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Aims and Scope

Turkish Journal of Range and Forage Science is the official publication of Society of Rangeland and Forage Science. The Journal is dedicated to publishing quality original material that advances rangeland management and forage crops production.

Turkish Journal of Range and Forage Science is a peer-reviewed, international, electronic journal covering all aspects of range, forage crops and turfgrass management, including the ecophysiology and biogeochemistry of rangelands and pastures, terrestrial plant–herbivore interactions, rangeland assessment and monitoring, effects of climate change on rangelands and forage crops, rangeland rehabilitation, rangeland improvement strategies, conservation and biodiversity goals. The journal serves the professions related to the management of crops, forages and grazinglands, and turfgrass by publishing research, briefs, reviews, perspectives, and diagnostic and management guides that are beneficial to researchers, practitioners, educators, and industry representatives.

Publication Date and Subscription Information

Turkish Journal of Range and Forage Science is published twice a year (June and December) as online.

SOCIETY OF RANGE AND FORAGE SCIENCE

TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

PUBLISHING POLICIES AND ETHIC PRINCIPLES

The publication process of the Turkish Journal of Range and Forage Science takes place within the framework of ethical principles. The procedures in the process support the quality of the studies. For this reason, it is of great importance that all stakeholders involved in the process comply with ethical standards.

Turkish Journal of Range and Forage Science expects its readers, authors, reviewers, and editors to take ethical responsibility.

The ethical codes expected from the studies and publication processes of the Turkish Journal of Range and Forage Science are stated below in the light of the guidelines and policies prepared by the Committee on Publication Ethics-COPE.(For detailed information COPE Code of Conduct and Best Practice Guidelines for Journal Editors).

Ethic principles for authors

The works must be original, not published elsewhere and in accordance with scientific research and publication ethics.
Authors should confirm that they have read and understood the author's instructions.
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All data in the article should be real and original.
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Turkish Journal of Range and Forage Science adopted the policy of providing open access with the publication.
Open access will lead to beneficial outcomes for humanity by increasing the global exchange of information.

There is no article processing and article submission charge from submitted articles for publication in Turkish Journal of Range and Forage Science.

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The authors have to check the articles against the plagiarism with the "iThenticate Plagiarism Detection" software before the manuscript submit. Except for the references section, the similarity index in the search will have to be below 20%. It is mandatory that the iThenticate software be provided in the report when the article is being recorded on the manuscript submit.

PEER REVIEW PROCESS

Review of manuscripts by peers, that is, scientists who are experts on the subject, is a vital part of technical publishing. Peer review has two fundamental purposes. The first purpose is to ensure the originality and soundness of the research, the methodology, the logic and accuracy of any theoretical work, the soundness of experiments and interpretation of data, and the logic of the conclusions. The second purpose is to provide comments and suggestions that will assist the authors to improve their manuscripts as they prepare subsequent drafts.

Initial Manuscript Evaluation

All manuscripts submitted for publication in Journal are firstly evaluated by the Technical Editor. Manuscripts which fall outside the aims and scope of the journal or is not enough for requirements of a scientific study are rejected or may be wanted some revisions at this initial point. Manuscripts are never accepted by editor without a reviewer report, at this early stage.

Policy of Peer Review

This journal, employs double blind peer review, where both the reviewer and author remain anonymous throughout the process.

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After initial evaluation, the manuscripts are sent to at least two reviewers which are determined editor and/or editorial board. If necessary, the number of reviewers can be increased by editor or Editorial Board. The reviewers are chosen from reviewer board according to their expertise.

Reviewers are asked to evaluate the manuscript's originality, methodology, contribution to the literature, presentation of results and support for the conclusions, and appropriate referencing of previous relevant studies. Reviewers might accept the manuscript, reject the manuscript or might require a revision for style and/or content. For publication of articles, two positive reports are required. In case one reviewer report is negative while the other is positive, the article is forwarded to a third reviewer for addition evaluation.

When a revision is required by the reviewer or reviewers, the author(s) are to consider the criticism and suggestions offered by the reviewers, and they should be sent back the revised version of manuscript in twenty days. If revised manuscript is not sent in twenty days, the manuscript is removed from reviewer evaluation process. Reviewers may request more than one revision of a manuscript. Manuscripts which are not accepted for publication are not re-sent to their authors.

Final Evaluation

After favorable opinions of reviewers, Editorial Board is made the final evaluation. The articles accepted for publication by Editorial Board are placed in an issue sequence.

Time of Peer Review Process

The peer review process that has long time is an important problem. Naturally, the author(s) wish to take an answer about their submissions. Turkish Journal of Range and Forage Science aims to complete the all peer review process within 8 weeks after submission (one week for initial evaluation, 6 weeks for reviewer evaluation and one week for final evaluation).

The author(s) that submit an article to the Turkish Journal of Range and Forage Science consider accepting of these peer review conditions and procedures.

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The Strategy of Utilize Unused Lands for Production Purposes in Turkey

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A R T I C L E I N F O

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A B S T R A C T

The aim of this study is to discuss the feasibility of the strategy to utilize unused land for production purposes in Turkey and the effects of land resources in Turkey on the implementation of the strategy. An unused (unproductive) land is a land that reduces the quality in terms of components that define a land, causes adverse conditions to affect the land use, and is not utilized for agricultural purposes within a crop rotation period of time. Published in the Official Gazette No. 30224 of 10/28/2017 and put into effect, the Year 2018 Program reads: "The utilization of unused agricultural lands for production purposes shall create models for the effective operation of agricultural farms". In addition, the sub-paragraph 11 on Policies and Measures, which are set out under the title of 5th Growth and Employment Strategy as a part of the 2019-2021 Medium Term Program in accordance with the Presidential Decree No. 108 of 9/20/2018, reads: "Organizational and legal infrastructure shall be established to utilize unused agricultural lands for production purposes." From this perspective, there is a need to reform the unplanned land use and the forms of property and use as it is one of the agricultural infrastructure problems in Turkey. The importance of introducing a system to give a true picture of the market land of agricultural lands and making sure it is influenced less by other industries is self-evident. The land resources that Turkey currently has, challenges concerning those lands and agricultural structure make it difficult to execute the strategy. There are some major social, economic, legal and technical barriers to the achievement of the goals. This study offers recommendations on how to remove those barriers based on the figures of a study commissioned by the Ministry of Agriculture and Forestry, and analyses the unused agricultural lands in Turkey and the possibilities to utilize them for production purposes. Agricultural lands are utilized for non-agricultural purposes, and the studies on how to utilize unused agricultural lands with conditions that reduce the quality of lands in terms of components that define a land point to a contradiction between what is intended and what is actual. Without making any land use plans, it is impossible for effort to develop a land use strategy to be efficient.

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1. Introduction

From past to present, lands have been utilized by human beings based on their needs and priorities, particularly for nutritional and housing purposes. Such needs and priorities vary in line with ever-changing demands over time. The only constant is the efforts to analyze capabilities to utilize agricultural lands in a more effective and efficient way. Based on an estimation, the size of agricultural lands will only grow by 10% around the world over the next 75 years whereas the global population will double, and the majority of the population growth will be focused on semi-arid and arid zones of the world where salinization is highly common. This scenario shows how important the sustainable management of natural resources is (Fischer 2020). As the effects of human-induced climate change steadily grow and they pose environmental threats to an alarming extent, the efforts to eliminate them are built up across the globe on a daily basis (Ahmed et al., 2007)

Through the improvement of agricultural and social infrastructure services, the promotion of rural development and welfare, and enhancement of the attraction of rural areas, the Food and Agriculture Organization (FAO) of the United Nations is intended to improve the living conditions and incomes of individuals and communities that reside in rural areas and live on agriculture. This will diversify economic activities in rural areas based on local know-how and scientific projects, mitigate land fragmentation, introduce on-land development services and modern irrigation systems, and improve irrigation efficiency. This will also enable to make efficient use of domestic and international funds allocated to promote rural development, and prevent agricultural lands from being utilized for non-agricultural purposes, conserve and improve land and water resources. Decision makers and users will have an easy access to figures collected through an agricultural information system.

In addition, practices of land consolidation will gain momentum, and agricultural lands will not be fragmented by inheritance, and problematic agricultural lands will be located, and land improvement and drainage efforts will be expedited, and agricultural lands will be utilized for their original purposes based on land use plans (Zhou et al., 2020).

Just like it is the case in Turkey, natural resources in underdeveloped and developing countries are under pressure due to the misuse of lands and unplanned land use, growing population, soil erosion in vulnerable ecosystems, multi-dimensional demands for scarce resources, a poor rural population, and shortage or lack of organizational aids.

Of them, the land use, which is not based on a certain plan, causes neighboring industries to conflict with one another in many aspects. Unplanned land use causes many ecological, social, economic and cultural problems such as soil being detached in a short while, floods as a result of excess surface runoff caused by soil detachment, replacement of valuable agricultural lands, settlements, dams and ports by soil detached, and hauling of soil on slopes and gradual reduction of soil thickness and emergence of bedrocks, loss of capacity for a land to retain and store water, and desertification namely formation of anthropogenic (man-made) dry lands, loss of habitats, increased rural poverty, rise in migration from rural to urban areas, and decline in visual value of lands. This causes degradation in natural resources and puts sustainable development at risk.

To eliminate such challenges, it is imperative to conclusively designate the lines of work for forestry, agriculture, pasture farming, settlements, industrial plants, transportation industry etc. based on bio-physical, social, economic, cultural and environmental variables, as they utilize lands, and predicate them on a land use plan and map. To be made based on scientific facts, this plan must meet demands, needs and expectations of the growing population, strike a balance for the conservation of current and future productivity of ecosystems, and thus provide a sustainable land use (Özartan 2013).

Land evaluation and land use plans must be based on make a rational analysis and assessment of prompt, accurate and sufficient information and data about soil and land resources based on modern technologies. Land evaluation is a type of estimation about the potential of a land for use. Land evaluation methods are usually divided into qualitative methods based on expertise and quantitative methods based on simulations (Permanandh 2011, Dengiz and Sarıoglu 2013). In this context, rational land use should be adopted that brings economic and environmental sustainability, which will reduce conflicts over scarce resources (İban, 2019; Myers, 2018; Drucker, 2012).

Most of the agricultural farms in Turkey do not have a sufficient land area, and agricultural lands are highly fragmented and not cultivated in an efficient way. The fact that farms do not have a sufficient size of lands increases transportation and shipping losses and costs for them. As a result, farmers cannot possibly attach due importance to their lands, fail to find an opportunity to utilize modern means and have capital accumulation. This makes it difficult to provide infrastructural services such as roads, utility water, drainage and leveling for such farms on fragmented lands and increases the cost, too (Allen et al., 1998).

The studies suggest that the arable land per capita was nearly 5 hectares in 1959, while it was almost cut in half in 2006, regressing to 2.5 hectares. It is estimated to regress further to 1.1 hectares by 2040. In addition, 2 to 5 million hectares of arable lands are being lost to erosion and/or drought for a variety of reasons.

Large-scale agricultural land lots are transferred by inheritance and they become smaller and smaller by each transfer and end up being non-arable from the economic standpoint. In fact, the number of agricultural farms amounted to 2.2 million and their land size was nearly 10 million hectares in Turkey back in 1950 while it regressed to 6 million hectares while the number of agricultural farms increased to over 3 million and the total size of agricultural lands went over 26 million hectares in 2001 after new agricultural lands were cleared for use. In addition to a sufficient size to engage in agriculture, soil productivity and health is of importance for production. 800 m^2 of fertile lands can provide 800 kg of foods needed annually per capita while it can take more than 1000 m^2 to provide the same amount of foods in unfertile lands (Nonhebel 2005).

The success of reforms to improve the agricultural structure in terms of eliminating problems caused by the misuse of agricultural lands depends on a comprehensive plan. Such improvements must be introduced in an effective way where all the plans are effectively made for the use and conservation of agricultural lands. Agricultural lands must be reformed and improved based on plans that attach primary importance to their agricultural functions, and natural habitats must be built and conserved as a part of a multi-dimensional program (Dengiz and Sarıoğlu, 2013).

An overview of agricultural lands around the world

The Earth has a total land surface of approximately 15 billion hectares, and agricultural lands, which amount to 5 billion hectares, constitute 37% of it. Based on the form of use of agricultural lands, field crops are grown on nearly 1.5 billion hectares of land while perennial plants are sown on 1.5 billion hectares of land (Ritchie and Roser, 2013). Nearly 45% of the world's population lives in families where agriculture is the primary income source (Bourguignon and Bussolo, 2013). At the same time, agriculture drives the economy of many developing countries. For this reason, the future of humanity depends on the sustainability of agricultural lands (Aznar-Sanchez et al., 2019). The allocation of natural land covers to land-use systems is an important dynamic of global environmental change affecting climate, hydrology, biodiversity and other world systems. However, on the global land surface; the continuous increase in infrastructures built to support people's material needs, such as residential, commercial, industrial, transportation and energy demands, also reflects the change in land uses. (Hansen et al., 2022). On the other hand, unsustainable use of lands and excessive consumption of natural resources due to climate change around the world can cause land degradation, drought, desertification, etc. posed problems (Yi et al., 2016; Tilman et al., 2011; Lambin and Meyfroidt, 2011). Losses of agricultural productivity and efficiency and global food crises adversely affect not only the agricultural business but also the global economy to a substantial extent. Climate change and growing world population force developed countries to lease fertile agricultural lands from Asian and African countries to meet their future needs for food.

Published by the Food and Agriculture Organization (FAO) of the United Nations, the World Agriculture: Towards 2010 indicates that there are potential lands as large as 1.8 billion hectares in addition to the aforementioned ones that can help increasing the size of agricultural lands in years to come. As noted in the aforementioned report, these lands, which can be utilized for agricultural purposes in years to come, are mostly located in Sub-Saharan Africa and South America. So much so that FAO estimates that the currently cultivated land should increase by 60 percent by 2050 to meet world food production. Global land cover data is presented in Figure 1.

Once the feasibility to expand agricultural lands around the world other than the aforementioned ones is analyzed, that it is highly limited and the size of agricultural lands in many countries including Turkey has peaked. However, it is known that a significant portion of agricultural lands around the world becomes non-agricultural lands on grounds of erosion, salinization, extensive use and allocation of lands for other industries.

While the feasibility to expand agricultural lands is being discussed on one hand, the use of agricultural lands for non-agricultural purposes and land degradation pose more and more threats to global agriculture. In fact, overgrazing, deforestation, unfavorable agricultural activities and misuse of agricultural lands cause 26% of global lands, which correspond to 1.2 billion hectares, to face the risk of degradation. On the other hand, the uncontrolled expansion of agricultural lands brings with it deforestation. As a result, the protection of biodiversity becomes a global threat (Kissinger et al., 2012). Due to the expansion practices in agricultural areas in the world, about three quarters of the forests have disappeared. This situation brings with it a decrease in the resistance of animal populations and other environmental effects (Maxwell et al., 2016; Baudron and Giller, 2014).

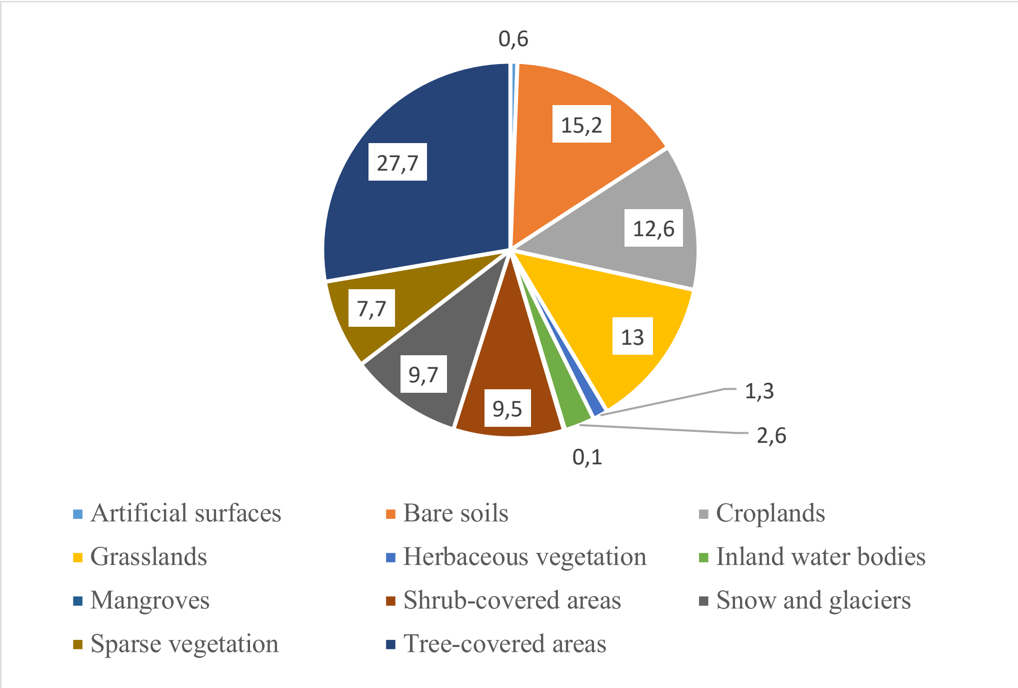

Figure 1. Global land cover layers according to FAO's new database.

As a part of the Global Assessment of Human-Induced Soil Degradation (GLASOD), the International Soil Reference and Information Center (ISRIC) reported that 15% of terrestrial lands have degraded to various extents as a result of human-induced activities. Of the lands, 55.7% have been degraded by water erosion, with 27.8% by wind erosion, 12.3% by chemical changes (loss of food, salinization, pollution and acidification) and 4.2% by physical changes (flood, compaction, subsidence) (Šarapatka et al., 2010). The global amount of soil detached is estimated to be 0.5 to 2 tons/ha/year while the amount of soil lost is 24 billion tons. The global population is expected to hit 9.3 billion by 2050, and the income per capita is expected to rise along with the growing population. It is estimated that income growth will increase protein demand and 45% of global agricultural lands, which correspond to 1.6 billion hectares, will serve to feed animals and produce feeds to meet the protein demand (Bahar et al., 2020). It is a challenge for sustainable land management to balance agricultural production and nature protection in meeting these demands, which are expected to increase gradually, and to minimize negative interactions (Chaplin-Kramer et al., 2015; Grau et al., 2013). Arid and semi-arid lands constitute nearly 41% of the world's total land size (Qader et al., 2021). Approximately 50% of the lands irrigated and cultivated in these climatic zones suffer from salinization to various extents (Gengmao et al., 2015). More than 20% of irrigated agricultural lands both in Turkey and around the world have been facing hypersalinity due to over-irrigation. It is reported that the world is home to 954 million hectares of land affected by salinization and limited productivity. Such problematic lands cover 50.8 million hectares in Europe, 320 million hectares in Asia, and 4.2 million hectares in Turkey along with those with moisture problem. Aridity and underlying problems manifest themselves and keep growing in many places. 1.5 million hectares of irrigable land per year are affected by salinization around the world.

All of the studies commissioned by international organizations refer to three main problems that must be addressed today in order to keep feeding the global population in 2050. They are as follows:

- Effective use of fresh water resources,
- Preservation of productivity in arable lands,
- Global warming and consequential drought that directly concern both water and soil.

As of 2016, 28 European Union member countries are home to 10.467,760 agricultural farms, and they cultivate 173.338,550 hectares of agricultural land. As for the share of EU member countries in total size of agricultural lands cultivated, France ranks first (16.05%). France is followed by Spain (13.40%), Germany (9.64%), the Great Britain (9.62%), Poland (8.31%), Italy (7.27%) and Romania (7.21%) respectively.

An overview of agricultural infrastructure and land use in Turkey

As it is home to diverse geological structures, climatic zones, vegetation and topographic characteristics, Turkey embodies most of the groups of soil that are widely common around the world. Coupled with various climatic conditions, the aforementioned characteristics enable to grow a wide range of products in Turkey. In this context, agriculture has a key social and economic importance for Turkey. As a matter of fact, about half of Turkey's total land area is devoted to agriculture. At the same time, this area is above the EU average. Developed for various purposes, classification systems offer classification of soils and lands they are situated on, and various management systems for various production systems. Based on their characteristics that limit soil cultivation, lands are divided into eight classes, ranging from 1st class lands being non-problematic to 8th class lands being not suitable for plant production. Of 8 classes of lands, the first four classes are suitable for cultivation while the remaining four classes are lands that must be under permanent vegetation such as forests and pastures.

Once the extent of misuse of absolute and potential agricultural lands of provinces is analyzed based on types of land use, it is concluded that 1.59% of the total land size is suitable for agriculture and yet unused. These lands correspond to 3.08% in agricultural farms that have 20 to 49 decares of land (Figure 2).

Only 1.3% of the unutilized potentially productive land suitable for agriculture is irrigated land, and the remaining 98.7% is non irrigated land. The total size of misused agricultural lands is 2.239,467 hectares. Of them, nearly 1.9x10^6 hectares of agricultural land are recoverable.

