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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 14 (1): 53-58, 2011
ISSN 1028-8880 / DOI: 10.3923/pjbs.2011.53.58

The Effects of Nitrogen and Phosphorus Fertilizer Application on Herbage Yield of Natural Pastures

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Abstract: This study was carried out in a natural pasture in Van province of Turkey between the years of 2004 and 2005 to determine the effects of nitrogen and phosphorus fertilization on herbage yield. The study was performed in randomized block with three replications. 0, 4, 8, 16 kg da^{-1} nitrogen and 0, 6, 12 kg da^{-1} phosphorus applications were examined. The effects of different nitrogen and phosphorus fertilizer applications on plant height, green herbage and crude protein yield were significant for both years. Depending on the increasing nitrogen and phosphorus applications, significant increases were in green herbage, hay and crude protein yields. According to results, differences between 8 and 16 kg da^{-1} doses of nitrogen and 6 and 12 kg da^{-1} doses of phosphorus applications were insignificant. In the first year, in terms of nitrogen applications, the highest green herbage, hay and crude protein yield (1423.1, 263.3 and 29.2 kg da^{-1}) were obtained from 8 kg N da^{-1}, in the second year, the highest values (1426.1, 602.7 and 67.8 kg da^{-1}) were obtained from 16 kg N da^{-1} application. As for the phosphorus applications, in the first year, the highest green herbage yield was 1142.2 kg da^{-1} at the 6 kg P_2O_5/da application, hay and crude protein yields (218.2, 23.1 kg da^{-1}) were recorded from 12 kg P_2O_5/da application. In the second year, the highest green herbage, hay and crude protein yields were (1335.8, 549.6 and 66.1 kg da^{-1}) determined at the 12 kg P_2O_5/da application.

Key words: Nature pasture, nitrogen, phosphorus, dose, fertilizer, herbage yield

INTRODUCTION

Natural pastures are one of the most important forage sources of Turkey. Due to uncontrolled utilization for long years, yield potential and herbage quality of pastures decreased. Consequently, serious problems arose in feed needs of animals and soil and water sources were affected from erosion.

In Eastern Anatolian Region, 50% of the produced winter forage is supplied from pastures (Tan and Serin, 1998). Therefore, the researches and applications to increase hay production of pastures have an important role in improving in animal production. Fertilization is an important method than the others to increase the herbage yield of pastures. In addition to increasing herbage yield, nutritive value of the herbage can also be increased by fertilization method (Altin *et al*., 2005).

Generally the alone application of nitrogen fertilizer in pastures enhances above-ground parts and has no effect on root development. Naturally, the resistance of the plants to drought decreases (Booker and Demir, 1963). In phosphorus-deficient soil, unless fertilization is applied, the root system of the plants weakens, tillage is reduced and maturation is delayed (Kacar, 1984). MacLeod (1969), showed that increasing the nitrogen content in the nutrient solution resulted in different 'yield curves' for the different potassium levels applied. Short term studies in a greenhouse and in a nutrient solution showed that phosphorus uptake and translocation was regulated by nitrogen. The process involved a decrease in the rhizosphere pH and an increase in the solubility of soil phosphates, with this combination increasing root growth and the physiological capacity of the root to absorb phosphorus (Kamprath, 1987).

In a study conducted in pasture, by the applied doses of N and P, Polat *et al*. (2007) obtained the highest dry matter yield (3407 kg ha^{-1}) and crude protein yield (464.1 kg ha^{-1}) when 150 kg ha^{-1} dose of P and 200 kg ha^{-1} dose of N were applied. Manga *et al*. (1986) reported that high dose of nitrogen significantly increased the yield in natural pastures, decreased crude ash and crude protein ratios and increased crude cellulose ratio. They reported that optimum fertilizer doses were 6 kg da^{-1} nitrogen, 3-6 kg da^{-1} phosphorus and 5 kg da^{-1} potassium. In a rangeland on which 10 kg da^{-1} nitrogen and 5 kg da^{-1} phosphorus were applied, Gokkus and Altin

