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Forage and seed yield, relationships among its characters in some grass pea (*Lathyrus sativus* L.) genotypes

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Abstract: The aim of this investigation was to determine the forage and seed yield, relationships among its characters in some grass pea genotypes. This study was conducted between 2017-2020 at Field Crops Department, Agriculture Faculty, Tekirdağ Namık Kemal University, Turkey in randomized block design with three replications. The characters which were determined in the study varied between; plant height 85.75-103.60 cm, number of branches/plant 5.40-6.42 pcs, number of pods/plant 19.12-27.66 pcs, pod width 9.57-11.60 mm, pod length 31.65-36.70 mm, number of seeds/pod 2.86-3.44 pcs, seed weight/pod 1.74-2.26 g, 1000-seed weight 218.88-260.26 g, seed yield 160.22-270.83 kg da^{-1}, herbage yield 1462.22-2226.67 kg da^{-1} and hay yield 564.18-373.74 kg da^{-1}. The highest plant height, number of branches/plant, number of pods/plant and seed yield were determined in genotype 'Karadağ'; however, the highest number of seeds/pod, herbage and hay yield were found in grass pea population 'Tekirdağ'.

Keywords: Correlation, forage yield, grass pea, hay yield, seed yield.

Bazı Mürdümük (*Lathyrus sativus* L.) Genotiplerinin Ot ve Tane Verimleri ile Bunlara Etkili Karakter Arasındaki İlişkiler

Öz: Araştırma, bazı mürdümük genotiplerinin yem ve tohum verimleri ile bunlara etkili karakterler arasındaki ilişkilerin belirlenmesi amacı ile Tekirdağ Namık Kemal Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü, Araştırma ve Uygulama Alanı'nda tesadüf blokları deneme deseninde 3 tekrarlamalı olarak 2017-2020 yılları arasında üç yıl süre ile yürütülmüştür. Çalışmada; bitki boyu 85.75-103.60 cm, bitkide dal sayısı 5.40-6.42 adet, bitkide meyve sayısı 19.12-27.66 adet, meyve eni 9.57-11.60 mm, meyve boyu 31.65-36.70 mm, meyvede tane sayısı 2.86-3.44 adet, meyvede tane ağırlığı 1.74-2.26 g, 1000 tane ağırlığı 218.88-260.26 g, tane verimi 160.22-270.83 kg da^{-1}, yeşil ot verimi 1462.22-2226.67 kg da^{-1} ve kuru ot verimi 564.18-373.74 kg da^{-1} arasında değişmiştir. Bitki boyu, yan dal sayısı, bitkide meyve sayısı ve tane verimi en fazla Karadağ genotipinde; meyvede tane sayısı, yeşil ve kuru ot verimleri ise Tekirdağ populasyonunda en yüksek belirlenmiştir.

Anahtar Kelimeler: Korelasyon, kuru ot verimi, mürdümük, tane verimi, yeşil ot verimi.

1. Introduction

Lathyrus L. is a genus of legumes family (*Fabaceae* L.), located in the *Vicieae* tribe, distributed in 15 parts and has 187 taxa (Allkin et al. 1983). Davis (1970) determined that 54 species of *Lathyrus* in flora of European and 58 species of *Lathyrus* in flora of Turkey. The species in the *Lathyrus* L. genus are used for different purpose. Only a few species are economically important as food and forage (Campbell 1997). Milczak et al. (2001) stated that, it is a major crop in parts of Asia and to a lesser extent in the Middle East, and in northern Africa. *Lathyrus* species being grown in almost every region of the Turkey, especially east and southern east part.

