Academic Analysis and Discussions in Agriculture, Forestry and Fisheries

Editor: Assist. Prof. Derya GÜLOĞLU

yaz yayınları

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İÇİNDEKİLER

SEED AND THE LAST 20 YEARS OF TURKISH SEED PRODUCTION

Mehmet ÖZ[1]

Seed has become the most essential input of crop production today. Even if you apply the perfect care procedures to plants, achieving the desired yield and quality is impossible. Studies have shown that if seeds developed through breeding studies are used, yield increases can exceed 100% in some plants. For this reason, producers have adopted that seed is significant in obtaining high yields in today's conditions (Baran, 2019).

Situations such as population growth and using agricultural land for other purposes have made it necessary to obtain more yield from the unit area. This goal can only be achieved using seeds that will respond to maintenance operations such as fertilization, irrigation, soil preparation, disease, and pest control at the maximum level (Altay, 2018).

For centuries, some of the products produced in previous years were used as seeds. However, since the 1800s, intensive studies have been carried out on seeds in some countries, especially in the USA, and as a result of obtaining high-quality seeds and their use in agriculture, seeds have gained the characteristic of commercial value.

In the 20th century, after the first quarter of this century, in some countries, particularly in the United States of America, seed production activities became institutionalized. In this period, seed production activities were transferred to the private sector,

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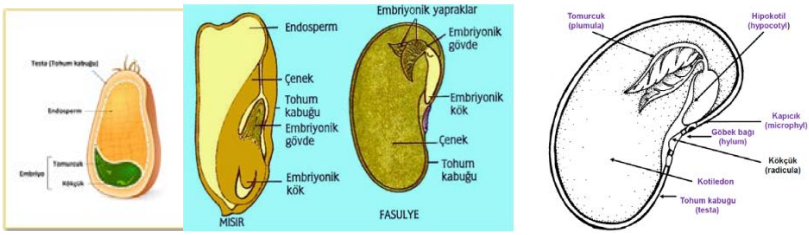
while the public sector dealt with the legislation and inspections related to the sector's activities. Quality standards were set so that seeds could be easily marketed as a commercial product. As in every sector, R&D activities in the seed sector are essential for developing existing genotypes, and the private sector has started to make serious investments in hybrid seeds, which they can now efficiently market. When the science of genetics revealed many findings about the genetic structure of plants, the development momentum in seed activities started to increase at a dizzying pace (Anonymous, 2017).

Industrialized countries develop their seed sector, a strategic product, and get significant shares from the world seed trade, which we will examine later. While the seed sector in these countries has a history of approximately 150 years, with solid capital accumulation and advanced technological research opportunities, the seed sector in our country is primarily private sector-oriented. It has a history of approximately 35-40 years (Anonymous, 2021).

1. WHAT IS A SEED AND SEEDING?

Seed: It is the generative reproductive organ that occurs after fertilization of the seed draft in the ovary of the female organs in plant flowers, containing the embryo and spare nutrients.

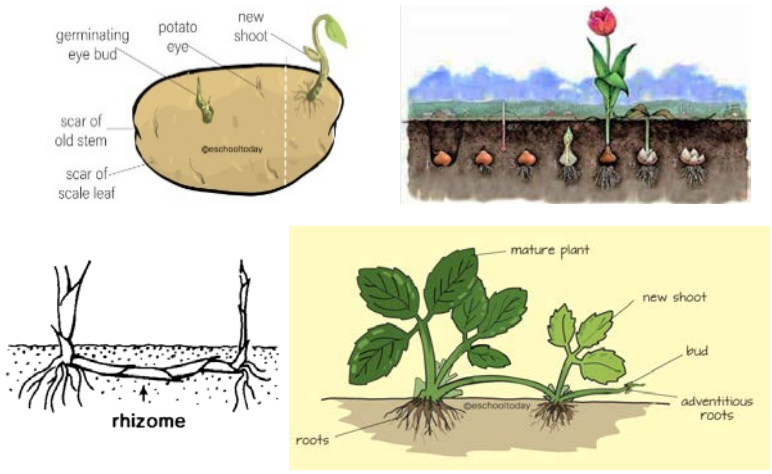
Figure 1. Parts of the Seed



Source: (Anonymous, 2023a and g)

Seeding: All generative and vegetative organs (seeds, tubers, bulbs, cuttings, rhizomes, stolons, siblings, etc.) that have the chance to produce new plants are called seeds. (Tufan Dülger, 2023).

Figure 2. Some Seed Samples



Source: (Anonymous, 2023j)

1.1. Parts of the Seed

The seed consists of the seed coat (testa), nutrient tissue (endosperm), pores, and embryo.

1.1.1. Endosperm (Nutrient Tissue): The plant embryo stores the nutrients it needs before and during germination. Depending on the plant species, these stores can be composed of carbohydrates, fats, and proteins. During the storage and germination process, the energy requirement of the plant embryo is met from the nutrient tissue containing the storage substances. After germination, the nutrient needs of the plant that reaches the soil surface are met by the green leaves. In cereals and some other plant species, the endosperm ends outside with the aleurone layer. During the development of the endosperm, the wall cells begin to

proliferate and form small cells that appear angular in cross-section. These cells can form several layers, their membranes thicken and form protein structures called living aleurone grains. However, in cereals, endosperm cells are starch-containing, dead cells with reduced protein content (Anonymous 2023g).

1.1.2. Seed Shell (Testa): The seed coat is formed by the fusion of the integuments in the ovary, and its shell is a protective structure. The walls of the shell cells are composed of different layers to fulfill their protective function better. The seed coat protects from water loss, embryo damage, and biological elements during storage, thus creating a protective barrier against risks such as embryo-damaging chemicals and diseases. Usually, the seed coat has a complex structure, but in some cases, there may be thinner structures, such as a thin inner seed coat. Anatomical features of the seed coat show differences between genera and species. For example, the presence of outer and inner cuticles, the number of layers of the coat, and the presence of protective cells can influence the physiological effects of the seed coat.

Furthermore, the seed coat can influence development and metabolism within the seed by regulating water and gas permeability. Some seed coats are gummy and play a role in water retention and dispersal. Another difference, called the hilum, is seen in the seed coat. The hilum is a slit, usually of a different color and shape than the seed coat, and can vary between species. In addition, many seeds have small holes on the surface, such as micropillars, and some species have feathers and wings on the seed coats, which help the seeds to spread (Şehirali and Yorgancılar, 2011; Arslanoğlu, 2023).

1.1.3. Embryo: The zygote is the structure formed from fertilization of the egg cell in the embryo sac and develops by mitosis and becomes the embryo. This embryo is the living part

of the seed that continues the generation. The embryo can form a variety of structures among different plant species and is usually composed of the following components:

a. Stalk (hypocotyl)

b. Rootlet (radicular)

c. Plumula

The embryo, formed by the fertilized egg cell, is formed by the plumula, which lies between the hypocotyl and the radicular and bears the first true leaves.

The first leaflets of the embryo are called pores or cotyledons and develop attached to the embryo. These pores feed on the endosperm until the plant germinates and can photosynthesize for some time after germination. In some higher plants, the pores store nutrients from the endosperm inside the seed and feed the seed coat, which is incapable of photosynthesis (Şehirali and Yorgancılar, 2011; Anonymous 2023g).

The plant embryo is of two types according to the number of pores in its structure:

a. Monocotyledonous (Monocotyledonous) plants: Monocotyledonous plants have a single pore in their embryos. Examples of these plants are maize and wheat. Monocotyledonous plants usually have herbaceous structures, and leaf veins are parallel. In the stem, conduction bundles are scattered, and there is no cambium.

b. Dicotyledonous (Dicotyledonous) plants: Dicotyledonous plants include beans, peas, and sunflowers. The leaf veins of these plants usually have a reticulated structure. In the stem, the conduction bundles are arranged around a central cylinder, with wood tubes on the inside and peel tubes on the outside. There is a cambium between the wood tubes and the sap tubes.

There may be differences among many plant species, such as the size of the seeds, the amount of endosperm they contain, the color of the seed coat, and the chlorophyll content (Şehirali and Yorgancılar, 2011; Anonymous 2023g).

Among many plant species, there may be differences in the size of the seeds, the presence or absence of endosperm, the color of the seed coat and the amount of chlorophyll they contain (Şehirali and Yorgancılar, 2011).

2. SEED CLASSES

Seed class refers to the generation or progeny sequence followed in the production process of seeds (Anonymous, 2023h; İşler, 2023).

2.1.Elite Seed

Newly bred seed or seed that has been bred for a long time but maintains and maintains the purity of the variety following the procedure, which is directly controlled by the breeder, which constitutes the beginning of the original seed and the source of other certified seeds.

2.2.Original Seed

Seed obtained from the elite seed or from the seed itself, which maintains the purity of the variety; grown under control in research, breeding, and trial institutions and controlled by the Seed Control and Certification Organization. The original seed constitutes the source of the certified seed class directly or through the rootstock seed.

2.3.Certified Seed

The original or self-sourced seed maintains the purity of the variety and is controlled by the Seed Control and Certification Organization. Controlled seed is produced and multiplied for

cultivation. A certified seed is a seed whose physical, genetic, and biological values are checked and certified by the authorized institutions of the state in the field from sowing to harvest and in the laboratory after harvest.

2.4.Raw Seed

Seed produced in original and certified seed classes that are not finally certified.

3. SEED GRADE

It is the production duration of any seed class in years (generations) (Anonymous, 2008a and b).

Elite

Original 1

Original 2

Certified 1

Certified 2

Certified 3

The number of stages of some field crops is as follows (Anonymous, 2023h, i):

Wheat, barley and oats:	3 years
Rye and triticale:	2 years
Paddy:	2 years
Chickpeas, lentils and beans:	2 years
Peanuts and soy:	3 years
Cotton:	2 years

Hybrid sunflower, hybrid cotton:	1 year
Hybrid corn:	1 year
Hybrid sugar beet:	1 year
Potato:	2 years

4. CHARACTERISTICS OF SEEDS

Seeds should have the following characteristics (İşler, 2023; Anonymous, 2023g)

Germination and germination rates should be high.

It should be plump and large.

Must not carry disease.

It must not contain weed seeds.

The proportion of living and non-living foreign matter should be low.

It should carry the genetic characteristics of the variety.

Humidity should be low.

4.1. Physical properties of seeds: The purity of any seed is studied to describe its properties such as thousand-grain weight, hectoliter weight, and moisture content.

Variety purity

1000 grain weight

Ratios of living and non-living foreign matter

Seeds must be free from diseases

Humidity

Hectoliter weight

4.2. Genetic characteristics of seeds: The genetic value of the seed is called the genetic value of the seed, which is not visible but manifests itself in the crop that grows after planting the seed.

High efficiency

Winter, heat, and drought resistance

Disease and pest resistance

Lying resistance

Earliness

4.3. Biological characteristics of seedlings:

Seed germination rate and vigor

Seed plowing speed and vigor

Table 1 shows the number of registered varieties of some field crops as of September 2023.

Table 1. Number of Registered Varieties of Some Field Crops 08.09.2023

BREAD WHEAT	448
MAIZE	318
POTATO	211
BARLEY	185
SUNFLOWER	178
SUGAR BEET	150
COTTON	144
PADDY	98
CLOVER	90
TOBACCO	57
CHICKPEAS	56
DURUM WHEAT	51
VETCH	50
SOYBEAN	49
DRIED BEANS	45
OAT	28
TRITICALE	28
SESAME	17

RAPESEED	16
SAFFLOWER	15
PEANUT	13
POPPY	11
SAINFOIN	9
RED LENTILS	4
LENTIL	4
DRIED BROAD BEANS	3
DRY BEAN	3
DRIED KIDNEY BEAN	1

According to September 2023 data, the number of registered varieties in our country is given in the Table (Anonymous, 2023c), considering the shares of the Central Directorate of Seed Registration and Certification of the Ministry of Agriculture and Forestry. According to these data, the number of registered varieties is 448 for wheat, 318 for maize, 211 for potato, 185 for barley, 178 for sunflower, 150 for sugar beet, and 144 for cotton. The species with the lowest registered varieties are lentil, dry broad bean, dry pea, and dry kidney bean.

5. INTERNATIONAL SEED TRADE

In the last quarter century, international seed trade has gained momentum in parallel with developments in the seed sector. This increase has been driven by developing of new seed varieties suitable for different ecosystems, specialization in seed production, and advances in seed technologies. Between 1970 and 2012, international seed trade increased 10-fold and the rate of increase during this period was higher than the growth rate of the worldwide seed market (Anonymous, 2023a).

International seed trade, around USD 1 billion in the late 1970s, increased rapidly in the mid-1980s. By 2012, total international seed trade exceeded USD 10.5 billion. This upward trend is continuing at the same pace today, and the two most

important players in international seed trade are the EU countries and the USA.

Currently, the value of seed production worldwide is estimated at approximately 50 billion dollars. The leading countries in this assessment include the USA ($12 billion), China ($10 billion), France ($2.8 billion), Brazil ($2.1 billion) and Canada ($2 billion). Turkey ranks 11th in this ranking with 0.75 billion dollars (Anonymous, 2023a and d).

As a result of all these developments, Turkey's exports increased its competitiveness in the international market in the seed sector, and the ratio of Turkey's exports to imports increased to 173% in 2022 when seedlings and ornamental plants were included (Anonymous, 2023a).

6. HISTORICAL DEVELOPMENT OF TURKISH SEED PRODUCTION

Although some regulations have been made in seed production since the establishment of the Republic, the conventional supply system was intensively applied until the 1960s. During this period, the public sector took various initiatives to develop our seed production. In 1925, seed breeding stations were operated in different regions of our country. In 1950, State Production Farms were assigned with seed production.

In 1963, the most important and influential legislation that disciplined the seed sector was Law No. 308 on the Registration, Control, and Certification of Seeds, which was adopted by the Turkish Grand National Assembly and entered into force (Çelik, 2000).

This law ensured the production and distribution of quality seed under the state's guarantee. As a result of this

discipline, Turkey became a member of the International Seed Testing Association (ISTA). Becoming a member of ISTA (International Seed Testing Association) was a significant step in the internationalization of our country's seed activities in the variety development process of the seed sector. Another step in seed production was the acceptance of Turkey to the OECD Seed Certification System in 1968 (Bağcı and Özer, 2021).

Since the mid-1980s, significant policy changes have occurred in Turkish seed production. While seed prices were previously determined by the state, private seed companies were allowed to determine the prices of the seeds they breed and produce. In 1984, regulations facilitating the international seed trade of private companies were put into practice. Our seed sector strengthened its internationalization efforts by becoming a member of the World Seed Federation (ISF) in 1998 (2023d).

In 2004, Law No. 5042 on the Protection of Breeders' Rights to New Plant Varieties, which provides support for the breeding of self-fertilizing plants, and its regulation were adopted by the Turkish Grand National Assembly and entered into force (Altındal & Akgün, 2007).

In 2006, with the enactment of Seed Law No. 5553 in line with international standards, the latest commercial, scientific and technological developments and in compliance with EU legislation, the sector paved the way for significant developments in seed production and trade.

In 2007, the International Union for the Protection of New Varieties of Plants (UPOV) Convention on protecting new plant varieties and plant breeders' rights under intellectual and industrial property rights was ratified. With the Seed Law, the entire seed, seedling, sapling, and ornamental plants sector was defined as the seed sector. The same law enabled the establishment of Unions (Anonymous, 2023b).

The Seed Incentive Decree entered into force in 1985. These incentive practices enabled internationally recognized seed companies to carry out R&D activities in our country, and in 1986, subsidies were started to be given to the seed sector, a new field of activity (Özkaya, 2015). In 1988, customs exemption was introduced for seed imports (Altındal & Akgün, 2007).

In 1985, seed producers organized and established the Turkish Seed Industry Association (TÜRK-TED) (Anonymous 2023a).

The purpose of Seed Law No. 5553, which entered into force after being published in the Official Gazette on 31.10.2006, is stated in the text of the law as follows: To realize the legal arrangements necessary for the restructuring and development of the seed sector. Again, with this law, the Turkish Seed Union (TÜRKTOB) was established as a supreme union for the components of the seed sector (Anonymous, 2006).

There are seven sub-unions under the roof of the Turkish Seed Union (TÜRKTOB) (Anonymous, 2006):

Plant Breeders Sub-union

Sapling Producers Sub-union

Seedling Producers Sub-union

Ornamental Plants Producers Sub-union

Seed Distributors Sub-union

Seed Industrialists and Producers Sub-union

Seed Growers Sub-union

Considering the 2023 data, the number of members of sub-unions is 73,464. The sub-union with the highest number of members is the Seed Growers Sub-union, with 62,000 members, and the sub-union with the lowest number of members is the

Seedling Producers Sub-union, with 224 members (Anonymous, 2023a).

According to the report published by TÜRKTOB in 2018, there are 832 organizations in the seed sector, and 778 of these organizations have 100% domestic capital, 22 have domestic-foreign capital, and 32 have 100% foreign capital (Anonymous, 2023d).

7. SEED PRODUCTION IN TURKEY

According to 2022 data, the amount of seed produced, seed requirement, amount of seed distributed, and the ratio of production to seed requirement were analyzed for some crops (Anonymous, 2023e).

Table 2. Seed Requirements According to 2022 Data

PLANTS	Cultivation area (da)	Sowing norm (kg/da)	Renewal period (yıl)	Amount of seeds produced (ton)	Seed requirement (ton)	Amount of seeds distributed (ton)	The rate of production meeting the requirement (%)
Wheat	66 287 386	20	3	454 451	441 916	443 978	102.7
Barley	31 994 876	20	3	169 444	213 299	169 228	74.2
Maize	9 118 849	2.5	1	79 876	22 797	61 847	350,3
Paddy	1 205 226	20	3	8 890	8 034	8 899	109.6
Sunflower	9 809 742	0.4	1	33 833	3 923	8 146	862.4
Soybean	380 090	9	1	3 064	3 420	2 522	89.6
Yer fıstığı	457 016	5	1	149	2 285	149	6.6
Sugar beet	2 975 096	0.4	1	1 575	1 190	2 063	132.3
Potato	1 391 716	250	2	481 929	173 964	495 708	277.0
Cotton	5 731 613	2	1	25 120	11 463	20 352	219.1
Chickpeas	4 568 339	10	3	19 567	15 227	19 463	128.5
Dry bean	970 520	10	3	3 521	3 235	3 590	108.8
Lentil	3 426 000	10	3	46 434	11 420	46 421	406.6
Rapeseed	411 455	1	1	27	411	2 657	6.6
Sesame	242 857	1	1	60	242	6	25.1
Yonca	6 435 927	1	4	3 691	1 608	3 115	229
Sainfoin	1 618 249	8	3	399	4 315	399	9.2
Vetchs	3 421 760	10	5	4 168	6 843	-	60.9
Safflower	262 375	1	1	541	262	-	206.4

Considering the 2022 TUIK data, seed requirements were determined by using the sowing areas of the plants we examined, the sowing norms recommended by the Ministry of Agriculture and Forestry (kg/da), and the renewal periods of the seeds (years).

We can calculate the seed requirement for wheat as follows:

Planted area 66 287 386 da

Sowing norm= 20 kg/da

Seed renewal period= 3 years

Seed requirement= 66 287 386 x 20 = 1 325 747 720 / 3 = 441 915 906 kg / 1000 = 441 916 tons.

For 2022, the amount of wheat seed produced by the public and private sectors is around 454 451 000 kg, which means the seed requirement has been fully met.

For the hybrid sunflower seed requirement, the calculation is made as follows:

Planted area= 9 809 742 da

Sowing norm= 0.4 kg/da

Seed renewal period= 1 year

Seed requirement= 9 809 742 x 0.4 = 3 923 896 / 1= 3 923 896 kg / 1000= 3 923 tons.

For 2022, the amount of sunflower seed produced by the private sector was around 33 833 000 kg, approximately 8.5 times more than the requirement, and the excess seed was exported.

The table shows that wheat, maize, paddy, sunflower, sugar beet, potato, cotton, chickpea, dry bean, lentil, alfalfa, and safflower seeds meet the need. On the other hand, seed production of barley, soybean, peanut, rapeseed, sainfoin and vetch is insufficient.

8. TURKEY SEED FOREIGN TRADE

Table 3. Quantity (Tons) and Value (1000 USD) of Seed Exports and Imports According to 2022 Data

PLANTS	Import quantity (ton)	Import value (1000 USD)	Export quantity (ton)	Export value (1000 USD)
Wheat	445	413	10 918	6 725
Barley	393	470	609	364
Maize	5 796	24 401	23 825	59 699
Paddy	30	30	21	14
Sunflower	518	10 659	26 205	109 133
Soybean	-	-	542	910
Peanuts	-	-	-	-
Sugar beet	524	11 806	36	278
Potato	17 233	11 687	3 454	1 154
Cotton	68	68	4 836	11 257
Canola	2 636	2 702	6	25
Forage crops	1 893	5 068	13 919	11 529
Vegetables	1 159	86 622	473	27 864
Grass and meadow grass	4 437	11 258	310	1 231
Others	2 597	4 430	1 258	2 480
TOTAL	37 329	169 614	86 412	232 663

Considering the 2022 Ministry of Agriculture and Forestry foreign trade data, Turkey imported 37 329 tons of seeds and paid 169 million 614 thousand dollars in return. On the other hand, our exports amounted to 86 412 tons, and a foreign exchange inflow of 232 million 663 thousand dollars was obtained from these exports. The ratio of exports to imports (232 663-169 614= 63 049 / 169 614 x 100) is 137.1%.

When we divide the import value by the import quantity (169 614 000 dollars / 37 329 000 kg), 1 kg of imported seed is 4.54 dollars. In comparison, when we divide the export value by the export quantity (232 663 000 dollars / 86 412 000 kg), 1 kg of exported seed is 2.69 dollars. This shows that the import value of 1 kg of seed is higher than the export value.

In terms of quantity, the highest imports were made for potatoes, with 17 233 tons, followed by corn with 5 796 tons. In monetary terms, the highest import value was paid for importing

vegetable seeds, with 86 622 thousand dollars. The value equivalent of 1 kg of imported seeds in vegetables is 74.7 dollars.

When we evaluate the situation of our country in terms of exports, the highest exports were in sunflower with 26 205 tons, followed by corn with 23 825 tons and fodder crops with 13 919 tons. Vegetable seed exports amounted to 470 tons. In monetary terms, the highest value was obtained from sunflower with 109 133 thousand dollars, followed by corn with 59 699 thousand dollars, and vegetables with 27 864 tons. If we reveal the monetary value of 1 kg of vegetables, we come up with 58.9 dollars (Anonymous, 2023e).

9. CHANGE IN PUBLIC AND PRIVATE SECTOR SEED PRODUCTION BETWEEN YEARS

The values of the public and private sectors in terms of quantity and proportion in seed production in Turkey in the last 20 years are analyzed in Table 4 (Anonymous, 2023f)

Table 4. Values Of Public and Private Sectors in Terms of Quantity and Proportion in Seed Production in Our Country in The Last 20 Years

Plants	2003			2012			2022		
	Public sector	Private Sector	P.S. rate (%)	Public sector	Private Sector	P.S. rate (%)	Public sector	Private Sector	P.S. rate (%)
Wheat	94 588	5 513	6	137 728	190 196	58	129 557	324 895	71.5
Barley	10 009	1 185	11	11 608	31 554	73	22 996	146 448	86
Soybean	7	336	98	66	2 182	97	22	3 042	100
Maize	198	22 201	99	151	32 645	100	129	79 747	100
Sunflower	20	5 608	100	-	14 732	100	15	32 818	100
Potato	5	25 390	100	8	185 478	100	152	481 777	100
Cotton	1 512	6 150	80	170	22 904	99	19	25 101	100
Vegetables	5	987	99	125	1 990	94	3	3 197	100
Forage crops	1 904	696	27	850	1 095	54	3 591	20 393	85

As mentioned in the introduction, the development of the seed sector in Turkey started in the mid-1980s. While the public sector produces some of the seeds of plant species important for our country, some are produced by the private sector.

According to 2003 data, 94% of wheat seed, one of the self-fertilizing plants and the most produced in Turkey was produced by the public sector, while only 6% was produced by the private sector. The share of the private sector in wheat increased to 58% in 2012 and 71.5% in 2022.

While the private sector shares in soybean and maize were 98% and 99% in 2003, respectively, in soybean, this ratio decreased to 97% in 2012 and was set at 100% in 2022, while in maize, it was 100% in both 2012 and 2022.

The private sector has produced 100% of seed production in sunflower and potatoes since 2003. Since hybrid sunflower production requires a particular breeding and production process, the private sector provides all of this production.

Twenty years ago, the public sector produced tiny (5 tons) of vegetable seed, whereas in 2012, this amount increased to 125 tons and proportionally to 6%. By 2022, the public sector will produce only 3 tons of vegetable seed production.