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(1986) reported that hay yield, crude protein yield and crude cellulose ratio of the rangeland increased, however crude ash ratio decreased. In their studies carried out in two natural rangelands, Buyukburc *et al.* (1991) obtained 153 kg da^{-1} hay in control parcel and after 5 kg N/da + 5 kg P_2O_5 and 7.5 kg N/da + 5 kg P_2O_5 /da fertilizer applications, they obtained 241.6 kg da^{-1} and 243.3 kg da^{-1} hay respectively. In other rangeland studies, while hay yield was 70.4 kg da^{-1} in control parcels, the researchers obtained 393.9 kg da^{-1} hay yield from 5 kg N/da + 5 kg P_2O_5 /da application and 434.6 kg da^{-1} hay yield from 7.5 kg N/da +5 kg P_2O_5 /da application. In a rangeland dominated by legumes, in their studies carried out six different doses of nitrogen varying between 0-25 kg da^{-1} combined with 10 kg da^{-1} phosphorus, Hatipoglu *et al.* (2001) reported that phosphorus application significantly increased hay yield, however the analyzed nitrogen applications did not cause a significant difference in the yield when compared to the phosphor application. In a study carried out in a natural pastures, Akdeniz (1992) reported that after increased nitrogen applications, hay and crude protein yields increased and they obtained the highest herbage yield from 15 kg N da^{-1}, 5 kg P_2O_5/da and 7.5 kg K_2O /da applications in the first year and from 15 kg N/da N, 5 kg P_2O_5/da and without potassium application in the second year. In a previous study carried out in a moderate-degree pastures containing 5-26% legume, the highest herbage yield (763.7 kg da^{-1}) was obtained from 15 kg N da^{-1} and 10 kg P_2O_5 /da application.

The present study aims to investigate the effects of different doses of nitrogen and phosphorus fertilizer combinations applied in natural pastures in Van province on herbage yield.

MATERIALS AND METHODS

The study was carried out in a pasture in Arisu village of Van province between the years of 2004 and 2005. According to average climatic data, the study area has an average temperature of 9.0°C and a total precipitation of 387.7 mm. Between the years 2004 and 2005, an average temperature of 9.5 and 9.0°C and an average precipitation of 426.7 and 337.9 mm were recorded. The study was carried out according to randomized block design with three replications. Parcel size was determined to be $3\times3 = 9$ m^2 and parcel intervals were planned to be 1.5 m and block areas intervals were planned to be 2 m. In the study four different doses of nitrogen (0, 4, 8 and 16 kg da^{-1}) and three different doses of phosphorus (0, 6 and 12 kg da^{-1}) were used. As nitrogen source, ammonium nitrate and as phosphorus source triple super phosphate was used. Fertilizer doses were applied to parcels which were determined after the snows melted in early spring each year. Harvesting was made according to inflorescences period of the poaceae. Plant heights were measured and averages were taken from each parcel at 20 points before the harvest. Each parcel was harvested in full, measured in the field and green herbage yields were determined. Plant material in harvested parcels was dried in incubator at 105°C and dry weights were calculated. Crude protein yields of the dries material were identified using Kjeldahl device. In both years of the study, two harvests were performed in each parcel.

Data were analyzed using the general linear model of SPSS statistical software version 11.5. The analyses were performed according to randomized blocks design (Efe *et al.*, 2000). Treatment means within each date were compared using Duncan's multiple range test with a 0.05 level of significance (Duzgunes *et al.*, 1987).

RESULTS AND DISCUSSION

Plant height: The effects of nitrogen and phosphorus applications on plant height are given in Table 1. According to the Table, in the first year of the study, the statistical effect of nitrogen applications on plant height was 1%; the effect of phosphorus applications was 5%. In the second year of the study, the reverse was the case.

In the first year of the experiment, in the first harvest, plant heights varied between 35.1 and 67.5 cm; in the second harvest, plant heights varied between 37.0 and 62.2 cm. According to the average of two harvests, the highest plant height values, in terms of nitrogen, were obtained from 8 and 16 kg da^{-1} applications (59.5 and 58.7 cm, respectively). The lowest plant height was measured as 39.0 cm from the parcels in which no nitrogen was applied. As for the phosphor applications in harvest averages, although there was no significant difference between the parcels in which 6 kg da^{-1} phosphorus was applied and the parcels in which no phosphorus was applied, the highest plant height was obtained from 52.3 cm and 6 kg da^{-1} application. Nitrogen x phosphorus interaction was not statistically significant; however the highest plant height value (62.1 cm) was obtained from 8 kg da^{-1} nitrogen and 12 kg da^{-1} phosphorus (Table 1). In the second year of the experiment, plant height values varied between 57.0 and 73.7 cm; in the second year, plant heights varied between 56.4 and 73.1 cm. According to the average of two harvests, the highest plant height obtained from 16, 8 and 4 kg da^{-1} nitrogen applications were found to be 67.7, 67.4 and 64.8 cm, respectively. As for the phosphorus applications, the highest plant heights