Grass pea (*L. sativus* L.), which is resistant to drought and excessive rainfall (Campbell et al. 1994; Hanbury et al. 1995), cannot grow in places where the temperature drops to -7 °C and the annual rainfall is below 250 mm (Tekeli and Ates, 2011). It is used as fodder (herbage, hay and grain), grazing, green manure and food (Karadağ et al. 2004; Tekeli and Ates, 2011). Grass pea seeds has up to 35% protein (Williams et al. 1994) on the contrary there are some substances in its species that have negative effects on nutrition as in many other legume species. The

most important of these items is ODAP (ß-NoxalylL-α, ß-diaminopropionic acid) the amount of which varies according to the genotype, abiotic and biotic stress conditions. One of the most common negative effects of ODAP is that it affects the central nervous system and causes permanent paralysis in the hind legs of humans and animals (Lathyrism) (Chowdhury, 1988; Urga et al. 1995). Gençkan (1983), Ergül (1988), Chowdhury (1988) and Gül et al. (2006) emphasized that the lathyrism is seen when colored grass pea seeds are consumed, but when white colored grass pea seeds are consumed the disease is not seen, and that the harmful effect is eliminated by boiling the colored seeds, in addition, it should be given to animals in a small amount and with accustoming. In the breeding studies to be carried out, increasing the forage and seed yield of grass pea, which has a high protein rate, with local genetic resources, as well as reducing the ODAP content that causes lathyrism are among the main objectives.

The aim of this research was to determine the forage and seed yield, relationships among its characters in some grass pea genotypes under Tekirdağ ecological conditions, Turkey.

2. Materials and Methods

This study was conducted between 2017-2020 at Tekirdağ Namık Kemal University, Agriculture Faculty, Field Crops Department, Research and Experimental Area in randomized block design with three replications. Four grass pea genotypes (cv. Gürbüz, cv. Karadağ, Tekirdağ and Diyarbakır populations) were used in the experiments. Climatic parameters and soil properties belonging to experimental area are given in Tables 1 and 2. The seeds were sown at a rate of 15 kg da^{-1} on 14.11.2017, 02.11.2018 and 13.11.2019. The plots consist of four rows of 5 m length with 25 cm row spacing. The area was cultivated before the sowing and basal fertilizer containing N and P (40 kg ha^{-1}) was incorporated into the soil. Weed control was done by hand. To determine the forage yield harvest was made at full-bloom stage of grass pea on 02.05.2018, 21.05.2019, 08.05.2020 and to determine the seed yield at physiological maturity stage on 02.07.2018, 08.07.2019, 29.07.2020. The morphological characters were determined in five plants, which were chosen from plots randomly. Plant height (cm), number of branches/plant (pcs), number of pods/plant (pcs), pod width (mm), pod length (mm), number of seeds/pod (pcs/pod), seed weight/pod (g), 1000-seed weight (g), seed yield (kg da^{-1}), herbage yield (kg da^{-1}), hay yield (kg da^{-1}) were described by Tenikecier et al. (2017) and TTSM (2001).

The means of three years results were analyzed with the TARIST statistical computer package (Açıkgöz et al. 1994). Mstat-C programmer was used for the comparison test (Fisher's Least Significant Difference, LSD) of the means (Düzgüneş et al. 1987).

Table 1. Climate Conditions of Experimental Area (2017-2020 and long term)
Çizelge 1. *Deneme alanına ait iklim verileri (2017-2020 ve Uzun yıllar)*

Months	Avarage Temprature (°C)				Monthly Total Precipitation (mm)				Relative Humudity (%)			
	2017 / 2018	2018 / 2019	2019 / 2020	Long Term	2017 / 2018	2018 / 2019	2019 / 2020	Long Term	2017 / 2018	2018 / 2019	2019 / 2020	Long Term
November	11.7	14.8	15.5	11.2	67.2	45.2	18.4	74.4	83.1	76.6	75.7	82.0
December	9.6	9.4	9.2	7.1	52.8	113.8	17.3	81.2	80.7	76.3	75.2	82.6
January	6.6	5.6	5.8	4.8	67.6	58.7	29.1	68.8	85.6	76.3	71.5	82.7
February	7.3	5.8	7.9	5.4	93.7	40.3	54.2	54.5	86.1	74.3	73.4	80.7
March	9.8	9.3	9.6	7.3	78.7	29.1	23.6	54.4	85.8	70.8	74.6	79.7
April	14.0	11.6	10.7	11.7	20.5	37.2	43.3	41.0	76.4	71.9	70.9	77.0
May	18.5	17.9	16.5	16.7	36.7	26.2	83.7	36.7	79.2	70.5	73.2	76.3
June	22.3	24.1	21.3	21.1	75.9	8.0	74.0	38.0	72.6	64.8	71.3	72.3
July	25.1	23.9	25.7	23.6	98.0	14.6	9.2	24.8	69.5	64.9	65.6	68.7
Mean	13.9	13.6	13.6	12.1					79.9	71.8	72.4	78.0
Total					591.1	373.1	352.8	473.8				

