World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Effects of different organic and chemical fertilizers on pasture biomass and botanical composition in Bolu-Aladağ

Özcan AKIN * and Mehmet ÖZCAN

Department of Watershed Management, Faculty of Forestry, Düzce University, 81620, Düzce Türkiye.

World Journal of Advanced Research and Reviews, 2026, 30(01), 2094-2102

Publication history: Received on 14 March 2026; revised on 19 April 2026; accepted on 22 April 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.1.1066

Abstract

This study investigates the effects of various fertilizer sources on the biomass yield of vegetation to enhance the productivity and sustainable management of pasture ecosystems. The research was conducted in the pasturelands of the Aladağ Forest Management Directorate in Bolu, Turkey, using a Randomized Complete Block Design with three replications. The treatments—including control, chemical fertilizer, varying doses of liquid vermicompost, and sheep manure—were analyzed based on their impacts on grasses (Poaceae), legumes (Fabaceae), and other botanical families.

The results demonstrated that chemical fertilization accelerated vegetative growth, yielding the highest biomass particularly within the grasses family (438,331 g/m^2). In the legumes family, sheep manure and low-dose vermicompost provided sustainable results competitive with chemical fertilization. While "other families," representing low-quality and invasive species, remained dominant in unfertilized control plots, fertilization was found to suppress these groups, providing a competitive advantage for high-quality forage plants. Furthermore, yield variations across blocks highlighted the restrictive role of locational factors on fertilizer efficiency. In conclusion, the selection of fertilizer sources based on the target botanical composition is of critical importance in pasture improvement strategies.

Keywords: Pasture Rehabilitation; Biomass Yield; Vermicompost; Sustainable Management; Fertilization

1. Introduction

Pasturelands cover approximately 80 million square kilometers globally and constitute more than 54% of the terrestrial surface, representing the most extensive land-use type on Earth. These vast ecosystems support the food security and economic well-being of nearly two billion people, either directly or indirectly, particularly in regions where livestock-based livelihoods are prevalent [1]. Meadows and pastures are generally natural plant communities that have adapted to the specific climatic and soil conditions of a given region. This vegetation structure primarily consists of a rich floristic composition dominated by perennial grasses and legumes, while also incorporating annual herbs and occasional woody species such as shrubs or small trees [2].

The vegetation in these areas is shaped by the process of "succession." Throughout the developmental stages, the soil structure and plant communities evolve through mutual interaction, reaching the "climax vegetation" level, which represents the most stable stage achievable under given environmental conditions. However, at every stage, the vegetation remains under the influence of abiotic factors such as precipitation and temperature, as well as biotic factors like grazing pressure [3]. Improper usage patterns can lead to the loss of the superior production capacity and ecosystem balance of these pastures. Consequently, the primary objective in scientific pasture management is to ensure sustainability by maintaining the vegetation at a level as close as possible to the biological and ecological climax [4].

* Corresponding author: Özcan AKIN

Beyond serving as the primary source of roughage for livestock activities and a safeguard for animal health, meadows and pastures hold critical importance due to their multifaceted ecological, environmental, and socioeconomic functions [4,5]. These vast ecosystems play a central role in vital processes such as the preservation of biodiversity, carbon sequestration, oxygen production, and the regulation of the water cycle [6,7]. Simultaneously providing functions such as erosion prevention, maintenance of soil fertility, and the provision of suitable habitats for wildlife and beekeeping, these areas integrate ecosystem sustainability and the socioeconomic structure through the recreational opportunities offered by their aesthetic appeal [4].

Since pasture ecosystems are built upon a delicate balance shaped by the interaction of numerous biotic and abiotic factors—such as climate, soil structure, topography, vegetation, animals, and human intervention—any degradation within these systems can reach a point that threatens the sustainability of the entire ecosystem [5].

Despite the strategic importance of pasturelands, these areas have increasingly become a shrinking life zone today. Human-induced factors, such as changes in land use, agricultural intensification, and shifting precipitation regimes due to global warming, pose a severe threat to grazing lands [2]. However, the degradation observed in pastures is not limited solely to human- and animal-centric impacts. Climate change, which has intensified in recent years, has become a fundamental element directly threatening pasture ecosystems. These climatic irregularities hinder the development of pasture vegetation, lead to disruptions in species composition, cause biodiversity losses, and result in significant declines in forage quality [5].