There are many forage crops classified as legumes and wheatgrasses. According to 2003 seed statistics, 73% of fodder crop seeds were produced by the public sector and 27% by the private sector, while the share of the public sector decreased to 46% in 2012. In 2022, forage seed production was close to 24 thousand tons, of which the public sector produced 15% and 85% by the private sector.

Generally, the public sector produces seeds of self-fertilizing crops, while the private sector produces crops such as

vegetables, sunflowers, and maize. Statistics published by the Ministry of Agriculture and Forestry reveal this situation.

Some reasons can be given to explain why the public sector produces seeds of self-fertilizing plants:

- Insufficient demand for seeds from farmers
- lack of legislation on variety protection and difficulty of supervision
- insufficient profitability
- insufficient supervision of the sale of foreign seeds in the market
- the fact that crops that do not have seed characteristics can be cultivated for years and marketed as seeds

The 2004 Law on the Protection of Breeders' Rights to New Plant Varieties introduced the possibility of protecting the seeds of self-fertilized plants. However, the most crucial problem here is the problem of supervision because these seeds, which are produced with great effort, expense, and process, can be marketed illegally or exchanged between farmers. This takes a long time to verify and prove beyond doubt, and it also causes seed companies to fall out with farmers.

Generally, the private sector produces the seeds of vegetables and foreign-fertilized plants. Hybrids are superior to standard varieties in terms of yield, quality, and other characteristics due to their genetic characteristics in vegetables and foreign-fertilized plants such as corn and sunflower, the necessity of renewal every year, the need for more infrastructure and technology, more laborious seed production, especially high profitability, marketing, distribution capability and innovation advantage (Altay, 2018; Anonymous, 2023d).

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SUGAR BEET AND SUGAR

Mehmet ÖZ[1]

1. SUGAR BEET

Sugar beet (*Beta vulgaris var. saccharifera* L.) is a biennial industrial plant in the Amaranthaceae family. The diploid chromosome number is 2n=18. *Beta maritima* is shown as a wild sugar beet. Wild forms of *B. maritima* are found along the Mediterranean coast. The eastern part of the Mediterranean and Asia Minor are shown as its origin (Arıoğlu, 2002). It is the only raw material of sugar produced in our country. Sugar beet is a plant with very high added value. It is very valuable as it is a source of employment both in the field and in the industry, as pulp (pulp), molasses, leaves, and head residues left in the field after harvest are used as animal feed, and as industrial input due to the production of alcohol and spirit from molasses (Er and Uranbey, 1998; Şiray, 2012; Yardımcı et al., 2012).

Sugar beet agriculture and industry: due to the fact that it requires advanced technology, it increases the level of agricultural knowledge and culture of producers, provides work and employment for all members of the family, and increases the welfare level of the agricultural sector, to keep the population in rural areas, sugar is one of the leading sectors supporting the slowdown of internal migration and the reduction of regional development gaps. Sugar has gained significant economic value in the last century with advances in agriculture and food technologies.

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The life of a plant begins with the germination of the seed and ends when the new plant produces seeds and is harvested. Sugar beet is a biennial plant and in the first year of its life, it forms its root body under the soil and leaves on the soil. In the second year, it is vernalized (cold) in the winter months and forms stem, branches, flowers and seeds (Er and Uranbey, 1998).

Although sugar beet is known as a temperate region plant due to its genetics, it can be grown in very different climatic conditions. If the sugar beet plant is selected the right variety, suitable location and careful maintenance activities are carried out, the sugar content can reach up to 24% (Memon et al., 2004). Root stem yield in sugar beet can vary between 7.000-9.000 kg/da and sugar content can vary between 12-24% depending on country location and climatic conditions (Rychcik and Zawiślak, 2002; Azam Jah et al., 2003; El-Karouri and El-Rayah, 2006; Ada et al., 2012; Turgut, 2012).

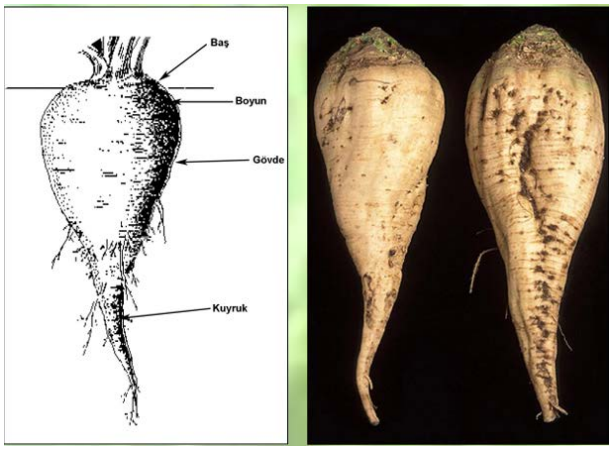
Sugar beet production is carried out on a contract basis. Production is carried out in the form of crop rotation agriculture for 3 or 4 years within the framework of the contract made with the producers every year. Crop rotation is applied with precision. Thus, soil fertility is maintained and the damage that diseases and pests can cause to sugar beet is reduced (Yılmaz et al., 2023).

1.1.Subsoil Organs of Sugar Beet

Subsoil organs consist of the root stem and the roots that grow out of it. The part of the sugar beet that is under the soil and used as an input in obtaining sugar is called the root body.

The root stem is mainly divided into four parts (Image 1):

Image 1. Sugar Beet Root



(Anonymous, 2023a)

1.1.1. Head: Starting from the point where the outermost and lower leaves emerge on the sugar beet root, the upper remaining part is called the head. This section contains a high amount of nitrogen, but the sugar content is quite low. The excessive nitrogen in the head hinders the crystallization of sugar, so it is undesirable. Therefore, during harvest, the head is cut off and discarded.

1.1.2. Neck (Hypocotyl): It is the part between the point where the leaves emerge and the point where the first roots emerge. Neither roots nor leaves are present in the neck.

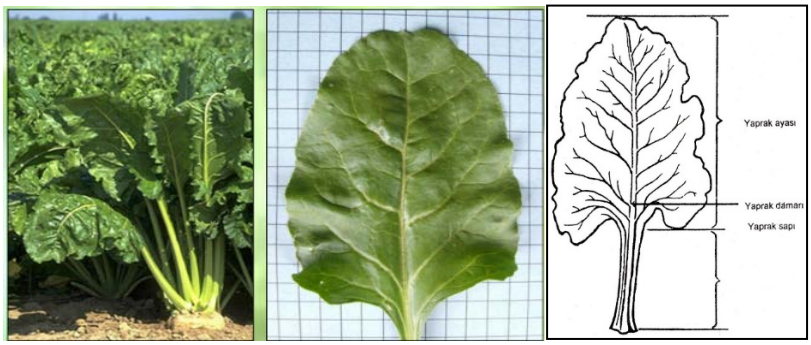
1.1.3. Stem: The root stem of the plant extends from the point where the first roots emerge to the tail where the stem narrows to a diameter of 2 cm. In terms of mass and volume, it is the largest part of the root stem. It is desired to be conical. On both sides of the stem, there are distinct hollows called spirals, shaped like the letter S. The fine roots emerging from these hollows allow the plant to absorb water and dissolved nutrients. This region is the richest in sugar content.

1.1.4. Tail: It is the part that is below the point where the root stem narrows to 2 cm. The tail can extend to depths of 1.0-1.5 m. Although the ratio of the tail to the sugar beet root is small, its function is significant. It serves as insurance against water deficiency for the plant and contains numerous fine roots. Due to its thinness, it remains in the soil during harvest (Koç, 1999; Anonymous, 2016).

1.2.Above-Ground Organs

1.2.1. Leaf: In the first year of sugar beet, there are between 35-50 leaves settled around the center of the head, with the youngest on the outer side and the oldest forming a rosette. The leaves have a wide blade. Leaves that develop in the second year are small and have narrow blades, appearing on stems and branches (Image 2).

Image 2. Sugar Beet Leaves



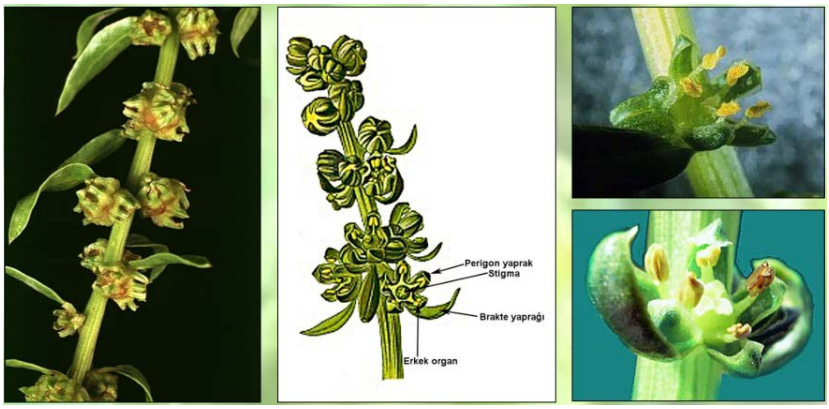
(Anonymous, 2023a)

1.2.2. Stalk: After the vernalization of sugar beets is completed in the winter months, the stalk grows from the awakening shoots at the top during May-June, with a height ranging from 1.0-2.0 m. It has an angular structure. Branches, flowers, and seeds develop on the stalk.

1.2.3. Flower: Flowers are located in clusters on flower stalks protected by bracts in the leaf axils. In sugar beets, there is

a structure called the perigon that assumes the protective function of sepals and petals. Inside the perigons, there are 5 male organs and a 2-3 headed female organ. Flowers are found individually or in pairs, or in groups of three in the axils of bract leaves. Flowers found singly are called monogerm, and those containing two or more flowers together are called poligerm or multigerm flowers. The opening of the flowers occurs from the main stem towards the lateral branches (Image 3).

Image 3. Poligerm and Poligerm Sugar Beet Flowers



(Anonymous, 2023a)

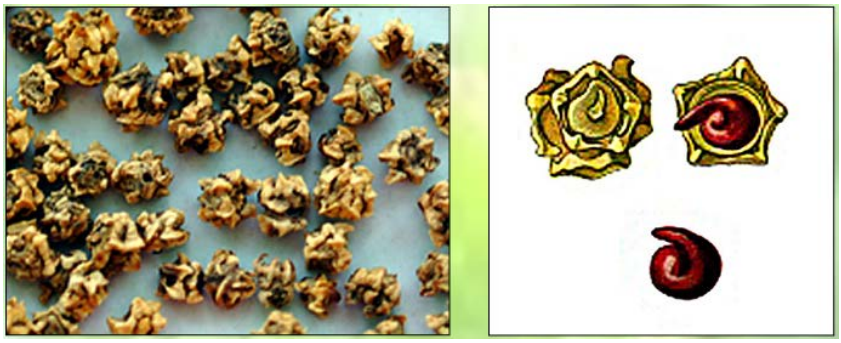
Sugar beet undergoes cross-pollination. Beet is a strongly self-incompatible plant. When plants are isolated, very few seeds may be produced, or none at all (Smith, 1980; Valdeyron, 1984).

When examined under a microscope, pollen grains are round with numerous indentations on the outer parts. It is estimated that there are around 17,000 pollen grains in each anther tube. This means 85,000 pollen grains per flower (Schneider, 1942). According to German scientists, the viability of pollen grains lasts up to a maximum of 24 hours. The environmental conditions, especially humidity, have the most significant impact on this viability period. Pollen grains are usually carried by the wind, and insects (bees, honey bees, thrips) play a lesser role in pollen movement. Bees may increase seed

yield, but plants seem to be visited by bees only when there is no other pollen available.

1.2.4. Seed: About 30 days after fertilization, the ovary develops, and seeds form within it. Monogerm seeds are obtained from monogerm flowers, while poligerm seeds are obtained from poligerm flowers. Technical monogerm seeds are obtained by singulating poligerm seeds in the factory. Monogerm seeds, carrying a single embryo, give rise to a single plant when germinated, while poligerm seeds produce as many plants as the number of embryos they carry. In our country, except for hybrid seed production, monogerm seeds are used (Image 4).

Image 4. Polygerm And Monogerm Sugar Beet Seeds



(Anonymous, 2023a)

2. VARIETIES

The sugar beet varieties used in our country are as follows:

a.Multigerm varieties: It is the term used for seeds formed by the coming together of two or more embryos

b.Technical monogerm varieties: These are seeds obtained by mechanically separating the multigerm seed cluster, and they are characterized by a standardized rate of single sprout formation.

b.Genetic monogerm varieties: Refers to seeds that genetically produce a single sprout (Anonymous, 2008).

The variety Beta vulgaris sacchariferae cultivated for sugar production, includes types that differ significantly from each other in terms of morphological, physiological, and quality characteristics.

Certainly, here is the translation of the descriptions of different sugar beet types:

a.E (Ertrag) Type Beets: These are beets with high root yield. Although the sugar content is low, the high root yield results in a high amount of sugar obtained per unit area.

b.Z (Zucker) Type Beets: These beets have a high sugar content, but their root yields are low. They are not preferred by producers, but they are a type desired by factories. They have a short development period, do not produce many leaves, and have small roots. They require a lot of water and are quickly affected by drought.

c.N (Normal) Type Beets: These beets fall between E and Z types in terms of sugar content and root. They serve as a compromise between producers and sugar factories.

d.ZZ Type Beets: These beets have very high sugar content but low root yields. They are used as parents in breeding programs.

e.EE Type Beets: In this type of beets, root yields are high, but sugar content is low (Anonymous, 2019; Bayraktar and Yıldız, 2023).

Within the Beta vulgaris species, there are four varieties with different morphological and quality characteristics, as well as different uses:

a.Beta vulgaris var. cicla: Also known as Swiss chard or chard. Its leaves are consumed as a vegetable, similar to spinach. The leaves and stems are well-developed, and the root part is thumb-thick and forked.

b. a.Beta vulgaris var. cruenta: Known as red beet or cucumber beet.

c. a.Beta vulgaris var. rapa: Known as forage beet or fodder beet. The sugar content in the stem is low, and the root is quite large.

d.Beta vulgaris var. saccharifera: Sugar beet cultivated for sugar production (Anonymous, 2023c).

3. CLIMATE REQUIREMENTS

Sugar beet seeds can begin germination at 7-8°C, but the optimal and quickest germination occurs at 25°C. Soil temperatures around 20°C after germination are crucial to positively impact the sugar content in the beet's root. Sugar beets are resilient plants that can withstand temperatures as low as -7°C during the initial growth period, but they may suffer damage at temperatures between 1-4°C in later stages. The highest sugar and beet root yield is obtained from sugar beets grown in locations where the night temperature is around 10-15°C and the daytime temperature is approximately 20-26°C.

The vegetation period varies between 170-200 days. Sugar beets utilize some of the sugar stored in their root for energy production through respiration.

$C_6H_{12}O_6 + 6O_2$ ------> $6CO_2 + 6H_2O + 38ATP$ Respiration Formula

Temperature increase accelerates respiration. Respiration begins at 0°C and doubles with every 10°C temperature rise.

Sugar losses due to respiration can reach significant levels, especially during dry and hot periods. Nighttime respiration-induced sugar loss can amount to about 30% of the sugar produced daily through photosynthesis, depending on nighttime temperatures.

As a long-day plant, sugar beet yields are positively influenced by a balanced sequence of sunny and cloudy days. For the accumulation of 1 kg of dry matter in sugar beets, 400-600 mm of water is needed. In regions where the annual total precipitation is between 600-700 mm and the rainfall is evenly distributed throughout the seasons, sugar beets can be grown without irrigation.

Sugar beet cultivation in Turkey is concentrated in regions other than the Mediterranean, Black Sea, Aegean, and Southeast Anatolia Regions. Approximately 94% of the regions where sugar beets are produced are at an altitude of at least 700 m. About 70% of the areas where sugar beets are cultivated have a continental climate, with an annual average precipitation of 300-500 mm in the Inner and Eastern Anatolia Regions. 24% are in the Mediterranean, Aegean, and Black Sea Transitional climate regions with an annual average precipitation between 350-500 mm, and 6% are in the Marmara and Black Sea Maritime climate regions with an annual average precipitation between 700-900 mm (Anonymous, 2023c; Anonymous, 2023d).

It is crucial for producers to understand that both in our country and globally, producing sugar and sugar beets, which are essential as a source of energy and a basic food item, in quantities that meet demand, at a high quality and economic level, and increasing producer incomes, can be achieved from planting to harvest with proper care processes and the use of the correct genotype. Different productions in various climate regions in our country result in significantly different yields and qualities of

products. In temperate regions near the sea, sugar beet root yields are high, but sugar content is low. In regions with harsh continental climates, such as Eastern Anatolia, root yields are low, but sugar content is high. In transitional regions like Central Anatolia, both root yields and sugar content are satisfactory.

4. SOIL REQUIREMENTS

The root of sugar beet, which is the purpose of cultivation, being in the soil emphasizes the crucial role of the soil. It thrives well in nutrient-rich sandy-loam, deep, humus-rich, and high-organic-matter soils. Clayey and stony soils are unsuitable for sugar beet cultivation, as they can disrupt the physical structure of the root, leading to forking. Sugar beets yield higher and better-quality crops in soils with a pH ranging from 6.0 to 8.0 (Anonymous, 2019; Anonymous, 2023c).

5. ROTATION

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6. SOIL PREPARATION

The recommended pre-crop for sugar beet cultivation in our country is cereals. The first process in soil preparation is stubble mulching, which enables the plant residues to be enriched

in organic matter by burying them in the soil after the pre-plant harvest. Stubble breaking and the first ploughing must be done in the fall. In order for the first ploughing to be done properly, the soil should be plowed and the stubble should be mixed immediately after the grain harvest before the shade is removed. Stubble should never be burned. If there is a plow base, a bottom plow should be pulled against it every 2 to 3 years before the first plowing. After the stubble breaking process, the field is left alone before the fall ploughing. If the field is grazed until the fall ploughing before winter (last ploughing), it should be harrowed superficially. Thus, water retention of the soil will be ensured and weeds will be killed. With this last ploughing before winter, the recommended autumn fertilization according to the results of soil analysis is also done at the same time (Anonymous, 2019; Anonymous, 2023i).

7. FERTILIZATION

The following criteria should be taken into consideration when determining the amount of fertilizer to be applied per unit area in sugar beet:

a. The ratio of available nutrients in the soil determined as a result of soil analysis

b. Genotype of the variety to be planted

c.Soil type

d. Irrigation facilities

e. It varies according to the targeted yield.

Three main plant nutrients stand out in sugar beet cultivation. These are nitrogen, phosphorus and potassium (N-P-K). The use of more or less fertilizer than required increases input costs as well as decreasing yield and quality.

7.1. Nitrogen Fertilizers: The main commercial nitrogen fertilizers used in sugar beet cultivation are ammonium sulphate (21% N), calcium ammonium nitrate (26% N) and urea (46% N). If nitrogen fertilizer is used more than necessary, it causes a decrease in sugar yield and environmental pollution. If more nitrogen is used than necessary, although there is a slight increase in root stem yield, the sugar content decreases as leaf development is encouraged. For these reasons, nitrogen fertilizer application should be stopped at least 2.5 months before harvest.

It is recommended to apply nitrogen fertilizers in parts. According to irrigation possibilities, half of the recommended fertilizer should be applied during seedbed preparation before planting or during planting, and the remaining half should be applied with irrigation before the first hoe or before rain. For sugar beet, fertilizer should be used in such a way that 14-18 kg of pure nitrogen is given per decare.

7.2. Phosphorus Fertilizers: The main phosphorus fertilizers used in beet agriculture are triple super phosphate (43-44% P) and super phosphate (18-19% P). It is a plant nutrient accepted as a macro nutrient for plants. Phosphorus regulates photosynthesis in plants, accelerates stem growth and increases plant resistance to diseases. In case of deficiency, growth slows down and plants become stunted. Red spots appear on the tips of the leaves, which then spread to the entire leaf. Since phosphorus fertilizers are considered immobile fertilizers, they should be buried in the soil during autumn tillage, preparation of the planting bed or during planting. For sugar beet, 10-11 kg of pure phosphorus per decare will be sufficient.

7.3. Potash Fertilizers: It is the plant nutrient that sugar beet needs the most after nitrogen. The most important role of potassium in plant metabolism is that it acts as an enzyme

activator. Due to these properties, potassium is an essential nutrient for the synthesis of carbohydrates and the transport of sugars to the tissues in the plant. The main potash fertilizers used in beet agriculture are potassium sulphate (50% P), potassium nitrate (46% P) and potassium chloride (60% P). In general, it should be mixed with phosphorus fertilizers in autumn, before the last plowing, under the plow.

7.4. Compound Fertilizers: Fertilizers containing two or more plant nutrients in different proportions are called compound fertilizers. These fertilizers are expressed in the order of nitrogen, phosphorus and potassium in % (15-15-15, 20-20-0, 18-46-0).

7.5. Organic fertilizers: No commercial fertilizer can replace well-burned farm manure. Producers who cannot reach farm manure sufficiently can use green manure, compost and stubble residues to improve the physical and chemical structure of the soil as well as enriching the soil with organic matter. Organic matter increases the aeration and water retention capacity of soils and reduces the risk of the formation of the cream layer.

Let us examine how to calculate the amount of commercial fertilizers that should be used according to these recommended pure plant nutrients. If we will do this through an example, let's assume that the producer will apply 10 kilograms of pure phosphorus and 18 kg of pure nitrogen per decare according to the criteria mentioned above. First of all, let's calculate the 10 kilograms of pure phosphorus that we will use as base fertilizer, the producer should prefer triple super phosphate, super phosphate and one of the DAP (18-46-0%) and 20-20-0 commercial fertilizers from compound fertilizers as a source of pure phosphorus (Koç, 1999; Anonymous, 2023i).

If we assume that the producer will apply 10 kg of pure phosphorus and 18 kg of pure nitrogen per decare, all of the P will be applied during sowing with a combined seeder, half of the N

will be applied during sowing and the other half in the second water, and the producer has DAP (18-46-0) and urea (46%) fertilizers in the warehouse, the calculation is made as follows:

P calculation

If 100 kg DAP fertilizer 46 kg P

X 10 kg P

X= 1000 / 46= 21.7 kg / da DAP is used.

With this approximately 21.7 kg of DAP, 21.7 x 18 / 100= 3.9 kg of pure N will be given at the same time. Since it is known that half of the nitrogen, that is 9 kg, will be given at planting, 9.0-3.9= 5.1 kg of pure nitrogen should be applied as urea. Now let's calculate this with proportion:

N calculation

If 100 kg of urea 46 kg of pure N

X 5.1 kg pure N

X= 510 / 46= 11.0 kg urea

The producer should mix 21.7 kg DAP and 11.0 kg urea fertilizers for each decare of land during planting.

Calculation of 9 kg/da pure nitrogen to be given in the second irrigation:

If 100 kg urea contains 46 kg pure N

X 9.0 kg pure N

X= 900 / 46= 19.5 kg urea should be used.

8. SOIL PREPARATION IN SPRING

Seed bed preparation in spring is a very important stage of sugar beet cultivation. The time of soil preparation, the equipment to be used, the depth of the seed bed and the good crumbling of the topsoil will affect the root body yield, physical and chemical quality of the sugar beet to be produced.

During seed bed preparation, nitrogen and phosphorus fertilizers should be applied as base fertilizer, and if herbicide is to be used against weeds before planting, the planting bed should be made ready by using second class tillage tools (Anonymous, 2019).

9. VARIETY SELECTION

Variety selection is a very important factor affecting unit area yield and quality in sugar beet farming. While determining the variety, it should have the following features:

a. It should be suitable for the climate and soil structure of the region.

b. It should be resistant to diseases and pests and should not go to seed in the first year.

c. It should have high root stem yield and sugar content.

d. Germination and plowing power should be high.

e. It should be well calibrated and sprayed with pesticides against soil-borne diseases and pests.

10. SOWING

The producer should be well aware of the following 5 factors in sugar beet sowing:

10.1. Sowing time

10.2 Sowing frequency

10.3. Sowing norm

10.4. Sowing method

10.5.f. Sowing depth

10.1. Sowing time: Sowing time is an important factor affecting the yield and quality of sugar beet. Since sugar beet is a plant produced according to the contracted production method, it has the initiative on the planting time, but it has no authority over the harvest time since the harvest time is determined by the beet regional chiefs. In a study, it was determined that every 1 day of delayed yield loss is 25 kg per decare. Therefore, early sowing, which is done when the risk of frost is reduced and the soil temperature is sufficient for germination, should always be preferred as it prolongs the development period of the beet and increases the yield (Koç, 1999).

According to long-term averages, 3% of sugar beet sowing in Turkey is carried out in February, 18% in March, 60% in April, 18% in May and 1% in June.