Table 2. Soil Properties of Experimental Area*
Çizelge 2. *Deneme alanına ait toprak özellikleri*

Parameter	Quantity	2017-2018	2018-2019	2019-2020
pH		7.58	7.55	7.08
Salt	%	0.02	0.02	0.02
Lime	%	0.65	0.63	0.60
Organik Matter	%	1.71	1.63	1.30
Total Nitrogen (N)	%	0.14	0.11	0.07
Phosphorus (P)	ppm	8.92	8.40	10.70
Potassium (KO)	ppm	296.49	290.73	154.50
Calcium (Ca)	ppm	3440.10	3571.40	3653.00
Magnesium (Mg)	ppm	117.31	116.48	489.10
Iron (Fe)	ppm	6.98	7.00	22.30
Copper (Cu)	ppm	1.60	1.60	1.83
Zinc (Zn)	ppm	1.00	0.90	1.00
Manganese (Mn)	ppm	19.63	19.58	74.37

*Soil samples analyses were performed by Tekirdağ Commodity Exchange laboratories.

3. Results and Discussion

The plant height, number of branches/plant, number of pods/plant, pod width, pod length, number of seeds/pod, seed weight/pod, 1000-seed weight, seed yield, herbage yield and hay yield for grass pea genotypes were given in table 3. The differences of the means of grass pea genotypes for plant height, number of pods/plant, pod width, pod length, number of seeds/pod, 1000-seed weight, seed yield, herbage yield and hay yield were determined statistically significant ($P<0.01$). The differences of the means of grass pea genotypes for number of branches means statistically significant at $P<0.05$, and the seed weight/pod was found not significant ($P>0.05$).

Table 3. Some morphological characters, forage and seed yield of grass pea genotypes (means of three years).
Çizelge 3*. Mürdümük genotiplerinin bazı morfolojik özellikleri ile yem ve tohum verimleri*

Characters	Genotypes				Means	LSD
	Gürbüz	Karadağ	Population Diyarbakır	Population Tekirdağ		
Plant height, cm	90.93b	103.60a	85.75b	92.95.b	93.31	8.732**
No. of branches/plant	6.11ab	6.42a	5.62bc	5.40c	5.89	0.649*
No. of pods/plant	20.43bc	27.66a	21.87b	19.12c	22.27	2.696**
Pod width, mm	9.57c	10.92ab	10.15bc	11.60a	10.56	1.136**
Pod length, mm	31.65b	36.70a	32.17b	36.08a	34.15	1.349**
No. of seeds/pod	3.33a	2.94b	2.86b	3.44a	3.14	0.265**
Seed weight/pod, g	1.89	2.26	1.74	1.93	1.95	NS
1000-seed weight, g	218.88b	249.17a	260.26a	258.10a	246.60	12.489**
Herbage yield, kg da^{-1}	1842.22b	1755.55b	1462.22c	2226.67a	1821.66	272.157**
Hay yield, kg da^{-1}	407.20b	392.46bc	373.74c	564.18a	434.39	19.711**
Seed yield, kg da^{-1}	169.49c	270.83a	160.22c	220.18b	205.18	18.270**

NS: Not significant; *: $P<0.05$; **: $P<0.01$

Plant height is the most effective character for seed and forage yield and depends on genotype, climate and soil conditions and other ecological factors (Ates, 2011). The plant height of grass pea genotypes varied between 85.75-103.60 cm and the maximum plant height (103.60 cm) was measured in genotype 'Karadağ'. Başaran et al. (2013), Seydoşoğlu et al. (2015), Tenikecier et al. (2017), Öten et al. (2017) determined that the plant height ranged from 30.14 to127.6 cm of grass pea genotypes. The plant height results are similar to those reported by Seydoşoğlu et al. (2015), Öten et al. (2017), Tenikecier et al. (2017).

