming broadly convex to nearly plane, surface dry, smooth, velvety, dark red to purplish red to brownish red. Context in pileus whitish yellow, pale yellowish under the epicutis, unchanging when cut. Hymenophore up to 12 mm in long, pale yellowish, narrower towards the margin; pores tiny up to 1.5 mm, concolorous with the tubes. Stipe 25–45 × 9–15 mm, cylindrical, solid, tapered downward, yellowish at the apex, dark reddish at the base. Odour and taste indistinct.

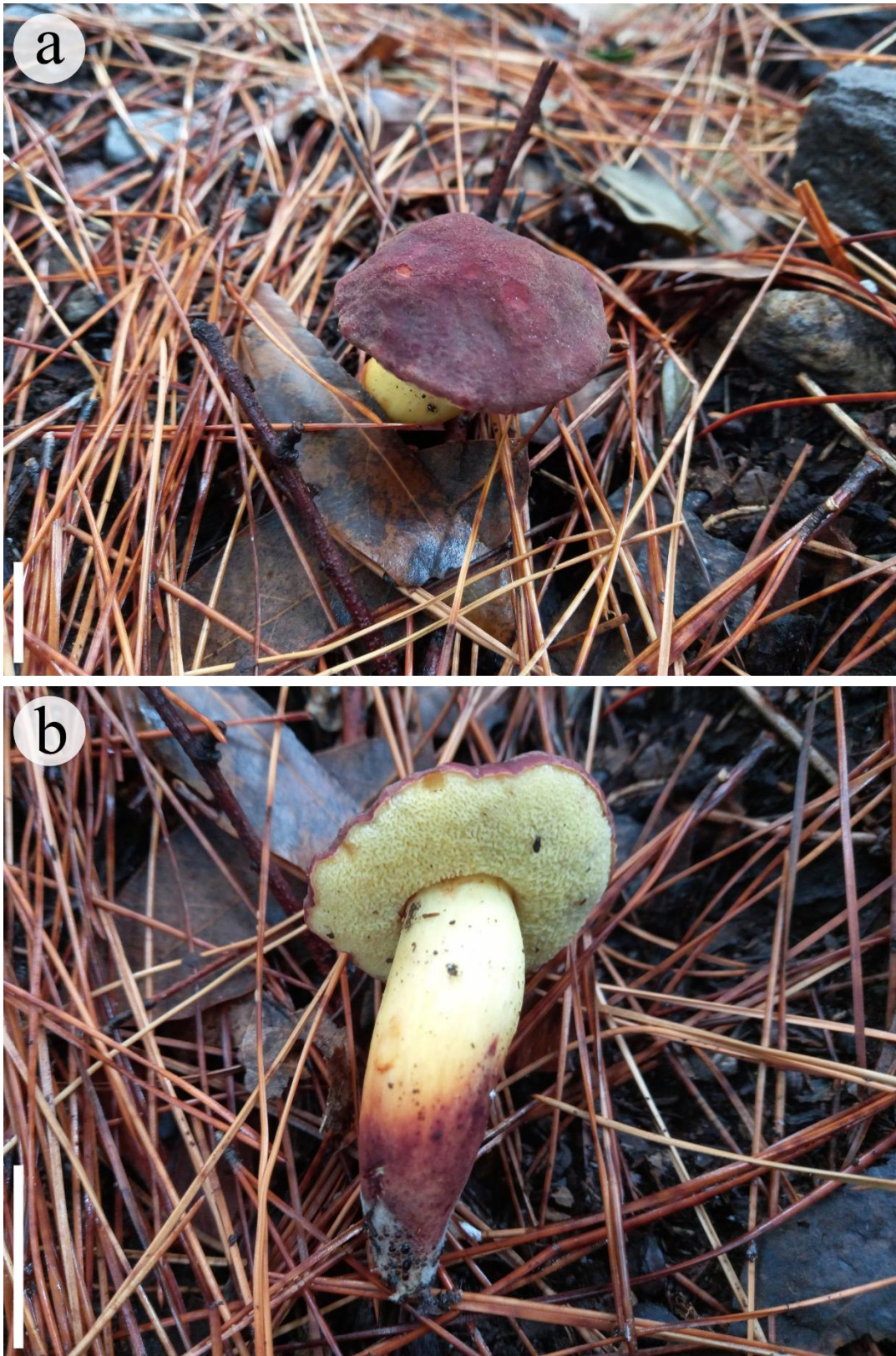
Basidiospores (10.5–)11.6–12.5(–12.9) × (5.2–)5.5–6.3(–6.8) μm, ellipsoid, smooth, thick-walled, brownish yellow in KOH. Basidia 35–48 × 9–14 μm, clavate, 4-spored, hyaline. Pleurocystidia 45–65 × 8–14 μm, fusoid-ventricose, hyaline, thin walled. Pileipellis a trichoderm consisting of cylindrical elements, terminal cells cylindrical, 25–56 × 5.5–14 μm, with an acute apex, with abundant yellowish intracellular pigment in KOH. Clamp-connections absent in all tissues.

**Habit and habitat:** Scattered to gregarious among *Pinus brutia* Ten. needles.

**Specimens examined:** TURKEY, Aydın Province, Kuşadası district, around Davutlar, under *Pinus brutia*, alt. 5 m, 27 October 2014, O. Kaygusuz, OKA-TR1680; GenBank: OP222679 for nrITS; *ibid.*, alt. 6 m, 28 October 2018, O. Kaygusuz, OKA-TR1681; GenBank: OP222680 for nrITS.

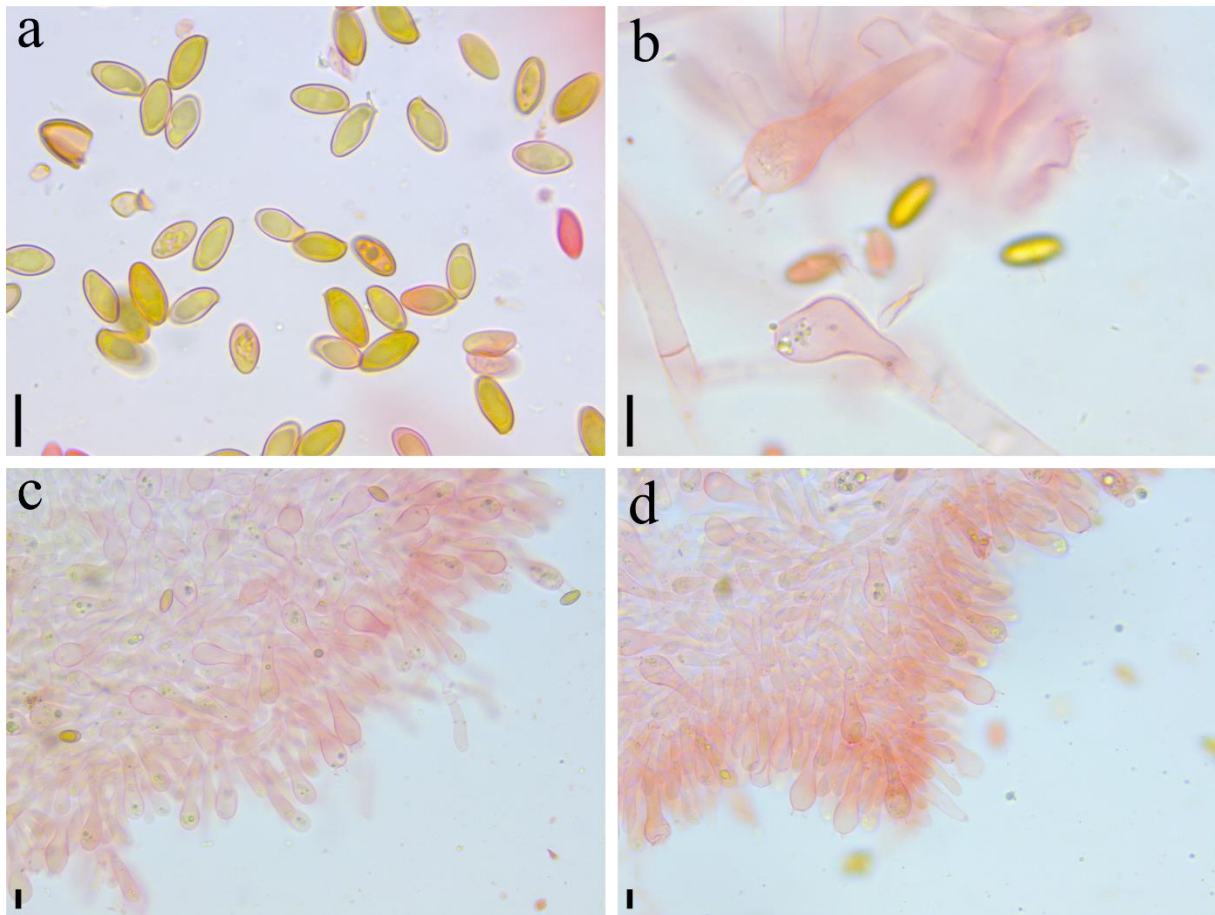


**Figure 1.** Phylogram inferred from RAxML analysis, based on nrITS1–5.8S–ITS2 data. Maximum-likelihood bootstrap (MLB)  $\geq 80\%$  is indicated above the branches. *Hortiobolus rubellus* (Krombh.) Simonini, Vizzini & Gelardi (KJ802929) was used as outgroup. The samples presented in this study are highlighted in red.



**Figure 2.** *Xerocomellus redeuilhii*. Fresh basidiomes in situ. Scale bars: 10 mm.





**Figure 3.** Microscopic features of *Xerocomellus redeuilhii*. a. Basidiospores. b-d. Basidia. Scale bars: 10  $\mu\text{m}$ .

#### 4. Discussion and Conclusions

According to the interpretation of numerous European authors, *Xerocomellus redeuilhii* was previously named as *X. dryophilus* (Thiers) N. Siegel, C.F. Schwarz & J.L. Frank. But it was discovered that *Xerocomus dryophilus* is a species that grows on the North American continent as opposed to the European one. For this reason, the new species *Xerocomellus redeuilhii* was proposed by Simonini et al. (2016). *Xerocomellus dryophilus* is distinguished by longer basidiospores (up to 16.1  $\mu\text{m}$ ), a more rosy red to pinkish brown basidiomes, and growing around *Quercus* (Frank et al. 2020).

Morphologically, *Xerocomellus redeuilhii* is similar to *X. sarnarii* Simonini, Vizzini & U. Eberh. and *X. poederi* G. Moreno, Heykoop, Esteve-Rav., P. Alvarado & Traba. *Xerocomellus sarnarii* is distinguished by a cracked pileus and a longer basidiospore size (Vizzini & Simonini 2015). *Xerocomellus poederi* differs in having a smaller size and growing in acid soils under *Quercus robur* (Moreno et al. 2016, Simonini et al. 2016).

The phylogenetically closest species to *Xerocomellus redeuilhii* is *X. fennicus* (Harmaja) Šutara. *Xerocomellus fennicus* from Europe differs in having vivid red to olivaceous grey basidiomes, the absence of a flame-red pigment at the base of the stipe, distinctly striate basidiospores, and mainly growing under *Betula* and *Alnus* (Harmaja 1999, Peintner et al. 2003).

*Xerocomellus redeuilhii* appears to be a species native to the Mediterranean region of Europe. So far, it is known from Croatia, Cyprus, France, Greece, Italy, Malta, Spain, and Turkey (Bozok et al. 2019). *X. redeuilhii* is only known from a single location in Turkey (Bozok et al. 2019). In this study, *X. redeuilhii* is reported from Aydın Province in the Aegean Region as a new locality record together with nrITS sequence data.

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## References

- Bozok, F., Assyov, B., Taşkın, H., Büyükalaca, S., (2019). A New Macrofungi Record for Turkey and Asia with Molecular Characterization: *Xerocomellus redeuilhii* (Boletales, Basidiomycota). *Mantar Dergisi*, 10, 1–9.
- Farid, A., Bessette, A.E., Bessette, A.R., Bolin, J.A., Kudzma, L.V., Franck, A.R., Garey, J.R., (2021). Investigations in the boletes (Boletaceae) of southeastern USA: four novel species and three novel combinations. *Mycosphere*, 12(1), 1038–1076.
- Frank, J.L., Siegel, N., Schwarz, C.F., Araki, B., Vellinga, E.C., (2020). *Xerocomellus* (Boletaceae) in western North America. *Fungal Systematics and Evolution*, 6, 265–288.
- Gardes, M., Bruns, T.D., (1993). ITS primers with enhanced specificity for Basidiomycetes application to the identification of mycorrhizae and rusts. *Molecular Ecology*, 2, 113–118.
- Garza-Ocañas, F., García Jiménez, J., Guevara-Guerrero, G., Martínez-González, C.R., Ayala-Vásquez, O., de la Fuente, J.I., (2022). *Xerocomellus carmeniae* (Boletales, Basidiomycota), a new fungus from northeastern Mexico. *Acta Botanica Mexicana*, 129, e2039.
- Hall, T.A., (1999), BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series*, 41, 95–98.
- Harmaja, H., (1999). *Boletellus fennicus*, a new species from Finland. *Karstenia*, 39, 37–38.
- Kaygusuz, O., Türkekul, I., Knudsen, H., Çolak, Ö.F., (2019). New records of *Pluteus* section *Hispidoderma* in Turkey based on morphological characteristics and molecular data. *Phytotaxa*, 413(3), 175–206.
- Moreno, G., Heykoop, M., Esteve-Raventós, F., Alvarado, P., Traba, J.M., (2016). *Xerocomellus poederi* sp. nov. in *Fungal Planet* 458. *Persoonia*, 36, 434–435.
- Peintner, U., Ladurner, H., Simonini, G., (2003). *Xerocomus cisalpinus* sp. nov., and the delimitation of species in the *X. chrysenteron* complex based on morphology and rDNA-LSU sequences. *Mycological Research*, 107, 659–679.
- Rinaldi, A.C., Comandini, O., Kuyper, T.W., (2008). Ectomycorrhizal fungal diversity: separating the wheat from the chaff. *Fungal Diversity*, 33, 1–45.

- Simonini, G., Gelardi, M., Vizzini, A., (2016). *Xerocomellus redeuilhii* sp. nov. *Rivista di Micologia*, 59, 123–127.
- Smith, M.E., Castellano, M.A., Frank, J.L., (2018). *Hymenogaster macmurphyi* and *Splanchnomyces behrii* are sequestrate species of *Xerocomellus* from the western United States. *Mycologia*, 110, 605–617.
- Stamatakis, A., (2014). RAxML version 8: A tool for Phylogenetic Analysis and Post-Analysis of Large Phylogenies. *Bioinformatics*, 30, 1312–1313.
- Šutara, J., (2008). *Xerocomus* s.l. in the light of the present state of knowledge. *Czech Mycology*, 60, 29–62.
- Vizzini, A., Simonini, G., (2015). *Xerocomellus sarnarii*. *Fungal Diversity notes* 111-252 taxonomic and phylogenetic contributions to fungal taxa, 219.
- White, T.J., Bruns, T., Lee, S., Taylor, J., (1990). Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis, M.A., Gelfand, D.H., Sninsky, J.J., White, T.J., (Eds.) *PCR Protocols: A Guide to Methods and Applications*. Academic Press, New York, pp. 315–322.
- Wu, G., Lee, Y.C., Zhu, X.T., Zhao, K., Han, L.H., Cui, Y.Y., Li, F., Xu, J.O., Yang, Z.L., (2016). One hundred noteworthy boletes from China. *Fungal Diversity*, 81, 25–188.

## **İHA görüntülerinin geometrik düzeltmesinin ağaç çap ve boy ölçümlerine etkileri / Effects of geometric correction of UAV images on tree diameter and height measurements**

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**Özet:** Orman ekosistemlerindeki değişkenlerin doğru, hızlı ve güvenilir bir şekilde tanımlanabilmesi ve analiz edilebilmesi için CBS ve uzaktan algılama teknolojilerinin entegrasyonu faydalı olabilmektedir. İHA gibi platformlardaki algılayıcılar yardımıyla elde edilen uzaktan algılama verileri sahip oldukları bazı sistematik ve rastlantısal geometrik hatalar nedeniyle çeşitli ön işlemlerden sonra kullanılabilir. Sistematik hataların giderilmesinde algılayıcıya ait kalibrasyon verileri kullanılırken, rastlantısal hataların giderilmesinde görüntü üzerinde konumu kesin olarak bilinen noktalar kullanılır. Geometrik düzeltme ya da rektifikasyon olarak adlandırılan bu işlem ile görüntüdeki yeryüzü ve algılayıcı kaynaklı geometrik bozulmaların giderilmesi, görüntünün dünya koordinatlarına dönüştürülmesi ve böylece ait olduğu alanın geometrik özelliklerini yansıtan bir uzaktan algılama verisinin üretimi amaçlanır. Bu çalışmanın amacı, İHA'dan alınan hava fotoğrafları üzerinde yapılacak olan geometrik düzeltme işleminin, ağaç çap ve boy ölçümlerine olan etkisini ortaya koymaktır. Bu çalışma, Isparta Orman Bölge Müdürlüğü Sütçüler Orman İşletme Müdürlüğü Çandır Orman İşletme Şefliği sınırlarında bulunan 3.2 hektarlık bir alanda gerçekleştirilmiştir. Bu alanda toplam 150 adet kesilmiş halde bulunan kızılçam ağacının göğüs çapı ve boyları İHA'dan elde edilen geometrik düzeltmesi yapılmış ve yapılmamış nokta bulutu ile ortomozaikler üzerinde ölçülmüş, sonuçlar arazide yapılan ölçüm sonuçlarıyla karşılaştırılmıştır. Geometrik düzeltme işleminin yapıldığı verilerde gerçekleştirilen ölçümlerin arazi ölçümlerine daha yakın sonuçlar verdiği ve güçlü bir korelasyon gösterdiği yapılan istatistiksel testlerle ortaya konulmuştur. Aynı zamanda nokta bulutu üzerinde gerçekleştirilen 3 boyutlu ağaç çap ve boy ölçümlerinin ortomozaik üzerinde gerçekleştirilen 2 boyutlu ölçümlere göre daha doğru sonuçlar verdiği de anlaşılmıştır. Günümüzde pratik bir uzaktan algılama aracı olarak tercih edilen İHA'lardan elde edilen görüntülerde, hassas konum ve ölçüm gerektiren çalışmalar için geometrik düzeltmelerin önemini vurgulamak istiyoruz.

**Anahtar Kelimeler:** Geometrik düzeltme, İHA fotogrametrisi, Nokta bulutu, Ortomozaik, Uzaktan algılama

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**Abstract:** Integration of GIS and remote sensing technologies can be beneficial for the accurate, fast and reliable identification and analysis of variables in forest ecosystems. Remote sensing data obtained with the help of sensors on platforms such as UAVs can be used after

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various preprocessing due to some systematic and random geometrical errors. While the calibration data of the sensor is used to eliminate systematic errors, points on the image whose location is precisely known are used to eliminate random errors. With this process, which is called geometric correction or rectification, it is aimed to eliminate the geometric distortions caused by the earth and the sensor in the image, to convert the image to world coordinates, and thus to produce a remote sensing data that reflects the geometric properties of the area it belongs to. The aim of this study is to reveal the effect of the geometric correction process on the aerial photographs taken from the UAV on the tree diameter and height measurements. This study was carried out in an area of 3.2 hectares located within the borders of Isparta Regional Directorate of Forestry, Sütçüler Forestry Operations Directorate, Çandır Forestry Operation Chief. The chest diameter and height of 150 pine trees, which were cut in total in this area, were measured on the orthomosaics with the geometrically corrected and unmade point cloud obtained from the UAV, and the results were compared with the measurement results made in the field. It has been revealed by the statistical tests performed that the measurements performed on the data where the geometric correction process was performed gave results closer to the field measurements and showed a strong correlation. At the same time, it was understood that the 3-dimensional tree diameter and height measurements performed on the point cloud gave more accurate results than the 2-dimensional measurements performed on the orthomosaic. We would like to emphasize the importance of geometric corrections for studies that require precise location and measurement in images obtained from UAVs, which are preferred as a practical remote sensing tool today.