10.2. Sowing density: In our country, the distance between rows is 45 cm and the distance between rows is 16-25 cm in sugar beet cultivation. In this case, 10 000 - 12 000 seeds are spent for 1 decare (1000 m2) area. Some producers may also prefer 8, 10 and 15 cm above the row to guarantee the number of plants per unit area. In this case, seed consumption is doubled.

10.3. Sowing norm: Sowing norm is the expression of the amount of seed to be spent for a decare area in g or kg. Assuming that 1000 grain weight is 10-12 g and 22,222 seeds are used, approximately 220 to 260 g of seed is consumed per decare. If the distance between rows is 20 cm, seed consumption per decare can be calculated as 110 to 130 g.

If it is assumed that a pneumatic precision sowing machine will be used in sugar beet planting, the number of seeds to be spent on 1 decare area is calculated as follows:

For an over-row distance of 10 centimeters:

Let the distance between rows be 45 centimeters and the distance between rows be 10 centimeters These units are first converted to meters and these two values are multiplied. 0.45 x 0.10 = 0.045 m^2. This figure is expressed as the area covered by a seed. Since 1 decare area is 1000 m^2, the amount of seeds sown per decare is 1000/0.045 = 22 222 seeds.

In order to examine whether the targeted amount of seeds has been sown at the end of the sowing process, the seeds sown during the sowing of 10 meters in length are counted and checked. According to the values we examined above, the number of seeds spent for 10 meters is expected to be 222 seeds. The same counting process can be done after emergence and the percentage of germination and emergence can be calculated by counting how many of the 222 seeds germinated and ploughed out of the 222 seeds sown in a 10-meter length. Considering that there are 100,000 seeds in a sugar beet seed unit, approximately 4.5 decares of land can be planted with one unit of seed.

Today, when seed and thinning costs are an important input, adjusting the seeder so that the distance between rows is 20 cm instead of 10 cm will reduce seed costs by half.

10.4. Sowing method: Sowing is done using mechanical precision or pneumatic precision seeders. It should not be forgotten that a properly made sowing is a very important element for high yield and quality. The seeder should be used after the necessary checks and maintenance operations have been carried out before sowing. In sowing with precision seeders, whether mechanical or pneumatic, the speed of the tractor pulling the seeder should not exceed 4 km/h. Excessive speed may cause

heterogeneous distribution of seeds and variation in sowing depths.

10.5. Sowing depth: Sowing depth is very important on the germination of sown seeds. In shallow sowing, germination cannot be realized due to easy moisture loss, while in very deep sowing, the plants are lost as yellow curls before they can bring their cotyledon leaves to the soil surface. Beet seeds should be sown at a depth of 2 to 5 cm depending on the type and moisture of the soil.

All operations other than struggle and irrigation that ensure the development of beetroot from planting to harvest and its protection from weeds, diseases and pests are called maintenance (Koç, 1999; Anonim, 2012; Anonim, 2023i).

11. CARE OPERATIONS

11.1. Breaking the cream layer

11.2. Thinning / singulation

11.3. Hoeing

11.4. Weed control

11.5. Disease and pest control

11.6. Uprooting stalking plants

11.1. Breaking of the cream layer: The impermeable layer that forms on the soil surface due to the effect of high temperature after irrigation or rain, especially in heavy structured soils, and prevents the newly germinating plant from reaching the soil surface is called the cream layer. It is possible to prevent the formation of the cream layer or to neutralize it with some applications. These are

11.1.1. Particularly sprinkler irrigation in order to soften the cream layer

11.1.2. Small cattle are moved around the field.

11.1.3. The roller should be pulled perpendicular to the planting direction.

It should not be forgotten that it should not be too late to obtain the expected benefits from these practices. For example, if 7-10 days have passed since sowing, options b and c should not be considered, because mechanical damage may be caused to young plants that are close to the soil surface. In this case, the only alternative is sprinkler irrigation, if possible, in the evening hours when the heat starts to lose its effect.

In order to avoid the risk of the cream layer that may be encountered in untempered and heavy structured soils, the producer should first irrigate the field where the sugar beet will be planted and plant when the soil is tempered.

11.2. Thinning and Singulation: In sugar beet production, pneumatic precision sowing machine can be used to sow at the desired frequency over the row, but some producers may not want to risk the output by producing frequently. In this case, thinning is necessary. The number of plants per unit area in a beet field and the good distribution of these plants on the surface is an important factor affecting yield and quality. When the beets reach the 4-5 leafed period, thinning is performed. The row spacing should be 20-25 cm. It is necessary to be careful not to damage the beets during the singling.

11.3. Hoeing: Even if weed control is done with pesticides, hoeing should be done to aerate the soil. Hoeing is done to prevent water loss by evaporation from the soil by breaking the capillary gaps in the soil, to warm the soil more quickly, to create a rough surface so that rainwater can penetrate

the soil more. Under the conditions of our country, one or two hoes are sufficient before the plants cover the soil surface. Although manual hoeing is much more effective, it is not preferred due to the difficulty of finding workers and increasing labor input costs, and is usually done by machine. Since the distance between rows is as narrow as 45 cm, care should be taken not to damage the side roots of the beets, not to remove too much clods and not to crush the beets (Koç, 1999).

11.4. Weed Control: Weeds are the biggest competitor of the nutrients used by sugar beet from the soil. For this reason, it is necessary to control weeds during the period from germination to harvest. While weeds share the beet's nutrients, water, air and sun, they are intermediate hosts for some diseases and pests. Weed control is done by hoeing and using herbicides. Weed control with herbicides can be done in three periods: pre-planting, pre-emergence and post-emergence. In recent years, varieties produced with SMART (smart seed) technology are more preferred.

11.5. Disease and Pest Control: The yield and quality seen after planting can only be obtained from healthy plants. As in every plant cultivation, it is very important for yield and quality to follow the possible diseases and pests in sugar beet agriculture and to carry out the necessary control program. The most important diseases that threaten sugar beet are as follows: Cercospora beticola, Ramularia beticola, Phoma betae leaf spot diseases, powdery mildew (Erysiphe polygoni), jaundice viruses, beet curly virus (CurlyTop), beet rust (Uromyces betae) and Rhizomania (Beet necrotic yellow vein virus (BNYVV)) root disease. The best way to control them is to prefer resistant varieties, if available, to use appropriate fungicides, to make crop rotation and not to use excessive nitrogen fertilizer.

As for pests, wireworm (Agriotes), beet flea (Chaetocnema), gall wasp (Gryllotalpa), earthworm (Agrotis), leafworm (Caradrina), beet fly (Pegomyia) and field mouse (Microtus) can be listed in general. The most effective control methods are cultural measures and the use of insecticides when necessary.

11.6. Uprooting stalking plants: Under normal conditions, sugar beet should be up in the second year. The first year's plants are considered as weeds. Not only the stems of these plants should be broken, but also the root stems should be removed from the soil.

12. IRRIGATION

Irrigation is the artificial delivery of water, which is necessary for the normal development of plants but cannot be met by natural precipitation, to the soil in the amount desired by the plant and with the appropriate method. Sugar beet, which yields a large amount of product from the unit area, is an industrial plant that needs water at certain intervals and amounts during the period from planting to harvest. As irrigation periods;

12.1. Emergence irrigation: If the sowing is late and humidity is lost, emergence irrigation is done before or after sowing.

12.2. Development period irrigation: It is recommended to make the first irrigation as late as possible for a healthier development of the beet root stem. Mild drought in the first months after planting causes the roots to go deeper. In this way, the plant is better supplied with water and nutrients. Beets that complete their root development in deep soil have high sugar yield and quality.

12.3. Pre-harvest irrigation: This is the annealing irrigation to facilitate harvesting and reduce harvest losses.

The number of irrigations varies according to irrigation methods. If keel or sprinkler methods are preferred, irrigation should be done 4-6 times by following the developments in the plant. Sugar beet, which will stay in the field for 6-7 months, should be given between 50-80 tons of water per decare in each irrigation depending on the condition of the soil.

Giving water to the field (irrigation methods) are gathered in three main groups in our country:

a) Flood Irrigation: Flood irrigation is a method that has low irrigation costs but consumes a lot of water and should never be preferred.

b) Sprinkler Irrigation: In the sprinkler irrigation system, water is sprayed under pressure from sprinkler heads placed at certain intervals on the land surface, into the air and then into the soil. Water is applied by sprinkling on the soil surface similar to natural precipitation.

c) Drip Irrigation: In drip irrigation, purified water is transmitted through a network of pressurized pipes to drippers placed near the plant. It is given to the soil surface under low pressure from the drippers. Especially with sprinkler irrigation, water droplets that remain on the surface of the plant for a long time increase the possibility of fungal disease called Cercospora. However, the drip irrigation system minimizes this risk by sending the water directly to the plant and ensures that the plants are healthier and more productive. In addition, the drip irrigation system uses less water and thus ensures more efficient use of water resources.

Whichever irrigation method is chosen, it is most important to avoid over- or under-watering. Over-irrigation

causes root rot and some diseases as well as wasting resources, while under-irrigation causes an increase in plant development and yield losses (Anonymous, 2012).

13. HARVEST

When technological maturity is reached, the process of removing the sugar beet root stems from the soil and cutting the leaves at the head is called harvesting. While harvesting can be done by manual labor, it can also be done with harvesting machines to reduce costs. Depending on the region, sugar beet reaches harvest maturity between mid-September and late October. Sugar beets, whose heads are cut off, are delivered to sugar factories with the dismantling and delivery permits obtained from beet regional chiefs. When loading into trailers or crates, care should be taken to ensure that the sugar beets are not grounded and that the head is cut flat. If these rules are not followed, a certain amount of the delivered sugar beet is cut as waste (Koç, 1999).

14. WORLD SUGAR BEET ECONOMY

Sugar beet is produced in 52 countries in the world and Turkey ranks 5th in terms of both cultivation area and production amount after Russia, USA, France and Germany with a share of 9.1%. In terms of yield, it ranks 2nd after Germany (Table 1). Turkey is among the countries that produce only from sugar beet due to its climatic conditions (Anonymous, 2022a).

Table 1. World Sugar Beet Cultivation Area, Production and Yield Values by Country

Countries	Cultivation area (ha)	Production (ton)	Yield (kg ha^{-1})
Russia	916.647	33.915.086	37.0
USA	462.280	30.497.740	66.0
France	420.890	26.195.460	62.2
Germany	386.000	28.618.100	74.1
Turkiye	336.348	23.025.738	68.5
Egypt	263.543	13.043.612	49.5
Poland	245.920	14.171.540	57.6
Ukraine	220.000	9.150.180	41.6
World	4.439.073	252.968.843	56.9

15. TURKISH SUGAR BEET ECONOMY

Sugar beet production in Turkey is carried out within the framework of the "Sugar Beet Production Contract" made with producers every year (Anonymous, 2022b). Thanks to this contract, producers do not experience any marketing problems and they know where they will sell their products before they start production. In addition, this production is carried out within the scope of rotational agriculture. Stevanato et al. (2019) state that sugar beet is usually included in a 3-5 year rotation according to local practices, soil conditions, climate, diseases, etc. In terms of rotation, it is stated that if sugar beet is grown continuously (monoculture), there will be a significant yield loss (Götze et al., 2017). Therefore, it is stated that sugar beet production should be grown according to a crop rotation cycle where a certain time interval is needed before replanting (Fikry et al., 2021).

In 2022, sugar beet cultivation area was 2 975 096 decares, production was 19 253 962 tons and yield was 6 472 kg/ha. In 2021, although the cultivation area was higher, production and yield values were higher (Table 2) (Anonymous, 2022a).

In 2020, 28.2% of the sugar beet cultivation area in Turkey was located in Konya, 8.1% in Eskişehir, 8.0% in Yozgat, 6.4% in Kayseri, while 32.5% of the production was realized in Konya, 8.5% in Eskişehir and 7.6% in Yozgat (Anonymous, 2022c). These values indicate that yield per decare is the highest in Konya.

Table 2. Sugar Beet Cultivation Area, Production and Yield Values in Turkey (TUIK=Turkstat, 2023).

Years	Cultivation area (da)	Production (ton)	Yield (kg da^{-1})
1995	3 122 510	11 170 569	3 577
2000	4 100 230	18 821 033	4 590
2005	3 358 120	15 181 247	4 521
2010	3 291 669	17 942 112	5 451
2015	2 744 873	16 022 783	5 837
2020	3 381 078	23 025 738	6 810
2021	3 054 051	17 767 085	5 818
2022	2 975 096	19 253 962	6 472

16. SUGAR

White sugar is crystallized sucrose produced from sugar beet or sugar cane, classified as white sugar (standard, refined, cube and crystal sugar), semi-white sugar, refined sugar, raw sugar and brown sugar).

Sugar quotas: In order to ensure stability in the production and supply of sugar in our country, sugar quotas have started to be determined in the Sugar Law No. 4634 published in the Official Gazette on 04.04.2001.

16.1. A Quota Sugar

It indicates the amount of sugar produced according to domestic demand that can be supplied to the domestic market during the marketing year. According to the Presidential Decree No. 7450 on the Determination of Sugar Quotas for the

2023/2024 Marketing Year, published in the Official Gazette dated August 2, 2023, the A quota was set at 2 million 837 thousand 250 tons.

16.2. B Quota Sugar

Indicates the amount of sugar produced corresponding to a certain proportion of the A quota to be held for safety margin. The B quota for the 2023/2024 marketing year is 141 863 tons. This value is 5.0% of the A quota.

16.3. C Quota Sugar

Refers to sugar produced outside of quotas A and B that cannot be marketed domestically, and raw and white sugar procured for processing on the condition of export. C quota production is not planned for the 2023/2024 marketing year (Anonymous, 2023b).

17. SUGAR SECTOR

The sugar sector in Turkey has been regulated by law since 1925. The Sugar Law No. 6747, which incorporated all the legislation published on the sugar industry, entered into force on 1/07/1956 and was repealed by the Sugar Law No. 4634, which entered into force on 19/04/2001 (Anonymous, 2001). The Sugar Authority was also closed down by the Decree Law No. 696 dated 24.12.2017, and its powers were transferred to the Ministry of Agriculture and Forestry (Anonymous, 2017).

The first beet sugar factory in Turkey was established in Uşak in 1926. The first Turkish sugar was produced at the Alpullu Sugar Factory established in Kırklareli in the same year (Anonymous, 2022a).

According to 2023 data, sugar production from beet in our country was carried out by 33 sugar factories owned by 7

companies. On 20.02.2018, the tender process for the privatization of 14 sugar factories (Afyon, Alpullu, Bor, Burdur, Çorum, Elbistan, Erzincan, Erzurum, Erzurum, Ilgın, Kastamonu, Kırşehir, Muş, Turhal and Yozgat Sugar Factories) was initiated by the Republic of Turkey Prime Ministry Privatization Administration, and 13 sugar factories were sold within this scope, and the sale of Kastamonu Sugar Factory was not realized since there was no bid. The transfer of 10 sugar factories was completed and the sale of 3 sugar factories (Burdur, Ilgın, Yozgat) was canceled, thus increasing the number of companies producing sugar from sugar beets in the sector to 15.

Turkish Sugar Factories, which produces sugar from beets and has a 36% share in the sector, is an Economic State Enterprise. Activities;

- 15 Sugar Factories (Ağrı, Ankara, Burdur, Çarşamba, Elazığ, Erciş, Eskişehir, Ereğli, Ilgın, Malatya, Kars, Kastamonu, Susurluk, Yozgat and Uşak)

- 2 Alcohol Factory,

- 2 Machine Factory,

- 1 Electromechanical Devices Factory,

- 1 Seed Processing Plant,

- 1 Research Institute.

Of the 33 beet sugar factories in production in Turkey, 15 belong to the public sector, 12 to the private sector and 6 to beet cooperatives. Currently, according to capacity, the share of the public sector is 37%, the share of cooperative factories is 36% and the share of private factories is 27%. Turkey's sugar production capacity is approximately 3.6 million tons/year. Turkey's share in world beet sugar production is 9% as of the 2020/2021 season and ranks 5th in the world with this production (Anonymous, 2022b).

17.1. Sugar Production

Sugar, which has been an important source of food for humans for centuries, was initially obtained only from sugar cane. However, this changed in the 19th century with the introduction of sugar beet cultivation and production from sugar beets. Cane and beet sugars do not differ in quality. However, the cost of cane sugar is lower than the cost of beet sugar due to the lower cost of production of sugar cane, which grows only in tropical and sub-tropical regions, lower processing costs and higher yields.

Depending on their geographical location, countries such as Turkey, the European Union, Russia and Ukraine generally produce sugar from beet; countries such as the USA, Japan and China produce sugar from both beet and cane; and countries such as Brazil, India, Mexico, Pakistan, Thailand and Australia produce sugar from cane.

In the 2021/22 season, global sugar production is estimated at 181 million 184 thousand tons in total, of which 38 million 471 thousand tons will come from beets and 142 million 713 thousand tons from cane. In the 2022/23 season, 79% of the sugar produced worldwide is expected to come from sugar cane and 21% from sugar beet.

Brazil is the world's largest sugar producer, accounting for 19.9% of production in 2021/22. It is followed by India with 19.2% share and EU countries with 9% share. Turkey ranks 10th with a share of 1.5%.

According to 2020-2021 data, the annual economic size of Turkey's sugar sector is approximately 38.5 billion TL in total, including 24.7 billion TL for beet sugar factories and 13.8 billion TL for starch-based sugar factories (2022d).

17.2. Sugar Consumption

Consumption is the main driver of the world sugar economy. Research shows that the largest consumers of sugar are also the leading producers. India, EU, China, USA, Brazil, Brazil, Indonesia, Russia, Pakistan, Mexico and Egypt are among the largest sugar consumers. Turkey ranks 11th globally with a consumption of approximately 2.9 million tons in the 2021/22 season.

While per capita consumption of sucrose-based sugar in the world is 21.4 kg per year in terms of white sugar, this value is 36.5 kg in Turkey (Anonymous, 2023e).

17.3. Foreign Trade

Globally, the high yield and low cost of cane-derived sugar has resulted in 90% of sugar trade being cane-derived. In 2021/22, Brazil, the world's largest sugar exporter, exported 25.6 million tons of its 36 million tons of white sugar production. This country was followed by Thailand (10 million tons) and India (8.8 million tons). Among importer countries, Indonesia is the largest importer in the 2021/22 season, followed by China, the USA, Bangladesh and Algeria.

17.4. Prices

International sugar trade is shaped by world stock exchange prices. The London Stock Exchange for white sugar and the New York Stock Exchange for raw sugar are important trading centers. The fact that the unit price of sugar obtained from cane is less than half of the unit price of beet sugar reduces the competitiveness of beet sugar. Although there is no significant difference in quality between cane and beet sugar, cane sugar, which accounts for a large share of world sugar production and exports, plays an important role in determining sugar prices.

Although world sugar prices are generally shaped by supply and demand conditions, external factors such as price speculation, oil and commodity prices, freight costs, exchange rate changes, interest rates, trade policies, inflation, political and financial turmoil, and the economic situation of countries can also affect prices.

In 2023 market conditions, London (No: 15) white sugar prices averaged $730.22 in September, while New York (No: 11) raw sugar prices averaged $593.12 (Anonymous 2023f).

18. STARCH-BASED SWEETENERS

In the world, caloric sweeteners are divided into two main groups: sucrose and starch-based. Sucrose-based ones are produced from sugar beet and sugar cane, while starch-based ones are produced from raw materials such as corn, wheat and potato. Starch-based syrups produced only from corn are generally called "corn syrup," while those containing fructose are called HFCS (High-fructose corn syrup).

In starch-derived fructose-containing syrups, those containing approximately 42% fructose and 55% glucose are called HFCS-42; those containing approximately 55% fructose and 41% glucose are called HFCS-55. Of these, HFCS-55 is considered as a substitute for sucrose obtained from beets (Anonymous, 2022b).

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OCCUPATIONAL SAFETY ANALYSIS IN FOREST FIRE WORKERS

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1. INTRODUCTION

One of the most challenging and dangerous tasks in forestry is fighting forest fires. Forest firefighters play a critical and dangerous role in bringing fires under control quickly. Forestry workers are constantly exposed to risks to their mental and physical health.

The working conditions of those involved in fighting forest fires are highly hazardous in terms of occupational health and safety. Therefore, it is crucial to assess the current situation using scientific methods in order to effectively respond to these fires. Various risk assessment methods are used to identify and evaluate the risks associated with forest firefighting operations.

Risk management generally involves the identification, evaluation and measurement of risks, leading to decisions for the management of those risks (Eke, 2005; Laininen, 2003). According to the Occupational Safety and Health Act No. 6331, risk assessment is defined as "the necessary studies to determine the hazards existing in the workplace or those that may come from outside, to analyze and rate the risks arising from these

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hazards and the factors causing these hazards, and to determine control measures". (URL-1, 2023).

Identifying elements that pose risks enables the development of solutions to eliminate these risks. The adequacy of the security measures corresponding to these solutions is tested and continuously monitored. Measures are reinforced through education, warning systems and alerts.

Several risk assessment methods are used in the identification and evaluation of risks focused on occupational health and safety (Saat, 2009; Tixier et al., 2002; Pinto et al., 2011).Risk assessment techniques are categorized into two main types: qualitative and quantitative. Quantitative risk analysis is performed using purely mathematical procedures. Qualitative risk analysis, on the other hand, involves the OSH professional predicting risks in advance, prioritizing them, and providing a qualitative assessment using verbal expressions such as low, medium, high, and very high, rather than numerical results. There are numerous methods for risk assessment, which is crucial for occupational health and safety (Özkılıç, 2005).

In forestry activities, risks can generally be grouped under the headings of physical risks, psychological risks, chemical risks, and biological risks (Ünver and Acar, 2011).

The preventive approach based on risk assessment began to be implemented with the enactment of Law No. 4857 on Occupational Safety and Health in 2003, along with the regulations derived from it. In this regard, Law No. 4857 was a milestone. In line with European Union standards in the field of occupational health and safety, the "preventive approach" prioritizes measures to be taken in the workplace and attempts to integrate a risk assessment-based approach into Turkish labor legislation (Yılmaz, 2013).

The matrix method (L-type matrix) is particularly used in evaluating cause-and-effect relationships. It is used in companies, especially to identify risks that require urgent intervention and immediate preventive measures (Ceylan and Başhelvacı, 2011).

The L-type matrix method, also known as the 5x5 matrix because of its ease of use, is favored in risk analysis. It is particularly useful for examining cause-and-effect relationships, but its success in complex systems depends on the experience of the analyst. This method is mainly used to quickly identify and address risks that require immediate attention (Özkılıç, 2005).

Marhavilas et al (2011) conducted a comprehensive study between 2000 and 2009, classifying 404 articles on risk assessment methods in the literature. The risk assessment methods were classified into the main classes of quantitative, qualitative, and mixed methods, with 65.63% identified as quantitative, 27.68% as qualitative, and 6.7% as mixed methods. The study extensively reviewed the 18 most commonly used methods in the literature, and Marhavilas et al. concluded that there is no single risk assessment method that is universally applicable to all industries and organizations. In addition, it was found that each risk assessment study differs in the method used for hazard assessment and implementation.

The aim of this study was to assess the risks faced by forest workers during firefighting by identifying hazards, using the L-Type Matrix and Analytic Hierarchy Process(AHP).

2. MATERIAL AND METHOD

The study is limited to the Izmir Forestry Regional Directorate, an area highly sensitive to forest fires and exposed

to numerous fires every fire season. The focus of the study is on the activities of forest firefighters in these forests.

2.1.L-Type Risk Analysis Method

Consistent with the results of the literature review, the L-type matrix risk assessment method was preferred for its ease of use and comprehensibility in general risk assessment for forest firefighters.

A risk assessment was carried out using the L-Type Matrix method for forest firefighters in Izmir who are actively involved in fighting forest fires(Bacı, 2023). The matrix (L-type matrix) method, which is widely used in occupational health and safety (OHS) risk assessment, is a systematic approach.

The method is chosen for its simplicity and ability to be performed by a single person. However, the success of the method depends on the experience of the analyst. It is recognized that the method may not be sufficient for processes with multiple stages or jobs with significantly different flowcharts. It is recommended for urgent situations that require immediate action in such companies (Ceylan and Başhelvacı, 2011).

The Risk Assessment Matrix, which shows the multiplication results of probability and severity, is considered the fundamental factors of risk assessment methods. The Risk Priority Score (RPS), obtained by multiplying the probability and severity values, is evaluated in five different levels of probability and five levels of damage severity, ranging from very low to very high. The resulting L-Type (5x5) Risk Priority Score (RPS) rating matrix is categorized into five levels, from insignificant (1) to stop (5).

