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PERFORMANCE OF FODDER PEA (*PISUM ARVENSE* L.) - FIDDLENECK (*PHACELIA TANACETIFOLIA* BENTH.) MIXTURE UNDER DIFFERENT NITROGEN DOSES

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ABSTRACT

The aim of this research was to determine the effect of different nitrogen doses on forage yield and quality in fodder pea-fiddleneck (*Phacelia tanacetifolia* Benth.) mixtures. This research was conducted at experimental areas of Field Crops Department, Agriculture Faculty, Namik Kemal University, Tekirdag located on The Marmara Sea coast of Turkey between 2010 and 2012. The tested variants were: fodder pea 50% + fiddleneck 50%; fodder pea 100% and fiddleneck 100%. The different nitrogen doses and mixtures affected the botanical composition, green fodder and dry matter yields, crude protein, ADF, NDF, P, Ca, K and Mg contents. The botanical composition changed with increasing N doses in all treatments. Contrary to fodder pea, fiddleneck and other species dry weight ratios increased depending on the N doses. The highest change in both fodder pea and other plant species dry weight ratios were observed between control and plots received 150 kg N ha^{-1}. In fodder pea 50% + fiddleneck 50% mixture, maximum green fodder and dry matter yields were 49.57 t ha^{-1} and 13.04 t ha^{-1}, respectively, by applying 150 kg N ha^{-1}, which was followed by 45.93 t ha^{-1} and 12.24 t ha^{-1} applying nitrogen at the rate of 90 kg ha^{-1}. The nitrogen application at the rates of 90 to 150 kg N ha^{-1} significantly increased Ca ratio over control. The maximum K ratio was observed in fiddleneck (120 kg N ha^{-1}), having 0.55% and 0.56% P ratios in 90 kg N ha^{-1} and 150 kg N ha^{-1} applications, respectively. Mg ratio was significantly lower in fiddleneck from plots not fertilized (control).

Key words: fiddleneck, fodder pea, mixture, nitrogen doses, yield, quality, mineral content.

INTRODUCTION

The forage used to feed animals in Turkey and other countries are provided by grassland, forage crops, forage crops-other than cultivated plants mixtures and the secondary products of other cultivated plants (Tekeli and Ates, 2011). The acreage of fodder pea (*Pisum arvense* L.) and other forage legumes continues to increase in the Thrace region, Turkey and the world. The new fodder pea cultivars (cv. Ates, cv. Tore etc.) are widely adapted in Thrace region as high-quality annual forages. When fodder pea is grown as a monoculture, it exhibit severe lodging after flowering. Therefore, fodder pea is often sown in mixtures with cereals that have an upright stature. Tall varieties of fodder pea are cultivated with cereals, reducing lodging and increasing hay yield and quality (Tan and Serin, 1996; Uzun and Acikgoz, 1998). Fodder pea-cereal and forage crops-other than cultivated plants mixtures are popular annual hay mixtures; the combined protein and energy level of these forages is superior to many other crops (Cash et al., 2001).

Fodder pea has many advantages as forage or grain in crop rotations; however until recently, lack of seed varieties, seed cost and other concerns have limited its use in Turkey and many other countries. The current increase in acreage and availability of fodder pea will likely improve its acceptance by livestock producers of Thrace region in Turkey (Arslan et al., 2012).

Total forage yield, quality and seasonal distribution of forage production may be of great importance to the livestock producer. Forage quality can be considered satisfactory when animals consuming the forage perform as desired. Three factors, which effect animal performance, are:

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a) Intake - forage must be palatable if it is to be consumed in adequate quantities to produce the desired performance;

b) Digestibility - nutrient content once the forage is eaten; it must be digested and converted to animal products;

c) Toxic factors - the forage must be free of components, which are harmful to the animals. Many factors affect forage quality for animals, so that no single characteristic can serve to predict animal production.

Some of the important factors that determine forage quality for animals are: growth stages, chemical composition, legume-grass or other species ratio, physical form, foreign material (particularly weeds and dust), damage or deterioration during harvest and storage, and the presence of anti-quality substances such as estrogens, thyrotoxic factors, and toxic amines and their condensation products (Arslan et al., 2012). Nitrogen (N) and other macro elements are major limiting nutrients for growth of forage crops and this explains the improvement in forage yield by external supply of these elements to soils that are deficient in them (Tena and Beyene, 2011).

