Turkish Journal of Range and Forage Science

Volume: 2 **Number**: 2 **Year**: 2021 E-**ISSN**:2718-0492

Published by Society of Range and Forage Science

Society of Range and Forage Science

TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

Volume **2** Issue **2** **2021**

TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

(International Refereed Journal)

Published by the Society of Range and Forage Science, Aydin, TURKEY.

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Date of Publication : December, 2021.

SOCIETY OF RANGE AND FORAGE SCIENCE

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.

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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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doi: 10.51801/turkjrfs.987396 Research

Turkish Journal of Range and Forage Science

https://dergipark.gov.tr/tr/pub/turkjrfs

Changes in Rangeland Condition and Health of Palandoken Mountain Rangelands Over Two Decades

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A R T I C L E I N F O

Received *26/08/2021*
Accepted *02/09/2021*

Keywords:
Highland rangelands
Plant functional groups
Range condition and health
Topography

A B S T R A C T

Rangeland plant communities respond to environmental changes depending on management practices, climate, topography, and time. The objective of the study was to determine the changes in abundancy of functional plant groups, range condition score, class, and health with different topographical characteristics between 1993 and 2013. Trends in the investigated characteristics changed depending on aspect and topography. While the abundancy of decreaser and increaser plants decreased, invader plant abundancy increased over two decades. Similarly, range condition score, class, and health also declined in this period. The changes in investigated properties showed uneven distribution among the sites due to uncontrolled grazing practices and site characteristics. The results indicated that range degradation has been continued under current grazing practices. Therefore, sustainable range management strategies should be put urgently into practice for the conservation of natural resources in the highland hilly rangelands of Turkey.

1. Introduction

Due to rugged topography and short growing season, rangeland covers large areas in the eastern Anatolia region of Turkey and has a significant role for the animal husbandry in the region. As in all of Turkey, the main problem of these areas, which are under common usage right, is uncontrolled grazing (Koc et al., 2014). Overgrazing is the main reason for rangeland degradation all over the world, and it causes decrement of desired plants in botanical composition, serious increment of invasive plants and consequently, a decline in the range condition and health (Beguin et al., 2011). Understanding the trend of range conditions and health provides fundamental insight for decision-maker to improve undesirable usage practices.

For the assessment of range condition score, plants are separated into three categories which are a) decreaser, b) increaser and d) invader (Koc et al., 2003). Decreaser plants are desirable because they are ambitiously preferred by grazers, whereas

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increasers are less and invaders are rarely preferred by grazers. Hence, the contribution of decreaser plants to the botanical composition decrease, increasers and invaders increase as the grazing pressure increase. If grazing pressure continues in the same extend through degradation, firstly increasers thereafter invader plans begin to decline. Consequently, land degradation has become a serious problem in the area. This degradation process, especially soil degradation, is the main reason for decreasing of invader plants (Amiri et al., 2008).

Nowadays, rangeland health classifications are preferred in the ecological classification of rangeland resources rather than range condition classification. Rangeland health classification is based on the integration of soil, canopy, and other ecological units whereas rangeland conditions are based on botanical composition (Koc et al., 2003). Thus, the range condition is not a good reference for the sustainability of rangelands (Anonymous, 1994) because soil-plant integration is not considered. As is range condition classification, there is no standard method for rangeland health or ecological site classification, which are used worldwide. For example, Koc et al. (2003) suggested a range health classification method for Turkey rangelands based on canopy coverage, Anonymous (1994) suggested a method based on plant diversity for USA rangelands. According to the Turkish Rangeland Act Regulation, determining range condition class is necessary to decide on management plans without rangeland health, but rangeland health is necessary for sustainable use of rangeland and suggested method is consistent with the Turkish Rangeland Act.

Overgrazing cause not only changes in botanical composition but also decreases canopy coverage (Koc, 2001). As canopy coverage decrease, accelerate erosion becomes a serious problem, and rangelands lose ecological functions and sustainability (Koc, 1995). Hence, rangeland health considered canopy coverage is a more important property than range condition. As canopy coverage increase erosion risk decrease (Arnalds and Barkarson, 2003), therefore, the management plans considering to save and to improve canopy coverage has crucial importance for sustainable use of the rangelands. As grazing pressure increase plant mortality increase and canopy coverage decrease and consequently successional trend reverse. This situation is the main reason for range degradation. In rugged terrains, grazing never shows even distribution. Generally, herds spent more time and visit frequently bottom or ridge top than slope terrains (Greenwood and McKenzie, 2001). On the other hand, as the degree of slope increase, sensibility to erosion increase in the area. Therefore, determining range condition and health class considering terrain characteristics and making a flexible management plan considering terrain characteristics contribute to sustainable use of these natural areas.

The goal of the present study was to determine spatial and temporal changes in range condition and health class under uncontrolled grazing pressure on the highland rangeland, which has rugged topography, in eastern Anatolia, Turkey.

2. Materials and Methods

This study was carried out on steppe rangelands of Palandoken Mountain, Erzurum, Turkey. The first vegetation sampling was done in 1993 by Koc (1995) and the second sampling was done after 20 years (2013) on the same sites. Nine study sites, which represented the general characteristics of the region rangelands were selected. The area had similar grazing history which uncontrolled, early- and late-season heavy grazing application for decades.

The experimental area consisted of sloping aspects in the back, footslope position, and summit and had never been cultivated. The information about the topographical characteristics of the experimental sites is given in Table 1. The plots were located gently to steep slopes on the area and the altitude of the sites were changed between 2035 and 2420 m. the experimental plots were covered by shortgrass steppe species of which common species were sheep fescue (*Festuca ovina*), astragales (*Astragalus* spp.) thymes (*Thymus* spp.), etc.

In the experimental sites, 3 composite soil samples were taken from surface to depth of 20 cm during both vegetation sampling years and analyzed for physical and chemical properties using the methods described by the Soil Survey Laboratory Staff (1992). The analysis results showed that there were no significant differences between the sampling years and the average values were given in Table 1. While the soil of S site had a loamy-sand texture class, the other sites' soils had a sandy-loam texture class. Soil organic matter content varied between 2.66 and 4.21% among sites soils and it was the highest in WF and the lowest SF soils. Soil pH was about neutral in all sites (Table 1). There were problems with respect to lime and salt contents of the soils. The study sites soils' were deficient in Olsen P content, which changed between 17.19 and 28.22 kg ha^{-1} (Table 1).

The general climatic characteristics of the study site are a semi-arid, continental climate with long, cold winters and short, arid summers. The nearest meteorological station to the study site is in Erzurum city, located at 1850 m altitude and about 10 km far from the sites. According to the station records, long-term average annual temperature and total precipitation were 5.6 ^{o}C and 432 mm, respectively. Annual total precipitation in 1993 and 2013 were 343 and 284 mm, and annual temperature in 1993 and 2013 were 3.8 and 5.3 ^{o}C, respectively. Total annual precipitation and average temperature were lower than long-term averages during the experimental years.

Vegetation surveys were performed in the second half of June, when the common species reached the flowering stage in both years, using the line-intercept method developed by Canfield (1941). A total of 8000 points were observed in each site in eight 10-m line-intercept transects considering the basal area. After determining the botanical composition of each site, the plants were grouped into decreaser, increaser, and invader classes considering their properties to determine the rangeland condition and the rangeland health classes calculated considering basal coverage. Range condition degree and classes, and health classes were determined considering the method suggested by Koc et al. (2003) for Turkey rangelands. According to the methods, range condition classes rated considering decreaser and increaser percentage as poor (1-25%), fair (26-50%), good (51-75%) and excellent (76-100%), and health classes rated considering canopy coverage as healthy (>40%), at-risk (30-40%) and unhealthy (<30%).

An arc-sin transformation was performed on the functional plant group data and then, the data belong to functional plant groups and range condition scores were subjected to analyses of variance based on a general linear model for repeated measurements using the StatView package (SAS Institute, 1998) and means were separated using TUKEY Multiple Range Test.

Table 1. Aspect, altitude, slope and soil properties information at the experimental plots.

Site	Altitude (m)	Slope (%)	Texture class	Organic matter (%)	P_2O_5 (kg/ha)	$CaCO_3$ (%)	pH	Salt
Summit (S)	2420	2	Loamy Sand	3.85	17.19	0.33	6.80	0.06
South Footslope (SF)	2276	25	Sandy Loam	2.66	17.49	0.45	6.95	0.05
South Backslope (SB)	2321	40	Sandy Loam	3.52	21.59	0.44	7.03	0.05
North Footslope (NF)	2035	21	Sandy Loam	3.87	21.69	0.38	6.89	0.04
North Backslope (NB)	2210	43	Sandy Loam	3.30	27.35	0.40	6.79	0.05
West Footslope (WF)	2191	18	Sandy Loam	4.21	21.62	0.33	6.83	0.08
West Backslope (WB)	2249	42	Sandy Loam	4.13	28.22	0.39	6.87	0.05
East Footslope (EF)	2113	20	Sandy Loam	4.13	23.72	0.37	6.65	0.10
East Backslope (EB)	2293	43	Sandy Loam	4.18	26.03	0.47	6.95	0.09

3. Results

The results of the analysis of variance are given in Table 2. As is seen in Table 2, site, year and site □ year interaction were significant at $p<0.01$ level for analyzed parameters. Since the study was aimed to determine changes over time, the changes between two sampling periods and their spatial distribution will be criticized in this paper.

Decreaser plants are good indicator for range condition. According to results, decreaser plants declined significantly (p<0.01) in the botanical composition over 20 years in the experimental area but these decreases did not show a similar trend in all sites (Table 2 and 3). The highest decreases were recorded on NF and NB and the least decreases were recorded on EF, EB, and S sites between the sampling years (Fig. 1).

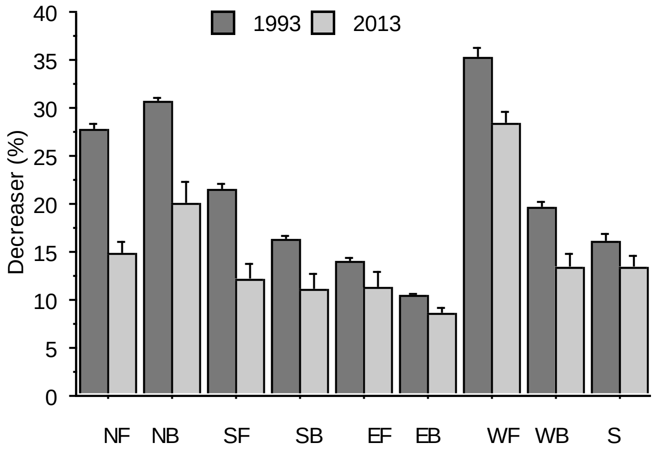

Fig. 1 Changes in decreaser plant abundance among the sites over the time

Table 2. The results of analysis of variance

	D.F.	Decreaser		Increaser		Invader		Range Condition	
		F	p	F	p	F	p	F	p
Site (S)	8	74.097	0.000	40.311	0.000	38.488	0.000	60.375	0.000
Year (Y)	1	145.596	0.000	56.641	0.000	192.021	0.000	149.115	0.000
S x Y	8	5.539	0.000	24.970	0.000	10.543	0.000	2.458	0.017

Table 3. Changes in functional plant groups, range condition score and health class depend on years and sites.

	Year	NF	NB	SF	SB	EF	EB	WF	WB	S	Mean
Decreaser	1993	27.72	30.66	21.37	16.29	14.05	10.46	35.29	19.56	15.97	21,26 A
	2013	14.78	20.09	12.12	11.03	11.21	8.54	28.24	13.37	13.29	14,74 B
	Mean	**21,25 C**	**25,38 B**	**16,75 D**	**13,66 DF**	**12,63 F**	**9,50 G**	**31,77 A**	**16,47 D**	**14,63 DF**	**18,00**
Increaser	1993	11.14	19.24	31.38	40.22	43.45	36.83	23.09	21.03	32.03	28,71 A
	2013	16.60	20.32	30.33	22.63	26.85	23.95	35.31	18.35	13.82	23,13 B
	Mean	**13,87 D**	**19,78 C**	**30,86 AB**	**31,43 AB**	**35,15 A**	**30,39 B**	**29,20 B**	**19,69 C**	**22,93 C**	**25,92**
Invader	1993	61.15	50.10	47.25	43.29	42.51	52.72	41.62	59.41	52.00	50,01 B
	2013	68.63	59.60	57.56	65.92	61.86	67.51	36.45	68.29	70.59	61,82 A
	Mean	**64,89 A**	**54,85 B**	**52,41 B**	**54,61 B**	**52,19 B**	**60,12 A**	**39,04 C**	**63,85 A**	**61,30 A**	**55,92**
Range Condition	1993	38.85	49.90	41.37	36.29	34.05	30.46	55.29	39.56	35.97	40,19 A
	2013	31.04	38.72	31.23	29.55	30.57	27.78	48.24	30.10	27.11	32,70 B
	Mean	**34,95 CD**	**44,31 B**	**36,30 C**	**32,92 CD**	**32,31 D**	**29,12 E**	**51,77 A**	**34,83 CD**	**31,54 D**	**36,45**
Range Condition and Health Class	1993	F-H	F-H	F-H	F-H	F-R	F-H	G-H	F-R	F-H	F-H
	2013	F-R	F-R	F-U	F-U	F-R	F-R	F-H	F-R	F-R	F-R
	Mean	F-R	F-R	F-R	F-R	F-R	F-R	G-H	F-R	F-R	F-R

H: healthy, R: risk and U: unhealthy.

The frequency of increaser plants showed decreases (p<0.01) in the botanical composition over 20 years (Table 3) but the trend in increaser plants frequency did not show a similar trend in all sites. While increaser plants frequency increase slightly on NF and NB, it did not show any significant changes on SF but it decreased on the other sites (Fig. 2).

