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Determination of Dry Matter Yield and Yield Components of Local Forage Pea (*Pisum sativum* ssp. *arvense* L.) Ecotypes

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ABSTRACT

Local forage pea (*Pisum sativum* ssp. *arvense* L.) ecotypes are commonly cultivated in the Eastern Anatolia Region for long years. The ecotypes show great variations in yields and plant characteristics and these genetically resources should definitely be protected and be used as breeding material. The current study was conducted to determine the dry matter yields and yield components of 18 forage pea ecotypes selected among 61 collected materials from Erzurum, Bayburt, Kars and Ardahan provinces. The experiments were carried out in the experimental fields of Atatürk University Agricultural Faculty during the years of 2008, 2009 and 2010 under irrigated conditions. Three-year averages revealed large variations in dry matter yield the number of days to harvest, plant height, lodging degree and forage quality parameters of the ecotypes. Dry matter yields of ecotypes varied between 4862 and 6854 kg ha⁻¹, the number of days to harvest between 79.0 and 91.1 days and plant heights between 68.8 and 102.0 cm. Among the investigated ecotypes, the Degirmencik-1 and Subatan were considered to be promising ecotypes for breeding studies and regional yield studies.

Keywords: Forage pea; Ecotypes; Dry matter yield; Hay quality

Yerel Yem Bezelyesi (*Pisum sativum* ssp. *arvense* L.) Ekotiplerinde Kuru Madde Verimi ve Bazı Özelliklerin Belirlenmesi

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ÖZET

Kuzeydoğu Anadolu Bölgesinde yerel yem bezelyesi (*Pisum sativum* ssp. *arvense* L.) ekotiplerinin yetiştiriciliği yaygındır. Verim ve bitkisel özellikler yönünden büyük varyasyonlar gösteren bu ekotiplerin koruma altına alınması ve ıslah materyali olarak değerlendirilmeleri gerekir. Bu araştırma Erzurum, Bayburt, Kars ve Ardahan'dan toplanmış 18

yem bezelyesi ekotipinin kuru madde verimi ve bazı özelliklerini belirlemek amacıyla planlanmıştır. Araştırma 2008, 2009 ve 2010 yıllarında Atatürk Üniversitesi Ziraat Fakültesi sulu deneme alanında yürütülmüştür. Elde edilen üç yıllık sonuçlara göre kuru madde verimi, ot hasat süresi, bitki boyu, yatma derecesi ve ot kalite özellikleri ekotipler arasında büyük değişim göstermiştir. Ekotiplerin kuru madde verimleri 4862-6854 kg/ha, ot hasat süreleri 79.0-91.1 gün ve bitki boyları 68.8-102.0 cm arasında değişmiştir. Bu ekotipler arasında Degirmencik-1 ve Subatan ekotiplerinin yeni çeşit geliştirmek için değerlendirilmesi ve bölge verim denemelerine alınması uygun gözükmektedir.

Anahtar Kelimeler: Yem bezelyesi; Ekotipler; Kuru madde verimi; Ot kalitesi

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1. Introduction

Forage pea (*Pisum sativum* ssp. *arvense* L.) has been cultivated in Ardahan, Kars and Bayburt provinces of Eastern Anatolia Region for long years. It is called “külür” by local farmers, is the best adapted to cool and humid environments, therefore, is a suitable crop for the ecological conditions of Eastern Anatolia. Under suitable conditions, hay yields can reach up to or even above 10 ton ha⁻¹ (Uzun et al 2005). The forage pea produces palatable and nutritious hay for livestock's. The crude protein ratio of forage pea hay at the flowering stage is around 17-21% (Turk et al 2011; Timuragaoglu et al 2004). High crude protein ratios mainly originated from high foliage and the leaf/stem ratio is 2.4 at the beginning of flowering and 1.4 at the end of flowering (Ozyigit & Bilgen 2006).

Local forage pea ecotypes have characteristics of a population with great variations in yield and some plant characteristics. However, there are insufficient investigation on cultivation techniques and breeding of these ecotypes. Therefore, they have great significance in breeding programs to develop a cultivar or to improve certain characteristics (Karayel & Bozoglu 2008).