One of the factors affecting the forage yield and quality traits of forage legumes is the number of branches/plant. While determining the highest number of branches/plant in genotypes 'Karadağ' (6.42 pcs) and 'Gürbüz' (6.11 pcs.), the lowest was found in population 'Tekirdağ' (5.40 pcs.)

(P<0.05). Rybinski et al. (2008), Kökten and Bakoğlu (2011), Başaran et al. (2013) and Özyazıcı and Açıkbaş (2019) reported that the number of branches/plant ranged from 3.00 to 13.60 pcs in grass pea, similar to the present findings.

The number of pods/plant, which is a morphological character that directly affects the seed yield, varied between 19.12 and 27.66 pcs. The highest number of pods/plant (27.66 pcs) was counted in genotype 'Karadağ'. Higher values for number of pods/plant (41.40-60.30 pcs) in grass pea were obtained by Rybinski et al. (2008) and Başaran et al. (2013). Kökten and Bakoğlu (2011) found pods/plant of 16.3-20.4 pcs for genotypes of grass pea.

The pod width results varied between 9.57-11.60 mm. The highest pod width of grass pea genotypes were determined in population 'Tekirdağ' (11.60 mm) (P<0.01). The lowest pod length were determined in genotype 'Gürbüz' (31.65 mm) and population 'Diyarbakır' (32.17 mm) genotypes, respectively. Polignano et al. (2005) determined pod width 7.00-19.00 mm and pod length 13.00-53.00 mm. Rahman et al. (2010) reported pod width 6.50-8.20 mm and pod length 26.00-30.00 mm. Başaran et al. (2013) stated that the pod length in grass pea between 27.30-35.70 cm. The pod width results are higher than Rahman et al. (2010) however, lower than Polignano et al. (2005). The pod length results are similar with Başaran et al. (2013) and Polignano et al. (2005), higher than Rahman et al. (2010).

The highest number of seeds/pod was obtained in genotype 'Gürbüz' (3.33 pcs) and population 'Tekirdağ' (3.44 pcs). Polignano et al. (2005), Rybinski et al. (2008), Başaran et al. (2013) and Seydoşoğlu et al. (2015) obtained 1.00-5.00 pcs of the number of seed per pod in grass pea genotypes, similar to the present findings.

The seed weight/pod of grass pea genotypes were determined between 1.74-2.26 g (P>0.05). 1000-seed weight, which is another factor affecting seed size and thus seed yield, is also very important in terms of good germination and strong seedling formation as well as its effect on high seed yield. Seeds which have high thousand seed weight; have high storage nutrients and strong embryos, they allow the formation of strong seedlings by germinating rapidly. The lowest 1000-seed weight (218.88 g) was found for grass pea genotype 'Gürbüz' compared to other genotypes. The 1000-seed weight results were higher to those reported by Bayram et al. (2004) (89.9-182.1 g), Gül et al. (2004) (124.4-144.9 g), Altuntas and Karadag (2006) (82.50-95.00 g), Başaran et al. (2013) (79.93-152.13 g) and Özyazıcı and Açıkbaş (2019) (78.37-126.78 g). Tavoletti et al. (2005) (79.0-276.0 g), Rybinski et al. (2008) (91.0-492.0 g) Polignano et al. (2009) (238-410 g) obtained that the similar 1000-seed weight in grass pea genotypes.