Applications of macro and microelements have a direct effect on the proportion of plant N present as true protein. The N uptake by the plant increases rapidly with the amount of N application and this leads to build-up of non-proteinic organic N, thereby decreasing the proportion of proteinic N with increased amounts of N applied. The effect of N fertilization on the amino acid profile of proteinic N is not fully described. According to the effect of N fertilization on the crude protein (CP) content of forage grass, cell wall digestibility may be lowered on less fertilized swards (Peyraud and Astigarraga, 1998). The aim of this research was to determine the effect of different nitrogen doses on forage yield and quality in fodder pea-fiddleneck (*Phacelia tanacetifolia* Benth.) mixtures.

MATERIAL AND METHODS

This research was conducted at experimental areas of Field Crops Department, Agriculture Faculty, Namik Kemal University, Tekirdag located on The Marmara Sea coast of Turkey (40° 59' N, 27° 34' E, elevation 17 m) between 2010 and 2012. The annual mean temperature is 10.5°C. The soil of the experimental area was xeralf, low in organic matter (1.12-1.41%), and moderate in phosphorus (P) content (59.2 kg ha^{-1}), but rich in potassium (K) content (569 kg ha^{-1}) and with pH 6.9-7.1. While the 41-year mean precipitation was 576 mm, the precipitation was 351.2 mm and 322.32 mm, respectively, in the two growth periods of the experiment (November 9 to May 17).

A two factorial experiment was set according to method of random block system in four replications during two years. Surface of main plot was 10 m^2. Row distances of 25 cm, sowing rates of 120 kg ha^{-1} (fodder pea) and of 20 kg ha^{-1} (fiddleneck) were used (Karadag and Buyukburc, 2003; Ates et al., 2010). The main factor included: fodder pea 50% + fiddleneck 50%; fodder pea 100% and fiddleneck 100% (Ates, 2012; Uzun and Asik, 2012). Certified seed of the fiddleneck variety Turan-92 and the fodder pea variety Tore were used. The seed rates for each species in the mixtures were calculated using the following formulas (Avcioglu, 1999): Utilization Value (UV) = Seed purity (%) x Germination vigour (%)/100; Seed Rate in Mixture = Ratio of species in mixture (%) x ten percent more than sowing rate (kg ha^{-1}) / UV.

Plots were seeded in the autumn (November 9, 2010 and November 1, 2011) and no herbicide was applied after sowing and during growth. Fertilizer N in the form ammonium nitrate was spread by hand to each row configuration at the sowing time and early spring (total amount divided into two equal part) of plots at six N levels: 0 (control), 30, 60, 90, 120 and 150 kg ha^{-1}.

Forage was harvested by cutting a 4 by 1 m area of each plot to a 3 cm stubble height when fodder peas reached full-bloom (first year, May 17; second year, May 21). Samples were weighed and the green fodder yield (t ha^{-1}) was calculated per hectare. After cutting, hay from all mixture plots was separated into fodder pea, fiddleneck and other species for analyzing the botanical composition (Sengul, 2003).

Samples (500 g herbage approximately) were put in an air circulation oven at 55 °C for 48 h and stored for one day at room temperature and weighed (Ates, 2012). Later, the dry matter (DM) yield (t ha^{-1}) was calculated. All dried samples were ground to small (<2 mm) pieces and used for the analyses.

The crude protein (CP) content (in DM, g kg^{-1}) was determined by the micro-Kjeldahl method. After plant samples were wet-fired with nitric-perchloric acid, P content (in DM, %) was determined spectrophotometrically. K, calcium (Ca) and magnesium (Mg) contents (in DM, %) were found using an atomic adsorption spectrophotometer.

The neutral detergent fibre (NDF, %) and acid detergent fibre (ADF, %) were determined following the procedures described by Romero et al. (2000). All samples were analysed in triplicate for CP, ADF, NDF and mineral contents. Variance tests were applied for statistical analysis. Whenever the interaction with years was not significant, means of two years for treatments were compared by the Duncan's Multiple Range Test. These results were analysed using the TARIST statistical program.

RESULTS AND DISCUSSION

The results of the analyses for the traits investigated are given in Tables 1 to 3. The different nitrogen doses and mixtures affected the botanical composition, green fodder and dry matter yields, crude protein, ADF, NDF, P, Ca, K and Mg contents. The botanical composition changed with increasing N doses in all treatments. Contrary to fodder pea, fiddleneck and other species dry weight ratios increased depending on the N doses. The highest change in both fodder pea and other plant species dry weight ratios were observed between control and plots which received 150 kg N ha^{-1}. N application reduced legume proportion (Kim et al., 2000) while P fertilizer increases legume proportion in vegetation (Henkin et al., 1998; Aydin and Uzun, 2005) and mixture. Factors affecting the response to fertilizer N include botanical composition, age of sward, seasonal distribution of fertilizer N, method of harvesting, frequency and height of defoliation, and whether removal is by grazing or by cutting (Hall and Vough, 2007). The decrease in fodder pea dry weight ratio because of N application was due to the higher utilization of the N fertilizers by fiddleneck and other plant species and their competitiveness ability compared to fodder pea.