The totality of technical, cultural, and physical interventions applied to increase the capacity of low-productivity pastures, improve the quality of the obtained forage, and ensure that animals benefit from this vegetation at the highest level is defined as "pasture improvement." In improvement studies, the primary priority is to enhance the quantity and quality of forage produced per unit area, while the ultimate goal is to achieve the most efficient conversion of this produced resource into animal products [8, 9].

Pastures are not merely forage production areas, but are critical life-support systems that provide habitats for wildlife, protection for water basins, recreational opportunities, and aesthetic values [10, 11]. From an ecological perspective, these areas have the potential to produce forage of the highest quality and quantity through their climax vegetation structure. However, changes in environmental conditions that hinder plant growth or interventions carried out without considering ecosystem principles cause the efficiency of nutrient cycling and energy flow between system components to decline. With the disruption of this balance, the vegetation cannot maintain its peak state; a process of thinning and withdrawal from the vegetation begins, starting with the most high-quality species [4,9,12].

Healthy and well-managed pastures exhibit a more productive, resilient, and stable structure, providing significantly higher ecosystem services and economic gains compared to degraded or weak pastures [11, 13-15].

Among the improvement methods applied to increase grazing capacity and enhance the quality of vegetation in pastures, fertilization is one of the techniques that yields the fastest and most effective results. The natural recycling of plant nutrients removed from pastures through grazing or mowing remains insufficient, particularly in areas under intensive use. This situation leads to the gradual depletion of nutrients in the soil and the thinning of the vegetation over time.

Fertilization activities in pasture improvement not only increase dry matter yield but also optimize the ratio of desirable species (legumes and high-quality grasses) within the botanical composition. However, at this point, it is a fundamental necessity for sustainability that the fertilization strategy to be applied is planned according to the pasture type, soil structure, and climatic characteristics.

2. Materials and methods

The Aladağ Forest Management Chiefdom, under the Aladağ Forest Management Directorate located in Bolu, Türkiye, was determined as the study area. Within the general area of 9152 ha of the Aladağ Forest Management Chiefdom, 7745,80 ha consist of forested areas, while 1406,20 ha are non-forested lands comprising highlands with meadows and pastures (Figure 1) [16]. The soil structure is an andesite massif [17], and the pH value exhibits moderately acidic characteristics [18].

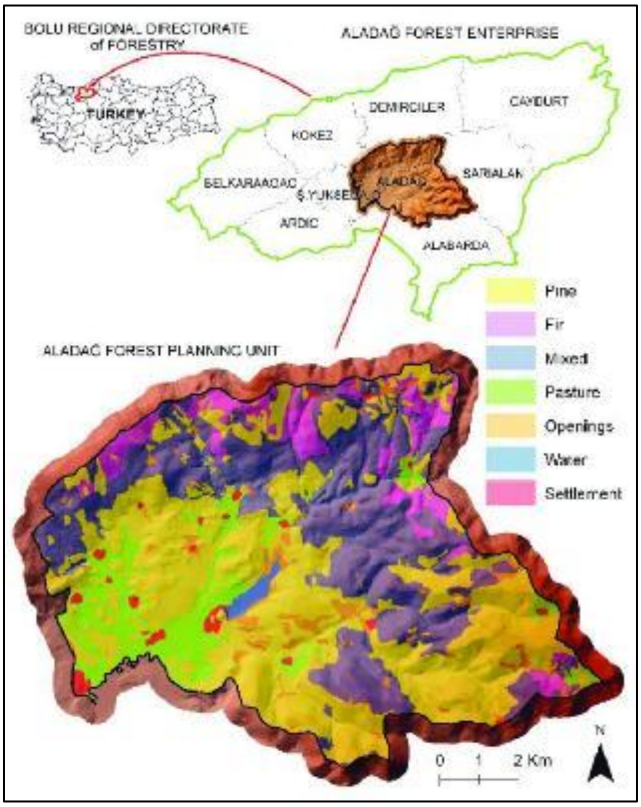

Figure 1 Location of the study area [16]

The research was established in a randomized complete block design with 3 replications on 30 plots, each measuring 5x4=10 m^2. Control, chemical fertilizer, vermicompost, and sheep manure Treatments were carried out in each block (Figure 2). Chemical fertilizer was applied to the soil at rates of 10-15 kg/da N and 5-7.5 kg/da P_2O_5, as recommended for the Black Sea Region, while farmyard manure was applied at 1000-1200 kg/da [9]. Liquid vermicompost was applied foliar-wise at doses of 500 cc/da and 1000 cc/da. At the end of the vegetation period, above-ground biomass samples were collected using quadrats of 0,25 m^2, brought to the laboratory, and dried in an oven at 50°C. .

