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Relationships between fertilizer application and nutritional values of plants in natural pastures

Ufuk Karadavut[1], Senol Yildiz[2], Kaðan Kokten[3*] and Adil Bakoglu[4]

[1]Department of Animal Science, University of Ahi Evran, Kirsehir, Turkey
[2]Department of Plant Protection, [3]Department of Field Crops, [4]Program of Field Crops, University of Bingol, Bingol, Turkey
*Corresponding author e-mail: kahafe1974@yahoo.com
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Abstract
This study was carried out in natural pastures in Konya, Karaman, Aksaray and Nigde Provinces in Turkey. The aim of the study was to determine the effect of nitrogen fertilizers on plant nutritional values and plant numbers in the grassland plots. Nitrogen doses @ 0, 5, 10, 15, 20 and 25 kg/da (1 da = 0.1 ha = 1000 square meter) were applied to pastures in the ammonium nitrate form. Number of plants in the plots and nutritional values of plants were monitored. Besides, dry matter (DM), digestible dry matter (DDM), crude protein (CP), digestible protein (DP) and ash contents were determined. The study revealed that *Festuca ovina* was the main plant of natural pastures. The number of plants increased upto 20 kg nitrogen/da. Similarly, nutritional values of plants also increased upto 20 kg nitrogen/da and thereafter they decreased.

Keywords: Botanical composition, Chemical composition, Fertilizer, Natural pastures

Abbreviations: A: Ash; **CP:** Crude protein; **DCP:** Digestible crude protein; **DDM:** Digestible dry matter; **DM:** Dry matter; **V:** Variation

Introduction

Pastures are the important components of the animal feeding in Turkey. The total pasture land area is 11.6 million ha (Anonymous, 2007). The amount of protein and carbohydrates provided through pastures in Turkey are 746.800 and 5.353.000 tons, respectively (Erkun, 1999). Pastures covering 24% of the total agricultural area in Turkey, produce sufficient amount of hay which is used in animal feeding. However, cattle and sheep are fed by industrial feed grains as high as 90% (Anonymous, 2005). But for the profitability of the agricultural businesses, pastures are important natural resources. Especially in cattle raising feeding costs comprise 75% of the total management cost. Animals can take better and cheaper nutrition from managed grazing areas (OôKiely, 2000). Silages made from natural pastures also contribute a lot during winter and early spring in terms of financial and strategic feeding (Keating and OôKiely, 2000 a). But pastures that are available from common fields in the villages are poorly managed. Fertilization for a few consecutive years in such pastures improves the preferred forage genera, whereas diminishes the annual and low quality (nutritional) plants (Altýn, 1999). In Central Anatolian pasture crops had riche enough trace elements and no need for trace element additions (Kaplan, 2013).Thus, fertilization was found very important in pasture management and improvement works.

Since nitrogen increases vegetative growth of plants, nitrogen fertilization in pastures is required to increase biomass yield. Whitehead (1995) reported that 25-40 kg/da nitrogen application resulted in a linear increase in pasture hay yield. Keating and OôKiely (2000b) applied 430 kg/ha nitrogen in a *Lolium perenne* and *Lolium multiflorum* dominated pasture and found that hay yield was to the maximum possible level. Koç *et al.* (2003), Sheldrics *et al.*(2003) and Hopkins *et al.* (2006) also found similar results in their studies. Unfortunately, in Turkey pasture fertilization is not a common practice. Heady and Child (1994) found that nitrogen fertilization did not change chemical composition of the forage but increased the biomass yields. On the other hand, nitrogen fertilization increased protein and digestible crude protein contents of pasture forages (Gillen and Berg, 1998; Sarwar *et al.,* 1999). Mc Kenzie and Jacobs (2002) reported that nitrogen fertilization also increased the proportions of P, K, S, Mg and Cl in plants.

In this study, our objective was to examine the effect of nitrogen fertilization on plant density and quality in natural pastures of Konya, Karaman, Nigde and Aksaray provinces in mid-south Anatolia region of Turkey.

Materials and Methods

The study was conducted in natural pastures of Konya, Karaman, Nigde and Aksaray provinces in mid-south

Anatolia region of Turkey. In each province, four different pastures (four replica) were selected that represented general properties of the provinces. From each pasture a 6 da (1 da = 0.1 ha = 1000 square meter) area was separated, then further divided in to six equal plots. Nitrogen fertilizations were applied manually into each plot at 0, 5, 10, 15, 20 and 25 kg/da in the form of ammonium nitrate. Nitrogen was applied twice, one was in March 10 and the other one was in April 10, 2009 and 2010 years. Pastures were harvested at appropriate stage from the experimental plots (Table 1), once at 6 cm height.

