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Yield Components, Morphology and Forage Quality of Native Alfalfa Ecotypes

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Abstract: Twelve native alfalfa (*Medicago sativa* L.) land races material from Van provinces in Turkey for 10-30 years in the same field in Turkey were investigated in this study. Seed used in this experiment are Adıgüzel-2, Ahlat-3, Alaköy, Çayırbaşı, Dilburnu, Erciş-3, Gülgören, Gülşinberk, Hıdırköy-2, Kasımoğlu-2, Mahmudiye, Otluca ecotypes and Kayseri population (as a check). Seeds planted in September 1999 and greenhouse for shoots measurements before flowering period. Plants harvested early flowering period. The result taken from this experiment clearly showed that there could be variation in yielding and chemical composition. There are significant differences in plant height, stem number, stem size, internode number, internode length, leaf area, leaflet length, dry matter yield, crude cellulose, crude protein, P, K, Ca and Mg rate and total non structural carbohydrates content ($P<0.05$). The longest stem was measured with Mahmudiye ecotypes (94.1 cm) besides 43.4 stem per plant observed with Kasımoğlu ecotypes. Erect form of Çayırbaşı ecotypes had the longest leaflet size (29.28 mm). The differences could be seen most clearly in crude cellulose Erciş-3 ecotype had the lowest CC (194.2 g kg^{-1}). On the other hand promising ecotypes were Çayırbaşı, Kasımoğlu-2, Gülgören, and Hıdırköy as a high yielding 37.7, 36.8, 35.4, and 33.1 g per plant respectively. Variation among alfalfas from this region may be especially valuable to conserve and utilize these germplazm resources.

Key words: *Medicago sativa*, dry matter, crude cellulose, crude protein, mineral matter

Introduction

Alfalfa is the most important forage crop in Turkey. Because of its adaptation capacity and high nutrition values. As a perennial crop, alfalfa is the high yielding economical crop with high feature value. Yield components are a function of vegetative growth rate and plant morphology. The yield components of a forage crop are number of plants per unit area, number of shoots (or tillers) per plant, and mass per individual shoot. Leaf area and leaf mass per shoot are commonly measured because they link yield components to studies of leaf physiology and nutritional value. Sometimes, crown width is recorded as an indirect measure of shoots per plant (Fick *et al.*, 1988).

Alfalfa plant parts have different nutrient concentrations. The concentration of most nutrients is greatest in leaves with the greater concentration of K in stems. Differences exist among leaves according to their position on the plant. Concentrations of N and P are less in basal leaves than the top of stems. In contrast, basal leaves have higher concentrations at Ca and Mg. Stem concentrations of N, P, Ca and Mg decrease from the top to the bottom of the shoot. The concentration of K increases progressively to near the top of the plant then decreases slightly. The variation in environmental conditions will influence nutrient concentrations in forage, because of changes in rate of dry matter production, ion movement in soil, root activity and the uptake of nutrients by the plant (Lanyon and Griffith, 1988).

Forage quality can be defined as the relative performance of animals when herbage is fed to livestock. It is the product of nutrient concentration, intake potential, digestibility and partitioning of metabolized products within the animal. In addition to the direct response of animals to forage quality, because of limitations associated with cost and time In using animals, however, forage quality often is estimated by in vitro or chemical means (Buxton *et al.*, 1996).

One of the most affected focuses on quality is the plant genus and species dependent on plant genotypes (Hacker and Minson, 1981; Marten, 1985). The content of the mineral matter obtained from forage crops should be a level to need the animal feeding requirements. Okuyan *et al.* (1986), provided that forage crops should be include for Ca 0.27- 0.50%, F 0.15-0.27%, K 0.30-0.80% and Mg 0.10-0.20 % (Çomaklı and Taş, 1996).The aim of this study was to compare the differences between some native alfalfa and nationwide produced crops Kayseri population in Turkey and the potential nutritive capacity of these native alfalfa ecotypes.

