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EFFECTS OF FERTILIZATION ON FORAGE YIELD AND QUALITY IN RANGE SITES WITH DIFFERENT TOPOGRAPHIC STRUCTURE

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ABSTRACT

Five range aspects were selected and three doses of N (0, 50, 100 kg ha^{-1}), two doses of P fertilizers (0, 50 kg ha^{-1}), as in combination, were used in this study to determine the effects of fertilization on dry matter yield and forage quality. The study carried out on the Palandoken Mountain rangeland, in Erzurum, in 2004 and 2005 years. Dry matter yield increased by the effects of fertilization and the highest value was in N_2P_1 treatment plots whereas the lowest was in control plots. The crude protein (CP) contents from fertilizer applications (N, P and N + P) were higher than that of the plots without fertilization. While the north aspect had the highest CP content, the south revealed lowest in terms of average of the study years. The highest acid detergent fiber (ADF) content was found to be in south and the lowest in west. ADF content decreased with fertilization and there were significant differences between fertilization and aspects. North aspect had higher and west aspect lower neutral detergent fiber (NDF) contents than those found in other aspects. But the NDF content had no significant difference from north, south and east aspects. N and N+P fertilizations had a significant difference from control and N_0P_1 treatment plots in the respect of NDF content. Fertilization increased total digestible nutrient of forages. The highest TDN was in west aspect, the lowest was in south aspect. According to the results of the study 100 kg ha^{-1} fertilizer can be recommended to increase dry matter and forage digestibility of rangelands.

Keywords: Range, aspect, chemical fertilization, forage yield, forage quality.

INTRODUCTION

Ruminants are best adapted to use range plants. Because they have microbes in their digestive systems that efficiently break down fiber, which is quite high in most range plants. However, animal breeding based on rangelands may be restricted by a number of factors. Perhaps the greatest constraints are those related to the grazing animals' ability to select and consume a diet supplying enough nutrients to meet daily requirements for maintenance and production (Ball et al., 2001). When grassland losses some nutrient by clipping or grazing, fertilizers are applied to replace the lost nutrient (Whitehead 2000).

All forage plants are composed of cells having fibrous cell walls for support and protection. Neutral detergent fiber (NDF) consists of the total fiber in the forage and relates to forage intake by ruminants (Rayburn 1991; Ball et al. 2001; Undersander 2007). Acid detergent fiber (ADF) is composed of highly indigestible fiber and relates negatively to forage digestibility (Rayburn 1991; Ball et al. 2001). Digestible dry matter (DDM) is the digestibility of forage, is often calculated from forage ADF (Rayburn 1991; Linn and Martin 1999). Relative feed value (RFV) index combines important nutritional factors (Linn and Martin, 1999). Total nitrogen concentration, used for estimate of crude protein content multiplying that by 6.25 in the forage is important since adequate intake of nitrogen is essential for animal productivity (Mattson 1980). Much of the protein in forages is degraded in the rumen by bacteria. These bacteria use this protein for growth and for digestion of the forage fiber (Rayburn 1991).

Crude protein, ADF and NDF content in forage can change with chemical fertilization (Black and Wight 1972; Probasco and Bjugstad 1980), and range aspects (Probasco and Bjugstad, 1980). Also digestible dry matters and relative feed values, calculated from ADF, NDF and crude protein values, can be affected by fertilization and aspect.

The aim of this study is to determine the effects of N and P fertilization on dry matter yield and feeding quality of forage in different rangeland aspects.

MATERIAL AND METHODS

This study was conducted on different aspects of range sites (east, west, south, north and summit) on Palandoken Mountain, in Erzurum for two years (2004 and 2005). N (0, 50, 100 kg N ha^{-1}), as ammonium sulphate, and P (0, 50 kg P_2O_5 ha^{-1}), as triple super phosphate, as in combination were used for fertilization; a randomized complete block experiment design, as three replications, was used in this study.

The study site is located on an average altitude of 2,450 m, and included in an ungrazed area. Annual average temperature is 5.7 ^{o}C, total annual precipitation 423.8 mm; monthly average humidity is 63.9 % in study area. The highest precipitation was in May (70.5mm), the lowest in August (16.6 mm) (Table 1).