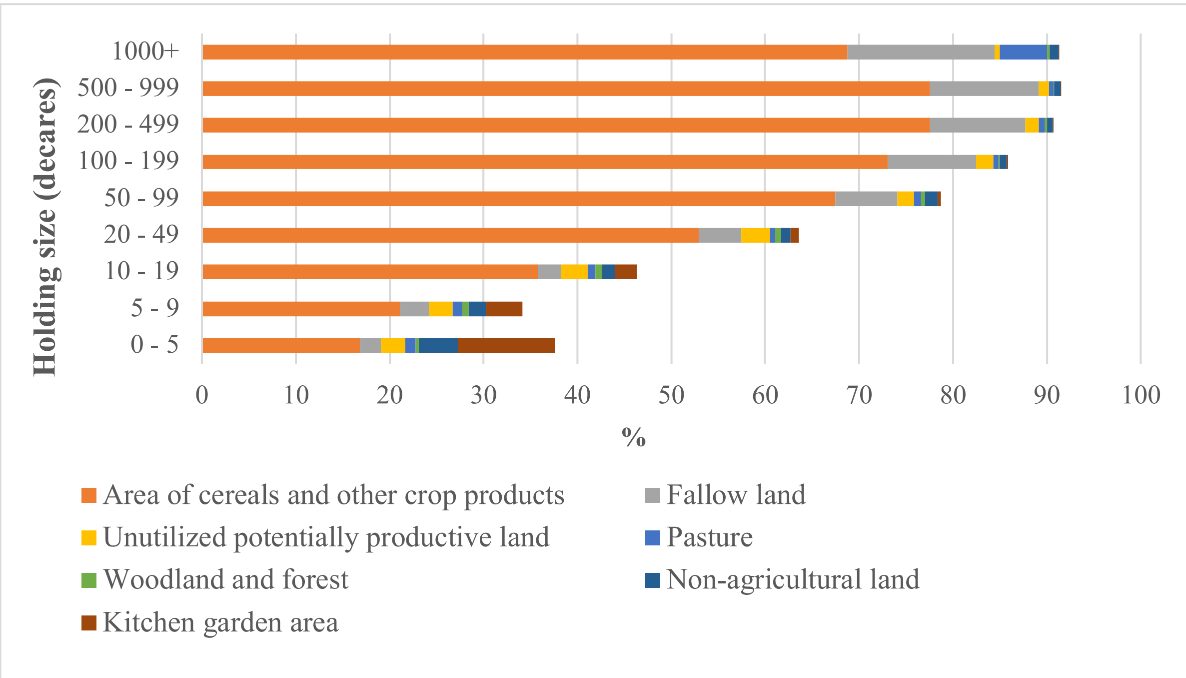

Figure 2. Distribution of land use by holding size, 2016.

The same applies to potential agricultural lands that are as large as nearly $2.5x10^6$ hectares. However, how to use and turn them into agricultural lands can become clear only after nation-wide plans are made for land use. The total size of lands subjected to improper land use that caused a rise in erosion and a decline in productivity as a result of cultivated agriculture on lands not suitable for cultivated agriculture is 6.274,168 hectares. The 5th Land Use Capability Class is a particular class as it consists of lands that are not slopping, situated at bottom lands with common drainage problems, suffering from floods on a frequent basis, and having poor soil engineering qualities and being not suitable for settlements. However, in Turkey, class 5 lands cover an area of 4346 km^2 (Atalay, 2016). 14.279,4 hectares of pasture, which is part of the 7th land use capability class, require checking soil profile characteristics in the phase of land use planning, and allocating some of them for forestry (Kuşvuran et al., 2011; Doğan, 2011; Erol, 2007).

Agricultural lands in Turkey are fragmented, dispersed, small, jointly-owned and sloping. Cultivated agricultural lands make up 23.20 million hectares of 77.79 million hectares (projection size) of land resources in Turkey, and the agricultural structure is usually based on the ownership of lands by small-scale family farms. Upon the expansion of lands cultivated throughout the Republican Era, the number of farms has increased and the size of farms on average has risen to nearly 60 decare. However, this is far from the size that agricultural farms need to make a decent living. This is considerably smaller than the EU average (130 decare.). Some measures were taken to preserve the average operational size of agricultural lands upon the introduction of reforms on land law back in 2014. With this being the case, the reforms to regulate and conserve agricultural lands have failed to improve land improvement and on-land development services to enable different geographical zones to engage in different agricultural cultivation activities, guide them and help them raise their scale as an economic enterprise, eliminate their problems and facilitate the use of agricultural lands (Anonymous, 2019). When it comes to percentile changes in the number of agricultural farms, the size of lands and scale of farms, some positive and negative changes have been introduced along with various practices of agricultural policy. The number of agricultural farms, changes by years and the size of agricultural lands they cultivate are presented in Table1 based on the Turkish farmer registration system (Tanrivermis 2003).

The size of farms grew over the years whereas the growth could not suffice to change the product patterns, productivity and quality that would define an economic production. One can argue that the provision of on-land development services has a positive impact on the rates of change displayed on the table. Table 2 displays the applications lodged for non-agricultural use of agricultural lands and the number of permissions granted.

Table 1. Number of agricultural farms and size of agricultural lands they cultivate according to the farmer registration system

Years	Number of farms	Change in %	Size, da.	Change in %	Scale of farm, da.
2002	2.588.666	-	164.960.377,91	-	64
2003	2.765.287	6.82	167.346.718,45	1.45	61
2004	2.745.424	-0.72	167.009.179,55	-0.15	61
2005	2.679.737	-2.39	165.826.141,16	-0.76	62
2006	2.609.723	-2.61	164.930.261,03	-0.54	63
2007	2.613.234	0.13	167.277.814,28	1.42	64
2008	2.380.284	-8.91	157.694.645,10	-5.73	66
2009	2.328.731	-2.17	154.360.406,82	-2.11	66
2010	2.320.209	-0.37	151.027.250,78	-2.16	65
2011	2.288.366	-1.37	156.287.667,33	3.48	68
2012	2.214.390	-3.23	153.438.732,86	-1.82	69
2013	2.183.270	-1.41	147.293.244,06	-4.01	67
2014	2.206.874	1.08	149.276.892,42	1.35	68
2015	2.197.319	-0.43	148.004.195,82	-0.85	67
2016	2.267.176	3.18	147.858.630,89	-0.10	65
2017	2.132.759	-5.93	148.437.131,87	0.39	70
2018	2.152.003	0.90	151.629.382,44	2.15	70
2019	2.083.022	-0.63	149.294.823,22	1.01	72
2020	2.127.957	0.97	150.943.261,16	0.98	71
2021	2.171.748	0.98	152.456.506,38	0.99	70

*Collected from the figures of the Ministry of Agriculture and Forestery

Table 2. Applications and outcomes for non-agricultural use under the Law No. 5403

Years	Number of Applications	Size of Lands (ha)	Size of Lands Permitted (ha)	Size of Lands Denied (ha)	Rate of Permission (%)
1989-2001	24.491	2.386.531,08	1.488.877,87	897.653,21	62
2002-2005	15.189	671.449,54	435.150,02	236.299,52	65
2006-2018	98.736	1.306.133,06	679.481,35	626.651,71	52
2018-2021	13,164	845.432,98	516.184,17	412.265,58	61
Total	151.580	5.209.547,66	3.119.693,41	2.172.870,02	60

*Collected from the figures of the Ministry of Agriculture and Forestry

Based on the figures on the table, 24.491 applications were lodged from 1989 to 2001 in a span of 12 years, and 1.488,877,87 hectares of agricultural land became out of production upon a change in the nature of lands. Over the past 30 years, 60% of 151.580 applications for non-agricultural use were approved, and 3.119.693, 41 hectares of agricultural land became out of production. Urbanization, migration to regions where industry is developed, and the new dimension brought by newly established universities to urbanization can be counted among the reasons for being excluded from agricultural production. This situation has led to the transformation of agricultural lands, especially around big cities (Bayar 2018; Kepenek 2016)

Agricultural lands are utilized for non-agricultural purposes, and the studies over how to utilize unused agricultural lands with conditions that reduce the quality of lands in terms of components that define a land point to a contradiction between what is intended and what is actual. This contradiction should not prevent us from exerting efforts to make unused agricultural lands productive (Anonymous 2015). On the contrary, it is of utmost importance to turn the strategy of making effective use of agricultural lands and conserving them into a sustainable format on one hand while running projects to utilize unused agricultural lands for production. Another factor affecting the change in agricultural areas is the socio-economic situation. As a matter of fact, the decrease in the economic inputs related to agriculture and the decrease in employment are also effective in the use of agricultural land. In particular, the share of the service sector in employment is increasing throughout the country (Figure 3).

The growth of the industry sector, accelerated the urbanization and accordingly, the service sector gradually grew. On the other hand, great activity is not observed in the agricultural sector. Considering that 12% of the immigrants in Turkey migrate to find a job, it is understood that the effect of employment is too great to be underestimated (TurkStat 2013). The change in agricultural areas also has an important relationship with the economic situation. While the share of agriculture in Gross Domestic Product (GDP) in Turkey was 10.0% in 2000, it decreased to 9.0% in 2010 and 6.7% in 2020. Considering all these situations, it is important to bring unused agricultural lands into the economy.

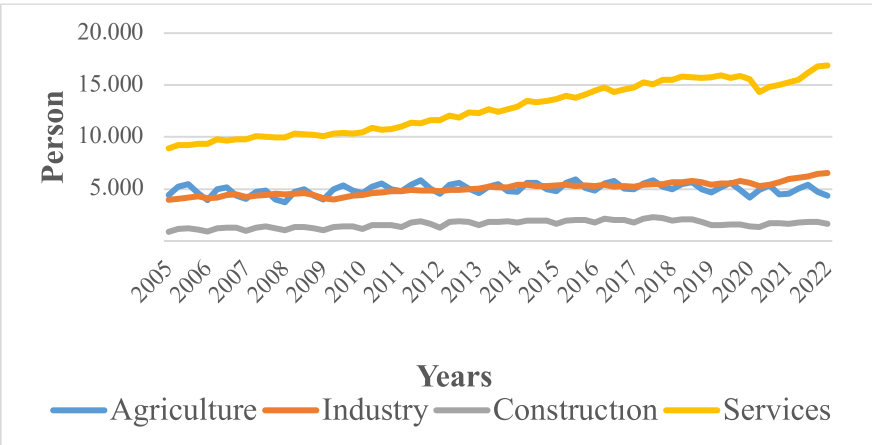

Figure 3. Employment by sector (2005-2022)

Available and unused agricultural lands

Soil; It is of vital importance within the ecosystem and land use boundaries for the sustainability of plant and animal production. The fact that soil, which is the most important production factor of agriculture, is a scarce resource that cannot be reproduced, also necessitates ensuring its sustainability. At the same time, unused lands should be evaluated according to their suitability for ecological safety purposes (Xiaoming and Hao.,2012). Agricultural lands must be utilized in a sustainable manner to provide people with reliable food supply, raise well-functioning generations as a safeguard of development, achieve rural development, improve the economy and create a habitable environment (Tahat et al., 2020; Nonhebel 2005). 23.5 million hectares of Turkey's total land assets consist of cultivated agricultural lands. In the last 10 years, there has been a decrease of approximately 1 million hectares in total arable land and land under permanent crops. As a matter of fact, it is predicted that the downward trend in agricultural areas will increasingly continue in the coming periods (Bayar, 2018).

As for the way agricultural lands are utilized in Turkey, 90% of them are cultivated on lands owned by an individual. Apart from agricultural production, agricultural lands in Turkey are heavily used for urbanization, industry, tourism, mining, highways, dams, canals, etc., It is used in public investments and other areas of use (Karakuş et al., 2019).

While the rate of land use lease stood at approximately 1.5% for a long time, the number of farms that cultivated lands of 5 hectares and above for themselves and others significantly rose between 1991 and 2006. It can be concluded from the aforementioned rise that medium and large scale farms exponentially grew by operating the lands of small-scale farms in particular through other means of land use.

Once it is analyzed along with the aforementioned facts, one can argue that agricultural lands in Turkey are utilized to the utmost extent while there are problems concerning the land use due to the fact that agricultural lands are utilized for purposes other than land use capabilities. Therefore; Implementation of regulations that will reduce the pressure of non-agricultural use of agricultural lands is among the objectives of the development plans (DSB 2019).

Table 3 displays agricultural lands in Turkey based on the Land Use Capability Class (AKKS).

Table 3. Agricultural Lands in Turkey based on AKKS

Land Use Capability Class	Characteristics	Area Covered, ha.	Share in Total Size, %
I	Suitable for any type of agriculture and cultivation	5.086.084	6,5
II	Moderately suitable for cultivation	6.712.873	8,6
III	Limited suitability for cultivation	7.282.763	9,4
IV	Special product with special measure	7.425.045	9,5
	Total	**26.506.765**	**34,1**
V	Uncultivated flat land with moist or rock tumuli	127.934	0,2
VI	Good pasture, good forest	10.825.762	13,9
VII	Degraded pasture, degraded forest	35.836.350	46,0
	Total	**46.790.046**	**60,1**
VIII	Non-arable land	4.542.896	5,8
	Total	**77.839.707**	**100**

Source: TOPRAKSU, Land Resources in Turkey, Ankara 1978; Ministry of Agriculture and Forestry, Annual Inventory, Ankara 2018.

Given the fact that the size of the first four classes of land has a 34.1 percent share in total size of lands based on the figures of AKKS, it is concluded that it is possible to engage in cultivated agriculture and perennial plant production on a land of nearly 26.5 million hectares across Turkey. However, 27.9 million hectares of land were utilized for agricultural production from 1990 to 2011 (Anonymous 2015). The use of the soil in accordance with the skill classes is very important in terms of sustainability. However, the areas needed by the sectors with high profitability (industry, housing, tourism, etc.) in Turkey are evaluated without considering the land use capability classes. As a matter of fact, the areas where the misuse of agricultural lands are most common are in the form of public investments for industry, urbanization and tourism, respectively (Karakuş et al., 2019; Akci et al., 2016; Yılmaz 2001). There is no study that covers the entire country about the inventory of agricultural lands that remain unused for a variety of reasons. However, the lands registered for production and the size of lands utilized for non-production purposes are calculated based on the farmer registration system (ÇKS), and it corresponds to 2 million hectares on average in consideration of differences in rates of change per year. The number and size of lots and the size of agricultural lands per farm are few for agricultural farms. The size of the lands that agricultural farms own had almost always been below 7 hectares. The initiative to utilize unused agricultural lands for production is a token of the fact that there is no other land to utilize for agricultural production and that this is the peak for land use.

As it is evident, the average size of farms is small and the land distribution is unbalanced in Turkey where small-scale agricultural farms are common. However, land fragmentation continues to be an exponential problem.

4. Conclusion

The fact that agricultural lands have been fragmented, dispersed and jointly owned since the proclamation of the Republic has created complicated challenges that are difficult to overcome. In addition, property and inheritance problems, misuse, erosion, salinization and unearned income generation on lands have made agricultural lands face the risk of a rapid extinction. Rural people mostly live on a variety of products and services made out of forests, agricultural lands and pastures. Therefore, it is of importance to make plans for the optimal spatial allocation of rural lands and manage them based on such plans. This is the only way to make effective and efficient use of land resources and promote rural development.

There is a need to legally and technically reform all procedures concerning the property and usage forms of agricultural lands, consolidation and on-land development services and agricultural lands.

It is a pressing need to establish a legal basis for a new organization to make an inventory of agricultural lands and engage in specialization efforts. Making a well-functioning inventory of unused agricultural lands must be the primary task of such an organization. Making such an inventory will shed light on the possibility to utilize such lands for agricultural production.

Actions must be taken to integrate unused agricultural lands into infrastructural initiatives and rural development projects, and exemplary projects must be introduced to local authorities to raise awareness about land use and protection measures. Decisions about how to utilize unused agricultural lands for production cannot be taken solely based on final reports of some workshops, and legal initiatives must be taken in a way to cover all agricultural lands in a participatory, multi-sector, multi-dimensional, multi-purpose and multi-criterion manner based on social (including demands of various industries), economic, environmental and cultural factors. As agricultural lands, which are situated around settlements, rise in value after being turned into land lots, it is more and more difficult to keep utilizing agricultural lands for production purposes. In order to stop the allocation of fertile lands for non-agricultural purposes, there must be unity and resoluteness for the protection of fertile agricultural lands, and instruments to achieve those goals must be selected in a consistent manner. It is also essential to make a thorough analysis and map out all existing agricultural lands and make land use plans accordingly. To do so, an organizational structure must be established to attach priority to agricultural development based on rural development, and land market regulations and biodiversity conservation. Steps to make an inventory of unused agricultural lands, eliminate setbacks arising from ownership and usage, and turn agricultural lands into means of production through lease, sales or merger must be promptly taken.

Based on land use planning and consistency in practice, a strategy must be adopted to attach priority to environmental sustainability, biodiversity, food supply and security that would prevent all lands and especially agricultural lands from being unused. Making land use plans and creating a soil database through soil analyses, setting clear-cut roles and responsibilities for ministries, public agencies and organizations about land management and use, and establishing a robust organizational structure for agricultural land management at the central and rural scale must be taken into consideration. The adoption of right policies for sustainable use of scarce land resources and agricultural lands depleted by erosion, quickly perished by non-agricultural use, polluted and degraded will not only enhance the success of development programs but also introduce a system to prevent lands suitable for agricultural production from being used for non-agricultural purposes in a way more effective than ever.

Sustainable agricultural production can be handed down to the next generations only if it is utilized in the most efficient way without causing means of production to be depleted and degraded.

A strategy to be adopted by Turkey to utilize unused agricultural land for production purposes will be beneficial to generate production value and protect agricultural lands in terms of its contribution to the aforementioned outcomes.

Competing interests

The authors declare no competing interests.

Competing interests

The data that support the findings of this study are available on request from the corresponding author.

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Research

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Determination of Forage Yield and Other Characteristics of Cowpea (*Vigna unguiculata* L.) Cultivars Sown at Different Times

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A B S T R A C T

In this study, which was carried out in Erzurum conditions to utilize cowpea cultivars and a cowpea landrace sown at different times as feed crops and determine some of their characteristics, 5 genotypes including 4 different cowpea cultivars (Akkız-86, Karagöz-86, Karnıkara, and Ülkem) and 1 landrace (red cowpea) were used, and treatment groups with 3 different sowing times (25 April, 10 May, and 25 May) were formed. The study was conducted with the Random Full Block Design and 4 replicates. According to the results, after the sowing of the cowpea cultivars and landrace at different times, the ranges of the values were 21.50-90.50 cm for plant height, 11.50-25.25 cm for first pod height, 8.25-18.75 cm for pod length, 1.75-19.00 for number of pods, 1.50-13.75 for number of seeds per pod, 935.00-3537.55 kg/da for green herbage yield, 157.40-760.38 kg/da for dry herbage yield, 8.93-12.27% for crude protein ratio, 16.48-26.71% for ADF ratio, and 21.89-36.99% for NDF ratio. Among the sowing times, the dates 25 April and 10 May were prominent. Consequently, the treatment at the sowing time of 25 April was found optimal in terms of the green herbage yield, crude protein ratio, ADF, and NDF values in terms of the identification of sowing times of the plant as a feed crop in Erzurum conditions. Among the cultivars, the Ülkem cultivar and the red cowpea landrace provided the best results as feeds.

1. Introduction

Agricultural production is influenced by several factors. Some of the main factors may be listed as seeding, irrigation, fertilizers, mechanization, pest control, drought, and global warming. Among these factors, global warming will affect and cause trouble in the agriculture sector in addition to affecting several other sectors. Therefore, it is important to identify heat-tolerant species ahead of time. One of the heat- and drought-tolerant plants is the cowpea.

The cowpea (*Vigna unguiculata* L. *Walp*), which is one of the most significant legumes worldwide, is an annual plant that is widespread in Africa, South America, Asia, and the United States (Xiong *et. al.,* 2016). It is a preferable plant for crop rotation as it not only loosens the soil with its roots but also increases the yield of the next crop by nitrogen fixation. It also has the capacity to grow in poor soils (Miller *et. al.,* 1984; Pemberton and Smith, 1990; İdikut *et. al.*, 2019). Cowpea cultivation covers an area of 14,447,336 ha globally, with a production quantity of 8.903.329 tons, and a yield of 6163 kg/ha. Its largest amount of production takes place in Nigeria with an area of 5.725.433 ha, followed by Burkina Faso at 1.354.100 ha and Mali at 454,274 ha (FAO, 2019). In 2020, 1,324 tons of cowpeas were produced in an area of 13,227 ha in Turkey, and the yield was 101 kg/da (Anonymous, 2020).

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The cowpea, which can also be utilized as a feed crop for animal nutrition, belongs to the legumes family and has 2.0-4.3% protein in its fresh pods and 4.5-5.0% protein in its fresh seeds. The protein content of matured cowpea seeds in their dry form varies in the range of 20.42-34.60% based on the cultivar and environmental conditions (Sehirali, 1988). Moreover, cowpea seeds contain 50-67% carbohydrates, 1.3% fats, 3.9% cellulose, and 3.6% ash. The protein content of its seeds is rich in terms of the amino acids Lysine and Tryptophan compared to cereal seeds and deficient in terms of the amino acids Methionine and Cystine compared to animal proteins (Davis *et. al.,* 1991).

Sowing time is one of the important agronomic factors that influence product development and yield (Kolte, 1985; Abdou *et. al.,* 2011). Environmental variables, especially temperature, play an important role in the selection of the sowing time. Sowing time is the key factor that affects the growth, development, and productivity of the plant (Kaleem *et. al.,* 2009; Kaleem *et. al.,* 2010). Selecting the appropriate sowing time is one of the most important factors that determine the yield of the cowpea plant. In general, in agricultural production economics, factors affecting the appropriate sowing time include climate parameters such as temperature, precipitation, day length, and wind, and environmental factors such as diseases, pests, weeds, and birds (Mazaheri and Majnoon, 2005). Among these, precipitation is the most significant determinant of sowing time (Lane and Jarvis, 2007; Adediran *et. al.,* 2018).

To achieve higher cowpea yield values per unit area, it is necessary to grow cultivars that adapt to the ecological conditions of the region better by using the appropriate cultivation techniques. For each plant species, adaptation studies should be carried out to determine the suitability of cultivars to the environmental conditions of the region (Ceylan and Sepetoglu, 1984). Therefore, in this study, it was aimed to investigate variations that could occur in some parameters of cowpea cultivars to be grown as feed crops for summer based on sowing times in the ecological conditions of the province of Erzurum in Turkey.

2. Materials and Methods

2.1. Material

The study was carried out in 2019 in the trial field of the Plant Production Application and Research Center at Atatürk University. The plant material consisted of 5 different genotypes, including the Akkız-86, Karagöz-86, Karnıkara, and Ülkem cultivars, and 1 landrace (red cowpea) (Table 1). DAP fertilizer was used at a quantity of 15 kg/da in the trial.