Materials and Methods

There are two main alfalfa ecotypes in Turkey; the best known is "Kayseri" the other "Ecotype" land rases is grown in Eastern Turkey. It is characterized by slower growth and lower yields in comparison with Kayseri. Twelve native alfalfas (*Medicago sativa* L.) collected from Van Lake region (Eastern region) in Turkey. The seed collected by Sengul (1985) most of them were cultivated in this region for more than 10 to 30 years. Each collection registered at Agricultural Research Institute at Erzurum, Turkey and recorded with its village name as an ecotype. Seeds used at this experiment were Adıgüzel-2, Ahlat-3, Alaköy, Çayırbaşı, Dilburnu, Erciş-3, Gülgören, Gülşinberk, Hıdırköy-2, Kasımoğlu-2, Mahmudiye, Otluca ecotypes and Kayseri population (as a check). Çayırbaşı and Kayseri were erect types and the others were either prostrate or semi prostrate form. All alfalfa seeds were sown in shallow boxes of soil (based on 3:1 rate of soil, sands and organic matter), plants grown in greenhouse. Shoots measurements were made on each of the 5 plants randomly before harvesting. Then each of single plants transplanted into plastic pots of soil on September 1999. Ten plants of each ecotype harvested at the flowering period, and material was determined drying at 78 °C for 24 h. Crude fiber and crude protein determination were made for dry matter (Jones, 1981; Akyıldız, 1984). P, K, Ca and Mg content were examined by Kacar (1972) technique. Data obtained from experiment were analyzed by using SPSS 10.0 statistical methods.

Results and Discussion

Shoot characters: Herbage yield of alfalfa (*Medicago sativa* L.) can be described by yield components of plants height, shoot per plant and yield per plants. Result of this experiment indicated that there were significant differences ($P<0.05$) between plant heights of ecotypes (Table 1). Mahmudiye ecotypes produced much longer plants (94.1 cm) whereas Erciş-3 ecotypes had the shortest plant (62.4 cm) and the other ecotypes had relatively decreasing plant height ranged from 68.2 to 88.1 cm. Plant height was correlated with leaf length ($r=0.558^*$). The average stem number of ecotypes was 37.5 and there were significant differences between ecotypes. Kasımoğlu-2 ecotypes had higher stem (43.4) than the others ecotypes, Alaköy and Çayırbaşı ecotypes showed lower stem (30.1). There wasn't any significant correlation between measured characters with stem numbers. But there was a negative correlation with leaf length ($r=-0.113$), dry matter yield ($r=0.164$), stem size ($r=-0.373$) and leaf area had higher positive correlation ($r=0.514$).

Although plant height and stem length may not be clearly distinguished in the literature, both field and growth chamber studies indicate that accelerated development associated with high stem height was from 53.4 to 65.8 cm. Akbari and Avcıoglu

Table 1: Plant height (PL, cm), stem number (SN), stem size (SS, mm), internode number (IN), internode length (INL, mm), leaf area (LA, cm^2), leaflet length (LL, mm) and dry matter (DM, g $plant^{-1}$) of alfalfa ecotypes.

Ecotype	PL	SN	SS	IN	INL	LA	LL	DM
Adiguzel-2	75.0	40.5	2.47	15.7	4.63	2.943	24.06	29.2
Ahlat-3	68.2	34.3	2.33	17.5	2.91	2.938	20.08	26.1
Alakoy	76.2	30.1	2.53	15.1	3.49	3.087	21.16	30.5
Cayirbasi	81.1	30.1	2.63	15.6	3.54	4.597	29.28	37.7
Dilburnu	74.1	41.6	2.30	18.5	3.45	3.447	16.61	23.6
Ercis-3	62.4	36.7	2.17	15.0	4.39	2.873	19.25	26.3
Gulgoren	74.1	42.5	2.20	14.2	2.71	4.153	25.13	35.4
Gulsinberk	72.4	37.2	2.13	18.6	3.98	3.793	21.01	29.9
Hidirkoy-2	73.3	38.5	2.23	17.2	5.71	3.000	22.26	33.1
Kasimoglu-2	79.2	43.4	2.47	16.1	3.71	4.130	21.76	36.8
Kayseri	85.5	34.4	3.80	15.1	4.52	6.200	26.95	42.6
Mahmudiye	94.1	35.2	2.00	19.8	5.40	3.143	22.34	26.9
Otluyazi	88.1	43.0	1.80	17.5	4.34	3.180	28.14	27.3
Mean	77.2	37.5	2.31	16.6	4.06	3.653	24.23	31.2
LSD (0.05;0.01*)	10.2	3.06	0.66*	2.64	2.03*	1.85*	3.86	6.83

