Turkish Journal of Field Crops, 2010, 15(2): 164-168

EFFECTS OF NITROGEN, PHOSPHORUS AND POTASSIUM FERTILIZATION ON THE QUALITY AND YIELD OF NATIVE RANGELAND

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ABSTRACT

This study was conducted to determine N+P+K applications on yield and some quality characteristics of native rangeland in Isparta-Turkey in 2002-2004 growing periods. Application of N+P+K was found to be considerably effects on forage dry matter yield. However, the yield from N application was found to be higher than that from no-fertilization. The highest dry matter yield was obtained 1306 kg ha^{-1}with $N_{80}P_{40}K_{50}$ and 1291 kg ha^{-1}, with $N_{80}P_{80}K_{50}$ treatments, respectively. The nitrogen fertilization affected the crude protein content of native rangeland. The highest crude protein content (11.11 to 12.17%) was obtained from 80 kg ha^{-1} N application while the lowest crude protein content (8.26 to 9.41%) was obtained from plots without N. The N fertilization significantly decreased native rangeland NDF, ADF and ADL content from 74.32 to 68.46%, 46.45 to 39.02% and 17.15 to 14.84%, respectively.

Key words: Fertilization, Dry matter, Crude protein, Acid detergent fiber, Cellulose.

INTRODUCTION

One of the most important factors affecting the Turkish farming system is the lack of availability of the cheap and high quality feedstuff. The feeding of low-quality forages such as; crop residues (wheat, barley straw) and low-quality hays with protein (meal) or energy supplementation (grain barley) to wintering ruminants is a common practice in Turkey. In addition, Turkey has 12.5 million hectares of rangeland and the major problem of raising livestock is the shortage of feed stuff. However, only 1/3 section of needed forage can be supplied. Plant vegetation has been weakening in big rates, as Turkey's rangelands have been considerably overgrazed for long years. Moreover, the production potential of Turkey's rangelands could be increased by appropriate management methods.

Range development programs designed to attain higher productivity include fertilization, among other practices (Le Houérou 1995, Guevara et al. 1997; Türk et al., 2005; Türk et al., 2007a; Bayram et al., 2009). Previous research has shown that fertilization, especially with N and P can increase dry matter yield of rangelands (Elliott and Abbott, 2003, Cazzato et al. 1999; Gillen and Berg, 1998; Barnhart et al. 1997; Jacobsen et al., 1996; Berg and Sims 1995; Türk et al., 2007a; Türk et al., 2007b).

Adequate nutritive value of herbage is essential for a high rate of live weight gain and overall livestock performance (Ball et al., 2001). Above ground herbage mass production and measures of nutritive value, such as; crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations, and in vitro digestibility of dry matter (DM), vary between years and plant growth stages within a given growing season (Ball et al., 2001). The cellular content of forage plants is almost totally digestible, but there is great variation in cell wall digestibility (Van Soest 1967). The digestibility of forage plants depends, therefore, mainly on the cellular content and the digestibility of the cell wall.

It is well known that the main components in the cell wall are cellulose, hemicellulose and lignin. Cellulose in young grasses is almost completely digested by ruminants, but lignification decreases digestibility with increasing maturation. Hemicellulose is composed of a mixture of different carbohydrates which vary in digestibility, whereas lignin is resistant to rumen fermentation (Thorvaldsson, 2006).

Inconsistent results have been reported on the effects of fertilization on CP, NDF and ADF concentrations. Min et al. (2002) reported that application at rates of 410, 690, 830, and 970 kg N ha^{-1} increased CP concentration compared with the control treatment, but ADF and NDF were not affected. Johnson et al. (2001) reported that NDF concentration of grasses decreased linearly with increasing N fertilization. Adeli et al. (2005) reported that NDF peaked at the low fertilization rate and then decreased with increasing fertilizer rates. On the other hand Belanger and McQueen (1998) observed that an increase in NDF concentration with increasing N fertilization with a quadratic nature of the response. Other researchers reported that increased N fertilization had almost no effect on NDF concentrations (Anderson et al., 1993; Rogers et al., 1996; Cuomo and Anderson, 1996).

The objective of this study was to determine the influence of N, P and K fertilization at different rates on rangeland DM yield, CP content, CP yield, NDF, ADF, ADL, CC, HC, LC and AC.