The frequency of invader plants is an easy indicator of range degradation. In the area, invader plant frequency increased significantly (p<0.01) over 20 years but these increases did not show a similar trend among the sites (Fig. 3). While invader plant frequency decreases slightly on WF, it was increased on the other sites. The increases were the highest on S, EF, and SB than the others.

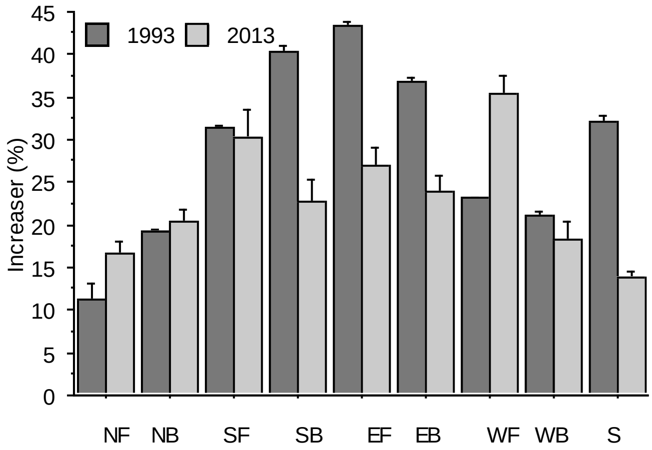

Fig. 2 Changes in increaser plant abundance among the sites over the time

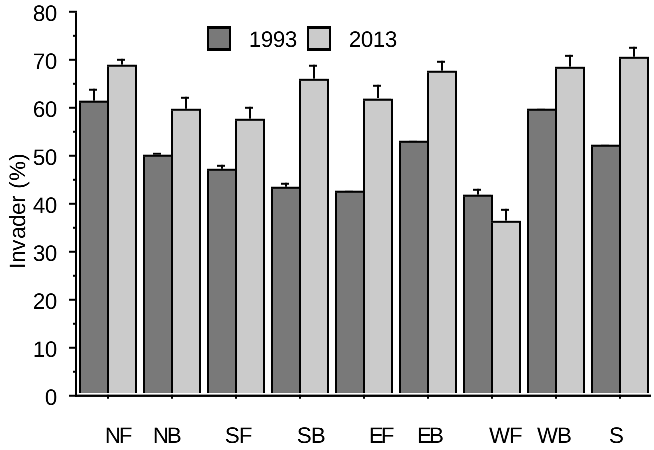

Fig. 3 Changes in invader plant abundance among the sites over the time

The range condition scores were decreased over 20 years (Table 2). These decreases showed a different trend among the sites (Fig. 4). The highest decrease in range condition score was observed on NB and SF, it was the least on EB. Expect for WF, all range sites were at the fair condition and healthy health class in the first sampling date. The fair range condition class retained but health class declined some sites, for example, rangeland health class drop-down unhealthy on south aspect. In general, both range condition class and health class declined over 20 years in the experimental area.

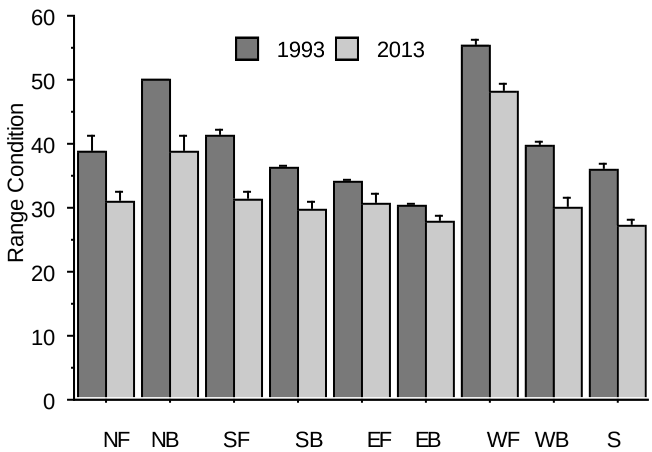

Fig. 4 Changes in range condition score among the sites over the time

4. Discussion

Range condition classification is made by considering the botanical composition and it provides basic information for decision-maker. While making the classification, the plants are grouped in three categories which are decreaser, increaser, and invader. The decreaser category consists of highly palatable plants that decline in abundance with increasing grazing pressure (Zhang et al., 2018). In the experimental area, decreaser plant percentage in the botanical composition declined about 21.26% due to overgrazing pressure, which has been continuing in the region for decades (Koc et al., 2020). This decline did not show a similar trend among the experimental sites. The plant begins to grow earlier in the spring on the south aspect due to receiving of more solar radiation, thus, herds are driven earlier and grazed heavily in this period. On the other hand, the plants the dry later than the others and the environment is cooler on the north aspect due to less solar radiation and therefore, north aspect provides more nutritious feed and comfortable climatic condition for herds during hot summer period. This situation causes overgrazing on these aspects in early spring and summer, respectively. Hence, the decreaser plant declined more on these aspects than the others during the experimental periods.

The increaser plants are preferred lesser by grazers because they provide less palatable feed. Although their frequency increase under moderate grazing pressure, it decreases under heavy grazing pressure (Altın et al., 2011). General decreases in increaser plant frequency are a result of continued heavy grazing pressure during the experimental period. The increaser plants increased significantly on WF and NF over two decades period. These increases and the serious decreases on the sites such as SB, EF and S probably originated from uneven grazing distribution (Altın et al., 2011). Apart from the differences of site characteristics, competition ability of these plants might also be responsible for this variation because competition ability changes depending on the plant. Consequently, both site characteristics and competition affect the successional trend in the community (Yunusbaev et al., 2003).

Invader plants are generally unpreferred by grazers due to low palatability or secondary metabolites/anatomical properties. Hence, their frequency increases under mismanagement conditions (Holechek et al., 2011). As opposed to decreaser and increaser, the invader plants' frequency increased in the experimental area over two decades. The main reason for this increase is overgrazing pressure, which continues in the region for decades. The spatial distribution of this increase was uneven because seasonal distributions of grazing and site characteristics are different among the sites. The differences in site characteristics affect the competition ability of the plants. In general, adverse site characteristics trigger undesired plant invasion (Altın et al., 2011; Holechek et al., 2011). Thus, invasive plants showed higher increases in back slope position in the experimental area over two decades. As is well known that as sloppiness increase the availability of site characteristics gets down on the rough topographic areas (Oztas et al., 2003).

Due to continued mismanagement practices, mainly early and overgrazing, the range condition score declined significantly over two decades. This is an expected result because there is no example in the world that a rangeland saves its condition under continued mismanagement practices (Holechek et al., 2011). As is in plant functional groups distribution, spatial distribution in the changes at range condition was uneven. The factors such as seasonal distribution of heavy grazing and site factors, which affect decreaser plant abundance also affected similarly range condition score.

Rangeland health is a simple indicator of the sustainability of rangeland functions. The method which was used in this experiment was based on canopy coverage to classify rangeland health class (Koc et al., 2003). Rangeland health mainly focuses on the integrity of the soil and natural vegetation and its sustainability (Gullap et al., 2020). Under accelerated erosion condition, to save sustainability of soil and consequently, vegetation is not possible, therefore, saving soil against accelerated erosion has to be the priority on the rangelands. Marshall (1973) explained that as the canopy coverage increase, accelerated erosion risk decrease on the rangeland. In the experimental area, since mismanagement, early and overgrazing, continue for decades, range deterioration continues because rangeland health declined over two decades due to decreasing plant density. Declining in rangeland health classes are not even all sites. The sites exposed to heavy grazing and harsh environmental factors exposed to more decreasing. Especially south aspects, which exposed to early grazing, freezing, and thawing, and seriously moisture stress due to more solar radiation showed serious rangeland health loss and the health class dropped to unhealthy over two decades. This situation is an early warning of seriously accelerated erosion on this aspect under current management practices.

In conclusion, the experimental results showed that range deterioration still continues in the region due to mismanagement practices. There has not been any regulation about mismanagement practices in the region as is country-wide up to now. Since south aspects received more solar radiation, snow melting earlier, and grazing started earlier. This practice has a detrimental effect on plant cover. Consequently, the rangeland health class drops down to a critical threshold against accelerated erosion. According to results, grazing distribution is not uniform in the areas so range degradation shift uneven on the area. Therefore, to stop range deterioration and improve current condition has crucial importance to sustainable use of natural rangeland. For this purpose, it is important regulating suitable grazing season, grazing capacity, and grazing distribution considering site characteristics.

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Turkish Journal of Range and Forage Science, 2021, 2(2): 44-51
doi: 10.51801/turkjrfs.982024

Research

Turkish Journal of Range and Forage Science

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Ontogeny and Fire Interact to Affect Competition between Grass and Shrubs

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A R T I C L E I N F O

Received *12/08/2021*
Accepted *06/09/2021*

Keywords:

Grass shrubs interaction
Fire
Old and young plant

A B S T R A C T

We investigated the effects of fire, grass and acacia age on the relative growth rate (RGR), relative neighbour effect (RNE), height and biomass of acacia and grass in the greenhouse condition. The experiment was arranged a completely randomized design with 10 replicates. Grass and shrubs were grown 17 weeks after establishment, thereafter, fire was applied, and observations were done 16 weeks later. Old grass tussock suppressed acacia seedling and sapling, but young grass facilitated acacia seedling and sapling. Young acacia suppressed the young grass but older acacia facilitated the growth of mature grass tussocks. After remove of biomass and the application of fire there was no significant effect but the height and biomass of all acacia seedlings were negatively affected by grasses In contrast to acacia, the effects of fire on the grass tussocks were reduced the above ground biomass.

1. Introduction

How do woody plants and grasses interact in woodlands and shrublands? The details of these interactions are still not clear, particularly with respect to the effects of the woody plants on grass growth and species composition. Researches are often focused on the importance of resources and disturbance. Plant facilitates other plants especially N2 fixing plants directly or actively by ameliorating harsh environmental conditions, by altering soil properties or by increasing availability of resources (Kurokawa et al., 2010). The effects of *Acacia* include the richer soil, grass leaf nutrients, reduced evapotranspiration, increased soil water due to hydraulic lift, and decreased soil water due to competition and increase grass productivity (Breshears et al., 1997; Ludwig et al., 2001; Ludwig et al., 2003; Treydte et al., 2007; Ludwig et al., 2008; Riginos et al., 2009). For example, nitrogen and phosphorus fertilization increased grass production outside and under canopies (Ludwig et al., 2001). Ludwig et al. (2003) showed that *Acacia* may lift and leaching between 75 and 225 L of water each night to area more than 300 m^2. Relative frequency of facilitation and competition will inversely proportional gradients of ecosystem productivity (Bertness and Callaway, 1994). The effect of species characteristics may change through ontogeny as depend on their magnitude and direction.

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Tree and/or shrub studies have shown positive effects on grass nutrition and productivity, but in addition, there are often negative effects (Higgins et al., 2000; Cramer et al., 2007). Grasses and woody plants have reciprocal competition and have contrasting growth forms. Because of different root niche, trees and/or shrubs are assumed to be able to valuable water and mineral nutrition from lower soil layers than grasses (Cramer et al., 2010). Grasses may also have both positive and negative effects on woody plants. Negative effects include suppression of tree and shrub seed germination, seedling growth and survival. Tree and/or shrubs are generally accepted as ineffective competitor when established. Because same grasses have allelopathic effects and most grasses areas have no any gaps. These situations are cause to reduction tree and/or shrub seedling growth (Nano and Clarke, 2010; Clarke and Knox, 2009; Cramer et al., 2010). Also this event contributes grass competition. While trees use mostly deeper soil moisture, grasses wets the soil surface is used more efficiently by fibrous roots than taproots. For this reason in vegetation is dominated by grasses (Herbel and Pieper, 1991; Erkovan et al., 2008). Effects of trees on grasses are cooler temperatures because of minimized evapotranspiration, leaf litter and N_2 fixation (Scholes and Archer, 1997). High grass productivity usually results in a large biomass accumulation combined with slow decomposition so that a large, dry fuel load accumulates. The result may be a severe fire, depending on weather patterns. But grasses can also have positive effects on these processes by providing suitable microclimatic conditions for tree and shrub seed germination and establishment (Aide and Cavalier, 1994). Environmental changes results from meristem environment by factor such as shading, water, nutrient etc. These factors changes results from morphological changes that it can be gradual or abrupt (Lawrence et al., 2003).

Fire can alter the species composition and consequently the structure, of vegetation as well as nutrient status and other attributes (Bullock, 2009; Esque et al., 2010). Different species of plants vary in their responses to fire. For example previous studies have shown that the following species were affected positively by fire; the endangered herb *Gentiana pneumonanthe*, the short-lived grass *Agrostis curtisii*, the matrix shrubs *Calluna vulgaris*, *Ulex minor* and *U. gallii*, the invasive grass *Molinia caerulea*, the invasive shrub *Cytisus scoparius* and the invasive tree *Betula pendula* (Gray, 1988; Chapman et al., 1989; Scandrett and Gimingham, 1989; Rees and Paynter, 1997; Stokes et al., 2004; Manning et al., 2004; Jacquemyn et al., 2005). The overall role of fire in species depends on population dynamics such as remove of competitor or mortality of species. Shrubs are usually more vulnerable than grasses to fire, and they may decrease competition by exposing grasses to the hazards of fire. However, fire can result in the breaking of seed dormancy, seedling growth and resprouting in shrubs that have been fire-damaged. Nano and Clarke (2010) suggested that the growth and survival of shrub seedlings dramatically decreases in the presence of adult grasses and sexual maturation may also be slow. In addition, grass competition and fire effects are important in producing shrublands-grassland mosaics. Fire can be an important disturbance in woodland or shrubland vegetation because it reduces grass cover and stimulates the germination of hard seed (Kraaij and Ward, 2006).