The trial was conducted in the province of Erzurum, which is in the Eastern Anatolia Region of Turkey and has an altitude of 1869 m. Erzurum is between the longitudes of E 40° 14' 15″ and E 42° 33' 35″ and the latitudes of N 40° 54' 57″ and N 39° 06' 10″. In Erzurum, winters are cold and have high precipitation, while summers are cool and dry. Some climate data of the province of Erzurum for the year 2019 are presented in Table 2.

The total precipitation in 2019 was 313.8 mm and lower than the long-term average (408.8 mm), and the average temperature in 2019 was 6.2°C and higher than the long-term average (5.6°C). The average relative humidity in 2019 was 65.9%, which was lower than the long-term average (67.7%). In May-July, when plants show active growth, temperatures are higher in Erzurum.

2.2. Soil properties of the research area

The texture class of the soil collected from the trial field was identified based on the Bouyoucos hydrometer method (Demiralay, 1993) and the soil was in the clayey-loamy class. Based on the methods described by Saglam (1994), the soil's pH was determined as 7.56. The carbonate ratio of the soil samples was measured as 1.14% using a Scheibler. The plant-available phosphorus ratio was found as 4.41 kg/da (Olsen and Summer, 1982).

Table 1. The cowpea plant and varieties used in the research and the companies from which they were supplied

Name	Latin Name	Variety	Institution of Supply
Cowpea	*Vigna unguiculata* L. *sinensis*	Akkız-86	Çoker Seeds
Cowpea	*Vigna unguiculata* L. *sinensis*	Karagöz-86	Çoker Seeds
Feed Cowpea	*Vigna unguiculata* L. *walp*	Ülkem	19 Mayıs Univ.Agr. Fac.
Cowpea	*Vigna unguiculata* L. *sinensis*	Karnıkara	Agrogen Seeds
Red Cowpea	*Vigna unguiculata* L. *sinensis*	Population	Adana

Table 2. Some Climate Values of Erzurum Province in 2019*

Months	Monthly Average Temperature (˚C)		Monthly Average Relative Humidity (%)		Monthly Total Precipitation (mm)	
	2019	**LTA**	**2019**	**LTA**	**2019**	**LTA**
January	-8.0	-10.6	80.0	81.0	13.9	17.9
February	-8.4	-8.2	84.9	80.5	26.9	20.0
March	-3.1	-0.9	79.3	74.4	24.7	34.3
April	4.2	5.8	73.4	67.8	68.9	58.6
May	11.9	10.5	60.3	67.2	63.8	70.6
June	17.8	14.9	57.2	61.5	23.6	45.1
July	19.0	19.5	49.4	53.5	3.0	22.3
August	20.3	19.9	46.0	49.6	11.6	18.8
September	14.5	14.5	51.7	52.5	28.4	20.0
October	9.8	8.1	56.3	67.8	11.0	56.9
November	0.1	0.4	65.9	75.0	14.8	25.3
December	-3.5	-7.2	85.8	81.5	23.2	19.0
Tot./Mean.	6.2	5.6	65.9	67.7	313.8	408.8

* Taken from Erzurum Meteorology Regional Directorate data. LTA: Long Term Average

Using the Smith-Weldon method, the organic matter ratio of the soil collected from the trial field was determined to be 1.01% (Nelson and Sommers, 1982). Consequently, as seen in the data shown in Table 3, the soils of the trial field were mildly alkaline, limy, sufficient in phosphorus, lacking in organic matter, and moderate in terms of plant-available potassium (Ozyazıcı *et. al.,* 2016).

Table 3. Some Physical and Chemical Soil Properties of the Research Area

Physical characteristics	
Texture Class	Argillaceous-Loam
Clay (%)	35.78
Silt (%)	29.50
Sand (%)	34.72
Chemical characteristics	
pH	7.56
Lime ($CaCO_3$ %)	1.14
Phosphorus (kg P_2O_5/da)	4.41
Potassium (kg K_2O/da)	171
Organic matter (%)	1.01

This study was conducted with the factorial arrangement in the random full block design and 4 replicates to investigate some feed crop parameters of cowpea cultivars sown at different sowing times (25 April, 10 May, 25 May) for summer in the ecological conditions of Erzurum. Sowing was performed at a sowing depth of 4-5 cm. Weed control and hoeing processes were carried out according to the states of the plants in the plots at all sowing times.

The parameters that were investigated in the study included plant height (cm), first pod height (cm), pod length (cm), number of pods, number of seeds per pod, green herbage yield (kg/da), dry herbage yield (kg/da), crude protein ratio (%), ADF (%), and NDF (%). The obtained data were subjected to analysis of variance with the SPSS package program, and Duncan's multiple range tests were conducted to identify the sources of significant differences between mean values.

3. Results and Discussion

The mean plant height (cm), first pod height (cm), pod length (cm), number of pods, number of seeds per pod, green herbage yield (kg/daa), dry herbage yield (kg/daa), crude protein ratio (%), ADF (%), and NDF (%) values of the cowpea genotypes that were examined in the study by sowing at three different times (25 April, 10 May, 25 May) in Erzurum conditions are shown in Table 4.

3.1. Plant Height

The effect of different sowing times on the plant height values of the cowpea cultivars was found statistically significant ($p<0.01$) (Table 4).

At different sowing times, the plant height values varied in the range of 40.85-57.70 cm. Based on the sowing time x cultivar interaction, the highest plant height was found as 90.50 cm in the red cowpea sown on 10 May, while the shortest one was found as 21.50 cm (Akkız-86) in the plants sown on 25 April. Among the sowing times, the tallest plants were obtained in the treatments on 10 May and 25 May, and their mean values were respectively 57.70 and 53.35 cm. The lowest mean plant height value was found as 40.85 (cm) in the plants sown on 25 April (Table 4).

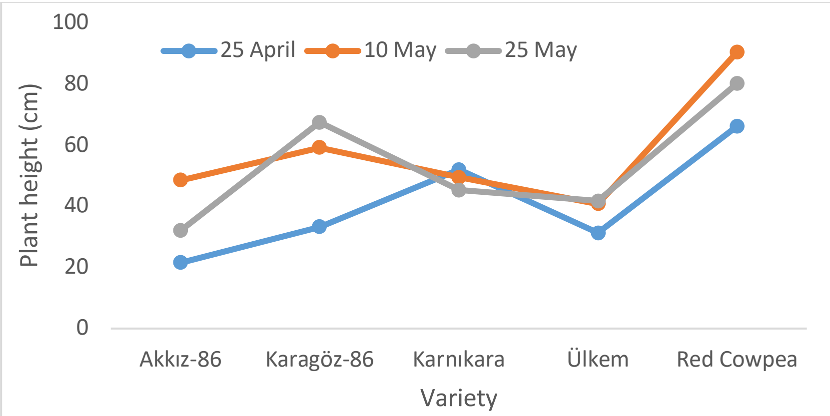

Figure 1. Effect of sowing time x variety interaction on plant height

The highest plant height in Akkız-86 was obtained on 10 May. The shortest plant height was taken in October 25th. In the Karagöz-86 genotype, the highest plant height was obtained on May 25, while the shortest plant height was obtained on April 25. Although there is not much difference according to the sowing times in Karnıkara variety, the highest plant height was obtained on April 25, while the shortest plant height was obtained on May 25. The shortest plant height was obtained on April 25 in Ülkem cowpea forage variety. On May 25, Ülkem gave the longest plant height. Red cowpea population showed the longest plant height in October 10, and the shortest plant height in October 25th. Considering the variety characteristics of red cowpea, it was determined that it formed more plant height in hot months. The effect of sowing time on plant height was different. (Figure 1.)

Plant height is a property that can be substantially influenced by the genetic properties of cultivars, environmental conditions, and cultivation conditions. While the results that were obtained in this study were higher than those reported by Toğay et al. (2014) and Karasu (1999), they were lower than those reported by Peksen and Artık (2004), Futuless and Bake (2010), Başaran et al. (2011), İdikut et al. (2015), Beycioğlu (2016), and İdikut et al. (2019), and they were similar to those reported by Sert and Ceyhan (2012), Magashi et al. (2014), and Ozçelebi (2021). Different results obtained regarding plant height could be attributed to the different climate and soil conditions, cultivars that were used, and cultivation conditions used by the researchers in different studies.

3.2. First Pod Height

The effect of the sowing time x cultivar interaction on the first pod height values of the cowpea cultivars was found statistically significant ($p<0.01$) (Table 4). At different sowing times, the first pod height values varied in the range of 14.35-19.55 cm. Among the cultivars, the highest mean first pod height was found as 21.83 cm in the Karnıkara cultivar, and the lowest mean first pod height was found as 14.08 cm in the Akkız-86 cultivar. Among the sowing times, the highest mean value of first pod height was determined to be 19.55 cm in the plants sown on 25 May, while the lowest value was 14.35 cm in those sown on 25 April. In terms of the cultivars, the highest mean value was found as 25.25 cm in the Karnıkara cultivar sown on 25 May, while the lowest value was found as 11.00 cm in the Ülkem cultivar sown on 25 April (Table 4).

Akkız-86 and red cowpea had the longest first pod height on 10 May and the shortest first pod height on 25 April. Karagöz-86, Karnıkara and Ülkem varieties showed similarity by giving the longest first pod height on 25 May. Karagöz-86 gave the shortest first pod height on May 10, while Karnıkara and Ülkem varieties gave on April 25 (Figure 2).

The results on the first pod height parameters in this study were similar to those reported by Atış (2000), Büyükkılıç (1995), Karasu (1999), Pekşen and Artık (2004), Pekşen (2007), Beycioğlu (2016), and Ozçelebi (2021), while they were lower than those reported by Başaran et al. (2011) and İdikut et al. (2019). These differences in different studies may be explained by ecological conditions and cultivars.

Table 4. Averages of Investigated Traits of Cowpea Varieties at Different Sowing Times

Sowing Times	Plant Height (cm)						First Pod Height (cm)					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	Mean **	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Kırmızı Börülce	Mean **
25 April	21.50	33.25	52.00	31.25	66.25	40.85 b	11.50	18.50	18.75	11.00	12.00	14.35 b
10 May	48.50	59.25	49.50	40.75	90.50	57.70 a	17.25	16.00	21.50	17.00	19.50	18.25 a
25 May	32.00	67.50	45.25	41.75	80.25	53.35 a	13.50	23.50	25.25	19.75	15.75	19.55 a
Mean**	34.00 c	53.33 b	48.92 b	37.92 c	79.00 a	50.63	14.08 b	19.33a	21.83 a	15.92 b	15.75 b	17.38
Sowing Times	**Pod Length (cm)**						**Pod Number (number)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****
25 April	9.25	11.00	8.25	8.00	8.00	8.90 c	1.75	4.75	2.00	1.75	4.50	2.95 b
10 May	11.25	12.00	8.75	18.50	18.75	13.85 a	19.00	5.75	6.75	10.75	12.00	10.85 a
25 May	8.25	13.75	9.50	12.00	15.25	11.75 b	11.50	7.25	5.00	12.25	14.75	10.15 a
Mean**	9.58b	12.25a	8.83 b	12.83 a	14.00 a	11.50	10.75 a	5.92 c	4.58 d	8.25 b	10.42a	7.98
Sowing Times	**Number of seeds per pod (number)**						**Green Grass Yield (kg/da)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****
25 April	1.50	4.25	3.50	4.50	3.75	3.50 b	1137.05	1540.43	1340.73	1963.53	3537.55	1903.86 a
10 May	7.75	7.00	8.00	4.75	11.00	7.70 a	1158.25	1773.85	1448.75	935.00	1617.38	1386.65 b
25 May	6.75	6.50	7.25	4.50	13.75	7.75 a	1137.93	1992.88	1151.48	1396.75	1429.50	1421.71 b
Mean**	5.33 bc	5.92 b	6.25 b	4.58 c	9.50 a	6.32	1144.41d	1769.05b	1313.65 c	1431.76 c	2194.81 a	1570.74
Sowing Times	**Hay Yield (kg/da)**						**Crude Protein (%)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****
25 April	447.35	345.40	157.40	309.43	571.68	366.25 b	11.50	18.50	18.75	11.00	12.00	14.35 b
10 May	440.88	402.25	535.25	354.38	532.13	452.98a	17.25	16.00	21.50	17.00	19.50	18.25 a
25 May	427.33	760.38	399.00	349.00	607.38	508.62 a	13.50	23.50	25.25	19.75	15.75	19.55 a
Mean**	438.52 c	502.68b	363.88 d	337.60 d	570.3a	442.61	14.08b	19.33a	21.83 a	15.92b	15.75 b	17.38
Sowing Times	**ADF (%)**						**NDF (%)**					
	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****	Akkız-86	Karagöz-86	Karnıkara	Ülkem	Red Cowpea	**Mean ****
25 April	21.13	21.93	20.63	25.40	26.66	23.15 b	36.99	25.27	21.89	30.38	25.04	27.92 b
10 May	24.48	22.17	22.13	29.73	26.65	25.03 a	32.72	29.65	29.43	28.97	35.90	31.33 a
25 May	16.48	26.71	19.93	28.61	23.85	23.12 b	22.35	34.33	27.93	31.11	33.20	29.78 a
Mean**	20.69 d	23.60 c	20.89 d	27.92 a	25.72 b	23.76	30.69ab	29.75 b	26.41 c	30.15 b	31.38 a	29.68

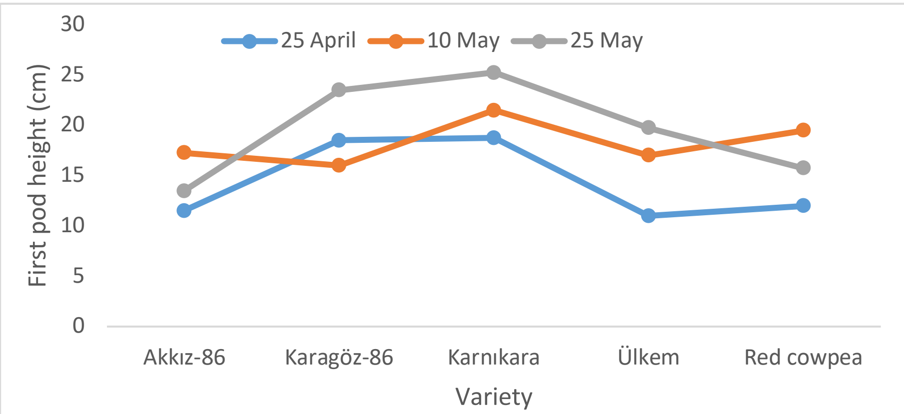

Figure 2. Effect of sowing time x variety interaction on first pod height

3.3. Pod Length

The effect of different sowing times on the pod length values of the cowpea cultivars was found statistically highly significant ($p<0.01$).

The pod length values varied in the range of 8.83-14.00 cm. Among the cultivars, the highest mean pod length value was 14 (cm) in red cowpea and the lowest one was 8.83 in the Karnıkara cultivar. In terms of the sowing times, the highest mean pod length value was 13.85 cm in the plants sown on 10 May, and the lowest one was 8.90 cm in those sown on 25 April. Considering all values, the highest mean value was found in the red cowpea plants sown on 10 May (18.75 cm).

Addo-Quaye et al. (2011), who stated that pod length is hereditary by 75.2%, found that environmental conditions have little to no effect on pod length in the cowpea plant. Previous studies reported pod length values of 7.40-14.76 cm (İdikut et al., 2015), 10.97-18.47 cm (Ünlü, 2004), 11.8-14.4 cm (Başaran, 2011), 12.62-16.06 cm (Peksen and Artık, 2004), 13.23-20.03 cm (Futuless and Bake, 2010), 13.35-38.81 cm (Oztokat and Demir, 2010), 9.60-12.36 cm (Akdag et. al., 1998), 13.77-17.63 cm (Magashi et. al., 2014), and 12.3-18.7 cm (Ozçelebi, 2021).

Varieties reacted differently to planting times. In Akkız-86, Ülkem and red cowpea, the highest pod length value was obtained on May 10, while the lowest value of Akkız-86 was on May 25; Ülkem and red cowpea yielded in October 25th. Karagöz-86 and Karnıkara cultivars showed similar development and gave the highest pod length value on 25 May, and the lowest pod length value on 25 April. (Figure 3).

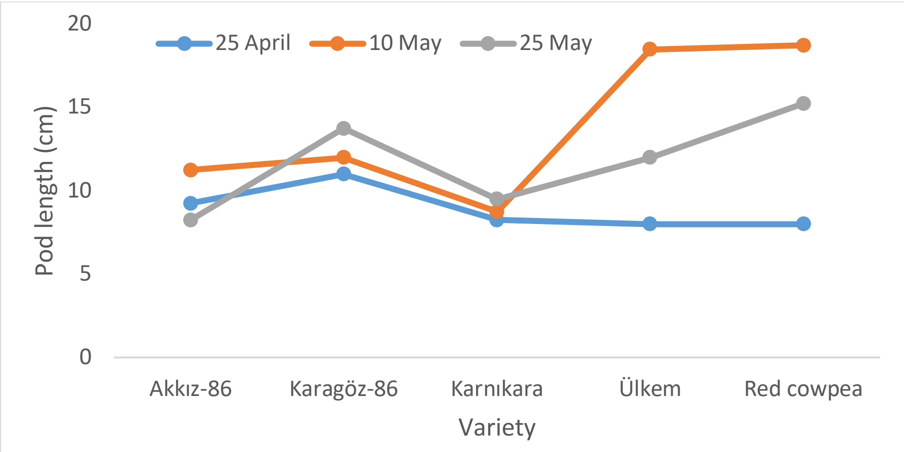

Figure 3. Effect of sowing time x variety interaction on pod length

3.4. Pod Number

The effects of the sowing times, cultivars, and the sowing time x cultivar interaction on the pod numbers of the cowpea cultivars were found statistically significant ($p<0.01$). The mean numbers of pods in the plants varied between 1.75 and 19.00. The mean numbers for different sowing times were in the range of 2.95 (25 April) - 10.85 (10 May). Among the cultivars, while the highest mean number of pods was 10.75 in the Akkız-86 cultivar, the lowest mean number of pods was 4.58 in the Karnıkara cultivar. Among all plants, the highest mean number of pods was found as 19.00 in the Akkız-86 cultivar sown on 10 May. The lowest mean numbers of pods in all cultivars were obtained in those that were sown on 25 April (Table 4).

Addo-Quaye et al. (2011), who reported that the production of more pods occurs in high-humidity conditions, determined that the mean number of pods in the plants in their study varied in the range of 6.9-8.3, differences among cultivars in terms of their numbers of pods were dependent on genetic factors, and the effect share of genetic factors was estimated to be 53.1%.

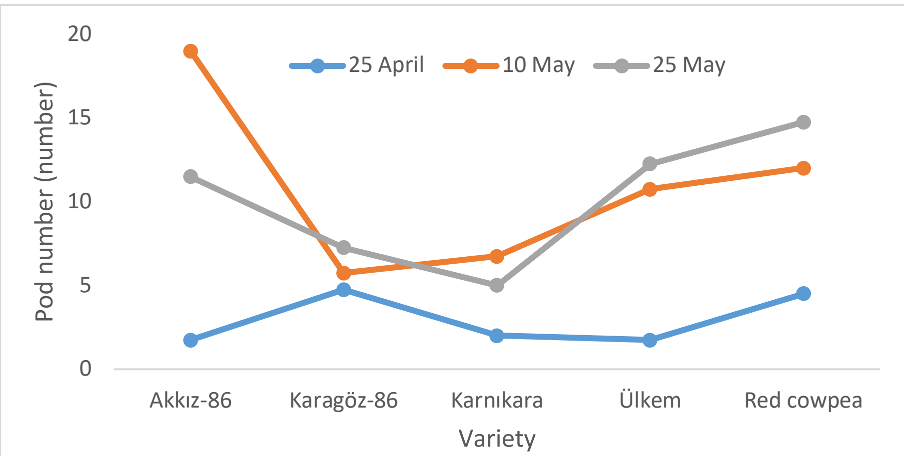

Figure 4. Effect of sowing time x variety interaction on pod number

The results that were obtained in our study were higher than those reported by Gülümser et al. (1989) (6.67-10 pods), Dhaka et al. (1992) (1.80-6.98 pods), Pekşen (2007) (3.2-8.0 pods), Addo-Quaye et al. (2011) (6.9-8.3 pods), and Beycioğlu (2016) (2.93-7.65 pods), whereas they were lower than those reported by Pekşen and Artık (2004) (8.20-16.06 pods), Pekşen (2005) (7.21-13.45 pods), Sert (2011) (2.0-14.59 pods), Ünlü and Padem (2005) (3.8-33.4 pods), Culha (2018) (8.33-17.92 pods), and Ozçelebi (2021) (16.3-35.8 pods). While the results of our study were similar to those in some studies, the differences between our results and those in other studies may be explained by different ecological conditions, cultivars, and cultivation parameters.

The least number of pods in all cultivars was obtained in 25 April sowing. Akkız-86 and Karnıkara varieties gave the highest number of pods on May 10; Karagöz-86, Ülkem and red cowpea cultivars yielded on May 25 (Figure 4).

3.5. Number of seeds per pod

The effect of different sowing times on the numbers of seeds per pod in the cowpea cultivars was found statistically highly significant ($p<0.01$). The mean numbers of seeds per pod were between 1.50 and 13.75. The mean numbers obtained for different sowing times were in the range of 3.50 (25 April) to 7.75 (25 May). Among the cultivars, the highest mean number of seeds per pod was 9.50 in red cowpea, while the lowest one was 4.58 in Ülkem. Among all plants, the highest mean number of seeds per pod (13.75 seeds) was found in the red cowpea sown on 25 May, while the lowest number (1.50 seeds) was found in the Akkız-86 cultivar sown on 25 April (Table 4).