**Keywords:** Geometric correction, UAV photogrammetry, Point cloud, Orthomosaic, Remote sensing

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## 1. Giriş

Türkiye’de 2020 yılı itibariyle 22.9 milyon ha (%29.4) orman varlığı ve bu ormanlardaki kızılçam ağaç türünün %22.74 oranda bulunduğu bildirilmiştir (OGM, 2020). Bu oran dikkate alındığı zaman kızılçamın Türkiye ormancılığı için önemli bir yerinin olduğunu söylemek mümkündür. Ormancılık faaliyetleri, uzun periyotlu ve ağır şartları bünyesinde barındıran işlemlerdir (Şafak ve Gül, 2012). Planlama, karar verme ve yönetim aşamalarından oluşan bu işlemlerin gerçekleştirilmesinde güvenilir, güncel ve ekonomik olarak elde edilecek verilere büyük bir ihtiyaç bulunmaktadır (Eker ve Özer, 2015; Buğday, 2016). Bu nitelikteki veriler, günümüzde çeşitli hava araçları ve uzaktan algılama teknikleriyle üretilebilmektedir. Uzaktan algılama yöntemiyle elde edilen hava fotoğrafları, yazılım fotogrametrisi kullanılarak işlendikten sonra ormancılıkta çeşitli çalışma alanlarında yaygın olarak kullanılmaktadır (Çoban, 2016). Orman ekosistemlerinin doğru ve hızlı bir şekilde izlenmesi ve analiz edilebilmesi için uzaktan algılama teknolojilerinin Coğrafi Bilgi Sistemi (CBS) ile birlikte kullanımı öne çıkmaktadır. CBS kullanıcıya planlama ve karar verme aşamalarında destek sunan, sahip olduğu işlevler ile ekonomik veri üretimine yardımcı bir araçtır. Uzaktan algılama verilerinin CBS’de altlık olarak kullanılabilmesi, onu çok güçlü bir veri kaynağı durumuna getirmektedir (Balcı vd., 2000; Çoban, 2016).

Uzaktan algılamada algılayıcı sistemler tarafından kaydedilen ve bilgisayar ortamında saklanabilen sayısal veriler, çeşitli amaçlar doğrultusunda işlenerek bilgi üretilmekte ve elde edilen çıktılar kullanıcının hizmetine sunulmaktadır (Yomralıoğlu, 2000). Fotogrametri ise fotoğrafik görüntülerin ve elektromanyetik enerjinin kaydedilmesi, ölçülmesi ve yorumlanması sonucunda fiziksel cisimler ve bunların çevresine ilişkin bilgileri toplayan ve bu bilgilerin

analizini yapan bir bilim dalıdır (ISPRS, 2022). Fotogrametri biliminin sağladığı en büyük avantaj, çiftler halinde belirli enine ve boyuna bindirme oranları uygulanarak alımı sağlanan görüntülerden üç boyutlu ölçümlere imkân sağlamasıdır (Yurtseven, 2008).

Hava fotoğrafı ve uydu görüntüleri gibi uzaktan algılama verileri, algılayıcı sensör ve algılanan nesnenin bulunduğu ortamın fiziksel özelliklerinden kaynaklanan bazı geometrik hatalara sahiptir. Söz konusu hatalar uzaktan algılama platformunun yüksekliğindeki ve hızındaki değişimler, yeryüzünün eğikliği, atmosferin etkisi gibi nedenlerle oluşabilir. Geometrik hatalar sistematik hatalar ve rastlantısal hatalar olarak ikiye ayrılır. Sistematik hatalar algılayıcıya ait bazı kalibrasyon verileriyle düzeltilebilirken rastlantısal hataların düzeltilmesi için yeryüzüne ait bilgilere ihtiyaç vardır. (Küpcü, 2015). Bu hatalar geometrik düzeltme (rektifikasyon) işlemiyle giderilebilir. Geometrik düzeltme, görüntüdeki yeryüzü ve algılayıcıdan kaynaklanan geometrik bozulmaların giderilmesi ve görüntünün istenilen dünya koordinatlarına dönüştürülmesi işlemidir (Çoban, 2006).

Geometrik düzeltmenin uygulanması için görüntüde homojen dağılmış, konumu belirgin yer kontrol noktaları (YKN) ve bu noktaların harita karşılıkları ile arasındaki matematiksel bağıntı kullanılır (Richards, 1993). YKN; yeryüzünde tesis edilen, koordinatları ve/veya yüksekliği jeodezik yöntemlerle belirlenen noktaların genel adıdır (BÖHY, 2018). İdeal olarak YKN'nin orijinal koordinatı ile dönüşüm sonrası oluşan koordinatlarının aynı olması beklenir ancak bu durum çok nadiren oluşabilir (Jensen, 1996). Genellikle YKN'nin orijinal konumu ile dönüştürülen görüntü üzerindeki konumu arasında bir uzaklık oluşur ve bu uzaklık Kök ortalama kare hatası (RMSE; Root Mean Square Error) olarak tanımlanır (ERDAS, 2002). Geometrik düzeltmede ulaşılabilecek doğruluk düzeyi haritalar için insan gözünün ayırt edebileceği en küçük çizgi aralığı olan 0.2 mm'nin harita ölçeğindeki karşılığı olarak kabul edilir (Koç, 1995). Uzaktan algılama verilerinin geometrik dönüşümünde ise hata sınır değeri piksel boyutunun yarısı (0.5 piksel) olarak alınır (Welch ve Usery, 1984). Geometrik doğruluk genellikle; uzaktan algılama verilerinin harita amaçlı kullanılabilmesi, raster-vektör verilerinin birlikte kullanılabilmesi, farklı raster verilerin birleştirilebilmesi, coğrafi konumun önem taşıdığı çalışmaların hassas bir şekilde yürütülebilmesi, CBS için altlık ve veri tabanı hazırlanabilmesi, uzunluk ve alan ölçümlerinin hassas bir şekilde yapılabilmesi vb. gibi amaçlar için önemlidir (Kaya vd., 2002).

Geometrik düzeltme işleminde kaynak koordinatlar, dönüştürülecek görüntü üzerine işlendikten sonra dönüşüm gerçekleştirilir. Bu dönüşümü gerçekleştirmek için belirlenen YKN'lerin çalışma alanı üzerindeki dağılımı ve sayısı önemlidir. Koordinat ataması yapılacak harita veya görüntüde çarpıklıkların oluşmaması için YKN'ler alana homojen dağılmalı ve özellikle çalışma alanının köşelerinde yeterli sayıda bulunmalıdır (Çoban, 2006). YKN'lerin sayısı ve çalışma alanına dağılımı, fotogrametrik ürünlerin konum doğruluğunu doğrudan etkilemektedir. Bu nedenle özellikle İHA fotogrametrisi çalışmalarında, YKN sayısının ve konumunun çalışma öncesinde doğru olarak belirlenmesi gerekmektedir. YKN'lerin sayısı doğrudan iş gücü, zaman ve maliyet değerlerini etkilediğinden uygun YKN tasarımı çalışmalarda oldukça önemlidir (İzci ve Ulvi, 2021).

YKN kullanılarak geometrik düzeltmenin yapılmasının İHA görüntülerinin kalitesini arttırdığı (Ruzgiene vd., 2015; Stöcker vd., 2017; Kapıcıoğlu vd., 2018; Rabah vd., 2018) ve bunun yanında YKN'lerin çalışma alanı üzerindeki dağılımının konumsal hassasiyeti etkilediği bilinmektedir (Wang vd., 2012). YKN sayısının artırılmasıyla hassasiyet ve doğruluğun arttığı görülmeye karşın (Ruzgiene vd., 2015; Aguera-Vega vd., 2017) belirli bir YKN sayısı için, optimum dağılım kullanılarak elde edilen doğruluğun, YKN'lerin kötü dağılması durumundan

iki kat daha iyi olacağı da bilinmektedir (Sanz-Ablanedo vd., 2018). Bu bağlamda İHA sistemleri ile YKN kullanmaksızın yüksek hassasiyet gerektirmeyen çalışmalarda gereksinim duyulan fotogrametrik ürünlerin hızla üretilebildiği fakat yüksek doğruluk gerektiren çalışmalar için YKN kullanımının kaçınılmaz olduğu söylenebilir (İzci ve Ulvi, 2021).

Bu çalışmada, İHA'dan elde edilen fotogrametrik ürünlerde gerçekleştirilecek geometrik düzeltmenin ağaç çap ve boy ölçümlerine etkisi araştırılmıştır. Türkiye orman arazilerinin çoğunlukla engebeli ve iletişim ağlarına erişim olanaklarının kısıtlı olması nedeniyle, bu alanlarda TUSAGA-Aktif ağlarına bağlanarak hassas konum ölçümlerinin yapılması ve YKN'lerin bu engebeli arazilerde çalışma alanına tesis edilmesi zor, yorucu ve zaman alıcı faaliyetlerdir. Ancak yüksek doğruluk gerektiren uzaktan algılama çalışmalarında elle ya da otomatik olarak geometrik düzeltmenin yapılması bir zorunluluk olarak karşımıza çıkmaktadır.

## 2. Materyal ve Yöntem

### 2.1. Materyal

Çalışma alanı; Isparta Orman Bölge Müdürlüğü, Sütçüler Orman İşletme Müdürlüğü'ne bağlı Çandır Orman İşletme Şefliği (Şekil 1) idari sınırları içinde bulunmaktadır. Çandır Orman İşletme Şefliği 10348.4 ha yüzölçümüne sahip olup, en düşük rakım 248 metre ve en yüksek rakım ise 1877 metredir. Çandır Orman İşletme Şefliği idari sınırlarının arazi örtü sınıflarına alansal dağılımları incelendiğinde; %76.2'si orman, %5.5'i tarım, %0.8'i yerleşim alanı ve %17.5'i sulak alan olarak nitelendirilmektedir. Meşcere türlerinin dağılımına bakıldığında; ibrelili meşcereler %62.2, geniş yapraklı meşcereler %0.1, karışık meşcereler %9.8 ve diğer alanlar %27.8 bulunma oranına sahipken işletmede en çok bulunan ağaç türü de kızılçam (%66.1) olarak karşımıza çıkmaktadır. Çandır Orman İşletme Şefliği'nin en fazla yayılış gösteren ve asli ağaç türü olan kızılçamın bulunduğu en düşük yükseltisi 259 metreyken en fazla 1489 metre yükseltiye kadar çıktığı belirlenmiştir (IOBM, 2021; USGS, 2022).



Şekil 1. Çandır Orman İşletme Şefliği konumu ve idari sınırları

Çalışma alanı olarak Çandır Orman İşletme Şefliği idari sınırları içerisinde olan bir kızılçam meşceresi seçilmiştir (Şekil 2). Kızılçam meşcereleri genellikle idare süresinin sonuna diğer bir deyişle ekonomik gençleştirme yaşına geldiğinde tıraşlama kesim yöntemiyle boşaltılmaktadır. Çalışma alanında 66. ve 67. bölmeler bulunmaktadır. Bu alan; göğüs yüksekliğindeki çapları 8-36 cm aralığında ve %70'ten fazla toprağı gölgeleme oranına sahip kapalılığı barındıran kızılçam meşcerelerini simgeleyen 'Çzbc3, Çzc3' ve çok küçük bir kısmı da kapalılığı %10'un altında ve yer yer taşlık açıklıklara sahip kızılçam meşceresini simgeleyen 'BÇz-T' rumuzlu alanları kapsamaktadır (IOBM, 2021). Çalışma alanı 3.2 ha büyüklüğe ve ortalama %48 eğime sahiptir.



Şekil 2. Çalışma alanının İHA ile üretilmiş ortomozaik görüntüsü

Bu çalışmada; 2018 yılının ilk çeyreğinde piyasaya sürülen DJI/Mavic Air marka ve modeldeki İHA kullanılmıştır. Söz konusu İHA 430 gram uçuş ağırlığına ve dahili 8 GB depolama alanına sahiptir. Maksimum 21 dakika uçuş süresi sağlayan 2375 mAh bataryasının yanında GPS ve GLONASS konumlandırma sistemleri de bulunan bu İHA, kameranın sarsılmasını önleyen gimbal düzeneği ve olası çarpışmaları önleyen 3 yönlü koruyucu görüş sistemi gibi güvenlik sistemlerini de bünyesinde barındırmaktadır. CMOS türünde ve 1/2.3 inç boyutundaki algılayıcı kamera, 12 mp çözünürlük, 2.8 diyafram açıklığı ve 85° görüş açısına sahiptir (DJI, 2022). Harici yazılımlar yardımıyla fotogrametrik amaçlı uçuşlar yapmaya yönelik asgari şartları sağlayan bu İHA; pratik kullanımı, taşıma kolaylığı ve uygun maliyeti gibi nedenlerle tercih edilmiştir. İHA'nın sahip olduğu dahili 8 GB depolama alanının yanında 256 GB depolama alanına sahip harici hafıza kartı da kullanılmıştır.

Çalışmada, İHA görüntülerinde geometrik düzeltmelerin yapılabilmesi için araziye YKN'ler tesis edilmiştir. Tesis edilen YKN'lerin İHA fotoğraflarında belirgin bir şekilde görülmesi, özellikle orta noktasının tespit edilebilmesi, fotogrametrik ürünlerde yüksek hassasiyete ulaşabilmek adına çok önemlidir. Bu nedenlerle 50x50 cm boyutlarında ve özel olarak tasarlanmış olan YKN'ler bu çalışmada kullanılmıştır (Şekil 3).





Şekil 3. YKN'nin yaklaşık 40 metre yükseklikteki İHA'dan görünümü

Araziye tesis edilen YKN'lerin ölçümü 2 adet hassas GPS ile gerçekleştirilmiştir. Arazi şartlarından dolayı çalışmalar sırasında TUSAGA-Aktif sistemine bağlanılamaması nedeniyle RTK yöntemine başvurulmuş, GPS'lerden bir tanesi koordinatları bilinen noktaya sabit olarak kurulup diğeriyle YKN'lerin ölçümleri gerçekleştirilmiş ve bu nedenle 2 hassas GPS'in birlikte kullanılması ihtiyacı doğmuştur. South markasının Galaxy G6 modeli olan GPS'ler santimetre altı hassasiyetlerde konum sağlama yeteneğine sahiptir. Bu GPS'lerle birlikte taşıyıcı platform olarak ise bir adet jalon ve bir adet tripod kullanılmıştır (South, 2022).

Bu çalışmada; arazi karnelerinin hazırlanması, arazi verilerinin işlenmesi ve çeşitli tanımlayıcı istatistiklerin belirlenmesi için Microsoft Excel yazılımı kullanılırken (Microsoft, 2022) yine bazı istatistiksel testlerin uygulanması amacıyla SPSS programı da kullanılmıştır (SPSS, 2022). Konumsal analizlerin yapılması ve ağaçların ortomozaik üzerinde çap ve boy ölçümlerinin gerçekleştirilmesi gibi amaçlar için bir CBS yazılımı olan ArcGIS yazılımı (ArcGIS, 2022); İHA'dan elde edilen hava fotoğraflarının işlenmesi, geometrik düzeltmelerin yapılması ve kesilmiş ağaçların çap ve boylarının ölçülmesi amacıyla ise Pix4d-mapper fotogrametri yazılımı kullanılmıştır (Pix4d, 2022).

Arazi çalışmalarında İHA'nın fotogrametrik alım şartlarına uygun olarak otomatik uçuşunu sağlamak adına ücretsiz erişime açık ve mobil bir uygulama olan Pix4d-capture yazılımı kullanılmıştır (Pix4d, 2022). Arazi çalışmalarında video kaydı, fotoğraf çekimi, Pix4d-capture programının kullanılması gibi amaçlar için kişisel bir akıllı cep telefonu kullanılmıştır. Çalışma alanındaki topoğrafyanın belirlenmesi (yüksekti, eğim ve bakı gibi) için gereken sayısal yükseklik modeli olarak 30x30 m piksel boyutlarında yüzey yükseklik değerlerine sahip SRTM-1 adı verilen ve ücretsiz erişilebilen radar uydu verilerinden yararlanılmıştır (USGS, 2022; Çoban ve Eker, 2009; Çoban vd., 2021).

## 2.2. Yöntem

Çalışma alanında bulunan toplam 150 adet kesilmiş haldeki kızılçam ağacının göğüs çapı ve boyu bireysel olarak ölçülmüş ve arazi karnelerine kaydedilmiştir. Bu ölçümler sırasında her bir ağacın dip kısmına o ağacın numarasını belirten A4 kâğıdı ve 1.3. metredeki kısmına ise yaklaşık 5x5 cm boyutundaki kağıtlar raptiye ile sabitlenmiştir. Son olarak ise ağacın en uç kısmına A4 boyutundaki kağıtlar koli bantlarıyla sabitlenmiştir. Sabitlenen bu kağıtlar ile büro çalışmalarında İHA'dan elde edilen fotogrametrik ürünlerden ağaç numarası, göğüs çapının ölçüleceği kısım ve uç kısmı gibi önemli noktalar kolaylıkla belirlenebilmiştir (Şekil 4). Ağaç ölçümlerinin tamamlanmasının ardından YKN'ler çalışma alanına homojen bir şekilde tesis edilmiştir. Çalışma alanına toplam 10 adet YKN tesis edilmiş olup tesis edilen YKN'ler hassas GPS'ler ile TUREF (Türkiye Ulusal Referans Sistemi) TM30 (3°'lik projeksiyon) koordinat sisteminde ölçülmüş ve ölçüm sonuçları cihaz belleğinde depolanmıştır. Bu işlemlerin ardından ise İHA uçuşları planlanmış ve gerçekleştirilmiştir.



Şekil 4. İHA görüntüsündeki ağaçlarda bulunan işaretler

Arazi çalışmalarının tamamlanmasının ardından İHA'dan elde edilen hava fotoğrafları işlenmiş ve bu çalışmada kullanılacak olan nokta bulutu ve ortomozaik gibi fotogrametrik ürünlerin üretimi gerçekleştirilmiştir. Tüm fotogrametrik ürünler TUREF TM30 koordinat sisteminde üretilmiştir. Araziye gerçekleştirilen İHA uçuşlarından elde edilen İHA fotoğrafları bu çalışma için toplamda 2 kez işlenmiştir. Bunun sebebi aynı veri setinin hem YKN'li hem de YKN'siz olarak işlenmesidir. Sonuç olarak çalışma alanı için geometrik düzeltmesi yapılmış ve geometrik düzeltmesi yapılmamış nokta bulutu ve ortomozaik ürünler oluşturulmuştur. Nokta bulutları kullanılarak Pix4d-mapper programında 3 boyutlu ölçümler (yükseklik bilgisinin de dahil edildiği ölçümler), ortomozaikler kullanılarak ise ArcGIS programında 2 boyutlu ölçümler (yükseklik bilgisi olmaksızın yapılan yatay ölçümler) gerçekleştirilmiştir. Tüm

ağaçlar her bir veri setinde 2 kez ölçülmüş ve ortalamaları alınmış, böylece operatör kaynaklı kaba hataların önüne geçilmeye çalışılmıştır. 150 adet kızılçam ağacı bu çalışma kapsamında Pix4d-mapper ve ArcGIS programıyla toplam 4 kez ölçülmüştür. Elde edilen ölçüm sonuçları ile tanımlayıcı istatistikler belirlenmiş, Pearson korelasyon analizi ve bağımlı örneklem T-testi uygulanarak sonuçlar ortaya koyulmuştur.

### 3. Tartışma ve Sonuç

Arazide alınan İHA fotoğraflarının işlenmesiyle çalışma alanı için 1.95 cm piksel çözünürlüğe sahip fotogrametrik ürünler üretilmiştir. Kullanılan İHA'nın yeryüzüne paralel uçuş özelliği bulunmaması nedeniyle uçuş yüksekliği deneme yanılma yöntemiyle ortalama olarak belirlenmiş ve 2 cm çözünürlük değerine yakın bir değere ulaşmak amaçlanmıştır. İHA kalkış noktasından 55 metre yükseklikte uçuş yapmıştır. İHA fotoğraflarının alımında %80 enine ve boyuna bindirme oranı kullanılmış, kamera açısı 90°'ye ayarlanmış ve İHA ortalama 4.75 metre/saniye hızla uçuş gerçekleştirmiştir. İHA fotoğraflarının işlenmesi sırasında YKN'ler farklı kombinasyonlar halinde denenmiş, çalışma alanının çevresine homojen olarak dağılmış olan en uygun YKN'ler geometrik düzeltmede kullanılarak minimum RMS değerine ulaşmak amaçlanmıştır. Geometrik düzeltme için 6 adet YKN kullanılmış ve 2.6 cm (0.75 piksel) RMS hata oranına ulaşılmıştır. 0.5 piksel hata sınır değerinin yakalanamamasının sebebi olarak ulaşılan çözünürlüğün çok yüksek olması ve hassas GPS'lerin arazi şartlarında ulaştığı hassasiyetin yetersiz kalması ( $\pm 2$  cm hassasiyetle koordinatlar alınmıştır) gösterilebilir.

