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EFFECT OF HARVESTING STAGES ON FORAGE YIELD AND QUALITY OF DIFFERENT LEAF TYPES PEA CULTIVAR

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ABSTRACT

This study is aimed to determine the effects of three different harvesting stages (beginning of flowering, full flowering and seed filling) on forage yield and quality of different leaf type pea (*Pisum sativum* L.) cultivars. Two semi-leafless cultivars (Ulubatli and Kirazli), two leafed cultivars (Golyazi and Urunlu) were used in this research. Dry matter (DM) yield, crude protein (CP) ratio, CP yield, acid detergent fibre (ADF), neutral detergent fibre (NDF), total digestible nutrients (TDN) and relative feed value (RFV) were determined. According to two years averages, Golyazi had the highest DM (2415 kg ha^{-1}) and CP yield (442 kg ha^{-1}). Harvesting at the late stages caused a reduction in forage quality. Contents of CP, TDN and RFV decreased with advancing growth while DM yield, CP yield, ADF and NDF contents increased.

Keywords: ADF, Crude protein, Dry matter yield, Pisum sativum, Semi-leafless

INTRODUCTION

Peas are widely grown for hay, pasturage or silage production either alone or mixed with cereals (McKenzie and Sponer, 1999). Field pea has a benefit over many other crops in that it has the ability to fix its own nitrogen. This makes it useful not only as an alternative crop but also adds rotational benefits. As a forage crop, pea hay and seed is rich in crude protein content, and most mineral elements (Acikgoz et al., 1985).

There are two main leaf types in field pea. One has normal leaves; the second type is the semi-leafless type (Zohary and Hopf, 2002). The main reason for the semi-leafless pea becoming popular was because of their improved standing ability (Heath and Hebblethwaite 1985). In semi-leafless cultivars, the leaflets are replaced with tendrils, the end result being less leaf area but better resistance to lodging (May et al., 2003). Reduced lodging aids in mechanical harvesting (Martin et al., 1994). Previous work showed that semi-leafless pea genotypes with reduced plant height had better light interception and canopy aeration than normal leaf types (Zain et al., 1983; Cawood, 1987). It also showed increased dry matter partitioning to fruits, improved water use efficiency and decreased susceptibility to fungal diseases (Berry 1985; Snoad, 1985; Armstrong, 1989). The ability of semi-leafless cultivars to withstand lodging and disease, and the fact that their morphology allows better aeration within the canopy, has all contributed to their commercial importance (Cote et al., 1992). In recent years, semi-leafless peas were preferred in mixtures over the leafed varieties (Rauber et al., 2001). However, semi-leafless peas were reported to be less competitive than leafed peas (Semere and Froud-Williams, 2001).

Many factors affect the rate of change in nutrient composition with advancing plant development and maturity stages. These factors may include any one or a combination of the following: plant type, climate, season, weather, soil type and fertility, soil moisture, leaf stem ratio, physiological and morphological characteristics and others, and may vary with annuals versus perennials, grasses versus legumes, etc. By themselves, nutrient composition levels are not necessarily the only criterion in evaluating the nutritive value of plants (Prates et al., 1975; Stobbs, 1975; Cook and Harris, 1979). Most plants show a similarity in declining nutrient composition with advancing development towards maturation (Rama et al. 1973; Stubbendieck and Foster, 1978; Tan et al., 2003; Rebole et al., 2004).

The main objectives of this study were to evaluate the influence of harvesting stages upon dry matter yield and forage quality of four pea cultivars varying in foliage type.

MATERIALS AND METHODS

The field experiments were conducted in 2010 and 2011 at Isparta (37^{o} 45' N, 30^{o} 33' E, elevation 1035 m) located in the Mediterranean region of Turkey. Total precipitation was 177 mm in 2010 (March–June) and 210 mm in 2011. The long-term average is 208 mm. Average temperature was 13.9 ^{o}C in 2010 and 12.7 ^{o}C in 2011. The long- term average is 12.8 ^{o}C.

The major soil characteristics, based on the method described by Rowell (1996) were as follows: the soil texture was clay-loam (clay: 29,3%, silt: 46.8%, sand: 23.9%); organic matter was 1.2% by the Walkley-Black method; total salt was 0.35%; lime was 8%, sulphur was 16 mg kg^{-1}, extractable P by 0.8N $NaHCO_3$ extraction was

3.1 mg kg^{-1}; exchangeable K by 1N NH_4OAc was 125 mg kg^{-1}; pH was 7.1 in soil saturation extract. Soil type was a calcareous fulvisol.

