Determination of Some Agronomic Characteristics of Forage-Pea *(Pisum sativum* L.) Lines in Antalya Conditions

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Abstract

This study was carried out to investigate the agronomic and morphological characteristics of 6 forage pea (*Pisum sativum* L.) lines from USA and Taşkent and Arda varieties under Antalya coastal conditions. The trial was set up as randomized complete block design with 3 replications in research area of Department of Field Crops of Agriculture Faculty in Akdeniz University in 2022-2023 growing seasons. In the present study; number of days to flowering is 49.67 to 50.67 days, plant height is 78.67 to 117.33 cm, number of pods per plant is 7.00 to 17.33, number of grains per pod is 4.33 to 8.33, herbage yield is 778.70 kg da^{-1} to 2468.21 kg da^{-1}, hay yield is 304.32 kg da^{-1} with 709.83 kg da^{-1}, grain yield between 38.92 kg da^{-1} and 107.94 kg da^{-1}, dry matter rate between 26.31% and 44.82%, biological yield between 228.00 kg da^{-1} and 818.49 kg da^{-1}, thousand grain weight between 107.83 g and 151.83 g, herbage crude protein ratio was found between 18.92% and 23.81% and seed protein ratio was found between 20.08% and 22.74%. According to the results obtained in the study, it was seen that peas gave successful results with a short vegetation period in Antalya coastal conditions and that the adaptation of lines obtained from abroad could compete with registered varieties.

Key words: Pea (*Pisum sativum* L.), Morphological characteristics, Yield

Antalya Koşullarında Yem Bezelyesi (Pisum sativum L.) Hatlarının Bazı Tarımsal Özelliklerinin Belirlenmesi

Özet

Bu çalışma; USDA (A.B.D.)'den getirilen 6 yem bezelyesi (*Pisum sativum* L.) hattı ile Taşkent ve Arda çeşitlerini Antalya sahil koşullarında agronomik ve morfolojik olarak incelemek amacı ile yürütülmüştür. Deneme tesadüf blokları deneme deseninde 3 tekerrürlü olarak Akdeniz Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümü deneme tarlalarında 2022-2023 sezonunda kurulmuştur. Araştırmada; çiçeklenme gün sayısı 49.67 ile 50.67 gün, bitki boyu 78.67 ile 117.33 cm, bitkide bakla sayısı 7.00 ile 17.33 adet, baklada tane sayısı 4.33 ile 8.33 adet, yeşil ot verimi 778.70 kg/da ile 2468.21 kg/da, kuru ot verimi 304.32 kg/da ile 709.83 kg/da, tane verimi 38.92 kg/da ile 107.94 kg/da, kuru madde oranı %26.31 ile % 44.82, biyolojik verim 228.00 kg/da ile 818.49 kg/da, bin tane ağırlığı 107.83 g ile 151.83 g, yeşil ot ham protein oranı , %18.92 ile %23.81 ve tohum ham protein oranı %20.08 ile %22.74 arasında bulunmuştur. Çalışmada elde edilen sonuçlara göre, yem bezelyesinin Antalya sahil koşullarında kısa vejetasyon süresiyle başarılı sonuçlar verdiği ve yurtdışından temin edilen hatların adaptasyonunun da tescilli çeşitlerle rekabet edebileceği görülmüştür.

Anahtar kelimeler: Morfolojik özellikler, Verim, Yem bezelyesi (*Pisum sativum* L.)

Introduction

In Turkey, animal husbandry most substantial problems are the need for high-yield, easy-to-digest and low-cost feed (Açıkgöz, 2005). Nevertheless, roughages are of major significance in enhancing carcass yield per animal and mitigating fodder costs (Kaya and Bilgen, 1995; Alçiçek et al., 1999; Arslan and Erdurmuş, 2012). Furthermore, in animal husbandry of our country, the roughage/mixed feed balance has gained weight in favor of mixed fodder. Yet, since the production quantities of raw materials for mixed fodder in our country cannot accomplish the requirement in this regard, and therefore Turkey is also predominantly dependent on foreign sources for fodder additives, a permanent impress is detected in noteworty of relevant raw materials. Naturally, this process has a unfavorable impact on the country economy. As a result of this situation, significant amounts of payments are made for imports. The most effective and permanent solution to this issue is to boost our production (Anonymous, 2021).