Botanical composition of the plots was measured by throwing a quadrate frame randomly, right before the cutting. Plants were dried at 65 °C for chemical composition analyses and 105 °C for 24 hours in oven for dry matter analyses. Then, dried samples were sent to Konya Soil and Water Research Institute for chemical composition and analyses were performed by referring to Tilley and Terry (1963), AOAC (1990), Angus *et al.* (1998) and Malik and Srivastava (1985). Statistical analyses were run on Minitab to calculate regression between nitrogen doses and biomass increase.

Table 1. Cutting time of pastures

Location	Cutting Time	
	First Year	Second Year
Konya	May 10	May 16
Karaman	May 24	May 22
Aksaray	May 18	May 21
Nigde	May 21	May 20

Table 2. Botanical composition of pastures of different Provinces

Provinces	Species (Number/m²)	Nitrogen doses (kg/da)					
		0	5	10	15	20	25
	Festuca ovina	1.7	2.0	2.7	3.8	4.9	4.3
	Thymus sp.	1.5	2.0	2.5	3.1	3.8	3.7
	Astragalus sp.	1.6	2.1	2.8	3.5	4.3	3.9
Konya	*Artemisia*	1.2	1.5	1.7	2.2	2.7	2.4
	Agropyron repens	1.1	1.3	1.7	2.4	2.5	2.4
	Dactylis glomerata	0.7	0.7	1.1	1.6	1.8	1.7
	Bromus inermis	0.2	0.4	0.9	1.5	1.9	1.7
	Other	0.8	1.1	1.3	1.9	2.1	2.0
	Festuca ovina	1.4	1.9	2.6	3.6	4.3	4.2
	Thymus sp.	2.6	3.1	4.1	5.2	5.8	5.6
	Astragalus sp.	0.4	0.7	1.0	1.2	1.6	1.6
Karaman	*Artemisia*	0.3	0.6	1.1	1.4	1.8	1.5
	Zhiziphora	0.2	0.4	0.7	0.9	1.3	1.3
	Bromus tenctorius	1.7	2.1	2.8	3.9	4.7	4.5
	Paganum harmala	0.6	0.7	0.9	1.3	1.4	1.3
	Stipa lagascea	0.4	0.5	0.7	1.0	1.3	1.2
	Other	0.7	0.9	1.2	1.7	2.0	1.9
	Festuca ovina	3.1	3.3	4.0	5.2	5.9	5.4
	Astragalus sp.	0.7	0.9	1.3	1.7	1.9	1.8
	Euphorbia	1.3	1.4	1.7	2.0	2.3	2.3
Aksaray	*Agropyron repens*	2.1	2.6	3.0	3.4	3.9	3.5
	Poa bulbosum	1.7	1.9	2.2	2.6	2.8	2.8
	Centaurea urvillei	0.2	0.2	0.3	0.4	0.6	0.6
	Other	0.8	0.9	1.3	1.5	1.9	1.7
	Festuca ovina	4.2	4.4	4.9	5.8	6.4	6.2
	Astragalus sp.	0.4	0.5	0.5	0.7	0.9	0.9
	Euphorbia	0.8	0.8	1.0	1.3	1.5	1.4
Nigde	*Hordeum bulbosum*	2.4	2.7	3.4	4.1	4.9	4.7
	Poa pratensis	1.6	1.8	1.9	2.6	3.0	3.0
	Phleum montanum	1.3	1.5	1.9	2.4	2.8	2.5
	Centaurea virgata	0.3	0.3	0.4	0.5	0.5	0.4
	Other	0.7	0.8	1.1	1.3	1.5	1.5

Results and Discussion

Sheep fescue (*Festuca ovina*) was the most frequently encountered common pasture plant species throughout the study area (Davis, 1965-70), thus, it was considered as the main plant of the studied areas. The highest density was observed of *Festuca ovina* and *Astragalus sp*. in Konya province, *Thymus sp.* and *Bromus tenctorius* in Karaman province, *Festuca ovina* and *Hordeum bulbosum* in Nigde province and *Festuca ovina* in Aksaray province. In general, the botanical composition of pastures didnâ t show a significant difference among the provinces, rather similarities were more common. Rapid increase in *Festuca ovina* species indicated that this species of grass is the most suitable plant of that ecology.