Since the data did not show a normal distribution, square root transformation was applied to the biomass values of the grass and legume families, and logarithm transformation was applied to the other family to ensure normality. Following these transformations, the data were tested using multivariate analysis of variance (univariate) with the SPSS25 computer program. Differences between means were compared using the Duncan test, a multiple comparison test.

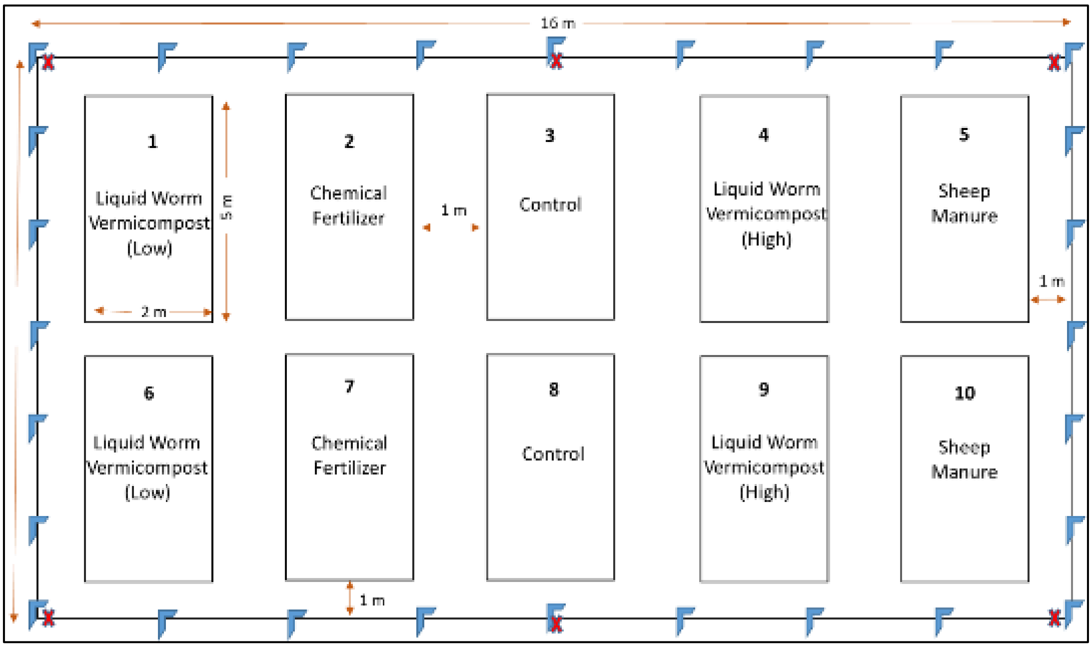

Figure 2 Schematic representation of the experimental field layout, plot dimensions, and spatial distribution of treatment groups.

3. Results and discussion

3.1. Data on The Grasses Family (Poaceae)

The Univarete test revealed statistically significant differences in the aboveground biomass yield of the grasses family both among blocks (Figure 3), treatments (Figure 4) and block*treatment interaction (Table 1) ($p < 0,05$). Based on the block-level evaluation, Blocks 1 and 3 exhibited similar and high yield values, while Block 2 significantly differed with a lower yield performance. Detailed analysis of the Table 1 data shows that chemical fertilizer reached the highest yield across all blocks, representing the peak performance level in Block 3 with 438,331 g/m^2.