In this respect, albeit the marked of forage crop agriculture has just begun to be understood, the cultivation area level has not yet been achieved to close the fodder deficit in the country conditions (Alçiçek et al., 2010). Seen that the area cultivated with forage crops in our country is extremely low meanwhile compared to overall agricultural area. Therefore, this rate definitely needs to be increased (Serin and Tan, 2009). Thus, permanent solution will be feasible through expanding the forage crops cultivation and product development.

Turkey is located in origin of forage pea, nevertheless reported that breeding studies, genetic and cytogenetic research on forage pea are not yet at the desired level (Endes and Tamkoç, 2007). Pea is an major legume forage plant (Asci et al., 2015) with its features such as being highly productive, needing relatively low nitrogen-containing fertilizers, providing nitrogen gain to the soil with microorganisms in root nodules (Janzen et al., 2014; Kadıoğlu et al., 2020), having clean stubble (Açıkgöz, 2005), being compatible with crop rotations (Angaw and Asnakew, 1994), being able to effectively combat diseases, pests and weeds by improving soil properties (Habtamu and Million, 2013) and supporting the struggle against erosion with crop rotation (Özeroğlu, 2021).

Environmental and climatic conditions affect the development and vegetation period of plants, their ripening time and stage, and therefore their productivity. In this case, there is a requirement to breed species suitable for varied soil and climate types in the cultivation of forage peas. It is stated that when grown in the appropriate period, it is possible to benefit from the herbage and hay grass of forage pea and moreover also to use it in pastures. In addition, it can also be used as green manure (Özkaynak, 1980).

Özeroğlu (2021) reports that new varieties suitable for distinct ecological environments should be cultivated in our country and that forage pea cultivation techniques should be improved and superior grain and herbage yields should be targeted. Thereby, the most substantial properties affecting the fertility in forage pea production are sowing-time and appropriate variety selection. Thus, early or late growing varieties adequate for climate and environmental conditions should be preferred. Moreover in forage pea production, according to the plant growing time, directly impresses the quality, majority chooses the appropriate variety to determine high grain yield and to ensure physiological maturity at the accurate time (Önder and Ceyhan, 2001). In general, in forage crops, with the delay in harvest time, the crude protein content diminishes, even though the cellulose content enhances (Soya, 1999).

In the study, agronomic and morphological characteristics of the genotypes were examined, their adaptation abilities were revealed and quality analyzes were made. The results detected were compared with two control varieties. Hence, yield and yield-related characteristics of genotypes in Antalya conditions were indicated, thus aiming to identify new variety candidates for producers.

Materials and Methods

The research was carried out in the research and application field of Akdeniz University, Faculty of Agriculture, Department of Field Crops. Monthly average temperature (°C), precipitation (mm) and relative humidity (%) of the experiment are presented in Table 1. And, the temperature and precipitation are at lowest in February. The weather conditions in February 2023 negatively affected the plants, causing leaf burns and some plant deaths, so the sowing was repeated on March 15. Therefore, thought that this may have been caused by the lower than normal temperature of that period.

Some physical and chemical soil analyses were performed on the field soil where the experiment was established and the soil properties were realized (Kacar, 2016). Moreover, evaluated, some physical and chemical properties of soil were given in Table 2. The loamy texture class soil, was determined to be neutral, salt-free, highly calcareous, insufficient in organic matter and available phosphorus, and sufficient in exchangeable potassium, calcium and magnesium content. In addition, micronutrient elements such as iron, zinc and copper were found to be sufficient, but manganese content was observed to be insufficient (Alparslan et al., 2005).

Table 1. Monthly climate data for the period of the experiment

Month	**Temperature (°C)**	**Precipitation (mm)**	**Relative Humidity (%)**
	2022-2023	**2022-2023**	**2022-2023**
November	16.80	75.00	71.20
December	14.00	54.20	83.70
January	11.40	391.10	73.60
February	10.20	7.10	47.90
March	14.70	101.40	66.00
April	16.20	25.00	71.00
May	20.20	80.50	75.60
June	24.80	13.00	72.00
Total	-	**747.3**	-
Mean	**16.03**	-	**70.12**