Table 2: Chemical composition, crude cellulose (CC), crude protein (CP), phosphor (P), potassium (K), calcium (Ca), and magnesium (Mg), total nonstructural carbohydrates (TNC) (g kg^{-1}) of alfalfa

Ecotypes	CC	CP	P	K	Ca	Mg	TNC
Adıgüzel -2	284.3	100.6	3.01	36.7	7.62	3.71	175.4
Ahlat -3	254.5	150.6	2.61	51.2	9.64	4.54	169.2
Alaköy	240.4	150.0	3.38	44.6	9.37	4.41	178.9
Çayırbaşı	283.6	140.0	1.90	40.30	10.42	4.73	138.6
Dilburnu	234.6	116.3	2.65	55.2	10.10	5.14	162.1
Erciş -3	194.2	174.4	2.65	40.7	9.10	4.76	161.9
Gülgören	227.1	173.1	2.58	47.8	8.96	4.51	143.5
Gülşinberk	308.4	88.1	2.34	48.3	8.81	4.45	157.5
Hıdırköy -2	249.5	133.1	2.51	45.0	8.41	4.19	160.7
Kasımoğlu -2	288.6	107.5	2.51	51.3	9.16	4.85	183.0
Kayseri	228.6	145.6	2.61	41.9	9.34	4.88	155.8
Mahmudiye	240.3	171.3	2.45	42.4	9.73	4.82	142.8
Otluyazı	269.1	117.5	3.12	53.1	9.87	4.93	182.2
Mean	254.4	136.0	2.65	46.0	9.28	4.61	162.4
LSD (0.05)	23.1	23.75	0.68	11.0	1.43	0.95	2.95

(1994) observed a significant correlation with plant height and leaflet length (r=0.50*) and stem number (r=0.95**). The other studies concluded that alfalfa plant height varied 45-70 cm (Arbi *et al.*, 1979; Volonec *et al.*, 1987; Peterson *et al.*, 1992). The assumed correlation between yield per shoot and yield per unit area may not hold, even in high yielding stands. Analysis of yielding component could help us understand how environment affects alfalfa development if the required information was available.

The number of shoots per plant typically increased with age, but in any growth cycle the maximum was usually set within 14 days of the start of growth (Leach, 1970). Smith (1970) observed no consistent temperature affect on alfalfa tillering, but in study of 2000 genotypes, McLaughlin and Christie (1980) observed that plant with higher shoot number matured earlier and had lower optimal growth temperatures than plant with lower shoot numbers. Pully (1980) measured increased stem number per plant as plant population decreased. Kayseri population studied by Alınoglu *et al.* (1979) indicated that stem size ranged from 2.1 to 9.2 mm. Volonec *et al.* (1987) observation was stem size 2.8 to 3.3 mm.

Stem size was also one of the important characters for the species. Stem size of the ecotypes averaged 2.31 mm. The most tick stem measured with Kayseri population (3.81 mm) the other ecotypes ranged from 2.00 (Mahmudiye ecotypes) to 2.63 mm (Çayırbaşı ecotypes). Stem size had highly significant differences (P>0.01) between ecotypes. Stem size was positively correlated with dry matter yield (r=0.720*) and leaf area (r=0.807*), leaf length (r=0.277). However there is negative correlation between internode number (r= -0.458) and shoot numbers (r= -0.373).

The origin, number and size of individual alfalfa shoots studied by Leach (1970), Singh and Winch (1974) reported that "Vernal" had more shoots per plants than "Sonora" at the early vegetative stage. Sato (1974) showed that stem diameter decreased with increasing temperature, a change that was probably associated with more lignifications. The mass to length ratio of the basal internode increased at lower temperatures (Smith, 1970). This could be due to thicker cell walls with relatively more cellulose, or to a longer growth period because of slower leaf appearance al low temperatures. Volonec and Cherney (1990) showed that shoot number per plant changed from 21 to 59. In addition to shoot elongation similar result were pointed out in some other studies (Smith *et al.*, 1991; Sengul, 1995; Tan and Sengul, 1999).