Variation in yield and plant characteristics of materials supplied from different sources is an expected outcome. Hay yields of forage pea cultivars and lines were reported to be between 2800-7950 kg ha⁻¹ (Uzun et al 2005; Sayar et al 2009). Karayel & Bozoglu (2008) reported plant heights of local forage pea populations as between 40 and 180 cm. Lodging is a serious problem in peas and cause significantly yield losing and forage

quality. Previous studies revealed that there were great differences among pea genotypes with respect to lodging (Turk et al 2011; Bilgili et al 2010). Hence, great variations for lodging traits among local populations are also expected.

The present study was conducted to determine dry matter yields and some agronomic characteristics of local forage pea ecotypes collected from the Eastern Anatolia Region and to select prominent genotypes for cultivar developing programs.

2. Material and Methods

The experiment was conducted at the experimental station of Agricultural Faculty of Ataturk University, Erzurum, which is located at an altitude of 1850 m and between 39° 59' N and 41° 61' E. Field observations were carried out during the growing seasons of 2008 and 2010. Climatic properties of Erzurum are characterized by long and extremely cold winter and cool, short and arid summer. The distribution of precipitation is uneven, with majority of precipitation received from autumn to spring. Total precipitation and annual mean temperature in the experimental years and long term average are given in Table 1. The second experimental year (2009) was relatively cooler and the last year (2010) was milder and precipitated (EMST 2010).

Soil in the study site is clay-loam textured with pH of 7.82. Organic matter content was 1.90% and corresponding available potassium and Olsen phosphorus content were 1980 kg K₂O ha⁻¹ and 88.0 kg P₂O₅ ha⁻¹, respectively.

A total of 18 local forage pea (*Pisum sativum* ssp. *arvense* L.) ecotypes were selected previous

Table 1- Climatic data of Erzurum for the experimental and long term periods*Çizelge 1-Erzurum ilinin deneme yılları ve uzun yıllara ait bazı iklim verileri*

Months	Average temperature (°C)				Total precipitation (mm)			
	2008	2009	2010	Long-term	2008	2009	2010	Long-term
April	5.2	4.3	5.6	5.4	54.9	42.7	54.2	58.4
May	10.3	10.0	10.4	10.5	65.0	43.2	63.6	70.0
June	14.6	14.7	15.9	14.9	38.2	76.2	50.5	41.6
July	19.1	17.2	19.5	19.3	24.4	29.2	55.5	26.2
Mean/Total	12.3	11.6	12.9	12.5	182.5	191.3	223.8	196.2

Table 2- Some morphological characteristics of forage pea ecotypes used in the experiment*Çizelge 2- Denemede kullanılan yem bezelyesi ekotiplerinin bazı morfolojik özellikleri*

Ecotypes	Origin	Flower color	Seed shape	1000-seed weight (g)
Ardahan	Center-Ardahan	Purple	Round	88.0
Arpalı	Aydıntepe-Bayburt	Purple	Dimpled	152.5
Asağıcambaz	Çıldır-Ardahan	Purple	Round	83.9
Balcesme	Gole-Ardahan	Purple	Dimpled	63.3
Burmadere	Damal-Ardahan	Purple	Round	74.6
Degirmencik-1	Aydıntepe-Bayburt	White	Angled	134.2
Degirmencik-2	Aydıntepe-Bayburt	Purple	Dimpled	100.1
Dogruiol	Arpaçay-Kars	Purple	Round	73.6
Eskibeyrehatun	Çıldır-Ardahan	Purple	Angled	86.3
Incili	Aydıntepe-Bayburt	White	Round	207.7
Kaslıkaya	Çıldır-Ardahan	White	Round	74.0
Oburcak	Damal-Ardahan	Purple	Round	101.8
Ovaçevirme	Hınıs-Erzurum	Purple	Angled	157.7
Paslı	Kağızman-Kars	Purple	Round	105.4
Serhat	Damal-Ardahan	Purple	Round	87.1
Subatan	Center-Kars	Purple	Round	97.7
Tepeköy	Damal-Ardahan	Purple	Round	92.9
Yigitkonagi	Gole-Ardahan	Purple	Round	75.7

years screening study conducted on pea ecotypes collected from 61 different locations of the Eastern Anatolia Region were used as the plant material in the experiments. The ecotypes were named with the location names in where they were collected. Some morphological characteristics of the pea ecotypes used in the experiment were summarized in Table 2.