Higher forage and seed yield are desired in forage crop cultivation. It is even more important to have high seed yield of coarse forage legumes, which seeds are also used in animal feeding. The highest seed yield (270.83 kg da^{-1}) was obtained from genotype 'Karadağ'. The seed yield results are higher than Karadağ and Yavuz (2010) (77.3-191.2 kg da^{-1}), Karadağ et al. (2012) (173.3-202.8 kg da^{-1}) and Özyazıcı and Açıkbaş (2019) (94.5-210.40 kg da^{-1}); similar with Türk et al. (2007) (24.2-331.3 kg da^{-1}), Öten et al. (2016) (263.00-447.00 kg da^{-1}) and Tenikecier et al. (2017) (76.67-315.00 kg da^{-1}).

The effect of genotypes on herbage and hay yield were found to be significant (P<0.01). Maximum herbage yield (2226.67 kg da^{-1}) and hay yield (564.18 kg da^{-1}) were determined for population 'Tekirdağ'. The results are similar to those reported by Karadağ et al. (2012), Seydoşoğlu et al. (2015), Öten et al. 2016, Öten et al. (2017), Tenikecier et al. (2017), Özyazıcı and Açıkbaş (2019).

Relationships between studied characters and correlation coefficients were given in Table 4. While determining a positive and statistically non-significant relationship between number of branches/plant and plant height (r= 0.522); a positive and statistically significant relationship between number of branches/plant and number of pods/plant (r= 0.589); a positive and non-significant relationship between number of branches/plant, pod length (r= 0.079), seed weight/pod (r= 0.561) and seed yield (r= 0.364);

a negative and statistically non-significant relationship between number of branches/plant, pod width (r= -0.241), number of seeds/pod (r= -0.200), 1000-seed weight (r= -0.254), herbage yield (r= -0.260) and hay yield (r= -0.535) was found. While Tenikecier et al. (2017) and Başaran et al. (2013) were determining a positive and statistically significant relationship between number of branches/plant and plant height, Sayar et al. (2013) was determined statistically non-significant relationship.

Table 4. Relationships among effective characters on forage and seed yield of some grass pea genotypes

Çizelge 4. *Bazı mürdümük genotiplerinin yem ve tohum verimine etkili karakterleri arasındaki ilişkiler*

	PH	NB	NP	PW	PL	NS	SWP	TSW	SY	HY	HayY
PH	1.000										
NB	0.522ns	1.000									
NP	**0.704***	**0.589***	1.000								
PW	0.380ns	-0.241ns	0.081 ns	1.000							
PL	**0.744****	0.079ns	0.447 ns	**0.868****	1.000						
NS	-0.064ns	-0.200ns	**-0.642***	0.209 ns	0.056 ns	1.000					
SWP	**0.698***	0.561ns	**0.578***	0.400 ns	**0.600***	0.059 ns	1.000				
TSW	0.189ns	-0.254 ns	0.315 ns	**0.659***	**0.592***	-0.402 ns	0.175 ns	1.000			
SY	**0.845****	0.364 ns	**0.650***	**0.645***	**0.914****	-0.044 ns	**0.753****	0.442 ns	1.000		
HY	0.237ns	-0.260 ns	-0.392 ns	**0.627***	0.512 ns	**0.806****	0.286 ns	-0.074 ns	0.362 ns	1.000	
HayY	0.007ns	-0.535 ns	-0.553 ns	**0.688***	0.475 ns	**0.744****	0.014 ns	0.167 ns	0.221 ns	**0.900****	1.000

Plant Height: PH; Number of Branches/Plant: NB; Number of Pods/Plant: NP; Pod Width: PW; Pod Length: PL; Number of Seeds/Pod: NS;

Seed Weight/Pod: SWP; 1000-seed Weight: TSW; Seed Yield: SY; Herbage Yield: HY; Hay Yield: HayY.; *: P<0.05; **: P<0.01; ns: P>0.05 and 0.01.