İHA fotoğraflarının işlenmesiyle çalışma alanı için geometrik olarak düzeltilmiş ve düzeltilmemiş nokta bulutu ve ortomozaikler oluşturulmuştur. Oluşturulan bu verilerden nokta bulutları kullanılarak Pix4d-mapper programında, ortomozaikler kullanılarak ArcGIS programında ağaçların çap ve boy ölçümleri gerçekleştirilmiştir. Pix4d-mapper programı uzunluk ölçümlerinin sonucunu 2 boyutlu (x-y koordinatları kullanılarak hesaplanır) ve 3 boyutlu (x-y-z koordinatları kullanılarak hesaplanır) olarak sunabilmektedir. 2 boyutlu ölçümlerin ortomozaik üzerinden ArcGIS programında yapılması planlandığı için Pix4dmapper programında yalnızca 3 boyutlu ölçüm sonuçları dikkate alınmıştır.

Ağaç boyları ölçüm sonuçlarının tanımlayıcı bazı istatistik sonuçları ele alındığı zaman (Tablo 1) geometrik düzeltmesi yapılmış ortomozaik ve nokta bulutunda gerçekleştirilen ölçümlerden elde edilen sonuçların geometrik düzeltmesi yapılmamış olanlara göre arazi ölçümlerine daha yakın istatistiksel sonuç verdiği görülmektedir. Elde edilen sonuçlara göre; geometrik düzeltmesi yapılmış nokta bulutunda gerçekleştirilen ölçüm sonuçlarının arazi ölçümlerine en yakın istatistiksel sonuçları, geometrik düzeltmesi yapılmamış ortomozaik üzerinde gerçekleştirilen ölçüm sonuçlarının ise en uzak sonuçları verdiği görülmektedir. Bununla birlikte geometrik düzeltmesi yapılmamış nokta bulutu verisinden elde edilen ölçümlerin geometrik düzeltmesi yapılmış ortomozaik veriden elde edilen ölçüm sonuçlarına nazaran daha başarılı olduğu da dikkat çeken bir diğer husustur. Bunun sebebinin ise; çalışma alanının yüksek eğim değerine sahip olması ve ortomozaik üzerinde yapılan ölçümlerde Z koordinatlarının dikkate alınmaması nedeniyle uzunluk ölçümlerinde eksik sonuçların ortaya çıkması olarak düşünülmektedir. Ağaç çap ölçüm sonuçlarına dair bazı tanımlayıcı istatistiksel sonuçlar ele alındığı zaman ise (Tablo 2) bilgisayar ortamında yapılan ölçümlere ait tanımlayıcı istatistiklerin genel olarak arazi ölçüm istatistiklerinden uzak olduğu görülmektedir. Bu durumun; İHA algılayıcı kamerasının teknik yetersizliği, çalışma alanındaki gölgelenme durumu, ağaçların duruşlarından kaynaklanan bireysel gölgelenme durumu, operatörün olası ölçüm hataları vb. gibi nedenlerden kaynaklandığı düşünülmektedir. Çarpıklık-basıklık değerlerinin tüm ölçümlerde +1.5 ile -1.5 arasında olması ve dolayısıyla ölçüm sonuçlarının normal bir dağılım gösteriyor olması ise

dikkat çeken bir diğer husustur (Tabachnick ve Fidell, 2013). Ayrıca yapılan Kolmogorov-Smirnov dağılım testiyle de ölçümlerin normal dağılım gösterdiği görülmüştür (%95 güven düzeyinde  $p>0.05$ ).

Tablo 1. Boy ölçüm sonuçlarının tanımlayıcı istatistikleri (n=150)

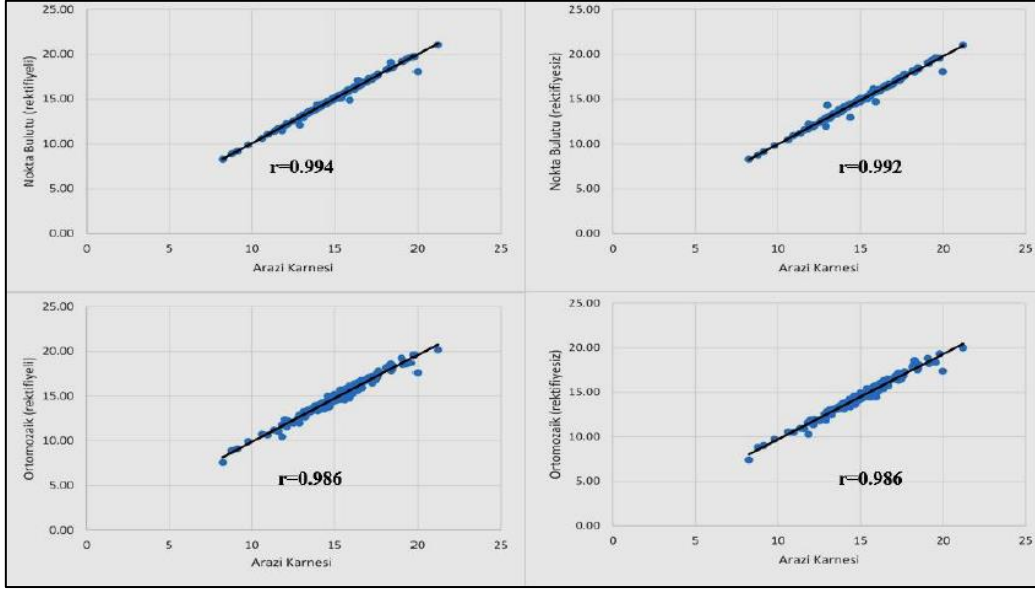
	Arazi Ölçümleri	Ortomozaik (rektifiyeli)	Ortomozaik (rektifiyesiz)	Nokta bulutu (rektifiyeli)	Nokta bulutu (rektifiyesiz)
<b>Ortalama</b>	15.07	14.80	14.57	15.10	14.96
<b>Standart Sapma</b>	2.22	2.19	2.15	2.22	2.19
<b>Basıklık</b>	0.65	0.53	0.53	0.55	0.60
<b>Çarpıklık</b>	-0.19	-0.29	-0.29	-0.22	-0.20
<b>Aralık</b>	12.97	12.64	12.55	12.81	12.75
<b>En Küçük</b>	8.23	7.55	7.43	8.28	8.29
<b>En Büyük</b>	21.20	20.19	19.98	21.08	21.04
<b>Toplam</b>	2260.63	2219.68	2185.36	2265.46	2243.58

Tablo 2. Çap ölçüm sonuçlarının tanımlayıcı istatistikleri (n=150)

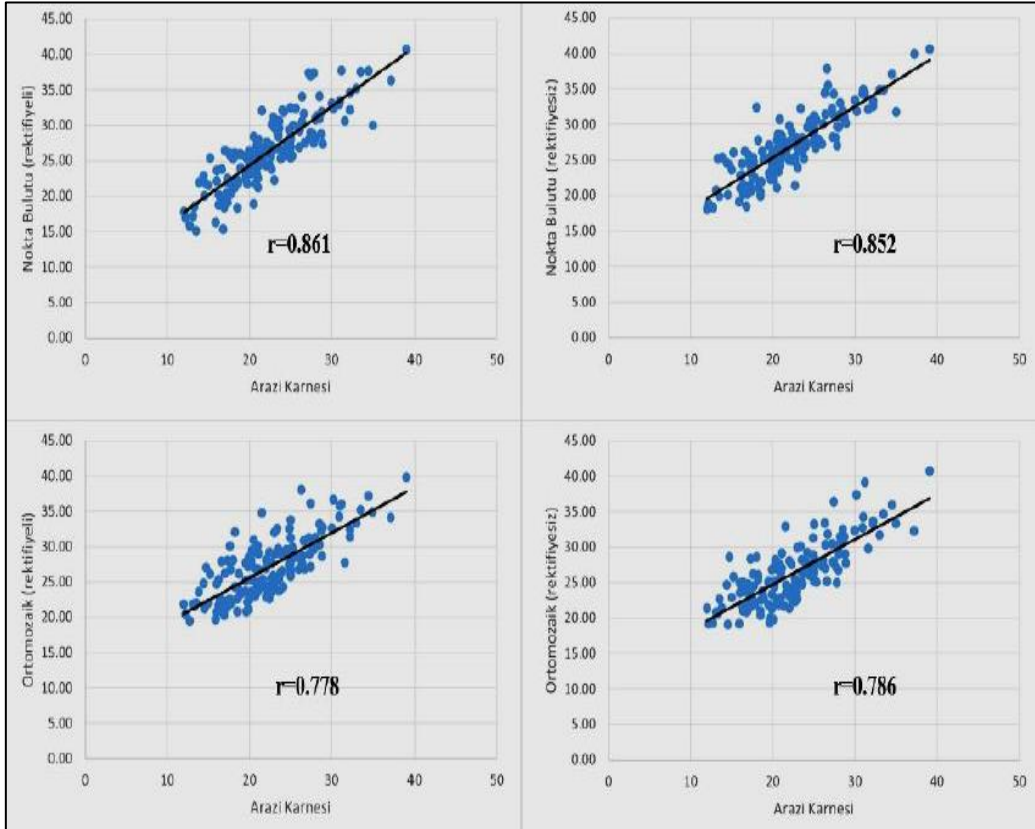
	Arazi Ölçümleri	Ortomozaik (rektifiyeli)	Ortomozaik (rektifiyesiz)	Nokta bulutu (rektifiyeli)	Nokta bulutu (rektifiyesiz)
<b>Ortalama</b>	15.07	14.80	14.57	15.10	14.96
<b>Standart Sapma</b>	2.22	2.19	2.15	2.22	2.19
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<b>Çarpıklık</b>	-0.19	-0.29	-0.29	-0.22	-0.20
<b>Aralık</b>	12.97	12.64	12.55	12.81	12.75
<b>En Küçük</b>	8.23	7.55	7.43	8.28	8.29
<b>En Büyük</b>	21.20	20.19	19.98	21.08	21.04
<b>Toplam</b>	2260.63	2219.68	2185.36	2265.46	2243.58

Tanımlayıcı istatistiklerin ardından değişkenler arasındaki ilişki, bu ilişkinin yönü ve şiddeti ile ilgili bilgiler sağlayan Pearson korelasyon testi de elde edilen ölçüm sonuçlarına uygulanmış ve arazi ölçüm sonuçları ile olan korelasyon katsayıları belirlenmiştir (Şekil 5-6). Buna göre geometrik düzeltmesi yapılmış nokta bulutu üzerinde gerçekleştirilen ölçüm sonuçlarının diğer tüm ürünlere kıyasla arazi ölçümleri ile daha güçlü bir korelasyona sahip olduğu görülmektedir. Bunun yanında hem çap hem de boy ölçümlerinde nokta bulutu üzerinden yapılan 3 boyutlu ölçümlerin ortomozaik üzerinde yapılan 2 boyutlu ölçümlere kıyasla daha başarılı olduğu da görülmektedir. Dikkat çeken bir başka husus ise sayısal ortamda yapılan boy ölçümlerinin çap ölçümlerine kıyasla daha başarılı bir sonuç vermiş olması, arazi ölçümleriyle daha güçlü bir korelasyon ilişkisine sahip olmasıdır. Geometrik düzeltmesi yapılmış ortomozaikten elde edilen çap ölçüm değerlerinin geometrik düzeltmesi yapılmayan ortomozaiğe göre daha zayıf bir korelasyon değerine sahip olması ise gözden kaçmayan bir diğer husustur. Son olarak, ölçümler arasında yapılan bağımlı örneklem T-testi sonuçlarına bakıldığı zaman ise rektifiyeli nokta bulutu üzerinde yapılan boy ölçümleri ile arazi ölçümleri arasında anlamlı bir fark bulunmazken (%95 güven düzeyinde  $p>0.05$ ) diğer tüm çap ve boy ölçümlerinin anlamlı bir farklılığa sahip olduğu belirlenmiştir (%95 güven düzeyinde  $p<0.05$ ).

Şekil 5. Boy ölçüm sonuçlarının korelasyon grafikleri ve korelasyon katsayıları



Şekil 6. Çap ölçüm sonuçlarının korelasyon grafikleri ve korelasyon katsayıları



Bu çalışmadan elde edilen bulgular ile; İHA fotoğraflarından üretilecek fotogrametrik ürünler üzerinde gerçekleştirilecek hassas çalışmalar için geometrik düzeltmenin gerekli olduğu, geometrik olarak düzeltilmiş verilerden elde edilen ağaç çap ve boy ölçümlerinin arazide gerçekleştirilen ölçümlere daha yakın sonuçlar verdiği ortaya koyulmuştur. Bunun yanında nokta bulutu üzerinden gerçekleştirilen çap ve boy ölçümlerinin ortomozaik üzerinden

gerçekleştirilen ölçümlere nazaran daha doğru sonuçlar verdiği de anlaşılmıştır. Ayrıca bu çalışmada İHA fotogrametrisi ağaç boyu ölçümlerinde çap ölçümlerine göre daha başarılı sonuçlar elde edilmiştir. Bu durumun önemli nedenlerinden birinin ağaçların konumu ve duruş açısı nedeniyle ortaya çıkan gölgelenme etkisi olduğu düşünülmektedir. Günümüzde pratik bir uzaktan algılama aracı olarak tercih edilen İHA'lardan elde edilen görüntülerde, hassas konum ve ölçüm gerektiren çalışmalar için geometrik düzeltmelerin önemini vurgulamak istiyoruz.

#### 4. Açıklama

Bu çalışma Isparta Uygulamalı Bilimler Üniversitesi Bilimsel Araştırma Projeleri Koordinasyon Birimince 2021-YL1-0137 no'lu proje ile desteklenmiştir.

#### 5. Kaynaklar

Aguera-Vega F, Carvajal-Ramirez F & MartínezCarricondo P (2017). Assessment of photogrammetric mapping accuracy based on variation ground control points number using unmanned aerial vehicle. *Survey*, 2017(98), 221– 227.

ArcGIS (2022). <https://www.arcgis.com/index.html> (Son erişim tarihi: 08.05.2022)

Balcı, İ., Çoban, H. O. & Eker, M. (2000). Coğrafi Bilgi Sistemi. *SDÜ Orman Fakültesi Dergisi*, 1 (A), 115-132.

BÖHYY (2018). Büyük Ölçekli Harita Ve Harita Bilgileri Üretim Yönetmeliği, 6. Madde/ N Bendi.

Buğday, E. (2016). Ormancılıkta Üretimin Planlaması ve Hassas Ormancılık Anlayışı. *Anadolu Orman Araştırmaları Dergisi*, 2(1-2), 54-57.

Çoban, H., O. (2006). Uydu Verileri İle Orman Alanlarındaki Zamansal Değişimlerin Belirlenmesi (Doktora Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü).

Çoban, H. O. & Eker, M. (2009). Srtm Verileri İle Bazı Topoğrafik Analizler: Isparta Orman Bölge Müdürlüğü Örneği. *SDÜ Orman Fakültesi Dergisi*, 2(A), 76-91.

Çoban, H. O. (2016). Türkiye'nin Yer Gözlem Uydu Sistemleri ve Ormancılık Uygulamalarında Kullanılabilirliği. *Türkiye Ormancılık Dergisi*, 17(1), 99-107.

Çoban, H. O., Eker, M., Durgun, H. (2021). Relations between topographic variables and forest ecosystems in Isparta Regional Directorate of Forestry. *International Conferences on Science and Technology (ICONST-LST-2021)*, September 8 to 10, Budva, Montenegro, pp. 4.

DJI (2022). Mavic Air User Manual Online. <https://dl.djicdn.com/downloads> (Son erişim tarihi: 10.05.2022)

Eker, M. & Özer, D. (2015). Üretim İşlerinde Hassas Ormancılık Yaklaşımı: Kavramsal Çerçeve. *Türkiye Ormancılık Dergisi*, 16(2), 183-194.

Erdas (2002). *Field Guide (Sixth Edition)*, ERDAS LLC, USA.

IOBM (2021). Isparta Orman Bölge Müdürlüğü Amenajman Planı.

ISPRS (2022). International Society for Photogrammetry and Remote Sensing online. <http://www.isprs.org> (Son erişim tarihi: 18.05.2022)

İzci, V. & Ulvi, A. (2021). Yer Kontrol Noktalarının Harita Üretimine Etkileri. In International Geoinformatics Student Symposium (IGSS) (Vol. 1, No. 1, pp. 41-47).

Jensen, J. R. (1996). Introductory digital image processing, Prentice-Hall Series in Geographic Information Science, USA, 0-13-205840-5.

Kapıcıoğlu H Ş, Hastaoğlu K Ö, Poyraz F, Gül Y (2018). Investigation of topographic effect in ground control point selection in UAV photogrammetry: Gaziantep/ Nizip. International Conference On Innovative Engineering Applications - CIEA 2018, 1174-1178.

Kaya, Ş., İnce, D. & Şahin, M. (2002). Uydu Görüntülerinin Çözünürlüğe Bağlı Geometrik Doğruluğunun Gps Ve Harita Koordinatları Kullanılarak Analizi. Selçuk Üniversitesi, 102, 16-18.

Koç, A. (1995). Bilgisayar Destekli Konusal Orman Haritalarının Üretimi ve Orman Bilgi Sisteminin Oluşturulması. (Doktora Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü).

Küpcü, R. (2015). Rasat ve Göktürk-2 Uydu Görüntülerinin Uzaktan Algılama Yazılımları İle Farklı Referans Verileri Kullanarak Geometrik Düzeltme Doğruluğunun Araştırılması. (Yüksek Lisans Tezi, Anadolu Üniversitesi Fen Bilimleri Enstitüsü).

Microsoft (2022). <https://www.microsoft.com/tr-tr/microsoft-365/> (Son erişim tarihi: 08.05.2022)

OGM (2020). 2020 Türkiye Orman Varlığı. <https://www.ogm.gov.tr/tr/ormanlarimiz/Turkiye-Orman-Varligi> (Son erişim tarihi: 22.05.2022)

Pix4d (2022). <https://www.pix4d.com/> (Son erişim tarihi: 08.05.2022)

Rabah M, Basiouny M, Ghanem E & Elhadary A (2018). Using RTK and VRS in direct georeferencing of the UAV imagery, NRIAG J. Astron. Geophys, 7(2), 220–226.

Richards, J. A. (1993). Remote Sensing Digital Image Analysis an Introduction, Second Revised and Enlarged Edition, Springer-Verlag, Berlin.

Ruzgiene B, Berteška T, Gečyte S, Jakubauskienė E & Aksamitauskas V Č (2015). The surface modelling based on UAV Photogrammetry and qualitative estimation, Measurement, vol. 73, pp. 619–627.

Sanz-Ablanedo E, Chandler J H, Rodríguez-Pérez J R & Ordóñez C (2018). Accuracy of Unmanned Aerial Vehicle (UAV) and SfM photogrammetry survey as a function of the number and location of ground control points used. Remote Sens. 10 (10).

South (2022). Galaxy G6 Measuring System User Manual Online. <https://globalgpsystems.com/wp-content/uploads/2020/03/Galaxy-G6-Measuring-System-User-Manual.pdf> (Son erişim tarihi: 08.05.2022)

SPSS (2022). <https://www.ibm.com/tr-tr/products/spss-statistics> (Son erişim tarihi: 08.04.2022)

Stöcker C, Nex F, Koeva M & Gerke M (2017). Quality Assessment of Combined IMU/GNSS Data for Direct Georeferencing in the Context of Uav- Based Mapping, ISPRS - Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci., vol. XLII-2/W6, pp. 355–361.

Şafak, İ. & Gül, A. U. (2012). Orman Mühendislerinin Orman İşlevlerine ve Ormancılık Faaliyetlerine Verdikleri Önem Düzeylerinin Değerlendirilmesi. SDÜ Orman Fakültesi Dergisi, 13, 123-133.