Internod's number and length: Internode's number was significant (P<0.05) whereas internode's lengths were highly significant (P<0.01). The average of nod number was 16.6 and mean of internode's length was 4.06 mm. Mahmudiye ecotype had more nodes (19.8) than the others. However internode's length of Hıdırköy-2 had longer internode (5.71 mm) than the rest (Table 1). The shortest internode's length was measured with 2.71 mm at Gülgören ecotype. The node length ranged from 2.91 to 5.40 mm (Mahmudiye ecotypes). Observation of ecotypes was negatively correlated with dry matter yield (r= -0.559*) and no significant correlation with stem size (r= 0.458) but positively internode's lengths (r=0.344) and plant height (r=0.320). There is no significant correlation measured with internode's length but notable correlation was found with plant height (r=0.351), stem number (r=0.344) and negative correlation with leaf area (r=-0.144). Internode's number and length under controlled environmental conditions could be useful in parietal purity testing genotypes stated by Perry and Larson (1974) and characterization of alfalfa cultivars has been suggested by Sheridan and McKee (1968) Varburton and Smith (1993) studied Indian and Middle eastern alfalfa varieties indicated that the internode number changed from 9.01 to 10.13. However internode's length was 6.72 to 7.37 cm. On the other hand Volonec *et al.* (1987) indicated that number of stem can be changed with plant population, as plant population increased stem number decreased from 13.9 to 12.7. Stem dry weight and internode's length was reduced with increasing moisture stress. Brown and Tanner (1983) showed that the stem extension rate was nearly constant throughout the vegetative regrowth period under well-watered conditions.

Leaf area and leaflet length: Leaf size of alfalfa ecotypes represents important characters of species. As observed for leaf area and leaf length, significant differences ($P<0.05$) were found among ecotypes. Measurement of the leaf area indicated that the highest leaf area belonged to Kayseri population (6.200 cm^2) and the lowest 2.873 cm^2 to Erciş-3 ecotype. However longest leaf belonged to Çayırbaşı ecotype (29.28 mm) whereas Dilburnu ecotype had the shortest leaf (16.61 mm) and remaining ecotype leaflet size ranged from 19.25 to 28.14 mm while average leaflet length observed 24.23 mm (Table 1). Leaf area was positively correlated with dry matter yield ($r=0.843^*$) and with stem size ($r=0.807^*$) also no significant correlation with leaf length ($r=0.510$) and negatively with internode's number ($r=-0.345$). Comparing with leaf length there is a positive correlation with dry matter yield ($r=0.625^*$), and plant height ($r=0.558^*$). Newly emerged alfalfa seedlings are relatively intolerant of low irradiances, which had larger leaflets at low light, alfalfa leaflets tended to be smaller at low than at moderate irradiances. Under low irradiance, alfalfa seedlings partitioned relatively more dry matter to leaves than to stems, as evidenced by higher leaf to stem ratios under such conditions (Fick *et al.*, 1988). Indian and Middle Eastern alfalfas studied by Volonec *et al.* (1987) indicated that leaflet area was 27.7 to 2.51 cm^2. Smith *et al.* (1991) measured with 27.7-to 35.6 cm^2 and leaf length was 1.64 to 1.88 cm. Alfalfa leaf morphology studied by Etzel *et al.* (1988) indicated that slow shoot elongation rate phenotype had more leaf area (3.2 cm^2) per plant than rapid shoot elongation rate of plant phenotype (2.4 cm^2) and both had less then seven and nine multifoliolate leaflet plants (2.4-5.9 cm^2) respectively. Peru and Diablo Verde varieties studied by Akbari and Avcıoglu (1994) found a significant correlation between plant height ($r=0.50^*$) and shoot number ($r=0.60^{**}$) with leaf area.

Dry matter yield: As observed in dry matter yield per plant, Kayseri population produced higher dry matter yield (42.6 g $palant^{-1}$) than the others. Meanwhile the average dry matter yield observed to be 31.32 g and in the other ecotypes dry matter yield ranged from 23.6 to 37.7 g (Table 1). The dry matter yield of ecotypes had significant differences, when all the 13 ecotypes were considered dry matter yield per plant at ecotypes were negatively correlated with internode number ($r=-0.559^*$) and positively with leaflet length ($r=0.625^*$), stem size ($r=0.720^*$) and with leaf area ($r=0.843^*$).