Table 1. The Climatic dates of Erzurum Province for 2004, 2005 years and Long Term Average (LTA)(*)

Month	Total Precipitation			Temperature (^{o}C)		
	2004	2005	LTA	2004	2005	LTA
January	14.3	26.6	22.8	-9.0	-13.6	-9.1
February	90.0	8.9	26.7	-8.7	-11.3	-7.8
March	33.7	46.5	35.0	-1.7	-3.1	-2.5
April	36.0	67.7	51.6	4.0	6.3	5.4
May	121.7	92.1	70.5	9.7	10.6	10.5
June	40.7	70.0	47.5	14.5	13.9	14.8
July	17.9	20.3	27.2	17.9	20.2	19.3
August	1.3	24.3	16.6	19.6	20.4	19.3
Sept.	6.0	15.4	24.5	13.8	14.0	14.5
Octb.	27.4	71.8	44.6	7.9	6.5	7.9
Nov.	43.6	15.2	34.0	-1.0	1.0	0.8
Dec.	8.2	21.1	22.9	-14.1	-3.9	-5.9
Tot./Mean	440.8	479.9	423.8	4.4	5.1	5.6

(*)The Official Directoryship of Meterorological Bulletion for Erzurum

Four composite soil samples were collected form surface layer of each aspect and analyzed for some physical and chemical properties. Particle size distribution of soil was determined by the hydrometer method (Gee and Bauder, 1982). Soil pH was measured using a hand held conductivity meter and pH electrode (Mclean 1982; Rhoades 1982). Organic matter was measured by Smith-Weldon method (Nelson and Sommers, 1982). Phosphorus was determined by spectrophotometer (Olsen and Sommers, 1982). Potassium was measured by atomic absorption (Rhoades 1982). Soil texture was sandy loam in east and summit sites, clay loam in north, loam in south and west. Soil pH was 6.2 in east and west, 5.9 in south and north, 6.3 in summit site. Soil organic matter content was 6.3, 4.8, 4.5, 4.1 and 6.6 %, and available K was 31.4, 28.4, 28.1, 27.5 and 29.7 kg da^{-1}and, Olsen P content was 2.5, 1.6, 2.4, 3.6 and 4.2 kg da^{-1} in range aspects of east, west, south, north and in summit site, respectively. Grasses had the highest proportion in north, being higher in east and south than west and summit. In west *Astragalus eriocephalus* had higher proportion than the other aspects. The results were submitted as average of two years.

Dry matter yield was determined by weighing after harvested, when dominant species began to flowering each year in July, from 1 m^{2} area of central part of each plots. Total number of plots was 90, areas of each plot were 9 m^{2} and total research area was 0.187 ha. Samples were oven-dried at 70^{o}C for 24 h, grounded to pass a 2 mm sieve, and divided 4 sub-samples. Total N content was determined by the Kjeldahl method and multiplied by 6.25 to give crude protein content (Jones 2001). Acid detergent fiber and Neutral detergent fiber analyzes were determined by (Van Soest 1963). Total digestible nutrient was determined by (Linn and Martin, 1999) equations (TDN%=88.9-(0.779 x ADF%). Crude protein yield was determined by multiplying crude protein content by dry matter yield.

Analysis of variance (ANOVA) was computed by SAS GLM (SAS Institute 2002). Differences among treatments were subjected to LSD test.

RESULTS

According to average of two study years, there were significant differences ($p<0.01$) among dry matter yield of range aspects and the highest dry matter yield (1557 kg ha^{-1}) was in north aspect, the lowest (948 kg ha^{-1}) was in west aspect. On the other hand, fertilization had significant ($p<0.01$) effects on dry matter yield. The highest dry matter yield (1426 kg ha^{-1}) was determined in N_2P_1 treatment plots; the lowest (944 kg ha^{-1}) was in control plots. There is no statistical difference between N_2P_0 and N_2P_1; N_0P_0 and N_1P_1 treatment plots (Table 2).