were found to be 68.6 and 68.5 from 12 and 6 kg da^{-1} doses. Although nitrogen x phosphorus interaction was found to be insignificant in statistical analysis, the highest plant height (73.4 cm) was obtained from 8 kg da^{-1} nitrogen and 12 kg da^{-1} phosphorus interaction (Table 1).

Study results indicated that fertilizer applications increased vegetation heights. The researchers reported that nitrogen accelerated vegetative growth and phosphorus encouraged root development and tillage and thus plant growth is enhanced (Booker and Demir, 1963; Kacar, 1984). In the second year, the significant effect of phosphorus on plant heights was supported by the approach of Booker and Demir (1963) and Kacar (1984).

Green herbage yield: In both years of the study, the effect of nitrogen and phosphorus applications on green herbage yield was found to be statistically significant at 1% level. In the first harvest in 2004, green herbage yields varied between 393.3 and 1730.0 kg da^{-1} and in the second harvest, yields varied between 486.7 and 1656.7 kg da^{-1}. In the year 2005, in the first harvest, green herbage yields varied between 740.0 and 1490.0 kg da^{-1}; and in the second harvest, the yield varied between 653.3 and 1613.3 kg da^{-1} (Table 2).

In the first year of the study, as for the average values of both harvests, the highest green herbage yield from 8 and 16 kg da^{-1} nitrogen applications were 1423.1 and 1273.3 kg da^{-1}. As for phosphorus

Table 1: Effect of nitrogen and phosphorus application on plant height (cm)

		2004				2005			
		Phosphorus dozes (P)				Phosphorus dozes (P)			
Cutting Number (CN)	Nitrogen dozes (N)	P_0	P_6	P_{12}	Ave. (NxCN)	P_0	P_6	P_{12}	Ave. (NxCN)
First cutting	N_0	35.1	41.8	39.3	38.8	57.0	67.8	59.0	61.3
	N_4	41.7	44.5	47.9	44.7	58.5	68.7	63.7	63.6
	N_8	57.0	63.2	63.1	61.1	59.9	69.3	73.7	67.6
	N_{16}	56.0	67.5	55.6	59.7	64.3	63.7	71.2	66.4
	Ave.(PxCN)	47.5	54.2	51.5		59.9	67.4	66.9	
Second cutting	N_0	37.0	40.8	39.7	39.2	56.4	64.4	62.8	61.2
	N_4	41.0	45.6	46.9	44.5	62.4	62.4	73.1	66.0
	N_8	52.0	60.7	61.0	57.9	58.7	69.4	73.1	67.1
	N_{16}	62.2	54.3	56.6	57.7	68.9	66.1	72.1	69.0
	Ave.(PxCN)	48.1	50.4	51.0		61.6	65.6	70.3	
					Ave.(N)				Ave.(N)
Ave.(PxN)	N_0	36.1	41.3	39.5	39.0c	56.7	66.1	60.9	61.2b
	N_4	41.4	45.1	47.4	44.6b	60.5	65.6	68.4	64.8ab
	N_8	54.5	61.9	62.1	59.5a	59.3	69.3	73.4	67.4a
	N_{16}	59.1	60.9	56.1	58.7a	66.6	64.9	71.7	67.7a
	Ave. (P)	47.8a	52.3a	51.3ab		60.8b	66.5a	68.6a	

Values with different letters show significant effect

Table 2: Effect of nitrogen and phosphorus application on green herbage yield (kg da^{-1})