The number of seeds per pod is a significant yield parameter in the cultivation of cowpea. Cultivation processes should aim to increase the number of seeds per pod (Ozkorkmaz, 2020). Among studies on numbers of seeds per pod, Sert (2011) reported these numbers in the range of 4.87-5.67 seeds, while Ceylan and Sepetoğlu (1983) reported them in the range of 2.27-8.57 seeds. While the results in our study were higher than those reported in the aforementioned studies, they were similar to those reported by Magashi et al. (2014) (8.73-10.70 seeds), Addo-Quaye et al. (2011) (11.6-11.7 seeds), Peksen and Artık (2004) (9-12 seeds), Futuless and Bake (2010) (13.14-17.11 seeds), Başaran et al. (2011) (9 seeds), Ünlü and Padem (2005) (5.9-11.1 seeds), Ozkorkmaz (2020) (10.76-11.53 seeds), and Ozçelebi (2021) (7.3-17 seeds).

In all genotypes, the minimum number of seeds per pod was obtained from 25 April sowing. In the red cowpea population, the maximum number of seeds was obtained on May 25, while the maximum number of seeds was determined on May 10 in other varieties (Figure 5).

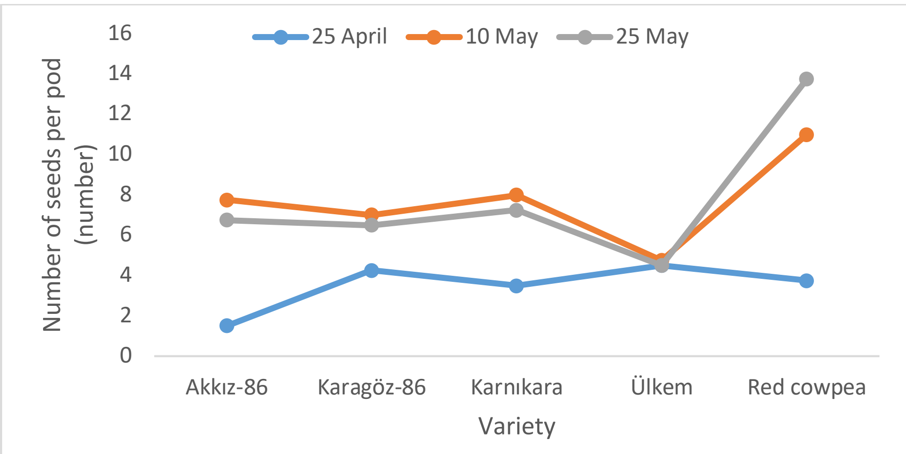

Figure 5. Effect of sowing time x variety interaction on number of seeds per pod number

3.6. Green Forage Yield

The effect of different sowing times on the green grass yield values of the cowpea cultivars was found statistically highly significant ($p<0.01$). The mean green grass yield values varied between 935 and 3537 kg/da. In the groups formed for different sowing times, these values were between 1386 kg/da (10 May) and 1904 kg/da (25 April). In the groups formed with different cultivars, the highest mean green grass yield was 2195 kg/da in red cowpea, while the lowest mean green grass yield was 1144 kg/da in Akkız-86. Among studies on green grass yield in cowpeas, yield values were reported by Etana et al. (2013) as 11.10-29.10 ton/ha, by Sallam and İbrahim (2016) as 3900-11900 kg/ha, by Jatasra et al. (1989) as 2865-3775 kg/da, by Atış (2000) as 2395-3133 kg/da in Hatay, by Beycioğlu (2016) as 2047.49-4466.25 kg/da in Kahramanmaraş, by Alaca (2017) as 2786 kg/da, and by Omar (2018) as 3013.54-4773.50 kg/da in Samsun. The green herbage yield results that we obtained in our study were lower in comparison to those reported in previous studies. The reason for this difference may be that other studies have used different procedures for different climate and soil properties. In our study, the cultivars that were sown early provided higher green grass yield values, while these values decreased as sowing was made later. Similarly, İdikut et al. (2019) also found that yield was higher at earlier sowing times and lower at later ones.

Although Akkız-86 did not react much to the planting time, it gave the highest green grass yield on 10 May and the lowest green grass yield on 25 April. Karagöz-86 gave the lowest yield on April 25 and the highest yield on May 25. The highest green grass yield was obtained on May 10 and the lowest grass yield was obtained on May 25 from Karnıkara variety. The highest green grass yield of Ülkem cultivar and red cowpea population was obtained in 25 April sowing, and the lowest green grass yields were obtained from 10 May and 25 May plantings, respectively (Figure 6). Green grass yields were found to be higher in cultivars with early sowing. It was determined that the yield decreased with the delay of sowing. As a matter of fact, Idikut et al. (2019) reported that the yield was high in early sowing and decreased in late sowing in their study (Figure 6).

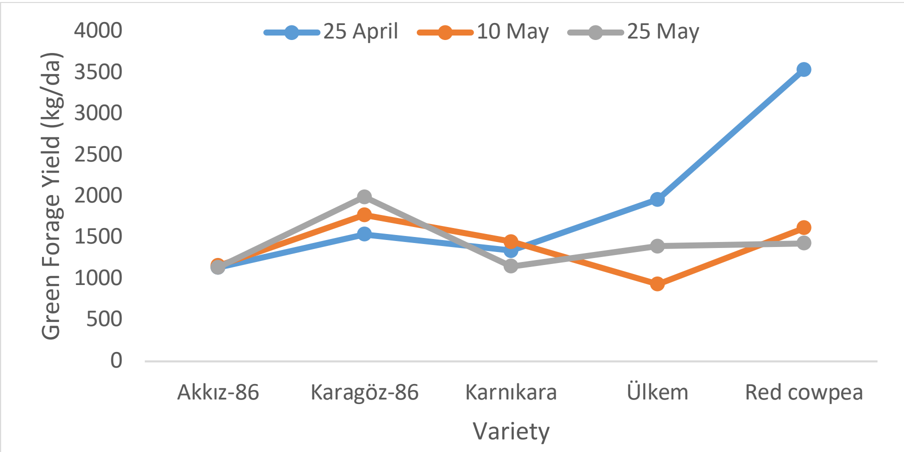

Figure 6. Effect of sowing time x variety interaction on green forage yield

3.7. Hay Yield

The effect of different sowing times on the hay yield values of the cowpea cultivars was found statistically highly significant (p<0.01). The mean hay yield values varied between 157 and 760 kg/da. In the groups formed for different sowing times, these values were between 366 kg/da (25 April) and 509 kg/da (25 May) The highest mean hay yield value was 570 kg/da in red cowpea, and the lowest value was 338 kg/da in Ülkem.

In studies on hay yield in cowpea plants, yield values were reported by Atış (2000) as 458-639 kg/da in Hatay, by İdikut et al. (2015) as 1228-2053 kg/da in Kahramanmaraş, by Beycioğlu (2016) as 451.40-1338.00 kg/da in Kahramanmaraş, by Alaca (2017) as 672.5 kg/daa, and by Omar (2018) as 507.09-687.77 kg/da in Samsun. İdikut et al. (2015) and Beycioğlu (2016) specified that their hay yield values were high because they harvested the plants by picking them with their roots. In previous studies investigating the cowpea as a first crop, hay yields were revealed by Jatasra et al. (1989) as 398.00-473.00 kg/da, by Thiaw et al. (1993) as 227.6-438.8 kg/da, by Boz (2006) as 148.00-476.00 kg/da, by Ayan et al. (2012) as 586-876.00 kg/da, by Etana et al. (2013) as 2.78-7.67 ton/ha in 2005 and 4.89-7.12 ton/ha in 2006, by Sallam and İbrahim (2016) as 600-1800 kg/ha, by Polat (2017) as 162.25-791.00 kg/daa, and by Ayan et al. (2017) as 978.0-1587.0 kg/da. The hay yield values that we found were similar to the values found by many researchers.

Akkız-86 variety gave the highest hay yield on 25 April and the lowest hay yield on 25 May. The highest hay yields of Karagöz-86 and red cowpea were obtained on 25 May, and the lowest hay yields were obtained from 25 April and 10 May, respectively. Karnıkara and Ülkem varieties gave the highest hay yields on May 10, while the lowest hay yields were on April 25 (Figure 7).

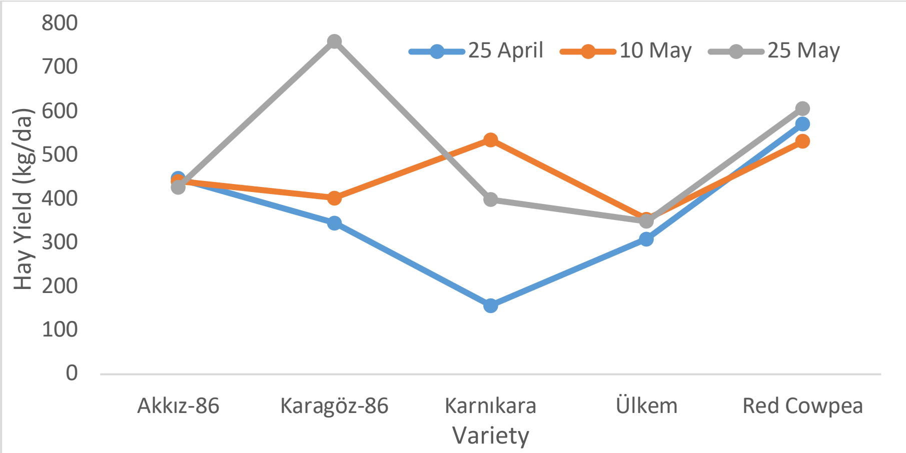

Figure 7. Effect of sowing time x variety interaction on hay yield

3.8. Crude Protein

In this study, among the cowpea cultivars, the highest crude protein ratio was found as 10.77% in the Ülkem cultivar, while the lowest crude protein ratio was found as 9.52% in the Karagöz-86 cultivar. Considering the sowing times, the highest crude protein ratio was found as 10.81% in the cultivars sown on 25 April, while the lowest crude protein ratio was found as 9.66% in the cultivars sown on 10 May. Overall, the highest value was determined to be 12.27% in the Ülkem cultivar sown on 25 April.

For the Akkız-86 cultivar, in particular, the highest and lowest crude protein ratios were found in the plants that were sown on 10 May and those that were sown on 25 May, respectively. For the Karagöz-86 cultivar, the highest and lowest crude protein ratios were obtained on 25 April and on 10 May, respectively. The highest crude protein ratios were obtained in the plants that were sown on 25 April for the Karnıkara cultivar, the Ülkem cultivar, and the red cowpea landrace. While the Karnıkara cultivar showed the lowest ratio when it was sown on 25 May, the Ülkem cultivar and the red cowpea landrace had the lowest ratios when they were sown on 10 May (Figure 8). In all plants, the crude protein ratios varied between 8.93% and 11.26%. These ratios declined as the sowing times progressed. It has been similarly reported that the crude protein ratio decreases in the further developmental phases of the plant.

Crude protein ratios in cowpea plants were reported by Jatasra et al. (1989) as 13.6-17.9%, by Boz (2006) as 25.60-28.10% in the leaves, by Gebreyowhans and Gebremeskel (2014) as 14.7-15.6%, and by Omar (2018) as 11.04-15.24%. The results of our study were similar to those revealed in some other studies.

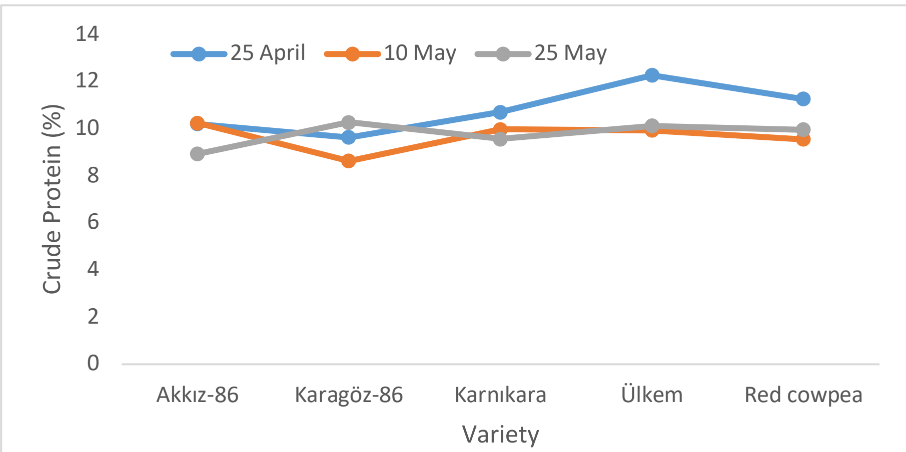

Figure 8. Effect of sowing time x variety interaction on crude protein

3.9. ADF (Acid Detergant Fiber)

According to the comparisons of different cultivars, the highest mean ADF value was 27.92% in the Ülkem cultivar, while the lowest one was 20.69% in the Akkız-86 cultivar. The ADF results of the Akkız-86 cultivar were within acceptable values. According to the comparisons of different sowing times, the highest mean ADF value was 25.03% in the cultivars sown on 10 May, while the lowest one was 23.12% in the cultivars sown on 25 May, which was determined to be acceptable. According to the results of our study, ADF ratios varied from cultivar to cultivar. Considering the sowing times, the best results were obtained in the 25 May treatment. Among all values, the best acceptable mean ADF ratio was determined as 16.48% in the Akkız-86 cultivar sown on 25 May (Table 4).

Cowpea fodder is rich in proteins (Khan *et.al.,2010*). ADF (acid detergent fiber), which contains cellulose and lignin, two of the main constituents of the cell walls in roughages, is used in feeding ruminants. In the identification of digestibility, the ADF ratio is an important criterion in roughages (Rayburn 2004).

NDF and ADF are parts of the cell wall that are very difficult to digest, and they affect feed quality negatively (Collins and Fritz 2003). It has been reported that ADF and NDF ratios in plants differ based on the developmental period of the plant, plant parts, cultivation practices, and environmental conditions (Cassida *et al.* 2000; Markovic *et al.* 2007).

In our study, the Karagöz-86 cultivar showed the highest ADF ratio when it was sown on 25 May and the lowest ADF ratio when it was sown on 25 April. The highest ADF ratios in the Akkız-86, Karnıkara, and Ülkem cultivars were obtained when they were sown on 10 May, and the highest ratio in the red cowpea landrace was obtained when it was sown on 25 April. While the lowest ADF ratios in the Akkız-86 cultivar, the Karnıkara cultivar, and the red cowpea landrace were obtained when they were sown on 25 May, the lowest ADF ratio in the Ülkem cultivar was obtained when it was sown on 25 April (Figure 9).

In studies on ADF ratios in cowpea plants, these ratios were reported by Ayan et al. (2012) as 26.50-30.20%, by Beycioğlu (2016) as 26.21-36.54%, by Ayan et al. (2017) as 25.27-34.09%, and by Omar (2018) as 20.05-28.00%. Gebreyowhans and Gebremeskel (2014) reported these ratios in the range of 47.00-57.2%.

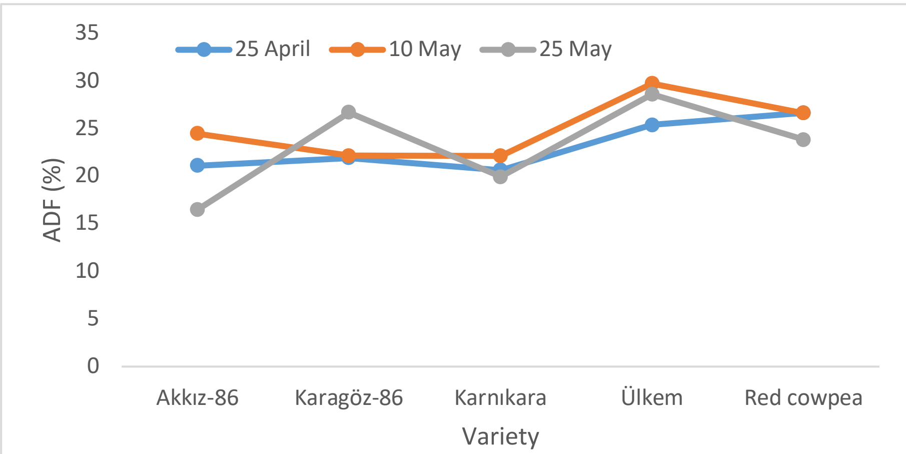

Figure 9. Effect of sowing time x variety interaction on ADF

3.10. NDF (Neutral Detergant Fiber)

According to the comparisons of different cultivars, the highest mean NDF value was 31.38% in the red cowpea landrace, while the lowest one was 26.41% in the Karnıkara cultivar. According to the comparisons of different sowing times, the highest mean NDF value was 31.33% in the cultivars sown on 10 May, while the lowest one was 27.92% in those sown on 25 April. The highest value among the genotypes was 35.90% in the red cowpea landrace. According to the results of our study, NDF ratios varied from cultivar to cultivar. Considering the sowing times, the best results were obtained in the 10 May treatment (Table 4).

The highest NDF ratios in the Akkız-86, Karnıkara, and red cowpea genotypes were obtained when they were sown on 10 May, whereas the highest ones in the Karagöz-86 and Ülkem cultivars were obtained when they were sown on 25

May. The lowest NDF ratio in the Akkız-86 cultivar was obtained when it was sown on 25 May, while these sowing times were 10 May for the Ülkem cultivar and 25 April for the Karagöz-86, Karnıkara, and red cowpea genotypes (Figure 10).

The NDF ratios that were determined in this study were lower than 41%. Studies on the topic reported NDF ratios for cowpea fodder in ranges of 24.51-42.55% (Beycioğlu, 2014), 48-55% (İdikut et al., 2015), 56.3-60.7% (Gebreyowhans and Gebremeskel, 2014), 29.43-35.62% (Ayan et al., 2017), and 24.48-36.64% (Omar, 2018).

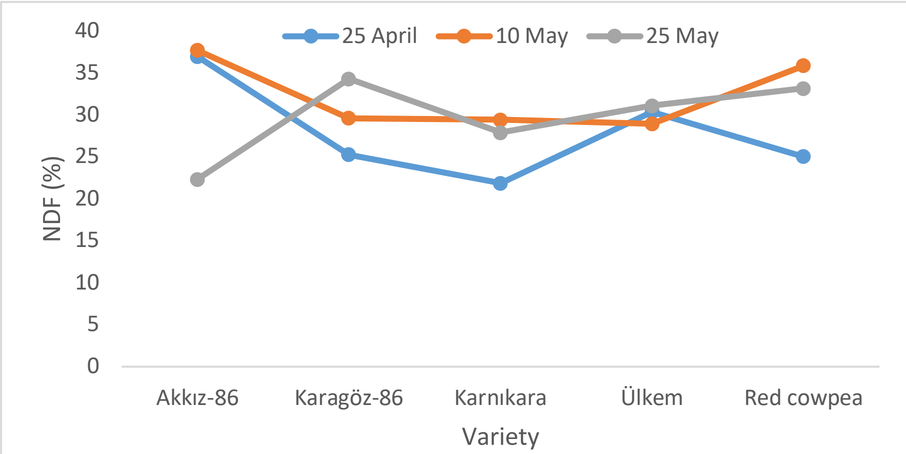

Figure 10. Effect of sowing time x variety interaction on NDF

4. Conclusions

Consequently, in this study, differences were observed in yield values and other yield-related parameters based on the sowing times and genotypes that were examined in Erzurum conditions. Accordingly, considering that the most favorable green herbage yield results were obtained in the red cowpea landrace in the 25 April treatment, the most favorable dry herbage yield results were in the red cowpea landrace in the 25 May treatment, the most favorable crude protein ratio results were in the Ülkem cultivar in the 25 April treatment, and the most favorable ADF and NDF results were respectively in the Akkız-86 and Karnıkara cultivars in the 25 May treatment, it may be stated that the Akkız-86 and Karnıkara cultivars had acceptable values, and 25 April could be preferred as the sowing time. Keeping in mind that the cowpea is a warm climate plant, it can be recommended for fodder production in the ecological conditions of Erzurum.

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The Seasonal Variation of Forage's Chemical Composition of a Semi-Arid Rangeland According to Altitude and Aspects

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This study was carried out on Kop Mountain, which is located at the intersection of Eastern Anatolia and the Eastern Black Sea in Turkey. Forage samples were taken from the semi-arid rangeland sites were analyzed for a status of the chemical composition according to altitude and aspect. In addition, the seasonal variation of the chemical composition was investigated by repeated analyzes in 3 different periods. In terms of aspect, the highest crude protein ratio (13.40%) occurred in the north, the lowest ratio (10.11%) occurred in the east, while the higher crude protein ratio (11.88%) was observed in the backslope in terms of altitude. The highest crude protein rate (15.15%) was found in May. The highest rate (53.67%) was found in the east and the lowest (45.86%) in the North in terms of NDF. NDF rates in May, July, and October were 48.27%, 47.11%, and 58.17%, respectively. The highest value (33.30%) was recorded in the west and the lowest value (27.66%) was recorded in the North in terms of ADF. ADF values observed in May, July, and October were determined as 26.98%, 30.93%, and 36.63%, respectively. According to the results of the research, it was determined that while the crude protein ratio decreased with the maturation of the plants, the elements forming the cell wall increased; and seasonal conditions changed and affected the forage quality.

1. Introduction

Rangelands and meadows are essential both as a feed source and sustainability of natural life. To derive benefits from rangelands in a manner that is compatible with long-term sustainability, it is important to ensure that they are used by following per under with the principles of forest management, that rangeland plant populations are safeguarded, and appropriate breeding activities are carried out using rangelands with the proper animal species and the number of animals, correct estimation of the grazing time, and selection of suitable breeding methods can become possible if all of the elements that impact the use of rangelands are taken into consideration. While grazing is the primary driver of rangelands, key elements such as altitude and aspect influence on rangeland vegetation. In a research (Gökkuş et al., 1993), the effects of altitude, slope, and aspect on sites of rangeland were assessed, and it was shown that as altitude increased, yield declined. The ratios of grasses, legumes, and other families were found to be different depending on the altitude in a study that was carried out by Çomaklı et al. (2012) on three rangelands located at 2000, 2500, and 3000 meters

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in altitude. Additionally, the canopy coverage rate was found to decrease as the altitude increased. Another factor affecting rangeland vegetation is seasonal variation. According to the study performed by Tarhan and Çaçan (2020) to discern the monthly variation and grazing season in rangelands based on the aspects, May was ascertained as the beginning of the grazing season for the rangelands in the Ormanardı village of the Bingol province, and May and June were the most productive months of the grazing season in terms of yield and quality as per the study results.