As can be seen from the table, local ecotypes have different flower and seed colors and seed shapes. One ecotype was Erzurum-originated, 3 ecotypes were Kars-originated, 4 ecotypes were Bayburt-originated and the remaining 10 ecotypes were Ardahan-originated materials.

The experiments were arranged in a randomized complete block design with three replications. The seeds were sown by hand with 100 seeds per m² seeding rate in early May in every year. The plot size was 3 m x 1.5 m, consisting of 5 rows spaced 30 cm. Forty kg ha⁻¹ N and 80 kg ha⁻¹ P₂O₅ were applied to soil before sowing (Tan & Serin 2012). Weed control was done by hand hoeing in the end of May. The plot was irrigated 2 times with flooding system when plant color turns dark green during the experiment.

The number of days to flowering was recorded when plant reach 50% flowering stage. Lodging score was rated by a 1 to 5 scale, where 1: completely upright and 5: completely lodged at the 50% flowering stage (TARM 2001). Ten plants were randomly sampled from each plot to determine plant height before harvesting. Plots were harvested by sickle in middle of the July in every year when plants reached 50% flowering stage. Plant samples were dried 48 h in an oven at 70 °C for estimation of dry matter yield. Dried samples were ground with a Wiley mill to pass a 1-mm screen and analyzed for nitrogen (N). The total N was determined using the Kjeldahl method and the crude protein was calculated by multiplying the N content by 6.25 (Bremner 1996). Acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyses were determined by Van Soest (1963).

In this paper, plant height, the number of days to harvest, lodging score, crude protein, ADF and NDF ratios of hay are presented as an average of three years and dry matter yields are presented for each year separately. The results were statistically evaluated by using MSTAT-C procedures and mean separations were made on the basis of least significant differences (LSD).

3. Results and Discussion

Significant differences were observed in the number of days to harvest, plant heights and lodging score of local forage pea ecotypes collected from different origins ($p < 0.01$) (Table 3). While the Serhat and Oburcak ecotypes reached harvesting stage earlier (79.0 and 79.2 days, respectively), Degirmencik-2

reached harvesting stage the latest (91.1 days). Degirmencik-1 (85.1 days) and Arpalı (85.3 days) were also late ecotypes for harvest. Years also had significant effects on the number of days to harvest. The plants reached harvesting stage later in the first year than the other years.

Plant heights were significantly different among ecotypes and varied between 68.8 and 102.0 cm. Degirmencik-2 (102.0 cm), Degirmencik-1 (94.3 cm) and Arpalı (93.2 cm), late ecotypes, had higher plant height than the others. Conversely, early maturing Gole-Ardahan-originated Yigitkonagi ecotype was found to be as the shortest (68.8 cm) ecotype. Plants height were shorter in the first and the last experimental years (81.1 and 77.7 cm, respectively) and higher in the second experimental year (89.5 cm).

Significant differences were also observed in the lodging score of local pea ecotypes. Although there was no totally lodged or up-righted material, lodging score varied from 2.2-3.2 among the ecotypes. The Degirmencik-1 ecotype has long plant height showed the greatest lodging degree. However, tall and late Arpalı ecotype had the lowest lodging degree. Ecotypes generally showed higher lodging degrees in the first experimental years than the other years (Table 3).

