Asian Journal of Chemistry Vol. 19, No. 7 (2007), 5351-5359

Effects of Nitrogen and Phosphorus on Botanical Composition, Yield and Nutritive Value of Rangelands

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This works report the effects of nitrogen and phosphorus on botanical composition, yield and quality of rangelands in Bursa area between 2001 and 2003. The research was set up as randomized complete block design with three replications starting in November-2001. Four different N doses (0, 50, 100 and 150 kg ha^{-1}) and three different P doses (0, 50 and 100 kg ha^{-1}) were applied and their effects on rangeland were investigated. Ammonium nitrate and triple super phosphate were used as nitrogenous and phosphorous fertilizers. All of the phosphorous fertilizer and 50 % of the nitrogenous fertilizer were applied in Fall and the remaining N fertilizer was applied in Spring. Effects of fertilizer applications on botanical composition, dry matter yield, crude protein concentration and crude protein yield were investigated. The results were analyzed to determine the most cost effective fertilizer doses. The average for over two years, nitrogen applications increased grass dry weight ratios, while it decreased legumes'dry weight ratios. The highest dry matter and crude protein yield was obtained from 100 kg ha^{-1} P + 150 kg ha^{-1} N treatments, while the lowest values was obtained from control plots. The economic optimum was determined in the highest fertilizer doses 100 kg ha^{-1} P + 150 kg ha^{-1} N producing 9.85 t ha^{-1} forage dry matter with a crude protein concentration of 120 g kg^{-1} and legume proportion of 9.72 %.

Key Words: Crude protein concentration, Dry matter yield, Economic benefits, Fertilization.

INTRODUCTION

Rangelands occupy approximately 16 % of 78 million ha area in Turkey. Large amounts of forage needed for feeding 11 million cattle and 29 million head sheep populations is provided by these rangelands[1]. In Turkey, the most important problem of raising livestock is the shortage of feed stuff and in fact only one-third of the needed forage can be supplied. Plant vegetation has been weakened considerably, as Turkey's rangelands

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have been considerably overgrazed for long years. However, the yield potential of our country's rangelands could be increased by appropriate management methods.

The most practical and effective method to increase dry matter production in rangelands is to use appropriate and adequate fertilization in these areas[2,3]. If sufficient and balanced fertilization is performed in regions getting feasible precipitation, it is possible to increase the yield of rangelands twice or higher[4-7]. The responses of rangelands to nitrogenous and phosphatic fertilizers in a variety of experiments have been very similar, but with a tendency towards greater responses in regions of high rainfall and leached soils than in the lower rainfall areas with more fertile soils[8]. The inadequate response to fertilization in drier areas could be explained by insufficient soil moisture or the low yield potential of the plants[8], with the former being the most likely. Generally, in regions where annual rainfall is less than 300-400 mm, fertilization of rangelands is not profitable[9].

Fertilization with nitrogen and phosphorus may improve not only dry matter productivity, but it also affects botanical composition of rangelands[10-13]. Phosphorus fertilization increases legume proportion while nitrogen fertilization reduces legume proportion in grassland[14-16]. Responses to phosphate have usually been observed only when applied together with nitrogen[8]. The rate of change in species composition on fertilized rangeland, is largely a function of the amount of nitrogen applied[8,17].

Forage quality can be described as the conversion of consumed forage to animal products. One of the main criterions is the crude protein concentration of forages[18]. At the same harvest maturity, legumes contain higher crude protein compared to grasses. Digestibility of hay increases with the increase in crude protein concentration[19]. High quality forages, in terms of animal feed, should contain 125 g kg^{-1} crude protein[20].

The objective of the present study was to determine the effects of nitrogen and phosphorus on botanical composition, dry matter yield, crude protein yield of ungrazed rangeland in Bursa area and to give brief economic analyses for fertilization regime for rangelands in Bursa area.