Table 2. Some chemical and physical properties of the soil used

pH	EC (dS m^{-1})	Lime (%)	OM (%)	N (%)	P (kg da^{-1})	K (kg da^{-1})
7.40	0.492	21.80	1.80	0.081	1.38	66.25
Ca (ppm)	Mg (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	Texture
6293	365	3.40	11.60	1.00	1.30	L

The experiment was carried out with 3 replications according to the randomized block design. Furthermore, in this study, forage pea (*Pisum sativum* L.) genotypes named FP190 (PI 358668), FP191 (PI 358665), FP192 (PI 358659), FP193 (PI 358650), FP194 (PI 358635) and FP195 (PI 358631), were obtained from the United States Department of Agriculture Gene Bank, were used. In addition, totally 8 genotypes were used in the experiment, with registered varieties named Taşkent and Arda being selected as controls. Sowing was deriven in 3 m x 30 cm intervals with 4 rows at November 22, 2022. And, seeds were sown manually in rows at a depth of 3-4 cm with a distance of 10 cm between rows. In the experiment, soil preparation for sowing forage pea was completed by ploughing and base fertilising. As a soil conditioner, humic acid called Agrolig plus was applied at 25 kg/da. Additionally, Ammonium sulphate and Di Ammonium Phosphate fertilizers were used as 4 kg N/da and 8 kg P2O5/da.

Approximately 2 weeks after sowing, emergence occurred in plots; However, the extreme cold and windy weather conditions experienced in February 2023 negatively affected the seedling, and leaf burns and even plant deaths were detected in plots. Since these extreme climatic conditions prevented the healthy completion of the experiment, the sowing was repeated on March 15. In the second experiment, accomplished germination was achieved, emergence was observed and the healthy development continued. Observations and measurements on plants were made as planned (flowering period (days), plant height (cm) (Anonymous, 2019)) and recorded. In the experiment, while the herbage was cut on May 30, 2023, the seed production harvest was carried out on June 25, 2023 (number of pods per plant (number, Ekiz, 1983), number of grains per pod (number, Sümerli and Ark, 2001), herbage yield (kg/da), dry matter ratio (%, Anonymous, 2019), hay yield (kg/da, Anonymous, 2019), seed yield (kg/da), biological yield (kg/da), thousand grain weight (g, TTSM, 2023). Crude protein ratio of herbage (%) and crude protein ratio of grain (%) were determined as reported by Kacar and İnal (2008).
In the statistical evaluation, variance analysis was applied according to the randomized block design with 3 replications, and Duncan multiple comparison test was used to determine the groups. Thereby, SPSS package program was used.

Results and Discussion

In this study, yield and agronomic characters of 6 forage pea lines and 2 varieties (control) obtained from the United States Department of Agriculture Gene Bank were investigated in Antalya coastal conditions. The variance analysis of the examined characteristics were presented in Table 3.

Table 3. Variance analysis for some agronomic characteristics of forage pea *(Pisum sativum* L.) lines in Antalya conditions.

SV	df	FD	PH	PN	GN	HBY	HY
Block	2	33.76**	4.35*	1.31^{ns}	0.80^{ns}	0.73^{ns}	1.10^{ns}
Variety	7	0.59^{ns}	2.42^{ns}	2.12^{ns}	8.26**	3.87*	3.30*
SV	df	GY	DMR	BY	TGW	HCP	SCP
Block	2	2.52^{ns}	0.32^{ns}	0.65^{ns}	3.57^{ns}	1.20^{ns}	2.11^{ns}
Variety	7	2.02^{ns}	6.66*	11.05**	14.06**	5.02**	4.81**

*Significant at the 0.05 probability level.**Significant at the 0.01 probability level. ns: non significant (FD: number of days to flowering, PH: plant height, PH: number of pods per plant, GN: number of grains per pod, HBY: herbage yield, HY: hay yield, GY: grain yield, DMR: dry matter rate, BY: biological yield, TGW: thousand grain weight, HCP: herbage crude protein ratio, SCP: seed crude protein ratio)

Based on the statistical analysis, it was noted that the blocks effect was statistically substantial at $p<0.01$ level on flowering days and at $p<0.05$ level on plant height. Furthermore, the effect of different varieties on the number of grains per pod, biological yield, thousand grain weight, herbage crude protein ratio and seed crude protein ratio was found to be markedly noteworthy at the 1% level, it was revealed that varieties had a significant influence on herbage yield, hay yield and dry matter rate at the 5% level (Table 3).