The experiments were established in a Randomised Complete Block Design with three replications on 15 and 22 March in 2010 and 2011. Two semi-leafless cultivars (Ulubatli and Kirazli), two leafed cultivars (Golyazi and Urunlu) were used in this research. Pea cultivars were harvested in three different harvesting stages (beginning of flowering, full flowering and seed filling). Individual plot size was 1.8 × 6 m = 10.8 m^2, consisting of six row spaced 30 cm. A fertilizer application (30 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5) was uniformly sprayed after sowing. The experiment was repeated on an adjacent site in the second year.

Plots were harvested by hand. Dry matter (DM) yield, CP ratio, CP yield, acid detergent fibre (ADF), neutral detergent fibre (NDF), total digestible nutrients (TDN) and relative feed value (RFV) were determined in samples taken from quadrats (1 m^2). Samples taken from each plot were dried at room temperature then dried in an oven at 65°C till they reached constant weight. After cooling and weighing, the samples were ground for analyses. Nitrogen content was analysed by the Kjeldahl method (Kacar, 1972). Crude protein content (N×6.25) and then crude protein yields were calculated. Total digestible nutrients (TDN), dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were estimated according to the following equations adapted from Aydın et al. (2010),

TDN = (-1.291 x ADF) + 101.35

DMI = 120/NDF % dry matter basis

DDM = 88.9-(0.779 x ADF % dry matter basis)

RFV = DDM% x DMI% x 0.775

The ANKOM Fibre Analyser was used for NDF and ADF analysis. ANKOM F57 filter bags were used for ADF and NDF analysis in this study. The data from 2010 and 2011 were analysed together with using the Proc GLM (SAS 1998). Means were separated by LSD at the 5% level of significance.

RESULTS

An analysis of variance indicated that there were statistically significant differences among pea cultivars in two year averages for DM and CP yield (Table 1). According to averages of two year, Golyazi had the highest DM (2415 kg ha^{-1}) and CP yield (442 kg ha^{-1}) while the lowest DM yield (1817 kg ha^{-1}) was obtained from semi-leafless cultivar Ulubatlı (Table 2). There were no statistically significant differences in CP ratio, ADF, NDF, TDN and RFV among pea cultivars.

The effects of harvesting stages were significant for all components in two year averages. Contents of CP, TDN and RFV decreased (21.85-16.26%, 71.81-66.05, 212.5-172.2, respectively) with advancing growth while DM yield, CP yield, ADF and NDF contents increased (1492-2809 kg ha^{-1}, 334-455 kg ha^{-1}, 22.88-27.34%, 31.11-36.52%, respectively) (Table 2).

Table 1. Results of Analysis of Variance Traits Determined.

Source of Variance	DF	DM Yield	CP Content	CP Yield	ADF	NDF	TDN	RFV
Year (Y)	1	**	ns	**	ns	ns	ns	ns
Block (year)	4	*	ns	ns	*	*	ns	ns
Cultivar (C)	3	**	ns	**	ns	ns	ns	ns
C x Y int.	3	ns	ns	ns	ns	ns	ns	ns
Harvesting Stage	2	**	**	**	**	**	**	**
HS x Y int.	2	ns	*	ns	ns	*	ns	ns
C x HS int.	6	ns	ns	ns	ns	ns	ns	ns
C x HS x Yint.	9	ns	ns	ns	ns	ns	ns	ns

DF, degrees of freedom; ns, not significant. * : $P < 0.05$, ** : $P < 0.01$.

DISCUSSION

There were statistically significant differences in DM yield among pea cultivars in two year averages. The DM yield of leafed cultivar Golyazi was significantly higher than those of the other three cultivars (Table 2). Average DM yield of the pea cultivars were lower than that of previous experiments (Uzun et al., 2005; Biederbeck and Boudman,1994). The reason for these differences was sowing season. The experiments were established in March 2009 and 2010 due to the harsh climate conditions in winter in the region.

In this study, the DM yields linearly increased at later harvest stages, as plants began to concentrate DM in pods and seeds. An enhanced DM yield with advancing maturity is consistent with results of several researchers (Munoz et al., 1983; Hintz et al., 1992; Osborne and Riedell, 2006; Turk et al., 2007; Turk et al., 2009). There were no statistically significant differences in CP, ADF and NDF ratios among pea cultivars. Crude

Table 2. Dry matter yield and forage quality measured in different cultivars and harvesting stages (averages of 2 years). Figures followed by the same letter do not differ significantly (P < 0.05).