Table 2. Dry matter yield of different range aspects (kg ha^{-1}) (Average of two years)

Fertilization	Range Aspects					
	East	West	South	North	Summit	**Means**
N_0P_0	867	819	916	1162	957	944 **d**
N_0P_1	870	833	923	1164	961	950 **d**
N_1P_0	1153	955	1045	1302	1017	1094 **c**
N_1P_1	1181	980	1061	1341	1164	1145 **b**
N_2P_0	1474	1043	1199	2186	1188	1418 **a**
N_2P_1	1505	1059	1222	2189	1159	1426 **a**
Means	1175 **b**	948 **d**	1061 **c**	1557 **a**	1074 **c**	1164

LSD: Fertilization (0.01) = 21,8; Aspect (0.01) = 19,9; Year * Aspect * Fertilization (0.01) = 68,9

Year had significant effect on dry matter yield and in second study year, dry matter yield was higher than that of the first study year (Figure 1). The interactions of year by aspect (Figure 3), year by fertilization (Figure 2), aspect by fertilization (Figure 4) and year by aspect by fertilization had significant effects ($p<0.01$) on dry matter yield of range aspects (Table 2).

Chemical fertilization affected the crude protein content of forage. Crude protein content from fertilizer applications (N, P and N + P), according to average of study years, was higher than that of the forages from the plots without fertilization, and there were significant differences ($p<0.01$) among fertilizer treatments and aspects. The highest CP content was determined in N_2P_1 treatment, which did not

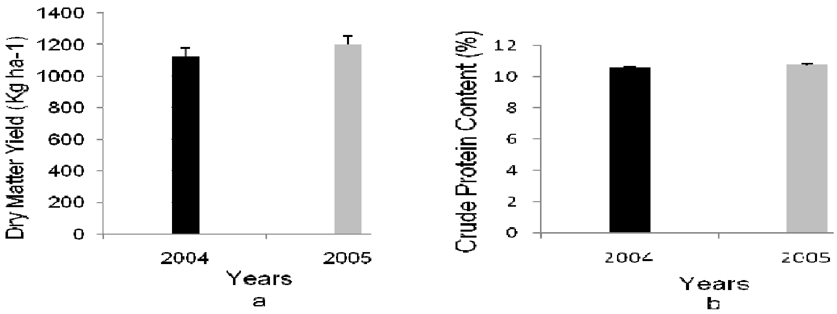

Figure 1. Changing of dry matter yield (a) and crude protein content of forage (b) in study years with LSD bar (lsd (dry matter):12,6;(crude protein): 0,058).

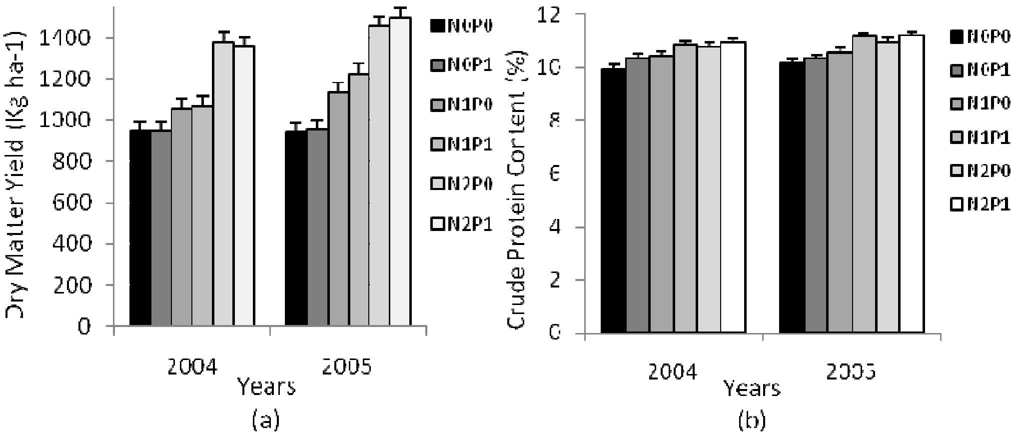

Figure 2. The effects of year by fertilization interaction on dry matter yield (a) and crude protein content of forage (b) with LSD bar (lsd for dry matter=48,7; crude protein =0,14).

