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RELATIONSHIPS BETWEEN FORAGE YIELD AND CHARACTERS IN SOME NARBONNE VETCH (*VICIA NARBONENSIS* L.) CULTIVARS SOWN IN EARLY SPRING AT SUBTROPICAL CONDITIONS

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Abstract
The aim of this research was to determine relationships among forage yield and its some characters in Narbonne vetch cultivars sown in early spring at subtropical conditions. This investigation was conducted between 2016-2018 years at Tekirdağ Namık Kemal University, Faculty of Agriculture, Field Crops Department Research and Experimental Area in randomized complete block design with three replications. Three Narbonne vetch (Bozdağ, Dikili and Özgen) cultivars were used. The plant height, number of branches per plant, stem diameter, number of leaves per plant were determined in ten plants. The plant height, number of branches per plant, stem diameter, number of leaves per plant, herbage and hay yields ranged from 40.75-43.09 cm, 1.67-2.72, 5.70-6.57 mm, 10.27-13.73 t ha^{-1} and 2.28-2.89 t ha^{-1}, respectively, in Narbonne vetch cultivars. A statistically significant and positive relationships were determined between herbage yield and hay yield, between stem diameter and herbage yield and between stem diameter and hay yield. The correlation coefficients analysis showed that the strongest effective trait on herbage yield in Narbonne vetch was the stem diameter. Stem diameter trait can be considered as the primary selection criteria for improving herbage yield in Narbonne vetch at early spring sowing in similar ecological conditions

Keywords: correlation coefficient, herbage yield, Narbonne vetch, path coefficient, Vicia narbonensis L.

1. INTRODUCTION

Vetches (*Vicia* sp.) are important source of protein, minerals, vitamins, flavonoids, etc. and have a major role in ruminant and non-ruminant animal nutrition (Orak et al., 2004). In 2018, global yield of vetches was 172 79 hg ha^{-1}. That year, 540 762 hectares were devoted cultivation of vetches in the world (FAOSTAT 2018). Narbonne vetch (*V. narbonensis* L.) ranks among the most important vetch species worldwide. Narbonne vetch center of origin is likely to be North-West Asia where the highest diversity of Narbonne vetch can be found (Maxted et al., 1991; Enneking and Maxted, 1995). The species is recognized as an invaluable crop in Turkey where it has been noted to be bruchid (*Coleoptera-Bruchidae)* tolerant and to survive temperatures of -30 ºC (Elçi, 1975; Birch et al., 1985). By contrast, in Italy, it is known to be susceptible to cold winters, Mateo-Box (1961) and Enneking and Maxted (1995) reported that the plant is able to withstand cold conditions in dry soils, but is adversely affected in the presence of too much moisture. Above ground parts of the plant may die off in cold winters, but in spring regrowth from the undamaged root system occurs (Mateo-Box, 1961). There may be different ecotypes with varying degrees of cold tolerance. This could also

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depend on other environmental factors, such as nutrient status and degree of acclimatization (Enneking and Maxted, 1995).
During the 19th century cultivated and wild varieties of Narbonne vetch are distinguished in the agricultural literature. The utilization of Narbonne vetch was similar to that of common vetch (*V. sativa* L.), but for favorable development it was known to demand more warmth, giving in exchange more pods and herbage. The plant was also known as an escapee from cultivation, indicating its potential to naturalize (Enneking and Maxted, 1995). Nowadays, it is cultivated in the Mediterranean, Middle East, North Africa and Middle and South Europe for grain or forage crop and green manure (Ateş, 2014). Therefore, advances in Narbonne vetch breeding may greatly contribute to the worlds forage supply.
Vetch breeders are expected to produce improved genotypes that give high yields of high quality herbage and grain. Environmental and genetic factors have been affected the forage and seed yield and quality traits of vetches. Therefore, genetic variation among traits is important for breeding and in selecting desirable types. A wide variety of morphological characteristics have been examined in vetches germplasm collections for their possible use in the improvement of the high quality forage and seed yield of vetches. Expression of different characteristics of often changed as the changing breeding material and environment. That's why, the information of characters associations between the traits themselves and with the traits themselves and with the forage yield is important for the breeding material subjected to selection for the high forage and seed yielding vetch genotypes. However, correlation coefficient analyses measures the magnitude of relationship between different morphological properties and determines the component character on which selection can be based for improvement in forage and seed yield. The simple correlation coefficients between yield and its components may not give satisfactory results. Moreover, in practice, selection criteria will contribute to selection based on direct effects. Path coefficient analyses have been used to evaluate selection criteria in several crops. This technique is useful in determining the direct influence of one variable on another, and also separates the correlation coefficient into its components of direct and indirect effects (Rodriguez et al., 2001; Yücel, 2004; Arslan, 2007).
The objective of this study was to determine relationships among forage yield and its some characters in Narbonne vetch cultivars sown in early spring at subtropical conditions.