Plant density increased as the nitrogen doses were increased (Table 2). However, plant density decreased in quadrate frames after 20 kg/da nitrogen application. Therefore, this dose (20 kg/da) was considered as upper limit and should not to be exceeded in nitrogen fertilization of pastures. In every location, chemical composition and pasture dry matter differed as the nitrogen doses were increased (Table 3). These differences were statistically significant.

Dry matter increased 168.1% at 5 kg nitrogen/da application in Konya and Karaman followed with 93.5 % at the same dose. Dry matter content slightly decreased at 20 kg nitrogen/da in Konya and Aksaray pastures whereas decrease in dry matter content started at 25 kg nitrogen/da in Karaman and Nigde pastures. Digestible dry matter content increased to a maximum (175.4%) at 5 kg nitrogen/da in Niðde pastures followed by Konya pastures (136.5%). Increase in digestible dry matter content was stopped at 20 kg nitrogen/da in all the provinces except Aksaray pastures where increase was stopped at 25 kg nitrogen/da.

Despite all the misuse of the pasture lands and mistreatments, it was observed that they produced an average of 1.5-2.0 tone/ha hay. Plants, having very different characteristics in pasture vegetation, penetrated their roots into the soil at different depth, each year. Nitrogen fertilization not only supported this formation, but also promoted the diversity of plant species. These findings were in agreement with the findings of Buxton *et al*. (1985). However, it was observed that the amount of nitrogen should be well adjusted, otherwise, over-doses of nitrogen applications might have adverse effect as well (Altzn, 1999).

Table 3. Nutrient contents of experimental pastures (Mean of two years)

Location	Nitrogen (kg da^{-1})	DM	V (%)	DDM (g/kg)	V (%)	CP (g/kg)	V (%)	DCP (g/kg)	V (%)	A (g/kg)	V (%)
	0	6.12	-	4.16	-	0.97	-	0.00066	-	24.42	-
	5	16.41	168.1	9.84	136.5	2.16	122.7	0.00089	34.84	26.17	7.2
	10	21.36	30.2	16.12	63.8	2.25	4.2	0.00123	38.20	27.28	4.2
Konya	15	22.48	5.2	16.28	1.0	2.88	28.0	0.00156	26.82	27.83	2.0
	20	22.35	-0.6	16.11	-1.0	3.15	9.4	0.00148	-5.12	28.32	1.8
	25	20.42	-8.6	15.04	-6.6	3.18	0.9	0.00144	-2.70	27.66	-2.3
	0	5.87	-	4.06	-	1.01	-	0.00036	-	21.30	-
	5	11.36	93.5	7.64	88.2	1.56	54.5	0.00054	50.00	24.20	13.6
	10	16.21	42.7	11.12	45.5	2.21	41.7	0.00098	81.48	24.96	3.1
Karaman	15	18.44	13.8	12.54	12.8	2.87	29.9	0.00121	23.46	25.77	3.2
	20	18.55	0.6	12.43	-0.9	2.90	1.1	0.00116	-4.13	26.48	2.7
	25	16.74	-9.8	11.87	-4.5	3.01	3.8	0.00109	-6.03	26.13	-1.3
	0	6.12	-	5.01	-	0.99	-	0.00047	-	23.92	-
	5	10.25	67.4	6.98	39.3	1.12	13.1	0.00079	68.08	26.07	8.9
	10	16.32	59.2	9.87	41.4	1.52	35.7	0.00131	65.82	27.24	4.4
Aksaray	15	18.25	11.8	11.52	16.7	1.98	30.2	0.00141	7.63	28.07	3.0
	20	17.53	-3.9	12.01	4.2	2.56	29.3	0.00136	-3.65	28.03	-0.1
	25	14.26	-18.6	11.63	-3.1	2.68	4.6	0.00110	-19.12	27.81	-0.8
	0	4.36	-	5.68	-	1.33	-	0.00057	-	17.46	-
	5	7.89	80.9	9.96	175.4	1.95	46.6	0.00088	54.38	19.28	10.6
	10	11.67	47.9	14.25	43.1	2.63	34.9	0.00111	26.13	19.93	3.4
Niðde	15	16.35	40.1	16.35	14.7	2.94	11.8	0.00132	18.91	20.12	5.9
	20	17.86	9.2	16.28	-0.4	3.00	2.0	0.00140	6.06	20.46	1.7
	25	16.54	-7.3	14.14	-13.1	3.12	4.0	0.00129	-7.85	20.38	-0.4

