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CHANGES IN LEAF AREA INDEX, LIGHT INTERCEPTION, QUALITY AND DRY MATTER YIELD OF AN ABANDONED RANGELAND AS AFFECTED BY THE DIFFERENT LEVELS OF NITROGEN AND PHOSPHORUS FERTILIZATION

Emine BUDAKLI CARPICI

Uludag University, Gorukle Campus, Faculty of Agriculture, Department of Field Crops, 16059 Bursa, Turkey
Corresponding author, e-mail address:ebudakli@uludag.edu.tr

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ABSTRACT

The object of this study was determine the effects of nitrogen (0, 50, 100, 150, 200 and 250 kg N ha^{-1}) and phosphorus rates (0, 50, 100 and 150 kg P_2O_5 ha^{-1}) on dry matter yield (DMY), leaf area index (LAI), light interception(LI), crude protein (CP) content, ADF, NDF and total digestible nutrient (TDN) of an abandoned rangeland in Bursa-Turkey in 2010 and 2011 years. Depending on the increases of nitrogen rates, the DMY, LI, CP, NFD and TDN increased, but ADF decreased. However, LAI did not indicated any relation with nitrogen rates. The highest dry matter yields were 9466.9 and 9008.2 kg ha^{-1} at 200 and 250 kg N ha^{-1} levels, respectively. The LAI, LI and CP contents were significantly affected by phosphorus rates. The highest LAI and LI values occured at 100 and 150 kg P_2O_5 ha^{-1} levels. The highest CP contents were obtained at rates of 50, 100 and 150 kg P_2O_5 ha^{-1}. On the other hand, no effects of phosphorus rates on dry matter yield, ADF, NDF and TDN were recorded. As a result, 150 kg N ha^{-1} can be recommended to increase dry matter yield and forage quality of an abandoned rangelands encountered in the experimental region.

Keywords: Nitrogen, phosphorus, dry matter yield, crude protein, ADF, NDF, TDN.

INTRODUCTION

Rangelands are the most important feed sources for animal husbandry in Turkey. The data of TUIK indicate that there are about 14.6 billion ha rangelands in Turkey most of which are useless (TUIK, 2009).

The most practical and effective method to increase dry matter yield and quality production in rangelands is to fertilize these areas with appropriate and adequate fertilizers (Frame 1992). Fertilization can increase dry matter yield up to two or three folds in ranges in the regions with an annual rainfall of over 400 mm (Elliot and Abbott, 2003). Increased N application generally increases hay production and crude protein content (Gokkus and Koc, 1995; Aydın and Uzun, 2005; Polat et al., 2007; Turk et al., 2007a; Turk et al., 2007b; Balabanlı et al., 2010; Celebi et al., 2011; Dascı and Comaklı, 2011).

All green plants contribute to primary production by photosynthetic activity in leaves that play a major role in this process. Therefore, an adequate leaf area is critical to plant regeneration for a constant primary production.Ideally, LAI among forage crops varies between 3 and 11, depending on the morphological and anatomical structure of species (Erkovan et al., 2009).

ADF and NDF are important quality characteristic for forages (Ayan et al., 2010). NDF is a measure of the cell wall content of forages and limits total feed intake in abundant forage diets. NDF content of pasture samples is affected by forage type. Forage ADF content is a measure of the cellulose and lignin in forage, and is the best indicator of forage digestibility and the fiber is needed by dairy cows to maintain milk butterfat test. Pasture samples differ in ADF due to forage type and month of the year. Single or mixed grass samples were higher in ADF than single or mixed legume samples (Rayburn, 1991).

Inconsistent results have been reported on the effects of fertilization on CP, NDF and ADF concents. Some researchers reported that there were positive effects of nitrogen on CP content of rangelands (Turk et al., 2007b; Balabanlı et al., 2010; Dascı and Comaklı, 2011). Balabanlı et al. (2010) reported that NDF peaked at the low fertilizer rates and then decreased with increasing fertilizer rates. On the other hand, Balabanlı et al. (2010) reported that phosphorus rate had no effect on CP content and ADF of rangeland. Dascı and Comaklı (2011) found that effects of phosphorus fertilization on NDF were no significant.

The objective of this study was to evaluate the responses of DMY, LAI, LI, CP, ADF, NDF and TDN of an abandoned rangeland to different rates of nitrogen and phosphorus fertilization.

MATERIALS AND METHODS

This study was conducted for two years (2010 and 2011) on an abandoned rangeland in Bursa (40° 11´ N, 29° 04´ E), located on the Southern Marmara Region of Turkey. Total precipitation and average temperature were found as 736.4 mm and 11.07 ^oC in 2009-2010; 438.9 mm and 10.34 ^oC in 2010-2011; 499.6 mm and 9.7 ^oC in long years (1975-2008), respectively (Table 1). Soil test values indicated a pH of 7, none saline, low values in lime and organic matter and rich in potassium.