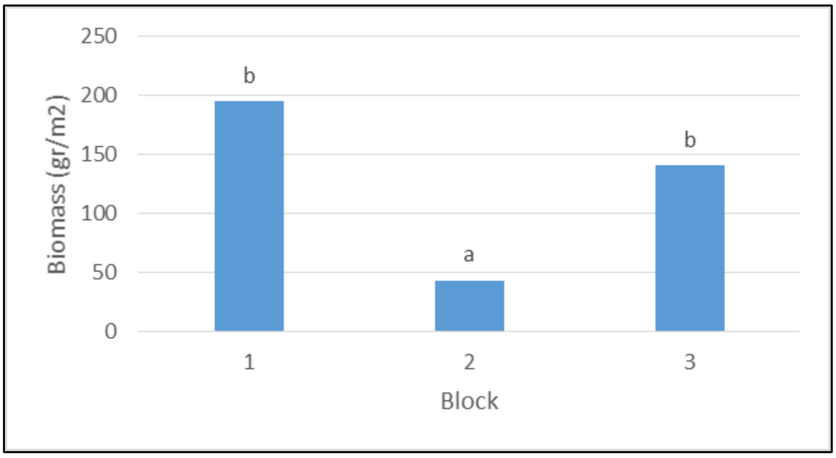

Figure 3 Effect of fertilizer treatments on yield of grass family on a block basis

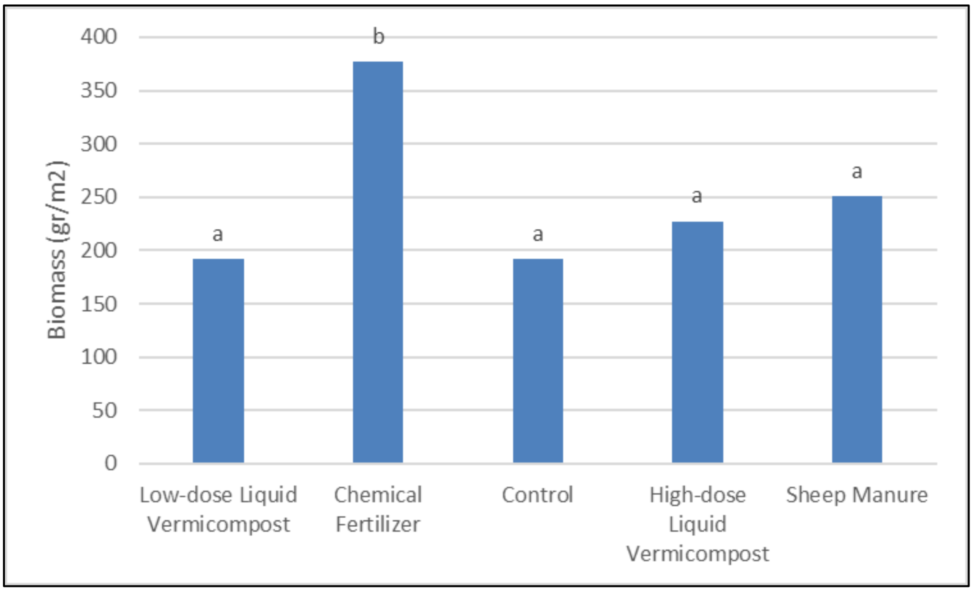

Figure 4 Effect of fertilizer treatments on yield of grass family on a treatment basis

Table 1 Effect of fertilizer treatments on yield of grass family on a block*treatment intreaction

Block / Treatment	Low-dose Liquid Vermicompost	Chemical Fertilizer	Control	High-dose Liquid Vermicompost	Sheep Manure
Block 1	288,035[b]	430,516[c]	205,141[b]	305,283[b]	234,904[b]
Block 2	76,246[a]	262,255[b]	69,494[a]	62,978[a]	80,316[a]
Block 3	211,891[b]	438,331[c]	300,707[b]	313,756[b]	437,316[c]

These findings align with literature stating that nitrogen fertilization increases forage production and raises the proportion of grasses within the botanical composition [19-21]. The increase provided by chemical fertilization can be attributed to the rapid availability of inorganic nutrients for plant uptake [22]. Conversely, the fact that most treatments in Block 2 remained in the lowest yield group confirms that the expected benefits of fertilization are highly dependent on localized factors such as soil moisture or site-specific conditions.