We planned that explain whether a demographic mechanism of shrub and grass ontogeny and coexistence can be determined. Coexistence shrub and grass during growing is advantage or disadvantage because of different growing form. We need to information how shrub and grass competition will be affected competition and fire as demographic and physiological. The role of fire on shrub and grass competition is a complex balance of positive or negative effects. We tested that how is fire affect new seedling and subsequent seedling shrub and grass ontogeny. Is there any interaction between root and shoot ontogeny and fire interact to competition these plants.

2. Materials and Methods

2.1. Experimental Design

The experiment consisted of combinations of different aged grass and shrubs in mixtures and grown alone with 10 replicates for each combination. The ages were (young grass seedlings (YG), mature grass tussocks (MG)), shrub seedlings (YS) and older shrubs saplings (OS). The mature grass tussocks and the older shrubs saplings were grown for 1 month prior to seedlings being transplanted for the mixed treatments. These combinations were (YG-YS), (YG-OS), (MG-YS), (MG-OS) in a completely randomized design. Hence there were 8 treatments each with 10 replicates for the first stage of the experiment these plants were grown for 17 weeks during which their growth was measured. At 17 weeks the aboveground biomass was harvested of both the shrubs and the grass and second treatment applied two half replicates. A flame was applied using a propane gas burner to the cut base of both the grass tussocks and acacia stem. These plants were grown for a further 16 weeks and both above and belowground biomass harvested.

2.2. Plant and Soil Material

The study was carried out under glasshouse conditions during 2010-2011 at the University of New England (Armidale-Australia). Mitchell grass (*Astrebla* sp.) and *A. farnesiana* were used in the experiment. Materials of both taxa were collected from Kirramingly Nature Reserve on 25.06.2010 according to the method of Whalley and Brown (1973). Mature tussocks of Mitchell grass were dug and placed in plastic bags and removed to glasshouse with in 12 hours where the soil was washed from the roots and the culms trimmed to about 1 cm of the bass. They left for a few days before being transplant to into pots. Acacia saplings were dug from moisture soil a placed in plastic bags and remove to the glasshouse about 12 hour and washed soil from the roots and planted into pots.

Seeds of Mitchell grass were obtained from Native Seeds Pty. Ltd, Melbourne and seeds of *A. farnesiana* were collected from Kirramingly. Ripened seeds of Mitchell grass placed in to germination trays after 1 week they were transplanted into pots with various combinations of grass and acacia plants. Seeds of acacia were scarified and placed into germination trays after 1 week they were transplanted into pots with various combinations of grass and acacia plants.

Plants were grown in 80 containers 50 cm high and 15 cm diameter filled with sand, a small amount of the soil (50 g) was applied to each pot for inoculation with *Rhizobium* bacteria by adding the soil and then watering it in. Before experiment starts, every pot was added to 20 g fertilizer (Osmocote). All pots were watered regularly on every two days by using tap water during experiment period. The pots were separated randomized in the glasshouse.

2.3. Plant Measurements

Every two weeks intervals, the height of acacia and grass ligula, acaia leaf and grass stem number was measured. After harvest, shrubs and grasses were carefully separated from stem, leaves and roots and were dried for 24 h at 80^0C for dry weight determinations. Dry mass of both of them was measured and it was used to determine of competition between grass and acacia. Grass and *Acacia* roots were carefully separated from the soil, and washed with tap water. They were dried in the oven for 24 h at 80^0C for dry weight determinations.

2.4. Data Analysis

Relative growth rate (RGR) was determined from the plant height differences at 15 days intervals fallowing by using (Ishikawa and Kachi, 2000).

$$RHGR = \ln (H_2 - \ln H_1)/(t_2 - t_1) \quad (1)$$

H_1 is the plant or stubble height at time t_1 and H_2 the plant height at time t_2.

Relative neighbour effect (RNE) was determined from the dry mass following equations by using (Oksanen et al., 2006).

$$RNE = (Wr-Wc)/\max (Wr, Wc) \quad (2)$$

RNE is relative neighbour effect, Wr is the performance of manipulated plants, Wc is performance of controls. This index compares the total biomass of *A. farnesiana* in the mix and with that grown as controls.

We tested before cutting and after cutting application. Grasses and acacia was growth during 17 weeks before cutting applications and than we applied to fire that the plants growth during the 16 weeks. We hypnotized firstly effects of growth ratio and relative neighbour effect in between old and young plants, before cutting application. This was tested using a two and three factor (RGR was tested three, RNE was tested two factors) ANOVA with RGR and RNE in plants height and above ground biomass. After cutting application, the first hypothesis to be tested was that burned and unburned plants had either any effect or no, and same hypothesis also to be tested was to old and young plants effects growing. In order to evaluate *A. farnesiana* responses to above and below ground ratios, height and leaves number was tested four factors ANOVA. The other hypothesis to be tested was fire and plant interactions that are effect of plant age, burned and unburned plant.

3. Results

Old grass tussocks had a stronger effect on acacia RGR (height growth) than younger grass seedlings after 17 weeks of growth ($F_{(1, 36)}$= 93.42, p>.0001) (Fig. 1). The growth of the older acacia saplings was more suppressed than younger acacia seedlings in competition with the old grass tussocks (Fig. 1). However, there was no interactive effect of plant age ($F_{(1, 36)}$= 1.49, p>ns). Whilst we found that old grass tussock suppressed the growth of acacia, young grass seedlings facilitated the growth of both acacia saplings and seedlings ($F_{(1, 36)}$= 5.876, p>0.0205) (Fig. 1). This was shown in the RNE where older grass tussock had a negative effect on the height growth of acacia seedlings (Fig. 2).

In contrast, the younger grass seedlings had a positive effect on the growth of acacia regardless of age ($F_{(1, 36)}$= 6.48, p>0.05) (Fig. 2).

Conversely the effect of acacia on aboveground grass biomass after 17 weeks of growth was positive when grown with older acacia saplings (Fig. 3) but the acacia seedlings suppressed grass biomass ($F_{(1, 36)}$= 29.6, p<0.001) (Fig. 3). This was shown in the RNE where young acacia suppressed the young grass but older acacia facilitated the growth of mature grass tussocks (Fig. 4). Overall there was no interactive effect of grass age and acacia age ($F_{(1, 36)}$= 1.7, p>0.1).

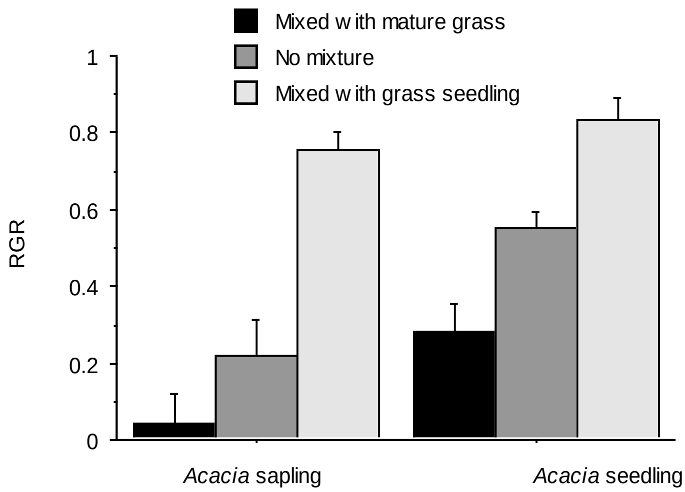

Fig.1 Relative growth rate (height growth) of acacia in competition with old and young grass

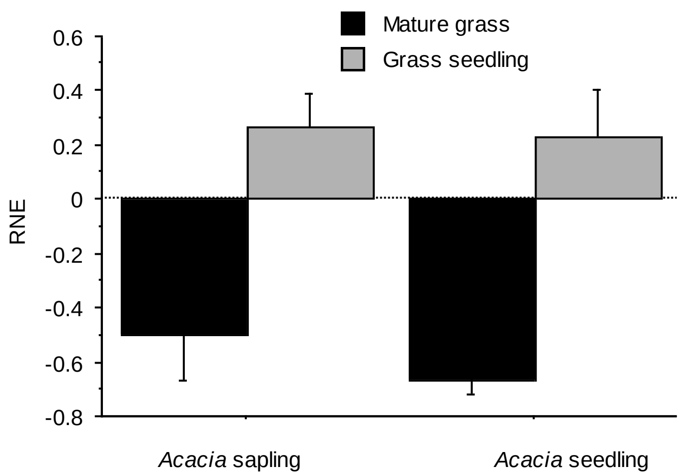

Fig. 2 Relative neighbour effect of grass on acacia.

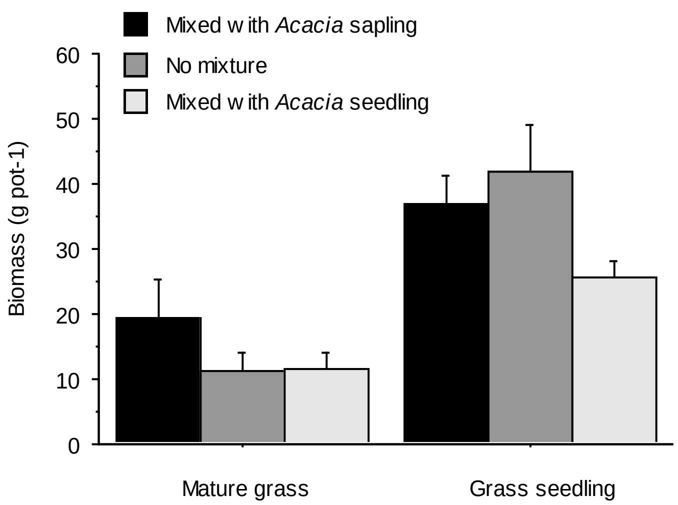

Fig. 3 The mass of grass in competition with old and young acacia

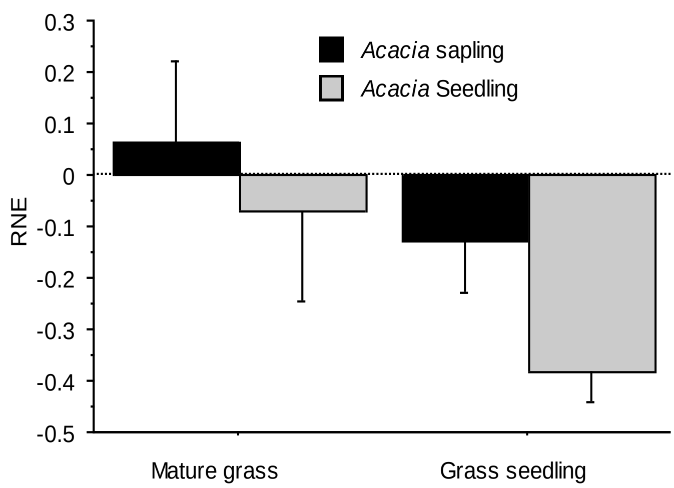

Fig. 4 The RNE of acacia on grass growth

After remove of biomass and the application of fire there was no significant effect of fire on acacia growth variables (Table 1). The height and biomass of all acacia seedlings were negatively affected by competition with grass (Table 1), although the older acacia sapling appeared to more negatively affected (Table 1) (Fig. 5) and mature grass had a stronger effect than the younger grass tussock after 16 weeks of regrowth competition (Fig. 6). In contrast to acacia, the effects of fire on the grass tussocks were to reduce the above ground biomass of the grass (Table 2) (Fig. 7), and this was independent of grass age and acacia age. However, there was no effect of fire all the age of grass or acacia on the relative neighbour effect for total biomass (Table 2), but overall strong competitive effect of acacia on grass.

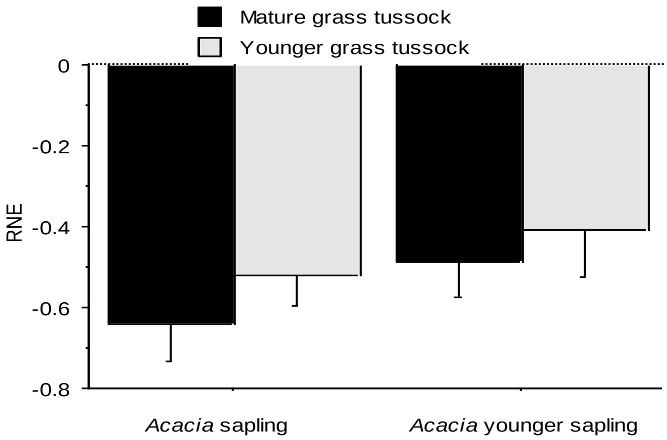

Fig. 5 The RNE of grass on acacia after biomass removal.

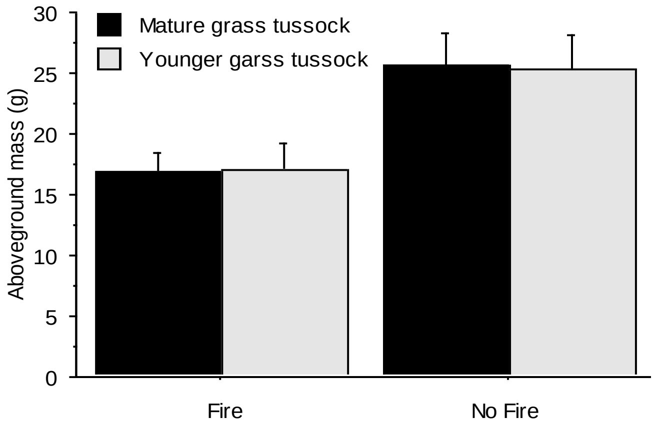

Fig. 6 The effect of fire on grass tussock aboveground biomass

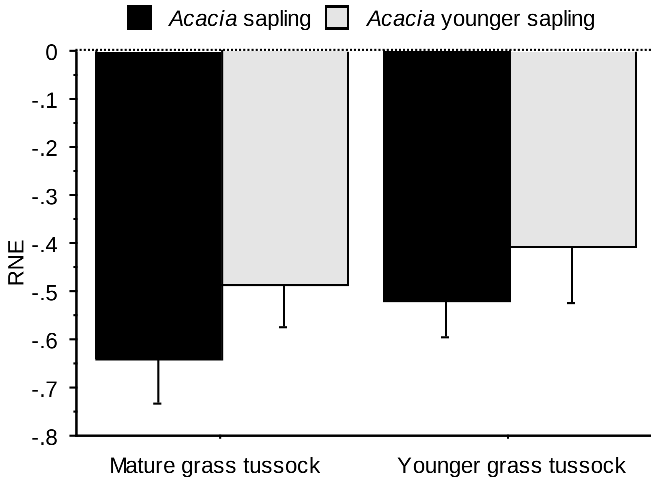

Fig. 7 The effect of acacia and fire on grass tussock

Table 1. Summary results of the effect of fire and grass neighbour on acacia growth attributes.