Significant differences were observed in the dry matter yields of local forage pea ecotypes collected from different locations both in individual and combined analysis of years. Degirmencik-1 and Subatan ecotypes had the highest dry matter yields in the first year (2008) (8200 and 8470 kg ha⁻¹, respectively) and followed by Balcesme, Tepeköy, Oburcak and Burmadere ecotypes (Table 4). The Serhat ecotype had the highest yield in the year of 2009 (6314 kg ha⁻¹), whereas, the Arpalı ecotype had the lowest yield in both years. In the last year (2010), dry matter yield was the highest in the Subatan ecotype (7470 kg ha⁻¹), followed by Degirmencik-1 (7007 kg ha⁻¹) ecotype. Three-year averages revealed the highest yields for Subatan (6854 kg ha⁻¹) and Degirmencik-1 (6768 kg ha⁻¹) ecotypes. Yields of these ecotypes were significantly different from the yields of other ecotypes. The average dry matter yields in 2008, 2009 and 2010

Table 3-Days to harvest, plant heights and lodging scores of pea ecotypes in mean of 2008, 2009 and 2010 years

Çizelge 3- Yem bezelyesi ekotiplerinin 2008, 2009 ve 2010 yıllarında hasada kadar geçen gün sayısı, bitki boyu ve yatma dereceleri

<i>Ecotypes</i>	<i>Days to harvest (day)</i>	<i>Plant height (cm)</i>	<i>Lodging score</i>
Ardahan	80.8 D-H ⁺	80.6 CDE	2.4 CDE
Arpalı	85.3 B	93.2 AB	2.2 E
Aşığıcambaz	81.7 DEF	80.8 CDE	2.6 B-E
Balcesme	82.4 CDE	74.8 D-G	2.7 A-E
Burmadere	81.4 D-G	73.1 EFG	2.4 CDE
Degirmencik-1	85.1 B	94.3 AB	3.2 A
Degirmencik-2	91.1 A	102.0 A	2.9 A-D
Dogruiol	81.4 D-G	81.0 CDE	2.4 CDE
Eskibeyrehatun	81.4 D-G	84.6 BCD	2.6 B-E
Incili	83.9 BC	89.0 BC	2.7 A-E
Kaslıkaya	81.4 D-G	85.6 BC	2.7 A-E
Oburcak	79.2 H	74.8 D-G	3.1 AB
Ovacevirme	82.9 CD	87.1 BC	2.6 B-E
Paslı	82.7 CD	87.2 BC	2.4 CDE
Serhat	79.0 H	79.0 C-F	2.7 A-E
Subatan	80.2 FGH	84.3 BCD	3.0 ABC
Tepeköy	79.4 GH	69.6 FG	2.4 CDE
Yığıtkonağı	80.4 E-H	68.8 G	2.3 DE
Years			
2008	89.4 A	81.1 B	3.1 A
2009	78.6 B	89.5 A	2.6 B
2010	78.7 B	77.7 B	2.3 B
<i>F-test (LSD)</i>			
Ecotype	** (2.2)	** (10.2)	** (0.6)
Year	** (0.9)	** (4.2)	** (0.3)
Ecotype x Year	** (3.8)	** (17.7)	** (1.1)

⁺, Values followed by different letters in a column represent significant differences; **, F-test significant at $P \leq 0.01$

were 6113, 5097 and 5495 kg ha⁻¹, respectively. Dry matter yield was statistically different among years and every years was different each other according to multiple range test (Table 4). The first year of high yield may be due to the fact that more than the number of days until harvest.

Crude protein content of dry matter showed significantly differences ($p < 0.01$) among local forage pea ecotypes and it varied between 15.64 and 17.70% (Table 5). The highest crude protein content was recorded at Degirmencik-2 ecotype and it was followed by the Asığıcambaz ecotype. The lowest crude protein contents were observed in the Incili

and Paslı ecotypes. The year effect was significant on the crude protein content ($p < 0.01$). The crude protein ratios were significantly lower in the first and second year (15.93 and 15.98%, respectively) than that of the last year (18.33%).

