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Nitrogen and phosphorus fertilization of rangelands affects yield, forage quality and the botanical composition

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Abstract

Nitrogen fertilization of rangelands in order to increase dry matter yield results in a decrease in legume ratios in botanical composition, which reduces forage quality. The objectives of the present study therefore were to investigate whether this negative effect of N fertilization on forage quality can be compensated by additional P application and also to determine the optimum fertilizer doses in rangelands to obtain economical benefits. Therefore, 0, 60, 120, 180 kg N ha^{-1} and 0, 26, 52 kg P ha^{-1} fertilizer rates were applied each year over a period of 3 years to 12 plots within each of 4 blocks. Botanical composition of the plots was determined and classified as grass, legumes and others for each treatment group based on dry weights. Dry matter yield, crude protein concentration and crude protein yield in treatment groups for each year were determined.

Consequently, averaged over the 3 years of experimental period, nitrogen fertilizer increased the dry matter yield. The dry matter yield was 1467 kg ha^{-1} in control plot, while it increased up to 3293 kg ha^{-1} in plot applied with 180 kg N ha^{-1} without P. Nitrogen fertilization slightly decreased the crude protein concentration in the forage dry matter from 120 g kg^{-1} in the non-fertilized control to 103–116 g kg^{-1} in the plots fertilized only with nitrogen. This effect can be explained by the observation that the nitrogen fertilization resulted in a decline of the legume proportion from 47% in the non-fertilized control to 5% with the highest N rate. The protein concentration in legume plants was always considerably higher than that in the grass and other species. Applying additional phosphorus compensated this negative effect of the nitrogen fertilization on the forage quality in terms of protein concentration. The economic optimum was found with the highest fertilizer doses providing 52 kg P ha^{-1} + 180 kg N ha^{-1} producing 4810 kg ha^{-1} forage dry matter with a crude protein concentration of 124 g kg^{-1} and legume proportion of 12%.

Keywords: Rangeland; N and P fertilization; Quality; Crude protein; Botanical composition; Economic benefits

1. Introduction

Rangelands in Turkey occupy approximately 16% of total 78 million ha area. A great majority of forage needed for feeding 11 million cattle and 29 million

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head sheep populations is provided by these rangelands. However, 300–900 kg ha^{-1} dry matter yield is lower than dry matter production potential of these rangelands. Therefore, it has paramount importance to increase dry matter production by improving rangelands in order to meet forage requirements of ruminants, which is in shortage in Turkey.

The most practical and effective method to increase dry matter production in rangelands is an appropriate and adequate fertilization of these areas (Frame, 1992). Fertilization, especially with N and P can increase dry matter production up to two- to three-fold from rangelands depending on the annual rainfall and moisture in the region (Elliott and Abbott, 2003). Generally, in regions where annual rainfall is less than 300–400 mm, fertilization of rangelands is not profitable (Guevara et al., 2000).

Fertilization may improve not only dry matter productivity, but it also affects botanical composition of rangelands (Kalmbacher and Martin, 1996). Some previous studies showed that there were positive relationships between botanical composition and the quality of forage of rangeland (Samuel and Hart, 1998). Forage quality can be described as the conversion of consumed forage to animal products. One of the main criterion is the crude protein concentration of in the forage (Gillen and Berg, 1998). At the same harvest maturity, legumes contain higher crude protein compared to grasses. Digestibility of hay increases with the increase in crude protein concentration (Van Soest, 1973).

Fertilization with nitrogen stimulates grass growth, but depresses the legumes growth (Lee and Lee, 2000). The growth of legume plants can be enhanced with P fertilizers in rangelands (Snyman, 2002). On the other hand, some studies revealed that the combined applications of N and P fertilizer resulted in the improvement of grass growth in rangelands but not in legume crops (Kalmbacher and Martin, 1996).

N fertilization affects the botanical composition negatively resulting in a lower legume proportion which results in less crude protein. The objectives of the present study therefore were to investigate whether this negative effect of N fertilization on forage quality can be compensated by additional P application and also to determine the optimum fertilizer doses in rangelands to obtain economical benefits.

2. Materials and methods

2.1. The experimental area

This study was conducted at Ondokuz Mayis University Research Station, Samsun located on The Blacksea coast of Turkey (41° 21′N, 36° 15′E, elevation 120 m) between 1998 and 2000. The growing season of the herbaceous vegetation begins in mid-February and ends in June in Samsun. While the 50-year mean precipitation was 665 l/m^2, the annual precipitations were 729, 637 and 698 l/m^2 for 1998, 1999 and 2000, respectively (Table 1).

Some major soil characteristics determined by the method described by Rowell (1996) were found to be as follows; the soil texture is clay; organic matter is 3.11%; extractable P by 0.5N $NaHCO_3$ extraction is 5.4 mg kg^{-1}; exchangeable K by 1N ammoniumacetate extraction is 163.5 mg kg^{-1}; pH is 6.7 in soil saturation extract and EC is 1.42 mS cm^{-1} in the same saturation extract.

Before the experiment started, botanical composition of experimental area based on weight was determined in eight quadrates, each equals 1 m^2, in May 1997. Botanical composition of experimental area consisted of 38% legumes; 35% grasses, and 27% plants of other families. Legumes in the botanical composition were mostly berseem (*Trifolium alexandrinum* L.), spotted medic (*Medicago arabica* L.), burclover *(Medicago hispida* Gaertn.*)* and red clover (*Trifolium pratense* L.); and grasses were slender meadow foxtail (*Alopecurus myosuroides* Huds.), cheatgrass (*Bromus tectorum* L.), rough bluegrass (*Poa trivialis* L.), and perennial ryegrass (*Lolium perenne* L.); and others plants were narrowleaf plantain (*Plantago lanceolata* L.), common sheep (*Rumex acetosella* L.), geranium (*Geranium* sp.) and corn buttercup (*Ranunculus arvensis* L.).

Table 1
Annual and seasonal total precipitation (l/m^2) in Samsun, Turkey

Years	Period	
	Growing season (February–June)	Annual (October–September)
1997–1998	317	729
1998–1999	240	637
1999–2000	360	698
50-Year average	257	665