2. MATERIALS AND METHODS

This investigation was conducted between 2016-2018 years at Tekirdağ Namık Kemal University, Faculty of Agriculture, Field Crops Department Research and Experimental Area in randomized complete block design with three replications. The soil of the experimental area was clayey with 7.50 pH, low in organic matter (1.50 %), poor in available nitrogen (0.12 %), phosphorus (19.80 kg ha^{-1}) and lime (0.60 %), rich in potassium (706.30 kg ha^{-1}). The monthly total rainfalls were 154.4 mm in 2016, 148.7 mm in 2017 and 229.6 mm 2018 respectively and it was 186.1 mm in long term (1940-2018). The monthly average temperatures were 13.4, 10.8 and 12.4 °C in experimental years (2016, 2017 and 2018) and 10.3 °C in long term. The monthly relative humidity averages were 78.7 %, 79.6% and 81.9 % and were similar to long term (79.8 %).
Three Narbonne vetch cultivars (Bozdağ, Dikili and Özgen) were used. The seeds were sown to 5 m long with 0.25 m spacing 6 rows with 150 kg ha^{-1} (Tekeli and Ateş, 2011) at early spring (15.02.2016, 20.02.2017 and 20.02.2018). Before sowing 40 kg ha^{-1} nitrogen and phosphorus fertilizers were applied. The plant height (cm), number of branches per plant, stem diameter (mm), number of leaves per plant were determined on ten plants, which were randomly chosen from all

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plots at full bloom stage (Ates, 2011). Stem diameter was measured between the third and fourth node. To determine the herbage yield (t ha^{-1}) harvests were made at full-bloom stage from 2.5 m^2 (first year: 01.06.2016, second year: 29.05.2017 and last year: 25.05.2018). Herbage samples were subjected to two turnings, the first one at 24 hours and the second 48 hours after it was spread on the field for drying. Then, approximately 500 g samples for each cultivars were stored for one day at room temperature and hay yield (t ha^{-1}) was calculated. The results of the study were analyzed with TARIST statistical programmer for determine the relationships and path coefficients of the means from the three years. Direct and indirect effects of traits were analyzed using path coefficient analysis as described by Dewey and Lu (1959), Rodriguez et al., (2001), Yücel (2004) and Sayar (2014). Herbage yield was considered be the dependent variable and the other properties were considered to be independent variables for the path coefficient analysis.

3. RESULTS AND DISCUSSIONS

The results for the herbage and dry matter yield and its some characteristics are given in Table 1. The plant height, number of branches per plant, stem diameter, number of leaves per plant, herbage and hay yields ranged from 40.75-43.09 cm, 1.67-2.72, 5.70-6.57 mm, 10.27-13.73 t ha^{-1} and 2.28-2.89 t ha^{-1}, respectively, in Narbonne vetch cultivars. Nizam et al., (2011) and Sayar and Han (2014) emphasized that plant height of Narbonne vetch genotypes varied from 43.02-78.85 cm and 67.5-76.1 cm, respectively. Stem diameter decrease of the digestibility and protein content of the forage, and leads to a resultant decrease in forage quality (Ball et al., 2001; Tan et al., 2013). Büyükburç et al., (1994); Anlarsal (1996); Cecen et al., (2005); Yılmaz (2008); Rahmati et al., (2012) and Seydoşoğlu et al., (2014) reported that the herbage yield varied from 20.02 to 37.95 t ha^{-1} in Narbonne vetch. Our findings are similar with previous reports of these characters.