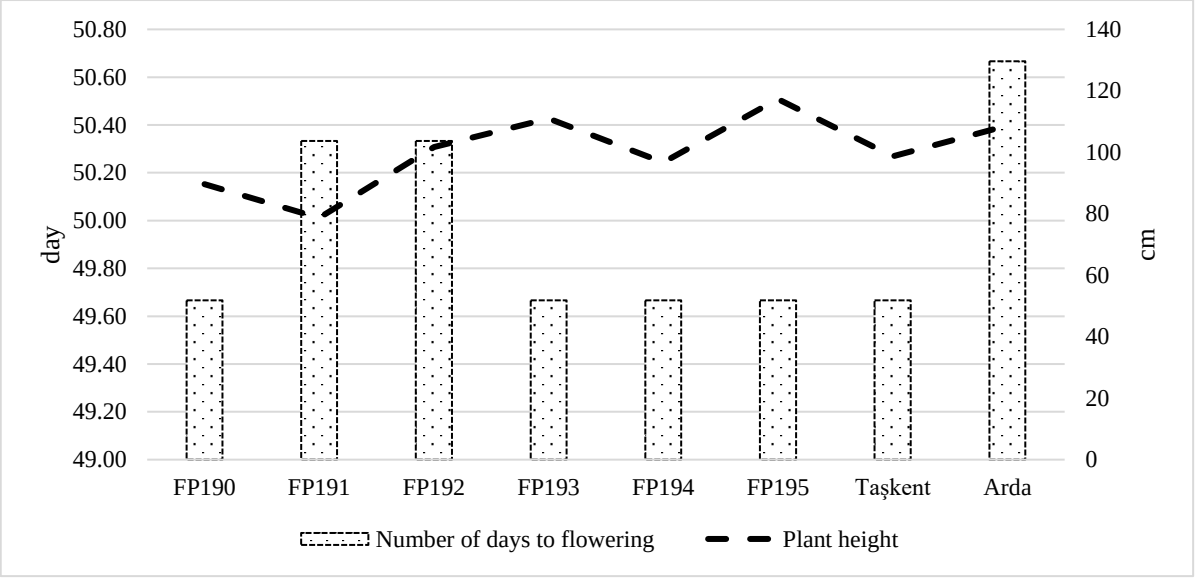


Figure 1. Average flowering days (day) and plant height of forage pea genotypes (*Pisum sativum* L.)

In the study, it was observed that flowering days of the genotypes varied among 49.67 and 50.67 days. Indicated that the genotypes approximately had very immediate values in terms of flowering days (Figure 1). Detected that the flowering period obtained in the study was lower than the 126.00-132.44 flowering days recorded in Diyarbakır ecological conditions. Thereby, thought that the lower determination found in the study may be due to ecological conditions, genetic genotype characteristics and sowing time. In addition, several studies suggeted that Kadıoğlu and Tan (2018), Varol (2016), Yörük (2016) and Seydoşoğlu (2013) reached the flowering days in forage pea varieties as 219.00-240.00 days, 271.00-295.00 days, 60.00-83.30 days and 157.80-175.50 days, respectively.

Moreover, determined that the plant heights varied between 78.67 and 117.33 cm. The genotype with the highest plant height was measured as FP195 (Figure 1). Konuk and Tamkoç (2018) indicated the plant height as 76.10-119.20 cm and the results were similar to that experiment. In studies conducted under Mediterranean climate conditions, Ömeroğlu (2016) determined the plant height to be between 74.40-92.60 cm, as Şahin (2019) measured among 18.95 and 52.79 cm. Differences in plant height may depend on the genotypes genetic characteristic and ability to adapt particular environment (Khan et al., 2013), especially since this character is environmently attached (Solberg et al., 2015).