Table 1. Monthly precipitation and temperature of growing season in the experimental area.

	Precipitation (mm)			Temperature (ºC)		
Months	Long Periods	2009-2010	2010-2011	Long Periods	2009-2010	2010-2011
November	85.4	80.6	24.0	10.3	10.1	15.5
December	96.4	119.1	152.6	7.1	9.5	9.8
January	80.3	149.7	72.4	5.4	7.0	5.6
February	66.2	178.9	18.4	5.9	9.3	6.0
March	62.7	115.3	67.4	8.5	9.0	8.3
April	65.2	63.4	76.8	13.0	13.4	10.5
May	43.4	29.4	27.3	17.7	19.2	16.7
Total	499.6	736.4	438.9	-	-	-
Mean	-	-	-	9.7	11.07	10.34

Nitrogen was applied as urea (46 % N) with 0, 50, 100, 150, 200 and 250 kg ha^{-1}rates. Phosphorus was applied as triple super phosphate (42-44 % P_2O_5) with 0, 50, 100 and 150 kg ha^{-1} rates. Fertilizers were broadcast by hand. Half of N and the entire of P_2O_5 were applied at the beginning of November. The remaining half of N was applied at the beginning of rapid growth period of vegetation (mid-March). Fertilizer treatments were applied randomly in complete block experiment design with three replications. The dimentions of each plot were 2m×1m (width and length). The distance between adjecent plots was 1 m.

Stands of the vegetation composed of mainly nine species of Fabaceae, ten species of Poaceae and nineteen species of some other plant families. Average percentages of two-year botanical composition consisted of 44.91 % legumes; 32.44 % grasses, and 22.65 % the other forbs.

Harvest of plots were made at mid-May in each year when the dominant grass species reached about 50% flowering stage. Before harvest, LAI (leaf area index) measurements were determined by LAI-2000 (LI-COR, Plant Canopy Analyzer). At the same stage, LI (light interception) values were determined by LI SA191-A Quantum Sensor and calculated according to a formula by Zaffaroni ve Schneiter (1989). After harvest, green forage samples were randomly taken from harvested green forages of each plot and put in cotton bags. They were oven-dried at 78 ºC for 48 hours and weighed, then dry weight percentages were calculated. Dry matter yield (DMY) of each plot was calculated by multiplying the fresh weight of plot with its dry weight percentages. Then, 1 g ground sample was used for the total nitrogen determination and 0.5 g for ADF and NDF. ADF and NDF were analyzed by sequential detergent analysis method (Goering and Van Soest, 1970) and total nitrogen by Kjedahl method. Crude protein (CP) content was calculated by multiplying total nitrogen with 6.25 constant. Total digestible nutrient (TDN) was determined by equation of TDN% = 88.9-(0.779 x ADF %) (Linn and Martin 1999).

Variance analysis was evaluated over two-year data. Variance analysis of each components such as DMY, LAI, LI, CP, ADF, NDF and TDN were made by using MINITAB and MSTAT-C programs. The LSD was used to group the means of nitrogen, phosphorus and their interactions when the F-test was significant.

RESULTS AND DISCUSSION

Data averaged over two years and subjected to variance analysis (ANOVA) are given in Table 2. Results of ANOVA indicated that the effects of nitrogen rates were of significance on most of parameters, but phosphorus rates were of limited significance on LAI and LI. Also, the effects of interactions between nitrogen and phosphorus on LAI and NDF were observed significant.

Nitrogen rates had significant ($p < 0.01$) effects on dry matter yield. 200 kg kg N ha^{-1} rate produced the highest dry matter yield (9466.9 kg ha^{-1}) while the lowest dry matter yield (6839.1 kg ha^{-1}) was obtained at plots without nitrogen (Table 2). Numerous workers have determined different nitrogen rates for maximum dry matter yield (Aydın and Uzun, 2005; Polat et al., 2007; Balabanlı et al., 2010; Celebi et al., 2011; Dascı and Comaklı, 2011). These are natural results due to the different ecologies and range vegetations. Nitrogen rates had no effects on LAI ranging from 5.62 to 6.17 (Table 2). However, LI significantly incerased with increasing nitrogen rates and reached a peak value at 150 kg N ha^{-1}. Response of CP content to nitrogen fertilization was statistically significant ($p < 0.01$). CP content increased up to 150 kg N ha^{-1} and then stayed stable at 200 and 250 kg N ha^{-1}. These results coincide with the finding of most workers (Turk et al., 2007a; Balabanlı et al., 2010; Dascı and Comaklı, 2011). The ADF content of hay in our rangeland changed significantly with the nitrogen rates. Hay of untreated plots yielded the highest ADF contents while 200 and 250 kg N ha^{-1} treated plots produced the lowest ADF contents. These indicated that there were negative relations between nitrogen rates and ADF contents (Table 2). These results were in accordance to those of some workers (Balabanlı et al., 2010; Dascı and Comaklı, 2011). The reason for these differences may be attributed to reducing effects of fertilization on ADF and increasing effects on digestibility (Ball et al., 2001) and to different botanical compositions studied at different locations. The NDF content significantly increased with increasing nitrogen rates up to 150 kg N ha^{-1}. After this rate, NDF content stood stil (Table 2). Similar results were reported by Dascı and Comaklı (2011). However, there were revers results reported by other workers (Balabanlı et al., 2010). TDN parameters also increased by nitrogen rates and there were significant difference between nitrogen rates. The highest TDN (62 %) was obtained at 250 kg N ha^{-1}, the lowest was at 0 kg N ha^{-1} (Table 2). Similar results were reported by Dascı and Comaklı (2011). TDN is more closely related to ADF content and as ADF content decreases, TDN increases (Linn and Martin, 1999; Undersander, 2007).