The effects of N doses and mixture on CP, ADF and NDF contents, green fodder and dry matter yields were significant (Table 2). 150 kg N ha^{-1} application significantly increased CP, green fodder and dry matter yields compared to other doses. In fodder pea 50% + fiddleneck 50% mixture, maximum green fodder and dry matter yields were 49.57 t ha^{-1} and 13.04 t ha^{-1}, respectively, by applying 150 kg N ha^{-1}, which was followed by 45.93 t ha^{-1} and 12.24 t ha^{-1} by applying nitrogen at the rate of 90 kg ha^{-1}. Data regarding NDF (39.9%) and ADF (28.9%) ratios in fodder pea have lowest ratios by applying nitrogen at the 30 kg ha^{-1}, while in fiddleneck minimum CP ratios were 7.8-7.9% by applying nitrogen at the rates 0 and 30 kg ha^{-1}.

Hubbard (2011) stated that forage legumes insure good protein for ruminants. High-producing dairy cows need hay with at least 20% CP, less than 30% ADF, and less than 40% NDF. Forages with better CP, ADF, and NDF values are not necessarily better for milk production. When CP is less than 35%, much of the forage passes through the rumen without being absorbed, so it is essentially wasted (Redfearn et al., 2008). Ates et al. (2010) emphasized that the CP, ADF, NDF and acid detergent lignin (ADL) ratios ranged from 6.65 to 13.22%, 36.20-37.33%, 41.42-45.60% and 16.41-23.70% respectively, in fiddleneck at different growth stages. The CP content and fractionation varied depending on the forage crop species or varieties (Ates, 2012). An increase in yield, ADF, NDF and CP with nitrogen fertilizer was also reported by

Papastylianou (1990), Peyraud and Astigarraga (1998), Aydin and Uzun (2005), Hall and Vough (2007), Ayub et al. (2008) and Afzal et al. (2012) for forage crops and mixtures, their results being similar to the present findings.

Table 1. Botanical composition (g kg^{-1}) of fodder pea-fiddleneck mixture, pure pea and fiddleneck (mean of two years)

Nitrogen doses (kg ha^{-1})	Mixtures						
	50% Fiddleneck + 50% Fodder Pea			100% Fodder Pea		100% Fiddleneck	
	Fiddleneck	Pea	Other species[1]	Pea	Other species[1]	Fiddleneck	Other species[1]
0	485.2cd*	501.3a	13.5b	989.9a	10.1d	990.1a	9.9c
30	495.1c	494.7a	10.2c	990.2a	9.8d	988.7a	11.3c
60	502.7c	480.9b	16.4a	970.3b	29.7c	978.2b	21.8b
90	570.8b	420.2c	9.0c	965.3b	34.7c	979.2ab	20.8b
120	581.5b	401.1d	17.4a	920.7c	79.3b	950.2c	49.8a
150	655.3a	339.7e	5.0d	900.7d	99.3a	949.9c	50.1a

* Means in the same column followed by the same letter are not significantly different according to Duncan's Multiple Range test at 5% level.
[1]Other species: *Brassica nigra* L., *Poa annua* L., *Ranunculus* spp., *Taraxacum officinale* F.H. Wigg., *Lolium perenne* L., *Coriandrum sativum* L., *Carthamus tinctorius* L.

Table 2. Green fodder and dry matter yields, crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents of 50% fiddleneck-50% fodder pea mixture, pure fodder pea and fiddleneck (mean of two years)