Factors	**DF**	**Height**		**Root length**		**Aboveground Biomass**		**Factors**	**DF**	**RNE**	
		F	*p*	F	*p*	F	*p*			F	*p*
Fire (F)	1	1.62	ns	0.11	ns	2.69	ns	Fire (F)	1	0.20	ns
Grass Mix (GM)	2	3.86	*	2.00	ns	13.82	***	Grass Age (GA)	1	1.423.45	ns
Acacia Age (AA)	1	6.76	*	0.33	ns	9.86	**	Acacia Age (AA)	1	3.45	ns
F x GM	1	3.53	*	0.61	ns	2.07	ns	F x AA	1	0.74	ns
F x AA	2	1.45	ns	0.63	ns	0.002	ns	F x GA	1	1.57	ns
GM x AA	2	0.91	ns	0.89	ns	2.01	ns	AA x GA	1	0.09	ns
F x GM x AA	2	1.50	ns	0.78	ns	1.57	ns	F x AA x GA	32	0.01	ns
Residual	48										

ns . p > 0.5, * p < 0.05. ** p < 0.01, *** p < 0.001

Table 2. Summary results of the effect of fire on grass growth attributes after remove.

Factors	DF	Root length		Aboveground Biomass		Factors	DF	RNE	
		F	p	F	p			F	p
Fire (F)	1	0.90	ns	19.84	***	Fire (F)	1	0.21	ns
Grass Mix (GM)	1	0.13	ns	0.08	ns	Grass Age (GA)	1	1.12	ns
Acacia Age (AA)	2	0.96	ns	0.10	ns	Acacia Age (AA)	1	2.05	ns
F x GM	1	0.99	ns	0.02	ns	F x GA	1	1.75	ns
F x AA	2	0.62	ns	0.04	ns	F x AA	1	1.96	ns
GM x AA	2	1.85	ns	2.86	ns	GA x AA	1	0.05	ns
F x GM x AA	2	2.99	ns	9.09	**	F x GA x AA	32	0.65	ns
Residual	48								

ns . p > 0.5, * p < 0.05. ** p < 0.01, *** p < 0.001

4. Discussion

Grass shrubs relationships unknown still clearly. But the competitive, facilitative or neutral effect between grasses and shrubs relationships determines vegetation properties (Higgins et al., 2000). Plant height and biomass of acacia were significantly affected by grass mixture and acacia age (Table 1). Grasses and woody plants have reciprocal competition and have contrasting growth forms. At the beginning of the growth, grass tussocks suppressed the acacia seedling and sapling but the grass seedlings facilitated the acacia growth. This was probably due to the shade effect of lack of belowground competition. Because of different root niche, trees and/or shrubs are assumed to be able to valuable water and mineral nutrition from lower soil layers than grasses (Cramer et al., 2010). Negative effects include suppression of tree and shrub seed germination, seedling growth and survival. Tree and/or shrubs are generally accepted as ineffective competitor in the beginning of growing. Hence, grass and acacia age were affected positively plant height and biomass of acacia. Researces reported that there are positive, negative or neutral effect between grass and wody species (Ludwig et al., 2001; Riginos et al., 2009). After removing of biomass of the regrowth of acacia plants was negatively affected by grass especially the mature grass tussock. Whilst fire reduced the above ground biomass of grasses this did not affect the strong competitive performance of grass, because belowground competition was stronger. Nano and Clarke (2010) showed that shrub seedlings growth dramatically decreases in the presence of adult grasses. In addition, grass competition and fire effects are important in producing shrublands-grassland mosaics. Fire can be an important disturbance in woodland or shrubland vegetation because it reduces grass cover and increases water loss. Hence, acacia seedling or sapling growth attributes were decreases.

Grass above ground biomass was significantly affected by fire (Table 2). Grass seedlings were also negatively affected by acacia but this was less so and some facilitative effect could appears established acacia because of especially nitrogen transfer grass tussocks. The increase in grass biomass when grown with acacia saplings may be expected doe to the nitrogen fixation effect. This situation must be originated from the grass benefit nitrogen fixing ability of acacia. Because the plant has nitrogen fixation ability provide a facilitative effect on neighbour plants with grown under nitrogen poor condition (Erkovan et al. 2008). Biomass production was not significantly affected by fire after removable of biomass (Table 2). After the fire, grass biomass decreased compared to not fire. The regrowth of grass was also negatively affected by acacia especially the acacia sapling, but fire did not effect the strong competition. However, firstly after fire at the early stages of plant growth may reduce axillary bud number and viability, this condition affects plant biomass (Gullap et al., 2018). Because burned stems regrowth rapidly due to effect of nitrogen transfer to the grass from acacia growing media.

In conclusion, we have shown, that old grass tussock suppressed the growth of acacia, young grass seedlings facilitated the growth of both acacia saplings and seedlings. Older grass tussock had a negative effect on the RNE of acacia seedlings (Fig. 2). In contrast, the younger grass seedlings had a positive effect on the RNE of acacia regardless of age. After remove of biomass and the application of fire there was no significant effect on acacia seedling and sampling The effects of fire on the grass tussocks were to reduce the above ground biomass of the grass. However, there was no effect of fire all the age of grasses or acacia on the RNE for total biomass, but competitive effect of acacia on grass. Grass shrubs interactions should be investigated further, and examined as an important factor such as environment in the field or vegetation experiments.

Acknowledgements

We thank The Scientific and Technological Research Council of Turkey (TUBITAK) for supporting to Dr. Erkovan. We also thank Dr. Knox, UNE and CMA.

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Turkish Journal of Range and Forage Science, 2021, 2(2): 52-62
doi: 10.51801/turkjrfs.954843

Review

Turkish Journal of Range and Forage Science

https://dergipark.gov.tr/tr/pub/turkjrfs

The Effect of Nanoparticle Applications on Plants under Some Stress Conditions

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A R T I C L E I N F O

A B S T R A C T

Received *20/06/2021*
Accepted *30/08/2021*

Keywords:

Drought
Heavy metal stress
Nanoparticles
Plant growth
Salinity

Plants are exposed to various abiotic stresses such as drought, salinity, high temperature, flooding and heavy metal stress. These stress factors have a significant negative effect on plant growth and yield and cause economic losses. Therefore, new approaches such as nanotechnology are used to reduce the harmful effects of these stresses on plants. Agricultural nanotechnology aims to improve sustainability in agriculture, to use water effectively and to protect against plant diseases, to eliminate environmental pollution and the effects of abiotic stress factors. Nanoparticles eliminate nutrient deficiencies in plants, increase the tolerance of plants to stress conditions by enabling the enzyme activities and the adhesion of bacteria that promote plant growth to the roots under abiotic stress conditions. In this review, the role of nanoparticles in ameliorating adverse effects on plants exposed to abiotic stress conditions will be emphasized.

1. Introduction

Unsuitable environmental conditions are defined as stress, and many abiotic and biotic environmental factors cause stress in plants. Abiotic stress conditions such as high or low temperature, waterlogging, drought, salinity, heavy metals and ultraviolet radiation adversely affect many morphological (plant height, leaf area, shoot length, root length etc.), physiological (net photosynthesis, PSII efficiency (*Fv/Fm*), stomatal conductance etc.) and biochemical (proline, soluble protein, soluble sugar content etc.) processes that directly affect plant growth.

Abiotic stress

As the world population increases, abiotic stress conditions will continue to be a greater challenge for crop production. During stress, physiological and biochemical changes occur in plant cells and growth and development decrease and as a result, plant yield is adversely affected. In order to achieve a sustainable production under changing climatic and stress conditions it is necessary to develop varieties resistant to stress conditions or to apply nanotechnology and other climate sensitive agricultural technologies.

Drought and heat stress are increasing seriously as a result of climate change and are among the abiotic stress factors that negatively affect crop production. In addition waterlogging, salinity and heavy metal stress are among the environmental factors that limit crop production almost all over the world (Ye et al., 2019). Drought affects the physiological and biochemical processes of plants

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especially the synthesis and accumulation of secondary metabolites. In arid conditions, some physiological changes occur in the plant, and some biochemical processes such as antioxidant enzymes and phenolic content are affected. Signals from roots to leaves are transmitted via xylem vascular bundles (Afshari et al., 2021). Turgor loss is observed in plants with drought stress. Dehydration increases in the protoplasm. The damage to the plant causes irreversible problems in cellular metabolism and the growth of the plant slows down. Due to water loss, cellular metabolism, ion accumulation, membrane structure integrity and protein structures are disrupted in the plant. Leaf size decreases, photosynthesis products are reduced, enzyme activity and amount are also affected. Drought also causes the formation of Reactive Oxygen Species (ROS) in plants and in connection with this it causes oxidative stress (Cruz de Carvalho, 2008).

Salinity is a common abiotic stress factor that causes significant reductions in plant growth. Soil salinity can affect seed germination by creating an osmotic potential that prevents water uptake outside the seeds or by Na^+ and $Cl^−$ ions (Tavakkoli et al., 2010). NaCl causes oxidative damage in different legumes, leading to a significant decrease in different growth parameters, seed nutrient quality and nodulation (Hernandez et al., 2000; Ahmad et al., 2008). To reduce and repair damage induced by oxidative stress plants have developed a set of antioxidant defense mechanisms both enzymatic and non-enzymatic. While ascorbate and carotenoids are two important non-enzymatic defense mechanisms against salinity, proline is the most discussed osmoregulatory substance under stress (Anoop et al., 2003).

Heavy metals include iron, zinc, manganese, copper, nickel, molybdenum and cobalt which are essential for plant nutrition and non-essential elements chromium, cadmium, mercury, and lead. All these elements are highly toxic to plants at high concentrations (White and Pongrac, 2017).

Toxic levels of heavy metals adversely affect various metabolic processes such as degradation or displacement of protein structures resulting from the formation of bonds between heavy metals and sulfhydryl groups (Hall, 2002), disruption of the integrity of the cytoplasmic membrane (Farid et al., 2013), causes suppression of vital events such as photosynthesis, respiration and enzymatic activity (Hossain et al., 2012).

Nanoparticles

Nanoparticles (NPs) are microscopic particles with sizes in the range of 1-100 nm (Khan and Upadhyaya, 2019). Most of the NPs that enter the cell from above-ground organs (cuticle, epidermis, stoma, hydatid and other openings) or underground organs (root tips, cortex, lateral root, wounds and other openings) have a variety of physiological and morphological effects on plants. The effects of these compounds vary depending on the plant species, growth period and growing conditions, application method, dose and exposure time (Dietz and Herth, 2011; Rizwan et al., 2017).

NPs which enter through stomata are carried within the plant by the phloem. NPs are transported as a result of pressure differences between leaves and roots depending on mass flow or pressure flow theory (Yıldız, 2018).

The way the nanoparticles are taken to the plant causes differences in many processes such as germination, antioxidant activity, macro and micro-nutrients, chlorophyll content, chloroplast number and photosynthesis in plants (Cinisli et al., 2019). Nanoparticle applications also change intra-root signals by affecting ethylene production of *Arabidopsis* roots (Syu et al., 2014).

Nanoparticles penetrate the cell membrane and cell wall. They reach the epidermis, xylem, central cylinder and finally the leaves (Tripathi et al., 2017). Before reaching the central cylinder, nanoparticles are passively transported in the endodermis (Judy et al., 2012). The uptake mechanism of nanoparticles is mostly through active transport.

Nanoparticles enter the plant root through osmotic pressure, capillary force and cell wall pores through plasmodesmatal connections or symplastic ways. Nanoparticles bind to the carrier protein via ion channels, aquaporin and endocytosis, form new pores and enter the plant cell. After nanoparticles enter the plant cell, they can be transported from one cell to another via plasmodesmata via apoplast or symplast (Usman et al., 2020; Fig. 1). The entry of nanoparticles through the cell wall depends on the pore size of the cell wall. Small-sized nanoparticles easily pass through the cell wall (Fleischer et al., 1999), while larger nanoparticles pass through stomata, hydathode and stigmas (Hossain et al., 2016).