Risk Priority Score = Probability x Severity

Based on the calculated Risk Priority Scores for the 5x5 L-type matrix risk assessment method, Risk Importance Degree (RID) and Corrective Preventive Action (CPA) data are obtained by referring to the RPS value range shown in Table 1(Güner, 2018).

Table 1. L Type (5x5) Risk Importance Degree (RID), Risk Priority Score(RPS)

Risk importance degree	RPS Value	Corrective Preventive Action (CPA)
(1) Insignificant	RPS ≤ 1	Additional control processes may not be needed to eliminate identified risks
(2) Low	1 < RPS < 8	Existing controls should be maintained, and the maintenance of these controls should be monitored
(3) Moderate	8 ≤ RPS < 15	Immediate activities should be initiated to reduce identified risks
(4) High	15 ≤ RPS ≤ 20	Emergency measures should be taken for these risks, and a decision on the continuation of the activity should be made after these measures
(5) Stop	RPS > 20	Activities should not be initiated until the identified risk is reduced to an acceptable level

Control measures are determined starting with the risk with the highest score in the identified hazard list. When determining the measures, the goal is to reduce the risk score to below an acceptable risk level after implementing the control measures. The "eliminate at source" approach is used to identify control measures..

2.2.Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), developed by Saaty in 1977, is a widely used multiple decision-making method for solving complex problems (Özbek and Eren, 2013; Chan et al., 2004; Fera and Macchiaroli, 2010). AHP addresses problems with a hierarchical structure consisting of at least one factor. In this hierarchy, the goal is at the top level, while main criteria and sub-criteria are found at lower levels (Saaty, 1994). A sub-criterion at a lower level affects a criterion at a higher

level, and the impact ratio is determined by comparing the criteria pairwise (Saaty, 1994).

While AHP is used in various fields for decision making, it is not commonly used in the context of occupational health and safety. In this method, a hierarchical structure is created with predetermined criteria, sub-criteria, and alternatives. Experts evaluate the alternatives based on the criteria. Ultimately, the decisions made allow the criteria to be ranked according to their weight values. In situations with multiple options, the most important criterion is determined based on the goal.

After establishing the hierarchical structure in AHP, a decision matrix, which is a pairwise comparison matrix, is created to determine the importance levels. At each level, the criteria are compared pairwise, taking into account the objective (Özbek and Erol, 2016; Özbek, 2017). The comparison scale recommended by Saaty and shown in Table 2 is used to create these matrices (Saaty, 1994).

Table 2. Standard Preference Table

Importance	Definition	Explanation
1	Equally important	Equal level of importance
3	Moderate important	One factor is slightly more important than the other
5	Strong important	One factor is significantly more important than the other
7	Very strong important	One factor is decidedly much more important than the other
9	Extremely important	One factor is extremely important compared to the other (Definite superiority)
2-4-6-8	Intermediate	Intermediate Values (Compromise values)

In the mutual evaluation of criteria, if one criterion has a certain superiority over the other, it is evaluated on a scale of 1 to 9. In cases where the same criteria are scored inversely, the reciprocal of the same score is used based on multiplication.

3. RESULTS

In practice, the L-Type Matrix from risk analysis methods and the Analytic Hierarchy Process from decision analysis techniques have been used. The forestry sector, with its natural working environment, is exposed to various hazards. The hazards listed in Table 3 were identified through a literature review of previous studies, analysis of accident stories, examination of photos and videos, and the utilization of existing accident records. Once these hazards were identified, the step-by-step presentation of the AHP solution strategy in the study was outlined.

After the hazards were identified, the study systematically presented a step-by-step Analytic Hierarchy Process (AHP) solution strategy, as shown in Table 3.

Table 3. Hazards Encountered in Forest Fires

T1	Smoke, Carbon Monoxide, Carbon Dioxide
T2	Fire
T3	Night Work
T4	Tree Falling, Impact
T5	Aircraft
T6	Ignition, Explosion, Flame
T7	Invisible Smoldering Fire, Burned Tree Roots
T8	Plant Communities Hindering Movement and Visibility
T9	Insufficient Number of Firefighting Devices, Lack of Periodic Checks
T10	Unfamiliarity with Emergency Equipment Locations
T11	Inaccessibility of Emergency Contact Numbers during Emergencies
T12	Use of Chemical Substances
T13	Heat Stroke, High Temperature, Fluid Loss
T14	Water Collection Pits, Fire Pools, Natural Water Sources
T15	Terrain Structure
T16	Fear, Excessive Haste, Unsafe Work
T17	Drinking Water and Spoiled Foods
T18	Inadequate Nutrition
T19	Stress, Fatigue, Sleep Deprivation
T20	Overconfidence
T21	Wet Ground
T22	Overloading, Manual Handling
T23	Pressure

T24	Dust
T25	Transport and Operation of Machinery
T26	Noise and Vibration
T27	Occupational Safety Training

After the hazards were identified in the first step, the importance and impact values of each hazard on each other were determined by the opinions of 8 different occupational safety experts using the 5x5 L-type matrix method. This evaluation is presented in Table 4. According to the table, when looking at the Risk Priority Scores (RPS) of the 27 hazards faced by forest firefighters, fire and combustion hazards are in first place, followed by lack of training in second place, and stress, fatigue, sleep deprivation in third place. Fear, excessive haste and unsafe work followed, as did falling trees and collisions. The risk scores determined by the experts' L-type matrix evaluation for these identified hazards were used in the AHP system to obtain intermediate matrices.

Table 4. Risk Scores by Occupational Safety Experts

Hazards	Expert 1	Expert 2	Expert 3	Expert 4	Expert	Expert 6	Expert 7	Expert 8	Total
T1	20	16	20	16	16	16	16	3	123
T2	20	20	20	20	20	16	20	9	145
T3	15	15	16	16	12	12	12	3	101
T4	9	8	12	10	8	16	10	9	82
T5	12	12	12	10	8	9	8	3	74
T6	20	20	20	16	20	20	20	9	145
T7	12	15	15	16	16	12	16	1	103
T8	12	12	12	10	10	9	10	3	78
T9	15	15	12	12	8	16	8	7	93
T10	8	10	8	10	8	8	10	9	71
T11	10	15	10	12	12	6	12	1	78
T12	20	16	20	16	16	12	16	5	121
T13	12	12	15	15	16	9	16	5	100
T14	10	10	10	10	12	12	12	3	79
T15	10	10	10	10	10	12	10	7	79
T16	12	12	12	12	12	12	12	7	91
T17	10	15	10	12	8	10	8	1	74
T18	15	12	15	12	10	8	10	1	83

T19	20	20	20	16	20	12	20	7	135
T20	16	15	15	15	12	8	12	3	96
T21	12	12	12	12	10	10	10	1	79
T22	15	16	15	16	16	12	16	1	107
T23	12	16	15	16	12	9	12	3	95
T24	12	10	12	12	12	8	12	1	79
T25	15	16	15	15	16	12	16	1	106
T26	16	15	16	15	12	8	12	3	97
T27	20	20	20	20	15	16	20	9	140
Total	380	385	389	372	347	310	356	115	

According to the L-type matrix method conducted by experts, the hazards with the highest risk priority scores are fire, ignition, explosion, flame, and lack of occupational safety training. The hazard with the lowest risk priority score is lack of knowledge of the location of emergency equipment. Measures that can be taken to address these risks identified by the L-type matrix include using a filtered full-face or half-face respirator while working, following work instructions, using personal protective equipment (PPE), providing training, and posting safety signs and labels.

After the L-type matrix assessment conducted by eight experts, the risk priority scores determined by the L-type matrix were used in the second stage for the AHP method.

In the second step, the risk scores of the hazards identified by the experts were divided by the column sum to obtain an intermediate matrix. Weighted percentage scores were then calculated.

In the third stage, pairwise comparison matrices were created through brainstorming based on the structure of forest fire operations to determine the importance, priority, or weighted percentage scores of hazards among themselves. Pairwise comparison matrices were created using the hazards identified by the L-type matrix. Hazards were compared with each other based on the goal considering the factor in the

hierarchy. After these comparisons, a matrix, referred to as the pairwise comparison matrix, was obtained. Matrices were created using the 1-9 comparison scale shown in Table 2 recommended by Saaty (1994). Comparisons were made for elements above the diagonal with all values of 1 for the pairwise comparison matrix. If a_{ij} represents the pairwise comparison value between the i-th and j-th criteria, the a_{ji} value is obtained from the equation $1/a_{ij}$. This property is called the reciprocity property (Saaty, 1994; Di Gironimo et al., 2013). Pairwise comparison matrices are square matrices of size n × n, as shown in equation (1).

$$A=\begin{bmatrix} 1 & a_{12} & a_{1n} \\ \vdots & 1 & \vdots \\ a_{n1} & a_{n2} & 1 \end{bmatrix} \quad (1)$$

In the fourth step, the weight values of all hazards were calculated. First, the matrix was normalized using equation (2). Then, equation (3) was used to calculate the weights of the hazards. Equation (2) was used to normalize the matrix. Equation (3) was then used to calculate the hazard weights.

$$a_{ij} = \frac{a_{ij}}{\sum_{n=1}^{i} a_{ij}} \quad (2)$$

$$w_i = \left(\frac{1}{n}\right) \sum_{j=1}^{n} a_{ij} \; i, j=1,2, \ldots ,n \quad (3)$$

The initial matrix was obtained by taking the geometric mean of the matrices resulting from the expert comparisons. After combining the matrices resulting from the pairwise comparisons of hazards by experts using the geometric mean method, this matrix was normalized and the criterion weights (w") were calculated. The resulting normalized matrix and parameters were established, and in the fifth step, a percentage weighting among the identified hazards was performed, as shown in Table 5.

Table 5. Percentage-Weight Rating

Hazards	wi(weighs)
T1	0.052747732
T2	0.086053768
T3	0.013682898
T4	0.058142607
T5	0.020721377
T6	0.050281772
T7	0.03773514
T8	0.023996408
T9	0.080172973
T10	0.036073915
T11	0.015268552
T12	0.031758297
T13	0.02779379
T14	0.01085634
T15	0.018761228
T16	0.068523019
T17	0.016300539
T18	0.018716021
T19	0.06411796
T20	0.051393938
T21	0.022514546
T22	0.016960163
T23	0.010130763
T24	0.011724257
T25	0.022387281
T26	0.013709142
T27	0.119475574

In the sixth step, the weighted percentages of each expert's AHP risk scores were obtained by multiplying them by the percentage weights of the hazards in Table 5. The rows of the table were then summed to determine the superiority of the risk scores among the twenty-seven hazards identified.

In the final step of the AHP process, the importance weights determined by the experts are multiplied by the wi values for each hazard, resulting in the priority value for each hazard. The hazard with the highest value is considered the highest priority and requires immediate intervention due to its importance. This process is repeated to achieve the desired result in the AHP method.

The consistency check of the AHP matrix is crucial to determine whether the comparisons made between hazards are consistent and to assess the accuracy of the results. Therefore, it is essential to check the consistency of the matrices obtained. Consistency is determined by calculating the Consistency Ratio (CR) developed by Saaty. The Consistency Ratio is calculated using the following formula T1: Consistency index, and RT1: Random Consistency Index.

$$CR=\frac{T1}{RT1} \tag{4}$$

$$T1=\frac{\lambda max-n}{n-1} \tag{5}$$

Xmax: The relative weight of the matrix

$RT1$=1,98*(n-2) (6)

$$CR=\frac{\frac{\lambda max-n}{n-1}}{1{,}98*(n-2)} \quad (7)$$

If the consistency ratio obtained through the formulas is below 0.1, it can be stated that the comparison matrix is consistent.

Xmax: 27 n=27

$$T1=\frac{\lambda max-n}{n-1}=0$$

$CR=\frac{\frac{\lambda max-n}{n-1}}{1{,}98*(n-2)}$, 0/[1,98*(27-2)] , 0 was found as.

As a result, the matrix is considered consistent since the CR ratio is less than 0.1 (Lainen, 2003). This consistency indicates a high degree of accuracy in the results.

When examining the AHP scores of the 27 hazards identified by each expert in fighting forest fires, the prioritization of hazards shows that occupational safety training is the first, followed by fire, and the third is the incorrect and unsafe use and inadequacy of tools and machinery. This is followed by fear, hasty and unsafe work, stress, fatigue, sleeplessness, falling and hitting trees, and being affected by smoke. Again, similar to the L-type matrix, hazards with high RPS scores also have high AHP scores.

4. DISCUSSION AND CONCLUSIONS

Looking at the Risk of Severity Scores (RSS) of the 27 hazards faced by forest firefighters, fire and burning hazards rank first, followed by lack of training in second place, and

stress, fatigue and sleeplessness in third place. Fear, rushing and unsafe work, and falling and being struck by trees follow in the next order. The risk ranking of hazards in our study reflects the nature of the profession, as the focus was on forest firefighters. Similar hazards may produce different results in different occupations.

The priority values used in the AHP analysis were determined by experts with sufficient knowledge, which was confirmed by the result of the consistency ratio. In AHP analysis, the hazard matrix derived from pairwise comparisons should be close to reality and accurate. To ensure this, selected experts must be knowledgeable about the research topic. Judgments made by individuals unfamiliar with the industry are likely to be inconsistent. In this study, the selected professional group was from the forest industry, and the OHS experts who conducted the AHP and L-type matrix analyses were also forest industry professionals.

Literature studies indicate that the most common hazards that lead to accidents among forest firefighters are fire hazards, falls, and slips. However, in this study, fire and burn hazards ranked first, followed by lack of training in second place, and stress, fatigue, and sleep in third place. Fear, rushing and unsafe work, as well as falling and hitting trees follow in the next order. This analysis confirms the realism of the study and its consistency with the literature.

The survey conducted by Menemencioğlu (2006) on working conditions and occupational accidents in forestry production activities revealed that negligence, inexperience, non-use of personal protective equipment, fatigue, sleeplessness and poor working conditions are prominent among the causes of occupational accidents. This study, which uses L-type matrix analysis, is consistent with these findings, emphasizing fatigue,

negligence, sleeplessness, difficult working conditions, and inexperienced and untrained workers as the most significant factors contributing to accidents.

The hazards assessed by the occupational safety experts were derived with the help of the study conducted by Sayın et al. (2014). The identified hazards show similarities with previous studies in the literature.

The study focused on forest firefighters and provided a unique perspective by incorporating occupational injury records, expert assessments, and L-type matrix risk analysis. The prioritization of hazards, identification of risk factors, and comprehensive methodology set this study apart from others.

While previous studies have addressed the hazards faced by wildland firefighters on a case-by-case basis, this study distinguishes itself by carefully defining its methodology and analyses, thus providing a unique approach. In addition, unexpected hazards and risks may be present in fire-related activities beyond those mentioned. Preventing such situations requires eliminating contact between the source of the hazard and the workers. Addressing the risks at their source is critical.

The study conducted a risk analysis by identifying the hazards and risks faced by forest firefighters affiliated with the İzmir Regional Forestry Directorate, which provided valuable insights.

According to the results of AHS and L-type matrix evaluations, the top three priorities are fire, ignition, explosion, flames, and occupational safety training, while the lowest risk pertains to the lack of knowledge about emergency equipment, falling and hitting trees. These risks are attributed to careless behavior, overconfidence, inexperience and lack of job training, and challenging terrain with inadequate use of personal protective equipment.

The hazards forest fire workers may face have been prioritized by experts using the AHP. This ranking can serve as preliminary data for future risk analyses for forest fire workers.

For future studies, different Multi-Criteria Decision Making (MCDM) methods can be combined to present alternative risk assessment approaches, which can be compared with existing methods.

In order to maintain an effective fight against forest fires, the number of workers should be increased, working hours should be extended and the average age should be reduced. Workers involved in forest fires should be provided with personal protective equipment in accordance with ILO standards and state-of-the-art technology to reduce hazards and risks.

This study will support research on firefighters in other regions of the country and provide a foundation for forest health and safety research in the region.

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EXAMINING THE EFFECTS OF SILVICULTURAL ACTIVITIES CARRIED OUT PRIVATE SECTOR ON THE EMPLOYMENT STATUS AND ECONOMIES OF PHYSICALLY DISABLED INDIVIDUALS IN TURKIYE DURING THE COVID 19 PANDEMIC

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1. INTRODUCTION

In international texts, disability is defined differently depending on the aim and scope. For instance, International Labor Organization defines it as "a person that is disabled and having significantly decreased possibility of fulfilling a suitable job, maintaining that job, and promoting in that job because of a physical and mental deficiency", whereas the General Assembly of the United Nations defines the disability as "various functional limitations arising from a person's deficiencies in physical, psychological, or sensory systems". World Health Organization defines it as "a person's not being in complete wellness from physical, psychological, and social aspects" (Kocabaş, 2018). In Türkiye, however, a disabled individual is defined as "a person who has difficulties in adapting to the social life and meeting daily needs because of losing physical, mental, psychological, emotional, and social skills congenitally or later due to any reason

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and needing protection, care, consultation, and support services" (Yurttakal, 2019). In the legal regulations in Türkiye, a disabled individual is defined as a person being affected by the attitudes and environmental conditions that limit them from completely and effectively participating in society as other individuals because of their various levels of losses in physical, mental, psychological, and emotional aspects" (Topgül and Yıldırım, 2018).

Disability is a factor for social exclusion. For disabled individuals, being excluded from social relationships, cultural and social activities, access to fundamental services, close environment, and economic field is considered as a secondary disability (Genç and Çat, 2013). For this reason, considering their adaptation to social life, it is very important for disabled individuals to be employed (Woynarowska, 2021; Chajduga and Ingaldi, 2021). Working plays an important role in increasing the self-confidence and life standards of disabled individuals, besides the contributions to the social and economic aspects (Anıl, 2019). A disabled person participating in business life and standing on his/her legs does not only earn financial income but also has an increased self-confidence and an increased commitment to society (Aköğretmen and Orhan, 2020).

The participation of disabled individuals in business life dates back to the early 20th century. In Europe, where the Industrial Revolution was made and demand for cheap labor force increased, disabled individuals were socially excluded even if they had the ability to work and they had to live off bagging or the support from their families (Şen, 2018). Since the mid-20th century, many developed countries such as England, France, and Germany have established and maintained education and employment support systems for disabled individuals. Despite decades of efforts to achieve the normalization and main stream, it is reported that disabled individuals have difficulties in

accessing the employment and education; OECD reported that, when compared to non-disabled individuals, disabled individuals are at two-times higher risk of unemployment and poverty (Mori and Sakamoto, 2018).

Especially after the Industrial Revolution, there have been significant changes in many aspects of life from social structure to economic life. Together with its difficult working conditions and approach ignoring worker safety, worker health, and social security and alienating the business life and production system away from human values, Industrial Revolution caused women, young people, and children employed as cheap labor force to continue their lives as disabled individuals, as well as an increase in the number of disabled people in the society. On the other hand, also World Wars I and II resulted in many individuals living their lives as disabled persons. The wars occurring during the process to date, the increase in the elderly population, occupational accidents, occupational diseases, and health problems are among the important factors contributing to the increase in the number of disabled people. Nowadays, it is estimated that more than 1 billion individuals (15% of the global population) live with a kind of disability (Şen, 2018). In Türkiye, the rate of individuals having a minimum of 1 disability in the population is 6.9% (5.9% for men and 7.9% for women) (TUIK, 2022).

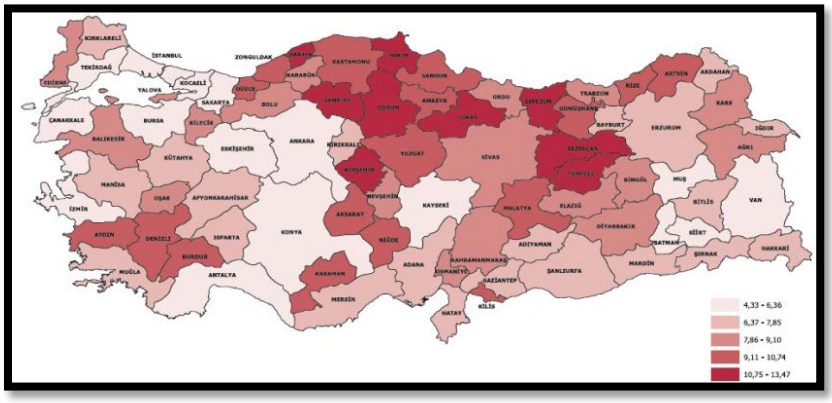
According to the United Nations Committee on the Rights of Persons with Disabilities, disabled individuals have the same rights and freedoms as other individuals do. As a part of human rights, the states shall take all the measures in order to ensure they completely and equally benefit all these freedoms and rights. However, it can be seen that it doesn't reflect to the participation in workforce. In Türkiye, the participation of disabled individuals in workforce is very low. During the COVID-19 pandemic that emerged after the year 2020, this rate further decreased and the employment of disabled individuals tended to decrease in many

industries. In the present study, it was aimed to examine the contributions to the employment policies and economies of physically disabled individuals during the silvicultural activities carried out by private sector in Türkiye during the process of COVID-19 pandemic.

2. MATERIAL and METHOD

Within the scope of this study, the employment status of physically disabled individuals in silvicultural activities carried out by the private sector between 2018 and 2021 in Bartın, Zonguldak, Kastamonu, Karabük, Bolu, Sinop, and Düzce provinces of Western Black Sea region, where the number of disabled individuals is high and there are intense forestry activities, was examined. This region is one of those with the highest rate of disabled population in Türkiye. The map showing the distribution of disabled population in Türkiye is presented in Figure 1.

Figure 1. Proportion of Persons With at Least One Disability (%)



(TUIK, 2022)

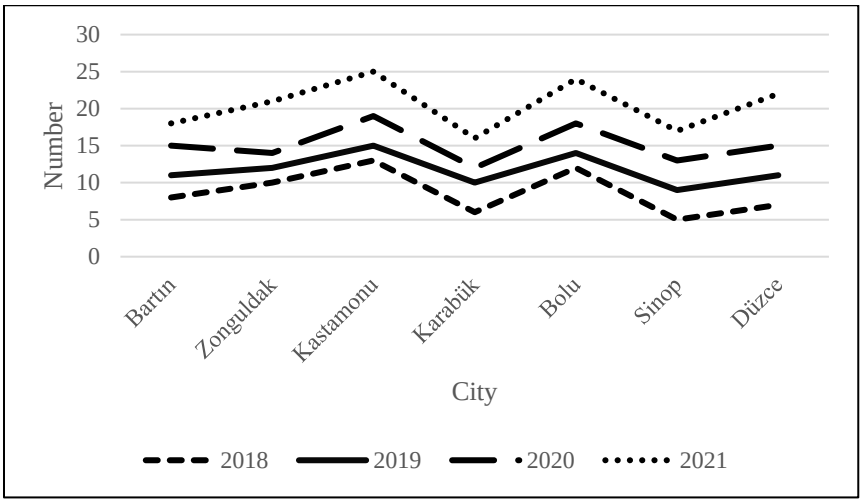
The data used in this study were obtained from Ministry of Labor and Social Security, Turkish Statistical Institute (TUIK), Turkish Employment Agency (ISKUR), General Directorate of

Forestry, Secretary of the Union of Forest Cooperatives, Secretary of the Chamber of Forest Engineers, specific private forestry companies operating in the Western Black Sea region. and accounting records of 126 worker posts working in the Western Black Sea region.

3. RESULTS

The distribution of physically disabled individuals working in silvicultural activities by private forestry companies in the Western Black Sea region during the pandemic is presented in Figure 2.

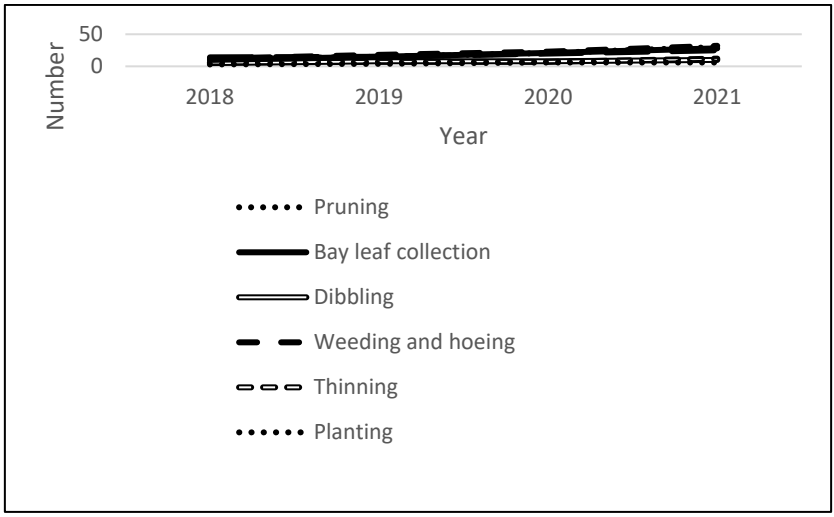
Figure 2. Distribution of Physically Disabled Individuals by Provinces



As seen in Figure 2, the number of physically disabled individuals employed in silvicultural activities by private forestry companies increased in all the provinces regularly on annual basis since year 2018. Given the graph, it can be seen that the highest increase was in Sinop province, that increases were observed in all provinces in all years, and that the increase in all the cities between 2018 and 2021 was at least 210%, which means the

number of physically disabled individuals employed in silvicultural applications by private forestry companies increased by more than two times. Examining the provinces, the highest employment of disabled individuals was in Kastamonu, followed by Bolu and Zonguldak. The types of silvicultural works, in which physically disabled individuals were employed during the pandemic, are presented in Figure 3.