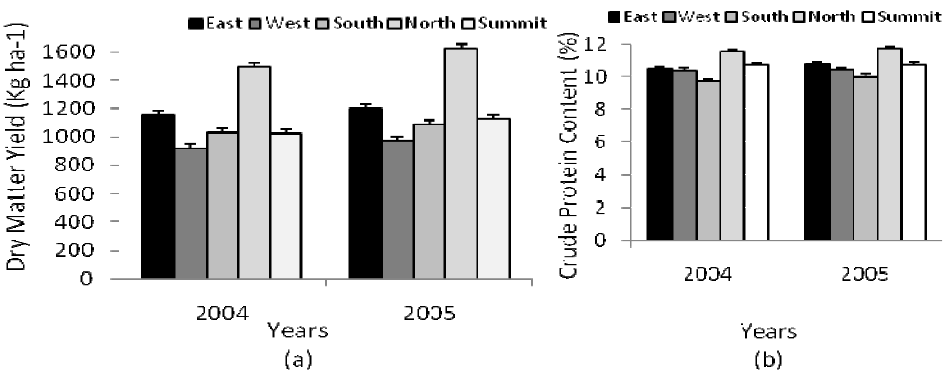

Figure 3. The effects of year by aspect interaction on dry matter yield (a) and crude protein content of forage (b) with LSD bars (lsd for dry matter:28,2; crude protein:0,13).

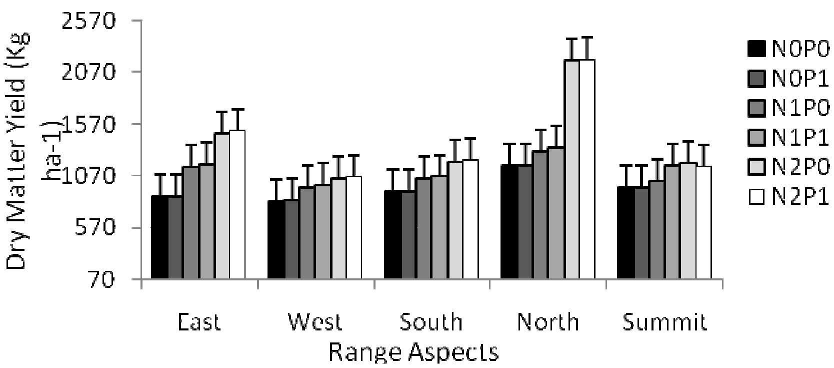

Figure 4. The effects of aspect by fertilization interaction on dry matter yield with LSD bar (lsd:69,6) (Average of two years).

differ from N_1P_1 treatment; the lowest was in control plots (N_0P_0). While north aspect had the highest CP content, south revealed the lowest in terms of the average of the study years (Table 3).

Table 3. Crude protein (CP) content of range forage in different range aspects (%) (Average of two years)

Fertilization	Range Aspects					**Means**
	East	West	South	North	Summit	
N_0P_0	10.5	9.7	9.3	10.4	10.5	10.1 **e**
N_0P_1	10.6	9.9	9.7	11.0	10.5	10.3 **d**
N_1P_0	10.5	10.3	10.1	11.2	10.4	10.5 **c**
N_1P_1	10.8	10.6	10.5	12.3	10.9	11.0 **a**
N_2P_0	10.7	11.1	9.7	12.1	10.8	10.9 **b**
N_2P_1	10.8	10.8	9.9	12.6	11.3	11.1 **a**
Means	10.6 **b**	10.4 **c**	9.9 **d**	11.6 **a**	10.7 **b**	10.6

LSD: Fertilization (0.01) =0,10; Aspect (0.01) =0,092; Year * Aspect * Fertilization (0.01) = 0,31

Year significantly affected ($p<0.01$) CP content and the second study year had higher crude protein content than the first study year (Figure 3). The interactions effects of year by aspect (Figure 3), year by fertilization (Figure 2), aspect by fertilization (Figure 5) and year by aspect by fertilization, respectively, had significant influence on crude protein content of forage.