Table 2. Effects of nitrogen and phosphorus rates on DMY (kg ha^{-1}), LAI, LI (%), CP (%), ADF (%), NDF (%) and TDN (%) of an abandoned rangeland (Average of two years).

Nitrogen Rate (kg ha^{-1})	DMY (kg ha^{-1})	LAI	LI (%)	CP (%)	ADF (%)	NDF (%)	TDN (%)
0	6839.1 c[1]	5.63	84.73 c	12.32 c	37.08 a	45.22c	60.02 b
50	7925.8 b	5.62	91.41 b	13.45 b	36.72 ab	47.25 bc	60.30 ab
100	8038.9 b	5.80	93.65 ab	13.87 b	36.34 ab	49.91 ab	60.60 ab
150	8680.0 ab	6.17	94.15 a	14.55 a	36.29 ab	51.50 a	60.63 ab
200	9466.9 a	6.03	93.81 ab	14.67 a	35.35 b	52.62 a	61.36 ab
250	9008.2 a	5.86	93.72 ab	14.82 a	34.53 b	50.44 a	62.00 a
Phosphorus Rate (kg ha^{-1})							
0	7949.3	5.46 b	89.35 b	13.15 b	36.55	50.59	60.42
50	8113.4	5.78 ab	90.44 b	14.23 a	35.73	48.08	61.07
100	8643.8	6.02 a	93.23 a	14.32 a	35.56	50.02	61.20
150	8599.4	6.14 a	94.63 a	14.08 a	36.36	49.26	60.58
Years (Y)	**	*	*	ns	**	**	**
Nitrogen (N)	**	ns	**	**	*	**	*
Phosphorus (P)	ns	*	**	ns	ns	ns	Ns
Y x N	ns	ns	Ns	ns	ns	*	Ns
Y x P	ns	ns	Ns	ns	ns	ns	Ns
N x P	ns	*	Ns	ns	ns	**	Ns
Y x N x P	ns	ns	Ns	ns	ns	*	Ns

1: Means of the same column followed by the same letter were not significantly different at the 0.05 level using LSD test.
*, **: F-test significant at p ≤/0.05, and p ≤/0.01, respectively. ns: not significant

Phosphorus rates had no effects on dry matter yield ranging from 7949.3 to 8643.8 kg ha^{-1} (Table 2). Similar effects of phosphorus rates on dry matter yield were reported by Dascı and Comaklı (2011). Aydın and Uzun (2005) and Balabanlı et al (2010) reported reverse results. Response of LAI to phosphorus rates was statistically significant. LAI increased up to 100 kg P_2O_5 ha^{-1} and then stayed stable 150 kg P_2O_5 ha^{-1}. LI was influced by phosphorus rate. The highest LI values were obtained 100 and 150 kg P_2O_5 ha^{-1} (Table 2). Phosphorus application affected CP content of forage. The lowest CP content value was obtained at untreated plots, the highest were at plots treated with 50, 100 and 150 kg P_2O_5 ha^{-1} (Table 2). Similar results were reported by Polat el al. (2007). On the other hand, Balabanlı et al. (2010) reported that phosphorus rate had no effect on CP content of rangeland. The effects of phosphorus rates on ADF, NDF and TDN were found insignificant (Table 2). Dascı and Comaklı (2011) found that effects of phosphorus fertilization on NDF were no significant; which is consistent with our results. Balabanlı et al. (2010) reported that ADF contetnt of rangeland did not vary significantly with the phosphorus rates. All of these results consistent or inconsistent with each other indicated that many factors may interfree in the effects of phosphorus to occure.

CONCLUSIONS

Overall evaluation of the findings resulted from this study indicates that nitrogen fertilization on an abandoned rangeland in Southern Marmara Region increased many parameters that have positive contribution to dry matter yield and its quality. On the other hand, phosphorus showed effects on parameters such as LAI, LI and CP but these effects were so limited that not to be taken into considiration. Thus, depending on a two-year result, we may recommend a 150 kg ha^{-1} nitrogen rate to be applied to abandoned rangelands in the experimental and the similar regions in order to produce economicly high and quality forage product.

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