	Nitrogen doses (kg ha^{-1})						
	Treatments	0	30	60	90	120	150
Green fodder yield (t ha^{-1})	50% F + 50% P**	30.33g*	35.33e	35.66d	45.93b	45.70bc	49.57a
	100% F	25.40h	30.23g	32.75fg	37.78cd	40.43c	46.73b
	100% P	30.12gh	31.15g	33.00f	35.11e	34.33f	35.44de
Dry matter yield (t ha^{-1})	50% F + 50% P**	7.54gh	9.05ef	9.62de	12.24b	11.72bc	13.04a
	100% F	7.05h	8.17f	8.23f	10.35c	10.13c	12.28b
	100% P	7.85g	8.11f	8.31f	9.33e	9.71d	9.47de
CP (%)***	50% F + 50% P**	12.4ef	12.7e	13.4d	14.3c	14.0c	14.4c
	100% F	7.8g	7.9g	8.1g	9.8f	9.9f	10.1f
	100% P	15.4b	15.5b	16.3ab	16.6a	16.4ab	16.7a
NDF (%)***	50% F + 50% P**	41.5de	41.2e	42.2de	44.4c	45.06bc	45.1bc
	100% F	45.4bc	44.8c	46.1b	46.7a	46.3a	46.8a
	100% P	40.7ef	39.9f	40.9ef	42.2de	42.7d	43.8cd
ADF (%)***	50% F + 50% P**	34.7ef	34.3f	34.9e	41.1ab	41.8a	41.0b
	100% F	37.7de	37.9de	38.0d	38.3d	38.7cd	39.2c
	100% P	29.4hi	28.9i	29.5hi	30.1h	31.0g	30.4h

- Means in the same column and each trait, followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 5% level.

**F: Fiddleneck, P: Fodder pea.
*** In dry matter.

Nitrogen application at the rates of 90 to 150 kg N ha^{-1} significantly increased Ca ratio over control (Table 3). The maximum K ratio was observed in fiddleneck (at 120 kg N ha^{-1}), while the P ratios were 0.55% and 0.56% with 90 kg N ha^{-1} and 150 kg N ha^{-1} applications,

respectively. Mg ratio was significantly lower in fiddleneck from plots not fertilized (control).

Anonymous (2001) reported that the requirement for major mineral nutrients for gestating beef cows or lactating beef cows is 0.6-0.8% (w/w) for K, 0.18-0.44% for Ca, 0.18-0.39% for P and 0.04-0.10% for Mg. The K, Ca and Mg levels in plants are usually in the range 1.39-2.50%, 0.77-3.00 % and 0.20-1.20%, respectively, which is adequate for plant growth (Essig, 1985; Acikgoz, 1994). The results were similar to those reported by these researchers.

Table 3. The calcium (Ca), phosphorus (P), magnesium (Mg) and potassium (K) contents in dry matter of 50% fiddleneck - 50% fodder pea mixture, pure fodder pea and fiddleneck (means of two years)

Contents	Nitrogen doses (kg ha^{-1})						
	Treatments	0	30	60	90	120	150
Ca (%)	50% F + 50% P**	1.24f	1.25ef	1.24f	1.26e	1.26e	1.27e
	100% F	0.79h	0.81gh	0.82g	0.82g	0.84g	0.83g
	100% P	1.60cd	1.62bc	1.59d	1.64a	1.64a	1.66a
P (%)	50% F + 50% P**	0.43cd	0.42d	0.43cd	0.44c	0.45c	0.47bc
	100% F	0.49b	0.52ab	0.52ab	0.55a	0.51ab	0.56a
	100% P	0.31ef	0.29f	0.28f	0.32e	0.32e	0.32e
Mg (%)	50% F + 50% P**	0.38cd	0.38cd	0.37d	0.39cd	0.41c	0.40c
	100% F	0.35e	0.37d	0.35e	0.37d	0.36d	0.37d
	100% P	0.46b	0.48a	0.48a	0.49a	0.48a	0.47ab
K (%)	50% F + 50% P**	1.88i	1.85j	1.91h	1.94gh	1.95g	1.95g
	100% F	2.27e	2.23f	2.31d	2.33c	2.41a	2.38b
	100% P	1.71m	1.68n	1.70mn	1.81l	1.81l	1.83k

*: Means in the same column and each element, followed by the same letter are not significantly different according to Duncan's Multiple Range Test at 1% level.
**F: Fiddleneck, P: Fodder pea.

CONCLUSION

According to the results, cultivation of a 50% fodder pea + 50% fiddleneck mixture for higher hay yield, for higher CP and mineral contents is recommended, and this mixture should be harvested at the full bloom stage of fodder pea. In addition, as one of the objectives of mixed cropping is to prevent lodging of the pea, we found that 150 kg N ha^{-1} application not successfully served this purpose. 90 and 120 kg N ha^{-1} applications are therefore recommended for green fodder and dry matter yields, mineral contents in the 50% fodder pea + 50% fiddleneck mixture and in fiddeleneck.

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