		2004				2005			
		Phosphorus dozes (P)				Phosphorus dozes (P)			
Cutting Number (CN)	Nitrogen dozes (N)	P_0	P_6	P_{12}	Ave. (NxCN)	P_0	P_6	P_{12}	Ave. (NxCN)
First cutting	N_0	393.3	550.0	560.0	501.1	740.0	896.6	1140.0	925.5
	N_4	726.7	983.3	910.0	873.3	756.6	836.6	1196.6	929.9
	N_8	1170.0	1356.0	1540.0	1355.6	1296.6	1456.6	1483.3	1078.8
	N_{16}	1066.7	1730.0	1180.0	1325.6	1386.6	1383.3	1490.0	1420.0
	Ave.(PxCN)	839.2	1155.0	1047.5		795.0	1143.3	1327.5	
Second cutting	N_0	486.7	690.0	623.3	600.0	653.3	826.6	1266.6	915.5
	N_4	720.0	880.0	1086.7	895.6	786.6	1420.0	1133.3	1113.3
	N_8	1161.7	1656.7	1653.3	1490.6	1186.6	1523.3	1363.3	1357.7
	N_{16}	1190.0	1290.0	1183.3	1221.1	1266.6	1416.6	1613.3	1432.2
	Ave.(PxCN)	889.6	1129.2	1136.7		973.3	1296.6	1344.1	
					Ave.(N)				Ave.(N)
Ave.(PxN)	N_0	440.0	620.2	591.7	550.6c	696.7	861.6	1203.3	920.5b
	N_4	723.3	931.7	998.3	884.4b	771.6	1128.3	1165.0	1021.6b
	N_8	1165.8	1506.7	1596.7	1423.1a	1241.6	1490.0	1423.3	1218.3a
	N_{16}	1128.3	1510.0	1181.7	1273.3a	1326.6	1400.0	1551.7	1426.1a
	Ave. (P)	864.4b	1142.1a	1092.1a		884.2b	1220.0a	1335.8a	

Values with different letters shows significant effect

applications, the highest yield values were 1142.1 and 1092.1 kg da^{-1} from 6 and 12 kg da^{-1} dose applications respectively. Although nitrogen x phosphorus interaction was found to be insignificant, the highest yield (1596.7 kg da^{-1}) was obtained from 8 kg da^{-1} nitrogen and 12 kg da^{-1} phosphorus application (Table 2).

In 2005, according to the average nitrogen applications of two harvests, it was found that the highest yield was obtained from 16 and 8 kg da^{-1} applications (1426.1 and 1218.3 kg da^{-1}, respectively). As for the phosphorus applications, the highest yield was obtained from 12 and 6 kg da^{-1} applications (1335.8 and 1220.0 kg da^{-1} respectively). In the second year of the experiment, nitrogen x phosphorus interaction was not found to be statistically significant. The highest green herbage yield (1551.7 kg da^{-1}) was obtained from 16 kg da^{-1} nitrogen ×12 kg da^{-1} phosphorus interaction (Table 2).

Significant increases were observed in green herbage yield after increased doses of fertilizer applications. The difference between 8 and 16 kg da^{-1} nitrogen and 6 and 12 kg da^{-1} phosphorus applications was not found to be significant in terms of their effects on green herbage. Therefore, the dose of the fertilizer should be determined after economic considerations. The findings are consistent with the findings of Alinoglu and Mulayim (1976).

Hay yield: In both years of the study, the effect of nitrogen and phosphorus applications on hay yield was found to be statistically significant at the level of 1%. In the first year, hay yields varied between 106.6 and 303.9 kg da^{-1} in the first harvest; 144.0 and 300.6 kg da^{-1} in the second harvest. In the year 2005, the yield varied between 303.2 and 664.2 kg da^{-1} in the first harvest; 309.0 and 668.6 kg da^{-1} in the second harvest.

When the averages of two harvests in the first year were analyzed, the highest hay yield (263.3 kg da^{-1}) from nitrogen applications was obtained from 8 kg da^{-1} application. The highest yield from phosphorus application was obtained from 12 and 6 kg da^{-1} applications (218.2 and 217.6 kg da^{-1} respectively). Nitrogen x phosphorus interaction was found to be significant at the level of 1% and the highest hay yield (286.5 kg da^{-1}) was obtained from 8 kg da^{-1} nitrogen x 6 kg da^{-1} phosphorus application (Table 3).