Table 1. Some morphological characters, herbage and hay yields

Characters	Minimum	Maximum	Mean±SE	CV %
Plant height (cm)	40.75	43.09	42.10±0.26	1.89
Branches/plant	1.67	2.72	2.24±0.12	15.64
Stem diameter (mm)	5.70	6.57	6.06±0.09	4.37
Leaves/plant	20.78	28.83	24.68±1.02	12.36
Herbage yield (t ha^{-1})	10.27	13.73	12.01±0.40	9.97
Hay yield (t ha^{-1})	2.28	2.89	2.55±0.08	9.06

The simple correlation coefficients were given in Table 2. There was a statistically significant and positive relationships were determined between herbage yield and hay yield (r= 0.939**), between stem diameter and herbage yield (r= 0.688*) and between stem diameter and hay yield (r= 0.797*). Forage yield, its affecting components and relationships among traits of some forage pea *(Pisum arvense* L.*)* genotypes in Hazro ecological conditions investigated by Sayar et al., (2011), they found that the similar correlations between herbage yield and the same traits for field pea (*Pisum arvense* L.) varieties. Sayar and Han (2014) reported that the relationships between herbage yield and dry matter yield statistically significant and positive (r= 0.725**), however main stem diameter and herbage yield (r= 0.077), main stem diameter and dry matter yield (r= 0.002) statistically not significant and positive in Narbonne vetch. By contrast with our results, Sayar (2014) found that the relationship between main stem diameter and herbage yield (r= -0.162*), main stem diameter and dry matter yield (r= -0.164*) statistically significant and negative in common vetch.

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Table 2. Correlation coefficients of Narbonne vetch cultivars between forage yield and its characters

	PH	NB	SD	NL	HY	HayY
PH	1.000					
NB	-0.071ns	1.000				
SD	0.204ns	0.621ns	1.000			
NL	-0.310ns	-0.047ns	-0.226ns	1.000		
HY	-0.195ns	0.254ns	0.688*	-0.326ns	1.000	
HayY	-0.169ns	0.429ns	0.797*	-0.105ns	0.939**	1.000

PH: Plant height, NB: Number of branches per plant, SD: Stem diameter, NL: Number of leaves per plant, HY: Herbage yield, HayY: Hay yield, ns: Not significant, *: $P<0.05$; **$P<0.01$

The relationships between plant height and stem diameter (r= 0.204), number of branches per plant and stem diameter (r= 0.621), number of branches per plant and herbage yield (r= 0.254), number of branches per plant and hay yield (r= 0.429) were obtained positive and not significant. The relationships between plant height and number of branches per plant (r= -0.071), number of leaves per plant (r= -0.310), herbage yield (r= -0.195), hay yield (r= -0.169) were found statistically not significant and negative. Besides, the relationships between number of branches per plant and number of leaves per plant (r= -0.047), stem diameter and number of leaves per plant (r= -0.226), number of leaves per plant and herbage yield (r= -0.326), number of leaves per plant and hay yield (r= -0.105) were determined statistically not significant and negative. Not similar result was reported by Sayar et al., (2012). They reported that the relationship between main stem diameter and herbage yield negative and not significant for Hungarian vetch (*V. pannonica* Crantz.).