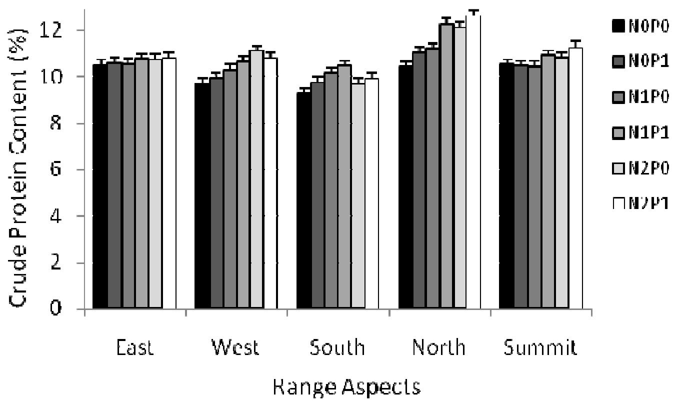

Figure 5. The effects of aspect by fertilization interaction on crude protein content of forage with LSD bar (lsd:0,23) (Average of two years).

There were significant differences ($p<0.01$) among ADF contents of forage in range aspects. The highest ADF content was in south while lowest in west. ADF content decreased with fertilization and there were significant differences between fertilizer treatments (Table 4).

Table 4. ADF content of range forage in different range aspects (%) (Average of two years)

Fertilization	Range Aspects					**Means**
	East	West	South	North	Summit	
N_0P_0	39.8	37.9	38.2	39.4	39.1	38.9 **a**
N_0P_1	39.3	38.8	38.4	37.9	38.1	38.5 **ab**
N_1P_0	38.2	36.5	40.7	38.6	37.3	38.3 **ab**
N_1P_1	39.9	37.2	38.6	39.5	37.3	38.5 **ab**
N_2P_0	37.4	35.2	40.4	39.5	37.1	37.9 **b**
N_2P_1	37.8	34.6	39.4	36.4	36.9	37.0 **c**
Means	38.7**ab**	36.7 **d**	39.3 **a**	386 **b**	37.6 **c**	38.2

LSD: Fertilization (0.01) =0,81; Aspect (0.01) =0,74; Year * Aspect * Fertilization (0.01)=2,56.

The first study year had higher ADF content than the second study year but had no significant effect. The interactions of year by aspect (Figure 6), aspect by fertilization (Figure 7) and year by aspect by fertilization had significant influence ($p<0.01$) on ADF content of forage.

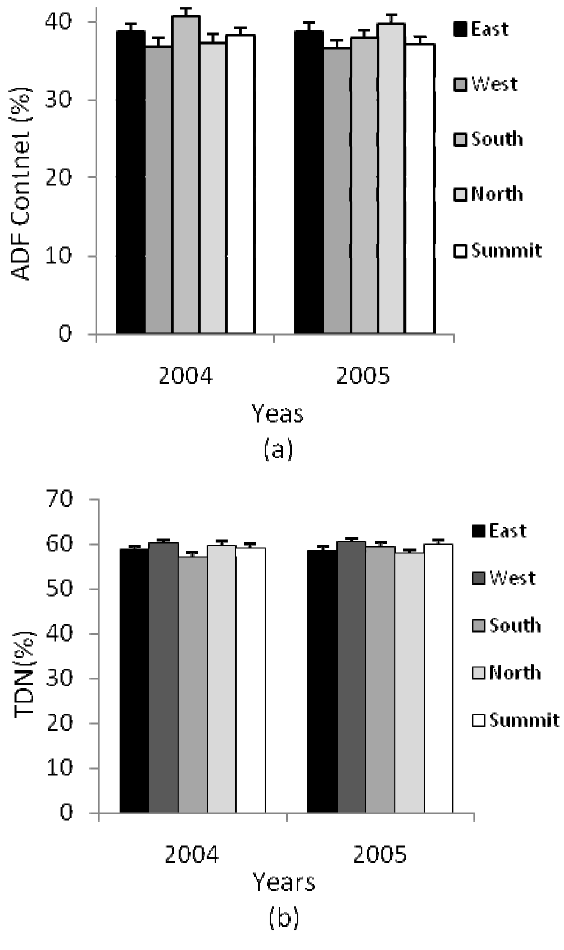

Figure 6. The effects of year by aspect interaction on ADF content (a) and TDN (b) with LSD bars (lsd for ADF:1,04; TDN: 0,81).