In the second year of the experiment, according to the averages of two harvests, the highest yield (602.7 kg da^{-1}) was obtained from 16 kg da^{-1} nitrogen application. As for phosphorus applications, the highest yield was obtained from 12 and 6 kg da^{-1} applications (549.6 and 537.7 kg da^{-1} respectively). Nitrogen x phosphorus interaction was found to be statistically significant at the level of 1% and the highest hay yield (666.4 kg da^{-1}) was obtained from 16 kg da^{-1} nitrogen x 12 kg da^{-1} phosphorus application (Table 3).

According to the findings of the study, the fertilizers with nitrogen and phosphorus content to be applied on the pastures in the region significantly increased hay yield. High hay yield was achieved particularly with nitrogen fertilization. In their fertilization experiments on rangelands and pastures, the researchers concluded that nitrogen fertilizers rapidly increased herbage yield (Altin *et al*., 2005; Gokkus, 1989; Gokkus and Koc, 1995; Comakli *et al*., 2005). In the study it was found that 8 kg da^{-1} nitrogen and 6 kg da^{-1} phosphorus applications will be sufficient for the pastures and higher doses do not result in significant increase in the yield. The findings are

Table 3: Effect of nitrogen and phosphorus application on hay yield (kg da^{-1})

		2004				2005			
		Phosphorus dozes (P)				Phosphorus dozes (P)			
Cutting Number (CN)	Nitrogen dozes (N)	P_0	P_6	P_{12}	Ave. (NxCN)	P_0	P_6	P_{12}	Ave. (NxCN)
First cutting	N_0	106.6	121.8	133.0	120.5	347.7	428.8	495.8	424.1
	N_4	181.3	194.2	192.2	189.3	303.2	468.7	420.6	397.5
	N_8	245.0	272.4	301.6	273.0	531.4	602.1	563.5	565.7
	N_{16}	211.3	303.9	228.1	2478	557.3	586.7	664.2	602.8
	Ave.(PxCN)	186.1	223.0	213.7		434.9	521.6	536.0	
Second cutting	N_0	144.0	148.7	188.0	160.2	327.8	433.5	525.8	429.0
	N_4	192.9	174.8	226.8	198.2	309.0	536.6	466.8	437.4
	N_8	193.2	300.6	267.1	253.7	503.9	578.6	591.9	558.1
	N_{16}	203.3	224.7	208.4	212.1	472.3	667.0	668.6	602.6
	Ave.(PxCN)	183.4	212.2	222.6		403.2	553.9	563.3	
					Ave.(N)				Ave.(N)
Ave.(PxN)	N_0	125.3	135.2	160.5	140.3d	337.8	431.2	510.8	426.6c
	N_4	187.1	184.5	209.5	193.7c	306.1	502.6	443.7	417.5c
	N_8	219.1	286.5	284.4	263.3a	517.6	590.3	577.7	561.9b
	N_{16}	207.3	264.3	218.3	230.0b	514.8	626.9	666.4	602.7
	aAve. (P)	184.7b	217.6a	218.2a		419.1b	537.7a	549.6a	

Values with different letters shows significant effect

Table 4: Effect of nitrogen and phosphorus application on crude protein yield (kg da^{-1})

		2004				2005			
		Phosphorus dozes (P)				Phosphorus dozes (P)			
Cutting Number (CN)	Nitrogen dozes (N)	P_0	P_6	P_{12}	Ave. (NxCN)	P_0	P_6	P_{12}	Ave. (NxCN)
First cutting	N_0	7.7	10.5	11.9	10.1	34.2	51.7	67.2	51.0
	N_4	17.3	18.7	16.0	17.3	34.0	54.4	51.9	46.7
	N_8	24.0	31.1	33.8	29.6	65.1	77.6	63.5	68.8
	N_{16}	23.9	34.4	27.1	28.5	60.0	63.5	73.2	65.6
	Ave.(PxCN)	18.2	23.7	22.2		48.3	61.8	64.0	
Second cutting	N_0	13.2	10.1	19.5	14.3	37.7	50.4	70.4	52.8
	N_4	16.0	13.9	18.9	16.3	31.9	67.1	55.2	51.4
	N_8	21.9	31.2	33.1	28.7	59.4	66.1	65.4	63.6
	N_{16}	23.4	26.6	24.3	24.7	51.7	76.2	82.0	70.0
	Ave.(PxCN)	18.6	20.5	23.9		45.2	65.0	68.2	
					Ave.(N)				Ave.(N)
Ave.(PxN)	N_0	10.4	10.4	15.7	12.2d	36.0	51.0	68.8	51.9b
	N_4	16.6	16.3	17.4	16.8c	33.0	60.8	53.5	49.1b
	N_8	22.9	31.1	33.4	29.2a	62.3	71.8	64.5	66.2a
	N_{16}	23.6	30.5	25.7	26.6b	55.8	70.0	77.6	67.8a
	Ave. (P)	18.4b	22.1a	23.1a		46.8b	63.4a	66.1a	