Eastern Anatolia region has the highest rangeland existence in Turkey. The country's total rangeland of 38% is located in this region (Anonymous, 2022). Kop Mountain, situated at the junction of Eastern Anatolia and the Eastern Black Sea, is part of the Eastern Black Sea Mountains. In the area situated near the intersection of the provinces of Bayburt, Erzurum, and Erzincan, mountain rangelands are used to raise livestock. In this research, variances in the chemical composition of forage samples from various altitudes and aspects of rangeland sites, seasonal variations in ADF, NDF, and Crude Protein ratios, and the consequences of these variations on forage quality were attempted to be identified.

2. Material and Method

The study was conducted by collecting samples from various portions of semi-arid rangeland sites of Kop Mountain, Turkey in 2019 and 2020, followed by laboratory analysis. Rangeland areas were determined to include 2 different altitudes and 4 different aspects.

The first altitude value chosen for the study was determined from the border of the agricultural land, while the second altitude value was chosen close to the summit. The first altitude value is called "footslope" and the second altitude value is called "backslope". It was discovered that the slopes of the research areas were similar. For this purpose, two different altitude measurements were taken into consideration at the footslope and backslope sites of Kop Mountain, with the aspect of the slopes (hillsides) serving as a starting point. Then, the four aspects of east, west, north, and south were identified. Rangeland sites at two distinct altitudes (1st altitude: 1871 -1985 m, 2nd altitude: 2372 - 2468 m) were chosen for each aspect, and the study was conducted in these eight rangeland sites.

The climate data for the research area were collected from the 12th Regional Directorate of Meteorology station in the district of Aşkale in Turkey, which is the closest station to the research area. Climate statistics show that the Aşkale meteorological station's annual average temperature for the 2013-2020 observation period was 7.6ºC, the average annual total precipitation was 386.95 mm, and the average annual relative humidity value was 64.7%. In the years 2019 and 2020, when the research was conducted, the average temperature was 7.4ºC in 2019, 7.9ºC in 2020, and relative humidity was 66.9% for 2019 and 61.6% for 2020. When the data is analyzed in terms of precipitation values, precipitation data for 2019 (373.1 mm) and 2020 (342.2 mm) were lower than the 2013-2020 average values.

In the laboratories of the Eastern Anatolian Agricultural Research Institute and the Faculty of Agriculture at Atatürk University, a total of 8 soil samples collected from the research area were examined. The results showed that soil had a neutral character (pH 6.74), organic matter content was 5.84% (rich), nitrogen rate was "high" (0.29%) and EC (salinity) rate was "slightly salty".

Three quadrats of 0.25 m^2 were harvested in May, July, and October to produce forage samples from the rangeland areas under study. When selecting the sampling locations on the rangeland, protected sampling areas were preferred. Forage samples were labeled and preserved in cloth bags after the procedures for sampling were carried out in three repetitions. The samples were gathered from two distinct altitudes and four distinct aspects, which are collectively referred to as Kop Mountain footslope and backslope sites. The forage samples that were predried in the greenhouse environment were dried at a temperature of 70ºC until they attained a constant weight. After drying, nitrogen ratios of the grounded forage samples were calculated by wet combustion using the Kjeldahl method to determine the crude protein ratio. The obtained total nitrogen ratios were multiplied by the advised 6.25 coefficient to calculate the forage plant's crude protein ratios (Adesogan et al., 2000), and crude protein ratios were calculated.

With the use of ANKOM Fiber technology, acid detergent fiber (ADF) analysis was performed on the plants obtained from rangeland areas to ascertain how much lignin and cellulose were present in their cell walls (Ankom, 2020). To lignin, cellulose, and hemicellulose amounts in the cell wall in forage samples, ANKOM Fiber technology was used for the neutral detergent fiber (NDF) analysis.

Following the analysis, the crude protein, NDF, and ADF values were analyzed according to the 4-factor (aspect x altitude x season x year) experimental design in randomized blocks with 3 repetitions (Yıldız and Bircan, 1994). After applying the arc-sin transform to the proportional data gathered from different rangeland sites, statistical analyses were conducted using SPSS (Version 20) software. The Duncan test was used to evaluate the statistically significant factor means based on the results of the variance analysis.

3. Results and Discussion

Table 1 shows the variance analysis results and the variation of crude protein, NDF, and ADF ratios in forage samples taken from rangeland sites according to the altitude, aspects, and season.

The evaluation of crude protein, NDF, and ADF values was provided below based on the information in Table 1.

Crude Protein (%)

The variance analysis of the crude protein ratio of the samples collected from the rangeland sites revealed non-significance regarding the research years (Table 1). Following the study years and combined analysis, the variation of aspect and seasonal crude protein ratio was shown to be very significant ($p<0.01$) While the values recorded in 2019 were insignificant based on altitude variable, the values recorded in 2020 and combined analysis were significant at 1% level.

Table 1. Variation of Crude Protein, NDF, and ADF Rates As Per Aspect, Altitude, and Season (%) and Variance Analysis Results of Crude Protein, NDF, and ADF Rates

	Crude Protein			NDF			ADF		
Aspect	**2019**	**2020**	**Combined Analysis**	**2019**	**2020**	**Combined Analysis**	**2019**	**2020**	**Combined Analysis**
East	10.46 C	9.74 C	10.11 C	54.59 A	52.74 B	53.67 A	35.29 a	30.45 A	32.87 A
West	12.05 B	10.24 C	11.15 B	49.53 BC	56.77 A	53.15 A	34.50 a	32.10 A	33.30 A
North	13.10 A	13.61 A	13.40 A	47.05 C	44.66 C	45.86 B	30.14 b	25.18 B	27.66 B
South	10.18 C	11.52 B	10.85 B	50.72 B	53.39 B	52.06 A	32.51 ab	31.95 A	32.23 A
Mean	**11.47**	**11.28**	**11.38**	**50.47**	**51.89**	**51.18**	**33.11 A**	**29.92 B**	**31.51**
Altitude									
Footslope	11.25	10.48 B	10.87 B	50.26	50.76	50.51	31.83 b	29.77	30.80
Backslope	11.69	12.07 A	11.88 A	50.68	53.02	51.85	34.39 a	30.07	32.23
Mean	**11.47**	**11.28**	**11.38**	**50.47**	**51.89**	**51.18**	**33.11 A**	**29.92 B**	**31.51**
Season									
May	15.39 A	14.90 A	15.15 A	46.78 B	49.76 B	48.27 B	26.43 C	27.53 B	26.98 C
July	12.22 B	12.17 B	12.20 B	45.81 B	48.41 B	47.11 B	34.38 B	27.48 B	30.93 B
October	6.80 C	6.76 C	6.78 C	58.83 A	57.50 A	58.17 A	38.52 A	34.74 A	36.63 A
Mean	**11.47**	**11.28**	**11.38**	**50.47**	**51.89**	**51.18**	**33.11 A**	**29.92 B**	**31.51**
Aspect	**	**	**	**	**	**	*	**	**
Altitude	ns	**	**	ns	ns	ns	*	ns	ns
Season	**	**	**	**	**	**	**	**	**
Aspect x Altitude	**	**	**	ns	ns	*	*	ns	ns
Aspect x Season	**	**	**	*	**	**	ns	*	ns
Altitude x Season	*	**	**	**	*	**	ns	*	*
Aspect x Altitude x Season	*	**	**	ns	**	**	ns	*	ns
Year	-	-	ns	-	-	ns	-	-	**
Year x Aspect	-	-	**	-	-	**	-	-	ns
Year x Altitude	-	-	**	-	-	ns	-	-	ns
Year x Season	-	-	ns	-	-	ns	-	-	**
Year x Aspect x Altitude	-	-	ns	-	-	ns	-	-	ns
Aspect x Season x Year	-	-	**	-	-	*	-	-	*
Altitude x Season x Year	-	-	ns	-	-	ns	-	-	ns
Year x Aspect x Season x Altitude	-	-	ns	-	-	ns	-	-	ns

*Mean scores marked with lowercase letters differ at 5%. **Mean scores marked with uppercase letters at 1%. ns: not significant

While aspect x altitude, aspect x season, year x aspect, year x altitude, and aspect x season x year interactions were very significant ($p<0.01$) in terms of both research years and combined analysis; year x season, year x aspect x altitude and altitude x season x year interactions were insignificant.

In 2019, the first year of the research, the north aspect had the greatest crude protein concentration (13.10%) while the south aspect had the lowest concentration (10.18%) (Table 1). Following the variance analysis findings of 2019, when the southern and eastern aspects statistically belonged to the same group, the crude protein ratios ($p<0.01$) were significantly different. In contrast to the results of the first year, the results for the year 2020 showed that the area in the north had the highest crude protein rate, with a value of 13.61%, while the area in the east had the lowest crude protein rate, with a value of 9.74%. According to the findings of the variance analysis conducted during the second year of the research, the east and west aspects were statistically classified as belonging to the same group, and the crude protein rate differences between the aspects were significant at the 1% level.

In contrast to the combined analysis of the 2020 values, which was determined to be statistically significant at the 1% level, the findings of the 2019 analysis were not statistically significant, based on results indicating the influence of the altitude factor on the crude protein ratio (Table 1). The crude protein ratio in the backslope (11.88%) was found to be higher than in the footslope sites (10.87%), despite the fact that the crude protein ratios were similar to one another in terms of altitude when the combined analysis was taken into account.

Table 1 shows the variation in crude protein ratios that occurred during the grazing season based on months. The data indicates that the highest crude protein rate (15.39%) for 2019 was recorded in May, while the lowest crude protein rate (6.80%) was recorded in October. In the second year of the study, the highest and lowest crude protein rates were observed in May (14.90%) and October (6.76%) respectively. Similar to the research years, the findings of the combined analysis showed that the highest crude protein ratio was observed in May and the lowest rate was in October. The season had a significant impact on the crude protein ratio ($p<0.01$) throughout all study years and combined analysis.

When evaluating the crude protein ratio's seasonal variation in terms of altitude and aspect, a significant difference was observed between the footslope and backslope sites of the north aspect. Additionally, it was discovered that the crude protein ratios in October differed more between aspects than altitude (Figure 1). This situation caused an aspect x altitude x season interaction.

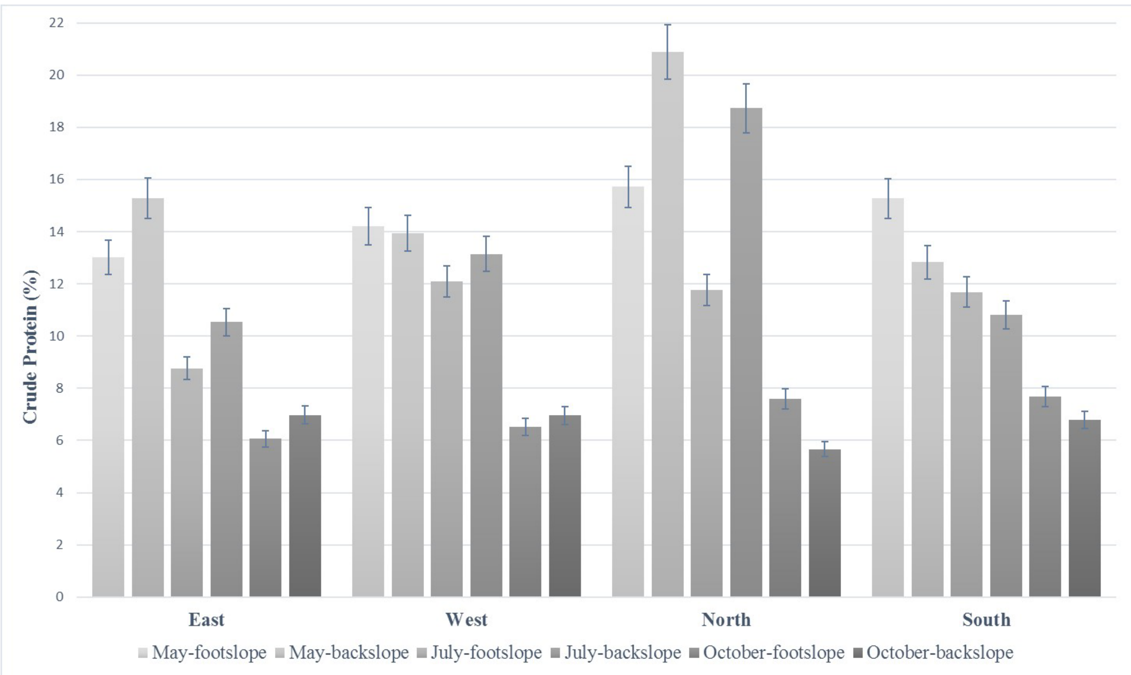

Figure 1. The aspect x altitude x season interaction of crude protein ratio according to the combined analysis

While The month of October showed similar results in terms of seasonal variations in the crude protein ratio as per the aspects in the experiment years, it was found that May and July showed more varied results in the research years (Figure 2). The effect of this situation caused a three-way interaction as aspect x season x year.

The crude protein ratio was highest in the north aspect (13.40%). It has been shown in several earlier studies that forage legumes had a higher ratio of crude protein (Andrae 2003; Shaver 2004; Rayburn et al., 2006; Rayburn 2020). This finding suggests that the high rate of legumes in the north may be responsible for the sites's reasonably high crude protein content. Additionally, the presence of more plentiful leafy and unmatured vegetation may have contributed to a greater crude protein ratio owing to the north's less restricting humidity factor (Holechek et al., 2004). Because plentiful leafy and green vegetation may have a greater protein content (Ball et al., 2001).

The variation in the crude protein ratio with respect to altitude determined insignificant based on the 2019 data; nevertheless, the results obtained in 2020 and the mean values revealed a very significant difference ($p<0.01$). In the combined analysis, the backslope site had a greater crude protein concentration than the footslope site. The higher ratio of crude protein in the backslope sites may be attributable to the increased soil moisture caused by the increased altitude. Because Dovel (1996) claimed that the variations in the crude protein ratios seen in forage samples were caused by changes in the vegetation and soil moisture as well as variations in the botanical composition.

Given the seasonal variation in the crude protein ratio, it can be seen that May, which marks the start of the grazing season, had the highest crude protein ratio. When maturation progressed as a result of the rise in temperature in July and October, the crude protein ratio gradually fell. In the study conducted by Ball et al. (2001), this phenomenon was attributed to the drop in the leaf-to-stem ratio that accompanies plant maturation, resulting in a fall in the protein ratio.

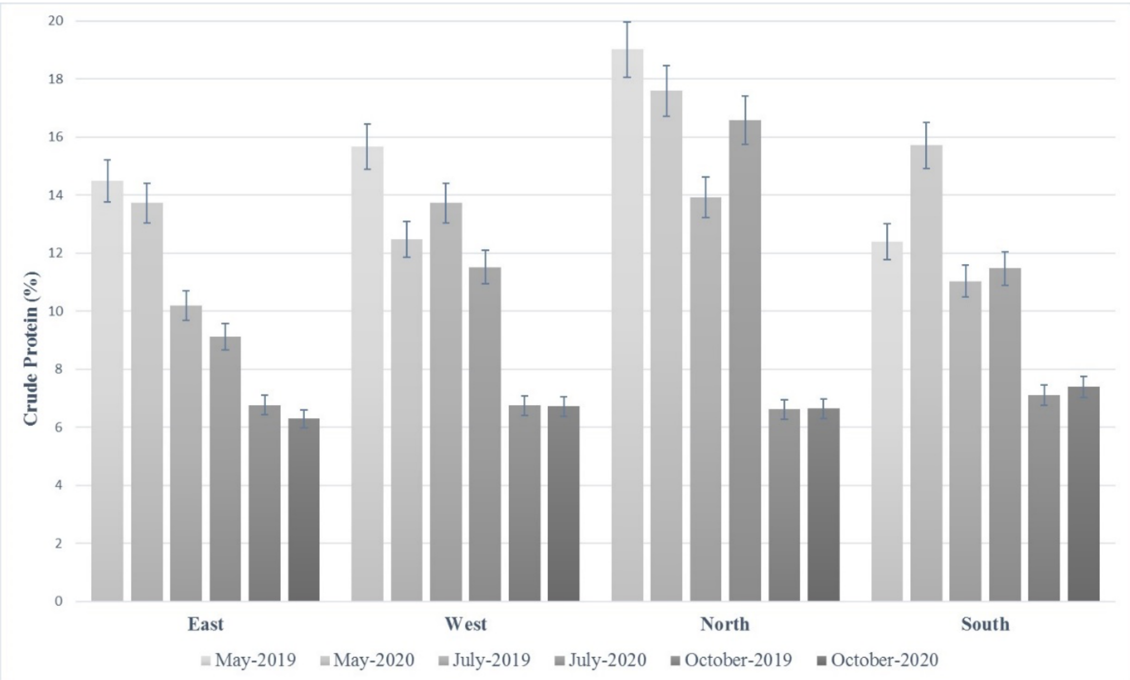

Figure 2. The aspect x season x year interaction of crude protein ratio according to the combined analysis

Neutral Detergent Fiber (NDF) rate (%)

The research years and altitude factor were determined to be insignificant, whereas the aspect and season were found to be significant at 1%, according to the variance analysis results of NDF rates obtained in rangeland parts (Table 1). According to the combined analysis, the aspect x altitude interaction was significant. While the aspect x season interaction was important for 2019, the combined analysis and 2020 results were concluded as significant at the level of 1%.

While the aspect x altitude x season interaction regarding NDF rates was insignificant in 2019, it showed a very significant difference in 2020 results and combined analysis. Aspect x season x year interaction was significant at the level of 5%. The altitude x season interactions based on the findings of the 2019 year and combined analysis of variance analysis and year x aspect interaction based on combined analysis were determined to be statistically significant at the 1% level. However, the aspect x season interaction has changed at the 5% significance level in 2019.

The change in NDF rates determined in the research areas according to the aspects was given in Table 1. As can be seen in the table, according to the variance analysis results of 2019, the highest NDF rate (54.59%) was detected in the east, and the lowest NDF rate (47.05%) was recorded in the north. No difference was found between the west, and the south and north aspect. In 2020, unlike the previous year, the west had the greatest NDF rate (56.77%), while the east and south were statistically in the same group, and the north had the lowest NDF rate (44.66%). According to the combined analysis, when the NDF change between the aspects was investigated, it was determined that the east, west, and south aspects were statistically in the same group, and the north aspect had the lowest NDF rate (45.86%) over the research years. Even though the influence of altitude on the NDF rate was determined to be insignificant, it was discovered that backslope sites had a higher NDF rate in both research years and the combined analysis (Table 1).

When examining the impact of seasonal variation on NDF rates (Table 1), it was established that May and July statistically belonged to the same group considering the results of the research years and combined analysis. Concerning 2019, 2020, and combined analysis findings, the highest NDF rate was recorded in October for all three time periods, at 58.83%, 57.50%, and 58.17%, respectively.

Assessing the seasonal variation of NDF rates in relation to aspect and altitude variables, it was found that there was a difference in NDF rates between the footslope and backslope sites by aspect and that October had a higher NDF value than the other two periods (Figure 3). The combined analysis that takes the effect of these factors into account showed that the aspect x altitude x season interaction has been very significant.

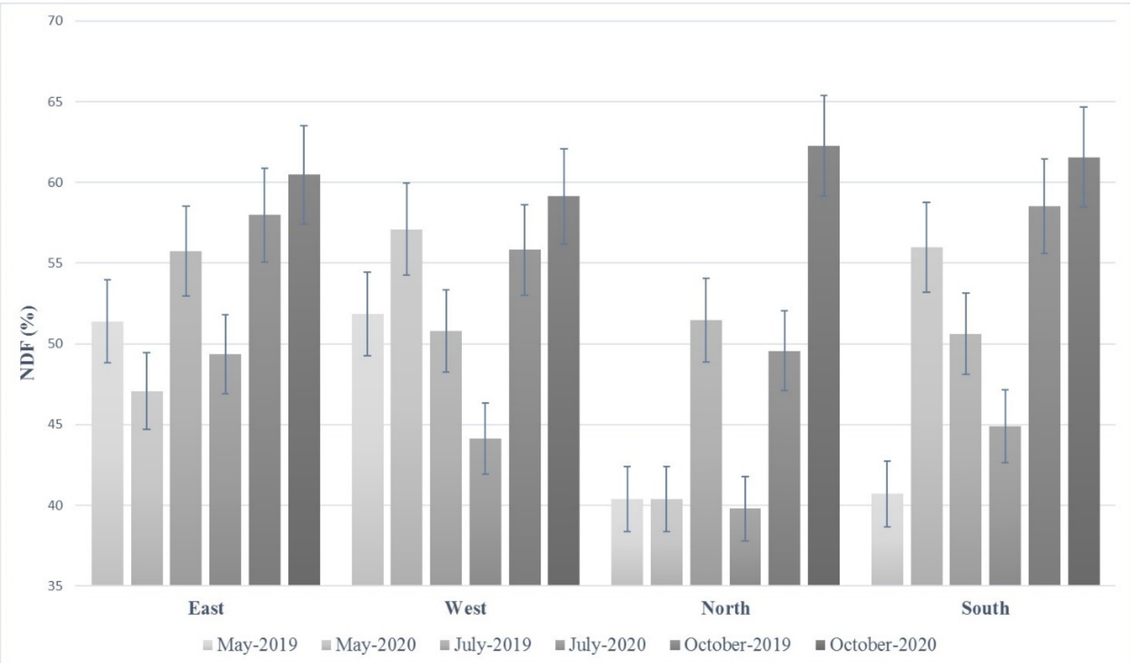

Figure 3. The aspect x altitude x season interaction of NDF rate according to the combined analysis

While a similar process was observed in October concerning seasonal variation of NDF rates as per the aspects during the experiment years, variability occurred in May and July (Figure 4). A three-way interaction of aspect x season x year has formed, particularly as a result of the elevated impact of these changes during the second year of the research.