Significant differences were determined in the ADF (21.53-27.88%) and NDF (32.33-40.28%) contents of local forage pea ecotypes (Table 5). Yığıtkonağı ecotype had the highest ADF ratio and Ardahan ecotype had the highest NDF ratio. ADF and NDF ratios were lower in the 2008 and 2009 than that of 2010 ($p < 0.01$). Differences in ADF and NDF ratios of the years were found to be significant ($p < 0.01$).

Table 4-Dry matter yields of pea ecotypes in 2008, 2009 and 2010 years and mean of three years (kg ha⁻¹)Çizelge 4-- Yem bezelyesi ekotiplerinin 2008, 2009, 2010 yılları ve üç yıllık ortalama kuru madde verimleri (kg ha⁻¹)

Ecotypes	Years			Mean
	2008	2009	2010	
Ardahan	6330 CDE ⁺	5180 B	4790 C	5433 B-E
Arpalı	4470 I	4100 C	6223 ABC	4931 DE
AsagıCambaz	4800 I	4797 BC	4990 C	4862 E
Balcesme	7130 B	4686 BC	5167 BC	5660 BC
Burmadere	6600 BCD	4737 BC	5753 ABC	5697 B
Degirmencik-1	8200 A	5097 B	7007 AB	6768 A
Degirmencik-2	5800 EFG	5556 AB	5440 BC	5602 BCD
Dogruiyol	5200 GH	4683 BC	5717 ABC	5200 B-E
Eskibeyrehatun	6270 CDE	5183 B	4580 C	5344 B-E
Incili	5530 FG	5233 B	5523 BC	5429 B-E
Kaslıkaya	5470 FGH	4947 BC	5590 BC	5336 B-E
Oburcak	6800 BC	5403 AB	5103 C	5769 B
Ovaçevirme	5470 GH	5453 AB	5977 ABC	5633 BCD
Paslı	5530 FG	5506 AB	4917 C	5318 B-E
Serhat	5930 DEF	6314 A	5386 BC	5877 B
Subatan	8470 A	4623 BC	7470 A	6854 A
Tepeköy	6630 BC	5390 AB	4620 C	5547 B-E
Yigitkonagi	5400 FGH	4860 BC	4640 C	4967 CDE
Mean	6113 A	5097 C	5495 B	5568
F-test (LSD)				
Ecotype	** (697)	* (952)	** (1862)	** (730)
Year				** (294)
Ecotype x Year				** (1249)

⁺ Values followed by different letters in a column represent significant differences; *, F-test significant at $P \leq 0.05$; **, F-test significant at $P \leq 0.01$

Ecotype x year interaction was significant for all investigated parameters ($p < 0.01$). This indicates that ecotypes were differently affected by yearly ecological (temperature, precipitation and so on) conditions. For instance, while the Subatan ecotype had the highest dry matter yields in 2008 and 2010, it had low dry matter yield in the year of 2010 (Table 4). Similar results are also observed for plant height, number of days to harvest and forage quality parameters.

The local pea ecotypes with different origins showed different performances in the study. Some of them reached early harvesting and 50% flowering stage. The earlier ecotypes reached harvesting stage for forage in 79-80 days (Table 3). Conversely, Degirmencik-2 ecotype was determined as a late

maturing ecotype and reached the forage harvest stage in 91.1 days. Although early or late ecotypes are significantly affected by environmental conditions, it is originally a genetic characteristic. Peas are an indeterminate plants and growing continue as long as environmental condition favorable if genetically restricted. Hence, the latest ecotype Degirmencik-2 had the tallest plants in the study. However, taller and late maturing ecotypes usually have higher lodging degrees. Thus, Degirmencik-1 and Degirmencik-2 ecotypes, late maturing ecotype, had the highest lodging degree among the investigated ecotypes. Various researchers also reported significant differences in the harvesting period, plant height and lodging scores of forage pea cultivars and lines (Sayar et al 2009; Oz & Karasu 2010; Tan et al 2012)

Table 5- Crude protein, ADF and NDF ratios of pea ecotypes in mean of 2008, 2009 and 2010 years

Çizelge 5- Yem bezelyesi ekotiplerinin 2008, 2009 ve 2010 yılları ham protein, ADF ve NDF oranları