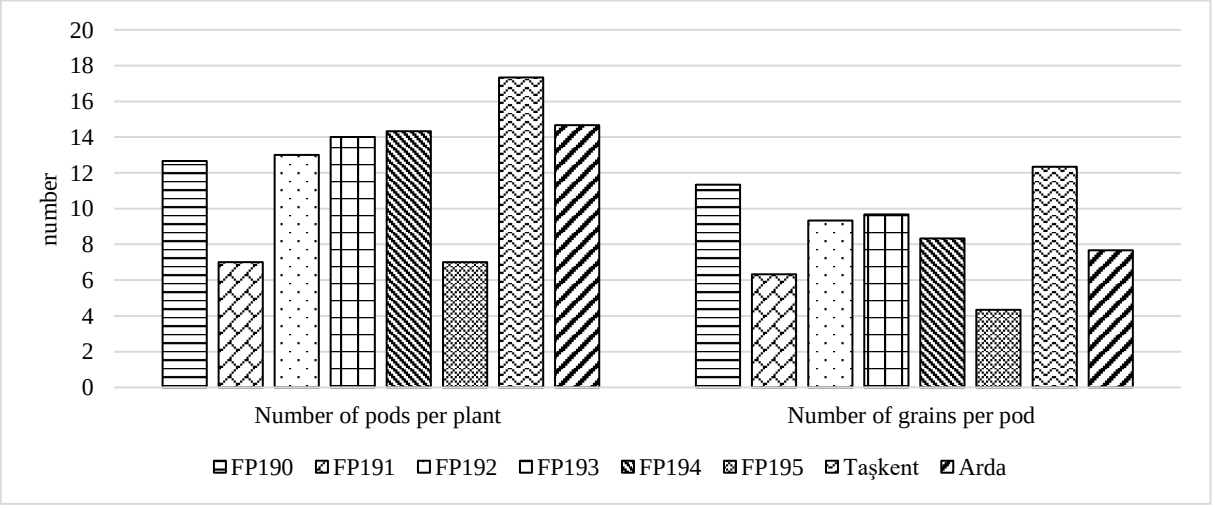


Figure 2. Averages of the number of pods per plant and the number of grains per pod (number) for forage pea genotypes (*Pisum sativum* L.)

Reported that the pod numbers of the forage pea genotypes changed between 7.00 and 17.33, and Tashkent was measured to have the highest pod number among the genotypes (Figure 2). Nonetheless, studies conducted with different forage pea varieties in distinct geographical regions have revealed that the number of pods per plant varies among varieties. Regarding this subject, stated that the number of pods per plant in forage pea varieties varied among Timurağaoğlu (2003) 5.0-12.0, Tan et al. (2012) 10.4-15.5, Alan and Geren (2012) 26.7-28.3, Sayar (2007) 5.6-9.0, Sayar et al. (2009) 6.4-10.0, Kadıoğlu and Tan (2018) 5.8-11.0, Özköse (2017) 3.3-9.0, Uzun et al. (2012) 8.7-11.4 and Kavut and Çelen (2017) 8.2-9.2.
Besides, observed that the highest and lowest grain numbers in the pod varied amid 4.33 and 8.33 (Figure 2). Meanwhile, observed that the average number of grains per pod obtained was higher than the study (3.50-4.30) conducted by Ömeroğlu (2016). Moreover, Harvey and Goodwin (1978) determined the number of grains per pod as 5.0-6.0, and Gençkan (1983) noted as 1.0-10.0. Additionally, Bilgili (1997) obtained as 4.0-5.0, Açıkgöz (2001) as 3.0-6.0, Timurağaoğlu et al. (2004) as 4.0-6.0.