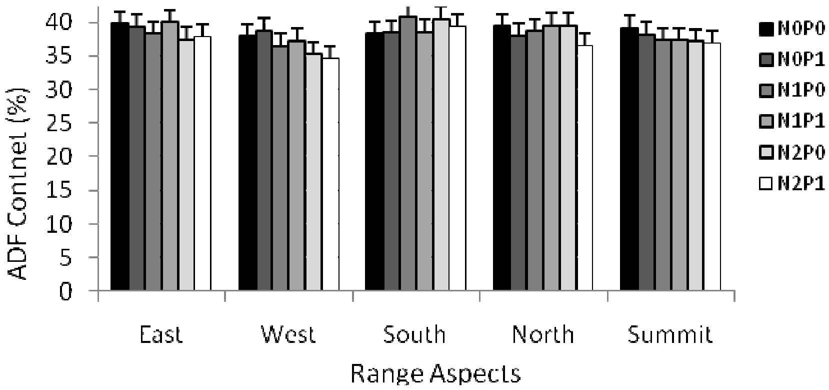

Figure 7. The effects of aspect by fertilization interaction on ADF content of forage with LSD bar (lsd:1,81) (Average of two years).

There was a positive relationship between NDF content and fertilization. The NDF content was higher in N and N + P fertilized plots than P and without fertilizer plots in the average of study years. N and N + P fertilization had a significant difference from control plots in the respect of NDF content but P fertilization (N_0P_1) did not show differences from plots without fertilizer; N_1P_0 treatment had the highest while N_0P_0 the lowest NDF content. North aspect had higher while west lower NDF content than the other aspects. But the NDF content had no significant difference among north, south and east aspects (Table 5). Year had no significant effect on NDF content. The interaction effects of aspect by fertilization (Figure 8) had significant influence ($p<0.01$) on NDF content of forage.

Table 5. NDF content of range forage in different range aspects (%) (Average of two years)

Fertilization	Range Aspects					
	East	West	South	North	Summit	**Means**
N_0P_0	61.5	55.4	59.9	59.5	59.8	59.2 **b**
N_0P_1	60.2	57.1	58.5	62.0	60.5	59.6 **b**
N_1P_0	61.9	60.2	60.7	64.8	60.3	61.6 **a**
N_1P_1	60.7	59.8	63.9	61.3	59.8	61.1 **a**
N_2P_0	62.0	60.8	60.8	61.7	60.4	61.4 **a**
N_2P_1	60.8	61.2	64.0	60.0	60.9	61.4 **a**
Means	61.2**ab**	59.1 **c**	61.3 **a**	61.7 **a**	60.3 **b**	60.7

LSD: Fertilization (0.01)=1,022; Aspect (0.01)=0,93; Year * Aspect * Fertilization (0.01)=3,23

Total digestible nutrient (TDN) increased by fertilization and there were significant difference between fertilizer treatments and aspects. The highest TDN was in N_2P_1 treatment plots, the lowest was in without fertilizer plots. West aspect had higher TDN than that of the other aspects, east aspect had lower than that of the other aspects. Total digestible nutrient, determined in east aspect, did not differ from south and north aspects (Table 6). Year had no significant effect on TDN. Year by aspect (Figure 6), aspect by fertilization (Figure 9) and year by aspect by fertilization interactions had significant; year by fertilization had no significant influence on digestible dry matter.

Table 6. Total Digestible Nutrient (TDN) of forage in different range aspects (%) (Average of two years)

Fertilization	Range Aspects					
	East	West	South	North	Summit	**Means**
N_0P_0	57.9	59.4	59.1	58.2	58.4	58.6 **c**
N_0P_1	58.3	58.7	59.0	59.3	59.2	58.9 **bc**
N_1P_0	59.1	60.5	57.2	58.8	59.8	59.1 **bc**
N_1P_1	57.8	59.9	58.9	58.1	59.9	58.9 **bc**
N_2P_0	59.8	61.5	57.4	58.1	60.0	59.4 **b**
N_2P_1	59.5	62.0	58.2	60.6	60.1	60.1 **a**
Means	58.7**cd**	60.3 **a**	58.3 **d**	58.9 **c**	59.6 **b**	59.2

LSD: Fertilization (0.01)=0,63; Aspect (0.01)=0,57; Year * Aspect * Fertilization (0.01)=1,99.