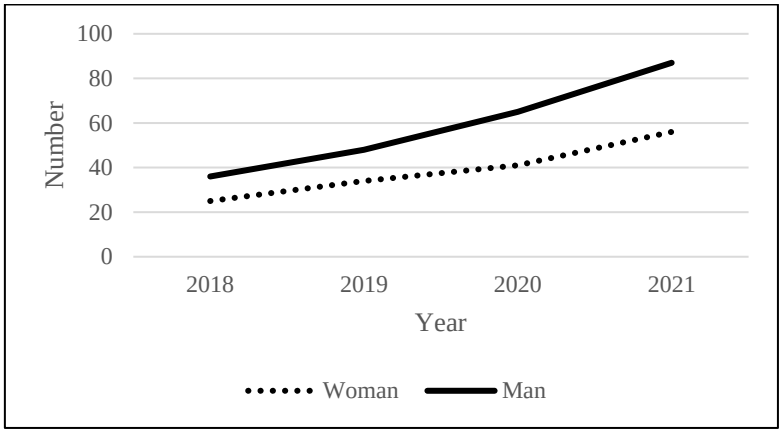
Figure 3. The Types of Silvicultural Works, in Which Physically Disabled Individuals Were Employed



Examining the types of silvicultural works, in which the physically disabled individuals were employed, it can be seen that the number of disabled individuals employed increased regularly in all the types of silvicultural works every year between 2018 and 2021. During this period, the highest number of disabled individual employment was in weeding and hoeing, followed by planting and bay leaf collection. Examining the change of disabled individuals employed in these jobs during the period 2018-2021, it can be seen that the highest levels of proportional increase were observed in collecting bay leaves, planting, and

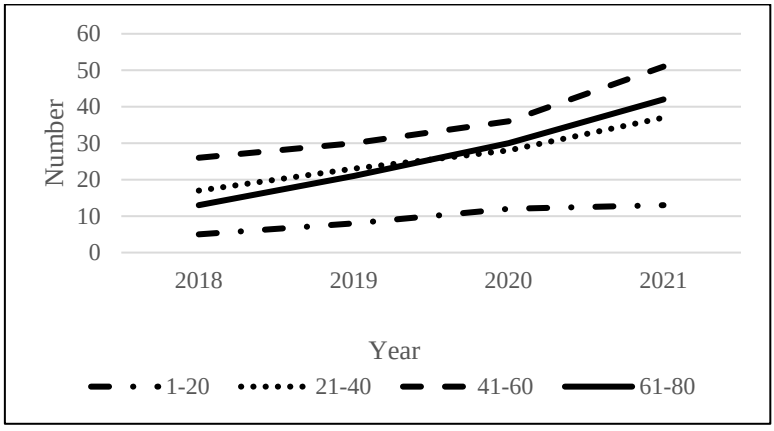
weeding and hoeing, respectively. The distribution of disabled individuals by gender is presented in Figure 4.

Figure 4. The Distribution of Disabled Individuals by Gender



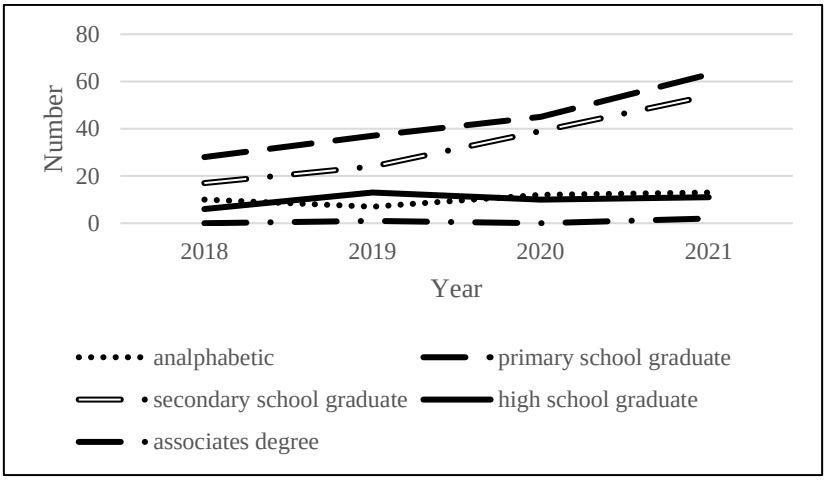
Within the scope of this study, it was determined that male employment was at a higher level. The share of women in total employment of disabled individuals was approx. 40%. Given the graph, it can be seen that the employment of disabled individuals annually increased constantly between the years 2018 and 2021 but the highest increase was observed in the year 2021. The distribution of disabled individuals by age is presented in Figure 5.

Figure 5. The Distribution of Disabled Individuals by Age



Examining the distribution of employed disabled individuals by age, it can be seen that most of them were aged between 41 and 60 years, whereas the lowest level of employment was below the age of 20 years. Moreover, although an increase was observed in the employment in all the age groups between the years 2018 and 2021, the highest level of proportional increase was observed in the age class of ≥61 years, whereas the lowest proportional increase was observed in the age group of 41-60 years. The educational status of physically disabled individuals is presented in Figure 6.

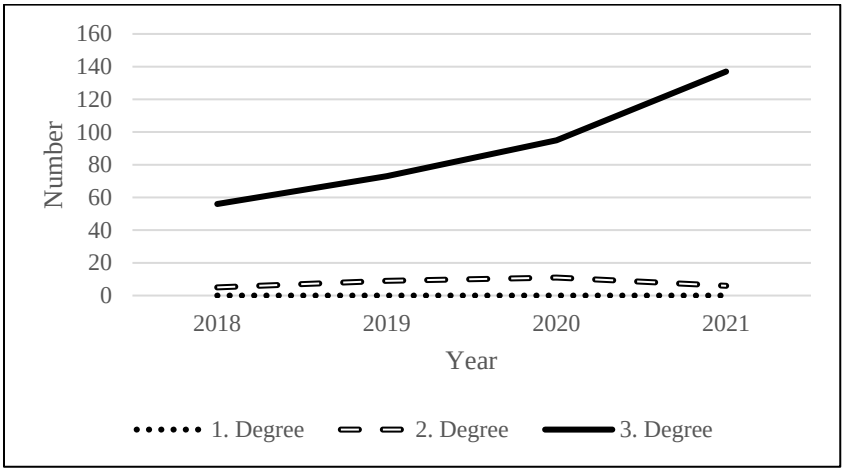
Figure 6. The Educational Status of Physically Disabled Individuals



As a result, it was determined that a large portion of disabled individuals that were employed were elementary and secondary school graduates. The most interesting result in the graph is that the rate of illiterate ones was higher than that of high school graduates. Besides that, the number of vocational school graduates was very low. Given the values presented in graph, it can be seen that the number of disabled individuals being employed increased in all the groups during the period 2018-2021 but the highest level of increase was found in the group of

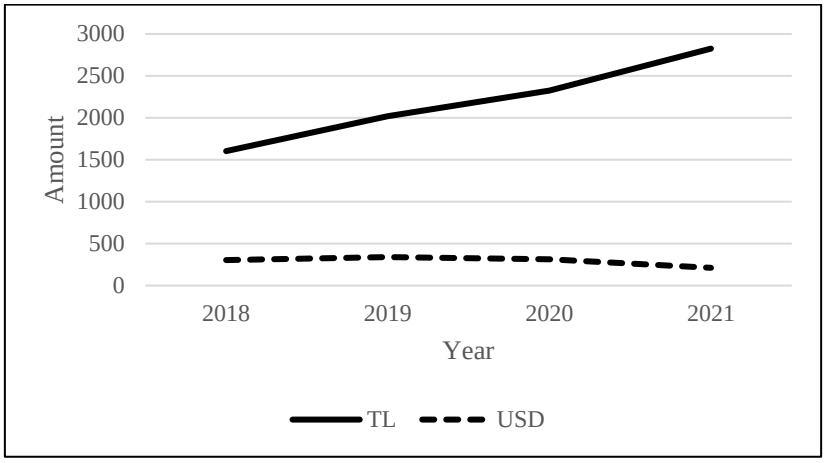
secondary school graduates. The distribution of disabled individuals in forestry jobs by the level of their physical disability is presented in Figure 7.

Figure 7. The Distribution of Disabled Individuals in Forestry Jobs by The Level of Their Physical Disability



As seen in the graph, the group with the highest employment rate in forestry jobs was the one of those losing their working power by 40-60% and shown as the 3rd group in the graph. The number of those employed in this group was 56 in year 2018 but increased to 73 in 2019, 95 in 2020, and 137 in 2021. The number of disabled individuals losing their working power by 60-80% and shown as the 2nd group in the graph was 5 in year 2018 but increased to 8 in 2019, 11 in 2020, and decreased to 6 in 2021. The individuals losing their working power by more than 80% were not employed in forestry jobs. The distribution of physically disabled individuals' income per capita by year is presented in Figure 8.

Figure 8. The Distribution of Physically Disabled Individuals' Income Per Capita by Years



Given the values presented in table, it can be seen that the income per capita of physically disabled individuals increased in TL between the years 2018 and 2021 but, considering the USD, it increased in 2019 but decreased in other years. The loss exceeded 30% in 2021.

4. DISCUSSIONS AND CONCLUSIONS

Within the scope of this study, the employment status of physically disabled individuals in silvicultural activities carried out by private sector between 2018 and 2021 was examined. As a result, it was found that the number of physically disabled individuals employed in forestry jobs annually increased in every year. Considering the provinces, it was determined that the provinces with the highest number of disabled individuals being employed were Kastamonu, Bolu, and Zonguldak, respectively. The highest worker employment was in weeding and hoeing and in planting. Accordingly, it can be seen that the employment rate is very high in sapling nursing and planting and the fact that sapling nursing and planting works in Kastamonu, Bolu, and

Zonguldak having a high employment rate for disabled individuals is higher than in other provinces caused a higher employment rate of disabled individuals in these provinces.

During the study, it was found that male employment was at a higher level in general and, in the employment of disabled individuals, the share of females was approx. 40%. Considering the distribution by age groups, it was found that the highest number of disabled individuals being employed was aged between 41 and 60, whereas the highest level of proportional increase was observed in the age group of 61 years and older. This result is thought to be related with economic conditions. The fact that the highest level of proportional increase was observed in the age group of 61 years and older corroborates the hypothesis that retired individuals need to work again because of the economic problems because the jobs examined here are seasonal/temporary ones. In parallel with the decrease in the earnings of the ones, who were earning higher than the minimum wage, in USD, it is clear that their purchasing power decreased and they had economic difficulties for this reason.

As a result, it was determined that a large portion of the disabled individuals being employed were elementary school and secondary school graduates and the portion of illiterate individuals was higher than that of high school graduates. This finding suggests that, besides the fact that these jobs were not requiring any knowledge or educational status, the income was also low. These jobs are preferred as the last option since the level of income is low and there is no continuity. The disabled individual group with the highest rate of employment in forestry jobs was the ones losing their working power by 40-60%. The disabled individuals losing their working power by 80% or higher were not employed in forestry jobs. This is because the silvicultural jobs are based on physical strength. Hence, persons with a high level of physical disability have difficulty in working

in silvicultural jobs and it is almost impossible for many job classes.

In conclusion, the silvicultural jobs are those fulfilled with physical force, not requiring qualified workers, offering no year-long continuity, and yielding a low level of income. Thus, the educational level of people working in these jobs is generally very low. Besides that, the results achieved here showed that the number of physically disabled individuals working in these jobs constantly increased during the period 2018-2021. This can be considered as a good point because the number of disabled individuals being employed increased. But, when considering the quality of jobs, it can be concluded that the physically disabled individuals had to work in forestry jobs that are considered as the last option by workers and it is partly because of the economic problems that COVID-19 pandemic caused. Hence, it was reported that disabled individuals face discriminative behaviors and exclusion in their environment and that their jobs are generally the low-wage and low-status ones, which are not preferred widely, which people are not happy with working in, and which are insufficient in terms of wage (Akman, 2021). COVID-19 further concretized the current inequalities, excluded the disabled individuals, and caused them to feel discriminated and marginalized (Rotarou, 2021).

World Health Organization (WHO) estimated that 740 million of 1.17 billion disabled individuals throughout the world are at working age and 2-4% of them have functional difficulties. These individuals constitute approx. 15% of any country and, in developing countries, the unemployment rate among the working-age disabled individuals is approx. 80-90% (Ghaneh-Ezabadi et al., 2021). In Europe, 17.6% of the population aged older than 15 years continue their lives with various disabilities. It was underlined that vast majority of disabled individuals under these conditions cannot participate in business life because of

societal and environmental obstacles (Toyoğlu, 2020). In Türkiye, the employment level of disabled individuals is far away from the point it should be. According to the data of the year 2021, labor force participation rate is 69.1% for men, 31.7% for women, and 50.2% in total but, among the disabled individuals, the labor force participation rate is 35.4% for men and 12.% for women (22.1% in total) (TUIK, 2022).

Previous studies showed that disabled individuals generally face a high level of poverty and unemployment (Bredgaard and Salado-Rasmussen, 2021). In European Union, because disabled individuals have limited access to job opportunities, the poverty rate among disabled individuals was higher than 70% (Toyoğlu, 2020). It was reported that it is very difficult anymore to allow disabled individuals to live with social benefits and that disabled individuals should participate in production (Girlevičienė and Kvietkauskienė, 2021). Having the daily increasing number, the disabled individuals consuming without participating in the production process would deteriorate the balance between population and resource. In order for the resources to be utilized at an optimum level, disabled individuals should participate in production process (Alvar, 2014).

However, there are significant problems in being employed and participating in production for the disabled person, whose physical skills are not at the same level as the normal individuals. The factors such as their low capacity to work, their low level of occupational knowledge since they couldn't have had sufficient education, the society's approach, and employers' concerns pose problems for the employment of disabled individuals (Karim et al., 2021; Shankar et al., 2021; Hashim et al., 2021). However, together with the social model, the approach to disability has changed and the subjects such as education, employment, accessibility, and attainability started being focused on (Ölmezoğlu, 2015). Moreover, the legal regulations oblige the

employment of disabled individuals, as in many other countries (Aköğretmen and Orhan, 2020). However, according to the data obtained from TUIK, the number of disabled individuals employed by the government has slightly increased during the period 2018-2021 but it significantly decreased since year 2019 in the private sector (TUIK, 2022). It is clear that COVID-19 played an important role in this decrease. Furthermore, previous studies reported that COVID-19 pandemic negatively affected the employment and employees' economic, social, and psychological conditions (Sheraton et al., 2020; Walton et al., 2020; Haleem et al., 2020; Webb et al., 2020; Padhan and Prabheesh, 2021).

Disabled individuals are a part of society and the participation of disabled individuals, the number of which is gradually increasing, in production is a necessity. Previous studies showed that the most important obstacle regarding their participation in production was the lack of education. In the present study, similarly, the increase in the number of disabled individuals working in forestry jobs might be partly because these jobs do not require qualified workers. Thus, in order for disabled individuals to adapt to the new business areas, the lack of education should be addressed first.

Employing disabled individuals as forest workers seems very difficult. The main reason for this is that working as forest worker necessitates physical effort but there are many different types of jobs related with forestry and disabled individuals can be employed in office positions. For instance, visually disabled individuals can be employed as a telephone operator or walking disabled individuals can be employed in the accounting department. After the preliminary training to be given in silvicultural jobs, walking disabled individuals can be employed as a construction machine operator, whereas other physically disabled individuals can be employed in recording and sales in nurseries.

5. ACKNOWLEDGMENTS

For their contributions to the present study, we would like to thank to General Directorate of Forestry, Turkish Employment Agency (ISKUR), Secretary of the Union of Forest Cooperatives, Secretary of the Chamber of Forest Engineers, Turkish Statistical Institute (TUIK) and specific private forestry companies operating in the Western Black Sea region.

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ASSESSMENT OF THE EFFECTS OF CLIMATE CHANGE IN BASIN MANAGEMENT STUDIES

Nilufer YAZICI[1]

1. INTRODUCTION

Global warming and climate change, which are among the most important problems threatening the world, have started to make themselves felt in different ways in different regions. Climate change is defined as changes in the average state or variability of the climate for decades or longer, regardless of the cause. Especially in semi-arid, arid, and semi-humid regions, agriculture, forestry and water resources are exposed to negative impacts due to climate change. Global warming increases the importance of water resources, and the importance of water increases even more as many regions of the world will face the risk of desertification. The decrease in water resources, which is one of the most important consequences of global warming, reaches dimensions that will prevent sustainable life. As a result of global warming, serious problems are experienced in water resources and it is expected to cause a decrease in agricultural and forestry products, energy shortage, and population movement from coastal areas to inland areas.

Today, global struggles for the control of greenhouse gas emissions cannot completely prevent climate change. Even if all greenhouse gas emissions are stopped at once, it is known that the gases currently in the atmosphere will further warm the earth.

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Therefore, adaptation to climate change has become a necessity to keep up with the changing climate and minimize the negative effects of climate change. Within the scope of all these adverse conditions, it is necessary to carry out basin management in a timely and integrated manner to minimize the risks that may occur in our country. Adaptation to the impacts of climate change aims to ensure that people's livelihoods, economies, and natural systems are less adversely affected by climate-induced changes, and in some cases to benefit from adaptation.

In this study, the effects of climate change on basin management and adaptation studies are discussed. As a result, our country's timely implementation of basin management practices as integrated and mitigating measures against climate change will be able to minimize the effects of climate change, which we cannot eliminate within the scope of existing and global world conditions.

2. BASIN AND WATERSHED MANAGEMENT

Basin, a river, or lake basin covers the entire area between the source of the river and the place where it ends, which gives water to the river. This area where the river collects and drains its waters with its main tributaries and side tributaries is also called a catchment (Anonymous, 2023). The catchment is the most important factor determining the amount or probability of flooding.

Basin management and planning can be defined as a sustainable planning and management system that aims the beneficial use and protection of all natural environment elements, especially water and soil resources in geological, geomorphological and hydrographically bounded areas, ensures that human activities benefit from the basin at an optimal scale, evaluates and protects the whole ecosystem (Mody, 2004; Baloc

and Tanık, 2007; Beheim et al., 2012; Garipağaoğlu and Uzun, 2019). Today, there are many institutions and organizations with different roles, activities, and functional weight in basin management-planning studies in Turkey (Akkaya, 2002; Efe and Sılaydın, 2009; Öztürk, 2011). The fact that our country is within the scope of the EU membership process has enabled EU water policies to have a guiding influence on Turkey's water resources management and policies (Karadağ and Barış, 2012).

3. CLIMATE AND CLIMATE CHANGE

Climate is defined as the average state of all weather conditions experienced or observed in any part of the earth over many years, or, more systematically, the synthesis of weather conditions in each area, defined by long-term statistics such as variability and mean values of atmospheric elements (İklim, 2023).

According to the United Nations Framework Convention on Climate Change, "Climate change" is defined as a change in climate because of human activities that directly or indirectly disrupt the composition of the global atmosphere, in addition to natural climate change observed over comparable time periods (UNFCCC, 1994).

3.1. Causes of Climate Change

It can be explained as the increase in average temperatures due to the increase in greenhouse gases in the atmosphere and as a result, the climate undergoes unexpected changes. The causes of climate change are divided into two as natural and human. The causes of climate change are divided into two as natural and human. It has been revealed that the main cause of global climate change is the increase in greenhouse gas emissions because of human activities. The burning of fossil fuels for transport,

electricity generation and industrial production causes greenhouse gas emissions, and these gases accumulate in the atmosphere and warm our world. Other human activities such as deforestation contribute to this situation. Factors such as greenhouse gases emitted, damages to nature and deforestation combine to cause global climate change, which adversely affects all living life (Aydem Enerji, 2023).

3.2. Effects of Climate Change in Turkey

The impact of climate change is not only an increase in temperatures, but also an increase in weather events such as droughts, floods, severe hurricanes, rise in ocean and sea water levels, increase in the acidity of oceans, melting of glaciers, etc. As a result of factors such as plants, animals, and ecosystems as well as human communities are under serious risk.

There are negative effects of climate change, which can be seen directly or indirectly. While some impacts can be predicted, others can only be realized when the consequences emerge. Humans and all other living things may face different problems due to climate change. The effects of global warming and climate change on human health, society and economy are closely related to each other. Increases in the frequency and severity of unpredictable weather events have started to be observed. Increasing temperature levels also lead to a prolonged pollen season and an increase in allergic diseases such as asthma. Its effects on plants and animals can damage the entire ecosystem (Aydem Enerji ,2023).

Problems caused by indirect effects;

o Increase in virus-borne diseases

o Diminishing water and food resources

o Deforestation and desertification

o Melting of glaciers

o Thermal expansion of sea water

o Salinization of water resources

o Increase in water and foodborne diseases

Turkey's diverse geographical and regional conditions are affected differently by the climate crisis. While our arid and semi-arid regions such as Southeast and Central Anatolia are struggling with desertification and drought, precipitation and therefore flood disasters (and erosion) will increase in the Black Sea region, Marmara, Aegean and Mediterranean regions will face thirst due to drying basins, and it is also predicted that the change in sensitive ecosystems will cause an increase in epidemics and pandemics.

4. IMPACTS OF CLIMATE CHANGE ON BASIN MANAGEMENT STUDIES

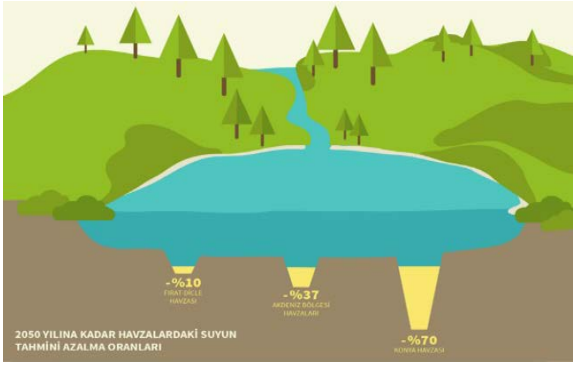
The gap between the water needs of people and the available water resources is growing in many parts of the world. The unbelievably rapid decline in groundwater levels, the unimaginable pollution of water, the disappearance of many rivers before they reach the sea, and the extremely increased use of water in industry and agriculture are the main reasons for this gap. In addition, the destabilization of the weather due to climate change leads to extreme weather events, unpredictability of water availability, exacerbation of water scarcity and pollution of water resources.

The changes in the atmosphere, which is one of the systems of the hydrological cycle, caused by climate change will lead to significant changes in hydrological processes such as precipitation, evapotranspiration, and runoff of the basins (Fıstıkoğlu and Biberoğlu, 2008; Karaman and Gökalp, 2010, Anonymous, 2023). Depending on the regions where the basins

are located, the important effects of climate change on water resources can be expressed as decrease or increase in surface water potentials, change in the feeding and therefore discharge of underground aquifers, change in the frequency, seasons and magnitude of extreme flows (floods and droughts), erosion problems caused by changing precipitation regime, vegetation cover and land uses, differentiation in the flow regimes of rivers fed by snow water, increase in agricultural water requirements. (Fıstıkoğlu and Biberoğlu, 2008; Karaman and Gökalp, 2010, Anonymous, 2023).

Increases in global temperature and the tendency of decreasing precipitation, which will be experienced with global warming, will reveal the issue of water problem and drought (Yönten, 2007). Especially in recent years, water shortages have been observed in some of our basins. Although climatic conditions are the main cause of these problems, overuse of water by not using it effectively in irrigation, illegal use of groundwater, problems arising from the operation of existing facilities, leakages and losses in the networks, delay in investments and deterioration in water quality can be listed (Figure 1) (Anonymous, 2022).

Figure 1. Estimated Rates of Water Depletion in The Basins



One of the most important negative consequences of the impact of global warming and climate change on precipitation

regimes is drought. As a result of irregular precipitation regime of a region, water deficit in summer and early autumn months may cause drought effect. Like precipitation, the relative humidity of the air also affects evapotranspiration (evaporation-sweating) and influences drought. In addition, in places where the soil water and plant balance (physical properties of the soil) is disturbed, the transition of precipitation to surface runoff without sufficient infiltration into the soil also causes drought. With global warming, many countries that are among the water-rich countries will start to be among the water-poor countries. The gradual drying up of water resources will increase the danger of thirst (Fıstıkoğlu and Biberoğlu, 2008; Karaman and Gökalp, 2010; Anonymous, 2023; Yönten, 2007).