This must be expected because of plants had longer shoot size, inter node number and even leave size (Hendershot and Volonec, 1989). The components of herbage yield of multifoliolated alfalfa studied by Volonec and Cherney (1990), stated that the herbage yield changes 24 to 53 g per plant. And early studies by Sengul (1995) and Tan and Sengul (1999) found similar responses on this related collection. Environmental effects on vegetative growth received attention because rapid vegetative growth is important for high yields under such harvest management. Some investigators compared environmental effects on plants of common chronological age while others compared plants of common developmental stage. The distinction is important because growth rates (measured by yield) and development rate (measured by morphology) respond differently to the environment.

Crude Cellulose: Crude cellulose (CC) content varied significantly depending on ecotypes ($P<0.01$). On average CC produced in Gülşinberk ecotype (308.4 g kg^{-1}) was higher than that of the others. Erciş-3 ecotype (194.2 g kg^{-1}) was the lowest of the all ecotypes and average crude cellulose was 254.3 g kg^{-1} (Table 2). The crude cellulose and lignin could be measured at the stage of harvested time of alfalfa in contrast of decreasing mineral matter and vitamin. As a matter of fact the digestion rate highly decreased connect to maturity timing (Barnes *et al.*, 1995). Manga, (1978) recorded that as the late maturity period crude cellulose increased 26.44 to 35.13%. Kincaid and Cronrath (1983) observed that at the early stage of grown had 21.3% crude cellulose it has been dropped by 9% at the stage of growing period. Sato (1974) showed that stem diameter decreased with increasing temperature, a change that was probably associated with more lignifications. The mass to length ratio of the basal internode increased at lower temperatures. This could be due to thicker cell walls with relatively more cellulose, or to a longer growth period because of slower leaf appearance al low temperatures.

Crude Protein: The crude protein of alfalfa increased with the availability of K (Bailey, 1983). The rate of symbiotic fixation of N that is characteristic of well-nodulated alfalfa may be decreased by inadequate K availability because of reduced enzyme activity (Duke *et al.*, 1980). This experiment indicated that there is significant differences ($P<0.01$) between ecotypes. Harvesting crude protein was higher at Erciş-3 ecotype (174.3 g kg^{-1}) whereas the lowest was Gülşinberk (88.1 g kg^{-1}) (Table 2). Increase in K availability increased nodule number, carbon exchange rate, and carbohydrate translocation from stems to nodules. Drought tended to increase stem CP off all legumes, but this response was consistent across all growth periods (Peterson *et al.*, 1992). Halim *et al.* (1989) reported a positive association of leaf CP and negative association of stem CP with increasing irrigation level in alfalfa. The contrasting response between leaves and stems studied bye Kincaid and Cronrath (1983) and Koç (1991). Koç and Gökkuş (1995) with bromus inermis, Tan (1995) with vicia sativa and Akgün *et al.* (1999) with tetraploid perennial rye grasses indicated that similar response of CP.

Phosphor: Studies on P concentration of the alfalfa ecotypes demonstrated that the highest yield was at 3.38 g kg^{-1} (Alaköy-2 ecotype) and lowest one was 1.90 g kg^{-1} with Çayırbaşı-3 ecotype (Table 2). Aging of the plants and deterioration of P stated changes from 1528 to 2197 ppm by Yolcu *et al.* (2000) with the *Medicago varia* 887-2967 ppm studied by Bakoğlu (1995). The concentration and quantity of P in harvested alfalfa forage are less than N or K. Mclsted *et al.* (1969) provide a critical value of 3.5 g kg^{-1} of P for the upper herbage at the early flowering stage. A sufficiency range of 2.6 to 7.0 g kg^{-1} of P for the upper 152 mm of the alfalfa plant has been suggested for first-cut alfalfa. Phosphorus concentrations, like other nutrients, generally decrease with maturity (Kincaid and Cronrath, 1983; Vaneys and Reid, 1987)