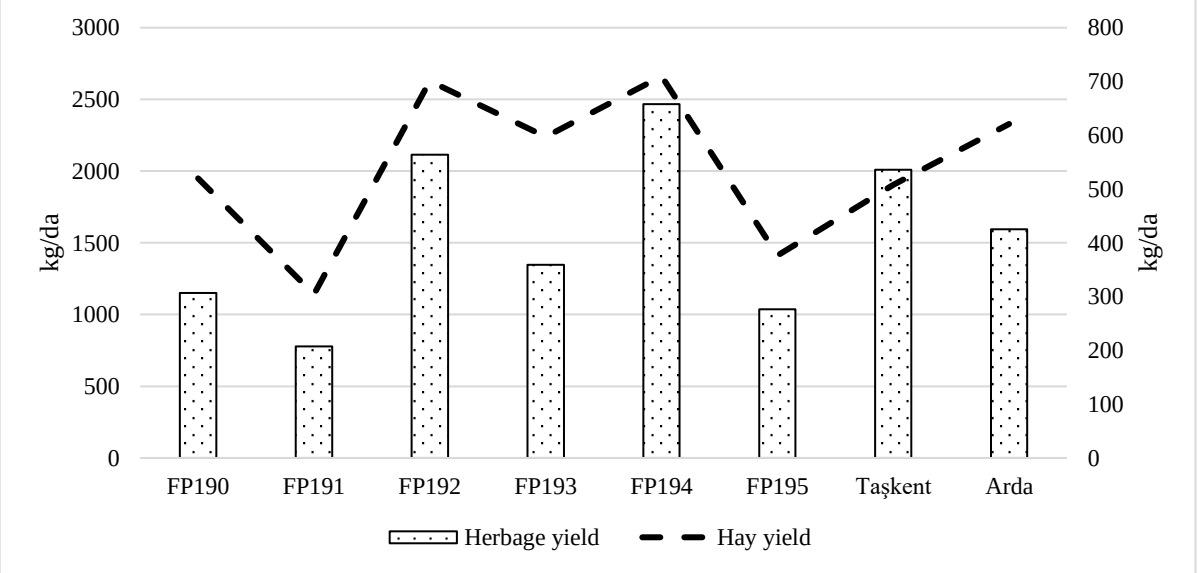


Figure 3. Average herbage yield and hay yield (kg/da) of forage pea genotypes (*Pisum sativum* L.)

As the herbage yields were examined, determined that it was betwixt 778.70 kg/da and 2468.21 kg/da. The highest herbage yield among the genotypes was measured as FP194 (Figure 3). This obtained herbage yield was found to be similar to the expriment (853.60 kg/da - 2442.00 kg/da) conducted by Karaköse (2018). Nevertheless, in the study conducted by Timurağaoğlu et al. (2004), herbage yield was noted as 1167.00-1710.00 kg/da. In the study detected by Seydoşoğlu (2013), herbage yield was between 1143.10-2417.60 kg/da. In Mardin ecological conditions, that was achieved as 3079.00-4078.00 kg/da by Aydın (2023). In Isparta province, was determined as 907.00-1109.00 kg/da by Ömeroğlu (2016).
Observed that the hay yields of the genotypes varied between 304.32 kg/da and 709.83 kg/da. The highest hay yield among genotypes was measured as FP194 (Figure 3). Moreover, Ömeroğlu (2016) reported the hay yield to be amid 221.0-281.0 kg/da. In addition, hay yield was determined to be between 166.90-1190.3 kg/da (Konuk and Tamkoç, 2018), 404.0-542.0 kg/da (Timurağaoğlu et al., 2004), 189.59-332.72 kg/da (Sayar, 2007) and 227.00 kg/da (Çakmakçı and Çeçen, 1996) in Konya, Ankara, Diyarbakır and Antalya ecological conditions, respectively.