Tabachnick, B. G. & Fidell, L. S. (2013). Using multivariate statistics (6th ed.), Boston: Allyn and Bacon.

USGS (2022). Shuttle Radar Topography Mission (SRTM) Data Download. United States Geological Survey, <https://earthexplorer.usgs.gov/> (Son erişim tarihi: 22.05.2022)

Wang J, Gea Y, Heuvelink G B M, Zhou C & Brus D (2012). Effect of the sampling design of ground control points on the geometric correction of remotely sensed imagery, Int. J. Appl. Earth Obs. Geoinf., vol. 18, no. 1, pp. 91–100.

Welch, R. & Usery, L. E. (1984). Cartographic Accuracy of Landsat 4 MSS and TM Image Data, IEEE, Transaction on Geoscience and Remote Sensing, Vol. GE-22, No:3.

Yomralıoğlu, T. (2000). Coğrafi Bilgi Sistemleri: Temel Kavramlar ve Uygulamalar. Seçil Ofset Basımevi.

Yurtseven, H. (2008). Yazılım Fotogrametrisi ile Orman Alanlarına Yönelik Coğrafi Verilerin Elde Edilmesi. (Yüksek Lisans Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü)



**Odunsu biyokütle envanter çalışmalarında İHA fotogrametrisinin kullanılabilirliğinin değerlendirilmesi /  
Evaluation of the usability of UAV photogrammetry in woody biomass inventory studies**

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**Abstract:** Turkey's theoretical woody biomass potential is quite high. Turkey is willing to reduce greenhouse gas emissions and minimize other environmental impacts by using renewable energy sources such as biomass. Tree bottom stumps and roots, which are a component of woody biomass in forests, remain in the stand after harvesting operations. The versatile demand for woody biomass limits the supply and consumption of biomass for energy purposes. Bottom log (subsoil part and associated main root) biomass is an important alternative raw material for small and medium-sized power generation plants. However, there are not enough inventory studies on the theoretical and technical potential of this biomass. The aim of this study is to test the performance and reliability of photogrammetric data obtained from UAV (Unmanned Aerial Vehicle) to determine the amount of bottom logs left in the field after production in a red pine stand where trimming intervention is applied. This study was carried out on an area of 2.34 hectares located within the borders of Isparta Regional Directorate of Forestry, Sütçüler Forestry Operations Directorate, Çandır Forestry Operation Chief. In this area, the diameter of a total of 40 bottom logs was measured on the orthomosaic and point cloud obtained from the UAV, the results were compared with the measurement results made in the field, and the performance of the UAV in the bottom log biomass measurement studies was evaluated by subjecting them to various statistical tests. Accordingly, it has been understood that the photogrammetric data produced by the UAV in the study area has a very high correlation with field measurements. With this study, it has been seen that bottom log measurements can be performed at a sufficient scale from the photogrammetric data to be produced from UAV photographs, and it has been demonstrated that UAV photogrammetry can be used in sensitive measurements such as diameter measurement. It can be said that modern technologies such as UAVs provide great convenience in forestry and the dissemination and development of the use of these technologies is of great importance.

**Keywords:** Biomass, Renewable energy, UAV photogrammetry, Point cloud, Orthomosaic

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**Özet:** Türkiye'nin teorik odunsu biyokütle potansiyeli oldukça yüksektir. Türkiye, biyokütle gibi yenilenebilir enerji kaynaklarını kullanarak sera gazı emisyonlarını azaltmaya ve diğer çevresel etkileri minimize etmeye isteklidir. Ormanlardaki odunsu biyokütlenin bir bileşeni olan ağaç dip kütükleri ve kökler, hasat operasyonlarından sonra meşcerede kalmaktadır.

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Odunsu biyokütlenin çok yönlü kullanım talebi, enerji amaçlı biyokütle arzını ve tüketimini sınırlandırmaktadır. Dip kütük (toprak altı kısmı ve bağlantılı ana kök) biyokütlesi küçük ve orta ölçekli enerji üretim tesisleri için önemli bir alternatif hammadde niteliği taşımaktadır. Ancak bu biyokütlenin teorik ve teknik potansiyeli konusunda yeterli envanter çalışmaları bulunmamaktadır. Bu çalışmanın amacı, tıraşlama müdahalesinin uygulandığı bir kızılçam meşçeresinde üretim sonrasında sahada kalan dip kütüklerin miktarının belirlenmesi için İHA (İnsansız Hava Aracı)'dan elde edilen fotogrametrik verilerin performans ve güvenilirliğini test etmektir. Bu çalışma, Isparta Orman Bölge Müdürlüğü Sütçüler Orman İşletme Müdürlüğü Çandır Orman İşletme Şefliği sınırlarında bulunan 2.34 hektarlık bir alanda gerçekleştirilmiştir. Bu alanda toplam 40 adet dip kütüğün çapı İHA'dan elde edilen ortomozaik ve nokta bulutu üzerinde ölçülmüş, sonuçlar arazide yapılan ölçüm sonuçlarıyla kıyaslanmış ve çeşitli istatistiksel testlere tabi tutularak İHA'nın dip kütük biyokütlesi ölçüm çalışmalarındaki performansı değerlendirilmiştir. Buna göre çalışma alanında İHA ile üretilen fotogrametrik verilerin arazi ölçümleriyle oldukça yüksek bir korelasyon ilişkisine sahip olduğu anlaşılmıştır. Bu çalışma ile İHA fotoğraflarından üretilecek fotogrametrik verilerden dip kütük ölçümlerinin yeterli ölçekte gerçekleştirilebildiği görülmüş, İHA fotogrametrisinin çap ölçümü gibi hassas ölçümlerde kullanılabilir olduğu ortaya konulmuştur. Ormancılıkta İHA gibi modern teknolojilerin büyük kolaylık sağladığı ve bu teknolojilerin kullanımının yaygınlaştırılması ve geliştirilmesinin büyük öneme sahip olduğu söylenebilir.

**Anahtar Kelimeler:** Biyokütle, Yenilenebilir enerji, İHA fotogrametrisi, Nokta bulutu, Ortomozaik

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## 1. Giriş

Ormancılık faaliyetleri geniş alanlarda ve zor arazi koşullarında yürütülen uzun vadeli iş ve işlemler olup bunların gerçekleştirilmesinde güvenilir, güncel ve ekonomik olarak elde edilecek verilere büyük bir ihtiyaç duyulmaktadır (Şafak ve Gül, 2012; Eker ve Özer, 2015; Buğday, 2016). Bu nitelikteki veriler, çeşitli hava araçları ve uzaktan algılama tekniklerinin birlikte kullanımıyla günümüzde kolaylıkla üretilebilmektedir (Çoban, 2016). Bilgisayar teknolojisindeki yazılımsal ve donanımsal gelişmeler, verilerin sayısal olarak elde edilebilmesi, depolanması, işlenmesi ve analizi olanaklarını arttırmış ve bu durum uzaktan algılama verisi gibi verilerden çok yönlü yararlanma olanaklarının geliştirilmesine neden olmuştur (Çoban, 2006). Uzaktan algılama verilerinin CBS'de altlık olarak kullanılabilmesi ise onu çok güçlü bir veri kaynağı haline getirmektedir (Balcı vd., 2000; Çoban, 2016).

Elektromanyetik enerji, yeryüzü üzerindeki objeleri aydınlattığında onlarla etkileşime geçerek nesnelere tarafından emilir, geçirilir, yansıtılır ya da saçılır. Yansıyan ve saçılan enerji, fotoğrafik kamera gibi algılayıcı sistemler tarafından tespit edilerek kaydedilebilir. Algılanan bu enerji ise bilgisayar ortamında saklanabilen sayısal veriye dönüştürülür ve bu veriler işlenerek istenilen bilgiler ortaya koyulabilir (Yomralıoğlu, 2000).

Günümüzde uzaktan algılama aracı olarak İHA'lar aktif bir şekilde kullanılmaktadır. İHA, diğer hava araçlarına nazaran daha düşük maliyetlerle elde edilebilmesi ve pratik kullanımı gibi avantajları sayesinde karşılaşılan problemlere uygun ve hızlı çözümler getirebilmekte ve ormancılık çalışmalarında izleme, yönetme ve karar verme süreçlerinde İHA'lardan aktif bir şekilde faydalanılabilmektedir (Buğday, 2019). İHA tabanlı verilerin fotogrametrik olarak değerlendirilmesiyle envanter çalışmalarında, bir yandan yersel ölçüm çalışmalarının minimuma düşürüldüğü diğer yandan da yüksek duyarlılıkta verilerin hızlı ve düşük maliyetle

elde edilebildiği bilinmektedir (Yurtseven vd., 2015). İHA sistemlerinin, ormancılık faaliyetlerinde karşılaşılabilecek olası bir problemi çözmek için temel çözümlerden biri olabileceği ve sistem ile elde edilen verilerin ise orman yönetimi ve planlanması aşamasında bilimsel dayanak olarak öne sürülebileceği düşünülmektedir (Menteşoğlu, 2016).

Yenilenebilir enerji kaynaklarına artan bağımlılık, hızlı ekonomik büyümenin neden olduğu çevresel baskıyı hafifletmek amacıyla hem gelişmiş hem de gelişmekte olan ülkeler için stratejik bir hedeftir (Schandl vd., 2016). Yenilenebilir enerji üretimi için birçok seçenek olmasına karşın biyokütle enerjisi kolay ulaşılabilir olması ve çok bulunması nedeniyle dikkatleri üzerine çekmektedir (Öztürk, 2016). Yenilenebilir bir enerji kaynağı olarak ormanlardan biyokütle üretimi; daha iyi orman yönetimi, artan enerji ihtiyacının karşılanması ve ekonomik kalkınmanın desteklenmesine katkı sunmaktadır (Eker vd., 2013). Bunun yanında özellikle Akdeniz bölgesindeki ormanlarda, orman yangını riskini azaltmak için odun biyokütlesinin zamanında sahadan uzaklaştırılması çok önemlidir. Böylece; hem uygun maliyetli bir enerji kaynağı olan biyokütlenin üretimi sağlanırken hem de ormanların korunmasına yönelik önemli bir adım atılmış olur (Eker ve Spinelli, 2018). Ayrıca biyokütle bileşenlerinin enerji kaynağı olarak kullanılmasıyla iş verimliliğine ve ekonomik gelire katkıda bulunacağı da düşünülmekte ve böylece meşcerelere uygun bakımın yapılması ve orman meşcerelerindeki kalitenin iyileşmesi beklenmektedir (Eker vd., 2018).

Türkiye, odunsu biyokütle potansiyeli yüksek bir ülke olup biyokütle gibi yenilenebilir enerji kaynaklarını kullanarak sera gazı emisyonlarını azaltmaya ve diğer çevresel gereksinimleri karşılamaya isteklidir. Biyokütle kaynağı olarak kesilmiş ağaçların toprak üstündeki dip kütükleri ile toprak altındaki kısımları ve bu kısımlara bağlı ana kök sistemi küçük ve orta ölçekli biyoenerji üretim tesisleri için çok önemli bir alternatif ürün olmasına karşın halihazırda teorik ve teknik açıdan yararlanılabilir dip kütük biyokütlesinin potansiyeli konusunda yeterli veri ve bilgi bulunmamaktadır. Sahada gerçekleştirilen ticari faaliyetlerin sonuçlarından yararlanılarak bir işletmede satışı yapılan kök/dip kütük kütleleri hakkında bilgi derlenebilmesine rağmen, envanteri konusunda yeterli çalışmalar bulunmamaktadır. Öte yandan fosil yakıtların kullanımı doğaya zarar vermekte ve orman ekosistemi gibi doğal ekosistemlerin tahribatına yol açmaktadır. Bu durum küresel ısınma gibi sorunları tetiklemekte ve dünyamızı tehdit etmektedir. Dolayısıyla, yenilenebilir ve temiz enerji kaynaklarının kullanımı hem doğal dengenin korunmasına katkıda bulunacak hem de ekonomik gelişme ve refahın arttırılmasında etkili olacaktır. Bu kapsamda, her türlü odunsu biyokütleden modern yöntemlerle yararlanılmalı ve maksimum enerji kazanımı sağlanmalıdır (Eker, 2014).

Bu çalışmada, İHA'dan elde edilen fotogrametrik veriler ile kızılçam sahasında gerçekleştirilen tıraşlama kesimi sonrası sahada kalan ve biyoenerji kaynağı olan dip kütüklerin tespiti ve ölçümü gerçekleştirilmiş, elde edilen sonuçlar arazi ölçümleriyle kıyaslanarak İHA'nın biyokütle hesaplamalarında kullanılabilirliği denetlenmiştir. 78 milyon ha' dan fazla yüzölçümüne sahip olan Türkiye'de 2021 yılı itibarıyla 23.11 milyon ha (%29.4) orman alanı bulunmakta ve bu ormanlarda kızılçam ağaç türünün %22.74 oranda bulunduğu bilinmektedir (OGM, 2021). Bu oran dikkate alınarak çalışma bir kızılçam sahasında gerçekleştirilmiştir.

## **2. Materyal ve Yöntem**

### **2.1. Materyal**

Çalışma alanı; Isparta Orman Bölge Müdürlüğü, Sütçüler Orman İşletme Müdürlüğü'ne bağlı Çandır Orman İşletme Şefliği idari sınırları içinde bulunmaktadır. Çandır Orman İşletme Şefliği 10348.4 ha yüzölçümüne sahiptir. İşletme sınırlarında görülen en düşük rakım 248 metre ve en

yüksek rakım ise 1877 metredir. Çandır Orman İşletme Şefliği'nin %76.2'si orman arazisi niteliğinde olup bu ormanların %62.2'si ibreli meşcerelerden oluşmaktadır. İşletmede en çok bulunan ağaç türü %66.1 oranla kızılçam olarak karşımıza çıkmakta ve kızılçamın şeflik sınırlarındaki dağılımının 259-1489 metre rakımlarda olduğu görülmektedir (IOBM, 2021; USGS, 2022).

Çalışma alanı; göğüs yüksekliğindeki çapları 8-36 cm aralığında ve %70'ten fazla toprağı gölgeleme oranına sahip kapalılığı barındıran kızılçam meşcerelerini simgeleyen 'Çzbc3, Çzc3' ve çok küçük bir kısmı da kapalılığı %10'un altında ve yer yer taşlık açıklıklara sahip kızılçam meşceresini simgeleyen 'BÇz-T' rumuzlu alanları kapsamaktadır (IOBM, 2021). Çalışma alanı 2.34 ha büyüklüğe sahip olup 423-470 metre rakım aralığında bulunmaktadır. Çalışma alanının ortalama yükseltisi 453.6 metre ve ortalama eğimi %34.2 olarak tespit edilmiştir. Çalışma alanındaki topoğrafyanın belirlenmesi (yükselti, eğim ve bakı gibi) için gereken sayısal yükseklik modeli olarak 30x30 m piksel boyutlarında yüzey yükseklik değerlerine sahip SRTM-1 adı verilen ve ücretsiz erişilebilen radar uydu verilerinden yararlanılmıştır (USGS, 2022; Çoban ve Eker, 2009; Çoban vd., 2021).



Şekil 1. Çalışma alanının İHA'dan üretilen ortomozaik görüntüsü

Bu çalışmada; 2018 yılının ilk çeyreğinde piyasaya sürülen DJI/Mavic Air marka ve modeldeki İHA kullanılmıştır. Söz konusu İHA 430 gram uçuş ağırlığına ve dahili 8 GB depolama alanına sahiptir. Donanmış olduğu CMOS türünde ve 1/2.3 inç boyutundaki algılayıcı kamer; 12 mp çözünürlük, 2.8 diyafram açıklığı ve 85° görüş açısına sahiptir (DJI, 2022). Harici yazılımlar yardımıyla fotogrametrik amaçlı (bindirmeli) uçuşlar yapmaya yönelik asgari şartları sağlayan bu İHA; pratik kullanımı, taşıma kolaylığı ve uygun maliyeti gibi nedenlerle tercih edilmiştir.

Çalışmada, İHA'dan elde edilecek fotogrametrik verilerde geometrik düzeltmelerin yapılabilmesi adına araziye yer kontrol noktaları (YKN) tesis edilmiştir. Araziye tesis edilen YKN'lerin ölçümü hassas GPS'ler ile gerçekleştirilmiştir. Arazi şartlarından dolayı çalışmalar sırasında TUSAGA-Aktif sistemine bağlanılamaması nedeniyle RTK yöntemine başvurulmuş ve bu sebeple 2 hassas GPS'in birlikte kullanılması ihtiyacı doğmuştur. South markasının Galaxy G6 modeli olan GPS'ler santimetre altı hassasiyetlerde konum sağlama yeteneğine sahiptirler. Bu GPS'lerle birlikte taşıyıcı platform olarak ise bir adet jalon ve bir adet tripod kullanılmıştır (South, 2022).

Arazi çalışmaları sırasında; dip kütüklerin çapının ölçülebilmesi için çap ölçer, ölçülen dip kütüklerin numaralandırılması için daha önce üzerine numara basılmış olan A4 kağıtları ve ölçüm sonuçlarının kaydedilmesi için arazi karneleri kullanılmıştır. Bu çalışmada; arazi karnelerinin hazırlanması, arazi verilerinin işlenmesi ve çeşitli tanımlayıcı istatistiklerin belirlenmesi için Microsoft Excel yazılımı kullanılırken (Microsoft, 2022) yine bazı istatistiksel testlerin uygulanması amacıyla SPSS programı da kullanılmıştır (SPSS, 2022). Konumsal analizlerin yapılması, harita üretimi ve dip kütüklerin ortomozaik üzerinde çap ölçümlerinin gerçekleştirilmesi gibi amaçlar için bir CBS yazılımı olan ArcGIS yazılımı (ArcGIS, 2022), İHA'dan elde edilen hava fotoğraflarının işlenmesi ve nokta bulutu üzerinde dip kütüklerin çapının ölçülmesi amacıyla ise Pix4dmapper fotogrametri yazılımı kullanılmıştır (Pix4d, 2022). Arazi çalışmalarında İHA'nın fotogrametrik alım şartlarına uygun olarak otomatik uçuşunu sağlamak adına ücretsiz erişime açık ve mobil bir uygulama olan Pix4dcapture yazılımı kullanılmıştır (Pix4d, 2022).

## 2.2. Yöntem

Çalışma alanında bulunan dip kütüklerden 40 tanesinin çapı arazide bireysel olarak ölçülmüş ve arazi karnelerine kaydedilmiştir. Bu ölçümler sırasında her bir dip kütüğün yanına numarasını belirten A4 kâğıtları konulmuştur. Bu kağıtlar yardımıyla İHA'dan elde edilen fotogrametrik verilerden dip kütüklerin kolaylıkla bulunması amaçlanmıştır (Şekil 2).



Şekil 2. Dip kütük ve numaraların İHA'dan görünümü

Arazi çalışmalarının tamamlanmasının ardından büro çalışmaları başlamıştır. Öncelikle İHA'dan elde edilen hava fotoğrafları Pix4dmapper programıyla işlenmiş ve bu çalışmada kullanılacak olan nokta bulutu ve ortomozaik gibi fotogrametrik verilerin üretimi gerçekleştirilmiştir. Tüm fotogrametrik veriler TUREF (Türkiye Ulusal Referans Sistemi) TM30 (3°'lik projeksiyon) koordinat sisteminde üretilmiştir. Fotogrametrik verilerin üretilmesinin ardından nokta bulutları kullanılarak Pix4dmapper programında 2 ve 3 boyutlu

ölçümler (yükseklik bilgisinin de dahil edildiği ölçümler 3 boyutlu, dahil edilmediği ölçümler 2 boyutludur), ortomozaikler kullanılarak ise ArcGIS programında 2 boyutlu ölçümler gerçekleştirilmiştir. Elde edilen ölçüm sonuçları ile tanımlayıcı istatistikler belirlenmiş, Pearson korelasyon analizi ve eşleştirilmiş örneklem T-testi uygulanarak sonuçlar ortaya konulmuştur. Böylelikle, dip kütük sayısı ve dip kütük çap ölçüleri belirlenmiş ve çap-biyokütle ağırlığı denklemlerinde kullanılabilecek uygunlukta veri elde edilmeye çalışılmıştır.