Cultivars	DM Yield (kg ha^{-1})	CP (%)	CP Yield (kg ha^{-1})	ADF (%)	NDF (%)	TDN	RFV
Urünlü	1972 c	18.88	355 c	25.11	34.02	68.93	189.55
Gölyazı	2415 a	18.74	442 a	24.87	33.75	69.24	191.58
Ulubatlı	1817 d	18.86	338 d	25.16	33.55	68.87	192.10
Kirazlı	2238 b	19.02	416 b	25.45	34.12	68.49	188.27
LSD	124	ns	15.4	ns	ns	ns	ns
Harvesting Stages							
BF	1492 c	21.85 a	334 c	22.88 c	31.11 c	71.81 a	212.48 a
FF	1995 b	18.52 b	375 b	25.22 b	33.94 b	68.79 b	189.76 b
SF	2806 a	16.26 c	455 a	27.34 a	36.52 a	66.05 c	172.15 c
LSD	136	1.52	17.6	1.92	2.14	2.11	13.46

BF, beginning of flowering; FF, full flowering; SF, seed filling

protein contents decreased with advancing stages in the present study. Besides N, and hence protein, most minerals also decline with advancing plant development (Rauzi et al., 1969). Maturity stage at harvest is the most important factor determining forage quality. Because P, Ca, Mg and K contents of forage decreased with delayed cutting, forage quality declined with advancing maturity (Blaser et al., 1986; Tan and Serin, 1996). These results are in agreement with our results. Mineral element content changes with maturity are related to the increasing stem to leaf ratio. Leaves are richer in mineral nutrients than stems (Tan et al., 1997) and the proportion of leaves declines to maturity because of senescence of the lower leaves or damage by diseases (Albrecht and Marvin, 1995).

Statistically significant CP yields differences among cultivars were observed in averages of two years (Table 1). Golyazi cultivar had the highest CP yield (442 kg ha^{-1}) while Ulubatli cultivar had the lowest CP yield (338 kg ha^{-1}). The CP yields showed a similar trend with DM yields. Our results confirm those of Uzun and Acikgoz (1998), Turk et al. (2011). Because DM yields increased at later harvest stages, CP yields also increased in the present study.

Acid detergent fibre and NDF content increased with the advancing plant growth. This could be explained by the decrease in proportion of leaves and the increase of the stems proportion with advanced maturity. The trends in ADF and NDF contents with increasing maturity are normally the reverse of protein (Oelberg, 1956; Rebole et al., 2004; Turk et al., 2009).

There were no statistically significant differences in TDN and RFV values among pea cultivars. The highest TDN value (71.81) obtained in before flowering stage, whereas the lowest TDN value (66.05) determined in seed filling stage. The TDN refers to the nutrients that are available for livestock. This variable is related to the ADF concentration of the forage. As ADF increases, TDN declines. As a result, animals are unable to utilize the nutrients that are present in the forage (Aydın et al., 2010).

The RFV is an index that is used to predict the intake and energy value of forages. This index is derived from the DDM and dry matter intake (DMI). Forages with an RFV value over 151, between 150-125, 124-103, 102-87, 86-75, and less than 75 are categorized as prime, premium, good, fair, poor and rejected, respectively (Uzun, 2010). Pea cultivars had relative feed values ranging from 188.3 to 192.1. According to RFV, all cultivars in this study had prime quality. The RFV decreased from 212.5 to 172.2 with advancing harvesting stages. The relative feed value is not a direct measure of the nutritional content of forage, but it is important for estimating the value of forage (Van Soest, 1982).

CONCLUSIONS

The results from the different cultivars and harvesting stages applied in pea in Mediterranean conditions of Turkey can be summarised as follows:

1. Golyazi had the highest DM and CP yield. The lowest DM yield was obtained from semi-leafless cultivar Ulubatli.
2. There were no statistically significant differences in CP ratio, ADF, NDF, TDN and RFV among pea cultivars.
3. Harvesting at the late stages caused a reduction in forage quality. Contents of CP, TDN and RFV decreased with advancing growth while DM yield, CP yield, ADF and NDF contents increased.

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