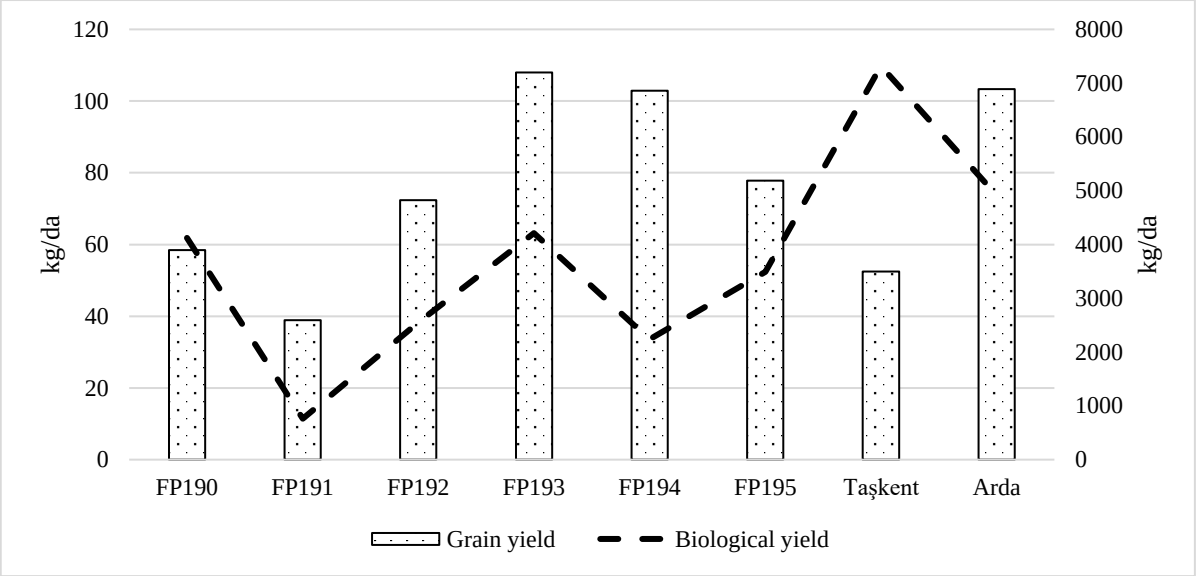


Figure 4. Average grain and biological yield (kg/da) of forage pea genotypes (*Pisum sativum* L.)

The grain yield of forage pea genotypes were recorded between 38.92 kg/da and 107.94 kg/da. Also, the highest grain yield was determined as FP193 (Figure 4). Sayar et al. (2009) in Diyarbakır, Yılmaz (2010) in Istanbul and Ömeroğlu (2016) in Isparta conditions, grain yield was determined as 115.46-210.46 kg/da, 113.70-205.00 kg/da and 159.10-165.10 kg/da.

When the biological yields of the genotypes were examined, found to be between 228.00 kg/da and 818.49 kg/da. The highest biological yield was detected as FP192 (Figure 4). In the study conducted in Sivas and Bursa conditions, the biological yield was noted among119.8-809.3 kg/da and 236.99-358.32 kg/da (Varol, 2016; Öz and Karasu, 2010).

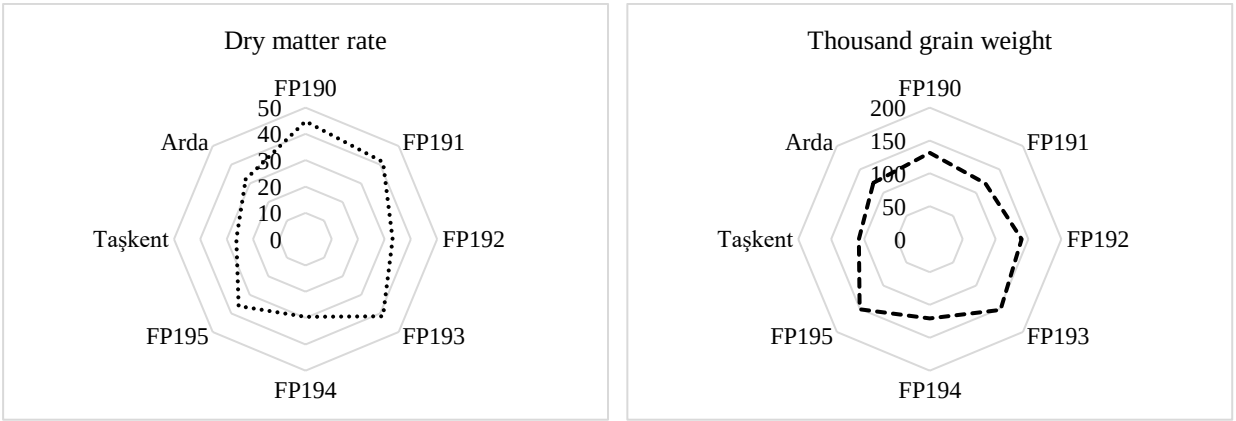


Figure 5. Average dry matter rate (%) and thousand grain weight (g) of forage pea genotypes (*Pisum sativum* L.)

In the study, the dry matter rate were obtained among 26.31% and 44.82%. The highest dry matter rate was measured as FP190 (Figure 5). However, it was observed that the dry matter rate of the forage pea varied between 14.9% and 27.2%, 17.81% and 18.12%, with 17.37% and 21.64%, respectively, according to Çeçen et al. (2005), Kavut (2016) and Yerlikaya (2022).

According to the data obtained, thousand grain weight realized between 107.83 g and 151.83 g. Determined the most in the FP193 genotype (Figure 5). Furthermore, in conditions of Diyarbakır, Bingöl and Giresun, thousand grain weight of forage pea varieties was found as 100.30-214.20 g, 109.7-244.8 g and 128.39-243.82 g (Seydoşoğlu, 2013; Karaköse, 2018; Kılınç, 2017).