### 3. Bulgular

Arazide alınan İHA fotoğraflarının işlenmesiyle çalışma alanı için 1.07 cm piksel çözünürlüğüne sahip fotogrametrik veriler üretilmiştir. İHA kalkış noktasından 35 metre yükseklikte uçuş yapmış, fotoğrafların alımında %80 enine ve boyuna bindirme oranı kullanılmış ve kamera açısı 90°'ye ayarlanmıştır. İHA fotoğraflarının işlenmesi sırasında geometrik düzeltme işlemi de uygulanmış; elde edilen fotogrametrik verilerin çözünürlüğün çok yüksek olması ve hassas GPS'lerin arazi şartlarında ulaştığı hassasiyetin yetersiz kalması ( $\pm 2$  cm hassasiyetle koordinatlar alınmıştır) nedeniyle ulaşılabilen en düşük RMS hata değeri olan 2.1 cm (1.9 piksel) değerine ulaşılmıştır.

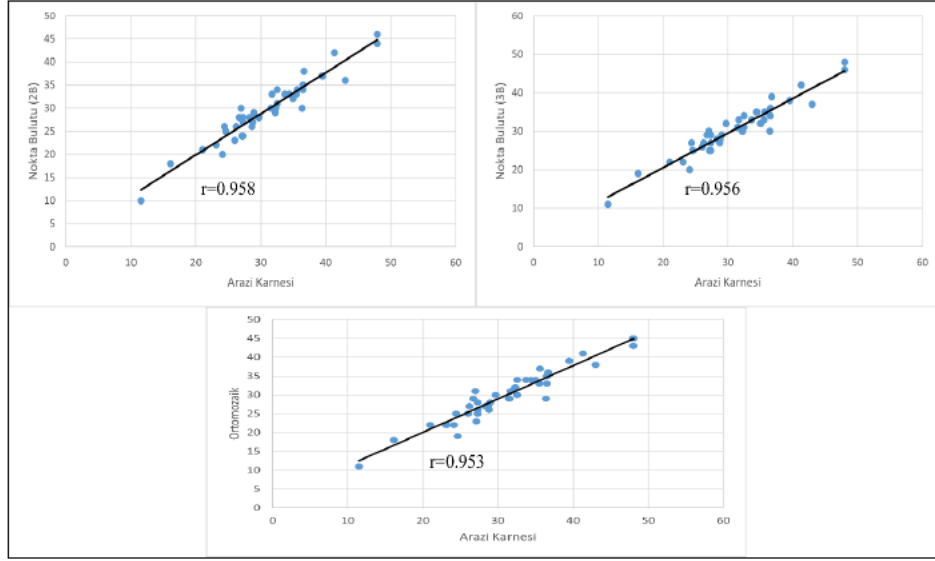
Dip kütük çapı ölçüm sonuçlarına ait tanımlayıcı bazı istatistik sonuçları ele alındığı zaman (Tablo 1) arazi ölçümlerine en yakın değerlerin 3 boyutlu nokta bulutunda yapılan ölçümlerdeki sonuçlara ait olduğu görülmektedir. Ortalama ve toplam değerler dikkate alındığı zaman ise en başarılı 2. sonuç ortomozaik üzerinde yapılan ölçümlere ait olmakla birlikte 2 boyutlu nokta bulutundan elde edilen ölçüm sonuçları da oldukça yakın sonuçlar göstermiştir. Çarpıklık ve basıklık değerlerinin tüm ölçümlerde 1.5 ile -1.5 arasında olması ve dolayısıyla ölçüm sonuçlarının normal bir dağılım gösteriyor olması ise dikkat çeken bir diğer husustur (Tabachnick ve Fidell, 2013). Ayrıca yapılan Kolmogorov-Smirnov dağılım testiyle de ölçümlerin normal dağılım gösterdiği görülmüştür (%95 güven düzeyinde  $p>0.05$ ).

Tablo 1. Ölçüm sonuçlarının tanımlayıcı istatistikleri (n=40)

	Arazi Karnesi	Ortomozaiik	Nokta Bulutu (2B)	Nokta Bulutu (3B)
Ortalama	30.9	29.8	29.6	30.4
Standart Sapma	7.5	7	7	7
Basıklık	0.89	0.53	1.16	1.35
Çarpıklık	0.07	-0.15	-0.07	0.08
Aralık	36.5	34	36	37
En Küçük	11.5	11	10	11
En Büyük	48	45	46	48
Toplam	1237	1190	1184	1215

Çalışmada uygulanan bir diğer test ise değişkenler arasındaki ilişki, bu ilişkinin yönü ve şiddeti ile ilgili bilgiler sağlayan Pearson korelasyon testi olmuş ve elde edilen ölçüm sonuçlarına uygulanarak arazi ölçümleri ile bilgisayar ortamında yapılan ölçümlerin ilişkisi incelenmiştir (Şekil 3). Buna göre en büyük korelasyon değeri 2 boyutlu nokta bulutu ölçümünde, 2. olarak 3 boyutlu nokta bulutu ölçümünde ve en küçük değer ise ortomozaikte gerçekleştirilen ölçüm sonuçlarında görülmüştür. Buna rağmen tüm ölçümlerin arazi karnesi ile güçlü bir pozitif korelasyona sahip olması dikkat çekmektedir.

Şekil 3. Fotogrametrik ölçümlerin arazi karnesiyle olan korelasyon ilişkisi



Çalışmada son olarak ise eşleştirilmiş örneklem T-testi uygulanmıştır. Uygulanan bu teste göre 3 boyutlu nokta bulutu ölçümünden elde edilen sonuçların arazi karnesine göre anlamlı bir farklılık göstermediği görülmüştür (%95 güven düzeyinde  $t=1.59$  ve  $p=0.12$ ). 2 boyutlu nokta bulutu ölçüm sonuçları ve ortmozaikten elde edilen ölçüm sonuçlarının ise arazi ölçümleri ile anlamlı bir farklılık gösterdiği anlaşılmaktadır (%95 güven düzeyinde  $p<0.05$ ).

#### 4. Tartışma ve Sonuç

Bu çalışmadan elde edilen bulgular ile; İHA fotoğraflarından üretilecek fotogrametrik verilerden dip kütük ölçümlerinin başarılı bir şekilde gerçekleştirilebildiği görülmüş, İHA fotogrametrisinin çap ölçümü gibi hassas ölçümlerde kullanılabilir olduğu ortaya konulmuştur. Ayrıca dikili ağaç gövde hacim tablolarına benzer bir yaklaşımla dip kütük çapına bağlı olarak toprak altı biyokütlenin hesaplanabildiği tabloların üretilmesi halinde İHA'ların toprak altı (dip kütük ve kök) biyokütle envanter çalışmalarında çok büyük bir kolaylık sağlayacağı düşünülmektedir. Bunun yanında nokta bulutu üzerinden gerçekleştirilen çap ölçümlerinin ortomozaik üzerinde gerçekleştirilen ölçümlere kıyasla daha doğru sonuçlar verdiği de anlaşılmıştır. Arazi ölçümlerine kıyasla daha pratik ve daha az maliyetli olan İHA fotogrametrisinin ormancılık ve diğer birçok meslek disiplinince başarıyla kullanılabileceği düşünülmekte, biyokütle envanteri gibi yüksek hassasiyet gerektiren birçok ormancılık faaliyetinde İHA'lardan yararlanılması gerektiği bu çalışmayla vurgulanmaktadır.

#### 5. Kaynaklar

ArcGIS (2022). <https://www.arcgis.com/index.html> (Son erişim tarihi: 08.05.2022)

Balcı, İ., Çoban, H. O. & Eker, M. (2000). Coğrafi Bilgi Sistemi. SDÜ Orman Fakültesi Dergisi, 1 (A), 115-132.

Buğday, E. (2016). Ormancılıkta Üretimin Planlaması ve Hassas Ormancılık Anlayışı. Anadolu Orman Araştırmaları Dergisi, 2(1-2), 54-57.

Buğday, E. (2019). Orman Yönetiminde İnsansız Hava Aracı Uygulamaları. II. International Eurasian Conference on Biological and Chemical Sciences. June 28-29, Ankara, 1617-1621.

Çoban, H., O. (2000). Bilgisayar Destekli Konusal Orman Haritalarının Üretilmesi (Yüksek Lisans Tezi, Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü).

Çoban, H., O. (2006). Uydu Verileri İle Orman Alanlarındaki Zamansal Değişimlerin Belirlenmesi (Doktora Tezi, İstanbul Üniversitesi Fen Bilimleri Enstitüsü).

Çoban, H. O. & Eker, M. (2009). Srtm Verileri İle Bazı Topoğrafik Analizler: Isparta Orman Bölge Müdürlüğü Örneği. SDÜ Orman Fakültesi Dergisi, 2(A), 76-91.

Çoban, H. O. (2016). Türkiye'nin Yer Gözlem Uydu Sistemleri ve Ormancılık Uygulamalarında Kullanılabilirliği. Türkiye Ormancılık Dergisi, 17(1), 99-107.

Çoban, H. O., Eker, M., Durgun, H. (2021). Relations between topographic variables and forest ecosystems in Isparta Regional Directorate of Forestry. International Conferences on Science and Technology (ICONST-LST-2021), September 8 to 10, Budva, Montenegro, pp. 4.

DJI (2022). Mavic Air User Manual Online. <https://dl.djicdn.com/downloads> (Son erişim tarihi: 10.05.2022)

Eker, M., Çoban, H. O., Korkmaz, M., Alkan, H., Özçelik, R., Gürlevik, N. & Acar, H. H. (2013). Ormancılıkta Hasat Artıklarının Tedarik Edilebilirliğinin Araştırılması.

Eker, M. (2014). Trends in woody biomass utilization in Turkish forestry. Croatian Journal of Forest Engineering: Journal for Theory and Application of Forestry Engineering, 35(2), 255-270.

Eker, M. & Özer, D. (2015). Üretim İşlerinde Hassas Ormancılık Yaklaşımı: Kavramsal Çerçeve. Türkiye Ormancılık Dergisi, 16(2), 183-194.

Eker, M. & Spinelli, R. (2018). Labor-intensive techniques for recovering energy biomass from forest tending operations. Biomass and Bioenergy, 115, 223-230.

Eker, M., Spinelli, R. & Gürlevik, N. (2018). Determining the quantity and quality of biomass obtained from the thinning of Turkish red pine stands. Biofuels, Bioproducts and Biorefining, 12(1), 12-21.

IOBM (2021). Isparta Orman Bölge Müdürlüğü Amenajman Planı.

Menteşoğlu, B. E. (2016). Düşük Maliyetli İnsansız Hava Araçlarının (İHA) Ormancılık Uygulamalarında Kullanımı. (Yüksek Lisans Tezi, İstanbul Üniversitesi, Fen Bilimleri Enstitüsü).

Microsoft (2022). <https://www.microsoft.com/tr-tr/microsoft-365/> (Son erişim tarihi: 08.05.2022)

OGM (2021). 2021 Türkiye Orman Varlığı. <https://www.ogm.gov.tr/tr/ormanlarimiz/Turkiye-Orman-Varligi> (Son erişim tarihi: 10.07.2022)



Öztürk, I. (2016). Biofuel, sustainability, and forest indicators' nexus in the panel generalized method of moments estimation: evidence from 12 developed and developing countries. *Biofuels, Bioproducts and Biorefining*, 10(2), 150-163.

Pix4d (2022). <https://www.pix4d.com/> (Son erişim tarihi: 08.05.2022)

Şafak, İ. & Gül, A. U. (2012). Orman Mühendislerinin Orman İşlevlerine ve Ormancılık Faaliyetlerine Verdikleri Önem Düzeylerinin Değerlendirilmesi. *SDÜ Orman Fakültesi Dergisi*, 13, 123-133.

Schandl, H., Hatfield-Dodds, S., Wiedmann, T., Geschke, A., Cai, Y., West, J., ... & Owen, A. (2016). Decoupling global environmental pressure and economic growth: scenarios for energy use, materials use and carbon emissions. *Journal of cleaner production*, 132, 45-56.

South (2022). Galaxy G6 Measuring System User Manual Online. <https://globalgpssystem.com/wp-content/uploads/2020/03/Galaxy-G6-Measuring-System-User-Manual.pdf> (Son erişim tarihi: 08.05.2022)

SPSS (2022). <https://www.ibm.com/tr-tr/products/spss-statistics> (Son erişim tarihi: 08.04.2022)

Tabachnick, B. G. & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.), Boston: Allyn and Bacon.

USGS (2022). Shuttle Radar Topography Mission (SRTM) Data Download. United States Geological Survey, <https://earthexplorer.usgs.gov/> (Son erişim tarihi: 22.05.2022)

Yomralıoğlu, T. (2000). *Coğrafi Bilgi Sistemleri: Temel Kavramlar ve Uygulamalar*. Seçil Ofset Basımevi.

Yurtseven, H., Akgül, M., Demir, M., Öztürk, T. & Gülci, S. (2015). İHA Verileri Üzerinden İbrelili Meşcelerde Obje Tabanlı Sınıflandırma Teknikleri İle Ağaç Bireyi Bazında Verilerin Elde Edilmesi. IV. Orman İnşaatı-Transportu Ve Teknolojileri Çalıştayı Ve Üretim İşlerinde Hassas Ormancılık Sempozyumu. 6 Mayıs- 4 Haziran, Kastamonu, 35-45.

## **Heat Island Effect and Material Solution in Settlements**

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**Abstract:** Urban heat islands are decreasing the quality of life day by day with the impact of global climate change. Settlements, which cover only 0.03% of the earth's surface, host more than half of the total population. The heat island effect occurs according to many parameters that develop with human activities. Reduction of vegetation cover, replacement of vegetation cover by hard ground, high energy use, dense built-up areas, the effect of traffic, building geometry and height that prevent air movements, and building materials are among the parameters that can be counted. The aim of the study is to address the effect of material on the building island. By evaluating the material properties together with the location, placement and density of the building, principles to reduce the heat island effect are tried to be developed.

**Keywords:** Heat island, material, building geometry, hard floor.

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### **INTRODUCTION**

The "urban heat island effect" is defined as the increase in the night temperature in urban areas as a result of the absorbed daytime radiation being released into the air during the night. Urban heat islands have a temperature several degrees higher than the surrounding rural areas. In parallel with global climate change and the intensity of urbanization, it negatively affects the quality of life day by day. It is known that greenhouse gas emissions resulting from human activities are among the main causes of global climate change and emission values increase with urbanization (IPCC, 2013). The use of fossil fuels, reduction of forests and vegetation that store carbon dioxide, industrial activities, chimneys of working and housing areas, air conditioners are the main sources that increase greenhouse gases (Orhan, 2021). Although urban settlements cover an area of 0.03 on the earth, they host 0.55 of the world population. This ratio is expected to increase to 0.68 by 2050 (U.N. 2018, URL 1). The aim of meeting the needs of the dense population is reflected in the density of construction in parallel. The interaction of electromagnetic radiation from the sun on the earth's surface with artificial topography occurs differently from rural rates, and some of the radiation is absorbed by the hard ground materials of dense and tall buildings and then converted into heat. Surface materials that heat up during the day retain heat energy in duct spaces where air ducts are closed and air movement is restricted, and reflect it at night. Since the reflection rate will be high in open spaces, the heated space cools down more quickly (Tozam, Karaca, 2018). Depending on the temperature increasing in direct proportion to the building density, the particles start to rise, and with the cooling of the air, they tend to collapse by moving horizontally towards the periphery (Göksu, 1993). Accordingly, dust clouds and heat islands are formed on the settlement in the

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form of dense fanus in the center and less dense fanus in the peripheries (Yüksel, Yılmaz, 2008) (Figure 1.).



Figure 1. Urban Heat Island

Tozam stated that urban heat islands have different characteristics in different layers of the atmosphere, so they can be considered as "urban atmospheric heat island" and "urban surface heat island", and urban atmospheric heat island can be divided into "urban cover layer" and urban boundary layer (Tozam, Karaca, 2018) (Figure 2).

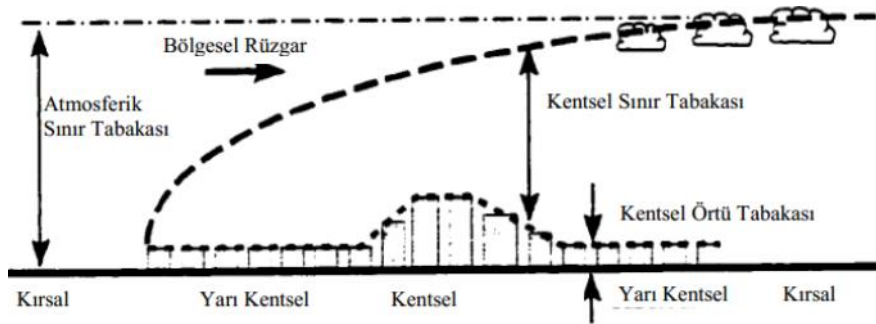


Figure 2. Urban Boundary and Urban Cover Layer (Tozam, Karaca, 2018)

The heat island effect can be evaluated depending on many parameters. Parameters such as the replacement of vegetation with hard ground, the increase in dark colored impermeable surfaces instead of green texture, the construction of buildings high and dense enough to prevent air flow, high energy use in settlements, vehicle density in traffic, albedo values of materials used in the built environment can be listed first... In addition, the heating temperature, colors and texture properties of surface materials are among the important effects on the heating of urban surfaces (Tozam, Karaca, 2018).

In the literature research, it was observed that the materials used in the building envelope have an important role in heat island formation, and there are few studies on ecological materials that will reduce the heat island effect. Within the scope of the study, heat island forming parameters, their effects on living life and measures to reduce the heat island effect were investigated. The materials used in the built environment, especially the materials forming the building envelope, were examined for the specified purpose.

### Urbanization and heat island

Open and green areas are important biotopes that regulate air movements and microclimate in urban settlements (Irmak, Avcı, 2019). While artificial areas that create heat island effect are increasing due to human activities, open and green areas are decreasing (Moradi, Tamer, 2017). Green areas and forests also play an important role in reducing the heat island effect by capturing carbon dioxide in the air due to human activities and producing oxygen. Dark colored surfaces that replace green areas absorb light rather than reflect it. The increase in impermeable hard ground prevents the passage of surface rainwater under the soil and reduces the efficiency of water. In rural areas, evaporation keeps the environment cooler, especially in forested areas,

as it takes heat from the environment (Suri, 2020). In urban areas, on the other hand, energy remains unconverted into latent heat and causes an increase in heat (Gallo, 1989). Therefore, unplanned growth of cities and industrialization affect the water cycle by creating Urban Heat Island (UHI) and play an important role in climate change (Yüksel, Yılmaz, 2008). Vital water resources evaporate more with the effect of warming. Forested areas and water resources occupied by settlements are anthropogenic impacts on the quantity, quality and regime (yield) of water and cause water scarcity (Suri, 2000). Climate change due to human actions is among the biggest vital problems on a global scale (Orhan, 2021). Radiation from the sun is absorbed by dark colored floor coverings and building surfaces and re-emitted after sunset. Large buildings slow down the speed of prevailing winds due to friction. Therefore, the cooling power of the wind is reduced during hot seasons (Hough, 1984). Narrow streets between tall buildings that block air movements delay the time of heat loss (Kum, 2006), and the heat energy retained during the day dissipates during the night, increasing the temperature (Figure 3).

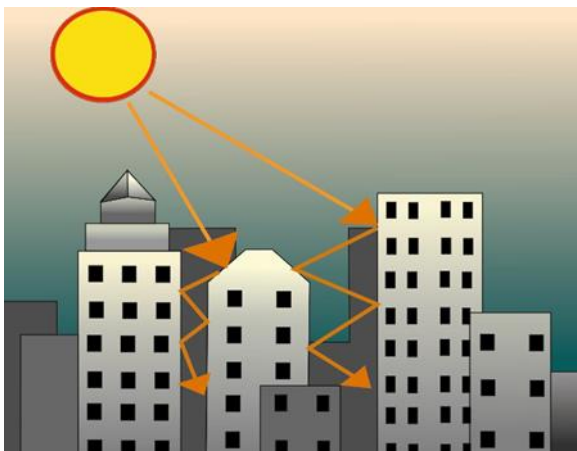


Figure 3. Heat Absorption in a Tall Building/Narrow Street (Güneş et al., 2021)

This situation, which causes a 2-4 degree temperature difference in urban areas, requires additional energy demand for cooling. It is stated that every 0.6 degree increase in air temperature increases energy demand by 1.50, 2.00 (Öztürk, 2021). Air conditioners used to cool down transfer heat to the outdoors while cooling the indoors. The heat energy emitted from vehicle engines, exhausts and industrial plants used for human activities are also among the factors that create urban heat islands. Buildings store heat according to their geometry and material properties. While solar radiation is reflected and dispersed in open areas, buildings in cities store the incoming heat (Gönençgil, 2011).