NDF is a cell wall component consisting of cellulose, hemicellulose, and lignin (Rayburn 2020). The type of plant, growth stage, leaf-to-stem ratio, and different cultural methods in rangelands can all affect the NDF rate (Lacefield et al., 1999; Ball et al., 2001). The research's findings demonstrate that, in addition to these factors, the aspect also has an impact on the NDF rate. In fact, both in the research years and in the combined analysis, the NDF rate according to the aspects demonstrated a statistically significant difference (p0.01) (Table 1). The east aspect's high rate grass may be what caused the highest NDF rate to be found there. According to research of Reuss (2001) and Darambazar et al. (2003), grasses have a greater concentration of NDF than legumes. The north may have the lowest NDF rate owing to the lower illumination rate in this aspect and the higher leaf-stem ratio as a result of the plants' later maturity stage.

There is a significant relationship between maturation and the increase in NDF rate (Kamstra et al., 1968; Pieper et al., 1974). Plant maturation is impacted by seasonal variation as well as other factors. The NDF rate caused a difference according to seasonal change within the parameters of the study, and as a consequence, the NDF values found in the combined analysis between 2019 and 2020 were statistically significant at the level of 1%. The combined study reveals that May and July statistically belonged to the same group and that their respective NDF rates of 48.27% and 47.11% were close. The highest NDF rate was observed in October (58.17%). It is anticipated that the NDF rate will be lower in May and July owing to the onset of plant growth at the beginning of the grazing season and the high leaf-to-stem ratio. On the other hand, the response of legumes and grasses to changes in temperature and precipitation varies, as tap root legumes may increase their rates under dry conditions, but the growth of fibrous-root grasses rises with increased surface precipitation. The ratio of legumes to grass in rangelands may change as a consequence of this circumstance, and these variations result in a periodic change in the NDF rate. Given that the NDF rate is higher than in legumes, especially in grasses (Collins and Fritz, 2003; Deak et al., 2007; Tan et al., 2019), it leads to the fact that the NDF rate is affected by the proportional change of these two families. In addition, in rangeland sites exposed to grazing, the NDF rate may rise as a consequence of a reduction in the leaves, which are the portions favored by animals, hence, causing an increase in the stem ratio along with the fact that plants grow old meantime. Studies performed by Twidwell et al. (1988) and Ball et al. (2001) revealed that plant stems contain higher NDF than other components. This situation also explains why the highest NDF rate was seen in October.

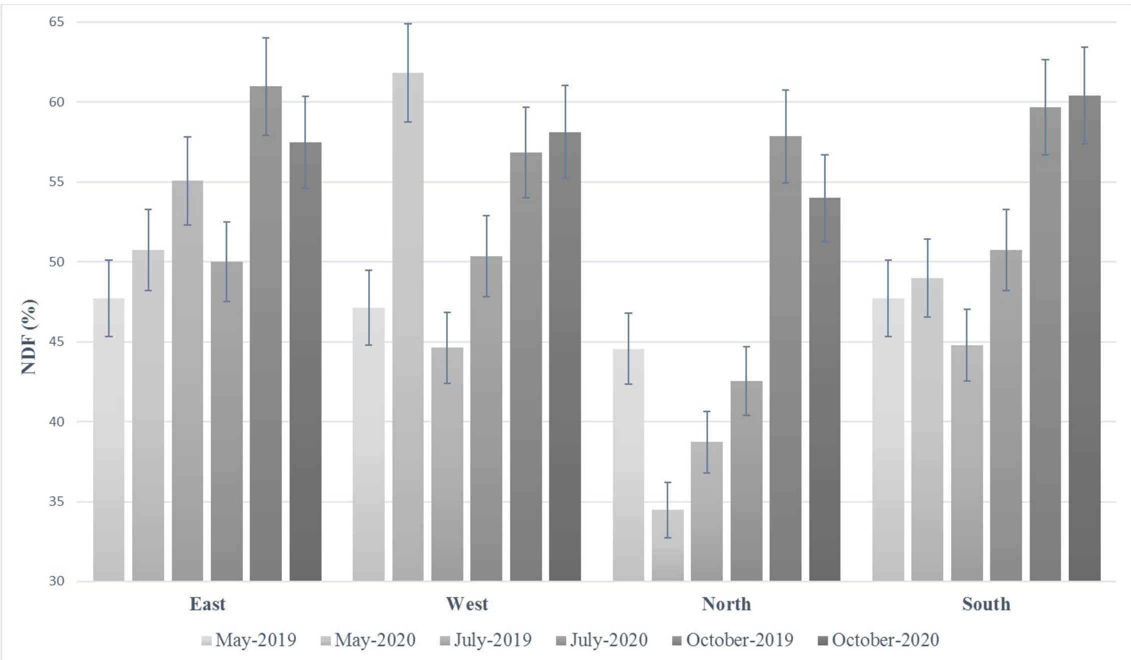

Figure 4. The aspect x season x year interaction of NDF rate according to the combined analysis

Acid detergent fiber (ADF) rate (%)

Examining the variance analysis findings for the rangeland sites that were the topic of the study (Table 1), it was discovered that the ADF rates are statistically very significant (p<0.01) when taking the research years and season variables into consideration. Furthermore, it was determined that the results of 2019 were 5% significant in terms of aspect, and lastly, it was determined that the combined analysis data and 2020 results were very significant. Altitude-wise, it was found that the combined analysis and findings for 2020 did not statistically vary from those of 2019 and that only the results from 2019 were significant at the level of 5%. According to the variance analysis findings of 2019, the interaction between aspect and altitude was significant; however, as indicated by the results of 2020, the interactions between aspect and season, altitude and season, and aspect x altitude x season were significant. As per the results of the combined analysis, while the interactions of altitude x season, and aspect x season x year were significant, it was found that the interaction of year x season showed a statistically significant difference.

In 2019, the first year of the research, the East had the highest ADF rate (35.29%), while the North had the lowest ADF rate (30.14%); statistically, the East and West were in the same group. Unlike the first year, the highest ADF rate in 2020 was determined in the West with a value of 32.10%. In the second year of the study, when the east, west, and south were statistically grouped, the north had the lowest ADF rate with a value of 25.18%. According to the combined analysis, the west, east, and south were statistically in the same group when it came to their ADF rates, with the west having the highest ADF rate (33.30%) and the north aspect having the lowest ADF rate (27.66%).

Only in 2019 was there a statistically significant difference in the ADF rate as per the altitude, in comparison to the previous years, and the ADF rate was higher on the backslope (34.39%) in comparison to the foot slope (31.83%). The combined analysis with 2020 revealed that the backslope sites had a greater rate of ADF, albeit this finding was not statistically significant (Table 1).

The effect of seasonal variation on the ADF rate was given in Table 1. According to the study years and mean values, it is evident from the table that the seasonal variation in the ADF rate is statistically significant at the 1% level. It was determined that the highest ADF rates for 2019 and 2020 were both recorded in October with values of 38.52% and 34.74%, respectively; while the lowest ADF rates were observed in May 2019 (26.43%) and in July 2020 (27.48%). The ADF rates were 36.63% in October, 30.93% in July, and 26.98% in May based on the combined analysis of the years. Significant variations between the features in terms of the change in ADF rates by months developed over the experiment years, particularly in the second year of the research. The three-way interaction as aspect x season x year was significant in the north because the ADF rate differed from the other aspects in terms of seasonal variation (Figure 5).

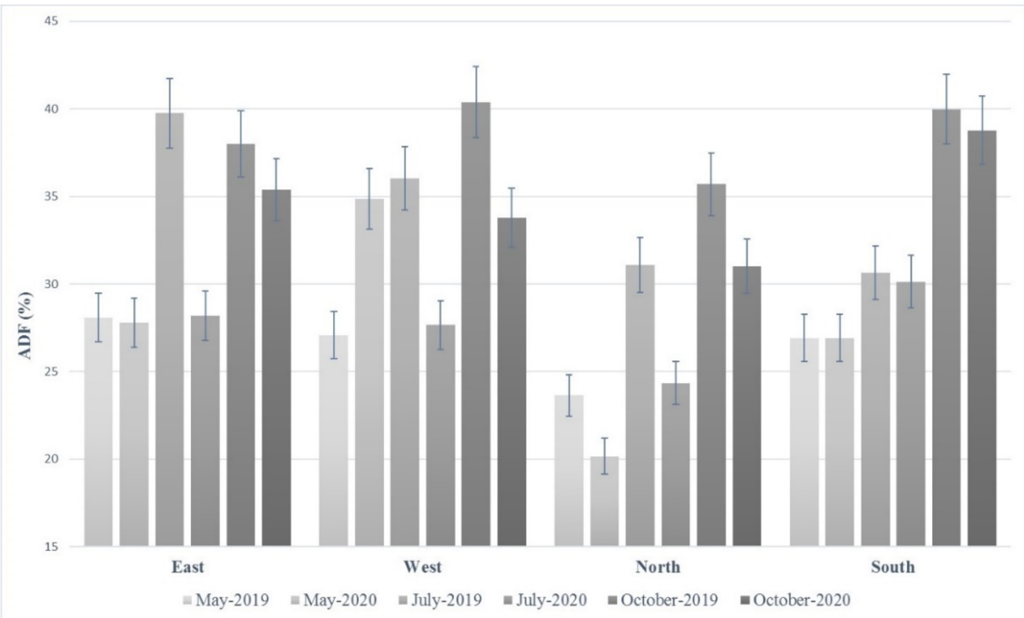

Figure 5. The aspect x season x year interaction of ADF rate according to the combined analysis

While the ADF rate was 33.11% in the first year of the study, it was 29.92% in the second year, varying statistically by 1% between the years of the research. This may be attributed to varying precipitation levels between research years. Rangeland forage ADF rate is an essential measure of the digestible nutrient rate (Rayburn, 2020), and there is a significant negative relationship between the digestibility rate and ADF rate (Barney, 2009). When looking at the combined analysis results, the change in the ADF rate by aspect was very significant ($p<0.01$), and the west (33.30%) had the highest ADF rate among the aspects. The reason for the highest rate of ADF might be because the vegetation matured sooner owing to the west's high rate of illumination. Because the leaf-stem ratio in plants decreases with maturation, ADF increases with the fiber ratio (Martiniello et al., 1997; Andrae 2003). The lowest ADF rate (27.66%) among the aspects was determined in the north. These plants grow later as a consequence of the temperature difference and low illumination rate of the north aspect, and as a result, the higher leaf-stem ratio has played a significant role in this outcome.

In terms of altitude, backslope sites had a higher ADF rate (34.39%) in 2019 than foot slope sites (31.83%). Due to partial grazing on rangelands and the effect of regrowth of vegetation in the footslope as they are being closer to the settlements, this may have led to lower ADF values.

The seasonal variation of the ADF showed very significant difference ($p<0.01$) both in the research years and in the combined analysis. According to the combined analysis, the highest ADF rate (36.63%) and the lowest ADF rate (26.98%) were discovered in October and May, respectively. Due to the low stem ratio in plants that are still at the start of the development phase in May, it is anticipated that the ADF rate will be low. So, ADF and other components of the cell wall are becoming more abundant in plants as they mature (Linn and Martin 1999; Kaya et al., 2004; Avcı et al., 2006). Variations in the climate also lead to changes in the vegetation, which have an impact on the seasonal variations in forage quality (Mountousis et al., 2008; Teka et al., 2012; Koç et al., 2014). This led to the conclusion that the rate of ADF increased at an accelerating rate between July and October, with October having the highest rate.

4. Conclusion

All rangeland sites that were the subject of the study had a crude protein ratio of above 7%, with the north being the aspect where this ratio was the highest. The lowest value of the crude protein ratio, which was obtained in October (6.78%), was shown to have declined since the start of the grazing season. The west had the highest ADF rate (33.30%) and the east had the highest NDF value (53.67%), both of which are significant variables influencing forage quality. In terms of seasonal variation, the ADF rate has increased linearly since May and reached the highest value in October. In NDF, there was only a small change in May and July, but a major increase was seen in October. The study's findings show that although the crude protein ratio drops as plants mature while the number of elements that constitute the cell wall increases, hence, the change in seasonal circumstances has an impact on the quality of the forage. In light of these findings, it has been determined that including the footslope sites in the grazing program in line with the management principles is crucial for the future of Kop Mountain semi-arid rangelands. And it was determined that doing both research and application studies for rangeland improvement would be beneficial.

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The Effect of Biochar Applications at Different Doses on Soybean Seedlings Grown in Salty Conditions

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This study was carried out in greenhouse of Ataturk University Plant Production Implementation and Research Center to investigate the effects of biochar application at different doses on the mineral element content of soybean seedlings under salt stress in Erzurum Province, Turkey. In the study, some mineral contents in the leaves and roots of soybean seedlings were investigated. The experiment, which was established in a completely randomized design with three replications in each of five pots, was factorial. According to the data obtained from the study, it was stated that while the leaf and root plant nutrient content of soybean seedlings decreased in salty conditions in general, the applied biochar increased the leaf and root plant nutrient content. This positive effect of biochar treatments on enhancing mineral element content was dose dependent. In conclude, biochar can be used as an amendment for increasing plant nutrient use efficiency of plants under saline conditions.

1. Introduction

Soybean (*Glycine max* L.), which offers more than 25 percent of protein in the world requirements in terms of feed and minerals, is one of the most significant oil plants and improves soil fertility via nitrogen fixation through nodosities on its roots (Alekel et al., 1998). Soybeans have been shown to stop the progression of cancer and osteoporosis and to improve coronary heart disease (Alekel et al., 1998). They are additionally utilized in the confectionery industry, infant food production, animal feed manufacturing, and energy generation from plants (Lucas et al., 2001). Owing to these significant characteristics, soybean production is consistently increasing, although it has not yet exceeded the noteworthy levels achieved by corn, wheat, and rice. The abiotic element known as salt stress, which has a negative impact on plant development and growth, is particularly dangerous to the soybean (*Glycine max* L.) and other species of legume (Ashraf and Wu, 1994; Kul et al., 2021).

Salinity, one of the greatest challenges to global food security (Abd El-Mageed et al., 2020), considerably influences the fresh and dry weight of the cultivated crops (Demir and Mazi, 2008; Galvan-Ampudia and Testerink, 2011). Most of biological processes in plants, such as development, growth, germination, and photosynthesis are severely impacted depending on the density and duration of salt stress (Mugdal et al., 2010), which dramatically influences water and osmotic pressure in plants (Bressan et al., 2008). In

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addition, high salt concentrations considerably altered the ion uptake in plants, increasing Cl^- and Na^+ uptake while decreasing the uptake of K^+, Ca^{+2}, Mg^{+2} and other cations (Parida et al., 2005; Kusvuran et al., 2008; Guo et al., 2015). Even though expensive and momentary methods such as enhancing salt irrigation water, employing species and varieties with high salt tolerance, or fertilization are used to reduce the effect of salt stress on plants, biochar implementations to improve physicochemical properties such as cation exchange capacity and Na^+ absorption have surfaced as a common method in recent years in terms of sustainable technology (Drake et al., 2016).

Biochar, which is rich in humic compounds (Lorenz and Lal, 2014), has gained significance as a green manure crop, a means of carbon sequestration in the soil, and an enhancer of soil productivity through agrochemical immobilization. In fact, studies indicate that biochar treatments have a considerable impact on a variety of soil parameters under biotic and abiotic stress conditions (Wu et al., 2014; Rizwan et al., 2016).

In this research, the impact of varying salt concentrations on the leaf and root mineral element content of soybean (*Glycine max* L.) was tested utilizing the biochar form of hazelnut shell, which is designated a fuel following hazelnut harvest.

2. Materials and Methods

The study was conducted in the greenhouses of the Atatürk University Plant Production Application and Research Center and the labs of the Field Crops Department of the Faculty of Agriculture. Containers containing soil, sand, and peat (3:1:1/v:v:v) were adjusted with biochar at three different concentrations: 0% (control), 2.5%, and 5% of soil weight. In the study, the biochar form of hazelnut shell, which was supplied by a private company, was used. In the research, salt was applied with irrigation water at 0, 50, and 100 mM NaCl. By sowing soybean seeds in pots, saline water applications were initiated. In order to avoid the seeds from being harmed by abrupt exposure to salt stress, the salt stress was first raised gradually by 25 mm, and the final dosages were set. The application dosages were adjusted by monitoring the EC values of the soil. In the study, 3 biochar (B0: without biochar (Control), B1: 2.5% biochar and B2: 5% biochar) and 3 salinity doses (0 (S0), 50 (S1) and 100 (S2) mM NaCl) in 9 different combinations (T0: S0B0, T1: S0B1, T2: S0B2, T3: S1B0, T4: S1B1, T5: S1B2, T6: S2B0, T7: S2B1, T8: S2B2) in a 3x9 factorial design with 3 replications. While SPSS (SPSS, 2010) was utilized for statistical analysis of the data, Duncan's multiple range tests were employed to assess the variations between the means.

3. Results and Discussion

Plant nutrient element contents except for of soybean leaves were dramatically and significantly reduced in line with the increase in salt, as shown in Tables 1 and 2.

When the S0B0 was compared with S1B0 and S2B0 applications, the N, P, K, Mg, Ca, B, Fe, Mn, Zn and S elements in the leaves decreased by 10-17%, 11-29%, 13-26%, 25-40%, 10-29%, 22-47%, 53-58%, 12-39%, 8-31% and 15-35% respectively, while the Na and Cl ratio increased by 33%-44% and 28%-49% respectively. In the study, the B2 application gave the highest concentrations of N (35%), P (18%), K (30%), Ca (77%), Mg (15%), Mn (10%), and B (23%), while the B1 application gave the highest concentrations of S (4%), Fe (8%), and Zn (5%). In the study, B2 application yielded the highest levels of N (39%), P (20%), K (52%), Ca (92%), and B (8.6%), while B1 application produced the highest levels of Mg (420%), S (5%), Mn (14%), Fe (103%), and Zn (36%) (Table 1 and Table 2). The highest content of N (27%), P (40%), K (81%), Ca (135%), and B (21%) in 100 salt application was recorded in B2 application, while the highest content of S (29%), Mn (29%), Fe (118%) and Zn (63%) was observed in B1 application.

In the study, mineral contents of roots except for Na and Cl showed a significant decrease as a result of the general increase in salt concentration (Table 3 and Table 4). When the S0B0 was compared with S1B0 and S2B0 applications in the experiment. the N, P, K, B, Mn, Ca, Zn, Fe and S elements present in the leaves decreased by 9-37%, 14-21%, 29-52%, 17-24%, 16-38%,14-28%, 19-41%, 19-30% and 27-49% respectively, while the Na and Cl ratio increased by 28-46% and 20-67% respectively. While the highest N (4%), P (12%), K (10%), Mg (15%), Mn (108%), Fe (11%) and Zn (7%) content was recorded within the B2 application with different biochar applications without using salt. the highest Ca (10%) and B (6%) content was obtained from the B1 application (Table 3 and Table 4).

Table 1. Leaf mineral content of soybean seedlings under salinity with biochar treatment[1]

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
T0	1.82 D	0.28 B	1.72 B	0.52 D	0.20 B	0.26 A
T1	1.95 C	0.29 B	1.80 B	0.65 C	0.19 B	0.27 A
T2	2.44 A	0.33 A	2.23 A	0.92 A	0.23 A	0.22 B
T3	1.63 E	0.25 C	1.49 CD	0.47 E	0.15 D	0.22 B
T4	1.90 CD	0.25 C	1.56 C	0.54 D	0.78 BC	0.23 B
T5	2.26 B	0.30 B	2.26 A	0.90 AB	0.19 B	0.18 C
T6	1.51 F	0.20 D	1.28 E	0.37 F	0.12 E	0.17 C
T7	1.88 CD	0.23 C	1.43 D	0.53D	0.16 CD	0.22 B
T8	1.91 C	0.28 B	1.80 B	0.87 B	0.16 CD	0.17 C

[1]Values followed by different small and capital letters in same column shows significant differences at P< 0.01 levels. respectively. using t-test. *Statistical difference at P< 0.01.

Table 2. Leaf mineral content of soybean seedlings under salinity with biochar treatment[1]

Treatments	Mn (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	B (mg/kg)	Cl (mg/kg)	Na (mg/kg)
T0	82.48 C	299.63 B	15.67 CD	9.12 B	1.27 E	498.28 CD
T1	89.09 AB	324.01 A	16.43 C	8.68 BC	1.32 E	468.49 EF
T2	90.43 A	305.17 B	16.37 C	11.21 A	1.27 E	512.02 C
T3	73.02 D	143.59 E	14.50 D	7.09 DE	1.63 B	664.79 B
T4	83.52 BC	291.46 B	19.70 A	7.27 CDE	1.37 E	453.04 F
T5	78.24 CD	167.43 D	14.97 D	7.70 BCD	1.27 E	468.06 EF
T6	50.56 F	125.16 F	10.87 F	4.85 F	1.89 A	715.15 A
T7	65.06 E	273.13 C	17.73 B	5.34 F	1.53 C	466.57 EF
T8	65.01 E	147.37 E	12.99 E	5.87 EF	1.46 D	482.36 DE

[1]Values followed by small and capital in a column shows significant differences at P< 0.01 levels. respectively. using t-test. ** Statistical difference at P< 0.01.

Table 3. Root mineral content of soybean seedlings under salinity with biochar treatment[1]

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
T0	0.94 A	1.47 C	0.60 B	0.29 C	0.067 AB	0.073 A
T1	0.95 A	1.56 B	0.61 B	0.35 A	0.050 CD	0.073 A
T2	0.98 A	1.64 A	0.66 A	0.32 B	0.077 A	0.073 A
T3	0.86 B	1.26 E	0.47 D	0.25 D	0.053 CD	0.053 B
T4	0.63 D	1.35 D	0.47 D	0.28 C	0.043 DE	0.047 BC
T5	0.95 A	1.44 C	0.52 C	0.29 C	0.067 AB	0.050 BC
T6	0.59 D	1.16 F	0.32 E	0.21 E	0.073 A	0.037 C
T7	0.99 A	1.26 E	0.66 A	0.23 D	0.037 E	0.037 C
T8	0.79 C	1.28 E	0.45 D	0.28 C	0.057 BC	0.043 BC

[1]Values followed by small and capital in a column shows significant differences at P< 0.01 levels. respectively. using t-test. *Statistical difference at P< 0.01.