EXPERIMENTAL

This research was carried out at Agricultural Research and Experiment Center of Agriculture Faculty, Uludag University, Bursa (40º 13' N, 28º 49' E, elevation 155 m) between 2001 and 2003. Bursa is located on The Marmara region, Turkey. The growing season of herbaceous vegetation begins in February and ends in June. Average precipitation was 894 and 653.5 mm in 2001-2002, 2002-2003, respectively, in the first year well above the long-term average (1928-1999) of 698.9 mm (Table-1).

TABLE-1
MONTHLY PRECIPITATION VALUES IN THE EXPERIMENTAL AREAS (mm)

	Long years (1928-1999)	2001-2002	2002-2003
November	76.3	70.2	67.9
December	99.9	109.5	28.8
January	91.2	62.3	65.3
February	77.7	42.7	106.2
March	69.5	87.9	33.1
April	61.0	126.5	112.1
May	50.7	50.5	45.7
June	31.0	25.2	2.4
July	24.2	38.2	0.0
August	18.8	45.2	0.0
September	39.2	88.6	66.9
October	59.4	147.2	125.1
Total	**698.9**	**894**	**653.5**

The major soil characteristics, based on the method described by Rowell[21] were found to be as follows; the soil texture is clay; organic matter is 1.1 %; total salt is 0.1 %; lime is 4 %, sulphur is 13 mg/kg, extractable P is 4.2 mg/kg; exchangeable K is 118.5 mg/kg; pH is 7.1.

Before the experiment started, botanical composition of experimental area based on weight was determined by quadrate method[1], each equals 1 m^2, in May 2001. Botanical composition of experimental area consisted of 31 % legumes; 22 % grasses and 48 % plants of other families. Legumes in the botanical composition were mostly *Onobrychis sativa* L., *Trifolium resupinatum* L., *Medicago falcata* L., *Melilotus officinalis* L. and grasses were *Bromus japonicus* L., *Lolium perenne* L., *Avena fatua* L. and others plants were *Matricaria camomilla* L., *Taraxacum serotinum* L. and *Senecio vulgaris* L.

An economic analysis was carried out using August 2006 prices for fertilizers (\$ 0.23 kg^{-1} ammonium nitrate, \$ 0.34 kg^{-1} triple super phosphate), cost of labour (\$ 13 labor cost of fertilizer, \$ 13 labor cost of harvest) and price of hay (\$ 16 kg^{-1}). In the present study, net benefit was calculated as follows: Hay Yield × Price of Hay- Total Expenditures.

Procedures

Fertilizer applications were randomly assigned to 12 plots within each of 3 blocks. Each treatment plot was 2 × 3 m (width and length) with a distance of 1m between each plot. Treatments were repeated in the same plot for 2 years, 2002 and 2003. Nitrogen was applied as ammonium nitrate (33.5 % N) with rates of 0, 50, 100 and 150 kg N ha^{-1}. Phosphorus was applied as triple super phosphate (46 % P_2O_5) with rates of 0, 50 and 100 kg P ha^{-1}. Fertilizers were spread by hand and then buried by a rake without disturbing the vegetation. Half of the N and all of P were applied at the beginning of November. The remaining N was applied at the beginning of rapid growth period of vegetation (mid-March).

Botanical composition, dry matter yield, crude protein concentration and crude protein yield were investigated in experiment.

Herbaceous vegetation was annually harvested within 6 m^2 area when grass plants reached full flowering stage at the beginning of June. Vegetation was handclipped at ground level. The green forage production/6 m^2 area was recorded. Plants in each plot were classified as legumes, grasses and the others as well as determining the dry weight ratio of each group for every year.

Samples taken from 1 m^2 area of each plot within each group were oven-dried at 60ºC and, dry weight ratios were calculated. Dry matter production of each plot was calculated through the values of green forage production and dry-weight percentage for each crop family.

Crude protein ratios of legumes, grasses and the other plants from harvested plots were determined by micro-Kjeldhal (N × 6.25) to determine crude protein concentration of each plot[22].