Global warming and climate change affect water resources both in terms of quantity and quality. With the increase in temperature, pollution concentrations increase due to decreases in precipitation and flows, leading to an increase in water quality problems (Küçükklavuz, 2009; Fıstıkoğlu and Biberoğlu, 2008). Drought and excessive rainfall put pressure on water quality. The decrease in the amount of water in rivers and lakes during dry months may lead to higher concentrations of pollutants, especially from point sources (e.g. from a factory), which will lead to a decrease in water quality. Prolonged drought will cause pollutants to accumulate on the soil surface, which will pose a risk to the quality of water resources when rainfall begins. Floods can increase the risk of deterioration of the quality of water resources, especially through overflowing sewers, agricultural areas, and urban runoff. (Anonymous, 2023).

Global warming may affect the living and breeding areas of many living things. In some regions, vegetation cover may decrease due to drought. This will have serious consequences in terms of economic losses (Albek, 2007; Karaman and Gökalp, 2010). Agricultural inputs are the most affected factor by climate

change. Changing climate can change agricultural practices. The effect of global warming on agriculture will be manifested by the change in the rain regime and the decrease in the amount of rain falling. Global warming reduces the amount of water and causes changes in soil fertility and product varieties. This will greatly affect the countries that have to sustain their lives directly dependent on the soil. In addition, in semi-arid and arid climate zones, where a large part of our country is located, it is foreseen that if necessary and adequate measures are not taken, agricultural ecosystem deterioration due to drought at certain rates and food security may be jeopardized. It is inevitable that changes in the water cycle and temperatures and possible seasonal shifts due to climate change will directly affect the agricultural sector, which is under the control of these systems. Depending on the change in temperature and precipitation patterns, there will be an increase in the distribution areas and types of agricultural pests. Projected climate changes in agriculture will affect production, production areas and animal husbandry, and the severity, frequency, and probability of increase in extreme weather events will significantly increase the risk of decreased yields in agriculture (Anonymous, 2023; TBMM, 2020 and 2021).

5. MANAGEMENT AND CLIMATE CHANGE PLANNING STUDIES

Since the biggest impact of climate change will be on water resources and the decrease in water reserves will occur with drought, this decrease in water reserves in response to the increase in the natural and agricultural water requirements of plants shows that more effective management of water resources will be mandatory in the future. Therefore, firstly, it is necessary to carry out planning studies of water resources. In this context, the need to integrate the adaptation approach to the impacts of climate

change into water resources management policies has been seen and issues such as basin-based water management, inter-sectoral water distribution, water saving, demand management, control of water use, expansion of observation network, increasing large volume artificial storage structures have started to be prioritized.

In the planning and management of water resources under the influence of global climate change, it should be considered to utilise the "uncertainty" theory, which has been increasingly brought to the agenda in recent years. In addition, in order to predict the future status of water resources more accurately under the influence of climate change, changes in land use and vegetation cover should be determined better and more comprehensively. In this framework, survey studies in this field should be given due importance by utilizing Geographical Information Systems and Remote Sensing technologies. (Anonymous, 2023; TBMM, 2020 and 2021).

It is now widely recognized that the agricultural sector is not only a victim of climate change, but also one of its causes. The destructive effects of climate change on agriculture should be addressed together with development, food security, environment, biodiversity, and sustainability of ecosystem services. Adaptation to the impacts of climate change should be one of the priority strategies in the production-oriented policies of the agricultural sector in Turkey. National and regional development strategies and action plans related to the sector should be renewed in this respect and/or sector-specific adaptation strategies should be prepared. In fact, many existing policies implemented for the activation of the agricultural structure include activities that directly or indirectly support adaptation to the impacts of climate change.

To adapt to the impacts of climate change in the agricultural sector, production, consumption, prices, insurance

systems, farmer support and market policies, productivity and competition, drought and desertification, protection of biological diversity, plant and animal health, plant production, animal husbandry and research and development issues, especially food security, should be addressed together. By integrating these issues into existing legal and institutional arrangements, strategic plans, policies, and programmers, it should be aimed to ensure sustainable use of natural resources in agriculture and to create an organized and highly competitive structure for adaptation to the effects of climate change on access to sufficient, safe, and nutritious food to meet the nutritional needs and food preferences of all people for an active and healthy life. (Anonymous, 2023; TBMM, 2020 and 2021).

The agricultural sector is one of the sectors that will be most affected by drought. This sector will be successful with the effective management of water resources on basin and field basis within the framework of agricultural production policies. To improve water management in the agricultural sector on basin basis, it is important to develop agricultural support policies, improve physical infrastructure services (digging canals for floods, alternative water collection mechanisms, etc.), reduce transmission losses, water harvesting in upper basins, and awareness raising activities on water saving. On the field basis, effective adaptation to climate change can be achieved through appropriate irrigation methods, planting drought-resistant plant species and varieties, taking measures to prevent soil moisture loss and using water of quality suitable for modern irrigation. (Anonymous, 2023; TBMM, 2020 and 2021).

To minimize and manage the disaster risks arising from the impacts of climate change, adaptation activities are being carried out increasingly in many countries today. For the management of natural disasters due to climate change, it is necessary to identify threats and risks, and for this purpose,

firstly, natural disaster risks such as floods, floods, avalanches, and landslides should be identified. As a matter of fact, in the National Climate Change Strategy, it is envisaged to identify natural disasters such as floods, avalanches, landslides etc. that are likely to increase due to climate change and to take necessary measures by using early warning systems to minimize the effects of disasters.

6. RESULT AND CONCLUSION

It is widely recognized that global climate change causes risks and losses beyond the limits of acceptability and threatens all living and non-living things. Climate change has a complex structure; therefore, this complex structure should be addressed, discussed and solutions should be developed by considering multidimensional processes.

It is known that because of climate change, sea level rise, mixing of salty water with fresh water and more frequent disasters, as well as the pressures on natural resources have started to increase with the effects of it. This situation shows the vulnerable position of Turkey against the impacts of climate change and requires the identification of potentially affected areas and taking measures in this direction in almost every field from all processes of climate-related strategies and policies to climate change adaptation strategies. In the current situation, sectors (agriculture, food, crop production, animal production, forestry, energy, industry, health, tourism, etc.) that need to take adaptation measures against the impacts of it should take some actions in this direction in their strategies and policies.

Developing strategies for adaptation and sustainable water management (surface and groundwater); Determining the needs of different sectors (drinking water, industry, irrigation) and ensuring realistic supply/demand balances, ensuring efficient use

of water resources and minimizing the pressures on water quality caused by sudden changes in the basin scale (drought and flood), development of dams (drinking water/industry water supply, irrigation, hydroelectric energy, flood control dams), construction of irrigation and drainage systems, development of water supply and treatment facilities should be planned.

It is necessary to evaluate the water collected at the basin scale and supplied to agricultural irrigation (water saving in the agricultural sector), to determine the agricultural water resources envisaged to be supplied within the framework of climate change, and to address agriculture and food security within this framework. Water resources management and operation policies and planning should be prepared in a way to ensure that the risks arising from disasters (flood control and future forecasts) are balanced with an optimal system/mechanism, assessments to be made for the management of water resources at the basin scale, existing and planned operation policies should be included in national and regional policies in the process of adaptation to climate change and decision-making mechanisms should be supported in this direction, water resources feeding wetlands should be identified and planned, measures should be taken within the scope of supplying the water needed by wetlands (reservoir structures, etc.) and ecosystem services should be provided efficiently, ensuring efficient management and sustainability of ecosystem services and controlling erosion and sedimentation.

To continuously monitor the effects of climate change, it is necessary to create new systems as well as improving the existing systems. In this respect, observations, research, and evaluations will be carried out to integrate the effects of climate change into water resources planning studies, and drought-related data will be collected, controlled, evaluated, and archived within the hydrological observation and monitoring system.

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EFFECTS OF PESTICIDES AND CHEMICALS ON ENVIRONMENTAL POLLUTION, AGRICULTURE AND HEALTH

Cansu DÖLEK[1]

1. INTRODUCTION

Agricultural soils can be contaminated with a wide range of compounds, from both direct inputs such as the application of pesticides and fertilizers and indirect inputs such as flooding and atmospheric deposition. Polluted soils also represent a secondary emission source of contaminants to surrounding air, surface waters, groundwater, and subsequently to oceans. The main sources of soil pollution in agricultural areas can be grouped as: 1) pesticides; 2) mineral fertilizers; 3) organic fertilizers (manure and sewage sludge); 4) wastewater for irrigation; 5) plastic materials such as films for mulching and greenhouses, drip irrigation tubes and empty packaging; 6) and rural wastes. Different contaminants are linked to each source. The use of pesticides in developing countries is gradually decreasing. Now, the pesticides produced are tried to be produced with high efficacy and low toxicity properties. In particular, drugs such as DDT and BHc are dangerous enough to be fatal (Anonymous 2021a).

All kinds of solid, liquid and gaseous wastes from nuclear power plants, factories, houses and car exhausts pollute air, soil and water. The amount of such waste is increasing day

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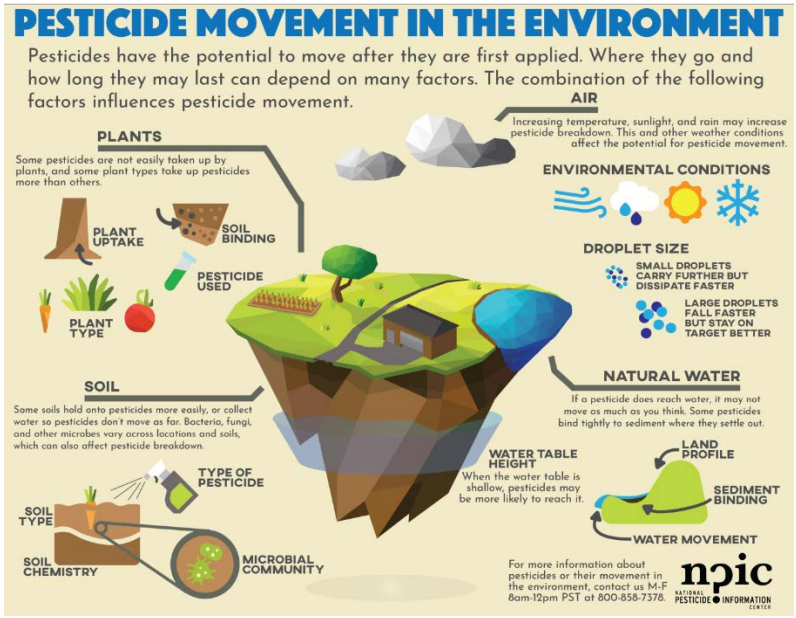
by day. In contrast to waste that can be recycled by decomposing or reusable waste such as plastics, these wastes do not decompose and they exhale harmful gases when burned (Syed, 2005). Substances used in the production of electronic parts and plastics do not disappear from the soil for a long time too, and causing many diseases by making ruins in the tissues of the biological environment living on land and in water (Kanat et al., 1992; Kızıloğlu and Bilen, 2005) (Figure 1).

Figure 1. Pesticide Movement in the Environment



Source: (Anonymous, 2022b).

2. TOTAL PESTICIDE USE IN THE WORLD

Herbicides, plant growth regulators and growth inhibitors account for 41.5%, insecticides for 27.1%, fungicides for 21.5% and other chemicals for 9.9% of the agricultural chemicals market on the earth. Among the pesticide markets, China, India, France, Germany, Germany, the USA and Japan stand out as the

major markets (Chakravarty, 2014). In Turkey in case, the market size is increasing day by day. There is attract the attention an intensive use of chemicals, especially against weeds, and other groups are used at a similarly high rate (Table 1). When are looked at the pesticide density applied worldwide, the increase continues exponentially in general. One of the most important factors of this is incorrect and excessive dose applications as for. The fact that European countries are not included in the top 10 countries shows that they prefer alternative methods of struggle more. Especially in recent years, interest in organic farming activities has also increased. But the Netherlands, which ranks 10th, is a European country both with high agricultural activities despite a narrow area and increasing the use of pesticides (Table 2).

Table 1. Total pesticide use in the world in 2020 (Tonnes) (Anonymous, 2020c)

Group	Value (2020) (Tonnes)
Fungicides and Bactericides	605 986
Herbicides	1 397 465
Insecticides	471 237
Pesticides (other)	186 436
Pesticides (total)	2 661 124

Source: FAO, 2022

Table 2. The Change of the Top 10 Countries That Use The Most Pesticides in Agriculture in the Last 30 Years (Anonymous, 2020d)

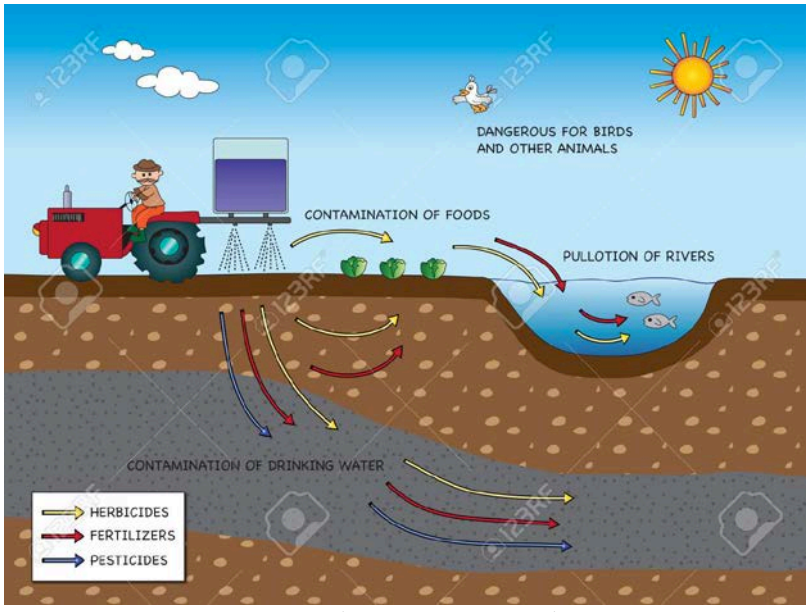
Land	1990 (kg/ha)	2000 (kg/ha)	2010 (kg/ha)	2015 (kg/ha)	2020 (kg/ha)
Saint Lucia	5,13	15,19	20,48	20,48	20,48
China, Hong Kong	16,43	7,83	9,11	12,44	18,33
Maldives	6,33	5,54	7,51	19,13	16,69
Oman	0,53	0,62	3,52	4,02	15,78
Israel	5,78	8,16	18,21	16,16	14,51
Ecuador	0,87	6,02	12,27	17,47	13,74
China, Taiwan	11,18	10,58	9,66	11,67	13,35
Japan	15,22	16,53	12,1	12,05	11,89
Belize	10,01	13,09	6,55	8,89	10,94
Netherlands	10,7	10,78	9,05	10,56	10,82

Source: FAO, 2022

3. ENVIRONMENTAL POLLUTION DUE TO HERBICIDES PESTICIDES AND INSECTICIDES

Pesticides that remain on the soil surface after soil and plant applications can reach groundwater and other water sources as surface runoff with rainwater or by being washed downward in the soil. Moved depending on the slope, vegetation cover, formulation, soil type and rainfall, pesticides can pass into groundwater. Pesticides proceed to break down also after reaching groundwater. When groundwater is contaminated, contamination can also occur in polluted water currents, rivers and lakes. When groundwater is contaminated, it is very expensive and difficult to clean. The best protection against groundwater pollution is pollution prevention (Yücel, 2007; Altıkat et al., 2009) (Figure 2).

Figure 2. Environmental Pollution Due To Herbicides Pesticides and Insecticides



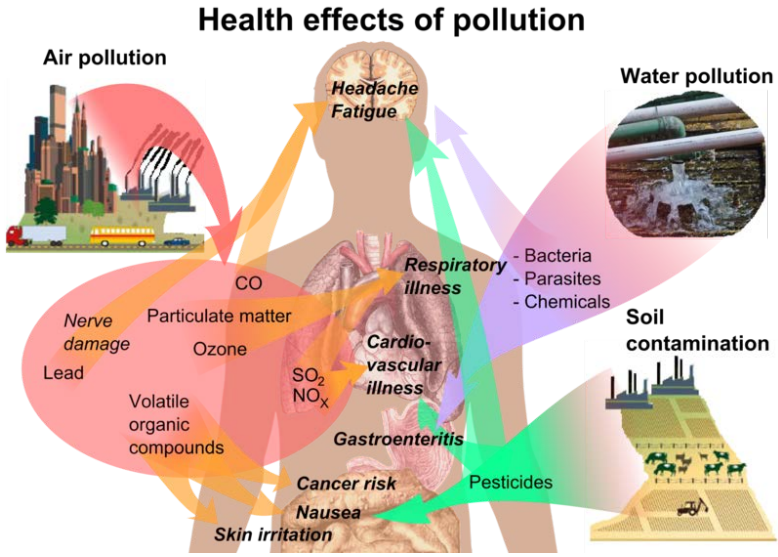
Source: (Anonymous, 2022e).

In toxicological studies to date have determined that pesticides cause poisoning in humans by entering through the skin, mouth and respiratory tract. Again, dose-dependent poisoning may occur as a result of accidental or direct exposed to pesticides during application. In addition, pesticides also affect parasitoids and predators, which are the most important factors that suppress pests in nature. These beneficial insects are more sensitive to pesticides and are highly damaged at disinfestation. The populations of natural enemies that keep pests populations in balance are affected by the continuous use of pesticides and result of this, pests are becoming problem. In addition honey bees, wildlife and domestic animals are also intensely affected by pesticide use (Yıldırım, 2008; Altıkat et al., 2009).

4. HEALTH EFFECTS OF ENVIRONMENTAL POLLUTION

Even very low levels of pesticide residues have been creating accumulation in the living organism. Therefore, the substances taken seriously affect human and animal health and the environment. The most effective but trouble-free use of pesticides is only possible with the establishment of a good control mechanism starting from the licensing stage and raising awareness of all organizations and individuals related to pesticides. Firstly, all properties of pesticides should be well known (Öncüer, 1995; Altıkat et al., 2009) (Figure 3).

Figure 3. Health Effects of Environmental Pollution



Source: (Anonymous, 2022f).

Soil pollution is happening as a result of pollutants solutions added to the soil or substances that appear to be pollutants. These environmental pollutants are chemical, physical and biological processes that affect the flora and fauna of the soil. These pollution sources, in terms of the formation, accumulation and transportation of pollutants, cause primarily soil pollution and consequently heavy metal pollution, groundwater pollution, river, stream, lake pollution and ultimately marine pollution (Jack, 2001). As a result of soil pollution, living life is negatively affected. For thousands of years, soil fertility has been raised with thanks to bacteria that break down organic wastes. However, the use of chemical fertilizers and pesticides has led to the inefficiency of soils, the loss of the ability of bacteria and the inability to break down waste (Fiedler, 1990; Syed, 2005; Kızıloğlu and Bilen, 2005).

Nitrogen and phosphorus fertilizers take the first place among the mineral fertilizers most applied to the soil for crop

production. As a result of excessive nitrate fertilization, nitrate washed from the soil is transported to groundwater and from here to surface waters, causing excessive growth of plants in the aquatic ecosystem and harmful to other living things (fish, shrimp, plankton, crabs, etc). This leads to a decrease food resources procured from marine which play an important role in human nutrition, and an increase in the amount of CO_2 in the atmosphere (Kreutzer, 1985; Kanat et al., 1991; Kızıloğlu, 1995; Kızıloğlu and Bilen, 2005).

Chemicals used in agricultural areas consist of two main groups: fertilizers and pesticides. The presence of various metals and chlorine in the active ingredients of the agricultural chemicals (pesticides) used cause an increase in metal levels and conductivity in the water resources around the agricultural areas. In addition, due to the impurities in the fertilizers used and the use of compost fertilizers, it is possible for metals such as Chromium (Cr), Nickel (Ni) and Molybdenum (Mo) to mix with the soil and therefore to be transported to aquatic environments (Alloway 1995; Kumbur et al. 2008).

Studies show that especially copper-based fungicides and fertilizers are quite widely used in agriculture. Although copper is an essential element for all living things, high concentrations of are known to adversely affect many organisms. The most prominent anthropogenic sources contamination with copper of waters and sediments have been determined as copper-based fertilizers and fungicides used in agriculture (Oliveira-Filho et al. 2004; Kumbur et al. 2008).

Until today, traditional methods of monitoring environmental pollution have been accepted as chemical analysis methods. However, while the data obtained by these methods show the presence of pollutants in the environment, they do not give an idea about the possible toxic effects of these

substances on living organisms living in the same environment (Taylan and Özkoç, 2007). In order to extinguish this negation, studies over the last few years have focused on "bioindicator" or "biomonitor" organisms that accumulate toxic substances. Thus, toxic substances analysis be made in biomonitor organisms and information about their levels in soil, water and air can be received (Aslanhan, 2012; Gadzała-Kopciuch et al., 2004). By analyzing the contaminants that living things accumulate in their tissues; The fact that the effects of these substances that cause environmental pollution on the environment in which living things live can be evaluated is the most important reason for the use of bioindicators (Tataruch and Kierdorf, 2003). Because these pollutants do not only remain in the environment, but also accumulate in the food chain by passing into the organism according to the ambient conditions. Organisms; it can also provide an understanding of the relationship between intra-organismal concentrations of pollutants and their resulting biological effects (Taylan and Özkoç, 2007). Since not all species in the ecosystem can be monitored, it is important to determine an appropriate bioindicator species in order to be able to assess the situation and trends in the ecosystem (Burger, 2006b; Topyıldız and Yarsan, 2014) (Figure 4).

Figure 4. The Impact of the Environmental Pollution Problem in the Future

Source: (Anonymous, 2022g).

Every factor that disrupts the ecological balance is a stimulus for living things in the environment. Living organisms also respond to these stimuli by nature. These basic characteristics of living organisms have revealed to the use of biological methods in environmental quality determination and monitoring studies. For this also, bioindicator groups (biological indicator species) are used. Bioindicators are organisms that respond to environmental pollution by changing their life functions or accumulating toxins in their bodies (Kazancı and Girgin, 1998). Living things survive when exposed to environmental changes thanks to complex defense and adaptation mechanisms. When the threshold of adaptation is exceeded, it has been observed to die these organisms (Gadzała-Kopciuch et al., 2004). By analyzing the toxic substances accumulated in the tissues of living organisms, information can be obtained about the effects of these contaminants, which cause environmental pollution, on the environment in which living organisms live (Tataruch and Kierdorf, 2003; Topyıldız and Yarsan, 2014).

DDT applied to crops was often reported also to be transported to the aquatic environment where it is rapidly metabolized to DDE and bio- accumulated in aquatic food chains being returned eventually to humans (Kale et al. 1999). Endosulfan was found to be metabolized by bacteria into endosulfan sulfate and could persist in soils and in aquatic sediments as a toxic chemical (Carvalho et al. 2002a,b). In general, these chemical compounds could undergo several chemical transformations and be transferred among environmental compartments, reaching other ecosystems outside the area of application and exerting toxic effects on nontarget species (Taylor et al. 2003; Carvalho, 2017).

Research on all these chemicals, in particular using carbon-14 labeled compounds, shed light on the degradation

rates in soils and in aquatic environments, and in accumulation by nontarget biota (e.g. Carvalho et al. 1992, 1997). Organochlorine compounds, such as DDT, HCH, heptachlor, toxaphene, and lindane, are in general, much more persistent and their residues may remain in soils and sediments over days, weeks, and even years (Carvalho et al. 2003).

5. CONCLUCION

Since pesticides are used excessive level, there has being a development of resistance and the doses even more increase each time. In order to prevent this situation, a different pesticide should be used every year, less doses should be used, the time required for harvesting should be observed and non-chemical applications (biological control, mechanical control, natural products) should be utilized. The use and production of many chemical products called POP (Persistent Organic Pollutants), which are also widely used in agriculture, are banned except in some special cases. Better education and awareness raising, disposal of pesticide packages without contaminating the environment, passing to good agriculture and organic agriculture practices, control of records and stricter supervision can also reduce these damages to some extend. In addition to pesticides, heavy metal levels in soil and food and excessive use of chemical fertilizers are also important issues that need to be addressed in terms of environmental pollution and human health. The impact of packaging waste after the use of pesticides on environmental pollution is quite high. Unconscious farmers do not properly eliminate the packaging of the pesticides they use in the field and leave this packaging in the irrigation canal or on the land in a random manner, causing a lot of damage to the environment. The fact that plastic material remains in nature for many years leads to pollution and disruption of the natural

balance of the land. Serious measures should be taken against this situation, packaging should be collected and destroyed by experts. Farmers using these chemicals should be provided with the necessary environmental training and chemical application certificates.