DISCUSSION

Increase in dry matter yield due to N fertilization because there is a significant correlation between N fertilization and dry matter yield. It was stated in some research that yield increase could be possible by applying of N into soil via fertilization (Rauzi and Fairbourn 1983; Jacobsen et al. 1996; Guevara et al. 2000; Andiç et al. 2001). As that there is a significant correlation between aspect and soil moisture content, N effectiveness and soil moisture content (Reid 1973), the highest dry matter yield was obtained from north aspects. The reason of the lower dry matter determined in west aspect can most probably related to the higher

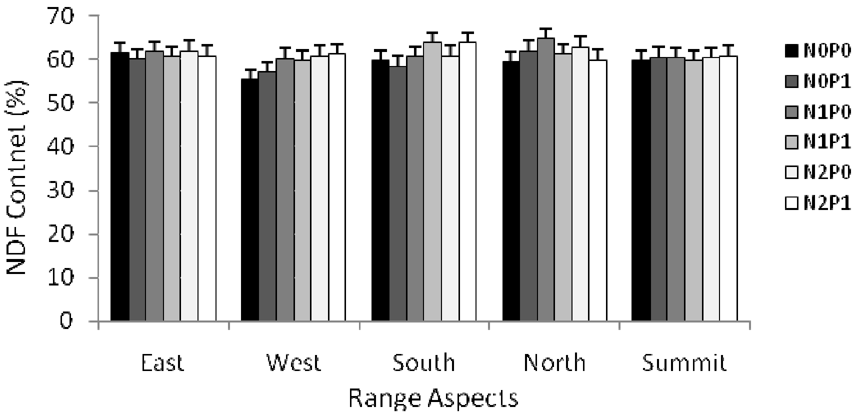

Figure 8. The effects of aspect by fertilization interaction on NDF content of forage with LSD bar (lsd:2,29).

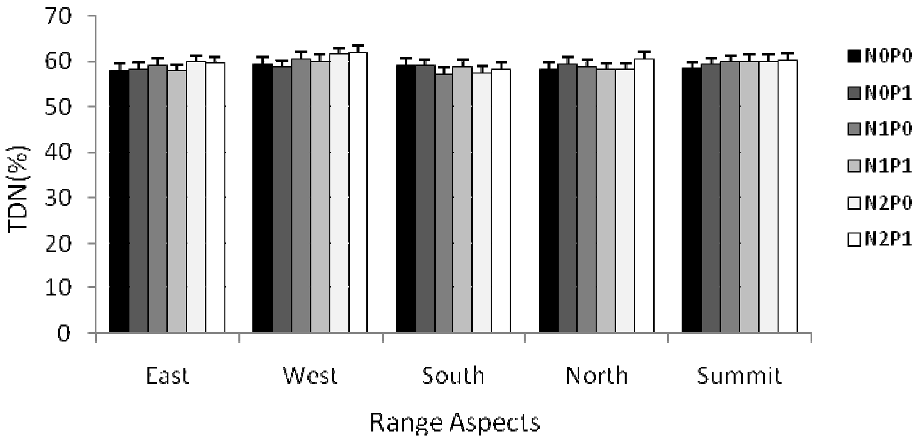

Figure 9. The effects of aspect by fertilization interaction on TDN of forage with LSD bar (lsd:1,41).

proportion of *Astragalus eriocephalus*. Because the proportion of many forage species is decreased by this plant species.

According to the results of the study, fertilization had positive effects on nitrogen content of forage. Plots fertilized with N, P and N + P had higher N content than those without fertilizer. These results can most probably result from increasing effects of N and P fertilization on nitrogen (Black and Wight 1972; Messman et al. 1991) and crude protein content of forage (Gillen and Berg, 1998).

Most rangelands are characterized by low total precipitation, and temperature can have as much influence on annual variation in forage production as does precipitation in with cool season plants regions (Holechek et al., 2004). The highest crude protein content was determined in north, the lowest in south aspect. These results can related to moisture and temperature difference between aspects, and their effects on forage quality, as that there is a significant correlation between aspect and soil moisture content (Reid 1973) because temperature on slopes increases as aspect changes from north to east to west to south, with shading effect (Holechek et al., 2004). In summer, plants especially grasses, lose quality as the season progresses. Forage quality declines with advancing maturity because the proportion of leaves, with higher in quality than stems, in forage declines as the plant matures. Likewise, the plants grow at higher temperatures; they can produce less leaf material (Ball et al., 2001). Determined higher CP content in north, which was less in south, might have resulted from the fact that vegetation of north was greener and had more leaves than south at the same harvest time.

