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Full Length Research Paper

Effects of the nitrogen and phosphorus fertilization on the yield and quality of the hairy vetch (*Vicia villosa* Roth.) and barley (*Hordeum vulgare* L.) mixture

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This study was intended to determine the effects of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and phosphorus rates (0, 30, 60, 90 and 120 kg P_2O_5 ha^{-1}) on dry matter yield, hairy vetch ratio, crude protein yield, acid detergent fiber (ADF), neutral detergent fiber (NDF) and total digestible nutrient (TDN) of hairy vetch-barley mixture (50:50) in Bursa-Turkey in 2009 to 2010 and 2010 to 2011 growing years. Dry matter and crude protein yields were affected by nitrogen rates, and the highest dry matter and crude protein yields were determined at 30 kg N ha^{-1}. Phosphorus rates significantly affected most of the components determined in this study. The highest values of dry matter and crude protein yields, hairy vetch ratio and TDN and the lowest value of ADF content were obtained at 30 kg P_2O_5 ha^{-1}. 30 kg N ha^{-1} and 30 kg P_2O_5 ha^{-1} may be recommended to be applied on hairy vetch-barley mixture in the similar experimental ecologies in order to produce economically high and quality forage product.

Key words: Hairy vetch, barley, mixture, nitrogen, phosphorus, dry matter yield, crude protein yield.

INTRODUCTION

Hairy vetch is an annual legume cultivated under rainfed conditions in the semi-arid regions of Mediterranean countries, integrated into the conventional cereal-fallow crop rotation system (Turk et al., 2009). Legume-grass mixtures increases not only forage yield, but also provide nursing and physical support for the companion legume (Soya, 1994). Thus, the potential benefits of legume-cereal mixtures over their monocultures might be due to their higher yield, protein and forage quality, yield stability and reduced incidence of pests, weeds, and diseases (Carr et al., 1998). Intercropping of vetch with barley grown for forage and grain may improve forage quality and yield.

Many researches have showed that vetch-barley mixture exhibited greater production than respective sole vetch or barley (Bugdaycıgil et al., 1996; Yılmaz et al., 1996; Dhima et al., 2007; Lithourgidis et al., 2007; Bayram et al., 2009; Ansar et al., 2010). Bingol et al. (2007) found that all of the mixtures of vetch with barley had significantly higher digestible dry matter and crude protein yield. Intercropping barley with common vetch improved forage quality and increased protein yield of barley without reducing dry matter yield (Thompson et al., 1992). On the other hand, there is no enough study evaluating the effects of nitrogen and phosphorus fertilization on dry matter yield and forage quality of vetch-barley mixture. However, this matter requires investigation scientifically and the presentation of the findings to the services of growers.

The objective of this study was to determine the effects of different rates of nitrogen and phosphorus fertilization on the dry matter yield, hairy vetch ratio, crude protein yield, acid detergent fiber (ADF), neutral detergent fiber (NDF) and total digestible nutrient (TDN) of hairy vetch-barley mixture.

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Abbreviations: ADF, Acid detergent fiber; **NDF,** neutral detergent fiber; **TDN,** total digestible nutrient.

MATERIALS AND METHODS

Field trials were conducted during 2009 to 2010 and 2010 to 2011

Table 1. Monthly precipitation and temperature in 2009 to 2010, 2010 to 2011 and in long years (1975-2008) in Bursa.

Month	Monthly precipitation (mm)			Monthly Temperature (°C)		
	Long years	2009-2010	2010-2011	Long years	2009-2010	2010-2011
November	85.4	80.6	24.0	10.3	10.1	15.5
December	96.4	119.1	152.6	7.1	9.5	9.8
January	80.3	149.7	72.4	5.4	7.0	5.6
February	66.2	178.9	18.4	5.9	9.3	6.0
March	62.7	115.3	67.4	8.5	9.0	8.3
April	65.2	63.4	76.8	13.0	13.4	10.5
May	43.4	29.4	27.3	17.7	19.2	16.7
Total	499.6	736.4	438.9	-	-	-
Mean	-	-	-	9.7	11.1	10.3

growing seasons on clay loam soil at the Agricultural Research and Experiment Center of Uludag University, Bursa (40° 11′ N, 29° 04′ E). Soil test values indicated a pH of 7, with none saline, low values in lime and organic matter and rich in potassium. Precipitation distribution and amount differed markedly between experimental years (Table 1). Total precipitation in 2009 to 2010 growing period was 236.8 mm over long years. These higher precipitation occurred in December, January, February and March. Precipitation in the second year was 60.7 mm less than that of the long years mean (Table 1). There were almost no differences between mean temperatures of the experimental and long years.

Hairy vetch cv. Selcuklu 2002 and barley cv. Akhisar-98 were used as plant entries. Ammonium nitrate (34%) was used as nitrogen source and four levels (0, 30, 60 and 90 kg ha^{-1}) were applied. The second factor of the experiment was phosphorus and was applied as triple super phosphate (42 to 44% P_2O_5) with 0, 30, 60, 90 and 120 kg ha^{-1} rates. Fertilizers were incorporated into the soil by hand broadcasting. Fertilizer applications were done at sowing. Fertilizer treatments were arranged randomly in complete block experiment design with three replications. Plot size was 1.2 × 4 m = 4.8 m^2 and in each plot, six rows were formed. Row spacing among rows was 20 cm.