### **Effects Of Heat Island On Human Health**

Depending on global climate change, urban heat islands affect human health directly or indirectly. In heat islands growing in parallel with the increase in urban settlements, temperature increase and air pollution directly affect human health. Extreme weather events such as storms, tornadoes, hailstorms and floods can directly cause deaths and the spread of infectious diseases. Emissions in the air increase with temperature and humidity. The increase and recurrence of many health problems is directly proportional to temperature. With increasing temperature, more energy is needed to maintain body heat balance. An increase in body temperature above 41 degrees Celsius can lead to health problems such as heatstroke, fever, dry skin, high pulse rate, and increasingly to seizures. It also increases the severity of chronic diseases such as asthma, diabetes, influenza, pneumonia, and cardiovascular diseases. During periods of high

temperatures, the resistance of children and the elderly with such diseases is reduced (Hardy, 2003). Air pollution also poses a significant risk for respiratory diseases such as allergies (Figure 4).

	HEALTH EFFECTS	POSSIBLE HEALTH PROBLEM	HIGH RISK GROUPS
HIGH TEMPERATURE	<ul style="list-style-type: none"> <li>Abnormally high body temperature</li> <li>Emergence and increase of disease-causing organisms</li> <li>Negative impact on air quality</li> </ul>	<ul style="list-style-type: none"> <li>Dehydration of the body</li> <li>Heat-related disorders such as heat stroke, fainting, cramps, rash, etc.</li> <li>Increasing asthma, COPD, allergies, etc.</li> <li>Increased respiratory and cardiovascular problems</li> <li>Increase in diseases carried by vector parasites</li> </ul>	<ul style="list-style-type: none"> <li>Little children</li> <li>The elderly</li> <li>People with chronic airway disease and long-term treatment</li> <li>People living in places with polluted air and poor ventilation</li> <li>Outdoor sports</li> <li>Those who have to take medication all the time</li> </ul>

Figure 4. High Temperature Related Diseases and Risk Groups (Prepared according to the table organized by WHO (WHO, 2004).

### Precautions Against Urban Heat Islands

In the majority of today's cities, there are pollutant sources that directly affect human health, such as air pollution and heat islands. A livable environment for human and environmental health requires sustainable, planned development and improvement. In planning at all levels, a holistic planning approach to prevent air-water-soil pollution is of great importance. For this reason, analyzing underground and aboveground natural resources at macro and micro scales and making settlement decisions according to sustainability criteria are among the basic approaches (Suri, 2018). In this context;

- Developing comprehensive policies to prevent air-water-soil pollution,
- Detailed examination of the relationship between environmental pollution and health,
- Strategic approaches that can be summarized under main headings such as "sustainable urbanization and construction", "regional development planning", "environmentally sensitive urbanization" (SDGs, 2019) can be considered among the basic practices that will provide direct solutions to health problems caused by dense urbanization and urban heat island.

Urban heat island effects can also be reduced through measures to be considered in local planning and urban design projects. At the planning stage, decisions such as population and building densities, building-parcel-road relations and building geometry, duct spaces providing air movement, type and location of functional areas, occupancy-vacancy ratios, open and green areas proportional to the population, etc. can be taken to guide urban design projects. In urban design projects; road sections whose routes are determined in the plan can be detailed, functional areas can be designed in integrity to establish the building-parcel-road relationship, and the type of surface covering materials can be detailed. These measures can be listed as follows.

- Compact urban planning to reduce the distances between functional areas,
- Paying attention to the balance of hard and soft ground in building installation and open areas, with vegetation, regulating the regime of precipitation coming to the surface, cleaning water, increasing the infiltration capacity under the soil,
- Canopy shading with plants in large areas such as parking lots, etc. Another solution is to provide energy to the surrounding islands with photovoltaic shades (Golden et al. 2006),
- Planting on building facades and roofs, intermediate floors of high-rise buildings,
- Reducing the heat island effect by diversifying tree species (Öztürk, 2021)
- To make planning decisions that prioritize pedestrian and non-motorized transportation,
- Safe, shaded and sheltered solutions that encourage pedestrian and non-motorized transportation routes to be used in different seasons and times,
- Ensuring green continuity on roads, using permeable surfacing materials,
- Ensuring integrity between the landscaping of functional areas and road green areas,
- Accessible, safe, affordable and comfortable solutions that encourage public transportation,
- Materials with high sunlight reflectivity (Konopacki et al. 1998),
- Choose materials used on the surface in light colors (Wong, 2002),
- Using ecological materials with low heat transfer in buildings that will not be affected by heat differences in hot and cold seasons (Figure 5)

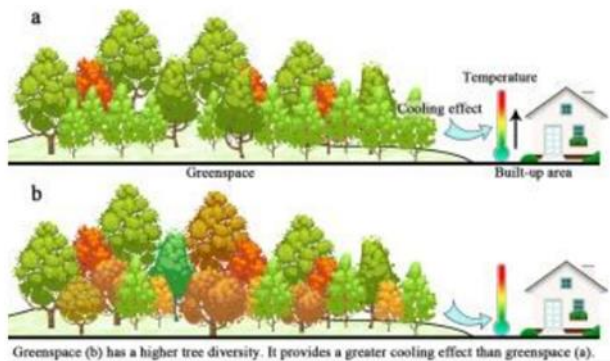


Figure 5. Various Uses of Tree Species (Öztürk, 2021)

### Building Envelope and Flooring Materials

The material used on urban surfaces interacts directly with solar radiation. Physical and chemical properties of the material, heating heat color, heat absorption, albedo properties affect the heat island differently. The material also stores or reflects heat depending on where it is used horizontally and vertically. Heat values will differ according to the floor, facade and roof, sunlit and shaded surface, sunbathing time, low or high elevation and wind conditions where the same material is used. Therefore, the physical and chemical properties of the material should be considered together with other parameters such as location, direction, air corridors, etc.

The heat retention and reflection capacity of materials is related to color, surface gloss, porosity, texture as well as physical and chemical properties. Absorption increases in direct proportion with dark colored building materials (Kum, 2006). In Figure 6, it is symbolically shown that the reflective white coating applied on the face of the brick wall used on the facade reduces the heat energy of the material. In a similar application by EPA, it was found that the reflective white surface reduces the heat by 3-5 degrees compared to the brick part (EPA, 2009).

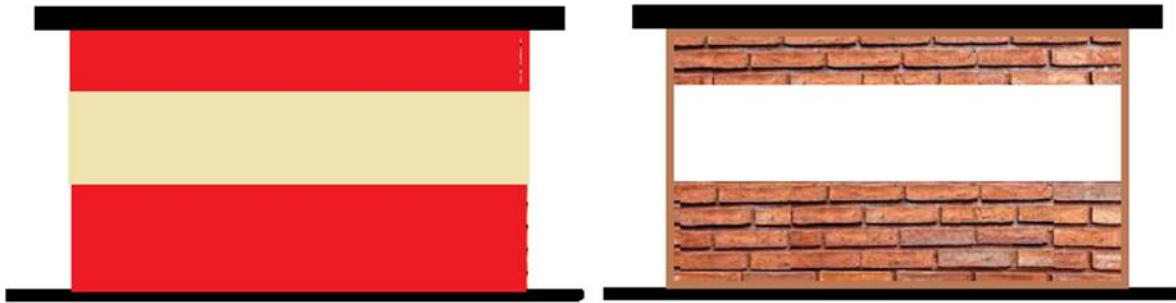


Figure 6. Albedo Effect by Material on the Facade (Adapted from EPA, 2012)

Dark colored rough surface materials such as asphalt, glass, concrete and stone absorb and store heat. For example, the reflectivity of traditional materials such as asphalt and concrete between 0.05 and 0.40 means that energy is retained at a rate of 0.95 to 0.60. Low albedo values in urban areas increase the temperature. Materials with high reflectance coefficients reduce surface temperature, but reflectance rates can change over time, depending on the type and age of the material (EPA, 2009). In the long term, this also needs to be assessed.

Permeable materials that allow air, water and water vapor to enter the gaps are among the alternative solutions for heat islands (Figure 7).



Figure 7. Permeable floor coverings (URL 1, URL 2)

Permeable asphalt, concrete and grid pavements help to reduce surface temperature due to evaporation as well as conveying rainwater to the groundwater table (Ferguson, 2005). Permeable pavements also prevent problems caused by puddles on roads as they also provide water drainage. The base temperature under permeable concrete pavements appears to remain similar to 'cooler' surface treatments such as soil and lighter concrete, even at higher surface temperatures. The heat transfer rate of permeable concrete with a total porosity of 23% was found to be approximately 59% of the heat transfer rate of conventional concrete for similar conditions. The use of permeable concrete instead of impermeable pavement surfaces can be considered a viable method to avoid increasing urban heat island effects and at the same time benefit from stormwater management (Haselbach, 2009).

The use of high energy and aggregates in the production of concrete consumes natural resources. As a solution to the high heat absorption of concrete, biocomposite building materials produced with plant-based aggregates and fibers containing a small amount of mineral aggregates can be used. The stalk of the hemp plant can be counted among the examples made for this purpose (Şahin, 2022) and the material produced in this way is defined as hemp concrete (HempCrete). The material with low thermal conductivity and high heat capacity (Arnaud,

Gourlay, 2012) has a high capacity for thermal insulation. When used as a filler between frame elements on the building facade, it can save energy used in heating and cooling, as well as reduce the heat island effect when designed with reflective surfacing materials. The use of fibrous plant materials in combination with certain binders to reduce the thermal effect has been discussed in many studies. Many plant fibers such as palm, walnut, barley, etc. can be used to make composite building materials. As a result of some studies, it has been stated that the greenhouse gas effect is reduced with the reduced thermal effect as a result of the use of plant fibers with the addition of clay (Oukarrouch et al., 2019).

On surfaces where the sun comes perpendicularly, the material can retain heat more, so surface material can be designed where the sun can come at an oblique angle. Reflective cladding materials can increase visibility at night, saving energy to be spent on lighting when it gets dark (US Dep., 2008).

## **CONCLUSION**

The heat island effect, which increases in direct proportion to urbanization, is one of the leading global problems that threaten living life. Its impact can be reduced with holistic approaches at global, national and local scales. The solution of socio-economic problems such as the destruction of natural areas as a result of human activities, uncontrolled shrinkage of forests, unplanned agglomeration of settlements and population, unconscious use and excessive consumption of resources, inequality in income distribution between regions, and lack of education requires coordination on an international scale. At the national level, it is imperative to develop holistic, sustainable strategies within the hierarchy of plans and to give direction to the lower levels. Energy is a resource needed at every stage of life. Therefore, sustainable clean energy use should be among the primary objectives of plans at all levels. Keeping cities away from overcrowding and adopting regional development are the first steps to ensure efficiency in resources. The compactness of cities will reduce the use and duration of motor vehicles, while pedestrians and bicycles will provide environmentally friendly access and reduce the level of pollution from transportation. The location of buildings, building-structure, building-parcel, building-road relationship can be designed according to the geometry that minimizes energy demand in hot and cold seasons. In less dense cities, the balance between hard and soft ground can be maintained, and building heights and distances can allow air passages. Covering the hard ground with permeable materials will facilitate access to the water needed by the plants in the soft ground. At the same time, the heat that the water evaporating into the substrate takes from its surroundings as it evaporates will reduce the heat on the surface. Ensuring the continuity of the planting on soft ground and roadsides without tearing them apart from each other contributes positively in terms of filtering emissions in the air and creating air corridors. It will be beneficial to choose planting and mixed species that collect greenhouse gases ( Öztürk, 2021). Surface materials that do not absorb heat will minimize the impact of urban heat islands by reducing their intensity. Water-permeable flooring materials will also ensure the continuity of greenery. Planting on rooftops, which are most exposed to the sun, not only provides thermal insulation to the building, but also cleans the air and keeps it cool. If well organized, it can also be used for urban agriculture and provide economy.

With plans, projects and applications based on interdisciplinary analyses that focus on people; solutions that reduce energy use, provide clean air by reducing the greenhouse gas effect, target water efficiency, reduce the amount of waste by using long-lasting materials, materials used on the surface; long-lasting, economical, low-maintenance, light-colored, light-colored, highly



reflective, permeable, ecological features, and reducing the effects on urban heat islands can be developed by selecting materials suitable for the building location-direction.

## REFERENCES

- Arnaud, I., Gourlay, E., 2012, "Experimental study of parameters influencing mechanical properties of hemp concretes," *Construction and Building Materials*, vol. 28, no. 1, 50-56,
- EPA, 2012. U.S. Environmental Protection Agency. 2012. "Cool Pavements." In: *Reducing Urban Heat Islands: Compendium of Strategies*.
- Ferguson, B., 2005, *Porous Pavements*, Pub. Location Boca Raton, Imprint CRC Press
- Gallo, K. P., 1989, Use of NOAA, AVHRR Data for Assesment of The Urban Heat Island Affect. U.S.A.: *Journal of Applied Meteorology*, No: 32.
- Golden, J.S. Carlson, J., Kaloush, K., Phelan, P., 2006, A Comparative Study of the Thermal and Radiative Impacts of Photovoltaic Canopies on Pavement Surface Temperatures. *Solar Energy*. 81(7): 872-883
- Göksu, Ç., 1993, *Sun and City*. METU Faculty of Architecture Publications, Ankara,
- Gönençgil, B. 2011, 'The Effects of Urbanization on Temperature Trends and the Concept of Urban Heat Island, *Physical Geography Research, Systematic and Regional*. Prof. Dr. M. Yıldız Hoşgören Memorial Armağan, Turkish Geographical Society Publication, No:6, pp. 127-136, Istanbul
- Güneş, C., Pekkan, E., Tün, M., 2021, Investigation of Urban Heat Island Effects in University Campuses Located in Eskişehir City Center through LANDSAT-8 Satellite Images, *National Research Journal of Environmental Sciences*, Issue 4(1): 22-32
- Haselbach, L. 2009, *Pervious Concrete and Mitigation of the Urban Heat Island Effect*. Transportation Research Board 88th Annual Meeting
- Hough, M., 1984, *City Form and Natural Process*. Cromm Helm, p. 201, London
- Irmak, M. A., Avcı, B., 2019, Investigation of Green Space Policies of European Green Capitals, *Nevşehir Journal of Science and Technology*, 8(Enar Special Issue) 1-19
- IPCC 2013, *Climate Change 2013, The Physical Science Basis, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, England
- Konopacki, S., Gartland, L., Akbari H. and Rainer, L., 1998, *Demonstration of Energy Savings of Cool Roofs, A Report Prepared for the U.S. Environmental Protection Agency, Heat Island Project*, University of California, Berkeley,
- Kum, G., 2006, *Urban Heat Island Study in Istanbul Using Göztepe, Kandilli and Şile Temperature Data*. p.4, Istanbul,
- Kum, G., Kılıç, S., 2013, The Effect of Urbanization on Temperature and Precipitation Parameters: The Case of Gaziantep. *Journal of Social Sciences*, Issue 6, p.22, Kilis.
- Moradi, M., Görer Tamer, N. (2017). The Impact of Urban Growth on Local Climate Change in the Case of Bursa. *Journal of Planning*, 27(1), 26-37.
- Orhan, O., 2021, Investigation of the Effect of Urban Growth on Ground Surface Temperature in Mersin Province, *Geomatics Journal - 2021*; 6(1); 69-76

- Ouakarrouch, M., El Azhary, K., Mansour, M., Laaroussi, N., Garoum, M., 2019, Thermal study of clay bricks reinforced by sisalfibers used in construction in South of Morocco, Energy Reports
- Öztürk, M., 2021, Urban Heat Island Effect, Independent Turkish, May 1, 2021
- SDG, 2019, Presidency of the Republic of Turkey, Strategy and Budget Directorate, Sustainable Development Goals Assessment Report 2019
- SURİ, L., 2018, Natural Threshold Evaluation Criteria in Planning, Istanbul Commerce University Journal of Science and Technology, 17(34), 47-71
- SURİ, L., 2020, Criteria For Determining Water Basin Boundary And The Importance Planning Decisions In Sustaing Water Resources, Fresenius Environmental Bulletin, 29(5)
- Şahin, M., 2022, Evaluation of Industrial Hemp Stalk Waste in Hemp Concrete Production with Different Binders, Düzce University Science and Technology Journal, 10 (2022) 233 – 243
- Tozam, İ., Karaca, Ü. B., 2018, Urban Heat Island Effect and Cool Roofs 9th National Roof & Facade Conference 12 - 13 April 2018 T.C. Istanbul Kültür University
- United Nations 2018 Revision of World Urbanization Prospects 16 May 2018 URL 1- <https://www.un.org/development/desa/publications/2018-revision-of-world-urbanization-prospects.html>
- URL 1. <https://specificationproductupdate.com/2017/09/22/growing-concerns-grass-concrete-limited/>
- URL 2, <https://www.yesilodak.com/betona-alternatif-8-yesil-yapi-malzemesi>
- U.S. Department of Transportation, Federal Highway Administration. European Road Lighting Technologies. International Technology Exchange Program: September 2008
- World Health Organization (WHO), 2004, Heat-waves: Risks and Responses. Health and Global Environmental Change (Series, No. 2). Geneva: German Weather Service (DWD). London School of Hygiene and Tropical Medicine and WHO/Europe
- Wong, N. H., 2002, A Study of the Urban Heat Island in Singapore, A Report of Heat Island Project, National University of Singapore
- Yüksel, Ü. D., Yılmaz, O. 2008, Detection and Evaluation of Urban Heat Island Effect in Ankara City in Summer Based on Remote Sensing and Meteorological Observations. Gazi University Journal of Engineering-Architecture Faculty, 23(4)

## **The Effect of Arbuscular Mycorrhizal Fungi on Walnut Production / Arbüsküler Mikorizal Fungusların Ceviz Üretimine Etkisi**

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**Abstract:** Walnut trees are among the most ecologically and economically important woody plant species in the temperate regions of the northern hemisphere. These trees, which are generally grown for timber and fruit production, are also ornamental plants frequently used in parks and gardens. Planting success of walnut seedlings is mainly determined in terms of root system morphology and nutritional status of seedlings. For all these reasons, rhizosphere conditions are critical for plant performance. Among the reasons for not obtaining stable results in walnut production are the fact that the high quality walnut varieties are not used in regions with suitable ecological conditions, adaptation problems, lack of certain standards, not knowing the biology of the species well, planting, irrigation, fertilization and harvesting errors, as well as walnut diseases and pests. All these are among the important factors affecting production and yield in walnut cultivation. Walnut trees can associate with soil-borne arbuscular mycorrhizal fungi (AMF), which are obligate biotrophs. In this association, the host plant reaches the soil mineral nutrients provided by the fungus, while the fungus obtains the carbon compounds produced photosynthetically by the plant. The beneficial effect of symbiosis between AMF and woody plants on seedling quality and field conditions has been known for many years. In this study, a detailed literature review was conducted on the effect of mycorrhizal fungi on walnut production. Currently available information shows that early inoculation with AMF improves seedling quality and planting success of planted walnut seedlings by increasing the number of lateral roots and plant phosphorus uptake, depending on the fungus and host.