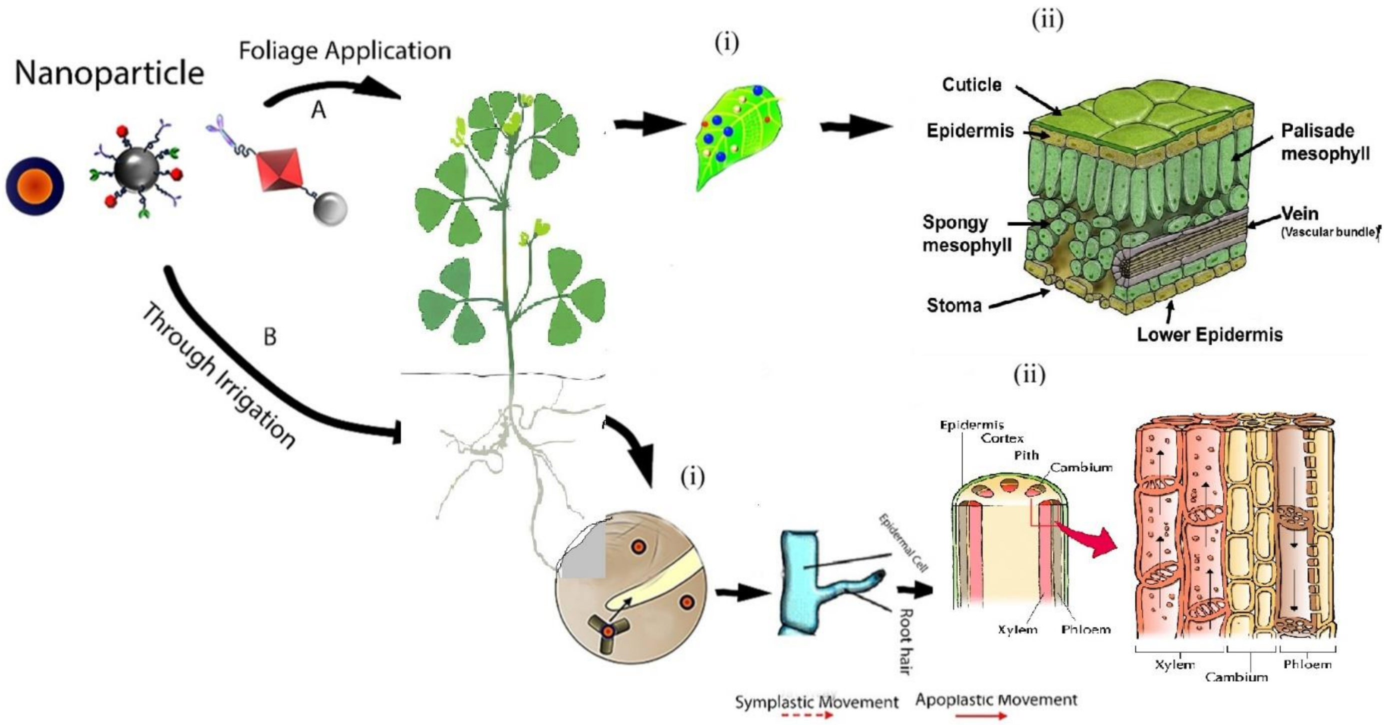

Fig 1. Uptake and transport mechanism of nanoparticles via leaves and roots. (A) uptake of nanomaterials by foliar application (i) entry of nanomaterials through leaf cuticle (ii) entry from epidermis layer to palisade and sponge parenchyma and transition to vascular cambium (B) uptake of nanomaterials by irrigation by plant roots (i) entry of nanomaterials through root hairs (ii) Access to xylem and phloem via epidermis and cortex (apoplastic and symplastic) (Usman et al., 2020).

Transport of nanoparticles occurs through stomata when the particle size is 40 nm or larger (Eichert et al., 2008). These nanoparticles accumulate in the stoma instead of the vascular cambium and are then transported to different parts of the plant via the phloem (Tripathi et al., 2017). Nanoparticles enter through parenchymatous intercellular spaces in the seed coat (Lee et al., 2010). However, in the seed coat, aquaporins play a role in regulating the entry of nanoparticles (Abu-Hamdah et al., 2004).

With the increase in nanotechnological applications, the use of nanomaterials with a high surface-to-volume ratio has also increased. The functions and usage areas of nanomaterials differ according to the size and composition of the nanoparticles (Tunca, 2015). When nanomaterials are used as fertilizers, the plant provides nutrients slowly, very small amounts are sufficient compared to chemical fertilizers, and they have a positive effect on the plant and nature by reducing the environmental risks caused by chemical fertilizers (Cinisli et al., 2019; Usman et al., 2020).

The environment and human health are adversely affected due to the unconscious and high doses of chemical pesticides and fertilizers in agriculture to increase the yield of plants. Therefore, it has become a necessity to replace pesticide and fertilizer applications with nanopesticides and nano fertilizers in order to reduce the use of chemical fertilizers, increase plant yield, and also support agricultural development (Bratovcic et al., 2021). Research into nanotechnology applications in agriculture has become increasingly popular in the last decade, and especially new nanoagrochemicals called "nanopesticides" and "nanofertilizers" have been the focus of attention (Kah, 2015).

Nano-fertilizers have very small dimensions ranging from 30 to 40 nm, can pass through stomata very easily, can hold many ions and are released slowly to meet the nutrients needed by the plant (Bal, 2019; Cinisli et al., 2019).

The effect of nano fertilizers on plant development and metabolism is due to the fact that they make plants resistant to biotic-abiotic stress conditions and diseases in variable and severe atmospheric conditions, as well as their effect on enzymatic and hormonal levels (Cinisli et al., 2019).

Nanopesticides can be synthesized by physical, chemical or biological methods. Nanopesticides and nanoformulations such as Ag, Cu, SiO_2, ZnO show better broad spectrum pesticide efficacy compared to conventional pesticides used. For this reason nanopesticides have a positive influence on the control of plant pests and diseases (Chhipa, 2017).

In recent years, chitosan-metal oxide nanoparticles have been used to ensure that the fertilizers to be applied to the plants are taken up more effectively by the plants. Chitosan application increases nitrate reductase, glutamine synthetase and protease enzyme activities in N metabolism and thus affects plant growth and development (Bal, 2019).

Zinc oxide nanoparticles increased germination percentage and improved seedling growth in peanut and corn plants (Prasad et al., 2012; Singh et al., 2017). While root length shortened in corn seedlings treated with 2000 mg/L 60 nm Al NP for 5 days, there was no adverse effect on *Raphanus sativus, Brassica napus, Cucumis sativus, Lolium perenne* and *Lactuca sativa* (Yang and Watts, 2005). Application of 2000 mg/L Zn nanoparticles significantly inhibited root growth in maize and stopped root growth of *Cucumis sativus, Glycine max, Brassica oleracea* and *Daucus carota* (Lin and Zhing, 2007).

Few studies have addressed the effect of nanoparticles on seed germination and seedling growth by seed pretreatment in forage and medicinal plants. In general, it has been observed that nanoparticle application to seeds increases seed germination, seedling growth and development, seedling viability and emergence rate (Khalaki et al., 2021).

Seed germination, root and shoot length, fresh and dry weight values of *Agropyron elongatum* were positively affected by SiO_2 nanoparticle application (Azimi et al., 2014). Abbasi Khalaki et al. (2016) emphasized that AgNPs increased the germination rate, root and shoot length, fresh and dry weight, average germination time and vitality index in *Thymus kotschyanus* plant. Similarly it has been reported that silver nanoparticles increase the germination rate in *Pennisetum glaucum* (Parveen and Rao, 2015) and *Festuca ovina* (Abbasi Khalaki et al., 2019a). Amooaghaie et al. (2015) emphasized that Ag NPs negatively affect the germination of *Brassica nigra*. In addition, it has been reported that *Medicago sativa* negatively affects shoot length, *Ocimum basilicum* root length, root and shoot dry weight, and shoot and root length in *Linum usitatissimum, Lolium perenne* and *Hordeum vulgare* (Al-Temsah and Joner, 2010; Ramezani et al., 2014; Yosefzaei et al., 2016).

SiO_2 nanoparticles applied to *Onobrychis sativa* increased shoot length, while TiO_2 nanoparticles increased germination time and percentage (Moameri et al., 2018a). Wang et al. (2011) found that Fe_2O_3 nanoparticles increased the germination of *Lolium perenne*. FeO NPs caused a decrease in mycorrhizal biomass, root and shoot length in *Trifolium repens* (Feng et al., 2013), *Satureja hortensis* (Peyvandi et al., 2011a), *Lolium perenne* and *Hordeum vulgare* (El-Temsah and Joner, 2010).

Feizi et al. (2013) observed that TiO_2 NPs positively affected germination in *Foeniculum vulgare*, Dehkourdi and Mosavi (2013) also reported same results about *Petroselinum crispum*, Ag NPs were found to increase shoot length and chlorophyll content in *Brassica juncea* and *Sorghum bicolor* (Namasivayam and Chitrakala, 2011; Sharma et al., 2012). It was stated that the root growth of *Thymus kotschyanus* and *Alopecurus textilis* was positively affected by SiO_2 NP application (Abbasi Khalaki, 2019a; 2019b).

Similarly, SiO_2 application to *Medicago sativa* increased plant height, number of tillers, yield, fresh and dry weight, chlorophyll and carotenoid content (Ma and Yamaji, 2006; Zmeeva et al., 2017). Siddiqui et al. (2007) reported that SiO_2 increased leaf fresh and dry weight and chlorophyll content in *Ocimum basilicum*. SiO_2 NP application was found to affect shoot and root growth negatively in *Sorghum bicolor*, *Stipa hohenackeriana* and *Secale montanum* plants (Lee et al., 2012; Moameri et al., 2018b; Moameri and Abbasi Khalaki, 2019).

ZNO NPs increased plant biomass, shoot and root length and chlorophyll content (Peyvandi et al., 2011b; Wang et al., 2011; Raliya and Tarafdar, 2013; Najaf Disfani et al., 2016; García-López et al., 2018; Yuan et al. 2018). TiO_2 NPs increased the essential oil content and yield in medicinal plants (Ahmad et al., 2018; Fazeli-Nasab et al., 2018). CuO NPs adversely affected the morphology, physiology and biochemistry of *Hordeum vulgare, Lolium perenne, Triticum aestivum* and *Medicago sativa* (Lee et al., 2008; Atha et al. 2012; Ramezani et al., 2014; Shaw et al., 2014; Hong et al., 2016).

Nanoparticles under salinity conditions

Nanoparticle applications gain importance in order to improve the harmful effects of abiotic stress conditions on plants, to obtain the desired yield and quality, and to increase the resistance of plants to salinity.

At the germination stage, the application of Ag nanoparticles to *Lathyrus sativus* L. plants under salt stress improved germination percentage, shoot and root length, and seedling fresh and dry weight. Therefore, it has been reported that Ag nanoparticles are important for osmotic regulation in *Lathyrus sativus* L. under salt stress, Ag application reduces the negative effects of salinity and the toxic effects of salt stress on the plant (Hojjat, 2019). Noman et al. (2020) stated that the application of Cu-nanoparticle to the soil reduces oxidative stress in wheat and significantly increases plant growth and yield. The application of nanoparticles in wheat not only increases plant growth, but also improves germination performance under salt stress conditions (Eshi et al., 2016). Pre-application of Ag-nanoparticles to wheat seeds changed antioxidant enzyme activities, reduced oxidative damage and increased tolerance to salt stress (Kashyap et al., 2015). Zinc oxide (ZnO) nanoparticles increased dry weight in sunflower under salt stress conditions (Torabian et al., 2016).

CeO NPs (100 and 200 mg/kg) improved the physiological parameters of *Brassica napus* L under salt stress (100 mM NaCl). Similarly, it was observed that the application of CeO nanoparticles to the canola under salt stress conditions increased the plant biomass (Rossi et al., 2016). The application of silver nanoparticles to basil seeds under salt stress conditions increased the germination of the seeds (Darvishzadeh et al., 2015; Hojjat and Kamvab, 2017).

In salt stress conditions, the application of silver nanoparticles to *Satureja hortensis* L. plants increased the plants' tolerance to salt stress, along with reduced germination rate and plant shoot length due to salt stress (Nejatzadeh, 2021). The application of silver nanoparticles to cumin plants under salt stress significantly increased the salt tolerance of the plants (Ekhtiyari and Moraghebi, 2012). Askary et al. (2017) reported that Fe_3O_4 nanoparticles have a protective role against oxidative stress caused by NaCl in mint.

Nanoparticles under drought conditions

Drought is one of the abiotic stresses that significantly limits crop production. Therefore, nanoparticle application is effective in mitigating the effects of drought on plants due to its many positive effects such as increasing antioxidant enzyme activity, improving phytohormone levels and effecting on physiological properties.

Application of analcite nanoparticles to soil in hot and dry conditions has been shown to promote germination and plant growth in wheat (Hossain et al., 2021). Application of ZnO NPs to soybean seeds in arid conditions increased the percentage of germination in seeds (Sedghi et al., 2013). The application of Cu and Zn NP to wheat plants under drought stress increased antioxidant enzyme activity and relative moisture content, decreased thiobarbituric acid, reagent accumulation, stabilized the photosynthetic pigment in leaves and alleviated the effects of stress (Taran et al., 2017). Under drought stress, SiO_2 nanoparticle application increased shoot length and relative water content in barley but reduced superoxide radical formation and membrane damage (Yıldız, 2018).

Jaberzadeh et al. (2013) emphasized that foliar application of titanium dioxide (TiO_2) NPs to wheat in arid conditions was effective in overcoming the yield reduction caused by drought stress. Application of copper nanoparticles to maize under arid conditions increased leaf water content, plant biomass, anthocyanin, chlorophyll and carotenoid content (van Nguyen et al., 2020). Ashkavand et al. (2015) emphasized that the application of SiO_2 nanoparticles to hawthorn grown under drought stress conditions led to a decrease in photosynthesis and stomatal conductivity in plants. However, it has been determined that silicon nanoparticles improve the effects of drought stress in bananas (Mahmoud et al., 2020). In moderate drought conditions, foliar application of silicon nanoparticles to coriander resulted in optimum antioxidant capacity and essential oil yield (Afshari et al., 2021).

Shallan et al. (2016) emphasized that the foliar application of SiO_2 and TiO_2 nanoparticles reduced their negative effects on cotton plants in arid conditions. The application of silicon nanoparticles to the soil decreased the harmful effects of drought by increasing the relative moisture content of the chickpea (Güney et al., 2007).