In order to get a clear picture of the interrelationships between different traits, the direct and indirect effects of different traits were worked out using path coefficient analyses in respect of the herbage yield (Singh et al., 2004). The results of path analyses are given Table 3. The direct effect of plant height on herbage yield was negative with a path coefficient of -0.1182 and a contribution of 30.38 %. Besides, the indirect effect of plant height on herbage yield via stem diameter (-0.0066, 1.72 %) and hay yield (-0.1671, 42.93 %) were negative too. On the other hand, the indirect effect of plant height on herbage yield via number of branches (0.0122, 3.12 %) and number of leaves (0.0851, 21.82 %) were positive. The direct effect of number of branches on herbage yield was negative (-0.1718, 26.92 %) accordance with indirect effect via stem diameter (-0.0202, 3.16 %). The indirect effect of number of branches on herbage yield via plant height (0.0084, 1.31 %), number of leaves (0.0128, 2.01 %) and hay yield (0.4251, 66.60 %) were positive. The stem diameter was effected herbage yield directly negative (-0.0325, 3.20 %). The indirect effect of the stem diameter on herbage yield via number of branches was negative (-0.1066, 10.51%). However, its effect on herbage yield via plant height (0.0241, 2.38 %), number of leaves (0.0621, 6.12 %) and hay yield (0.7889, 77.79 %) were positive. The direct effect of number of leaves on herbage yield (-0.2746, 63.82 %) and in direct effect via hay yield (-0.1037, 24.09 %). But, the indirect effect of number of leaves on herbage yield via plant height (0.0366, 8.52 %), number of branches (0.0080, 1.87 %) and stem diameter (0.0073, 1.71 %) were positive. The direct effect of hay yield on herbage yield was positive (0.9903, 86.97 %). While the indirect effect of hay yield on herbage yield via plant height (0.0200, 1.75 %) and number of leaves (0.0287, 2.52 %) were positive, the indirect effect via number of branches (-0.0738, 6.48 %) and stem diameter (-0.0259, 2.27 %) were negative.

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Table 3. The direct and indirect effects on herbage yield of its characters in Narbonne vetch cultivars

PH vs HY	r= -0.195ns		NB vs HY	r= 0.254ns	
Direct effect	-0.1182	30.38 %	Direct effect	-0.1718	26.92 %
Indirect effect via NB	0.0122	3.12 %	Indirect effect via PH	0.0084	1.31 %
Indirect effect via SD	-0.0066	1.72 %	Indirect effect via SD	-0.0202	3.16 %
Indirect effect via NL	0.0851	21.82 %	Indirect effect via NL	0.0128	2.01 %
Indirect effect via HayY	-0.1671	42.93 %	Indirect effect via HayY	0.4251	66.60 %
SD vs HY	**r= 0.688***		**NL vs HY**	**r= -0.326ns**	
Direct effect	-0.0325	3.20 %	Direct effect	-0.2746	63.82 %
Indirect effect via PH	0.0241	2.38 %	Indirect effect via PH	0.0366	8.52 %
Indirect effect via NB	-0.1066	10.51 %	Indirect effect via NB	0.0080	1.87 %
Indirect effect via NL	0.0621	6.12 %	Indirect effect via SD	0.0073	1.71 %
Indirect effect via HayY	0.7889	77.79 %	Indirect effect via HayY	-0.1037	24.09 %
HayY vs HY	**r= 0.939****				
Direct effect	0.9903	86.97 %			
Indirect effect via PH	0.0200	1.75 %			
Indirect effect via NB	-0.0738	6.48 %			
Indirect effect via SD	-0.0259	2.27 %			
Indirect effect via NL	0.0287	2.52 %			

PH: Plant height, NB: Number of branches per plant, SD: Stem diameter, NL: Number of leaves per plant, HY: Herbage yield, HayY: Hay yield, ns: Not significant, *: P<0.05; **P<0.01

Singh and Chaudhary (1977) reported that if the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be reason of correlation. In such situations, the indirect causal factors must be considered simultaneously. Explanation of the relationships between seed yield and some morphological traits in smooth bromegrass (*Bromus inermis* Leyss.) by path analysis studied by Seker and Serin (2004), they determined that the significant correlation between yield and most of the yield components, only few traits had strong direct effect on forage yield. Sayar (2014) found that the strongest effective traits on fresh forage yield in common vetch genotypes were respectively dry matter yield and main stem height. He reported that the dry matter yield and main stem height traits should be considered as the primary selection criteria for improving forage yield in common vetch. The present results were not similar to those reported by these researchers.

4. CONCLUSIONS

The correlation coefficient analyses measures the magnitude of relationship between various morphological traits and determines the component characteristics on which selection can be based for improvement in herbage yield of Narbonne vetch. Nevertheless, path analyses help to determine the direct effect of properties and their indirect effects on herbage yield. Simple correlation coefficients analysis showed that the strongest effective trait on herbage yield in Narbonne vetch was the stem diameter. Consequently; stem diameter trait can be considered as the primary selection criteria for improving herbage yield in Narbonne vetch at early spring sowing in similar subtropical conditions.

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