Traceability of the chemicals used by farmers should be ensured and quality control units should be established to food companies working with these farmers. It should carry out inspections at certain time intervals by companies, and crops should not be harvested until a certain day, especially after the use of systemic effective drugs. Harvesting crops before that date have been leading to chemical residues and causing damage in terms of human health. Pesticides have been storing by farmers at their homes or farms. Unintended consequences such as poisoning or even death will occur if people who live with the farmer and do not have the necessary knowledge about the drug are exposed to the harmful effects of storage errors or open packaging.

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USE OF SOME SPECIFIC TREE SPECIES FOR REDUCING THE HEAVY METAL POLLUTION IN AIR CONDITIONS IN THE URBAN ECOSYSTEMS

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1. INTRODUCTION

Growth of the world population in recent years, the increase in urban population brought many problems with it (Kilicoglu et al., 2021). Within this scope, the smart city systems that are designed and constructed as a very harmonic combination of natural components (urban forests, habitat, wetland regions, flora, fauna, etc.) and modern technology (smart house and environment systems) started being preferred by many individuals living in city centers. However, even in smart city systems, the air pollution arising from human activities is one of the leading problems (Arıcak et al., 2019). Such that, it is estimated that 1 of every 8 individuals throughout the world dies of reasons arising from air pollution. The air pollution reaches at its highest level in urban areas, where the population intensity is

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at a higher level and it was announced that 92% of world population leaves in regions with low air quality (Cetin, 2021).

Among the components of air pollution, heavy metals have a specific significance for human health because they tend to bioaccumulate within the living organisms, they do not easily dissolve and disappear in nature. Moreover, some of them might be toxic, carcinogenic, and lethal even at low concentrations and Mn, Cu, Fe, and Ni that are necessary for living organisms might have harmful effects when at high levels (Ucun Ozel et al. 2020; Sevik et al., 2019).

Air metals in the air generally originate from industrial activities and traffic (Cetin et al., 2020). Thus, the urban areas incorporating industrial facilities and intense traffic are the regions with a high level of air metal pollution (Ucun Ozel et al., 2019; Aricak et al., 2020). It is very important to reduce the air metal concentrations in air due to their effects on human health and environment.

The plants grown in areas with a high level of air metal pollution collect the heavy metals in water, soil and air in their body and, thus, they contribute to reducing the heavy metal pollution in these environments. For this reason, many studies have been carried out on the removal of heavy metals from the soils contaminated by heavy metals (Lal et al., 2018; Jin et al., 2019; Ancona et al., 2020).

Since plants also accumulate the heavy metals from air in their bodies, they have potential of use in decreasing the air metal pollution in the air (Cesur et al., 2021; Wei et al., 2021). The removal of pollutants is very efficient in certain plant species and they are used in the environment–friendly biotechnology, which is named phytoremediation (Gawronski et al., 2017). However, the heavy metal accumulation capacity of plants varies between the organs (Sevik et al., 2020; Turkyilmaz et al., 2020) and, in

order to effectively use them in reducing the heavy metal pollution in air, it is necessary to determine the suitable plant species first. The study, it was aimed to determine the plant species collecting the highest amounts of Cr, Pb, and Zn elements in their bodies among the plants grown in an intense traffic region.

2. MATERIAL AND METHOD

The study was carried out on the samples collected from the city center of Ankara which is the capital city of and one of the largest cities in Turkey. Within the scope of this study, the plant samples were collected from Ulus-Kızılay region, where there is a very intense traffic. Within this context, approx. 30cm branch specimens were collected from *Acer negundo* (An), *Platanus orientalis* (Po), *Aesculus hippocastanum* (Ah), *Robinia pseudoacacia* (Rp), *Ailanthus altissima* (Aa), *Tilia tomentosa* (Tt) and *Fraxinus excelsior* (Fe) species that are widely used in urban landscaping. The branch specimens were collected after the vegetation period and then packed and taken to the laboratory. The leaves on the branches taken to the laboratory were picked, the branches were shivered using steel blades, barks and woods were separated and the bark, leaf, and wood samples were obtained for each species.

The samples were dried at room temperature for 15 days and then dried at 45°C within glass petri plates in a drying oven for 2 weeks. Half gram of dried samples was added with 6 ml 65% HNO_3 and 2 ml 30% H_2O_2 and placed into a microwave oven. The microwave oven was set to increase to 200 °C in 15 minutes and to remain at this temperature for 15 minutes. The samples were burnt in Milostone Ethos one model microwave oven and then the samples prepared in solution form were taken to balloons, filled to 50ml using ultrapure water, and they were prepared for heavy metal analysis in GBC Integra XL-SDS-270

ICP-OES device. Then, for the analysis of samples, the plasma of ICP device was burnt and ultrapure water was circulated in the system for 15 minutes in order to ensure the balance. By preparing standard solutions for elements to be analyzed, a calibration graphic was drawn. Then, the samples were place into the system and reading was performed. Since 0.5g of sample was completed to 50g using water, the analysis results were multiplied by 100. By creating different calibration graphics at ppm or ppb levels for the analysis result not falling within calibration graphic, the reading process was repeated. All the measurements were triplicated.

The data obtained were subjected to variance analysis using SPSS package program and, for the factors found to include differences that are significant at the confidence level of 95% ($P<0.05$), Duncan test was used. The homogeneous groups were obtained and the data were interpreted by simplifying and tabulating.

3. RESULTS

Error ratio, F value obtained from variance analysis, mean values of Cr concentration by species and organ, and groups obtained from Duncan test are showed in Table 1.

Table 1. Variation of Cr Concentration

Species	Leaves	Bark	Wood	F Value
Rp	382,7 Ca	248,3 Ba	76,7 Aa	1728,755***
Po	582,1 Cb	268,9 Ba	240,0 Ae	611,786***
An	1326,8 Ce	335,5 Bb	193,2 Ac	608,072***
Fe	2446,7 Cg	522,0 Bc	118,9 Ab	1874,971***
Aa	1860,9 Cf	689,7 Bd	210,4 Ad	627,238***
Ah	688,6 Bc	299,4 Aab	234,3 Ae	83,402***
Tt	983,4 Cd	477,2 Bc	129,2 Ab	12567,886***
F Value	482,192***	92,171***	317,933***	

According to analysis, it was detected that the change of Cr concentration between species and also between organs in all species was statistically significant (P<0.001). Given mean values and Duncan test results, it can be stated that the Cr concentrations were in order of leaf>bark>branch in all the species. The difference between Cr concentrations of wood and leaves vary between 2.4 folds in several species (Po) and more than 20 folds in several species (Fe).

Examining the species-level changes in leaves with the highest Cr concentrations, it was determined that the lowest value was in Rp (382.7 ppb), whereas the highest level was found in Fe (2446.7 ppb) species. The highest value is more than 6 folds of the lowest one. The change of Zn concentration by species and organ is showed in Table 2.

Table 2. Variation of Zn Concentration

Species	Leaves	Bark	Wood	F Value
Rp	38,7 Bc	40,3 Ce	19,4 Ac	1787,332***
Po	13,4 Aa	20,5 Bc	42,2 Cf	2654,035***
An	52,0 Ce	19,8 Ac	22,4 Bd	6711,217***
Fe	37,9 Bc	47,7 Cf	19,9 Ac	127,615***
Aa	43,5 Cd	37,0 Bd	25,1 Ae	19577,333***
Ah	11,7 Ca	6,6 Ba	5,2 Aa	1960,187***
Tt	26,8 Cb	8,3 Bb	6,1 Ab	12926,333***
F Value	478,758***	1215,653***	2327,877***	

According to analysis, it was detected that the change in Zn concentrations, as with the Cr concentrations, showed statistical significance in all organs and all species (P<0.001).

Examining the mean values and the groupings as a result of Duncan test, it was found that the highest Zn concentrations were obtained in leaves in An, Aa, Ah, and Tt, barks in Rp and Fe, and wood in Po. The highest Zn concentration was found in leaves of An (52.0 ppm), barks of Fe (47.7 ppm), and woods of Po (42.2 ppm). Accordingly, it is difficult to say that Zn concentration varied regularly between species or organs. The

distribution of Pb concentration by species and organs is showed in Table 3.

Tablo 3. Variation of Pb Concentration

Species	Leaves	Bark	Wood	F Value
Rp	7029,8 Ca	4973,9 Bc	1182,3 Ab	130,035***
Po	8948,6 Bab	2153,2 Ab	2383,8 Ad	34,881***
An	16069,8 Cc	2293,2 Bb	642,8 Aa	566,976***
Fe	9028,6 Cab	5919,4 Bd	2343,2 Ad	26,640**
Aa	14481,0 Cc	7948,5 Be	585,9 Aa	181,942***
Ah	10130,8 Cb	921,6 Aa	1227,7 Bbc	652,621***
Tt	14502,0 Cc	850,0 Aa	1360,7 Ac	336,198***
F Value	19,563***	262,294***	267,598***	

According to the results, it was detected that the change of Pb concentration was statistically significant in all species and all organs of all species ($P<0.01$). Examining the mean values and groupings obtained from Duncan test, it can be seen that the highest Pb concentrations were observed in leaves in all the species. The lowest concentrations were, however, observed in woods of all species other than Ah (the values obtained from woods and barks in Po were in the same group as a result of Duncan test). According to these results, as with the Cr concentrations, it was found that the order of Pb concentrations was leaf>bark>branch.

Examining the species-based changes in the leaves with the highest Pb concentrations, it can be seen that the lowest value was observed in Rp (7029.8 ppb) and the highest level was observed in An (16069.8 ppb). The highest value found in leaves is more than 2 folds of the lowest value. However, it was determined that there are >9 folds of difference between the highest (Aa) and lowest (Tt) values found in the barks.

4. DISCUSSIONS

The results obtained the present study revealed that the concentrations of Cr, Zn, and Pb significantly changed by both species and organs. Among the elements examined here, Cr is a carcinogenic element and is one of the most toxic heavy metals for living organisms (Shahid et al., 2017). Thus, it is one of the heavy metals studied most in terms of environmental risks.

According to result, it was detected that the Cr concentrations were in the order of leaf>bark>branch in all the species. It was found that the Cr concentrations in leaves ranged between 382.7 ppb and 2446.7 ppb and that the difference between Cr concentrations in woods and leaves exceed beyond 20 folds in certain species. Different studies reported similar results for Cr. Sevik (2021) determined that, among the species grown in high level of traffic, the Cr concentration in leaves was found to be 288.0 ppb in *Tilia tomentosa*, 503.6 ppb in *Ligustrum vulgare*, 698.5 ppb in *Catalpa bignoides*, and 1447.3 ppb in *Aesculus hippocastanum*. Sawidis et al. (2011) determined that the Cr concentrations in leaves of *Platanus orientalis* in regions with air pollution were 0.388 µg/g in Salzburg, 0.472 µg/g in Belgrade, and 0.621 µg/g in Thessaloniki. In their study, Sevik et al., (2019) reported that the highest value was found to be 7046.6 ppb in the leaves of *Aesculus hippocastanu* grown in high-traffic region. The Cr concentrations might increase to much higher levels in shrubs. Mossi (2018) reported the Cr concentration to increase up to 15303 ppb in *Juniperus Sabina* leaves and to 13388 ppb in *Mahonia aquifolium* leaves.

Pb, which is another element examined here, is of a specific importance among the metals and it is toxic in any case. Pb is the leading one among the heavy metals creating the most damage to the ecologic system through human activities (Sevik et al., 2020). It was reported that more than 90% of the lead in

atmosphere has originated from the use of leaded petrol since 1925 (Yalçın and Yalçın, 2013; Çavuşoğlu and Çakır Arıca, 2007). Thus, the relationship between Pb and traffic intensity has been examined in numerous studies. On this subject, Sevik et al., (2019) examined the change of Pb, Cr, and Cu concentrations in leaves, seeds, and branches of *Acer platanoides, Prunus ceracifera, Tilia tomentosa, Aesculus hippocastanum* and *Fraxinus excelsior* depending on the traffic intensity. The authors reported that all the elements increased with the increasing traffic intensity and the increase was more remarkable especially in Pb and Cr. In their study carried out on the leaves of *Aerva javanica, Abutilon pannosum, Calotropis procerra and Conocurpus lancifolia* Alzahrani et al. (2019) determined that the concentrations of Cd, Cr, Cu, Ni, and Pb increased with the traffic intensity.

According to the study results determined that, as with Cr concentrations, the concentrations of Pb were in order of leaf>bark>branch. It was determined that, in the leaves where the highest Pb concentrations were obtained, Pb concentration ranged between 7029.8 ppb (7.03 ppm) and 16069.8 ppb (16.07 ppm). Sevik et al. (2019) stated that, in *Ailanthus altissima* leaves, Pb concentration increased to 8.18 ppm in high traffic intensities. Batır (2019), in a study, reported the highest Pb concentration to be 3.54 ppm in scarlet firethorn.

Examined in the present study, Zn is a necessity for humans, animals, and plants but it is toxic when at high concentrations (Mossi, 2018). In many studies carried out before, it was aimed to reveal the amount of increase in Zn concentration in relationship with the traffic intensity (Turkyilmaz et al., 2018; Hmeer, 2020). The previous studies showed that Zn in the leaves of broad-leaved plants potentially originates from the atmospheric accumulation (Liang et al., 2017; Santos et al., 2019).

In the study, it was determined that the Zn concentration reached 52.0 ppm in leaves, 47.7 ppm in barks, and 42.4 ppm in woods. Accordingly, it is difficult to state that Zn concentration regularly varies between species and organs. This finding may be interpreted as the transfer of Zn between the organs. The previous studies reported that the transfer of certain elements between the organs is at a high level, whereas this transfer remained at a very low level for certain elements (Savas, 2021; Koc, 2021). Given the results of this study, it can be concluded that the transfer of Cr and Pb between the organs was at a very low level, whereas the transfer of Zn was at a very high level.

In order for the plants to be used effectively in reducing the heavy metal pollution in air, it is necessary to determine the areas with high level of heavy metal pollution first and then to specify which plants accumulate which heavy metals in their bodies at a higher level. Although heavy metals may originate from different sources, the heavy metal pollution in air generally arises from anthropogenic sources and the most important heavy metal sources were reported to be industrial activities and traffic (Sevik et al., 2020). Hence, the locations around the industrial facilities and the regions having high traffic intensity have high level of heavy metal pollution in air (Alaquori et al., 2020). In the plants grown in these regions, the inlet and bioaccumulation of heavy metals that can enter the plants' bodies through soil or air occur as a result of a very complex mechanism (Turkyilmaz et al., 2018).

In this study, the highest heavy metal concentrations were generally obtained from the leaves. Leaf is an organ carrying out the photosynthesis process, ensuring the air inlet and release via stomas, and having the most interaction with heavy metals in the air (Sevik et al., 2020). as with the species examined here, the leaves generated intensely by the non-evergreen plants intake the heavy metals into their body and these leaves dropping at the end

of vegetation period intake the heavy metals in air into their bodies and contribute to decreasing the heavy metal pollution in the air. However, this is proportional to the number of leaves. Thus, it can be stated that the scrub-type plants having fewer leaves cannot be effectively used in reducing the heavy metal pollution in air. For instance, Mossi (2018) reported that the Cr concentration in *Mahonia aquifolium* leaves reached up to 13388 ppb. Besides that, since this species have a very small crown diameter and consequently very low amount of leaves, the amount of heavy metal that it can absorb from the air would be very lower than the plants in form of tree. Hence, in determining the species that will be effective most in reducing the heavy metal pollution in air, the number of leaves should also be considered in addition to the heavy metal concentration in the leaves.

5. CONCLUSIONS

In the study, the concentrations of Pb, Cr, and Zn elements that are the most important heavy metals for human and environment health in leaves, barks, and woods of 7 different species in regions with high level of heavy metal pollution especially due to traffic intensity were determined. Hence, it was aimed to determine which ones of these species would be fit more the purpose of decreasing the heavy metal pollution in air.

The results obtained in this study showed that especially the concentrations of Cr and Pb were ordered in leaf>bark>branch. Hence, in determining the most suitable species for eliminating the heavy metals from air, considering the heavy metal concentrations in leaves should be more suitable. Since the leaves are the organs that have the highest level of interaction with air, are generated at the highest amount, and are the renewed organs, they make the most contribution to decreasing the heavy metal pollution in air.

Among the plants to be used in decreasing the heavy metal pollution in air, the species with leaves having a high heavy metal concentration are very important. For this reason, *Acer negundo* and *Tilia tomentosa* with the highest Pb concentration in their leaves can be used in decreasing the Pb pollution, whereas *Fraxinus excelsior* and *Ailanthus altissima* can be used in reducing the Cr pollution. Among these species, especially *Acer negundo* and *Fraxinus excelsior* are of importance thanks to their wide crown diameter and more leaves.

Although 7 species were investigated in this study, much more species are used in the urban landscaping works. Thus, it is recommended to increase the number and diversity of species in further studies, include the leaf surface area into calculations, and examine the factors affecting the heavy metal accumulation potential such as growth conditions and genetic structure.

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DETERMINATION OF CHLOROPHYLL CONTENT VARIATION DEPENDENT ON DIRECTION AND SPECIES USING A PORTABLE CHLOROPHYLL METER (SPAD)

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1. INTRODUCTION

All living organisms depend energetically on photosynthesis, which is the source of oxygen and nutrients in the atmosphere (Öncel et al., 2004; Şevik et al., 2016). Photosynthesis, one of the fundamental biochemical processes in plants, is directed by the chlorophyll pigment (Samdur et al., 2000). Chlorophylls stored in the chloroplasts of green plants are known as the essential components of photosynthesis and concentrate there (Srichaikul et al., 2011). Furthermore, chlorophyll production in plants occurs depending on the depth of sunlight, which is the primary energy source in photosynthesis (Srichaikul et al., 2011). Chlorophyll and carotenoids are responsible for absorbing light in plants (Güneş and İnal, 1995). Studies highlight that the content of chlorophyll in plants is an important indicator of plant development, stress tolerance, and

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productivity (Murchie and Lawson, 2013; Kalaji et al., 2017). Moreover, variability in chlorophyll content has been associated with plant nutrition, environmental effects, and genetic factors (Zivcak et al., 2013).

Leaf chlorophyll content, which is a determinant of plant metabolism, photosynthetic activity, and chloroplast content, is a parameter regularly measured and provides significant clues about plant health (Srichaikul et al., 2011; Hasanuzzaman et al., 2013). Chlorophyll content is an important experimental variable in plant biology research and offers crucial information about the physiological status of the plant (Lamb et al., 2012). It can vary depending on various environmental factors such as water stress, salt stress, light intensity, air quality, growth stage, and fertilizer applications (Zavoruev and Zavorueva, 2002; Elkoca, 2003; Yıldırım et al., 2008; Dai et al., 2009; Demirel et al., 2010; Acar et al., 2011; Şevik et al., 2012; Atar et al., 2020). Changes in chlorophyll content can provide information about a plant's physiological characteristics (Chen et al., 2007). There are various methods available to determine chlorophyll content.

Traditional methods typically involve chlorophyll extraction and the spectrophotometric determination of the absorbance of these extracts. Among these, the most common relies on organic solvent extraction of leaf tissue, such as dimethyl sulfoxide, acetone, petroleum ether, methanol, etc. The obtained absorbance values are converted into concentrations using published equations (Arnon, 1949; Lichtenthaler et al., 1983; Porra et al., 1989) and their modifications. The extraction process is time-consuming; each leaf is pulverized, and procedures are applied to extract chlorophylls (Demiralay et al., 2019). However, recently developed devices can measure chlorophyll content without requiring leaf pulverization, even without detaching the leaf from the branch. These devices work by measuring the light absorbed or reflected by the leaf. Optical

methods generally provide a chlorophyll index and do not directly yield chlorophyll content per unit area or chlorophyll concentration per unit mass (Markwell et al., 1995; Gamon and Surfus, 1999). New optical methods do not necessitate leaf pulverization or detachment, enabling rapid field measurements.

Affordable portable optical chlorophyll meters like SPAD-502 (Konica Minolta, Osaka, Japan) are commonly utilized (Pinkard et al., 2006; Uddling et al., 2007; Marenco et al., 2009; Atar et al., 2020; Atar and Güney, 2021). This device measures absorbance at two different wavelengths of light: 660 nm (red) and 940 nm (near-infrared). While chlorophyll strongly absorbs red light, near-infrared light serves as a reference wavelength, correcting for differences in leaf structure (Lichtenthaler, 1987). The fundamental theoretical basis of these chlorophyll content measurement devices has been extensively explained by Markwell et al. (1995). The absorbance spectrum obtained from chlorophyll extraction using an 80% concentration solvent in acetone exhibits peaks between 400–500 nm and 600–700 nm, while no absorbance is detected in the near-infrared region (Porra et al., 1989). The SPAD-502Plus device utilizes this advantage by measuring absorbance in both the red and near-infrared regions. Utilizing this information, it quantifies the chlorophyll content in the leaf as a numerical SPAD value (Richardson et al., 2002).

The use of portable chlorophyll measurement devices offers several advantages over traditional methods (Murchie and Lawson, 2013; Kalaji et al., 2017). Some of the advantages of using these portable devices include the rapid completion of measurements under consistent environmental conditions, cost-effectiveness, the ability to examine numerous samples across vast areas, conducting multiple measurements on each sample, and preserving the vitality of samples (Murchie and Lawson, 2013; Kalaji et al., 2017). Additionally, these devices allow for

future re-measurements, enabling data collection for subsequent analyses of the samples (Murchie and Lawson, 2013).

In urban living, urban green spaces serve as important meeting points for people (Özel and Ertekin, 2012; Cetin and Sevik, 2016; Turna, 2017). The color of plant leaves is a significant factor in selecting plants for landscape design, particularly playing a substantial role in aesthetics. Shades of green are directly associated with the amount of chlorophyll in plants (Kaya, 2009; Cetin, 2017). Chlorophyll pigments in plants can exhibit highly sensitive responses to various environmental conditions (Lepeduş et al., 2003). Additionally, chlorophyll amounts can vary depending on leaf position and plant species (Gond et al., 1999). This study aims to reveal the variation in chlorophyll content of certain tree and shrub species within the Karadeniz Technical University Kanuni Campus concerning leaf position and species.

2. MATERIAL AND METHOD

The study selected 10 tree and shrub species (*Arbutus andrachne, Arbutus unedo, Ceratonia siliqua, Laurus nobilis, Cinnamomum camphora, Prunus laurocerasus, Osmanthus heterophyllus, Acer pseudoplatanus, Magnolia grandiflora, and Liqustrum*) located within the Karadeniz Technical University Kanuni Campus as samples. Measurements using a portable chlorophyll meter (Minolta SPAD-502, Osaka, Japan) were conducted to determine the variation in chlorophyll content of leaves belonging to each selected species in different directions (north, south, east, and west).

SPAD measurements were carried out on healthy, intact, fully sun-exposed leaves. For each direction of a species, measurements were taken on five leaves at the end of the 2021 growing season. Chlorophyll measurement involved three

readings on a single leaf (tip, middle, and close to the petiole) to obtain an average Chlorophyll Concentration Index (CCI) value. The chlorophyll meter was designed and manufactured based on Inada's principles (1963).

Data analysis was performed using the SPSS 23.0 statistical program. Variance analysis (one-way ANOVA) was conducted to determine the statistical significance of differences in chlorophyll content concerning different species and leaf directions. Groups that might arise based on species and directions were identified using the Duncan test.

3. RESULTS

The chlorophyll contents of certain natural tree species at the KTU Kanuni campus were determined as SPAD (CCI) values within the scope of the study. The results obtained regarding the minimum, maximum, and mean SPAD values of the investigated species are presented in Table 1.

Table 1. SPAD (CCI) values for minimum, maximum, and mean chlorophyll content of species

Species	Minimum	Maximum	Mean	SE
Arbutus andrachne	41,70	57,90	49,63	0,80
Arbutus unedo	63,60	79,80	72,04	0,92
Ceratonia siliqua	44,20	56,30	53,18	0,67
Laurus nobilis	31,70	48,40	42,33	0,95
Cinnamomum camphora	32,90	49,30	43,61	0,94
Prunus laurocerasus	58,40	88,50	70,08	1,49
Osmanthus heterophyllus	55,80	66,00	61,48	0,61
Acer pseudoplatanus	44,10	54,10	48,44	0,58
Magnolia grandiflora	44,40	60,90	54,17	0,87
Liqustrum	10,30	75,90	37,59	3,81

SE: Standard error

When examining the results presented in Table 1, the minimum chlorophyll amount was obtained in the *Ligustrum* species, measuring 10.30 CCI, whereas the maximum chlorophyll

amount was observed in the *Prunus laurocerasus* species, reaching 88.50 CCI. Regarding the average chlorophyll amounts, the lowest result of 37.59 CCI was recorded in the *Ligustrum* species, while the highest result of 72.04 CCI was identified in the *Arbutus unedo* species.