A randomized complete block experimental design was used in the study. The data was analysed with Repeated Measures Analysis of Variance using SAS program[23]. Means were seperated by LSD at the 5 % level of significance.

RESULTS AND DISCUSSION

Phosphorus and nitrogen application and their interactions had significant effects on dry weight ratios (Table-2). According to two years averages, as P doses increased from 0 to 100 kg ha^{-1}, legume dry weight ratios increased from 32 to 49 %, while grass dry weight ratios decreased from 23 to 18 %, the dry weight ratios of other families decreased from 45 to 33 % (Table-2). However, N treatments decreased legumes dry weight ratios from 32 to 9 % and dry weight ratios of other families from 45 to 39 %, but it increased grass dry weight ratios from 23 to 52 % (Table-2). According to interactions between N and P, the highest legume dry weight ratio was obtained from $P_{100}N_{50}$ treatment (38 %), the highest grass dry weight ratio was obtained from $P_{100}N_{150}$ treatment (60 %) and the highest dry weight ratios of other families were obtained from $P_{50}N_{50}$ (45 %) treatment (Table-2).

TABLE-2
DRY WEIGHT RATIOS (%) OF LEGUMES, GRASSES AND PLANTS BELONG TO OTHER FAMILIES WITH DIFFERENT FERTILIZATION TREATMENTS

Fertilizer treatments	Legumes			Grasses			Others		
	2002	2003	Average	2002	2003	Average	2002	2003	Average
Main Effects (P)									
0-0 (Control)	29 d	34 d	32 d	22 h	25 g	23 i	49 a	41 ab	45 a
50	38 b	47 b	43 b	18 i	18 h	18 j	44 b	35 d	40 bc
100	46 a	52 a	49 a	17 i	20 h	18 j	37 e	29 e	33 f
Main Effects (N)									
50	20 f	28 f	24 f	38 f	33 f	35 f	42 c	40 bc	41 b
100	14 h	17 i	16 i	46 d	46 c	46 d	40 d	36 d	38 d
150	8 k	11 j	9 k	53 c	50 b	52 c	39 d	39 bc	39 cd
Interactions (P-N)									
50-50	23 e	32 e	27 e	30 g	27 g	28 h	48 a	42 a	45 a
50-100	15 g	22 g	19 h	41 e	39 e	40 e	43 bc	39 c	41 b
50-150	10 j	11 j	11 j	59 a	48 c	54 b	31 g	41 abc	36 e
100-50	36 c	40 c	38 c	30 g	32 f	31 g	34 f	28 e	31 g
100-100	24 e	21 h	22 g	46 d	44 d	45 d	30 g	35 d	33 f
100-150	11 i	9 k	10 jk	58 b	62 a	60 a	31 g	30 e	31 g
LSD	1.06	1.12	0.75	1.36	1.98	1.16	1.74	2.23	1.37
Averages (year)	23 B	27 A		38	37		39 A	36 B	

Values within columns with different letters differ significantly ($p < 0.05$).
Values within the last row with different letters differ significantly ($p < 0.05$).

The years had a significant effect on dry weight ratios. Legume dry weight ratio in the first year of experiment was 23 % and then it increased to 27 % at the second year (Table-2). Grass dry weight ratio was 38 % in the first year and it was 37 % in the second year of experiment. The dry weight ratio of the plants from other families decreased from 39 to 36 % in the 2nd year at the experiment (Table-2).

When data was combined over two years, dry matter production was significantly increased depending on the nitrogen and phosphorus doses used. Dry matter production was 2.84 t ha^{-1} in control plots, while it increased to 9.85 t ha^{-1} in plots which received the $P_{100}N_{150}$ treatment (Fig. 1a).