In the mixtures, seeds of species were blended before sowing and then sown in the same rows. Seeding rates for the pure stands were 80 and 200 kg ha^{-1} for hairy vetch and barley, respectively. The ratio between hairy vetch and barley was 50:50 in the mixture and the seed rate of each species in the mixture was determined by multiplying pure seed rate and proportion of each species. The ratio 50:50 between hairy vetch and barley, and harvesting time at 50% flowering stage used in this study was determined in a previous research (Bayram et al., 2009). Sowing was done by hand on November in 2009 and 2010, respectively.

Furthermore, stands were harvested when hairy vetch reached 50% flowering stage. After harvest, fresh forage samples from plots were randomly taken and put into cotton bags. They were oven-dried at 78°C for 48 h and weighed, then dry weight percentages were calculated. Dry matter yield of each plot was calculated by multiplying the fresh weight of each plot with its dry weight percentages. The contribution of hairy vetch to the dry matter yield in a mixture of each fertilizer treatment plot was determined as percentage. Also, 1 g ground sample was used for the total nitrogen determination by Kjedahl method, while 0.5 g was used for ADF and NDF. ADF and NDF were analyzed by sequential detergent analysis method (Goering and Van Soest, 1970). Crude protein yield was calculated by multiplying dry matter yield of each plot with its crude protein content and converted to yield per hectare.

The components studied in this research were dry matter yield, hairy vetch ratio, crude protein yield, ADF, NDF and TDN. Variance analysis were conducted over two-year data of components by using randomized complete block experimental design, and 1 and 5 % were used for significance levels. LSD of 5% was used to determine the different groups of fertilizer treatments when variance analyses of a component was found significant. All calculations were made by using MINITAB and MSTAT-C programs.

RESULTS AND DISCUSSION

Data averaged over two years and subjected to variance analysis (ANOVA) are given in Table 2. Results of ANOVA indicated that the effects of nitrogen rates were of significance only on dry matter and crude protein yields, but the effects of phosphorus rates were determined on most components. In addition, the effects of interaction between nitrogen and phosphorus on hairy veth ratio was observed significant (Table 2). The effects of nitrogen rates on dry matter yields were significant ($p < 0.05$) and 30 kg N ha^{-1} rate produced the highest dry matter yield (10779 kg ha^{-1}), while the lowest dry matter yields (8439 and 8794 kg ha^{-1}) were produced by plots untreated or treated with 90 kg N ha^{-1} (Table 2).

Numerous workers have determined different nitrogen rates for maximum dry matter yield in common vetch-barley or hairy vetch- barley mixture (Cimrin et al., 2001; Karaca and Cimrin, 2002; Mohsenabadi et al., 2008). These are natural results due to the different ecologies, cultivars of vetch and barley, and mixture rates. Nitrogen rates had no effects on hairy vetch ratios and they ranged from 43.36 to 46.95% (Table 2). Similar results were reported by Karaca and Cimrin (2002).

However, reverse results were reported by some other workers (Cimrin et al., 2001). The response of crude protein yield to nitrogen fertilization was statistically significant ($p < 0.01$). All rates of nitrogen increased crude protein yield but there were no differences among their effects (Table 2). Mohsenabadi et al. (2008) reported that nitrogen fertilizer increased the crude protein yield of vetch-barley mixture. The values of ADF, NDF and TDN unaffected by nitrogen rates ranged from 33.73 to 35.39%, 49.60 to 58.32% and 61.34 to 62.62%, respectively (Table 2).

The effects of phosphorus rates on dry matter yields

Table 2. Effects of nitrogen and phosphorus rates on dry matter yield (kg ha^{-1}), hairy vetch ratio (%), crude protein yield (kg ha^{-1}), ADF (%), NDF (%) and TDN (%) of hairy vetch-barley mixture (mean of two years).

Nitrogen Rate (kg ha^{-1})	Dry matter yield (kg ha^{-1})	Hairy vetch ratio (%)	Crude protein yield (kg ha^{-1})	ADF (%)	NDF (%)	TDN (%)
0	8439^{b}	46.95	925.4^{b}	33.73	49.60	62.62
30	10779^{a}	45.43	1342.3^{a}	34.05	54.25	62.38
60	9915^{ab}	46.60	1215.3^{a}	35.10	51.60	61.56
90	8794^{b}	43.36	1249.7^{a}	35.39	58.32	61.34
Phosphorus rate (kg ha^{-1})						
0	8429^{d}	55.94^{c}	946.4^{c}	35.26^{abc}	57.91	61.43^{abc}
30	11256^{a}	70.81^{a}	1613.2^{a}	31.74^{c}	52.56	64.18^{a}
60	10140^{b}	61.94^{bc}	1323.4^{b}	39.88^{a}	53.40	57.84^{c}
90	9199^{c}	64.53^{ab}	1381.0^{ab}	38.76^{ab}	55.65	58.71^{bc}
120	9239^{c}	65.90^{ab}	1362.5^{ab}	33.36^{bc}	53.91	62.92^{ab}
Years (Y)	ns	*	ns	ns	ns	ns
Nitrogen (N)	*	ns	**	ns	ns	ns
Phosphorus (P)	**	**	**	*	ns	*
Y × N	ns	ns	ns	*	ns	ns
Y × P	ns	*	ns	ns	ns	ns
N × P	ns	*	ns	ns	ns	ns
Y × N × P	ns	ns	ns	ns	ns	ns