MATERIALS AND METHODS

This study was conducted at Isparta (37º 45' N, 30º 33' E, elevation 1035 m) where located on the Mediterranean region of the Turkey in the period of 2002-2004. Total precipitation and average temperature were found to be 574.2 mm and 8.46 ºC in 2002-2003; 544.7 mm and 8.49 ºC in 2003-2004; 519.9 mm and 8.38 ºC in long years, respectively (Table 1).

Table 1. Monthly precipitation and mean temperature in the experimental area.

Months	Precipitation (mm)			Temperature (°C)		
	Long Term	2002-2003	2003-2004	Long Term	2002-2003	2003-2004
November	45.4	38.0	13.7	7.7	8.2	7.4
December	94.3	99.2	151.6	3.6	0.9	2.5
January	84.8	23.2	201.4	1.7	6.3	0.7
February	75.5	106.8	49.9	2.7	0.2	2.9
March	60.6	48.0	4.9	5.7	3.9	7.6
April	68.4	133.2	76.6	10.6	9.7	10.9
May	55.5	89.5	20.8	15.4	17.1	15.5
June	35.4	36.3	25.8	19.6	21.4	20.4
Total	519.9	574.2	544.7	-	-	-
Mean	-	-	-	8.38	8.46	8.49

The major soil characteristics, based on the method described by Rowell (1996) were found to be as follows; the soil texture: Clay, organic matter ratio: 1.3%, total salt ratio: 0.2%, lime ratio: 7%, sulphur content: 11 mg kg^{-1}, extractable P content: 3.8 mg kg^{-1}, exchangeable K content: 112 mg kg^{-1}, pH: 7.2.

Fertilizer applications were Randomized Complete Block assigned to 10 plots within each of 3 blocks. Each treatment plot was dimension of 3m×4m (width and length) with a distance of 1m between each plot. Treatments were repeated in the same plot for 2003 and 2004. Nitrogen was applied as ammonium nitrate (33.5-0-0), phosphorus was applied as triple super phosphate (0-46-0) and potassium was applied as potassium sulphate (0-0-52).

Ten different fertilizer combinations ($N_0P_0K_0$, $N_0P_0K_{50}$, $N_0P_{40}K_{50}$, $N_0P_{80}K_{50}$, $N_{40}P_0K_{50}$, $N_{40}P_{40}K_{50}$, $N_{40}P_{80}K_{50}$, $N_{80}P_0K_{50}$, $N_{80}P_{40}K_{50}$ and $N_{80}P_{80}K_{50}$) were utilized in the present research. Fertilizers were broadcasted by hand and then buried by a rake without disturbing the vegetation. Half of the N and all of P and K were applied at the beginning of November. The remaining N was applied at the beginning of rapid growth period of vegetation (mid-March).

Dry matter (DM) yield, crude protein (CP) content, CP yield, NDF, ADF, ADL, cellulose (CC), hemicellulose (HC), lignin (LC), ash (AC) were investigated in experiment.

Herbaceous vegetation was annually harvested within 8.75 m^2 area after ignoring 0.5 m area from all sides of the plots when grass plants reached full flowering stage at the beginning of June. Vegetation was hand clipped at ground level. And then, green forage production per 8.75 m^2 area was recorded. Samples taken from each plot were oven-dried at 70 ˚C till they reach to constant weight and, dry weight ratios were calculated. Dry matter yield of each plot was calculated through the values of green forage production and dry-weight percentage. Crude protein content was determined by micro-Kjeldhal (Nx6.25) (Technicon, 1977). Pasture samples were immediately dried, weighed, and ground for determinations of NDF and ADF concentrations. The ANKOM Fiber Analyzer (Model No: ANKOM220, Ankom Technology, Fairport, NY) and ANKOM F57 filter bags were used for NDF, ADF and ADL analysis (Anon. 2006). Cellulose, hemicellulose and lignin content of materials were calculated by using NDF, ADF and ADL values. Samples were burned at 600 ºC in an ash-oven to determine crude ash. Crude ash ratios were determined from the ratio of sample weights before and after burning.

A randomized complete block experimental design was used in the study. The data was analyzed with Repeated Measures Analysis of Variance using SAS program (SAS 1998). Means were separated by LSD at the 5 % level of significance.