Drought stress resulted in greater enhancement of the negative effect of Cd in wheat, while the application of ZnO NPs ameliorated both Cd and drought stress (Khan et al., 2019).

Nanoparticles under heavy metal stress

Under heavy metal stress conditions, soil or foliar applications of nanoparticles eliminate the negative effects of stress, improve plant growth and photosynthesis, and reduce oxidative stress-induced toxicity. Therefore, the application of nanoparticles appears to have a potential role in remediation of heavy metal-contaminated environments.

In heavy metal stress conditions nanoparticle application to plants helps to decrease heavy metal concentration in soil regulate the expression of heavy metal transfer genes in plants, increase plant antioxidant systems, improve physiological functions and stimulate the production of protective agents (e.g. root secretions, phytochelatin and organic acids) (Rui, 2021). Application of silicon nanoparticles to maize plants under arsenic stress conditions improved the reduction in total chlorophyll, carotenoid and total protein content. In addition, it was revealed that the negative effects of arsenic stress on the maximum quantum efficiency, photochemical quenching and non-photochemical quenching of FS II decreased with the application of silicon nanoparticles (Tripathi et al., 2019). Soil application of TiO_2 NPs effectively limited Cd toxicity by increasing physiological parameters and photosynthesis rate in soybean. Therefore, TiO_2 NPs are of great importance in mitigating the effects of heavy metal-induced oxidative stress (Singh and Lee, 2016). The activities of enzymes such as superoxide dismutase, ascorbate peroxidase increased and the effects of oxidative stress decreased in pea seedlings under chromium stress with silica nanoparticles (Tripathi et al., 2015).

de Sousa et al. (2019) revealed that Si NPs alleviate Al toxicity by activating the antioxidant defense system in maize plant. Konate et al. (2017) emphasized the protective role of Fe_3O_4 nanoparticles against cadmium-induced oxidative stress in wheat.

Zhang (2019) reported that the foliar application of Se NPs to Chinese cabbage under Cd stress increased the biomass, plant height, leaf chlorophyll content, SOD and GSH-Px content of Chinese cabbage, while the Cd content and MDA content of the leaves decreased. Similarly, it has been emphasized that silicon nanoparticles reduce Cd stress in rice (Wang et al., 2015). Combined application of foliar ZnO NP and soil biochar to plants under cadmium stress was more effective against Cd stress (Ali et al., 2019; Rizwan et al., 2019a).

Under Cd stress conditions, application of FeO NPs to wheat, soil and foliage both decreased leaf electrolyte leakage rate, Cd content in grains, as well as increased antioxidant enzyme activity and dry weight of wheat. In addition, foliar application of Fe NPs is more preferred than soil application. This is due to many factors such as the absorption of Fe in the soil, pH and interaction with other minerals during absorption. Co-application of Fe nanoparticles with biochar (Rizwan et al., 2019a) alleviated the effects of Cd stress in rice (Hussain et al., 2019).

20 mg/L Fe_3O_4 nanoparticle application reduced cadmium accumulation in tomato plant and improved cadmium toxicity by increasing nutrient intake (Rahmatizadeh et al., 2019).

Nano-fertilizers aganist commercial fertilizers

Nanoparticles improve the solubility and distribution of insoluble nutrients in the soil, increase the efficiency of fertilizers in plant production and the uptake of nutrients in the soil thereby saving fertilizer. Nanofertilizers also prolong the effectiveness of fertilizers and reduce losses through washing. On the other hand in commercial fertilizers, there is less benefit for plants due to the large particle size and less solubility. As a result of high fertilizer release toxicity occurs, which disrupts the ecological balance of the soil. After some of the fertilizer is used by the plants the remaining part turns into insoluble salts in the soil. In addition high losses occur due to washing.

2. Results

Recently, nanotechnological studies have come to the fore in coping with stress conditions in crop production. Nanoparticles promote physiological and biochemical processes to increase plant growth and development under stress conditions. Plants on the other hand give different responses depending on the size, shape, application method and physicochemical properties of nanoparticles. The application of the nutrients needed by the plant in the form of nanomaterials enables the plant to benefit from the fertilizer at the maximum level. The application of nanoparticles increases the adhesion in the soil due to their large surface areas and prevents them from being easily washed away. Thus, the cost of chemical fertilizers and environmental pollution will be prevented. The effectiveness of NPs even at very low concentrations and the effect on plants varies depending on the species and dose. Compared to conventional fertilizers, they appear as an alternative solution to overcome the problems related to abiotic stress in plants because they are more efficient and effective.

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Turkish Journal of Range and Forage Science, 2021, 2(2): 63-72
doi: 10.51801/turkjrfs.942253

Review

Turkish Journal of Range and Forage Science

https://dergipark.gov.tr/tr/pub/turkjrfs

The Current Situation, Problems, and Suggestions for Forage Crops in Muş Province

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A R T I C L E I N F O

Received 24/05/2021
Accepted 09/06/2021

Keywords:

Forage crop
Livestock
Rangeland
Roughage

A B S T R A C T

With this study, the current situation in terms of forage crop cultivation in Muş province and offered solutions for the problems are discussed. The agroecological characteristics of the province and its current situation regarding forage crop cultivation have been investigated. Although most of the roughage requirement is met in the province of Muş, whose economy is based on livestock, it is determined that the number of forage plant species grown in the province is small, and the yield is low. The first thing that should be initiated in the province of Muş is quality and sustainable forage cultivation. All animal breeders should be informed about the importance of roughage to livestock. Concerning the current problems in the province, the solutions of narrowing the fallow areas by increasing forage crop cultivations areas with suitable crop alternations, increasing the use of certified seeds for quality production, reducing the grazing pressure on the meadow range, and providing necessary information at every stage of forage crop cultivation were offered for more and higher quality production.

1. Introduction

Animal farming is a sector that grows the country's economy and provides the highest added value to the unit investment. It plays a key role in society's nutrition and is the main source of income for rural areas. Furthermore, the livestock sector provided the possibility to increase income by transforming forage crops, which are a source of plant protein, into high-quality animal proteins. Animal proteins are essential for organizations to develop, raise, and live a healthy life because of the amino acids they contain. Moreover, it is well recognized that ten essential amino acids, which are not observed in vegetable proteins, are only obtained through sufficient and balanced amounts in animal proteins (THH, 2019; Ataseven et al., 2020). Yet, the lack of quality roughage from the past to the present is one of the most serious problems in livestock production (Soya et al., 2004). It is widely acknowledged that feed costs account for roughly 70% of all animal production costs (Alçiçek et al., 2010; Kuşvuran et al., 2011; Turan et al., 2015; Bıçakçı and Açıkbaş, 2018). As a result, while improving the efficiency and quality of animal products, which are critical in the human diet, is achievable with ideal nutrition, the fundamental principle of ideal nutrition is achievable with quality feeding (Acar et al., 2020). Animal production cannot become possible financially if agricultural enterprises that do not place sufficient emphasis on the feed plants

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required by the livestock sector in Turkey, which plays an important role in agriculture (Altın et al., 2009). Roughages, which are fairly affordable and have a crude fiber content of greater than 16-18% in dry matter, are beneficial to ruminant digestion and normally contain more than 14 percent water, come forward in this regard (Anonymous, 2015). At the same time, roughages are suitable for the nutritional physiology of ruminant animals and provide mechanical satiety in animals.

Roughages are primarily made up of rangeland and pasture feeds and herbs produced from forage crops grown in agricultural areas (Gökkuş, 1994). Rangelands are privileged in terms of being a feed source because of their natural vegetation and biodiversity, as well as their characteristics such as gene resource, wildlife habitat, increasing soil fertility, and protecting and developing water resources (Açıkgöz, 2001; Altın et al., 2011). It is reported that there is 14.6 million ha of rangeland in our country (TOB, 2019); regrettably, these areas lose their yield power for various reasons, including the usage habits against the management plans that have existed for a long time and a lack of timely maintenance. In addition, the number of good forage plant species that are enjoyed and eaten by animals is steadily decreasing, and many of them now lack vegetation (Yulafçı and Pul, 2005; Yolcu and Tan, 2008; Alçiçek et al., 2010; Sayar et al., 2010; Altın et al., 2011; Kuşvuran et al., 2011; Temel and Şahin, 2011; Budak, 2013, Severoglu and Gullap 2020). Forage crop farming is the most convenient and cost-effective way of supplying feed predicated on all of these factors (Kuşvuran et al., 2011).

Aside from providing feed, which is one of the key elements in livestock production, forage crops have a positive impact on the physical and chemical properties of soils, and thus the yield and quality of the successor cultivated plants (Sağlamtimur et al., 1998; Açıkgöz et al., 2005). That being said, they are critical in terms of being a low-cost source, storing the nutrients required for animal stomach microflora, having important minerals and vitamin resources, capacity to improve animal reproductive performance, and resulting in high-quality animal products (Serin and Tan, 2001). For healthy and profitable livestock breeding, access to high-quality roughage is essential. To do so, we must, first and foremost, increase the production of forage crops in our country, except for rangelands and pastures. Despite the fact that forage cultivation locations have increased in recent years as a result of the initiatives, this rise is still insufficient to meet the roughage needs of our current animal assets.

Forage crop cultivation accounts for 36 percent of total field land in Germany, 31 percent in the Netherlands, 30 percent in Italy, and 25 percent in France and England in countries with developed livestock farming. (Açıkgöz et al., 2005). The ratio of forage crops cultivation area in Turkey’s field agriculture is 13.65%, and its ratio to total cultivated areas is 9.10% (TURKSTAT, 2019a). Notwithstanding the aid, the proportion of forage crops in total agricultural production in our country and region is insufficient to meet the quality roughage requisites of animals. According to data from 2019, our country’s forage crop production deficit is estimated to be approximately 28.4 million tons of high-quality roughage (Anonymous, 2019a; 2019b). This lack of high-quality roughage unquestionably leads to the animals being fed lower-quality feed (stem, hay, etc.). Field waste products such as hay, only used to fill up animals rather than nourish them and end up causing energy loss due to their daunting digestion, occupies large portions in animal nutrition in our country (Ozkan, 2015). In our country, traditional animal feeding habits include hay as a primary source of roughage and feeding animals with mainly hay and concentrate feed (Altın et al., 2009). As a result, forage crop farming is the critical step towards achieving a constant supply of high-quality roughage (Akman et al., 2006). Working to improve the quality and efficiency of forage crop farming will also help alleviate the overuse of pastures and rangelands. Rangelands and pastures that have deteriorated or are on the verge of deterioration due to increased production will have the chance to regenerate (Koc et al., 2014).

Several studies have been carried out to determine the current status of forage crops and rangeland pastures, the animal assets, and the ratio of fulfilling the needs of forage animals in Turkey’s several regions (Sayar et al., 2010, Turan et al., 2015; Sayar 2017; Demiroğlu Topçu and Ozkan, 2017, Bıçakcı and Açıkbaş, 2019; Gülümser et al., 2019; Ozkan, 2020), yet, a comprehensive study has not been conducted in the province of Muş until now. As a result, this study aims to evaluate solution suggestions for forage crop difficulties in Muş province as a whole, taking into account forage crop cultivation areas and production rates, the number of cattle and ovine animals, feed crop support, and land use ratios.

2. Statistics Related to the Muş Province

2.1. Agroecological Characteristics of Muş and Current Land Status

Muş province, which has Turkey's third-largest plain, is considered the greatest agricultural area of the Eastern Anatolia Region, particularly the Upper Murat Region, owing to its fertile agricultural lands and abundant water resources (Erinç, 1953). In Muş province, which is neighboring Erzurum at the north, Bitlis, Diyarbakır and Batman at the south and southwest, Bingöl at the west, and Ağrı and Bitlis at the east, there are rugged mountainous lands not exceeding 3000 meters and plains at an altitude of 1200-1500 meters (Ersungur and Aslan, 2014; Dölek and Harunoğulları, 2018). Muş province has a continental climate with a sizeable temperature difference between day and night and frosty, cold, and long winters. Annual temperatures are on average -10 °C in winter and above 25 °C in summer. The amount of precipitation is, on average, 765 mm annually (Sönmez, 2010). Although the province's agricultural products are limited in variety, the plants grown are usually cold-resistant. Furthermore, because there is no intensive agriculture in the plain, the soils are very clean (Arslan, 2018).

If we look at the usage of land in the province of Muş, there is a total of 866.833 ha of land available in the province, which covers 1.1% of Turkey's land; of them, there are agricultural land (41.2%) 357.342 ha, rangeland (8.3%) 72.099 ha, pasture land (38.8%) 336.062 ha, forest land (9.2%) 79.999 ha, and land area that is unfit for agriculture (2.5%) is 21.331 ha (Table 1). Rangeland and pastures account for 47.1% of the province's total land assets, followed by agricultural lands, which account for 41.22%. (Muş Provincial Directorate of Agriculture and Forestry Briefing, 2020). This province, which is one of the most important livestock centers in the Eastern Anatolian Region, has a high - 80 percent- pasture animal breeding rate (Muş Plain Agriculture and Livestock Workshop, 2017).

2.2. Change in Crop Production Indicators in Muş Province

As shown in Table 2, which depicts the use of agricultural lands in Muş province, grains are the most cultivated product group, accounting for approximately 40% (133.510 ha), followed by forage crops 17.2% (61.612 ha). With 26,139 ha, fallow lands account for 7.3 % of lands in Muş province. The province has a limited amount of vegetables, fruits, industrial oil, and tuber plants in cultivation. In the province of Muş, as in most other provinces in the Eastern Anatolia Region, pasture-based livestock forms a major part of the people's livelihood.

Table 1. Land assets and their distribution in Muş province

Land Type	Amount (ha)	% Of Total Land
Farmland	357.342	41.2
Rangeland	72.099	8.3
Pastures	336.062	38.8
Forest	79.999	9.2
Unfit for Agriculture	21.331	2.5
Total	866.833	100

Mus provincial directorate of agriculture and forestry brief, 2021.