**Keywords:** *Juglans regia*, agroforestry, symbiosis, mycorrhiza.

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**Özet:** Ceviz ağaçları, kuzey yarımkürede bulunan ılıman bölgelerde ekolojik ve ekonomik açıdan en önemli odunsu bitki türleri arasında yer almaktadır. Genel olarak kereste ve meyve üretimi için yetiştirilen bu ağaçlar aynı zamanda park ve bahçelerde sıklıkla kullanılan süs bitkileridir. Ceviz fidanlarının dikim başarısı temel olarak kök sistemi morfolojisi ve fidanların besin durumu açısından belirlenmektedir. Tüm bu nedenlerle rizosfer koşulları bitki performansı için kritik önem göstermektedir. Ceviz üretiminde istikrarlı sonuçların alınamamasının sebepleri arasında üstün nitelikli olarak belirlenen ceviz çeşitlerinin uygun ekolojik koşullara sahip bölgelerde kullanılmaması, adaptasyon sorunları, belirli standartların olmaması, türün biyolojisinin iyi bilinmemesi, dikim, sulama, gübreleme ve hasat hataları ile birlikte ceviz hastalık ve zararlıları gelmektedir. Tüm bunlar ceviz yetiştiriciliğinde üretimi ve verimi etkileyen önemli faktörler arasında yer almaktadır. Ceviz ağaçları, zorunlu biyotroflar

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olan toprak kaynaklı arbusküler mikorizal funguslar (AMF) ile ilişki kurabilmektedir. Bu birliktelikte konukçu bitki fungus tarafından sağlanan toprak mineral besinlerine ulaşırken, fungus ise bitki tarafından fotosentetik olarak üretilen karbon bileşiklerini elde etmektedir. AMF ve odunsu bitkiler arasında gerçekleşen simbiyozun fidan kalitesindeki ve arazi şartlarındaki faydalı etkisi uzun yıllardan bu yana bilinmektedir. Bu çalışmada, mikorizal fungusların ceviz üretimine etkisi hakkında detaylı bir literatür incelemesi yapılmıştır. Hâlihazırda mevcut bilgiler, AMF ile erken dönemde aşılamanın, fungusa ve konukçuya bağlı olmak üzere, bitkide yan köklerin sayısını ve bitki fosfor alımını artırarak plantasyonu yapılan ceviz fidanlarının fidan kalitesini iyileştirdiği ve dikim başarısını artırdığını göstermektedir.

**Anahtar sözcükler:** *Juglans regia*, tarımsal ormancılık, simbiyoz, mikoriza.

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## Giriş

Ceviz, *Juglans* cinsine ait, kışın yaprak döken yaklaşık 21 türe verilen genel isimdir. *Juglans* cinsi ağaçlar yaprak, çiçek ve meyve morfolojilerine göre Trachycaryon (*J. cinerea*), Rhysocaryon (black walnuts), Cardiocaryon (heartnuts) ve Dioscaryon (*J. regia*) olmak üzere dört bölümde sınıflandırılmaktadır. Cins çoğunlukla kuzey yarımkürenin ılıman ve subtropikal bölgelerine dağılmakla beraber, Orta Amerika ve Güney Amerika'nın batısındaki And Dağları boyunca birkaç türü yayılım göstermektedir. Ticari kullanım için yetiştirilen başlıca türler arasında *J. regia* L., *J. nigra* L., *J. hindsii* Jeps. ve *J. cinerea* L. bulunmaktadır. Cinsin tüm türleri meyve üretmekle beraber dünya çapında kabuklu yemiş üretimi için üstün meyve özellikleri ile en yaygın olarak bilinen tür *Juglans regia* (Anadolu cevizi, İran cevizi, İngiliz cevizi)'dir (Bernard ve diğ., 2018; Mortier ve diğ., 2020).

Ceviz ağaçları; yüksek kereste kalitesi, süs bitkisi özelliği ve meyve besin değeri ile hem insanoğlu hem de yaban hayatı için önemli bir doğal kaynaktır (Bender ve Bender 2005; Bernard vd., 2018). Ayrıca antioksidan ve antiinflamatuvar özelliklere sahip çok çeşitli flavonoidler, fenolik asitler ve polifenoller içermekte (Jaiswal ve Tailang 2017), kabuk veya yaprakları özellikle geleneksel tıpta dünya çapında kullanılmaktadır (Amaral ve diğ., 2004). Bu ağaçların doğrudan ekonomik faydaların yanı sıra, tarımsal ormancılık açısından da çok çeşitli ekosistemlere ekolojik katkı sağladığı bilinmektedir (Shukla ve diğ., 2012).

Ürün artışı, hastalıklara direnç, yüksek kereste kalitesi ve verimi ceviz üretiminde istenilen en önemli kriterler arasında yer almaktadır. Ceviz üretimi temelde biyolojik ve ekonomik açıdan verimli çeşitlerin çoğaltılmasına ve iyi yönetilmesine bağlıdır. Kaliteli meyve bahçelerini oluşturmak için fidanlıklarda hastalık zararlılara en iyi tolerans gösteren, gelişimi ve canlılığı iyi olan fidanları üretmek amacıyla seçilen nitelikli anaçlara aşılama işlemleri yapılmakta ve sonrasında belirli bir boyuta ulaşan fidanlar kullanılmaktadır (Verma, 2014).

Dikimden sonra yavaş büyüme, iyi gelişememe gibi sorunlar ceviz bahçelerinde en sık karşılaşılan sorunlardandır (Peixe ve diğ., 2015). Fidanların fidanlıklardaki beslenme durumu, bu fidanların dikimden sonra hayatta kalmaları üzerinde doğrudan etkilidir. Azot (N), fosfor (P) ve potasyum (K) gibi mineraller fidanların dikimden sonra gelişmelerini ve hayatta kalmalarını olumlu yönde etkilemektedir (Landis ve diğ., 1989). Odunsu türler üzerine yapılan çalışmalar, kök sistemi morfolojisinin fidan performansının en önemli belirleyicilerinden biri olduğunu göstermektedir. Kökün iyi çalışması anaç ve toprak kalitesine ayrıca teknik bakımlara bağlıdır. İyi gelişmiş kökler toprak matrisine demirleme sağlayarak besin alımını kolaylaştırmaktadır (Grossnickle ve MacDonald 2018; Mortier ve diğ., 2020).

Bu bağlamda, toprağın köklerle yakın etkileşim içindeki bölgesi olan rizosfer, bitki performansı için kritik öneme sahiptir. Bu bölge, toprak ve bitki sağlığı için hayati önem taşıyan karmaşık organizma topluluklarını bulundurmaktadır. Tüm bu nedenlerle, ekosistem fonksiyonlarının rizosfer mikrobiyomunu yöneterek geliştirilebileceği düşünülmekte ve çalışmalar gerçekleştirilmektedir (Bender ve diğ., 2016; Buee ve diğ., 2009).

Çoğu ağaç türünün kökleri, mikoriza adı verilen simbiyotik ilişkiler oluşturan özelleşmiş toprak kaynaklı funguslar tarafından kolonize edilmektedir (Kariman ve diğ., 2018). Ceviz ağaçları, zorunlu biyotroflar olan toprak kaynaklı AMF ile ilişki kurabilmektedir. AMF ve odunsu bitkiler arasında gerçekleşen simbiyozun fidan kalitesindeki ve arazi şartlarındaki faydalı etkisi uzun yıllardan bu yana bilinmektedir. Mikorizalı köklerin genel olarak bitki beslenmesini desteklediği, stresli olumsuz yaşam alanlarında dikilen bitkilerin adaptasyon ve yaşama oranlarını artırdığı, bitki verimini ve kalitesini etkilediği ve patojenleri biyolojik olarak kontrol altına alarak hastalıklara karşı direnç sağladığı bildirilmektedir. Bu çalışmada, mikorizal fungusların ceviz üretimine etkisi hakkında detaylı bir literatür incelemesi yapılmıştır.

### **Mikoriza ve Ceviz Fidanı Kalitesine Etkisi**

Mikoriza terimi, bitki kökleri ve mantarların simbiyotik birlikteliğini tanımlamak için ilk olarak Albert Bernhard Frank (Frank, 1885) tarafından kullanılmıştır. Bu birliktelikte, konukçu bitki mineral besinleri alırken, mantar fotosentetik olarak türetilmiş karbon bileşiklerini elde etmektedir (Brundrett, 1991; Harley ve Smith, 1983). Mikorizaların bilim insanları tarafından yapılan farklı sınıflandırma şekilleri olmakla birlikte günümüzde en sık kullanılan sınıflandırma şekli morfolojik ve fizyolojik özellikler temeline dayanan, Harley ve Smith (1983) tarafından oluşturulan ve yedi ayrı kategoriye içeren sınıflandırmadır. Farklı fungus ve konukçu bitki gruplarının şekillendirdiği bu mikorizal gruplar; arbusküler mikoriza, ektomikoriza, ektendomikoriza, erikoid mikoriza, arbutoid mikoriza, monotropoid mikoriza ve orkide mikoriza'dır. Bunlar arasında en yaygın görülen mikorizal birliktelikler arbusküler mikoriza, ektomikoriza, erikoid mikoriza ve orkide mikorizadır.

Mikorizal funguslar, köklerin yüzey alanını artırarak bitkilere özellikle N, P ve K gibi mineral besin maddelerinin alınmasında yardımcı olmakta ve bitkinin sağlıklı gelişiminde kilit bir rol üstlenmektedir (Marschner, 1993; Marschner, 1995; Smith ve Read 2008). Mikoriza oluşturmuş kökler yüksek toprak sıcaklıklarına, kuraklığa, toprak toksinlerine ve aşırı toprak asitliliğine karşı dayanıklılığını artırmakta, ayrıca hastalık ve zararlılara karşı bitkinin savunma mekanizmasına destek sağlamaktadır (Arya ve diğ. 2010; Harley, 1969). Farklı şartlar altında yapılan çalışmalar, mikorizaların bitkilerin sağlıklı ve güçlü kökleri üretmesini sağlayarak olumsuz stres koşullarına karşı kendilerini güçlendirdiklerini göstermektedir (Dunabeitia ve diğ., 2004, Tsimilli-Michael ve Strasser 2008).

*Juglans* cinsine ait türlerin çoğunlukla AMF ile ilişkili olduğu bildirilmektedir (Comas ve Eissenstat 2009; Comas vd., 2014). AMF yaşamlarını devam ettirebilmek için bitki kaynaklı karbona ihtiyaç duymakta ve bu amaçla bitki köklerini kolonize etmektedir (Keymer vd., 2017). Bunun karşılığında funguslar konukçu bitki köklerinin erişemeyeceği toprak hacimlerine ulaşmakta ve konukçularına toprak mineral besinlerini almak için destek sağlamaktadır (Frise ve Allen, 1991; Roth ve Paszkowski 2017; Wang ve diğ., 2017).

AMF, bitkinin gelişimini ve beslenme durumunu iyileştirdiği, dikim stresini azalttığı ve fidanların arazi şartlarında hayatta kalma oranını artırdığı için rizosferin önemli bir biyotik bileşenidir (Carpio ve diğ., 2003; Davies, 2008; Mortier ve diğ., 2020). Odunsu bitki türlerinin

fidan kalitesini ve arazi performansını iyileştirmede AMF simbiyozu büyük önem göstermekte ve bilim insanları tarafından uzun yıllardan bu yana kabul edilmektedir (Cordell ve diğ., 1987; Kormanik ve diğ., 1982; Kormanik 1985; Mortier ve diğ., 2020).

Ağaçların genellikle oluşturduğu iki ana mikorizal ilişki; Zygomycota şubesinde (Bonfante ve Venice 2020) funguslarla olan arbusküler mikorizal ilişkiler ve çoğunlukla Ascomycota ve Basidiomycota şubelerinden funguslarla olan ektomikorizal (EM) ilişkilerdir (Brundrett 2009; Mortier vd., 2020; Wang ve Qiu 2006). Belirli bir cins içindeki ağaçlar genellikle aynı tip mikorizaları bulundurmaktadır ve bu ilişkiler genellikle familyalar içinde benzerlik göstermektedir. Juglandaceae familyasında bulunan *Carya* spp. EM tipini oluştururken, *Juglans* spp. ağırlıklı olarak AMF ile ilişki kurmaktadır (Brundrett 1991). Mikorizal birliktelik tipi, konak ağacın filogenetik akrabalığı ile sistematik olarak ilişkili göstermemektedir. Farklı mikorizal tiplerle ilişkili ağaçlar, besin arama ile ilgili kök özelliklerinde büyük farklılıklar göstermektedir. Tüm bu nedenlerle AMF kolonizasyonunun cevizin kök morfolojisi ve anatomisine bağlı olduğu bilinmektedir (Kong ve diğ., 2019; Mortier ve diğ., 2020).

Mikorizal bağımlılık, belirli bir toprak verimliliği düzeyinde mikoriza yokluğunda bitkinin büyümemesi olarak tanımlanmıştır. Bu nedenle, mikorizal bağımlılık, bir bitki türünün veya genotipinin kendine bağlı bir özelliğidir ve büyük ölçüde kök yapısı tarafından kontrol edilmektedir (Janos, 2007; Plenchette ve diğ., 1983). Bitkide çapı 1 veya 2 mm'den küçük emici kökler bitkinin besin ve su alım kapasitelerinin göstergeleridir (Guo ve diğ., 2008). İnce, emici kökleri olan bitki türleri P sınırlı topraklarda AMF'ye gereksinim duymazlar çünkü bu kökler besine ulaşmada oldukça etkilidir. Aksine, kalın köklü türlerin besin alımı konusunda sınırlı yetenekleri bulunmakta, bu nedenle, besin maddeleri alımında mevcut yüzey alanını artıran ince yapılı AMF'nin varlığından yararlandıkları bildirilmektedir (Liu ve diğ., 2015; Liu vd., 2019). Ayrıca, kök anatomisi ve işlevinin köklerdeki dallanma konumuna göre değiştiği ve ceviz ağaçlarının AM besin alım kapasitesinin birinci ila üçüncü sıra köklerle ilişkili olduğu bildirilmiştir (Guo ve diğ., 2008; Mortier ve diğ., 2020).

Ceviz fidanları tohum çoğaltma veya bitki doku kültürü ile üretilmektedir. Dikim sonrasında bu fidanların sağlıklı gelişme ve hayatta kalma oranları düşüktür. Ceviz ağaçları da dahil olmak üzere çoğu mikotrofik odunsu bitki türünde fidan bahçelerinin başarısı, büyük ölçüde AMF birlikteliklerine ve dikimden sonra mineral kaynakları elde etme hızına bağlı olmaktadır. Bu durum, fidanların başarılı gelişmesi için ceviz fidanlarının seçilmiş AMF ile aşılmasının (biyotizasyon) önemini artırmıştır (Grossnickle ve diğ., 2018; Grosnickle ve MacDonald 2018; Hackett ve diğ., 2010; Smith ve Oku 2008).

Fidan kalite değerlendirmesi, hem fiziksel özelliklere dayalı morfolojik kaliteyi hem de metabolizmaya dayalı fizyolojik kaliteyi içermektedir. Her ikisi de ağaçlandırılmanın başarısını etkileyen önemli faktörlerdir. Bu nedenle, mikorizal ceviz fidanlarının dikim başarısına göre kalitelerinin derecelendirilmesinde yer altı ve yer üstü morfolojik ve fizyolojik parametreler yardımcı olmaktadır (Haase, 2008; Mortier ve diğ., 2020). Fidan kalite değerlendirmesi, fidanların büyüme ve gelişme ile ilişkili morfolojik özellikleri ölçmeyi amaçlamaktadır. Bu, yer altı ve yer üstü parametreleri dahil olmak üzere çeşitli özelliklerin bir kombinasyonunu içermektedir (Jacobs ve diğ., 2005).

Cevizin AMF ile aşılmasının kök biyokütlesini, uzunluğunu ve hacmini önemli ölçüde iyileştirdiği bildirilmektedir (Hetrick ve diğ., 1988). AMF ile kolonizasyon çoğu durumda yan köklerin sayısını ve odunsu bitkilerin kaynak alım kapasitesini artırmaktadır. Bu özellikler ceviz fidanlarının morfolojik derecelendirmesi için önemlidir (Guo ve diğ., 2008; Zadworny ve

Eissenstat 2011). Ancak köklenme özelliklerine kolayca erişilemediği için, odunsu bitki gelişimi ile ilişkili yer üstü parametrelerin tahribatsız ölçümleri yapılmaktadır. Kök sisteminin boyutu ve gövde hacmi fidanın hayatta kalma potansiyelinin bir göstergesidir. Benzer gözlemler, genellikle fotosentez kapasitesinin bir göstergesi olarak kullanılan gövde biyokütlesi ve yüksekliği ile yapılmaktadır (Fajardo ve diğ., 2014; Haase, 2008).

Yapılan bazı çalışmalarda, AMF ile aşılammış *Juglans* sp. fidanlarında yaprak sayısı, alanı ve biyokütlesi aşılammamış kontrollere göre daha yüksek bulunmuştur. Bu yer üstü parametreler için kaydedilen pozitif tepkiler, bitkiler tarafından C asimilasyonundaki artışa bağlanmaktadır. Bitkiler daha iyi besin mevcudiyetinin bir sonucu olarak yapraklara daha fazla C tahsis etmektedir. Aşılammaların ardından yapraklarda P, N ve K konsantrasyonlarında artışlar belirlenmiştir (Fajardo ve diğ. 2014; Mortier ve diğ., 2020). AMF ile aşılamanın *Juglans* sp. fidanlarının kalite özelliklerini ve mikorizal kolonizasyon derecesini de etkilediği bildirilmiştir. Benzer şekilde, fidan genotipi ve mikoriza etkileşimine bağlı olarak, kök boğazı çapı, yaprak alanı, kök ağırlığı ve uzunluğu ve kolonizasyon oranları farklılıklar göstermektedir (Dixon 1988). Gübrelemenin ceviz köklerinin AM kolonizasyon derecesini kontrol ettiği bulunmuştur. Ceviz ağaçlarını fosfatla gübreleme ceviz ağaçlarının AMF ile kolonizasyonunu ve bunların çeşitliliğini azaltmaktadır (Mortier ve diğ., 2020). Ceviz ağaçlarının kaba kök mimarisi, toprak besinlerini emme konusunda sınırlı bir içsel yeteneğe sahip olduğundan, AMF ile aşılı ceviz fidanlarında bitki N ve P konsantrasyonları, mikorizal olmayan bitkilere göre daha yüksektir. Bu nedenle ceviz ağaçları mikorizal ağ aracılığıyla simbiyozdan yararlanmaktadır (Mortier ve diğ., 2020).

## Sonuç

Mevcut bilgiler, ceviz ağaçlarının AMF ile erken dönemde simbiyozunun, plantasyonu yapılan ceviz fidanlarının fidan performans özelliklerini ve hayatta kalma başarısını iyileştirebildiğini göstermektedir. Sonuçlar tümüyle ele alındığında, bitkideki lateral köklerin sayısının ve bitki P alımının artmasının bir sonucu olarak, AMF ceviz başarısını büyük ölçüde desteklemektedir. Mikorizal aşılama, özellikle *Juglans* fidanlarının gelişimi ve dikim başarısı bakımından iyi bir performans oluşturmaya yardımcı olmaktadır. Ayrıca tarımsal ormancılık sistemlerinde, derin mikorizal köklü ceviz ağaçları, çevredeki bitki örtüsü için AMF'nin kaynak görevini yapmaktadır. Anaç ıslahı ve üretimi bağlamında, AMF ile ceviz ağaçlarının simbiyozu, çeşitli hastalık ve zararlılara karşı bitkinin toleransını ve ekolojik koşullara adaptasyonunu potansiyel olarak geliştirecek uygulamalara yol açmaktadır. Ancak, AMF ile biyotizasyon her ne kadar ceviz fidanı kalitesinde ve hayatta kalma özellikleri üzerinde etkili olsa da, mikorizasyonun etkisi, fungus ve bitki ortaklarının doğasına ve ayrıca toprak özelliklerine bağlı olmaktadır. Ağacın kök yapısı, emici köklerin çapı ve dallanma sırası gibi faktörler de mikorizal kolonizasyon başarısını önemli oranda etkilemektedir. Son olarak, her ceviz çeşidinin kalite özelliklerini iyileştirmek için morfolojik ve fizyolojik tepkilerini entegre eden, biyolojik tahlillere dayalı etkili bir mikorizal inokulum seçilmesi önerilebilir. Ceviz yetiştiriciliğinde mikorizaların etkileri hakkında uzun soluklu ve daha detaylı çalışmalara ihtiyaç bulunmaktadır.

## Kaynaklar

Amaral JS, Seabra RM, Andrade PB, Valentão P, Pereira JA, Ferreres F (2004) Phenolic profile in the quality control of walnut (*Juglans regia* L.) leaves. *Food Chem* 88:373–379. <https://doi.org/10.1016/j.foodchem.2004.01.055>.