RESULTS AND DISCUSSION

There was a significant yield response to fertilization. Application of N+P+K affect forage dry matter yield. Yield from N application was higher than that from no-fertilization. The highest dry matter yield was obtained from $N_{80}P_{40}K_{50}$ and $N_{80}P_{80}K_{50}$ treatments (1306 and 1291 kg ha^{-1}, respectively) (Figure.1).

Combining the yield and protein data allowed the mean crude protein yield to be calculated. For the control plots this averaged 65.8 kg ha^{-1} over the two years (Figure 2). This increased to 151.1 and 158.9 kg ha^{-1}, respectively by $N_{80}P_{40}K_{50}$ and $N_{80}P_{80}K_{50}$ treatments. On the other hand, the plots without N had the lowest crude protein yield (65.8 to 77.5 kg ha^{-1}) (Figure. 2).

Nitrogen fertilization affected the crude protein content of native rangeland. The highest crude protein content (11.11 to 12.17%) was obtained from 80 kg ha^{-1} N application while the lowest crude protein content (8.26 to 9.41%) was obtained from plots without N (Table 2)

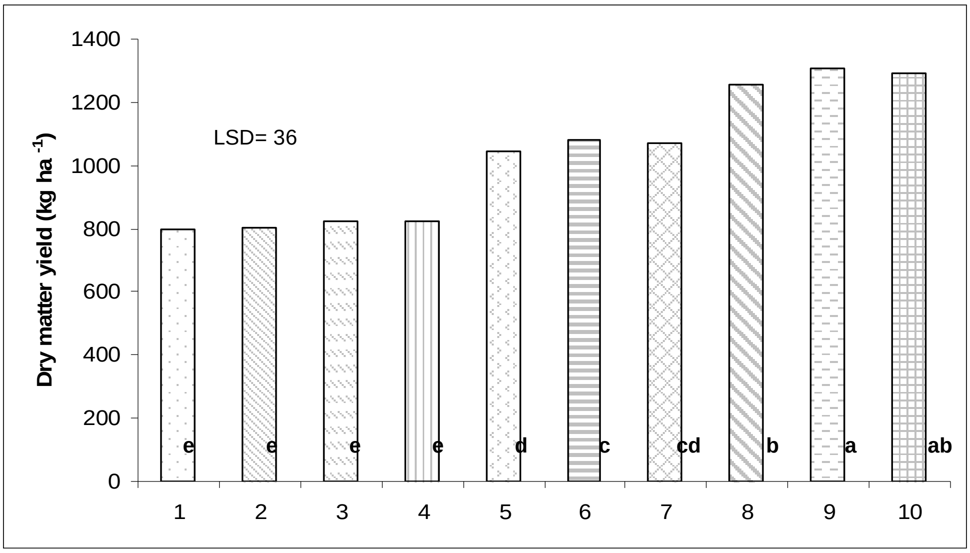

Figure 1. The means of dry matter yield (kg ha^{-1}) of native rangeland in Mediterranean region, Turkey. Values with different columns differ significantly at P<0.05.Treatments: 1. $N_0P_0K_0$; 2. $N_0P_0K_{50}$; 3. $N_0P_{40}K_{50}$; 4. $N_0P_{80}K_{50}$; 5. $N_{40}P_0K_{50}$; 6. $N_{40}P_{40}K_{50}$; 7. $N_{40}P_{80}K_{50}$; 8. $N_{80}P_0K_{50}$; 9. $N_{80}P_{40}K_{50}$; 10. $N_{80}P_{80}K_{50}$.

Table 2. The means of CP, NDF, ADF, ADL, HC, CC, LC and AC % of native rangeland in Mediterranean region, Turkey. Values with different columns differ significantly at P<0.05.