3.2. Data on the legumes family (fabaceae)

Univariate test results indicated statistically significant differences between blocks ($p < 0.05$) (Figure 5), but no statistically significant difference between treatments and the block*treatment interaction. ($p > 0{,}05$). However, a one-way analysis of variance (ANOVA) revealed a statistically significant block-treatment interaction ($p<0.05$), and a significant difference was identified between the blocks (Table 2). Regarding general fabaceae family yields by block, Block 1 stood at the peak with the highest biomass yield, while Block 2 remained in the lowest yield group, dropping to levels as low as 23,740 g/m^2 (High-dose Liquid Vermicompost) (Table 2).

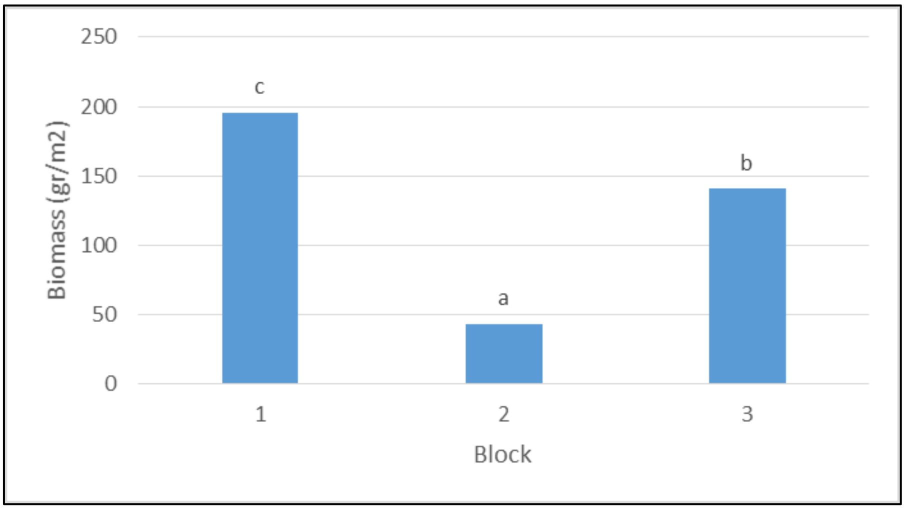

Figure 5 Effect of fertilizer treatments on yield of legumes family on a block basis

Table 2 Effect of fertilizer treatments on yield of grass family on a block*treatment intereaction

Block / Treatment	Low-dose Liquid Vermicompost	Chemical Fertilizer	Control	High-dose Liquid Vermicompost	Sheep Manure
Block 1	196,702^{c}	205,339^{c}	193,529^{c}	187,008^{c}	195,942^{c}
Block 2	52,080^{a}	54,150^{a}	39,422^{a}	23,740^{a}	47,153^{a}
Block 3	145,873^{b}	133,312^{b}	161,100^{b}	145,386^{b}	119,308^{b}

Literature frequently emphasizes that nitrogen fertilization tends to decrease the legume ratio, thereby potentially reducing forage quality [23-25]. In this study, it was observed that while chemical fertilization dominated the grasses, legume development remained secondary to locational factors (block differences). The performance of sheep manure and low-dose vermicompost on legume biomass can be linked to the positive effect of organic materials on vegetation content [26]. The sharp decline observed in the high-dose vermicompost confirms that dosage increases do not always correlate linearly with yield and that botanical composition must be carefully considered [27].

3.3. Data on other families

According to the Univariate results, although there was no significant difference between blocks and treatments ($p > 0.05$), a difference was observed between the control plot and the other plots. The unfertilized control plot exhibited generally higher biomass values for other families, reaching its highest level in Block 1 with 69,400 g/m2. In addition, chemical fertilization and low-dose vermicompost treatments significantly suppressed this family (Table 3). Without any intervention, invasive or low-quality species become dominant in the pasture area. This proves that "no intervention" is not an option for pasture improvement.

Table 3 Effect of fertilizer treatments on yield of other family on a block*treatment intereaction

Block / Treatment	Low-dose Liquid Vermicompost	Chemical Fertilizer	Control	High-dose Liquid Vermicompost	Sheep Manure
Block 1	35,588	31,138	69,400	33,091	41,342
Block 2	34,907	23,242	36,770	40,340	33,330
Block 3	31,222	35,300	47,786	47,478	32,252

This situation is consistent with [28] who reported that in unfertilized pastures, high-quality species decrease and are replaced by low-quality species adapted to poor conditions. In fertilized plots, particularly with chemical fertilizer, the suppression of other families supports literature suggesting that fertilization strategies create a competitive advantage for desirable species (grasses/legumes) while inhibiting weeds [19,29]. Ultimately, it is evident that fertilization which does not improve botanical composition cannot maintain its impact long-term [4] highlighting the critical role of proper fertilization in suppressing "other families."