While determining a positive and statistically significant relationship between number of pods/plant and plant height (r= 0.704); a positive and statistically significant relationship between number of pods/plant, seed weight/pod (r= 0.578) and seed yield (r= 0.650); a negative and statistically important relationship between number of pods/plant and number of seeds/pod (r= -0.642); a positive and statistically non-significant relationship between number of pods/plant, pod width (r= 0.081), pod length (r= 0.447) and 1000-seed weight (r= 0.315); a negative and statistically non-significant relationship between number of pods/plant, herbage yield (r= -0.392) and hay yield (r= -0.553) was found. Tenikecier et al. (2017) reported that a positive and statistically non-significant relationship between number of pods and seed weight/pod (r= 0.064), a negative and statistically significant relationship with seed weight/pod (r= -0.607). Başaran et al. (2013) determined a positive and statistically significant relationship between pods/plant and seed yield per plant (r= 0.916). Öten et al. (2016) reported a negative and statistically non-significant relationship between number of pods and seed yield (r= -0.017), number seeds per pod (r= -0.076). While determining a positive and statistically non-significant relationship between pod width and plant height (r= 0.380); a positive and statistically significant relationship between pod width, pod length (r= 0.868), 1000-seed weight (r= 0.659), seed yield (r= 0.645), herbage yield (r= 0.627) and hay yield (r= 0.688); a positive and statistically non-significant relationship between pod width, number of seeds/pod (r= 0.209) and seed weight/pod (r= 0.400) was found. While determining a positive and statistically significant relationship between pod length and plant height (r= 0.744); a positive and statistically significant relationship between pod length, seed weight/pod (r= 0.600), 1000-seed weight (r= 0.592) and seed yield (r= 0.914); a positive and non-significant relationship between pod length, number of seeds/pod (r= 0.056), herbage yield (r= 0.512) and hay yield (r= 0.475) were found.

On the other hand, negative and statistically non-significant correlations were determined between number of seeds/pod and plant height (r= -0.064). The positive and statistically significant relationship between number of

seeds/pod and herbage yield (r= 0.806) and hay yield (r= 0.744); the positive and statistically non-significant relationship between number of seeds/pod, seed weight/pod (r= 0.059); the negative and statistically non-significant relationship between number of seeds/pod and 1000-seed weight (r= -0.402) and seed yield (r= -0.044) were found. While determining a positive and statistically significant relationship between seed weight/pod and plant height (r= 0.698); a positive and statistically significant relationship between seed weight/pod and seed yield (r= 0.753); a positive and statistically non-significant relationship between seed weight/pod, 1000-seed weight (r= 0.175), herbage yield (r= 0.286) and hay yield (r= 0.014) was found.

While determining a positive and statistically non-significant relationship between 1000-seed weight and plant height (r= 0.189); a positive and statistically non-significant relationship between 1000-seed weight, seed yield (r= 0.442) and hay yield (r=0.167); a negative and statistically non-significant relationship between 1000-seed weight and herbage yield (r= -0.074) was found. While determining a positive and statistically significant relationship between seed yield and plant height (r= 0.845); a positive and statistically non-significant relationship between seed yield, herbage yield (r= 0.362) and hay yield (r= 0.221) was found. While determining a positive and statistically non-significant relationship between herbage yield and plant height (r= 0.237); a positive and statistically significant relationship was found between herbage yield and hay yield (r= 0.900). A positive and statistically non-significant relationship was determined between hay yield and plant height (r=0.007).

3. Conclusion

Its concluded that the highest plant height, number of branches, number of pods and seed yield were determined in Karadağ genotype, however the highest number of seeds/pod, herbage yield and hay yield were determined in population 'Tekirdağ'. As a result, in the province where the study was conducted and in regions with similar climatic conditions, when the aim was to produce grain from grass pea, genotype 'Karadağ', when the aim was to produce herbage and hay yields, population 'Tekirdağ' can be recommended. Besides, genotypic improvement using phenotypic selection for populations 'Tekirdağ' and 'Diyarbakır' there will also require selection multiple locations under different ecological conditions.

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