N– P – K	CP	NDF	ADF	ADL	HC	CC	LC	AC
0 – 0 – 0	8.26 d	74.32 a	46.45 a	17.15 a	27.87	29.30 a	6.85 a	10.30 e
0 – 0 – 50	8.28 d	74.04 ab	46.04 a	17.02 ab	28.00	29.02 ab	6.29 b	10.73 d
0 – 40 – 50	9.67 c	73.37 ab	45.53 a	16.93 ab	27.84	28.60 ab	6.28 b	10.65 d
0 – 80 – 50	9.41 cd	74.04 ab	45.34 a	16.90 ac	28.70	28.44 b	6.17 b	10.73 d
40 – 0 – 50	10.42 bc	72.50 bc	44.00 b	16.68 bd	28.50	27.32 c	5.28 c	11.40 c
40– 40 – 50	10.63 bc	71.45 cd	43.42 b	16.49 cd	28.02	26.93 cd	4.97 d	11.52 c
40– 80 – 50	10.42 bc	70.48 d	42.88 c	16.25 d	27.60	26.63 cd	4.42 e	11.83 b
80 – 0 – 50	11.11 ab	71.40 cd	41.73 d	15.29 e	29.67	26.44 d	3.25 f	12.04 ab
80–40–5 0	12.17 a	69.72 de	40.00 e	15.28 e	29.72	24.72 e	3.08 fg	12.20 a
80–80–50	11.70 ab	68.46 e	39.02 f	14.84 e	29.44	24.18 e	2.77 g	12.07 ab
LSD (%5)	1.40	1.78	0.75	0.46	2.13	0.83	0.35	0.26

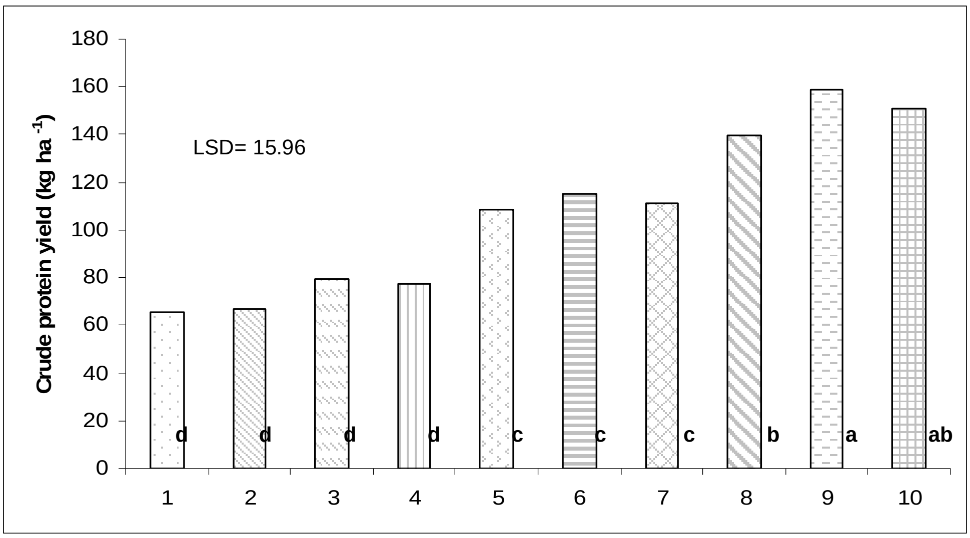

Figure 2. The means of crude protein yield (kg ha^{-1}) of native rangeland in Mediterranean region, Turkey. Values with different columns differ significantly at P<0.05.Treatments: 1. $N_0P_0K_0$; 2. $N_0P_0K_{50}$; 3. $N_0P_{40}K_{50}$; 4. $N_0P_{80}K_{50}$; 5. $N_{40}P_0K_{50}$; 6. $N_{40}P_{40}K_{50}$; 7. $N_{40}P_{80}K_{50}$; 8. $N_{80}P_0K_{50}$; 9. $N_{80}P_{40}K_{50}$; 10. $N_{80}P_{80}K_{50}$

N fertilization significantly decreased native rangeland NDF, ADF and ADL content from 74.32 to 68.46%, 46.45 to 39.02% and 17.15 to 14.84%, respectively (Table 2). The NDF, ADF and ADL concentrations of fertilized herbage were significantly lower in plots with additions N+P than in plots without added P. The NDF, ADF and ADL concentrations were affected by N+K fertilization. Increasing N fertilization decreased cellulose and lignin contents from 29.30 to 24.18% and 6.85 to 2.77% (Table 2). Cellulose and lignin contents decreased from N+P and N+K fertilization. However, application of N, P and K did not affect hemicellulose content of native rangeland. Therefore, changes in one of these fractions affect one or more of the other fractions.