The earlier the plants mature, the higher stem proportion they have, and stems have higher ADF content than that of leaves (Ball et al., 2001), and also as forage plants mature, the amount of ADF content increases (Linn and Martin, 1999). Because south aspect receives more sun light, temperature is higher and high temperature affects plant maturity. The high ADF content in south aspect can be related to these conditions. Higher ADF content in north aspect is normally expected due to higher grass proportion than east and south aspects. However, higher temperature might have more effect than grass proportion on ADF content in south aspect. Just as (Ball et al., 2001) stated that plant maturity can dramatically affects the digestibility of forages. The reason why lower ADF content was found in west aspect is related to the higher proportion of *Astragalus eriocephalus* and the shading effects of these plants on vegetation. Because plants, grown in shade are greener and they have lower ADF content than more mature plants, depending on the leaf ratio (Linn and Martin 1999; Ball et al. 2001). There were negative relations between fertilization and ADF content; also there were significant differences (p<0.01) between treatments (Table 3). The reason for this difference may be attributed to reducing effects of fertilization on ADF and increasing effects on digestibility (Ball et al., 2001).

The NDF content was lower in plots without fertilizer and fertilized with P than that of the N and N+P fertilized plots. The reason for that there were significant differences between NDF content of fertilizer treatments may be attributed to the increasing effects of fertilization on fiber content of forage (Messman et al., 1991). NDF content of forage had significant difference between range aspects, being the lowest in west, which may be associated with having higher *Astragalus eriocephalus* and less grass proportion. As in ADF content, wide above ground biomass of *A. eriocephalus*, by shading effects, can cause high leaf proportion, the lower NDF content in west aspect may be related to lower NDF content of leaves and lower proportion of grasses with higher NDF content. The highest NDF content was in north, and this aspect did not differ from east and south aspects. However, north and east have higher grass proportion than south; the plants were more mature in south aspect at the same harvest time due to the effects of higher temperature. Likewise, (Linn and Martin, 1999) stated that forages at the same maturity will be higher in fiber when growth occurs during high temperatures compared to cool or normal temperatures, because temperature affects maturity period, owing to increase in NDF content of forages.

Total digestible nutrient is more closely related to ADF content and as ADF content decrease, TDN increase (Linn and Martin 1999; Undersander 2007). The reason for that there were significant differences between total digestible nutrient of fertilizer treatments may be related to the difference in ADF content of forages. Similarly to the changing in TDN by the effects of fertilization, range aspects showed parallel results with ADF content. The lowest ADF content was in west, the highest in south, contrary to the highest TDN was in west, the lowest in south. Digestible nutrients can also related to maturity of plant cells, because as plant cells mature, cell walls increase in amount of fiber. This increase in fiber results in decreased cell wall digestibility (Lyons et al., 1996). The reason for lowest TDN in south aspect can associated with more mature plants by effect of temperature and the reason for the highest TDN in west aspect can related to the shading effects of *A. eriocephalus* on plants, leads to higher leaf proportion and greener forage. Higher leaf proportion might have caused higher digestibility in west aspect. Likewise, (Linn and Martin, 1999) stated that if plants losses the leaves, digestibility decreases.

Results obtained in the present study showed that fertilization had positive effects on crude protein content of forage. NDF content and TDN was increased, ADF content was decreased by fertilization. Decrease in ADF, cause to increase in TDN, can be positive for forage quality because the lower ADF content means the higher digestion. High NDF content has negative effects on forage quality but the results in this study, showed that NDF content increased by fertilization was not significant for quality.

According to these results, for rangelands that are similar to our research area, 10 kg N da^{-1} fertilizer can be recommend to increase dry matter and forage quality, especially high digestibility of forage. Application of 100 kg ha^{-1} is recommended some researcher, studied in rangelands of the region, for high forage yield and quality (Altın 1975; Gökkuş 1984).

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