Means of the same column followed by the same letter were not significantly different at the 0.05 level using LSD test. *, **: F-test significant at p ≤/0.05, and p ≤/0.01, respectively; ns,not significant; ADF, acid detergent fiber; NDF, neutral detergent fiber; TDN, total digestible nutrient.

were significant ($p < 0.01$) and the highest dry matter yield (11256 kg ha^{-1}) was obtained at 30 kg P_2O_5 ha^{-1}, while the lowest dry matter yield (8429 kg ha^{-1}) was obtained at 0 kg P_2O_5 ha^{-1}. As the rates of phosphorus increased, the dry matter yields decreased (Table 2). Cimrin et al. (2001) reported that phosphorus fertilizer significantly increased dry matter yield and they found the highest dry matter yield at 80 and 120 kg P_2O_5 ha^{-1} levels. However, some researchers reported that phosphorus rate had no effect on dry matter yield of vetch-barley mixture (Karaca and Cimrin, 2002). Phosphorus rates increased hairy vetch ratio in the mixture significantly, but the highest ratio was obtained at 30 kg P_2O_5 ha^{-1} (Table 2). Phosphorus application also affected crude protein yields of sowings. The lowest crude protein yield was obtained at the untreated plots and the highest was at 30 kg P_2O_5 ha^{-1} treated plots (Table 2). Similar results were reported by Cimrin et al. (2001) and Karaca and Cimrin (2002).

Moreover, the ADF content of the mixture changed significantly with the phosphorus rates. However, the effects of rates were not of consistent rule. The lowest ADF content (31.74%) was obtained at 30 kg P_2O_5 ha^{-1} treatment, and the other rates yielded forages that contained higher than or equal to those of the untreated plots (Table 2). In this study, phosphorus rates had no effect on NDF contents and ranged from 52.56 to 57.91% (Table 2). Meanwhile, TDN values were affected by phosphorus fertilizer applications but there were no regulated rules seen about the effects of fertilizer rates. The lowest and the highest TDN were observed at 60 and 30 kg P_2O_5 ha^{-1} rates, respectively, and the values of other rates took place between the highest and the lowest TDN values (Table 2).

Conclusıons

This study was conducted under rainfed conditions of Southern Marmara Region in order to determine the nitrogen and phosphorus needs of hairy vetch and barley mixtures sown at 50:50 mixed ratio. For this purpose, 0, 30, 60 and 90 kg ha^{-1} rates of pure nitrogen and 0, 30, 60, 90 and 120 kg ha^{-1} rates of pure phosphorus were used. Dry matter yield and some quality parameters of the mixtures were measured and the average values of two-year experiment were evaluated and discussed. The results extracted from the study were as follows:

(a) Nitrogen fertilization exhibited its effects only on dry matter and crude protein yields,
(b) The dry matter yield at 30 kg N ha^{-1} rate was the highest, followed by 60 kg N ha^{-1} rate. The 90 kg N ha^{-1} rate made no difference from unfertilized plots,
(c) The effects of nitrogen rates on crude protein yield were same but higher than that of unfertilized plants,

(d) Phosphorus fertilization did affect all parameters but NDF contents,
(e) Dry matter yields at all phoshorus rates were higher than that of unfertilized plants, and the 30 kg P_2O_5 ha^{-1} rate produced the highest yield followed by 60 kg P_2O_5 ha^{-1} rate,
(f) Hairy vetch ratio was the lowest level at unfertilized plots, and the highest at 30 kg P_2O_5 ha^{-1} rate, (g) Appearances of the effects of phosphorus fertilization on crude protein yields were very similar to those on hairy vetch ratios. Plots not treated with phosphorus produced less dry matter yield than plots treated with different phosphorus rates. The highest crude protein yield was obtained at 30 kg P_2O_5 ha^{-1} rate,
(h) 30 kg P_2O_5 ha^{-1} rate produced forage lower in ADF and higher in TDN, but 60 kg P_2O_5 ha^{-1} rate produced forage completely different than that of 30 kg P_2O_5 ha^{-1} rate.

Depending on the two-year results, 30 kg ha^{-1} rates of nitrogen and phosphorus may be recommended to be applied on hairy vetch-barley mixture blended at 50:50 ratio and grown under the Southern Marmara Region in order to produce economically higher and quality forage product.

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