The highest ash content was obtained from $N_{80}P_{40}K_{50}$, $N_{80}P_{80}K_{50}$ and $N_{80}P_{0}K_{50}$ treatments (12.20, 12.07 and 12.04%, respectively) while the lowest ash content (10.3%) was obtained from control plot (Table 2).

Nitrogen fertilization increased DM yield. The highest dry matter yield was obtained from $N_{80}P_{40}K_{50}$ and $N_{80}P_{80}K_{50}$. This result is consistent with previous research that has shown fertilizer was one of the most efficient methods to improve DM production in native rangeland (Elliott and Abbott 2003; Gillen and Berg, 1998; Barnhart et al. 1997; Jacobsen et al., 1996; Berg and Sims 1995; Power 1985).

Crude protein production depends on dry matter yield in treatments and crude protein concentration in plants, which changes according to plant species. In fact, fertilizer affected crude protein production and also botanical composition. Therefore, the higher crude protein yield in this study might be related to effects of fertilizer, which directly affects dry matter yield.

Potassium and phosphorous fertilizers did not directly affect the CP content. However, increasing N fertilization resulted in an increased CP content. An increase in crude protein content due to N or N+P+K applications has also been reported in numerous studies (Rubio et al., 1996; Gillen and Berg, 1998; Guevara et al., 1997).

The NDF concentration decreased with increasing N fertilization. As found in this study, Johnson et al. (2001) reported that the NDF concentration linearly decreased with increasing N fertilization. Adeli et al. (2005) found that NDF peaked at the low fertilization rate and then decreased with increasing fertilizer rates. In contrast to our results, Rogers et al. (1996) reported that increased N fertilization had only marginally effect on the NDF concentration. Malhi et al. (2004) found that effects of only P and K fertilizer on NDF were no significant; this result is consistent with our results.

The ADF concentration in the native rangeland did not vary significantly with the P and K fertilizer, but it changed significantly with the N fertilizer. In plots without N, ADF changed from 45.34 to 46.45%. The lowest ADF percentage (39.02%) was determined in $N_{80}P_{80}K_{50}$ treatment. This result is similar to the work by Adeli et al. (2005) who reported that maximum ADF concentration was obtained from low fertilizer treatment.

The applications of N had significant effects on ADL. The highest ADL values (between 16.90 and 17.15%) were obtained from plots without N, while the lowest ADL (14.84%) was obtained from $N_{80}P_{80}K_{50}$-treatment. Wolf and Boberfeld (2003) reported that the value of ADL increased with increasing amounts of N, but the concentration of energy decreased in tall fescue, this result is consistent with our results.

Fertilizer treatments significantly decreased lignin content. Increasing N fertilization resulted in decreased lignin content. Holubek et al. (1999) reported that non-fertilized semi-natural grassland contained on average 5.50 to 6.08% lignin while fertilized semi-natural grassland contained on average 5.77 to 6.20% lignin. Lignin is indigestible plant component, giving the plant cell wall its strength and water impermeability.

Ash ratio changed significantly with N and K, but it did not vary significantly with P. This result was in accordance with the result reported by Altin (1975).

The effects of fertilizer treatments on hemicellulose content were found no significant. Hemicellulose is long chains of sugar compounds associated with plant cell walls.

Cellulose content was significantly influenced from fertilizer treatments. The plots without N gave the higher cellulose content than the plots with N. Grimes (1967), found that the cellulose content was lower on N fertilized pastures than on pastures not fertilized with N. The results found in this study confirm the findings of Grimes (1967) for cellulose. Archibeque et al. (2001) responded to increase N with a decrease in cellulose and lignin levels in switchgrass, this results in consistent with our results.

CONCLUSIONS

The application of N, P and K fertilizer were considered essential for optimum forage yield and quality of native rangeland as the two year research conducted in Mediterranean conditions of Turkey. The results from the different N, P and K fertilizers applied in natural rangeland in Mediterranean conditions of Turkey can be summarized as follows: The increasing N fertilizer effects increasing yield of DM and CP. This increasing yield level of DM and CP were greater with P and K application. The application of N with combination P+K reduced the percentage of NDF, ADF, ADL, LC, CC and AC. The application of N with P+K was found to be no considerable effect on HC.

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