Table 4. Root mineral content of soybean seedlings under salinity with biochar treatment[1]

Treatments	Mn (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	B (mg/kg)	Cl (mg/kg)	Na (mg/kg)
T0	6.40 D	32.33 AB	4.45 AB	2.64	2.60	462.21 EF
T1	6.42D	29.79 BC	4.72 A	2.80	3.14	488.81 DE
T2	13.34 A	35.84 A	4.75 A	2.65	3.81	493.41 DE
T3	5.39 E	26.27 CD	3.62 C	2.20	3.11	589.71 C
T4	5.31 E	25.26 CD	4.14 B	2.67	1.35	447.77 F
T5	10.44 B	35.52 A	4.14 B	2.45	4.76	558.52 C
T6	3.97 F	22.70 D	2.61 D	2.00	4.34	672.44 A
T7	5.17 E	28.59 BC	3.39 C	1.62	3.71	510.40 D
T8	9.47 C	29.35 BC	3.57 C	3.90	3.45	634.85 B

[1]Values followed by small and capital in a column shows significant differences at P< 0.01 levels. respectively. using t-test. *Statistical difference at P< 0.01.

Study results also show that B2 has the highest amount of N (11%), P (14%), K (11%), Ca (16%), Mg (26%), Mn (94%), Fe (33%) and Cl (53%) while B1 has the highest amount of B (22%) in 50 mM salt application. The highest P (10%), Ca (33%), S (16%), Mn (139%), Fe (30%), Zn (37%) and B (95%) were seen in the B2 application while the highest N (68%) and K (107%) content was determined in the B1 application for 100 salt applications.

Soluble salts, which are easily absorbed by plants, prevent the plant from uptaking water, disrupt the soil structure and adversely affect plant growth (Kanber et al., 1992; Gungor and Erozel, 1994). Furthermore, because salt stress in plants increases the quantity of Cl and Na ions in the environment, it contributes to nutritional deficiency in plants by decreasing the concentrations of essential nutrients such as K^{+}, NO^{-3} and Ca^{+2}. In the research, it was stated that although the Cl and Na content of the plant's leaf and root samples increased owing to rising salt levels, the overall mineral content decreased significantly. In this situation, which occurs in the nutrient content of the plant, it is possible that the excess Na^{+} ion taken by the plants will adversely affect the ion balance in consequence of the increase in the salinity level. Because the ion imbalance caused by increased salt stress both limits the uptake of essential elements that are important for plant nutrition and causes various physiological problems in the plant (Gorham et al., 1985). In numerous research (Yildirim et al., 2008; Zhu et al., 2008; Rouphael et al., 2012), it was discovered that salt stress considerably reduced the mineral element content of plant leaves and roots. As a matter of fact, in a study, it was determined that the negative effects of salt stress were reduced by biochar applications; oxidative stress level and membrane damage decreased, root, stem growth, flower formation and fruit set increased (Karabay, 2017). It has been found that varying amounts of biochar applications, notably B2 application relative to other applications, give a greater favorable influence on the mineral content in the leaves and roots, preventing the detrimental effect of salt stress on the mineral content of the soybean plant. Our findings are also supported by comparable investigations (Xue et al., 2012; Chaganti and Crohn, 2015; Ekinci et al., 2022).

4. Conclusion

In the study, it can be concluded that salinity stress conditions could adversely affect mineral nutrient content of the leaves and roots of the soybean plant, resulting in nutritional deficiency. Yet, the study also revealed that the biochar's improved the mineral content of the plant, so mitigating this detrimental impact of salinity stress. Based on the study results, it can be inferred that the application of biochar derived from hazelnut waste contributed to the enhanced growth of soybean seedlings subjected to salinity stress. Moreover, incorporating biochar as an amendment has the potential to alleviate moisture stress in agricultural areas. The utilization of hazelnut shells as a raw material for biochar production offers a promising avenue in this regard.

Conflict of Interest

There is no conflict of interest among the authors.

Credit authorship contribution statement

All authors equally contributed to the manuscript.

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Exogenous Salicylic Acid Application During Germination of Silage Maize (*Zea mays* L.) Exposed to PEG-Induced Drought Condition

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The aim of study was to investigate the effects of salicylic acid on germination and seedling parameters of maize cultivars (*Zea mays* L.) under drought stress conditions. The research was carried out in a factorial experiment design with four replications in random blocks. In this study, three different silage maize cultivars were used (Side, Pehlivan and Burak). Drought conditions were established using Polyethylene glycol-6000 (PEG-6000) at three different levels (0.-0.4 MPa and -0.8 MPa). Salicylic acid applications were calculated at three different doses of 0-0.1-0.2 mM. The parameters examined in Side cultivar gave superior results exposed to drought conditions compared to other cultivars. Differences were determined in the response of maize cultivars to drought stress, and statistically noteworthy diminishes were also observed as the drought level enhanced. It was displayed that salicylic acid applications generally boosted germination and seedling parameters exposed to drought conditions compared to control. The maximum shoot lenght was detected at 0.2 mM SA dose with 2.30 cm but that did not exhibit significant numerical differences. SA applications, on the other hand, did not have an effect on root length. Moreover, the best result of shoot fresh weight was recorded in 0.1 mM SA application, as root fresh weight gave the best in 0.2 mM SA application. Furthermore, when a correlation is made between the specified parameters, the highest relation was markedly positive and linked between GR and GI (r: 0.99, p<0.01). In this study, it was found that the growth deficiency that may occur under drought stress conditions that maize seeds may encounter during the germination period can be reduced and even improved by salicylic acid applications.

1. Introduction

Water restriction stress is a universal matter, restricting crop fertility and the last climate change scenarios got it more essential and imperiled food security (Abd El-Mageed et al., 2016). Water restriction is also in the substantial restrictions impressing product productivity (Anjum et al., 2011) and yield comprising significant cereals (Golbashy et al., 2010; Joshi et al., 2016; Hasanuzzaman et al., 2020). Drought conditions induce physiological, biochemical, and molecular modifications in plants (Shao et al., 2009), influencing cereal metabolism, growth, and yield fertility (Paupi`ere et al., 2014; Liang et al., 2020).

Water deficit seriously impresses plant physiology, modifying processes, such as osmotic potential, stomatal conductance (Brilli et al., 2019), carboxylation efficiency, photosynthesis rate (Wu

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et al., 2020; Xu et al., 2020), water potential (Taiz and Zieger, 2002), transpiration rate, growth (Sattar et al., 2021; Chakma et al., 2021), germination (Gökkaya and Arslan, 2023) osmolyte accumulation, and the statement of specific genes (Furlan et al., 2012; Abid et al., 2018). Furthermore, below in vitro situations, Polyethylene glycol (PEG), a non-ionic water polymer, is not anticipated to pass through plant tissue rapidly, is completely utilized to cause water stress (Macar et al., 2009). Since PEG does not go into the apoplast, water is drawn from the cell wall. Therefore, PEG solutions imitate dry soils in well than the others which infiltrate the cell wall (Verslues et al., 1998).

The damage extent to the physiological, cellular and molecular responses of plants to drought stress varies depending on the plant growth stage. Seed germination is the most noteworthy biological processes in the plant varieties cycle and immensely susceptible to its existing environment. Successful seed germination mostly affects the yield favorably. In addition as known, weak germination is common cause of decrease in plant yield in arid and semi-arid areas (Shatpathy et al., 2018; Yilmaz and Kizilgeçi, 2022).

Successful planting of normal seedlings, particularly under unfavorable environmental situations, is immediately addicted on the balanced synthesis of plant hormones (Gharbi et al., 2018; Shatpathy et al., 2018). These hormones, which are synthesized endogenously in plants, are considered as defense function compounds (Mohaddes Ardebili et al. 2019) and those that reduce lipid peroxidation (Nazari et al. 2020) in stress situations. External application of plant hormones is one of the most widely used techniques to reduce the effects of environmental stress on germination (Eisvand et al. 2010; Hajiabbasi et al. 2020).

Salicylic acid (SA) functions in the regulation of various physiological processes in plants (Shakirova et al., 2003). These tasks are to evolve plant growth (Metwally et al., 2003; Khodary, 2004, Wang et al., 2013), transpiration rates, stomatal regulation and photosynthesis (Khan et al., 2003), ion uptake and transport (Gunes et al., 2005), flowering and protein synthesis (Zaki and Radwan, 2011; Ullah et al., 2012), inhibition of ethylene synthesis (Ghassemi-Golezani et al., 2015) especially in drought conditions (Latif et al, 2016).

Selection and breeding is known to be essential to produce stress tolerant crop plants, but besides, exogenous application of osmoprotectants, growth promoting compounds to plants has been considered as a temporary solution to mitigate the negative effects of different stresses on plants in the last decade. The aim of study was to conducted with the effects of salicylic acid on germination and seedling parameters of maize (*Zea mays* L.) under drought stress conditions.

2. Material and Methods

This experiment was carried out in the forage crops laboratory, Department of Field Crops, Akdeniz University, Turkey during the autumn of 2022. The maize (*Zea mays* L.) seeds were obtained from Western Mediterranean Agricultural Research Institute. Three varieties were selected as Side, Pehlivan and Burak, that were provided as genetic material, that materials were harvested in 2022. Ten seeds from each cultivar were chosen and placed in 9 mm petri dishes, two Whatman filter papers were lined in. The petri dishes were settled in a growth chamber at 20 ºC under photoperiodic condition 16 hours light 8 hours dark. The experiment was carried out in four replications with factorial arrangement according to the randomized blocks design. Observations were recorded daily. Three drought stress levels causing 0, -0.4 MPa and -0.8 MPa were calculated by the equation of Michel and Merrill (1973) using PEG 6000 concentration. Salicylic acid was administered at doses of 0-0.1-0.2 mM due to its therapeutic effect. 10 ml of solution was used for moistening in each application. The study ended on the seventh day.

Germinatcion tests were carried out according to ISTA rules (2017). The seed of germination (MGT) was calculated using formulas described by Majda et al. (2019). Germination rate (GR) was calculated according to Xia et al. (2019). Germination index (GI) and seedling vigor index (SVI) were counted by the method of Xia et al. (2019). The root/shoot ratio (R/S ratio) was calculated as the following equation (Shtaya et al., 2021).

$$\text{MGT(day)}=\sum \frac{\text{number of seeds germinated on the } i^{th} \text{ day}}{\text{number of days to count the } n^{th} \text{day}} \quad (1)$$

$$GR(\%)=\frac{\text{number of germinated seed}/}{\text{total number of seed tested}}*100 \quad (2)$$

$$GI=\sum\frac{\text{the number of germinated seeds in day}}{\text{day of counting seed germination}} \quad (3)$$

$$SVI=\frac{\text{germination percentage}*\text{average seedling lenght}}{100} \quad (4)$$

$$R/S\ ratio=\frac{\text{roots lenght}}{\text{shoot lenght}} \quad (5)$$

Data obtained for the investigation subjected to analysis variance using R (ANOVA) and means were compared by one-way ANOVA and post hoc test of Duncan in the agricolae, which differed significantly at 0.05 levels. (4.3.19) package program.

3. Results and Discussion

According to variance analysis of the plant growth parameters of maize cultivars exposed to drought conditions with effects of salicylic acid application and were given in Table 1 and Table 2.

Based on variance analysis, maize cultivars gave a statistically noteworthy effect on experimental parameters except MGT, GR and GI ($p<0.01$). Similarly, boosting drought conditions substantially affected the growth parameters ($p<0.01$), yet only root fresh weight was significantly influenced ($p<0.05$) except mean germination time, germination rate, germination index, seedling vigor index. Moreover, increasing salicylic acid application caused notable ($p< 0.01$) effect on root length. The mean germination time, shoot length, root fresh weight and root/shoot ratio were noteworthy influenced by the cultivars and enhancing drought level interactions. Closely, cultivars and increasing salicylic acid doses caused a statistically ($p<0.01$) substantial change in germination and growth parameters of maize. Enhancing drought and salicylic acid interaction conditions showed a meanful effect on parameters examined in the study, except root parameters. Furthermore, that application interactions did not cause a statistically noteworhty change in the SVI and RL. (Table 1 and 2).

Table 1. Results of variance analysis on germination and growth parameters of salicylic acid doses in maize cultivars exposed to drought stress levels

Source of Variance	df	Mean Germination Time	Germination Rate	Germination Index	Seedling Vigor Index	Shoot Length	Root Length
C	2	0.44	94.52	49.86	14.10**	15.36**	126.22**
DL	2	1.63	499.60	743.85	0.31	29.93**	11.21*
SA	2	2.71	545.83	836.50	0.43	0.924	15.71**
C*DL	4	2.61*	391.60	575.75	0.32	3.15**	6.42
C*S	4	4.07**	680.96**	1038.65**	0.63**	3.90**	18.01**
DL*SA	4	3.45*	744.63**	1066.59**	0.35*	1.41**	0.82
C*DL*SA	8	2.35*	487.58*	698.43*	0.19	2.73**	3.29

*Significant at the 0.05 probability level.**Significant at the 0.01 probability level. (Cultivar: C, Drought level: DL, Salicylic acid: SA)

Table 2. Results of variance analysis on growth parameters of salicylic acid doses in maize cultivars exposed to drought stress levels

Source of Variance	df	Shoot Fresh Weight	Root Fresh Weight	Total Biyomass	Root/ Shoot Rate
C	2	4704.56**	48207.30**	88454.20**	35.20**
DL	2	58221.45**	15150.19*	110460.07**	47.71**
SA	2	2181.80	4529.44	6267.86	1.31
C*DL	4	1675.62	9297.07*	13173.95	14.38**
C*S	4	5424.96**	13991.86**	26207.77**	5.95*
DL*SA	4	3367.59**	7564.95	17746.17*	8.99**
C*DL*SA	8	7122.54**	6931.35*	22977.06**	8.24**

*Significant at the 0.05 probability level.**Significant at the 0.01 probability level. (Cultivar: C, Drought level: DL, Salicylic acid: SA)

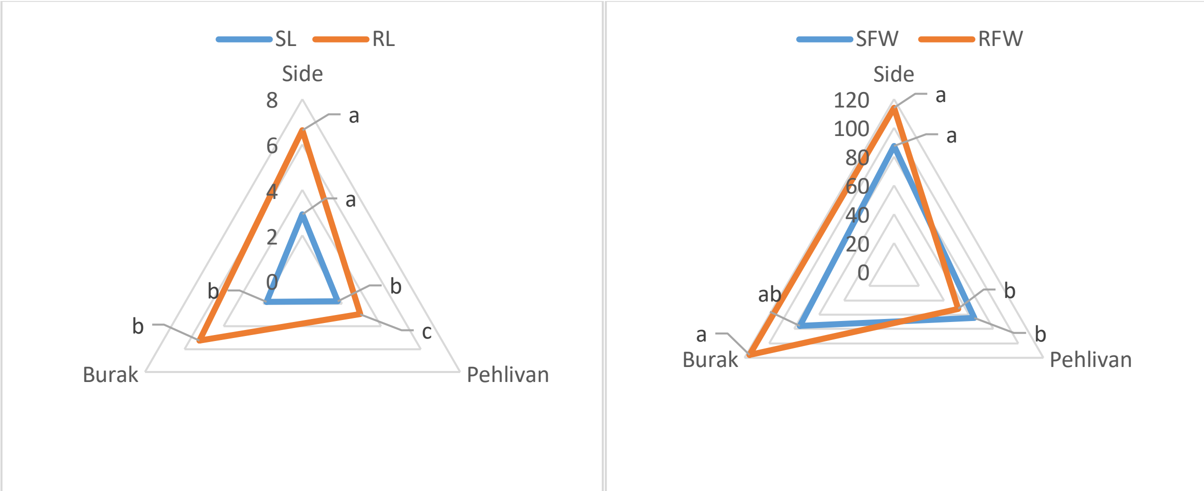

Figure 1. Effects of salicylic acid doses on growth of maize cultivars under drought conditions (Shoot length: SL, Root length: RL, Shoot fresh weight: SFW, Root fresh weight: RFW).

The effects of salicylic acid doses on germination and growth of maize cultivar exposed to drought stress were given in Figure 1 and Table 3. In this experiment investigated on silage maize cultivars, a distinction was recorded as expected. The unfavorable effects of drought stress on the growth, improving, and yield of maize is attached to the intensity of water deficit, growth stage and genotype (Ghassemi-Golezani et al. 2018).

In general, the best results were obtained in the Side cultivar. In this cultivar, shoot lenght was found almost half times higher than the others. Moreover, the root lengths were determined to be much longer than the shoot lengths. And, the root lengths were determined to be much longer than the shoot lengths. When examined in terms of fresh weight, the lowest averages were detected in Pehlivan, as expected based on observations of their length (Figure 1). The responses of the cultivars under stress conditions differ in terms of the parameters studied (Vishnupradeep et al., 2022)

Side was observed as an major cultivar from the standpoint of both component characteristics and germination speed, cause its mean germination time was the maximum. Germination rate and germination index were determined close and did not show a statistically substantial difference. It was stated that the difference between the root and shoot lengths of the Burak cultivar was high and therefore the R/S ratio was the highest, nevertheless the lowest total weight was found in this cultivar (Table 3).

Table 3. The effects of salicylic acid doses on growth parameters of maize cultivars exposed to drought stress levels

Cultivars	Mean Germination Time (day)	Germination Rate (%)	Germination Index (%)	Seedling Vigor Index (%)	Root/ Shoot Rate	Total Biyomass (mg)
Side	5.71	83.80	100.00	2.46a	2.66b	201.33a
Pehlivan	5.93	80.56	99.99	2.45a	2.08b	103.96b
Burak	5.88	82.18	97.96	1.37b	4.01a	168.76a

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.

The germination and growth parameters of maize cultivars under drought stress were displayed in Figure 2 and Table 4. As predicted, whilst the means were recorded at the superiorly in the control application, it was determined as the least in the PEG application at the dose of -0.8 MPa. The drought levels boosted as the growth declined. Some symptoms of drought stress lead to diminished leaf water content, loss of turgor pressure and stomatal closure, resulting in decreased cell and plant growth (Estaji and Niknam 2020). These negative effects adversely affect germination.

The parameters most affected by PEG-induced drought stress were noted as shoot length and fresh weight. Notwithstanding no large numerical difference was recorded in root lengths, it was found to be statistically noteworthy. Moreover, the maximum and minimum root fresh weight were obtained as 110.12 and 70.80 mg, respectively (Figure 1). The decreasing results of experiment were similar to the studies on plant height (Ye et al., 2016), fresh weight (Ghazi 2017; Shemi et al., 2021; Naz et al., 2021), root lenght (Bijanzadeh et al., 2019; Tanveer et al., 2023; Baltacier et al., 2023).

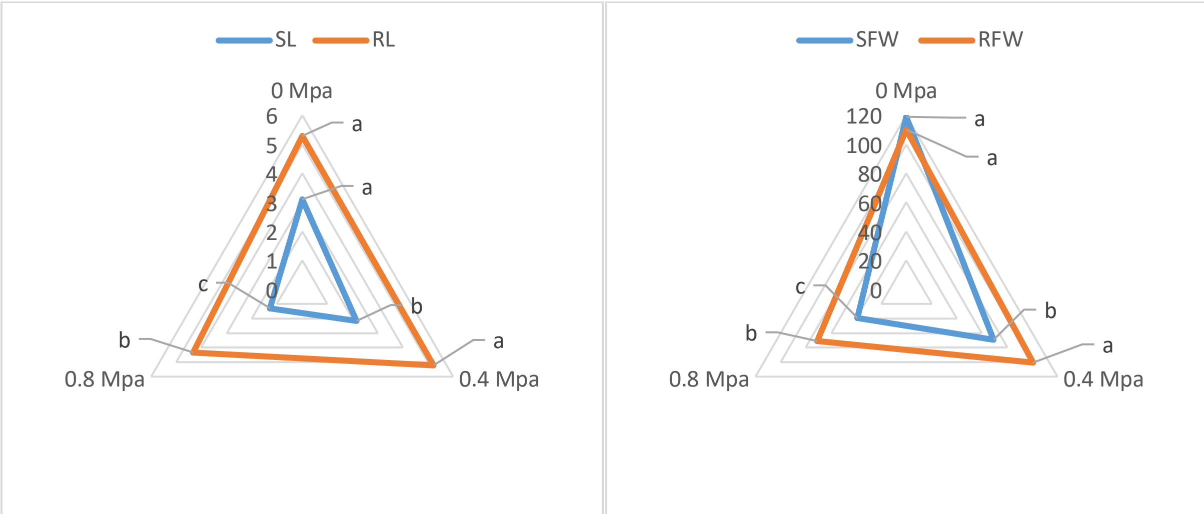

Figure 2. Effects of drought conditions on growth of maize cultivars (Shoot length: SL, Root length: RL, Shoot fresh weight: SFW, Root fresh weight: RFW).

Table 4. The growth parameters of maize cultivars exposed to salinity

Drought Level (MPa)	Mean Germination Time (day)	Germination Rate (%)	Germination Index (%)	Seedling Vigor Index (%)	Root/ Shoot Rate	Total Biyomass (mg)
0 MPa	5.73	86.34a	104.39a	2.20	1.82c	214.78c
-0.4 MPa	5.70	79.17b	95.60b	2.02	2.81b	155.16b
-0.8 MPa	6.08	81.02ab	97.95ab	2.20	4.12a	104.11c

Different letters next to values indicate statistically different means at $p<0.05$ level, and $p<0.01$ levels.