Ecotypes	Crude protein (%)	ADF (%)	NDF (%)
Ardahan	16.20 C-G ⁺	22.60 EF	40.28 A
Arpalı	17.12 A-E	22.00 EF	36.08 DE
Asağıcambaz	17.57 AB	23.87 CDE	37.61 B-E
Balcesme	17.07 A-F	22.52 EF	39.70 AB
Burmadere	16.42 B-G	21.71 EF	37.55 B-E
Degirmencik-1	17.37 ABC	21.53 F	35.84 E
Degirmencik-2	17.70 A	23.13 DEF	36.02 DE
Dogruiyol	16.28 C-G	26.16 AB	39.68 AB
Eskibeyrehatun	16.84 A-G	21.89 EF	35.70 E
İncili	15.64 G	21.57 F	36.84 CDE
Kaslıkaya	16.66 A-G	22.51 EF	37.32 CDE
Oburcak	17.29 A-D	26.05 ABC	37.80 B-E
Ovaçevirme	17.31 A-D	25.97 ABC	37.64 B-E
Paslı	15.88 FG	23.29 DEF	36.00 DE
Serhat	16.11 D-G	25.21 BCD	32.33 F
Subatan	17.22 A-E	26.83 AB	38.08 BCD
Tepeköy	16.75 A-G	23.72 DEF	35.88 E
Yigitkonagi	16.04 EFG	27.88 A	38.84 ABC
Years			
2008	15.93 B	22.05 B	35.00 B
2009	15.98 B	22.96 B	35.62 B
2010	18.33 A	26.39 A	40.91 A
<i>F-test (LSD)</i>			
Ecotype	** (1.23)	** (2.24)	** (2.15)
Year	** (0.50)	** (0.92)	** (0.88)
Ecotype x Year	** (2.12)	** (0.39)	** (0.37)

⁺ Values followed by different letters in a column represent significant differences; **, F-test significant at $P \leq 0.01$

Dry matter yields of ecotypes showed significant differences and varied between 4862 and 6854 kg ha⁻¹ in three years average. Differences in yields performance in ecotypes with different characteristics is expected results originated from genetic potential differences. Similar results were also reported by other researchers (Acikgoz et al 2009; Uzun et al 2005; Tekeli & Ates 2003). Taller plants with longer growth periods usually have higher yields (Tan et al 2012). In the present study, tall and late ecotypes had also higher dry matter yields. However, yield parameters are not limited only to the length of the growth period and plant height. Degirmencik-1 ecotype with a high dry matter yield is a tall and late ecotype, although the Subatan ecotype with the highest dry matter yield is an early ecotype with medium-height plants (Table 4).

Among the investigated forage pea ecotypes, Degirmencik-2 had the highest crude protein content; Yigitkonagi had the highest ADF content and Ardahan had the highest NDF content (Table 5). In addition to genetic differences, characteristics of plant growth affect their chemical compositions under similar growing condition. This mostly results from differences in the plant leaf/stem ratio and tissue morphology (Tan & Mentese 2003). Ozyigit & Bilgen (2006) reported lower fiber contents for forage crops with higher leaf/stem ratios. Uzun et al (2005) and Turk et al (2011) investigated nutrient quality of difference forage pea genotypes and reported significant differences among the genotypes.

Ecotype x year interaction had significant effects on investigated parameters of the study (Table

3, 4 and 5). Such differences were mainly due to different responses of ecotypes to varying ecological conditions of the years. Experimental years had differences in temperatures and precipitations (Table 1). These differences affected the early and late ecotypes differently. Tan et al (2012) and Uzun et al (2005) also reported significant genotype x year interactions for peas.

4. Conclusions

In conclusion, investigated local forage pea ecotypes collected from different location of the Eastern Anatolia Region showed great variation with respect to dry matter yield and yield components. According to three-year averages Degirmencik-1 and Subatan ecotypes gave promising results. Hence these two ecotypes should be used in location trials in order to develop new variety for hay production.

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