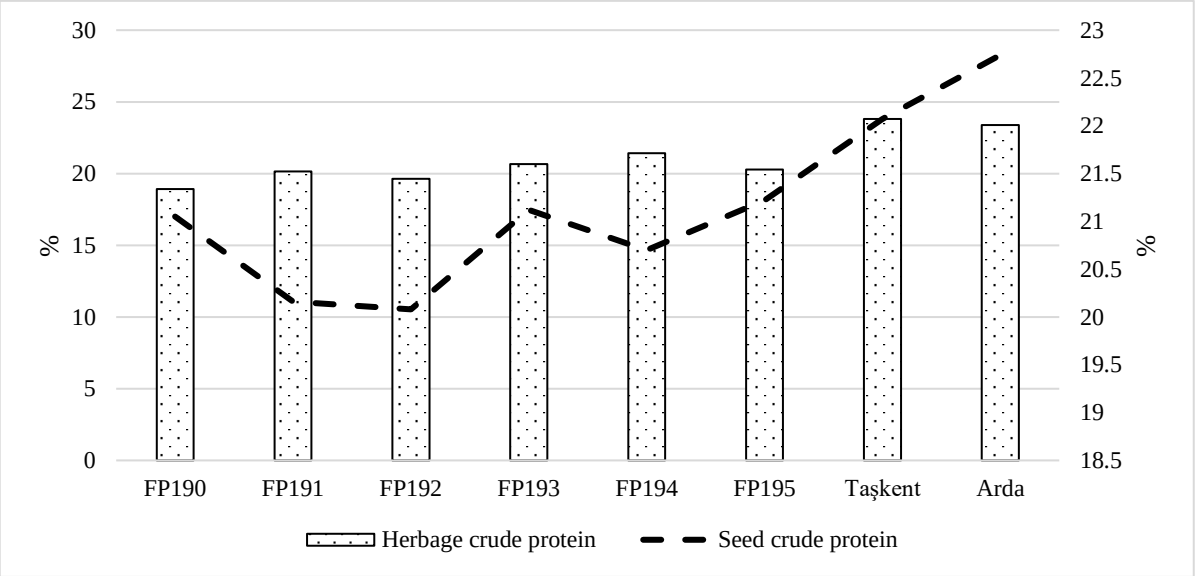


Figure 6. Average herbage and seed crude protein content (%) of forage pea genotypes (*Pisum sativum* L.)

Observed that the herbage crude protein rate in the study varied between 18.92% and 23.81%. In addition, the highest herbage crude protein rate was measured in Taşkent (Figure 6). Timurağaoğlu et al. (2004) found that the crude protein rate were between 18.00% in Ankara conditions, Çomaklı et al. (2012) found that among 18.50% in Erzurum conditions, Aydın (2023) detected that amid 16.21% and 23.59% in Mardin conditions, and Tankuş (2020) indicated between 19.12% and 27.34% in Harran conditions.
When seed crude protein rate were examined, seen that found between 20.08% and 22.74%. Among the genotypes, the highest seed crude protein rate was obtained as Arda (Figure 6). Açıkgöz (2001) detected the crude protein rate in the seed as 19-22% in Bursa conditions. Yerlikaya (2022) noted as 17.54% - 18.17% in Bursa. Thereby, thought that the genetic structure distinction and soil properties may have affected the differences with other studies.

Conclusion

The roughage deficit, has been experienced for current years, continues to be the major issue of animal production in Turkey. Thereby, in the current situation, both producers dealing in animal production complain about not being able to make profitable manufacture due to input (forage) costs and consumers extremely delate about not being able to access affordable animal products (meat, milk, etc.). Moreover, the fundamental solutions to situation is the production of forage crops, has got progressively substantial in recent years. Within framework, legume forage species with a short one-year vegetation period reach to the fore. Essentially, with unique characteristics, forage peas are successfully grown by adapting to the conditions of Antalya as well as other regions. Meantime, observed that genotypes used in experiment carried out in Antalya coastal conditions are appropriate for the cultivation of forage crops. It is believed that pursuing research on this topic in the near future would be more utility to better figure out the adaptation these genotypes will offer to the region.

Conflict of interest: There is no conflict of interest between the authors.
Author Contribution: The authors declared that they have contributed to the article equally. All authors discussed the results and contributed to the final manuscript.

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