- Arya, A., Arya, C., Misra, R. (2010) Mechanism of action in arbuscular mycorrhizal symbionts to control fungal diseases. In: Arya A, Perello AE (eds) Management of fungal plant pathogens. CABI, pp 171–182.
- Bender, DA. and Bender, AE. (2005) A dictionary of food and nutrition. Oxford University Press, Oxford.
- Bender, SF., Wagg, C., and van der Heijden, MGA. (2016) An underground revolution: biodiversity and soil ecological engineering for agricultural sustainability. *Trends Ecol Evol* 31:440–452
- Bernard, A., Lheureux, F. and Dirlewanger, E. (2018) Walnut: past and future of genetic improvement. *Tree Genet Genomes* 14:1.
- Bonfante, P., Venice, F. (2020) Mucoromycota: going to the roots of plant interacting fungi. *Fungal Biol Rev* 34:100–113.
- Brundrett, MC. (1991) Mycorrhizas in natural ecosystems. *Adv Ecol Res* 21:171–313.
- Brundrett, MC. (2009) Mycorrhizal associations and other means of nutrition of vascular plants: understanding the global diversity of host plants by resolving conflicting information and developing reliable means of diagnosis. *Plant Soil* 320:37–77.
- Buée, M., De Boer, W., Martin, F. et al (2009) The rhizosphere zoo: an overview of plant-associated communities of microorganisms, including phages, bacteria, archaea, and fungi, and of some of their structuring factors. *Plant Soil* 321:189–212.
- Carpio, LA., Davies, FT., Arnold, MA. (2003) Effect of commercial mycorrhiza on growth, survivability, and subsequent landscape performance of selected container grown ornamental nursery crops. *J Environ Hortic* 21:190–195.
- Comas, LH., Eissenstat, DM. (2009) Patterns in root trait variation among 25 co-existing North American forest species. *New Phytol* 182:919– 928.
- Comas, LH., Callahan, HS., Midford, PE. (2014) Patterns in root traits of woody species hosting arbuscular and ectomycorrhizas: implications for the evolution of belowground strategies. *Ecol Evol* 4: 2979–2990.
- Cordell, CE., Owen, JH., Marx, DH. (1987) Mycorrhizae nursery management for improved seedling quality and field performance. In: Inter mountain Forest Nursery Association (ed) Meeting the Challenge of the Nineties Proceedings. Oklahoma General Technical Report RM 151, Oklahoma City, pp 105–115.
- Davies, FT. (2008) How mycorrhizal fungi can benefit nursery propagation and production systems? Combined Proceedings International Plant Propagators' Society 58:539-548.
- Dixon, R. (1988) Seed source and vesicular-arbuscular mycorrhizal symbiont affects growth of *Juglans nigra* seedlings. *New For* 2:203– 211.



- Dunabeitia, M., Rodriguez, N., Salcedo, I., Sarrionandia, E. (2004) Field mycorrhization and its influence on the establishment and development of the seedlings in a broadleaf plantation in the basque country, *Forest Ecology and Management*, 129-139.
- Fajardo, L., Cáceres, A., Arrindell, P. (2014) Arbuscular mycorrhizae, a tool to enhance the recovery and re-introduction of *Juglans venezuelensis* Manning, an endemic tree on the brink of extinction. *Symbiosis* 64:63–71.
- Frank, A.B. (1885) *Über die auf Wurzelymbiose beruhende Ernährung Gewisser Baume durch unterirdische Pilze*, *Ber. dt. bot.*3, 128-145.
- Friese, CF., Allen, MF. (1991) The spread of VA mycorrhizal fungal hyphae in the soil - inoculum types and external hyphal architecture. *Mycologia* 83:409–418.
- Grossnickle, SC., MacDonald, JE. (2018) Why seedlings grow: influence of plant attributes. *New For* 49:1–34.
- Guo, D., Xia, M., Wei, X., Chang, W., Liu, Y., Wang, Z. (2008) Anatomical traits associated with absorption and mycorrhizal colonization are linked to root branch order in twenty-three Chinese temperate tree species. *New Phytol* 180:673–683.
- Haase, DL. (2008) Understanding forest seedling quality: measurements and interpretation. *Tree Planters Notes* 52:24–30.
- Hackett, W., Leslie, C., Grant, J., Lampinen, B., McGranahan, G., Anderson, K., Beede, B., Buchner, R., Caprile, J., DeBuse, C., Hasey, J., Manterola, N., Robinson, R., Kluepfel, D., Browne, G., and Mike McKenry, M. (2010) Clonal propagation of walnut rootstock genotypes for genetic improvement, walnut research reports. California walnut board, pp 65– 83
- Harley, J.C. (1969). *The Biology of Mycorrhizae*, Leonard Hill, 2nd edition, London.
- Harley, J.L., Smith, S.E. 1983. *Mycorrhizal Symbiosis*, Academic Press, London, UK.
- Hetrick, BA., Leslie, JF., Wilson, GT. et al (1988) Physical and topological assessment of effects of a vesicular–arbuscular mycorrhizal fungus on root architecture of big bluestem. *New Phytol* 110:85–96.
- Jacobs, DF., Salifu, KF., Seifert, JR. (2005) Relative contribution of initial root and shoot morphology in predicting field performance of hardwood seedlings. *New For* 30:235–251.
- Jaiswal, BS. and Tailang, M. (2017) *Juglans regia*: a review of its traditional uses phytochemistry and pharmacology. *Indo Am J Pharm Res* 7(09).
- Janos, DP. (2007) Plant responsiveness to mycorrhizas differs from dependence upon mycorrhizas. *Mycorrhiza* 17:75–91.
- Kariman K, Barker SJ, Tibbett M (2018) Structural plasticity in root fungal symbioses: diverse interactions lead to improved plant fitness.

- Keymer, A., Pimprikar, P., Wewer, V. (2017) Lipid transfer from plants to arbuscular mycorrhiza fungi.
- Kong, D., Wang, J., Wu, H., Valverde-Barrantes, OJ., Wang, R., Zeng, H., Kardol, P., Zhang, H., Feng, Y. (2019) Nonlinearity of root trait relationships and the root economics spectrum. *Nat Commun* 10:2203.
- Kormanik, PP. (1985) Effects of phosphorus and vesicular–arbuscular mycorrhizae on growth and leaf retention of black walnut seedlings. *Can J For Res* 15:688–693.
- Landis, TD., Tinus, RW., McDonald, SE., Barnett, JP. (1989) Seedling nutrition and irrigation. The container tree nursery manual, vol 4. USDA Forest Service Agriculture Handbook 674, Washington.
- Liu, B., Li, H., Zhu, B., Koide, RT., Eissenstat, DM., Guo, D. (2015) Complementarity in nutrient foraging strategies of absorptive fine roots and arbuscular mycorrhizal fungi across 14 coexisting subtropical tree species. *New Phytol* 208:125–136.
- Liu, W., Zhang, Y., Jiang, S., Murray, PJ. et al (2019) Spatiotemporal differences in the arbuscular mycorrhizal fungi communities in soil and roots in response to long-term organic compost inputs in an intensive agricultural cropping system on the North China Plain. *J Soils Sediments* 19:2520–2533.
- Marschner, H., (1993). Zinc uptake from soils, *Zinc In Soils and Plants*, Springer Netherlands, 59-77.
- Marschner, H. (1995). *Mineral Nutrition of High Plants*. Second edition. Academic Press, London, pp 566-595.
- Mortier, E., Lamotte, O., Martin-Laurent, F., & Recorbet, G. (2020). Forty years of study on interactions between walnut tree and arbuscular mycorrhizal fungi. A review. *Agronomy for Sustainable Development*, 40(6), 1-21.
- Peixe, AP., Alpendre, J., Barroso, R. et al (2015) New strategies for in vitro rooting and plantlet acclimatization of the 'Paradox' (*Juglans regia* × *Juglans hindsii*) rootstock. *Acta Horti* 1083:287–293.
- Plenchette, C., Fortin, JA., Furlan, V. (1983) Growth responses of several plant species to mycorrhizae in a soil of moderate P-fertility. I. Mycorrhizal dependency under field conditions. *Plant Soil* 70: 199–209
- Roth. R., Paszkowski, U. (2017) Plant carbon nourishment of arbuscular mycorrhizal fungi. *Curr Opin Plant Biol* 39:50–56.
- Shukla, A., Kumar, A., Jha, A., Dhyani, SK., and Vyas, D. (2012) Cumulative effects of tree based intercropping on arbuscular mycorrhizal fungi. *Biol Fertil Soils* 48:899–909.
- Smith, SE., Read, DJ., (2008). *Mycorrhizal Symbiosis*, Academic Press, San Diego, USA.

- Tsimilli-Michael M., Strasser R.J. (2008) In vivo assessment of stress impact on plants' vitality: Applications in detecting and evaluating the beneficial role of Mycorrhization on host plants, *Mycorrhiza: State Of The Art, Genetics And Molecular Biology, Ecofunction, Biotechnology, Eco-Physiology, Structure And Systematics*, Editor: Varma A., 3rd ed., Springer, 679-703.
- Verma, MK. (2014) Walnut production technology. In: Singh SK, Munshi AD, Prasad KV, Sureja (eds) Training manual on teaching of post graduate courses in horticulture (Fruit Science). Post Graduate School, Indian Agricultural Research Institute, New Delhi
- Wang, B., Qiu, YL. (2006) Phylogenetic distribution and evolution of mycorrhizas in land plants. *Mycorrhiza* 16:299–363.
- Wang, W., Shi, J., Xie, Q., Jiang, Y., Yu, N., Wang, E. (2017) Nutrient exchange and regulation in arbuscular mycorrhizal symbiosis. *Mol Plant* 10: 1147–1158.
- Zadworny, M., Eissenstat, DM. (2011) Contrasting the morphology, anatomy and fungal colonization of new pioneer and fibrous roots. *New Phytol* 190:213–221.

## **Determination of Antioxidant Properties of *Paliurus Spina-christi* Distributed in Different Sites in Türkiye**

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**Abstract:** Research on determination of antioxidant activity of Christ's thorn (*Ziziphus spina-christi* L.) has been conducted. This study aimed to determine the antioxidant properties of Christ's thorn plant collected from different regions of Turkey (Anamur-Mersin, Fethiye-Muğla, Bayramiç-Çanakkale) at the same time were investigated by using a CUPRAC method. This study showed that antioxidant capacity was determined 0.0132 mmolTR/g for Anamur, 0.0177 mmolTR/g for Fethiye, 0.0281 mmolTR/g for Bayramiç. This result indicates that A significant difference was observed between regions and antioxidant capacity increased from south to north.

**Keywords:** *Paliurus Spina-christi*, antioxidant, CUPRAC.

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### **1. Introduction**

*Paliurus spina-christi* Mill. (Rhamnaceae), commonly known as Jerusalem thorn, garland thorn, Christ's thorn, or crown of thorns, is a perennial thorny shrub of widespread distribution in dry and rocky places in the Mediterranean region and southwest and central Asia, from Morocco and Spain east to Iran and Tajikistan (Polunin and Huxley, 1981; URL1; 2022).

The flowers of the blackthorn plant develop between May and July depending on the weather conditions. Flower colors are yellow, medium sweet and slightly bitter. Among the people of gorse, it is also called with local names such as messianic thorn, draga thorn, ox-eye, ilm, bush thorn, yellow bush, yellow thorn. It is traditionally used in the treatment of diuretic, antirheumatic, hypocholesterolemic, tonic and chronic obstructive pulmonary disease (Zor et al., 2017; Şen., 2018). It is also stated that blackthorn fruit extracts have an antidiabetic effect (Takim,2018).

When gorse extracts were examined in terms of phytochemicals, it was determined that flavonoids and tannins were found in all parts of the plant, amino acids, alkaloids in the bark and sterols in the fruits (Brantner and Males., 1999).

In this study, it was aimed to determine the antioxidant properties of the black bush plant, which has a natural distribution in Turkey. The results of the study will raise awareness in terms of better recognition of the black bush plant, its use for therapeutic purposes, and its contribution to the list.

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## 2. Materials and Methods

### 2.1. Plant Material

*Paliurus spina-christi* (Blackthorn) seeds were collected on the same day (6 July 2022) from forest areas in Bayramiç-Çanakkale, Anamur-Mersin and Fethiye-Muğla cities of Türkiye. The samples were extracted by grinding at the place where they were collected and the obtained extract was stored at +4 °C until analysis. Unground samples of the collected seeds were characterized.

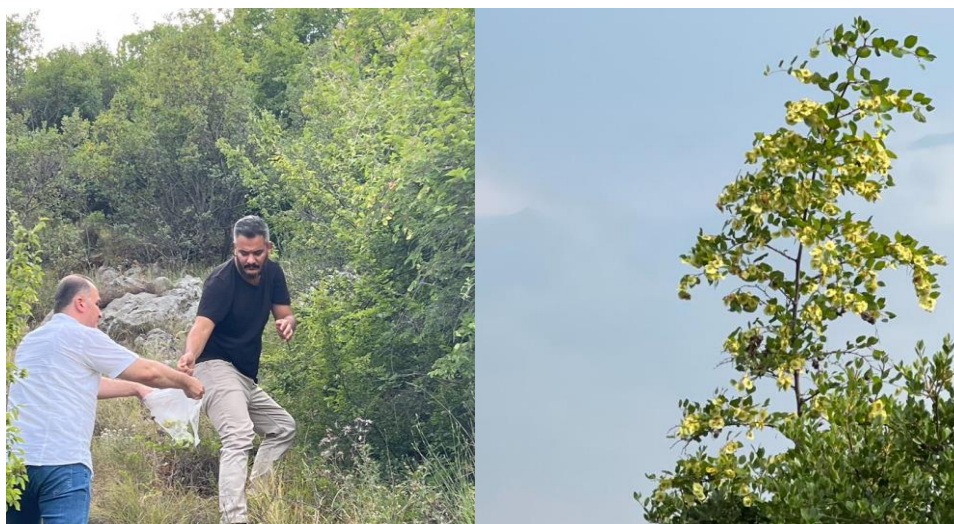


Figure 1. Collected *Paliurus spina-christi* Mill. from different sites in Türkiye

### 2.2. Extraction of ground samples

*Paliurus spina-christi* seeds were ground and extracted with ethanol. The milled sample: ethanol ratio was used (1:10) in the extraction. The ground sample was placed in ethanol and kept at 25°C for 12 hours, and the extract was filtered at the end of the period.

### 2.3. Determination of total antioxidant capacity by CUPRAC method

The CUPRAC method, developed by Apak et al (2004), was used in the study. This method is a widely applicable antioxidant capacity determination method, such as plasma antioxidants, flavonoids, and food polyphenols, using a chromogenic oxidant Cu (II)-neocuproin (Nc) reagent. Appropriately positioned phenolic hydroxyls are converted into corresponding quinone structures by the CUPRAC redox reaction, and the Cu(I)-Nc chelate formed as a result of this redox reaction gives maximum absorbance at 450 nm. The resulting color is the result of a charge transfer in the metal→ligand direction.

According to this method, 1 mL of copper (II) solution, neocuproin solution and ammonium acetate buffer are added into a glass tube, respectively. 0.5 mL antioxidant solution and 0.6 mL distilled water were added, and the tubes were shaken well. The solutions prepared with a total volume of 4.1 mL were kept closed for 30 minutes at room conditions. At the end of this period, absorbance values were measured at 450 nm against the reference solution without sample. Three parallel test groups were prepared for each measurement. Measurements made

against the reference solution at 450 nm were recorded. The data obtained were calculated as mmol/g trolox equivalent according to the formula below.

Reference Solution: 1 mL Cu<sup>2+</sup> + 1 mL Nc + 1 mL NH<sub>4</sub>Ac + 1.1 mL H<sub>2</sub>O

Sample Solution: 1 mL Cu<sup>2+</sup> + 1 mL Nc + 1 mL NH<sub>4</sub>Ac + 0.5 mL antioxidant + 0.6 mL H<sub>2</sub>O

$$\text{TAC (mmol TR/g - sample)} = \frac{A}{\epsilon} \times \frac{V_t}{V_0} \times \text{S. f.} \times \frac{V_e}{m}$$

A: Sample absorbance measured at 450 nm

ε: molar absorption coefficient of TR compound in CUPRAC method (16700 L mol<sup>-1</sup>.cm<sup>-1</sup>)

V<sub>t</sub>: Total volume of CUPRAC solution (4.1 mL)

V<sub>0</sub>: Sample volume (mL)

S.f.: Dilution factor

V<sub>e</sub>: Volume of the prepared extract (mL)

m: The amount of sample taken in the extraction process (g)

### 3. Results and Discussion

#### Total antioxidant capacity results

Table 1 shows the total antioxidant capacity of *Paliurus Spina-christi* seeds which obtained from different areas of Türkiye. Plant seeds were collected from the regions where it spreads from north to south in Turkey. The results are very interesting that the antioxidant capacity of the plant decreases as you go from north to south. Antioxidant capacity of seeds collected from Çanakkale, the northernmost region. It is almost twice the size of Anamur, the southernmost region. Arslan and Kaya (2021), in their study titled "Investigation of Antimicrobial and Antioxidant Activities of *Paliurus spina-christi* Mill. in Kahramanmaraş", found 0.284 trolox equivalents in the ethanol extract of the fruit of the plant and 0.71 trolox equivalents in the leaves, according to the CUPRAC method. On the other hand, On the other hand, Ceylan et al. (2020) determined the antioxidant capacity of flower seeds of *Paliurus spina-christi* Mill samples collected from Artvin-Seyitler region to be 0.45 according to the CUPRAC method, and 0.19 to the samples collected from Giresun-Kale region. As seen in these studies, the plant produces very different metabolites depending on the growing region.

**Table 1.** Total antioxidant capacity of *Paliurus Spina-christi*

Sample	CUPRAC total antioxidant capacity (mmolTR/g-sample)
<i>Paliurus Spina-christi</i> seed extract from Bayramiç-Çanakkale	0,0281 ± 0.0278
<i>Paliurus Spina-christi</i> seed extract from Anamur-Mersin	0,0132 ± 0,013
<i>Paliurus Spina-christi</i> seed extract from Fethiye-Muğla	0,0177 ±0,0178

### 4. Conclusions

The data revealed that TAC of the *Paliurus Spina-christi*. seeds are low. However, the total antioxidant capacity of the seeds of the same plant collected on the same day varies greatly according to the region where it is grown. Researching this subject may help us to establish a

connection between the climatic conditions in which the plant grows and the metabolites of the plant. More comprehensive studies to be conducted in larger regions may provide us with information about the effects of climate change.

## References

- Apak, R., Güçlü, K., Özyürek, M., Karademir, S. E. (2004). Novel total antioxidant capacity index for dietary polyphenols and vitamins C and E, using their cupric ion reducing capability in the presence of neocuproine: CUPRAC method. *Journal of agricultural and food chemistry*, 52(26), 7970-7981.
- Arslan, L., Kaya, E., (2021). Investigation of Antimicrobial and Antioxidant Activities of *Paliurus spina-christi* Mill. in Kahramanmaraş, Turkey. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, 24(6), 1161-1169.
- Brantner, A.H., and Males, Z. (1999). Quality assessment of *Paliurus spina-christi* extracts. *Journal of ethnopharmacology*, 66(2), 175-179
- Ceylan, Ş., Harşıt, B., Saral, Ö., Özcan, M., Demir, İ. (2020). Comparison of antioxidant and antimicrobial activities of plant extracts *Centaury* (*Hypericum montbretii* and *Hypericum bupleuroides*) and *Blackthorn* (*Paliurus spina-christi* Mill) in Artvin, Giresun region of Turkey.
- Polunin, O., Huxley, A., 1981. *Blumen am Mittelmeer*. Verlagsgesellschaft, Munich, p. 157.
- Şen, A. (2018). Antioxidant and anti-inflammatory activity of fruit, leaf and branch extracts of *Paliurus spina-christi* P. Mill. *Marmara Pharmaceutical Journal*, 22(2).
- Takım, K. (2018). Effect Of Karacali Fruit Extracts On Some Blood Parameters In Diabetic Rats Induced By Streptozotocin. *Kahramanmaraş Sutcu Imam University Journal Of Natural Sciences*, 21(2), 148-156.
- URL1, 2022. [https://en.wikipedia.org/wiki/Paliurus\\_spina-christi](https://en.wikipedia.org/wiki/Paliurus_spina-christi)
- Zor, M., Aydın, S., Güner, N. D., Başaran, N., & Başaran, A. A. (2017). Antigenotoxic properties of *Paliurus spina-christi* Mill fruits and their active compounds. *BMC complementary and alternative medicine*, 17(1), 229.