To elucidate the variation in chlorophyll content concerning directions, sampling was conducted from all four directions. Table 2 presents the average chlorophyll amounts of all species according to directions. Accordingly, the highest chlorophyll amount (55.96 CCI) was obtained from leaves sampled in the west direction, while the lowest chlorophyll amount (51.34 CCI) was determined in leaves sampled in the north direction.

Table 2. Results for minimum, maximum, and mean chlorophyll amounts (CCI) by directions

Direction	Minimum	Maximum	Mean	SE
North	10,30	73,70	51,34	2,06
South	15,30	88,50	52,17	1,90
East	28,80	79,60	53,55	1,77
West	44,30	78,60	55,96	1,38

SE: Standard error

The SPAD values for the chlorophyll content of leaves sampled from all four directions for each species are presented in Table 3. Upon reviewing the results concerning directions, it is evident that the chlorophyll content of each species varies across different directions. However, despite the variability in chlorophyll content based on species, on average, it has been determined that leaves oriented towards the west possess a higher chlorophyll content compared to other directions.

Table 3. SPAD (CCI) values for the chlorophyll content of species in different directions

Species	North	South	East	West
Arbutus andrachne	47,72	48,76	52,40	49,62
Arbutus unedo	70,50	69,78	74,20	73,68
Ceratonia siliqua	52,10	54,54	52,04	54,04
Laurus nobilis	36,60	41,64	44,50	46,58
Cinnamomum camphora	42,00	40,62	45,28	46,54
Prunus laurocerasus	70,72	71,80	70,80	66,98
Osmanthus heterophyllus	59,00	60,68	63,86	62,36
Acer pseudoplatanus	50,60	46,72	46,96	49,46
Magnolia grandiflora	56,94	55,38	51,50	52,84
Liqustrum	27,20	31,76	33,92	57,48
Mean	51,34	52,17	53,55	55,96

The statistical significance of differences in chlorophyll amounts among species, direction, and species × direction interactions was determined through variance analysis. It was revealed that the differences in chlorophyll amounts for each variable were statistically significant at a 99% confidence level (Table 4).

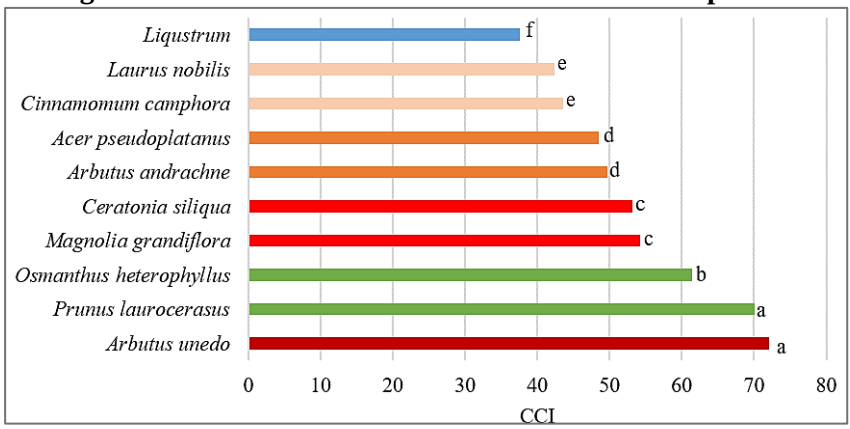
Table 4. Results of variance analysis

	Sum of Squares	df	Mean Square	F	*P*
Species	23967,477	9	2663,053	89,034	0,000
Direction	612,366	3	204,122	6,824	0,000
Species×Direction	2975,587	27	110,207	3,685	0,000

After establishing the statistical significance of differences among species through variance analysis, the Duncan test was conducted to identify groups among the species. The obtained results are presented in Figure 1. The Duncan test revealed the formation of six distinct groups among the species. Accordingly, the species *Arbutus unedo* and *Prunus laurocerasus* constitute the first group with the highest SPAD value, while *Osmanthus heterophyllus* stands alone in the second group. The species *Magnolia grandiflora* and *Ceratonia siliqua* form the third group, *Arbutus andrachne* and *Acer pseudoplatanus* form

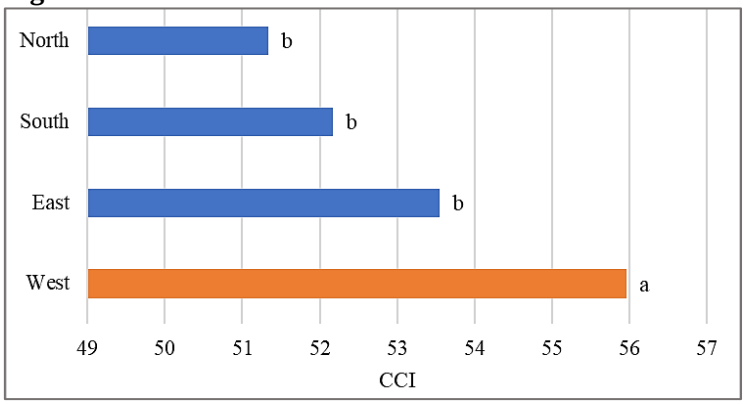
the fourth group, *Cinnamomum camphora* and *Laurus nobilis* form the fifth group, and the species *Liqustrum*, with the lowest SPAD value, stands alone in the last group.

Figure 1. Duncan Test Results for SPAD Values of Species



Due to the statistically significant differences found among chlorophyll amounts of leaves sampled from different directions, the Duncan test was employed to determine the groups among the directions (Figure 2). Accordingly, leaves from the West direction, possessing the highest SPAD values, form the first group, while leaves from other directions, grouped together, constitute the second group.

Figure 2. Duncan test results for SPAD values of directions



3. DISCUSSION AND CONCLUSIONS

The morphological, physiological, anatomical, and phenological characteristics of plants can vary not only due to genetic makeup but also in response to environmental conditions (Güney et al., 2016; Atar and Turna, 2018; Atar et al., 2020; Bayraktar et al., 2021). Research indicates that the chlorophyll content in leaves is influenced by various environmental factors (Dai et al., 2009; Kaya et al., 2015; Çetin, 2017; Atar and Güney, 2021).

The study conducted on tree species at the KTU Kanuni campus involved determining the chlorophyll contents of sampled species as SPAD (CCI) values. Additionally, leaf samples were taken from each species in four different directions to assess whether leaf orientation had an impact on chlorophyll content. The study concluded that there were statistically significant differences in chlorophyll content both among species and among directions, at a 99% confidence level. Among the species, the lowest average chlorophyll content was recorded in *Ligustrum* species at 37.59 CCI, while the highest chlorophyll content was found in *Arbutus unedo* at 72.04 CCI. Similarly, leaves sampled from the west exhibited the highest chlorophyll content.

The annual and seasonal fluctuations in plant pigments are closely related to adverse growth conditions such as intense sunlight in summer, low temperatures in winter, and seasonal water scarcity (Sauceda et al., 2008; Kancheva et al., 2014). High temperatures and intense light can lead to a decrease in chlorophyll levels (Brett and Singer, 1973). In a study involving 26 plant species used in landscaping in Samsun, chlorophyll levels were measured at 11.04 CCI in *Robinia pseudoacacia* and 144.82 CCI in *Yucca gloriosa*, with variations observed among other species falling between these two values (Zeren et al.,

2018). Another study conducted in the Sivas examined chlorophyll levels in plant species used for landscaping, revealing the lowest chlorophyll content in *Platanus orientalis* (11.48 CCI) and the highest in *Elaeagnus angustifolia* (129.04 CCI) (Zeren et al., 2017). In a study on indoor plants, Çetin (2016) reported an average chlorophyll content of 11.86 CCI in *Begonia coccinea* and a level of 145.12 CCI in *Ficus elastica*, indicating a difference exceeding tenfold between these species.

In the rapid transformation witnessed on Earth over centuries, increased environmental degradation and disruptions in ecological balances have underscored the importance and escalation of research concerning the sustainability and health of plants. Determination of chlorophyll content finds applications in various domains such as assessing plant cold tolerance, water stress, and ozone damage (Perks et al., 2004; Jangpromma et al., 2010; Kulaç et al., 2012; Phothi et al., 2017; Nemeskéri and Helyes, 2019). Enhancing and expanding research focused on more practical and effective methods for determining chlorophyll content in relation to different plant characteristics could contribute to the non-destructive measurement of chlorophyll content over time on the same leaves, aiding studies related to processes like photosynthesis or aging. In this context, the use of portable chlorophyll meters offers significant advantages in determining chlorophyll content.

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MORPHOLOGICAL CHARACTERISTICS AND QUALITY CLASSIFICATION OF *Picea orientalis* (L.) LINK SEEDLINGS AT DIFFERENT AGES

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1. INTRODUCTION

In Turkey, significant efforts have been made from the past to the present to increase and sustain the presence of forests. The forest coverage in our country was 20,199,296 hectares in 1973 and reached 22,933,000 hectares by 2020, encompassing 29.4% of the country's landmass. However, 44% of these forests are normal, while 56% are characterized as degraded forests. The transformation of degraded forest areas back into efficient and productive ones, both qualitatively and quantitatively, holds paramount importance for the continuity of various functional benefits provided by forest ecosystems (Anonymous, 2020).

To secure the future and minimize the risks of forest establishment and afforestation efforts, which involve extended durations and high costs, it is imperative to employ superior genetic qualities of seeds and seedlings (Çalışkan and Boydak, 2017; Gregorio et al., 2017). Additionally, the success of afforestation initiatives, from both economic and biological standpoints, is contingent upon environmental conditions, appropriate planting techniques, land preparation, timing, and the

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use of high-quality seedlings (Gezer and Yücedağ, 2006). Seedlings of high quality are characterized as those that achieve the expected levels of growth and survival after being planted (Johnson and Cline, 1991; Mattsson, 1997).

The advancements observed in afforestation efforts have also accelerated studies in tree breeding. The percentage of quality in the seedlings to be grown in nurseries primarily depends on the quality of the seeds used. The primary challenge in this regard is determining the origin in terms of region, altitude, and trees from which high-quality seeds can be sourced. Therefore, identifying populations with superior trees and progressively improving them through their breeding could lead to achieving superior attributes. Rational utilization of existing forest areas in terms of both quality and quantity should be enhanced (Turna and Güney, 2009). It is emphasized that morphological characteristics of seedlings such as diameter, length, stem-root ratio, and dry weight significantly influence the quality attributes of seedlings established in afforestation areas (Şevik et al., 2003). The utilization of high-quality seedlings in afforestation endeavors could contribute to increased planting success, reduced completion efforts, and the production of higher quality and quantity of timber in a shorter time frame per unit area (Bilgin, 2019).

Morphological features are the most often assessed qualities in seedling quality classifications because they are inexpensive and simple to measure (Mexal and Landis, 1990; Yahyaoğlu and Genç, 2007). Assessing morphological aspects doesn't require specialized tools or much training, in contrast to physiological qualities. Measuring root-collar diameter and seedling length are the easiest morphological parameters to measure. (Haase, 2008). Morphological characteristics have been used in several studies to assess the quality of seedlings in a variety of species (Donahue and Upton, 1996; Apholo and Rikala,

2003; South et al., 2005; Aksu and Tilki, 2015; Ivetić et al., 2016; Ayan et al., 2020a; Atar, 2021; Güney et al., 2023). However, there is a limited number of studies in the literature regarding the classification of seedling quality for the Oriental spruce, which is one of our tree species with significant distribution areas in Turkey.

Picea orientalis (L.) Link, recognized as a paleo-endemic tree species (Yahyaoğlu et al., 1991), holds significant importance within the forest ecosystems of Turkey's Eastern Black Sea region. This species exhibits widespread presence in the northeastern sector of the Black Sea region and in adjacent areas within the Caucasus. The expanses of pure and mixed oriental spruce forests initiate just west of the Melet River in Ordu, Turkey, and continue along the southern stretches of the Caucasus Mountains into Georgia. Its natural distribution commences at the coastal regions and ascends to elevations as high as 2400 meters above sea level (Kayacık, 1980).

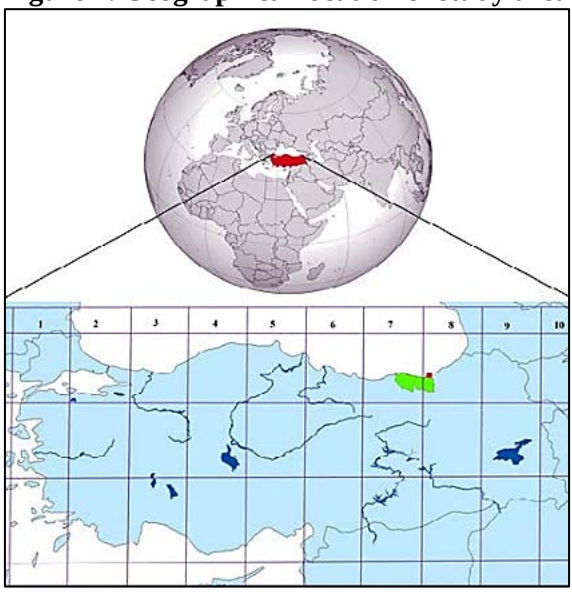
In this study, (I) the determination of certain morphological characteristics of Oriental spruce seedlings at different ages and (II) the identification of quality classes of seedlings based on Turkish Standards Institution (TSE) seedling standards and sturdiness quotient were aimed at.

2. MATERIAL AND METHOD

In this study, 1 and 3-year-old Oriental spruce (*Picea orientalis* L.) seedlings, raised from seeds collected from Giresun-Bicik origin, were used as the material. The seedlings utilized as material were cultivated in the Trabzon-Of Forest Nursery. Geographically, the nursery is located at 40° 58' 39" to 40° 59' 19" north latitude and 40° 19' 34" to 40° 20' 19" east longitude (Figure 1). Its average elevation from sea level is 5 meters. The nursery spans a total area of 242,000 square meters.

The region experiences cool and highly rainy summers, coupled with cold winters. Situated at the base of the valley, the nursery encounters cooler nights while days exhibit typical Eastern Black Sea climatic conditions. The soil composition consists of a sandy-loamy structure, primarily comprising a mix of sand and silt. Being an old riverbed, the nursery area is generally flat (Anonymous, 2007–2011).

Figure 1. Geographical location of study area



At Trabzon-Of Forest Nursery, Oriental spruce seedlings are cultivated in ENSO-type containers. Peat and perlite are used as the filling materials. Planting of Oriental spruce seeds is initially done in 84-cell ENSO-type containers. One-year-old seedlings spend their first growth phase in the 84-cell containers and are subsequently transferred to 24-cell ENSO-type containers at the end of this initial growth period. The 1-year-old seedlings used in the study were grown in 84-cell ENSO-type containers, while the 3-year-old seedlings were cultivated in 24-cell ENSO-type containers. All nursery operations (irrigation, shading, weed

control, maintenance, etc.) were routinely and systematically conducted.

Measurements related to morphological characteristics were conducted on a random and three-repeated sample of 50 seedlings from containerized seedling production beds. Root-collar diameter and seedling length values were measured for 1 and 3-year-old seedlings. Additionally, the calculated values of morphological traits and the sturdiness quotient were determined.

The seedling length (SdL) was measured with an accuracy of ±0.1 cm using a meter, while the root collar diameter (RCD) was measured with a digital caliper with an accuracy of ±0.01 mm. Sturdiness quotient (SQ) was determined by the ratio of seedling length (mm) to root collar diameter (mm). The sturdiness quotient signifies the vitality and robustness of the seedling (Thompson 1985; Aldhous 1994; Jaenicke 1999).

The seedlings were classified based on the SQ values into quality seedlings (SQ < 50), medium-quality seedlings (50 < SQ < 60), and low-quality seedlings (SQ > 60) (Yahyaoğlu and Genç, 2007). Additionally, to determine the quality classes of Oriental spruce seedlings, compliance with TS 2265/February 1988 TSE standards was assessed using the quality classes of coniferous species (Table 1).

Table 1. Quality classes of Oriental spruce seedlings according to TS 2265/February 1988 standards

Seedling Age	Seedling Class	SdL (cm)	RCD (mm)
1	I	≥ 4.0	≥ 2.0
	II	3.0 – 3.9	
	Non-standard	< 3.0	< 2.0
3	I	≥ 13	≥ 2.0
	II	10.0 – 12.9	
	Non-standard	< 10.0	< 2.0

(Anonymous, 1988)

The basic statistics (mean, standard deviation, standard error, minimum and maximum values, ranges) for the seedling

length, root-collar diameter measurements, and calculated sturdiness quotient values were computed using the SPSS 26.0 statistical software.

3. RESULTS

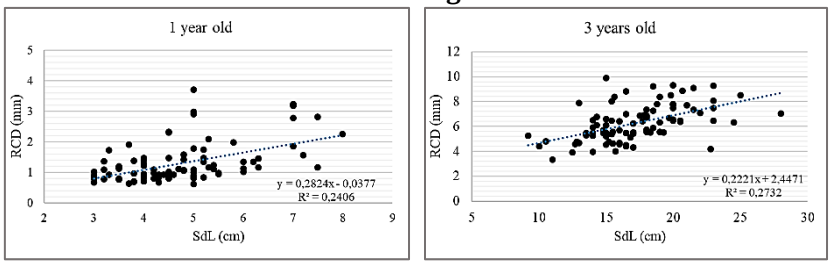
The basic statistics for seedling length, root-collar diameter, and sturdiness quotient values obtained from seedlings are presented in Table 2. The lengths of 1-year-old seedlings vary between 3.00 cm and 8.00 cm, with an average seedling length of 4.76 cm. For 3-year-old seedlings, lengths range from 6.00 cm to 28.00 cm, with an average seedling length of 17.22 cm. Observing the minimum and maximum values for seedling length, a considerable range of variability is evident. RCD for 1-year-old seedlings ranges between 0.62 mm and 4.25 mm, with an average of 1.33 mm. In 3-year-old seedlings, RCD ranges from 3.32 mm to 9.90 mm, with an average of 6.27 mm. Similar to seedling length, there is a notable variability between the maximum and minimum RCD values. Looking at the results for the SQ, the average SQ value for 1-year-old seedlings is 40.58, while for 3-year-old seedlings, the SQ value is determined to be 28.25.

The relationship between root-collar diameter and seedling length in Oriental spruce seedlings was separately evaluated for one- and three-year-old seedlings. Accordingly, the correlation coefficient between root-collar diameter and seedling length was determined as $R2 = 0.24$ for one-year-old seedlings and $R2 = 0.27$ for three-year-old seedlings (Figure 2).

Table 2. Statistical data on the seedlings' morphological characteristics

		Seedling age	
		1-year old	3-year old
SdL(cm)	Mean	4.76	17.22
	Standard deviation	1.13	3.45
	Standard error	0.12	0.36
	Minimum	3.00	6.00
	Maximum	8.00	28.00
RCD (mm)	Mean	1.33	6.27
	Standard deviation	0.73	1.46
	Standard error	0.08	0.15
	Minimum	0.62	3.32
	Maximum	4.25	9.90
SQ	Mean	40.58	28.25
	Standard deviation	13.73	6.01
	Standard error	1.45	0.63
	Minimum	5.88	15.15
	Maximum	80.85	54.29

Figure 2. The relationship between RCD-SdL in Oriental spruce seedlings



The compliance of seedlings with TSE standards was evaluated based on criteria related to seedling length and root-collar diameter. It was determined that 12.2% of one-year-old seedlings met the criteria for the first-quality class, while 87.8% were considered discarded seedlings. There were no seedlings classified in the second-quality class. Concerning the sturdiness quotient, it was observed that 76.7% of one-year-old seedlings were of quality, while only 6.5% were categorized as low-quality. Notably, there exists a significant inconsistency between the TSE quality standards and the sturdiness quotient for one-year-old

seedlings. As per TSE standards, 92.2% of three-year-old seedlings were classified in the first-quality class, 6.7% in the second-quality class, and 1.1% were considered discarded seedlings. Based on the sturdiness quotient, 98.9% of three-year-old seedlings were of quality, 1.1% were of medium quality, and no seedlings were categorized as low quality. It was observed that the results between TSE standards and the sturdiness quotient for three-year-old seedlings generally aligned and demonstrated coherence (Table 3).

Table 3. Classification of quality based on sturdiness quotient and TSI standards

Seedling age	Quality classes of TSI (%)			SQ (%)		
	I	II	Non-standard	Quality	Medium Quality	Low Quality
1-year old	12.2	0.0	87.8	76.7	16.7	6.6
3-year old	92.2	6.7	1.1	98.9	1.1	0.0

4. DISCUSSION AND CONCLUSIONS

The primary criterion used in the early research on seedling quality categorization was seedling length (Yahyaoğlu and Genç, 2007). While some researches suggested a negative link between seedling length and survival rate (Larsen et al., 1986; Dirik, 1991), Semerci (2002) demonstrated a positive correlation between these two measures. Furthermore, compared to seedling length, it has been proposed that root-collar diameter is a more important factor in seedling quality assessment (Şimşek, 1987; Yahyaoğlu and Genç, 2007). In this study, the average lengths of one-year-old and three-year-old seedlings were determined to be 4.76 cm and 17.22 cm, respectively. The mean RCD values for the seedlings were obtained at 1.33 mm for one-year-old seedlings and 6.27 mm for three-year-old seedlings. Observation of the minimum and maximum values for seedling length and root-collar diameter reveals a substantial range of variability. Indeed, Ayan et al. (2020b) highlighted a considerable

range of variation in seedling lengths and indicated high heterogeneity in seedling production across different ages of stone pine seedlings. Genç (1992) emphasized the significance of Oriental spruce seedlings used in afforestation projects having a minimum length of 20 cm and a minimum root-collar diameter of 8 mm.

The four-year growth performance of common hornbeam seedlings was investigated in a research by Atar et al. (2018), and the results showed that there were notable variations in seedling length and root-collar diameter between various populations. Similar to this, research on the Oriental beech species showed that different populations varied significantly in terms of root-collar diameter and seedling length (Gülseven et al., 2019). Likewise, variations in populations have been illustrated in species such as Oriental spruce (Atasoy, 1996; Güney et al., 2019), Kazdağı fir (Velioğlu, 1999), Oriental beech (Güney et al., 2016), Turkish red pine (Işık, 1994; Işık and Kara, 1997), Taurus cedar (Yahyaoğlu et al., 2012), Anatolian black pine (Şimşek et al., 1985), common hornbeam (Güney et al., 2015; Atar et al., 2017; Atar, 2021), and Oriental hornbeam (Güney et al., 2013; Atar et al., 2014; Atar and Güney, 2021) common using various morphological traits to depict variations among populations.

In seedling quality classification, another criterion of preference is the sturdiness quotient, where a smaller sturdiness quotient value is desired concerning seedling quality, indicating higher success rates in planting for seedlings with lower sturdiness quotient values (Genç, 1992). Atar et al. (2023) observed that as the age of oriental hornbeam seedlings increased, the percentage of high-quality seedlings based on the sturdiness quotient was found to be 24%, 32%, 34%, and 18%, respectively. Kestek (2012) reported the highest SQ value at 39.6% for conventionally grown control seedlings among one-year-old stemless oak seedlings, while the lowest SQ value at 28.7% was

observed for tube-grown seedlings. In a study involving various populations of Oriental beech seedlings, all populations were classified as high-quality due to their SQ values being less than 50 (Gülseven et al., 2019). According to Atar (2021), based on the sturdiness quotient, 11.5% of common hornbeam seedlings and 27.2% of oriental hornbeam seedlings were categorized as high and medium quality, whereas 88.6% of common hornbeam seedlings and 72.8% of oriental hornbeam seedlings were classified as low-quality and unsuitable for use. Another study indicated variation in SQ values for *Quercus brantii* based on planting density, ranging from 43 to 53 (Çanakçı, 2011). It was stated that 100% of *Acer pseudoplatanus*, 93.3% of *Fagus orientalis*, and 97.8% of *Carpinus betulus* were classed as low-quality seedlings based on SQ values in a research examining the morphological traits of certain broad-leaved forest tree seedlings (Ayan et al., 2020a).

When examining the results between TSE quality standards and the sturdiness quotient, significant inconsistencies were noted in the classifications of one-year-old seedlings, whereas classifications of three-year-old seedlings were found to be coherent. Based on the data collected, these findings imply that the TSE seedling quality standards and the sturdiness quotient criteria alone are not adequate to assess the quality of oriental spruce seedlings that are one-year-old.

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