The application of fertilizers had a significant effect on crude protein concentration as well, especially nitrogen fertilization increased crude protein concentration. The highest crude protein concentration was obtained from P_0N_{150} (132.3 g kg^{-1}) and $P_{50}N_{150}$ (133.7 g kg^{-1}) treatments, while the lowest nitrogen concentration (98 g kg^{-1}) was obtained from the control plot (Fig. 1b).

The crude protein yield exhibited a similar trend to dry matter production (Fig. 1c). Crude protein yield significantly increased depending on the nitrogen and phosphorus doses while control plots had the lowest crude protein yield (279 kg ha^{-1}), $P_{100}N_{150}$ treatment gave the highest crude protein yield (1182 kg ha^{-1}) in the experiment.

According to economic analyses results, the fertilization with nitrogen and phosphorus was found to be beneficial. The maximum benefit was obtained from the application of 100 kg ha^{-1} P + 150 kg ha^{-1} N with a sum of $ 1424 kg ha^{-1} (Fig. 2). Net benefit was $ 481 in control plots, while it increased to $ 1424 in plots which received the $P_{100}N_{150}$ treatment.

The fertilization with nitrogen and phosphorus affected botanical composition of rangeland[13]. Phosphorus fertilization increases legume proportion while nitrogen fertilization reduces legume proportion in grasslands[14]. Grasses may also respond to phosphorus when supplies in the soil are low. However, response to applied phosphorus is not usually profitable unless nitrogen supplies are adequate[6]. The increase in nitrogen caused a decrease in yields of *O. sativa*, *T. resupinatum* and *M. falcate*, the increase in phosphorus decreased yields of *L. perenne* and *B. japonicus*. Contrary to legumes, grass dry weight ratios increased depending on nitrogen doses and decreased depending on phosphorus doses in present findings. The present results are in agreement with the findings[11,15,16]. Nitrogen is the most important nutrient used for growing grasses. In case of legumes, nitrogen will not be needed, since these plants can take nitrogen from the air and use it for their own growth and later provide nitrogen to the grass.