Values with different letters show significant effect

similar to those reported by Buyukburc *et al.* (1991), Akdeniz (1992), Tahtacioglu *et al.* (1993) and Hatipoglu *et al.* (2001).

Crude protein yield: In both years of the study, the effect of nitrogen and phosphorus fertilizer applications on crude protein yield was found to be statistically significant at the level of 1%. In 2004, in the first harvest, crude protein yield values varied between 7.7 and 34.4 kg da^{-1}; in the second harvest the yield varied between 10.1 and 33.1 kg da^{-1}. In 2005, the yield varied between 34.0 and 77.6 kg da^{-1} in the first harvest and the yield varied between 31.9 and 82.0 kg da^{-1} in the second harvest (Table 4). As for the average of both harvests in the first year, the highest crude protein yield (29.2 kg da^{-1}) was obtained from 8 kg N da^{-1} nitrogen application; the highest phosphorus yield (23.1 kg da^{-1}) was obtained from 12 kg P_2O_5/da application. However, there was no statistical significance between the first and second doses of phosphorus. Nitrogen x phosphorus interaction was found to have a statistical significance of 1%. The highest crude protein yield (33.4 kg da^{-1}) was obtained from 8 kg da^{-1} nitrogen x 12 kg da^{-1} phosphorus application (Table 4).

In the second year of the study, as for the average of two harvests, the highest crude protein yield (67.8 kg da^{-1}) was obtained from 16 kg N da^{-1} nitrogen application; the highest yield (66.1 kg da^{-1}) from phosphor applications was obtained from 12 kg P_2O_5/da application. However, the findings indicate that there was no significant difference between N_8 ve N_{16} and P_6 and P_{12} levels of nitrogen applications. In other words, with the increase in application levels, no proportional increase was achieved in the yield. Nitrogen x phosphorus interaction was found to be significant at the level of 1%. The highest crude protein yield (77.6 kg da^{-1}) was obtained from 16 kg da^{-1} nitrogen x 12 kg da^{-1} phosphorus application (Table 4).

Gokkus and Altin (1986) reported significant increases in protein yield with 10 kg da^{-1} nitrogen and 5 kg da^{-1} phosphorus doses. Akdeniz (1992) reported that they have obtained high crude protein yields with 15 kg da^{-1} nitrogen and 5 kg da^{-1} phosphorus applications. Polat *et al.* (2007) obtained highest crude protein yield from the applied doses of 200 kg ha^{-1} N and 150 kg ha^{-1} P. In light of these results, because the amount of nitrogen and phosphorus doses show variety in different ecologies and vegetations while determining these doses, the effect of different ecologies and vegetations should be considered. Therefore, conducting regional studies are important.

CONCLUSIONS

In this study which analyzed the effects of various nitrogen and phosphorus doses on herbage yield in natural pastures, it was determined that nitrogen and phosphorus doses significantly affected plant height, green herbage and crude protein yield. Parallel to increasing fertilizer doses, significant yield increases were observed in analyzed criteria. However, the difference between the highest dose of nitrogen (16 and 8 kg da^{-1}); and the difference between the highest dose of phosphorus (12 and 6 kg da^{-1}) was not significant. According to these results it was concluded that in natural pastures having the same ecology, 8 kg da^{-1} nitrogen dose and 6 kg da^{-1} phosphorus dose applications would be sufficient for economic and

environmental aspects. Considering the current status of natural pastures, these areas should be conserved and the practices for increasing the density of the flora should be applied.

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