4. Conclusion

The effects of different fertilizer sources on pasture vegetation reveal that the botanical composition underwent significant changes in terms of both quality and quantity depending on the Treatments.

- **Grasses and Legumes Dominance:** It is observed that chemical fertilizer and high-dose vermicompost treatments provided a significant increase in grass and legume families compared to the control plot. This demonstrates that nutrient supplementation directly enhances the high-quality forage value of the meadow.
- **Control Plot and Other Families:** It is noteworthy that the biomass of other families (weeds) remained high in the control plot, where no fertilization was applied. This finding suggests that invasive or low-quality species more easily occupy space in the meadow without fertilization, whereas fertilization (especially with chemical and animal-based fertilizers) enables cultured species to gain competitive power and suppress these groups.
- **Comparison of Fertilizer Sources:** Sheep manure and high-dose vermicompost showed competitive yields with chemical fertilizer in the legume family, highlighting the potential of organic fertilization in pasture improvement. Particularly, the high performance of sheep manure in fabacea family yield in the 3rd block (437,316 g/m^2) points toward the lasting and sustainable impact of animal-based fertilizers.
- **Block Effect:** The overall lower yields observed in Block 2 across all families indicate that locational factors play a restrictive role on yield, independent of fertilizer effectiveness.

Compliance with ethical standards

Acknowledgments

The first author was supported by the YÖK 100/2000 scholarship (Climate Change Priority Area).

This study was supported by the Scientific Research Projects Coordination Office under the LÜTEP (Graduate Learning Thesis Projects) no. 2023.02.02.1397, titled “Effects of Different Breeding Methods on Plant Growth and Carbon Sequestration in the Soils of Bolu Aladağ Grassland”.

We would like to thank the Presidency of YÖK and the Rectorate of Düzce University for their contributions.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this paper.

Authors' contributions

The first author conducted field setup, sample collection, analyses, literature review, and writing. The second author conducted field setup, analyses, revisions, and approved the final version.

References

[1] UNCCD. Global land outlook thematic report on rangelands and pastoralism. United Nations Convention to Combat Desertification; 2024.

[2] Gibson DJ, Newman JA. Grassland and climate change: An overview. In: Gibson DJ, Newman JA, editors. Grasslands and Climate Change. Cambridge: Cambridge University Press; 2019. p. 1-15.

[3] Holechek JL, Pieper RD, Herbel CH. Range management: Principles and practices. 6th ed. Pearson; 2011.

[4] Altın M, Gökkuş A, Koç A. Rangeland and pasture management. 2nd ed. Ankara: Republic of Türkiye Ministry of Agriculture and Forestry; 2025. [Turkish].

[5] Şen C, editor. Rangeland and pasture management. Ankara: Akademisyen Yayınevi; 2025. [Turkish].

[6] FAO. Pasture and fodder systems under climate change. Rome: Food and Agriculture Organization of the United Nations; 2018.

[7] Gökkuş A. Forage plants of meadows and pastures. Erzurum: Atatürk University Faculty of Agriculture Publications; 1999. [Turkish].

[8] Altıntaş G, Altıntaş A, Çakmak E, Demir O. A research on the sustainability of improved pastures: Case of Sivas-Amasya-Tokat]. Tarım Ekonomisi Araştırmaları Dergisi. 2018;4(2):1-16. [Turkish].

[9] Altın M, Gökkuş A, Koç A. Rangeland and pasture improvement. 2nd ed. Ankara: Palme Yayınevi; 2021. [Turkish].

[10] Gökkuş A, Koç A. Rangeland and pasture management. Erzurum: Atatürk University Faculty of Agriculture; 2001. (Lecture Publications No. 228). [Turkish].

[11] Özyazıcı MA, Yavuz T, Sürmen M. Rangeland management: General principles of rangeland management. In: Şen C, editor. Rangeland and pasture management . Ankara: Akademisyen Kitabevi; 2025. p. 93-122. [Turkish].