When the crude protein content was examined, the highest increase (122.7% was observed at 5 kg nitrogen/da in Konya pasture. Crude protein exhibited a continuous increase, although later the increase was slowed down but never turned to be negative. Change in crude protein content by nitrogen fertilization in pastures was also found statistically significant. Digestible crude protein proportions were differed as the nitrogen doses were increased in pastures and these differences were statistically significant. The increase in digestible crude protein was highest (81.48%) at 10 kg nitrogen/da in Karaman pasture. However, the increase in digestible crude protein content was stopped at 20 kg nitrogen/da in all the pastures except Nigde province where the increase of DCP stopped at 25 kg nitrogen/da. In this study, a reduction in nutritional quality of grasses was observed at 20 kg nitrogen/da indicated that the greater amounts of nitrogen doses were not beneficial.

Table 4. Regression equations and determination of coefficients

Dry matter	**R^2**
y_{Konya} =-1.453x^2+12.76x-4.424	0.98
$y_{Karaman}$ =-0.990x^2+9.165x-2.53	0.99
$y_{Aksaray}$ =-1.145x^2+9.862x-3.352	0.96
y_{Nigde} =-0.595x^2+6.894x-2.659	0.96
Digestible dry matter	
y_{Konya} =-1.063x^2+9.54x-4.337	0.97
$y_{Karaman}$=-0.626x^2+5.949x-1.384	0.99
$y_{Aksaray}$=-0.381x^2+4.092x+0.961	0.98
y_{Nigde}=-0.884x^2+8.002x-1.816	0.99
Crude protein	
y_{Konya} =-0.884x^2+8.002x-1.816	0.99
$y_{Karaman}$ =-0.789x^2+8.052x-7.783	0.87
$y_{Aksaray}$ =-0.381x^2+4.092x+0.961	0.98
y_{Nigde} =-0.090x^2+1.053x+0.12	0.95
Digestible crude protein	
y_{Konya} =-0.054x^2+0.550x+0.105	0.94
$y_{Karaman}$ =-0.057x^2+0.565x-0.219	0.94
$y_{Aksaray}$ =-0.092x^2+0.789x-0.286	0.96
y_{Nigde} =-0.048x^2+0.490x+0.108	0.95
Ash	
y_{Konya} =-0.298x^2+2.833x+21.45	0.99
$y_{Karaman}$ =-0.293x^2+2.964x+18.88	0.97
$y_{Aksaray}$ =-0.255x^2+2.447x+22.21	0.99
y_{Nigde} =-0.191x^2+1.866x+15.98	0.96

In general, fertilization had useful contributions in terms of increasing forage yield and diversity. Thus, studies conducted in our country and elsewhere indicated that vegetation benefitted from precipitations in fertilized pastures and this ultimately led to increase in forage yield and quality (Büyükburç, 1983; Feyter *et al.,* 1985; Büyükburç *et al.,* 1989; Büyükburç, 1991; Pamo and Yonkeu, 1993; Yavuz, 1999 and Yavuz *et al.,* 2008; Ismail *et al.,* 2014). Additionally, nitrogenous fertilizers also increased water holding capacity of the soil (Macleon *et al.,* 2007). It was likely that the increase in the number of plants in such an arid region pastures, with increasing dose of nitrogen, was due to the increased water holding capacity, besides the direct effect of the fertilization. But, the excessive doses of nitrogen led to decrease in digestibility of the nutrients (Thomas *et al.,* 1981).

Regression equations and determination of coefficients for the studied parameters of pastures under different provinces were also carried out (Table 4).Coefficients of features like dry matter, digestible dry matter, CP and DCP were generally greater than 95% except Karaman pastures where coefficients were low in CP (0.873) and DCP (0.949). The calculated coefficients of determination were highly successful to describe the changes in nutritional values of pastures.

Conclusion

Nitrogen fertilization increased the plant numbers and their nutritional values in the study area pastures. But the doses of fertilizer should not exceed the 20 kg nitrogen/da. Otherwise, excessive amount of nitrogen might show negative effects.

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