Potassium: The concentration of most nutrients are greatest in the leaves with the greater concentration of K in stems a significant exception. The K requirement of alfalfa is greater than that for any other nutrient. A sufficient K concentration of the alfalfa plant at early flower is 25 g kg^{-1} (Kelling, 1982). Data taken from this experiment indicated that K content of native alfalfa ecotypes was significantly different ($P<001$). The average K content was 46.0 g kg^{-1}. Plant harvested from Dilburnu ecotypes were highest at the rate of 55.2 in contrast Adıgüzel ecotypes were lowest at level of 36.7 g kg^{-1}. The other ecotypes ranged from 51.4 to 40.3 g kg^{-1} respectively (Table 2). The composition of the alfalfa plant is not uniform (Kim *et al.*, 1990; Mayland *et al.*, 1992), however and the impact of the proportion of various plant parts and their respective concentrations should be recognized when plant samples are used for diagnostic purposes. The concentration of K increases progressively to near the top of the plant then decreases slightly. The variation in environmental conditions will influence nutrient concentrations in forage, because of changes in rate of dry matter production (Porter and Reynold, 1975).

Calcium and Magnesium: Calcium and Mg concentrations in alfalfa are greater than for the grasses at equivalent stages of maturity. For this reason, alfalfa is considered a superior source of these nutrients in animal rations than cither forage grasses. At this experiment the average Ca rate was 9.28 g kg^{-1} while Mg was 4.61 g kg^{-1} (Table 2). Actual concentrations can be quite variable as a result of several factors, including soil texture, pH and date of harvesting. For example, Adams (1980) found Ca content of alfalfa decreased from 14 g kg^{-1} at a l June harvest to 9.5 g kg^{-1} 4 weeks later. The Mg content dropped from 1.9 to 0.8 g kg^{-1} during the same period. Calcium and magnesium are associated closely with soil acidity and liming as mentioned. Kelling (1982) gives sufficiency ranges in the top 152 mm of first-cut alfalfa as 5 to 30 g kg^{-1} for Ca and 3 to 10 g kg^{-1} for Mg. *Medicago varia* examined by Bakoğlu (1995) plant harvested early stage showed higher Ca (3.14 %) than late stage (1.82%), while Mg rate was 3132 to 1531 ppm respectively.

Total non-structural carbohydrates: Total non-structural carbohydrates (TNC) in roots are important for persistence and may be utilized to support regrowt of alfalfa fallowing defoliation. TNC concentration typically decline as regrowt begins and increased as plants begin to flower (Etzel *et al.*, 1988). Averaged over all ecotypes root TNC concentration was 162.4 g kg^{-1}. The root of Kasımoglu plants produced greatest TNC concentration (183.0 g kg^{-1} and it was lowest in ecotype of Çayırbaşı (138.6 g kg^{-1}) and the other ecotypes ranged from 148.8 to 182.2 g kg^{-1} (Table 2). There is a negative correlation with leaf area (r= −0.358), and positive with shoot numbers of ecotypes (r=0.330). Pearson and Hunt (1972) found that the rate of leaf area accumulation for primary growth was about equal in 20/15 and 30/25°C environments, but was faster for regrowth in the 20/15°C environment, possibly because of higher TNC at the lower temperature. For the first 7 d of regrowth, Totana had maximal rates at about 27°C and Rhizoma at about 33°C.

In conclusion the result taken from this experiment clearly showed that there could be variation in yielding and chemical composition. Native alfalfa collected from Van province in Turkey revealed that significant differences in stem length, stem number, stem size, internode number, internode length, leaf area, leaflet length, dry matter yield, crude protein, P, K, Ca and Mg rate, and TNC these differences could be seen most clearly in crude cellulose. Erciş-3 ecotype had the lowest CC (194.2 g kg^{-1}). On the other hand promising ecotypes were noticed Çayırbaşı, Kasımoğlu-2, Gülgören and Hıdırköy as a high yielding 37.7, 36.8, 35.4 and 33.1 g per plant respectively.

The inherent genetic variability of alfalfa makes generalization risky without comprehensive studies of divergent genetic material. More comprehensive work is needed to develop his variability. Understanding of variation among alfalfas from this region may be especially valuable in effort to conserve and utilize these germplazm resources.

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