[12] Tükel T. Sustainable use management of natural resources. Istanbul: Cinius Yayınları; 2021. [Turkish].

[13] Oesterheld M, Sala OE, McNaughton SJ. Effect of animal husbandry on herbivore carrying capacity at the regional scale. Nature. 1992;356:234-236.

[14] Wessels KJ, Prince SD, Carroll M, Malherbe J. Relevance of rangeland degradation in semi-arid northeastern South Africa to the non-equilibrium theory. Ecological Treatments. 2007;17:815-827.

[15] Teague WR, Dowhower SL, Baker SA, Haile N, DeLaune PB, Conover DM. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. Agriculture, Ecosystems & Environment. 2011;141:310-322.

[16] Gürkan M, Zengin H, Özcan M, Değermenci AS. Determining plant species diversity of Scots pine stands in the Bolu Aladağ region of Türkiye. BOSQUE. 2023;44(1):65-8.

[17] Duyar A. Seasonal variation of soil arthropods (Arthropoda) in fir (Abies bornmulleriana Mattf.) ecosystems in Bolu-Aladağ [PhD Thesis]. Istanbul: Istanbul University, Graduate School of Natural and Applied Sciences; 2014. [Turkish].

[18] Kantarcı MD. Researches on the phenomenon of clay transport and accumulation in soil section under temperate climate conditions. Istanbul University Journal of the Faculty of Forestry. 1980;30(2):156-190. [Turkish].

[19] Cosper HR, Thomas JR, Alsayegh AY. Fertilization and its effect on range improvement in the northern great plains. J Range Management. 1967;20:216-222.

[20] Büyükburç U. Researches on the possibilities of improvement of pastures in Yavrucak Village of Ankara through fertilization and resting. [Associate Professorship Thesis]. Ankara: Rangeland Pasture and Forage Crops Research Institute; 1980. [Turkish].

[21] Tükel T, Hatipoğlu R. A research on the effects of burning and nitrogen fertilization at different times on the yield and botanical composition of a natural rangeland dominated by Hyparrhenia hirta L. Staff under Çukurova conditions. Doga Journal. 1989;13:438-449. [Turkish].

[22] Jacobsen JS, Lorbeer SH, Houlton HAR, Carlson GR. Nitrogen fertilization of dryland grasses in the northern great plains. Journal of Range Management. 1996;49(4):340-346.

[23] Manga İ, Altın M, Gökkuş A. The effects of long-term fertilizer applications on the yield, vegetation and some soil characters of ranges of Erzurum. Doga Journal of Agriculture and Forestry. 1986;10(2):235-243. [Turkish].

[24] Aydın İ, Uzun F. Effects of different improvement methods on yield and botanical composition of natural pasture in Salur Village of Ladik Town. Turk J Agric Forestry. 2000;24:301-307. [Turkish].

[25] Uslu SÖ, Hatipoğlu R. Effects of Different Fertilizer Treatments on Rangeland Yield and Botanical Composition in Yeniyapan Rangeland of Araplar Village, Türkoğlu District, Kahramanmaraş. Türkiye VII. Field Crops Congress; 25–27 June 2007; Erzurum, Türkiye. p. 50–53. [Turkish].

[26] Vintu V. Increase in Yields of Festuca valesiaca Pastures in the Jiia-Bahlui Basin with Organic and Mineral Fertilizer Treatments. Cercetari Agronomice in Moldova. 1993;26(1-2):110-116.

[27] Kökten K, Çaçan E, Özdemir S. The effect of fertilization on botanical composition in meadows and rangelands. ISPEC 10th International Conference on Agriculture, Animal Sciences and Rural Development; 18-19 July 2022; Sivas, Türkiye. [Turkish].

[28] Özaslan A. The effects of scarification, fertilization and herbicide treatments on the improvement of bottom rangeland vegetation under Erzurum ecological conditions. [Master's Thesis]. Erzurum: Atatürk University Graduate School of Natural and Applied Sciences; 1996. [Turkish].

[29] Lermi AG. The effect of nitrogen and phosphor fertilizers on hay yield, hay quality and botanical composition of forest grasslands in Bartın. [PhD Thesis]. Ankara: Ankara University Graduate School of Natural and Applied Sciences; 2009. [Turkish]