Table 2. Usage status of agricultural lands in Muş province

Product Group	Planting Area (ha)	Ratio (%)
Grains	133.510	37.3
Forage Crops	61.612	17.2
Industrial Oil Crops	6.516	1.8
Vegetables	4.131	1.1
Legumes	2.831	0.79
Fruit	1.331	0.37
Tuber Plants	143	0.04
Fallow	26.139	7.3
Other Agricultural Lands	125.604	35.1
Total	357.342	100

Mus provincial directorate of agriculture and forestry brief, 2021.

2.3. Some forage crops cultivation lands and production amounts in Muş

While forage crops account for 25-30% of total agricultural land in countries with well-developed livestock farming (Semerci and Kurt, 2006), this figure is only 19.8% in the province of Muş, despite the province's unquestionably high forage crop production capacity. In the province of Muş, forage crops are grown on approximately 61 thousand hectares, with clover being the most commonly cultivated forage crop with 49.426 hectares. Muş province ranks first in terms of clover cultivation area and production volume when compared to other provinces, but it ranks almost last when looked at their yield. Sainfoin (5.438 ha) is the province's second most widely planted forage crop, preceded by vetch (3.576 ha) and corn (2.313 ha). With the financial assistance provided, the production of vetch and corn, particularly corn, began to increase significantly in Muş province (Table 3).

Table 3. Forage crops cultivation areas in Muş city center and districts (ha)

District Name		Clover	Sainfoin	Vetch	Silage Corn	Total
Bulanık	Cultivation area	4.389	1.220	250	138	5.997
Hasköy	Cultivation area	5.600	65	100	25	5.790
Korkut	Cultivation area	6.500	350	-	10	6.860
Malazgirt	Cultivation area	2.700	1.500	900	45	5.145
Varto	Cultivation area	8.220	800	350	41	9.411
Center	Cultivation area	22.017	1.503	1.976	2.054	27.553
Total	Cultivation area	49.426	5.438	3.576	2.313	60.753

Turkish Statistical Institute (TÜİK)'s data in 2020.

The total forage crop production amount in Muş province is 1.515.248 tons, and 81% (1.234.224 tons) of them are clover (Table 4). Clover is followed by corn silage (114.190 tons), sainfoin (106.200 tons) and vetch (60.634 tons) (Table 4).

2.4. Cattle and small ruminant assets in Muş Province

The province of Muş is known for its intensive livestock breeding; the total number of cattle/bovine animals is 331.881, and the total number of small ruminants is 1.235.552. Of the bovine animals, 77.225 are European cattle breeds, 181.254 are crossbred cattle, 66.371 are native cattle and 7.031 water buffalo. Of the ovine animals, 999.262 are sheep, and 236.290 are goats. While the total number of cattle is the highest in Bulanik district (125.712 thousand headcounts), the highest number of small ruminants are found in the Central district (565.862 thousand headcounts) (Table 5).

2.5. Cattle/Bovine animal unit (BAU) capacity of Muş province

The coefficients used by Acar et al. (2020) were used to calculate the bovine animal unit in Muş province (Table 6). The BAU was calculated by adding the values obtained by multiplying the number of animals with the animal units. Corresponding to the total number of animals in the province of Muş, BAU was calculated as 371.506.

Table 4. Forage crop production amounts in Muş city center and districts (tons)

District Name		Clover (Green grass)	Sainfoin (Green grass)	Vetch (Green grass)	Corn silage	Total
Bulanık	Production Quantity	109.743	26.840	4.767	6.945	148.295
Hasköy	Production Quantity	151.200	1.560	2.200	1.250	156.210
Korkut	Production Quantity	182.000	9.100	-	450	191.550
Malazgirt	Production Quantity	32.400	16.500	4.050	1.350	54.300
Varto	Production Quantity	164.400	16.128	6.125	1.450	188.103
Center	Production Quantity	594.481	36.072	43.492	102.745	776.790
Total	Production Quantity	1.234.224	106.200	60.634	114.190	1.515.248

Turkish Statistical Institute (TÜİK)'s data in 2020

Table 5. Cattle and small ruminant assets (headcount) in Muş province

District Name	Bovine animal				Small ruminant		
	Cattle	Calf	Water buffalo	Total	Sheep	Goat	Total
Bulanık	97.559	27.660	493	125.712	138.285	20.405	158.690
Hasköy	15.217	5.818	1.730	22.765	27.153	16.659	43.812
Korkut	15.991	5.063	2.447	23.501	82.361	28.680	111.041
Malazgirt	41.978	19.565	99	61.642	45.041	7.111	52.152
Varto	30.411	9.391	20	39.822	276.043	27.952	303.995
Center	39.955	16.242	2.242	58.439	430.379	135.483	565.862
Total	241.111	83.739	7.031	331.881	999.262	236.290	1.235.552

Turkish Statistical Institute (TÜİK)'s data in 2020.

Table 6. Calculation of bovine animal unit (BAU) value for Muş province

Animal Species	Number of animals	Animal Unit	Bovine Animal Unit (BAU)
European Cattle Breeds	77.225	1,00	77.225
Native cattle	181.254	0,75	135.940
Crossbred cattle	66.371	0,50	33.185
Water buffalo	7.031	0,90	6.327
Sheep	999.262	0,10	99.926
Goat	236.290	0,08	18.903
Total	1.567.433	-	371.506

Calculated from the Turkish Statistical Institute (TÜİK)'s data in 2020.

2.6. Muş province roughage production amounts (tons)

The amount of hay was calculated using the green grass production amounts in Muş province and the dry matter rates used by Acar et al. (2020) for forage crops and silage. The amount of hay produced from these areas in Muş province, which has 408.161 hectares of rangeland pastures, was calculated using the value of 100 kg da-1 used by Çaçan and Yüksel (2016), and the quantity of hay generated from these locations in Muş province, which has 408.161 hectares of rangeland pastures was calculated as 408.161 tons (Table 7).

2.7 Current animal asset and roughage need in Muş

Table 7 shows the roughage ratio gained from the province of Muş's forage cultivation areas, rangelands, and pastures to fulfill the demand of the existing animal stock. Rangeland and pasture lands provide 408.161 tons of roughage, while forage crops and silage production provide 458.000 tons of roughage. The value of the animal asset in the province in terms of BAU is 371.506 BAU, and the annual roughage need of the current animal asset (371.506 x12.5 hay x 365 days) is 1.695 million tons. The province's roughage shortfall is 828.839 tons, with a 51.10% ratio of supplied roughage to meet the demand (Table 8).

Table 7. Muş Province Roughage Production (tons)

	Clover	Sainfoin	Vetch	Corn silage	Rangelands and Pastures
Green grass production (tons)	1.234.224	106.200	60.634	114.190	408.161 ha
Dry Matter Ratio (%)	30	30	30	33	100 kg / da
Hay amount (tons)	370.267	31.860	18.190	37.683	408.161

Calculated from the Turkish Statistical Institute (TÜİK)'s data in 2018.

Table 8. The ratio of total roughage produced in Muş to fulfill the needs of the existing animal stock

Fodder/Hay Obtained From Rangeland Pastures	408.161 tons
Hay Obtained From Forage Crops	420.317 tons
Hay Obtained From Silage Cultivation	37.683 tons
Total	866.161 tons
Total Animal Assets	371.506 BAU
Roughage Requirement	1.695 million tons
Roughage Deficit	828.839 tons
The ratio of roughage Produced to Meet the Needs	51.10%

Calculated from the Turkish Statistical Institute (TÜİK)'s data in 2020.

2.8. Financial aid provided to some forage crops in Muş province

Every year, the Ministry of Agriculture and Forestry assists farmers in improving agricultural production and ensuring long-term sustainability. Concerning financial aids for forage crop, perennials receive 90 TL per decare, annuals receive 60 TL, corn silage receives 60 TL, and forage crops grown in dry conditions receive 40 TL. The cultivation areas of forage crops in Muş province have increased owing to these subsidies (Harmanşah, 2018). When looking at the amount of state subsidy provided in Muş province over the last three years, it is clear that the funded cultivation area has increased significantly. In the last three years, 23 million TL financial aid was provided to 9.225 farmers for approximately 300 million da land in Muş province (Table 9).

Table 9. Financial aid provided to Muş province forage crops (da)

	Years		
	2017	**2018**	**2019**
Total number of farmers	2.319	3.502	3.404
Total Cultivation area	75.404.704	112.123.829	112.307.433
Clover	39.251.807	73.542.449	78.569.528
Sainfoin	17.051.564	21.862.458	18.943.106
Vetch	15.759.039	13.208.541	9.578.234
Corn Silage	3.342.294	3.450.560	4.690.467
Other plants supported	-	59.821	526.098
Total financial aid (TL)	3.998.824	10.387.889	8.397.127

Mus provincial directorate of agriculture and forestry brief, 2021.

3. Problems of forage crop cultivation in Muş and suggested solutions

To bridge the existing roughage shortfall across the country and mitigate the excessive pressure on rangeland pastures, forage crop agriculture must be given the attention it deserves. Notwithstanding, a few mistakes and issues with forage crop cultivation exist, and all of these correlate to problems in Muş, as well as other provinces. To summarize the missteps and possible solutions, particularly in the province of Muş, first one should ascertain the existence of roughage production by determining the lands where farmers will cultivate forage crops, rangeland pastures, and usability potential as soon as possible in the province of Muş. Implementing comprehensive training on forage crop cultivation, from seedbed preparation to harvest time, will be extremely beneficial in addressing some of the incorrect practices, particularly in Muş, where seeds are small and seedling development is delicate. Furthermore, land fragmentation in Muş province, as well as Turkey in general, impedes agricultural integrity. The farmers can't make good use of the province's treasury lands because they make up most of the land. As a result, the lands should be consolidated as soon as possible.

Even though some forage crop cultivation areas have increased due to forage plant financial aids, these increases have not yet reached the desired dimensions, preventing a profitable yield. Consequently, experts should monitor forage crop areas that are sponsored in terms of sustainability at all stages. Farmers should be informed about these aids, and these aids should be diversified and increased. On the other hand, because our country lacks a healthy seed market, the seed constraint, and is one of the country's most serious bottlenecks, forces farmers to use seeds with low purity that lack seed characteristics. In this case, it directly reduces efficiency and quality. Seeds of sufficient and high quality are in short supply in the Muş province. Because increasing the planting areas without overcoming the seed problems is perceived as a dream. The number of forage plants (clover, sainfoin, vetch, corn) cultivated in the province is quite low.

Producers should be offered breeding training seminars. Local farmers should be instructed on growing forage crops in full compliance with ecological conditions to help solve all of these problems. The technical staff of the relevant

Provincial Directorates of Agriculture and Forestry and faculty members of the Faculty of Applied Sciences Plant and Animal Production and Technologies Departments should support farmers more. Farmers should also be provided practical information through the organization of regular field days at appropriate times to emphasize the importance of forage crops in animal nutrition. To ensure that pastures are used in compliance with management principles and prevent problems providing quality roughage to animals even outside the grazing season, forage cultivation should be incentivized and boosted. New forage crop species adequate for the ecology of the Muş province should be identified, seeds of the cultivated species should be provided after undergoing various adaptation and yield trials, and alternative forage crops for the cultivated species should be identified. Farmers should be encouraged to use certified seed, and they should be informed about new species.

4. Results

With its vast pastures, Muş province is one of the most important livestock centers in Eastern Anatolia. That being said, in the province of Muş, a lack of quality roughage is a major issue due to several factors, including the use of rangeland and pasture areas as the primary source of the province’s roughage needs and inadequate forage plant aids, excessive and timeless grazing while not being able to graze these areas with the appropriate number and breed of animals.

As a result, in order to solve the roughage problem in Muş, whose economy is based on agriculture, whose agriculture is based on livestock, and whose livestock breeding is based on rangeland-pasture and forage plants, it is necessary to ensure the use of pastures according to management principles, to increase the cultivation areas of forage crops and implement alternation systems, to diversify and increase the financial subsidies, and providing adequate training, we should overcome obstacles to forage crop agriculture.

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Turkish Journal of Range and Forage Science, 2021, 2(2): 73-78
doi: 10.51801/turkjrfs.1002322

Review

Turkish Journal of Range and Forage Science

https://dergipark.gov.tr/tr/pub/turkjrfs

Main Problems Encountered in Green Field Facility and Solution Suggestions in Turkey

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A R T I C L E I N F O

Received *29/09/2021*
Accepted *05/11/2021*

Keywords:

Turf areas
Turf problems
Suggestions for solutions

A B S T R A C T

In this article, essential questions and solutions in turf management practices encountered in Turkey were discussed. It is a fact that turf culture gained significance in the country during recent years. However, there are many handicaps in turf establishment and management activities in this sector. Since the proper techniques are not imposed during turf studies, turf areas are lost in a very short period of time deteriorated. Main problems are; lack of experienced stuff, lack of infrastructure, effect of different ecologies, failures in genus and species preferences, over use of seed supplies, lack of high quality seed sources, lack of maintenance measures.

1. Introduction

The most important plant elements of the environment we live in are green areas. Natural beauties can reveal their true potential thanks to green spaces. As a result of rapid population growth, the longing for green grows even more due to the dense and distorted construction in the cities. In addition to giving people peace of mind thanks to the attractiveness of green colors, green areas also have many benefits such as preventing erosion by covering bare lands with vegetation, soil improvement, protecting nature, reducing the temperature by 5-12 °C by absorbing solar radiation, and doing sports activities and excursions on it (Beard, 1973; Uzun, 1992; Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

Green area culture has started to gain importance in our country in recent years. Among the reasons for this; young generations' applications they see in the world thanks to technology and communication and their demand for them, expressing their desire to do sports in higher quality areas, without going abroad in order to prevent the loss of time, especially for a high-income group; demanding the construction of football, tennis, golf and similar sports fields and also ensuring that this is transformed into a tourism sector. In addition, with some legal regulations made in recent years, it can be shown that it is compulsory to include green areas in the zoning areas. It should be accepted that green areas, whether optional or legal obligation, are one of the most important plant elements that should be included more in our environment in terms of human and environmental health.