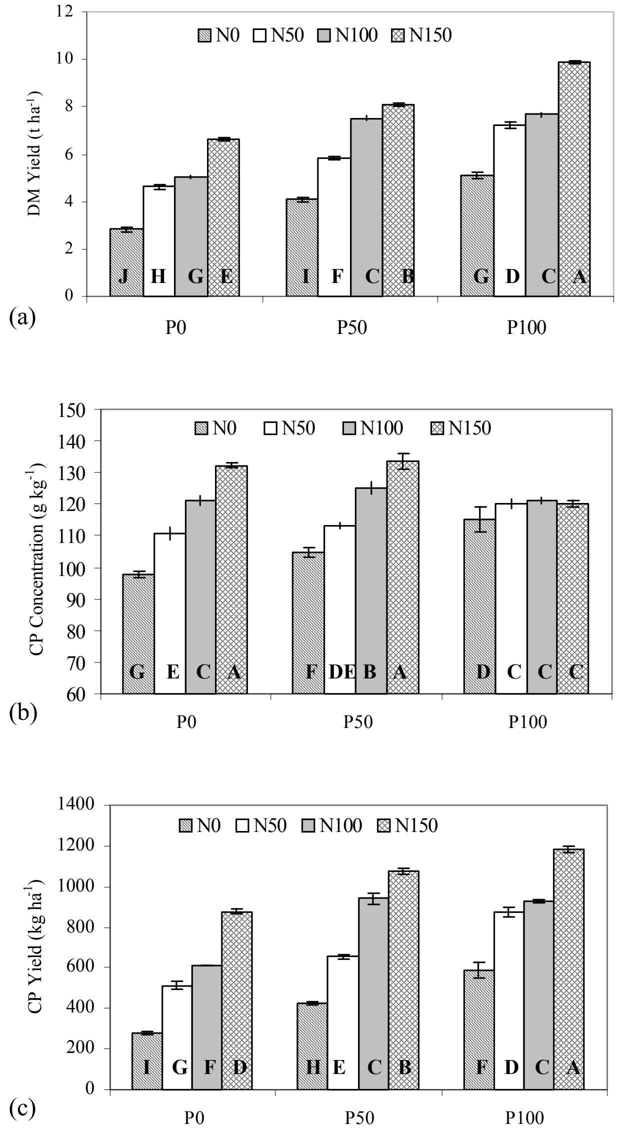

Fig. 1. Dry matter yield (a), crude protein concentration (b) and crude protein yield (c) on a rangeland with different fertilization treatments for 2 years. Values with different letters within columns differ significantly at the level of $p < 0.05$. Error bars indicate SD

Dry weight ratios of legumes increased from 23 to 27 % during years. This could be explained by competitiveness of legumes, which grow faster than grasses when P levels are adequate. The reason of the decrease in dry weight ratio of other families during the experiment may be the fact that cutting performed in plots in 2002 may have decreased competitiveness of *S. vulgaris*, *M. camomilla* and *Bupleurum intermedium*.

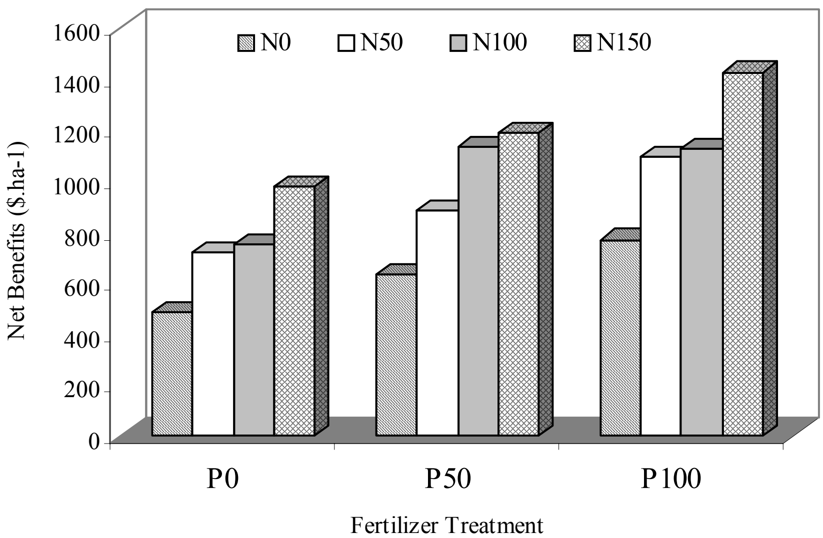

Fig. 2. Net benefits for the fertilization experiment of a rangeland in Bursa area

Fertilization is the most practical and effective way to improve grassland productivity. In this research, yields of dry matter per hectare ranged from 2.84 t without fertilizer to 9.85 t when fertilized with 100 kg P+150 kg N per hectare. Increases in dry matter yield, as found in this study, have been reported from many studies of nitrogen and phosphorus fertilization on rangelands[1,2,24,25]. Reports have indicated that dry matter production in grasses can be increased up to two to three times or more by fertilizing with nitrogen[6,7]. In this study, the crude protein concentration in the forage dry matter was 98.0 g kg^{-1} in control plots. The increase in fertilizer doses resulted in an increase in crude protein concentration. Yildiz[20] reported that crude protein concentration should be 125 g kg^{-1} in forage with high quality. The forage quality obtained from this study in terms of crude protein was close to reported value.

The increase in nitrogen and phosphorus doses caused increase in crude protein yield in the present study. Because, crude protein yield depends on dry matter yield in plots and crude protein concentration in plants, which changes according to plant species.

This study indicated that fertilizing with nitrogen and phosphorus can be profitable. The application of additional nitrogen continued to give excellent yield responses for each kg of nitrogen with the most profitable return from the 100 kg P + 150 kg N treatment per hectare (Fig. 2).

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(*Received*: 9 October 2006; *Accepted*: 16 June 2007) AJC-5710