Interestingly, germination time was detected close to non-drought conditions with PEG at -0.4 MPa level, and even a little faster mean germination time in drought condition. On the contrary, the slowest germination was observed at the level of -0.8 MPa. The negative effects of drought conditions on plant growth criteria were determined, even the root/shoot ratio was approximately one in non-drought stress conditions, as it enhanced fourfold in the drought highest dose. Furthermore, this was another proof that the roots lengthen meanwhile the trunk shortens under stress conditions (Table 4). Droght produced a extraordinary reduction in germination percentage (Yilmaz and Kizilgeçi, 2022), germination index and seedling vigor index compared to control. Similar results of drought stress on germination were noted by Shatpathy et al. (2018), Ilyas et al. (2020) and Tanveer et al., (2023).

The corrective effect of low salicylic acid doses on maize cultivars germination and growth exposed to drought stress conditions were exhibited in Figure 3 and Table 5. The supreme means were obtained at 0.2 mM SA level. It was displayed that low doses impressed the growth criteria. The maximum shoot length was detected at 0.2 mM SA dose with 2.30 cm but that did not exhibit significant numerical differences. SA applications, on the other hand, did not have an effect on root length. Moreover, the best result of shoot fresh weight was recorded in 0.1 mM SA application, as root fresh weight gave the best in 0.2 mM SA application (Figure 3). The curative effect of salicylic acid in drought conditions was determined close to this research (Ghazi, 2017; Koo et al., 2020; Sohang et al., 2020; Shemi et al., 2021).

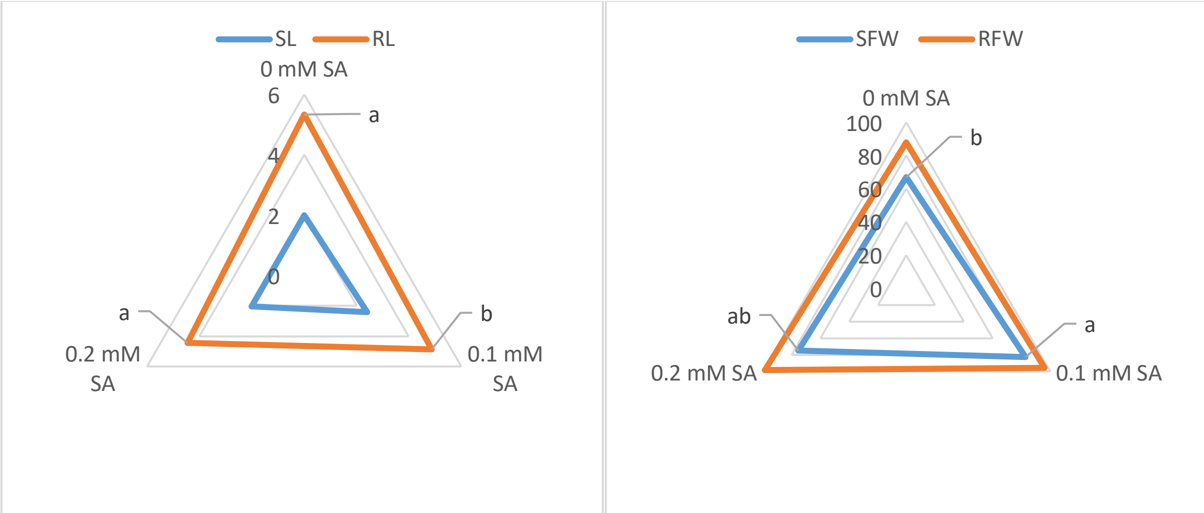

Figure 3. Effects of salicylic acid doses on growth of maize cultivars (Shoot length: SL, Root length: RL, Shoot fresh weight: SFW, Root fresh weight: RFW).

Table 5. The effects of salicylic acid doses on growth parameters of maize cultivars

Salicylic acid (mM)	Mean Germination Time (day)	Germination Rate (%)	Germination Index (%)	Seedling Vigor Index (%)	Root/ Shoot Rate	Total Biyomass (mg)
0 mM	5.99	85.19a	103.11a	2.19a	3.06	145.95
0.1 mM	6.00	83.57ab	100.94ab	2.12ab	2.70	156.00
0.2 mM	5.52	77.78b	93.89b	1.97b	3.00	172.10

Different letters next to values indicate statistically different means at p<0.05 level, and p<0.01 levels.

SA applications did not have much effect on mean germination time, germination time was found to be 5.84 days on average. The highest GR and GI levels occurred without SA administration. Moreover, the root/shoot ratios were not statistically different in general and were found to be approximately as 3 (Table 5). The application of low doses of salicylic acid reduces the effect of inhibiting germination in drought conditions, is also supported by other studies (Miura and Tada, 2014; Kulak et al., 2021). Salicylic acid increases water absorption in seeds. The use of salicylic acid prevented the destructive effects of drought stress on germination (Shatpathy et al., 2018; Bahrabadi et al., 2022) and growth (Tanveer et al., 2023; Sohang et al., 2020).

Table 6. Correlation of germination and growth parameters in maize cultivars

	MGT	GR	GI	SVI	SL	RL	R/L	SFW	RFW
GR	0.891**								
GI	0.899**	0.995**							
SVI	0.558**	0.622**	0.662**						
SL	-0.168	0.044	0.024	0.177					
RL	0.122	0.273**	0.219*	0.100	0.412**				
R/L	0.207*	0.095	0.068	-0.226*	-0.518**	0.327*			
SFW	-0.077	0.124	0.100	0.090	0.790**	0.308**	-0.491**		
RFW	-0.076	0.079	0.037	-0.119	0.500**	0.580**	-0.069	0.526**	
TB	-0.008	0.183	0.151	0.072	0.685**	0.552**	-0.267**	0.791**	0.854**

*Significant at the 0.05 probability level.**Significant at the 0.01 probability level. (Mean germination time: MGT, Germination Rate: GR, Germination index: GI, Seedling Vigor index: SVI, Shoot length: SL, Root length: RL, Root/shoot rate:R/S, Shoot fresh weight: SFW, Root fresh weight: RFW, Total biomass: TB).

The values of Pearson's correlation coefficients between germination and growth parameters of salicylic acid doses in maize cultivars exposed to drought stress levels were given in Table 6. RL had the most association with other parameters. The maximum relation was markedly positive and linked between GR and GI (r: 0.99, $p<0.01$). MGT was positively correlated with GR (0.891**), GI (0.899**), SVI (0.558**) and R/L (0.207*). Similarly, GR observed noteworthy positive correlations with GI, SVI and RL ($p<0.01$). In addition, a strong positive correlation was determined between GI and SVI (r: 0.662, $p<0.01$) and also moderate relation was reported between GI and RL (0.219*). Moreover, SL showed high positive association with RL, SFW, RFW and TB. Obviously, it substantially negatively correlated with R/L. That parameter did not have any significant correlation with germination parameters. Furthermore, R/L, SFW, RFW and TB exhibited strong relation with RL. A marked negative correlation was detected between SFW and TB. And also, RFW and TB showed noteworthy with SFW ($p<0.01$, Table 6).

4. Conclusion

As conclusion, PEG-6000 induced drought stress reduced germination and growth parameters. And, cultivars also were found to be different responses. The parameters examined in Side cultivar gave superior results exposed to drought conditions compared to other cultivars. Furthermore, noted that salicylic acid applications produced an boost in the parameters investigated under improving drought conditions. Thereby, thought that the different levels of drought and salicylic applications effect applied in the experiment on growth during the germination period may be beneficial for future research.

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Researchers Contribution Rate Declaration Summary

The authors declared that they have contributed to the article equally. All authors discussed the results and contributed to the final manuscript.

Statement of Conflict of Interest

Author has declared no conflict of interest.

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Macro Element Content of Herbage under Different Nitrogen and Phosphorus Fertilization in Savucak Rangeland

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The study was carried out in the rangeland of the Savucak village of Karakoçan district in Elazığ province in 2021 and 2022. The study aims to determine the macro element content of the herbage where five different nitrogen doses (0, 5, 10, 15, 20 kg da^{-1}) and phosphorus (0, 4, 8, 12, 16 kg da^{-1}) were applied. Macro element contents such as calcium (Ca), magnesium (Mg), potassium (K) and phosphorus (P) of dried and ground plants were determined. The research was carried out in randomized blocks with three replications following two-factor factorial experiment design. It was determined that the effect of increasing nitrogen doses on the macro element contents of the herbages was statistically significant, while the effect of the increasing phosphorus doses on the macro element contents of the herbages except phosphorus was statistically significant. It was observed that Ca, Mg, K, and P contents of herbage decreased with the increasing phosphorus, but they increased with the increase of nitrogen doses. It was determined that the Ca, Mg, K and P contents increased with the increase of the nitrogen dose, but the increase in the phosphorus ratio did not have any effect on the Ca, Mg, K and P contents of the pasture herbage. According to the results, it was concluded that 10 kg da^{-1} nitrogen and 4 kg da^{-1} phosphorus fertilization is appropriate in Elazig and rangeland with similar ecologies.

1. Introduction

In countries where animal husbandry is developed, mineral nutrients lost from the system due to herbage cut from meadow-pasture areas or grazing and this should be added to the system as input. Fertilization studies begun in the 19th century in order to increase the efficiency of meadows and pastures. Turkey's rangeland areas have been the main source of roughage for Anatolian livestock for centuries and it still maintains this feature. Rangelands of Turkey, for which no fertilization and improvement studies have been carried out for centuries, have been largely destroyed and lost their yield potential. Animals need food to survive. In our country, the roughage needs of livestock are met from meadows and pastures, forage crops grown in field agriculture and residues of agricultural products (Küçük et al. 2016).

One of the improvement methods applied to increase the productivity of rangelands is fertilization. Fertilization ensures that the mineral content of the plants in the meadow-pasture

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vegetation, which has sufficient quality forage plants in the vegetation, is balanced. Besides obtaining high-quality roughage for more animals from meadows and pastures, it is also possible to protect the soil with fertilization. However, in order to provide the expected benefits in fertilization in rangelands; It is necessary to determine the appropriate fertilizer type and dose, taking into account the botanical composition of the vegetation, the use of vegetation, the nutrient content of the pasture soil, the climatic conditions of the region where the pasture is located, and the economy of fertilization (Altın et al. 2005).

It is necessary to create better vegetation by improving the rangeland of Turkey and to feed the underground water resources by keeping the precipitation waters more (Altın et al. 2010). One of the most applied methods in rangeland improvement is fertilization. Considering the species composition of the vegetation and the precipitation, it is possible to increase the yield of the rangeland 2-3 times with an appropriate fertilization (Gökkuş and Altın 1986; Tükel et al. 1996; Altın et al. 2007). Nitrogen and phosphorus are the nutrients that are most deficient in the soil of our country and therefore affect the yield the most. The effectiveness of fertilizers varies according to the application time and amount of rain fertilizer (Çomaklı et al. 2005).

In addition to the botanical compositions of the pastures, the chemical content of the existing plants in the pasture or the herbage obtained from these plants should also be known. Quality roughage is of great importance in animal nutrition, and the quality of the feed varies according to the content of sufficient nutrients and mineral elements and their ratio in the feed. The feed value of pasture plants, in other words their nutrient and mineral element contents, varies according to the botanical composition of the grass (legumes, grasses and other families), soil and climate characteristics and utilization (grazing) factors. Quality herbage is consumed and digested more by animals, and even quality herbage is digested more in the digestive system of animals than low quality herbages (Ensminger et al. 1990).

In this study, it was aimed to determine the effect of five different nitrogen (0, 5, 10, 15 and 20 kg da^{-1}) and phosphorus doses (0, 4, 8, 12 and 16 kg da^{-1}) combined on the macro element content of the grasses of a natural pasture in the Savucak village of Karakoçan district in Elazig.

2. Material and Methods

The research was established in the rangeland of Savucak village, Karakoçan District of Elazığ Province, in the vegetation period of 2021-2022 and 2022-2023. In the study, the effects of five different nitrogen (0, 5, 10, 15 and 20 kg da^{-1}) and five different phosphorus doses (0, 4, 8, 12 and 16 kg da^{-1}) and the combinations of these doses on the macro element contents of the pasture herbages were investigated in both vegetation periods. Urea (46% N) was used as nitrogen fertilizer and TSP (44% triple super phosphate) fertilizer was used as phosphorus fertilizer. Nitrogen fertilization was done in spring and phosphorus fertilization was done in autumn in both years. The research was established in randomized blocks according to the two-factor factorial design with three replications. The research area consisted of 10 x 10 m = 100 m^2 and a total of 25 plots, one plot for each combination. For each application and combination, the plot size was 2 x 2 = 4 m^2.

The analysis of the soil sample taken from 0-30 cm depth of the land subject to the research was carried out in the laboratories of the Department of Soil Science and Plant Nutrition, Faculty of Agriculture, Bingöl University. According to the results of the analysis, it was determined that the research area has a clay-loam soil structure, there is no salinity problem and the soil pH is neutral. It was determined that the organic matter and nitrogen content were moderate, the lime and phosphorus content was low and the potassium content was sufficient. According to the data received from the Elazığ Meteorology Directorate; It was determined that the Karakoçan district of Elazığ province was warmer, less rainy and less humid in the years when the research was conducted.

At the end of May, which coincides with the beginning of the head of the dominant plant groups in the rangeland area in 2021 and 2022, three randomly determined areas in each plot were harvested in three replications with the help of a 33 x 33 cm quadrat frame (Çaçan and Başbağ 2019). After the cut herbage samples were dried in an oven at 78°C for 24 hours, they were ground and made ready for analysis (Cinar et al. 2020). In the study, ICP-MS device (Inductively Coupled Plasma-Mass Spectroscopy) was used to determine the calcium (Ca), magnesium (Mg), potassium (K) and phosphorus (P) contents of pasture herbages (Başaran et al. 2021).

Analysis of variance was applied to the combined data of the two years obtained from the study, using the JMP statistical package program in accordance with the two-factor factorial experiment design in randomized blocks with three replications. The differences of the groups were compared according to LSD test and P≤0.05 significance level (JMP, 2018).

3. Results and Discussion

The effect of nitrogen fertilization on all the macro element contents, phosphorus doses on the Ca, Mg and K contents, and the nitrogen × phosphorus interaction on the Ca, K and P contents of the herbage are statistically significant.

The effect of different nitrogen doses on the Ca, Mg, K and P contents of the pasture herbage is significant and the lowest values were obtained from the control group and the plots that fertilized by 5 kg da^{-1} nitrogen. The highest Ca, Mg, K and P contents were obtained from the plots fertilized 10, 15 and 20 kg da^{-1} nitrogen. It is seen that the highest P rates in terms of Ca, Mg, K and P were obtained from the control group and the plots fertilized 4 kg da^{-1} phosphorus. However, P, unlike N, gave its lowest values in all the remaining applications. It has been determined that the interaction of different nitrogen and phosphorus doses is important for all four macro element contents of pasture herbages. It is seen that the macro element contents decrease systematically with the increase of the nitrogen and phosphorus doses in the combination (Table 1).

Table 1. Macro element contents of pasture herbages of different nitrogen and phosphorus applications (%)

Calcium (Ca)						
Nitrogen/ Phosphorus	**P0**	**P4**	**P8**	**P12**	**P16**	**Average**
N0	1.30 ab	0.97 c	1.00 ab	1.00 ab	1.07 ab	**1.06 B**
N5	1.05 ab	1.29 ab	1.01 ab	1.04 ab	0.97 c	**1.07 B**
N10	1.30 ab	1.39 a	1.06 ab	1.03 ab	1.00 ab	**1.16 AB**
N15	1.12 ab	1.25 ab	1.36 ab	1.20 ab	1.08 ab	**1.20 A**
N20	1.21 ab	1.25 ab	1.16 ab	1.14 ab	1.19 ab	**1.19 AB**
Average	**1.20 AB**	**1.23 A**	**1.12 B**	**1.08 BC**	**1.06 C**	
Magnesium (Mg)						
Nitrogen/ Phosphorus	**P0**	**P4**	**P8**	**P12**	**P16**	**Average**
N0	0.28	0.28	0.27	0.25	0.24	**0.26 C**
N5	0.30	0.26	0.31	0.26	0.26	**0.28 B**
N10	0.29	0.35	0.30	0.27	0.26	**0.29 AB**
N15	0.35	0.34	0.32	0.32	0.30	**0.33 A**
N20	0.30	0.34	0.35	0.33	0.32	**0.33 A**
Average	**0.30 A-C**	**0.32 A**	**0.31 B**	**0.29 BC**	**0.28 C**	
Potassium (K)						
Nitrogen/ Phosphorus	**P0**	**P4**	**P8**	**P12**	**P16**	**Average**
N0	2.62 a-e	2.18 e	2.28 de	2.66 a-e	2.49 c-e	**2.44 C**
N5	3.01 a-c	2.76 a-e	2.76 a-e	2.75 a-e	2.49 c-e	**2.76 B**
N10	3.19 a	3.16 a	2.87 a-d	2.66 a-e	2.65 a-e	**2.91 AB**
N15	2.98 a-c	2.53 b-e	3.11 ab	2.67 a-e	2.75 a-e	**2.81 AB**
N20	3.03 a-c	3.09 ab	3.10 ab	2.96 a-c	2.84 a-d	**3.00 A**
Average	**2.97 A**	**2.83 AB**	**2.74 B**	**2.74 B**	**2.64 B**	
Phosphorus (P)						
Nitrogen/ Phosphorus	**P0**	**P4**	**P8**	**P12**	**P16**	**Average**
N0	0.36 ab	0.36 ab	0.30 b	0.30 b	0.36 ab	**0.34 B**
N5	0.38 a	0.34 ab	0.36 ab	0.34 ab	0.34 ab	**0.35 B**
N10	0.41 a	0.38 ab	0.35 ab	0.39 a	0.37 ab	**0.38 A**
N15	0.38 a	0.39 a	0.41 a	0.39 a	0.37 ab	**0.39 A**
N20	0.36 ab	0.41 a	0.38 ab	0.38 a	0.37 ab	**0.38 A**
Average	**0.38**	**0.38**	**0.36**	**0.36**	**0.36**	

Means shown with the same letter are statistically indistinguishable from each other within the error limits of P≤ 0.05 according to Duncan test.

In studies conducted to determine the chemical content of grasses obtained from pastures, it is reported that the chemical compositions of the pasture feed generally vary according to the type of plant they contain, the botanical composition of the vegetation, climate and soil characteristics, and the time of sampling (Kaya et al. 2003; Bayraktar 2012; Çetiner et al. 2012; Gökkuş et al. 2013; Polat and Bayraklı 2019).

The results obtained regarding the calcium contents of pasture herbages are among the limit values reported by Kacar (1984) as 0.10-10.0% for plants. While Bayraktar (2012) determined the calcium content of herbages in the grasslands at different elevations to be 0.36-0.65% and 0.27-0.74% in the herbages in the forest pastures, Aydın and Başbağ (2017) determined the calcium content of the herbages at different elevations as 1.09%.

In previous studies, it has been reported that the magnesium content of plants varies between 0.02% and 2.50%, and this value is between 0.059% and 0.316 in meadow plants (Kacar 1984). Considering that the magnesium ratio that some quality forage crops should contain should be in the range of 0.04-0.08% (Okuyan et al. 1986), it can be said that the results obtained in terms of magnesium content in the pasture herbages examined as a result of the research are more than sufficient.

It is known that the potassium content of plants varies between 0.2% and 11% in dry matter (Kacar 1984). It is seen that the pasture herbage in which the research was conducted is within the general limits specified in terms of potassium content. In the study carried out to determine the herbages quality of the pastures located at different elevations of Diyarbakır/Karacadağ, the potassium ratio of the pasture herbage was determined as 2.42% (Aydın and Başbağ 2017).

It is seen that the average 0.34-0.39% phosphorus ratios obtained for the P content of pasture herbages are within the limit values determined as 0.16-0.38% for sheep (NRC 2007) and 0.17-0.59% for cattle (NRC 2000). In the study carried out by Aydın and Başbağ (2017) to determine the herbage quality of the pastures at different elevations, the phosphorus rate of the pasture grass was determined as 0.34%.

In the study conducted to determine the macro element contents of some plants in the pastures, it was reported that the Ca, Mg and K contents of the pasture plants were determined as 1.00%, 2391 ppm and 3.85%, respectively (Bakoğlu et al. 1999). In the study conducted to determine the nutritional value of herbage in a pasture where fertilizer was applied, the Mg and K contents were determined as 2.46 g kg^{-1} and 21.44 g kg^{-1}, respectively, in 2007, and 2.57 g kg^{-1} and 24.10 g kg^{-1}, respectively, in 2008 (Ayan et al. 2010). On the other hand, in the study conducted to determine the nutritional values of the herbages of the highland pastures with traditional grazing, it was reported that the K and Mg contents of the pasture herbages were determined as 2.4% and 2687 ppm, respectively (Çomaklı et al. 2008).

In the study, it is seen that the opposite is the case with the increase in nitrogen doses, where the Ca, Mg, K and P contents of pasture herbage decrease with the increase in phosphorus doses. In some previous studies, it was reported that the Ca and Mg contents of pasture herbage decreased with the increase of nitrogen doses, but the K content did not change (Algan and Aydın 2015; Algan et al. 2016). On the other hand, it was reported that N and P fertilization increased the K content in some studies (Algan and Aydın 2017; Kacorzyk and Głąb 2017). Turk et al. (2007) reported that with increasing nitrogen doses, the K content of the herbages increased and the Mg content decreased. Aydın and Uzun (2008) reported that N, K and Mg fertilization and their combinations in pastures increased Ca and Mg contents and decreased K content of pasture herbage. Çaçan and Kökten (2023), reported that the Ca, Mg, K, and P contents of pasture herbage decreased systematically with the increase of nitrogen and phosphorus doses.

4. Conclusion

According to the research results, it was determined that the effect of fertilization with different nitrogen and phosphorus doses on the macro element contents of pasture herbage was statistically significant. In the study, it was determined that the macro element contents of the herbages, except P, decreased with the increase of the phosphorus doses, and the macro element contents increased with the increase of the nitrogen doses. Therefore, considering the ecological conditions of the region where the research was conducted, it is seen that 10 kg da^{-1} nitrogen and 4 kg da^{-1} phosphorus fertilization is appropriate in terms of meeting the roughage needs of animals and making fertilization economical.

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