In this article, the main problems encountered before, during and after the establishment of green areas in Turkey and some basic suggestions for their solution are presented.

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2. Major problems encountered and solution suggestions

2.1. Lack of qualified personnel

In our country, the number of scientifically trained and specialized staff on green areas is not enough yet. Today; Landscape Architecture Departments operating in the Faculty of Agriculture, the Faculty of Forestry and the Faculties of Architecture-Engineering work mainly on architecture, and the production of plant materials used in the landscape is usually left to the Field and Horticultural Departments of the Faculties of Agriculture. Turfgrass and green space culture is included in the discipline of agronomy in contemporary countries, and it is carried out in our country with the joint efforts of meadow-pasture and forage crops scientists.

Emphasis is placed on training intermediate staff in order to eliminate the shortage of technical staff, and even in some Vocational Schools with technical infrastructure and suitable ecological conditions (except İzmir Bayındır Vocational School and Antalya Serik Vocational School where this program is available; in places where the sector is dense such as Adana, Bursa, Yalova, Sakarya, Kocaeli) Opening programs under the name of “Turfgrass Establishment and Management Program” should be brought to the agenda and necessary infrastructure studies should be carried out and necessary initiatives should be made with relevant institutions and organizations (Salman et al., 2007; Yilmaz et al., 2012). In addition, the definitions of professional specialization, authorization and employment of graduates of this program should be determined by a regulation and recorded.

2.2. Infrastructure deficiencies

It will be used especially in seed production with special tools and equipment that will level the areas where the green field will be established, prepare the seed bed, perform the planting and maintenance operations; The inadequacy of sowing, hoeing, harvesting, threshing and packaging machines is one of the most important problems. Most of these machines are imported from abroad at high prices. Although there are some domestic productions such as lawn mowers, they remain limited. By making the necessary investments, the sector should be provided with better quality seed production at a cheaper price (Salman et al., 2007; Yilmaz et al., 2012).

2.3. Disregard for different ecological conditions

Despite the fact that our country has very different ecologies, there is a misconception that grass seed mixtures prepared without considering whether they are suitable for cool and hot climate conditions can be applied to almost any region. Adaptation studies should be carried out and regional mixtures should be prepared in accordance with scientific rules in regions with similar characteristics in different regions of our country (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.4. Selection of species and varieties suitable for the intended use

Since the purpose of using the green area is not decided in advance, the established area is destroyed in a short time. Green areas should be established by taking into account the appropriate mixing ratios of the species and varieties suitable for the purpose. green areas; It is created in many different places and for different purposes, such as park-garden arrangement, recreation and picnic areas, under trees and building shadows, areas where sports such as football, bowling, golf and tennis are played, racehorse paddocks, roadsides and greening of slopes. For example, planting the mixture that should be used in the golf course in an area that will be used as a football field will cause the area to deteriorate in a short time (Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.5. Not paying attention to the time of sowing

Although green field grasses can be planted from the beginning of spring to late autumn, they are not suitable as the plantings will be at risk due to the extreme heat in the summer. Spring plantings; It should not be preferred unless there is a necessity, due to the increasing warming of the days and the emergence of the necessity of irrigation and the intense weed emergence. On the contrary, it should be preferred in terms of both economy and green space quality, especially in the autumn months when the weather is cool, irrigation is not needed or very little, and the annual weeds have completed their life. In the studies carried out in the ecological conditions of Tokat and Sakarya, no significant problems were encountered in the plantings made in July in summer and in late November in autumn. However, it should not be overlooked that the ecological conditions in those years allowed these plantings (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.6. Lack of quality seed production

As mentioned in the infrastructure deficiencies, sector-specific mechanization cannot be achieved, the seed production areas cannot be selected well, the seed production in the selected areas is not carried out by well-trained personnel with sufficient knowledge for seed production and the seed production to be used in the green field facility is not sufficient in terms of technology and infrastructure. not have; It causes poor quality seed production and at the same time, the seeds produced are costly due to the high inputs. By making the necessary investments in this regard, we must eliminate our dependence on foreign sources by producing quality seeds that we need, and we must be able to export seeds by demonstrating our competitive power (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012).

2.7. Lack of healthy data on seed

While producing a total of 2,761 tons (annual average 251 tons) of turfgrass seeds between 2006 and 2016 in our country, it spent $100 million by importing a total of 46,867 tons (an annual average of 4,261 tons) turfgrass seeds in the same period (Yilmaz et al., 2012; Anonymous, 2021). However, there is no clear information about how much of this amount is used in the new green field facility, how much is used in the top seeding, how much is used in the renewal of the deteriorated area built a few years ago, and how much is exported as trading. For example, it is reported that 4,164 tons of imports, 316 tons of exports and 454 tons of domestic grass seed production were made in 2008 (Yilmaz et al., 2012; Anonymous, 2021), but it was not possible to find out whether the export was made from imports or domestic production. In addition, if 50 gr/m^2 seed is planted on average with 5,000 tons of seeds, 100,000 decares (10,000 hectares) of green area are established. In this case, 500,000 decares of green space facilities should have been built in the last five years, and the research and observations made are far below these figures. For this reason, excessive seed waste and issues related to trade should be examined.

2.8. Waste of seeds

The amount of seed to be planted per unit area should be calculated and discarded in accordance with the prepared seed bed. For example, although Acikgoz (1994) and Avcioglu (2014) reported that about 20-40 kg of seeds per decare from a quaternary mixture is sufficient, it is not seen that less than 70 kg of seed is planted in many places today, and even more than 100 kg of seeds are witnessed. Indiscriminate and indiscriminate seeding also causes economic loss. Considering that the seeds are imported, it will be seen that this loss is much larger (Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.9. Introducing variety names to the market by changing them frequently

A large number of varieties belonging to a species are bred by many different companies, but seeds that are not very different from each other, but presented to the market by showing them as different, are encountered. At the same time, the names of the varieties are changed every few years on the grounds that they are newly bred, and users who do not know much about the subject are confused. Unfortunately, it is observed that the performance of a variety that is presented as new instead of a variety sometimes does not even reach the previous variety. However, it should be ensured that a variety that has proven its quality, known and sought after by users, remains in the market for a longer period of time (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012).

2.10. Unnecessary degradation of green spaces

Green areas, suitable species and varieties are selected in appropriate proportions and if the necessary care conditions are followed, they continue their vitality and usability for many years. However, it is known that many public green areas are deteriorated and re-established even though they are usable every year or every few years. To the municipality officials who do this work; “Why is the same place broken down and rebuilt?” when asked; It is extremely sad to receive answers such as "giving jobs to party contractors" and "it is done for the citizens to see the municipality working". These practices, made for political and economic reasons, are nothing but a waste of national wealth (Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.11. Unprofessional cut grass cultivation

One of the biggest problems is the depletion of fertile lands caused by unconscious cut grass growers who do not have a specific production facility and brand, do not care about natural resources and the environment. Especially in recent years, the need for green spaces has increased due to the spread of green space culture and some compelling rules for landscaping. Especially in the provinces of Sakarya, Düzce, Kocaeli and Bursa, fertile fields are rented for 2-5 years at very high prices and in cash, during this period, grass is planted and cut 2-10 times, 1-2 times a year, and approximately 2-4 cm. soil layer is carried from the field. At the end of the rental period, it is understood later that the fertile top soil layer of the field was taken away and no material was put in its place. The farmer who rents his field for a high price can see what his field has become when the lease period ends. Unfortunately, these practices still continue. This situation must be inspected by authorized public institutions and organizations and necessary measures must be taken. Such businesses that do not comply with the rules should not be given the necessary license to do this business (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014). In addition, it is one of the practices that can be considered to impose an obligation to employ "turfgrass technicians" to businesses that produce grass.

2.12. Insufficient maintenance

Indispensable maintenance operations for green areas; irrigation, fertilization, mowing, rolling, seasonal maintenance, top seeding and sandblasting, and combating weeds, diseases and pests. Irrigation; Yellowing, drying, color differences and failure to grow occur in the green area as a result of not being made on time, with appropriate methods, in necessary and sufficient quantities, from good quality water sources. Irrigation should be done by knowing the wilting point of the grass and it should be applied with an appropriate method in sufficient quantities when necessary. Fertilizing; Not knowing with which fertilizers, when and in what interval and how much to make, again causes the field to deteriorate. Scientific studies should be made and published in media organs accessible to green field lovers, and different media should be used for this purpose. At least in the provincial directorates of the Ministry of Agriculture and Forestry, there should be "grass technicians" who are experts in the subject. In forms; cutting height, cutting shape, cutting time, technical features of the machine used and the sharpness of the blades should be considered. Format height varies with the intended use, for example deep shapes also require frequent formatting. Such areas are usually the parts of the golf courses where the holes are located. In terms of form, shape should not be made in the same direction all the time, it should be shaped from different directions each time. The mowing time should be in cool times, usually close to the evening, when the grass is dry and water loss will be less. The speed of lawnmowers is 5-7.5 km/h. Using machines faster than this will result in machine splashes and poorly mown areas. The sharpness of the knives is extremely important. Unsharpened blunt blades break the leaf tips instead of cutting them and cause the plant to lose excessive water and infect the plant with disease factors. Rolling; A light roller, which can be found behind the machine in any form, not only ensures that the area is as dense as necessary, but also provides different views by tilting the grass. Seasonal maintenance and rolling in early spring and at the end of autumn in order to prevent the roots of plants from airing and drying, especially in areas that are loosened due to frost heaving and long-term snow and rains in winter, positively affect the life of the green area. In addition, all maintenance operations must be reviewed within the seasonal maintenance. In addition, seasonal maintenance of frequently and excessively used areas should be done at least four times a year. Depending on the purpose of use, there are also areas that need to be maintained at the end of spring and beginning of summer. Especially football fields are areas that require intensive care and should be under constant care. The most important maintenance time of such sports fields starts at the end of the season, and it is made ready for frequent and extreme use by making intense efforts to be trained for the next season. Top seeding and sandblasting; In cases where the deteriorated parts of the green areas can be seeded from the top, decomposition and re-seeding should be avoided, and the area should be saved by top seeding under appropriate conditions. In addition, due to excessive chewing, pitting should be filled by sandblasting and the area should be leveled. Weed control, if the weeds in the area can be removed, should be taken mechanically by hand and with sharp tools without damaging the grass. Spraying can be done in areas where there are too many weeds to be removed by hand. In this case, necessary measures should be taken to prevent harm to people and pets living in the area. Fight against diseases and pests; In general, these problems are not seen very often in areas that are regularly and properly maintained. However, if the weather is very hot, fungal diseases can be seen if excessive irrigation is done. By adjusting the irrigation frequency and amount, this problem can usually be overcome without spraying. As a pest, mice, rats, weasels and calfsuckles can cause more damage in the first periods, that is, when the green areas are not fully dense. In the following periods, this damage will be less. Mechanical methods are the first to be applied for these pests, and spraying can also be done when necessary (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

2.13. Failure to make underground installation on time

Leaving the electricity, water, wastewater and planting of tall plants after the green area facility and not making the applications that may cause the deterioration of the green area affect the quality of the area negatively (Salman et al., 2007; Yilmaz et al., 2012).

2.14. Ignoring the drainage channels

As a result of not paying attention to the drainage systems that prevent the accumulation of irrigation water and rain water in green areas in most places, the green areas deteriorate in a short time and at least the grass quality deteriorates. This problem is of greater importance, especially in flat sports fields without slopes. For this reason, the most suitable drainage method for the area must be determined and established before the seed sowing process (Acikgoz, 1994; Salman et al., 2007; Yilmaz et al., 2012)

2.15. Lack of spare grass paddocks

Some areas may need urgent renovation from time to time, especially due to the rapid deterioration in sports fields. In this case, planting is done in most places, which is not correct. It is more economical and easier to have a spare grass area kept ready in a suitable place instead of planting. The deteriorated part is cut off and replaced with a suitable piece from the spare grass field, and the field is made ready for sports immediately (Salman et al., 2007; Yilmaz et al., 2012; Avcioglu, 2014).

3. Conclusion

Scientists who conduct scientific studies on green areas in our universities, have master's and doctoral theses prepared and prepared, have many more questions to answer and many different problems to overcome. It is necessary for the subject employees to eliminate the deficiencies with a good organization and to constantly renew and develop themselves. For this reason, the most important expectations from researchers working in different ecologies are to cooperate closely in overcoming existing problems by conducting joint scientific studies and sharing information. In order to become a widespread non-governmental organization in this regard, it should focus on promotional activities by establishing an association or platform. The problem of foreign dependency should be put to an end by establishing the necessary communication with authorized institutions and organizations. The long-standing habit of bringing cut grass from abroad should be stopped. In recent years, the grass of many stadiums in our country, especially Istanbul Türk Telekom, Samsun 19 Mayıs, Şanlıurfa GAP Arena, Istanbul Olympic, Trabzon Şenol Güneş, has been brought from abroad. It is especially regrettable that people from abroad are urgently brought in for a few match maintenance (only watering, mowing and fertilizing). In our country, there are lawn experts at the doctoral level who can overcome this situation, but their knowledge is not consulted and evaluated for various reasons. In order to train well-equipped "Turfgrass Technicians" as well as expert staff with a doctorate, a "Grass Field Establishment and Management Program" should be opened in universities in regions with suitable infrastructure and ecological conditions, where the industry is the busiest and where there are application areas, employees should be supported and trusted, this dependent situation must be put to an end and further wastage of the country's resources must be prevented.

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