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Effect of Autumn and Spring Sowing Dates on Hay Yield and Quality of Oat (*Avena sativa* L.) Genotypes

[1]Nevzat Aydin, [2]Zeki Mut, [2]Hanife Mut and [3]Ilknur Ayan
[1]Karamanoglu Mehmetbey University, Vocational School, Karaman 70200, Turkey
[2]Department of Field Crops, Faculty of Agriculture, University of Bozok, Yozgat 66100, Turkey
[3]Department of Field Crops, Faculty of Agriculture, Ondokuz University of Mayis, Samsun 55130, Turkey

Abstract: The objective of this study was to investigate the effects of sowing on hay yield and quality of oat genotypes. Sixteen oat genotypes were grown over the consecutive four growing seasons in Samsun, North of Turkey. Hay yield and quality were significantly different between genotypes and sowing dates. Hay yield, Crude Protein (CP), Acid Detergent Fibre (ADF), Neutral Detergent Fibre (NDF), Total Digestible Nutrients (TDN), Relative Feed Value (RFV), Ca, K, P and Mg contents of hay were determined. Hay yield of the oat genotypes in the autumn sowing was higher than in the spring sowing while hay quality (CP, ADF, NDF, TDN, RFV and some elements) in the autumn sowing was lower than in the spring sowing. The hay yield of late-maturing and tall genotypes like Yesilkoy-330, Yesilkoy-1779, Faikbey and Seydisehir (12.1, 12.2, 12.4 and 12.9 t ha^{-1}, respectively) were higher compared with the other genotypes in sowed in autumn. But quality of these genotypes in autumn sowing was lower than the other genotypes. In spring sowing, genotypes Samsun and Kupa had the highest hay yield and fairly high quality. Ca, K and P contents of hay were adequate for ruminants in both sowing dates but Mg content was not adequate. This study showed that sowing date had great effect on hay yield and quality potential of oat genotypes.

Key words: Oat, genotypes, hay yield, ADF, NDF, quality, Turkey

INTRODUCTION

In Turkey, the capacity of natural grassland was lower as well as other forage crops production that are an important feed source was undeveloped and therefore, remains inadequate for present livestock. As alternative feed source, uses of small grain cereals forage could be partly solved for scarcity of available forage (Çelik and Bulur, 1996). Small grain cereal forages are greatly adjusted highly multi-purpose forages used for pasture, green chop, silage and hay (Fohner, 2002). Cereal forages are a major crop both in Turkey and in many parts of world and their importance is increasing because of their significant economic and environmental benefits (Braunwart *et al*., 2001). Oat (*Avena sativa* L.) is used extensively as feed for livestock because of its high-quality as well as its high-forage yield (Moreira, 1989; Zhang *et al*., 1998). Oat varieties are sown either in the fall or in the spring in Turkey. Oat can be grown either at coastal regions in spring as well as in fall or inland regions of Turkey in spring due to frost damage. Oat genotypes can be generally grown for both grain and forage in Turkey. Several studies have evaluated grain oat genotypes for forage yield. Riveland *et al*. (1977) evaluated 12 genotypes and found that medium to late-maturing genotypes produced the greatest forage yield.

Anderson and Kaufmann (1963) evaluated 25 genotypes in Canada and concluded that breeding for forage yield was unnecessary because late-maturing genotypes were suitable for both seed and forage production. Kaufmann (1961) and Stuthman and Marten (1972) also reported that late-maturing genotypes had high forage yield but Stuthman and Marten (1972) found no relationship between forage yield and grain yield. Folkins and Kaufmann (1974) found that five oat genotypes ranked the same for forage and grain yield in 1 year but not in 2 other years. If a grain oat is to be used as a forage oat in dairy regions, it is important that the oat also have good forage quality (Cherney and Marten, 1982). Some researchers argued that the value of high quality forage for improving body weight gain on ruminant animals (Waldo and Jorgensen, 1981; Linn and Martin, 1989). Juskiw *et al*. (2000) stated that quality

Corresponding Author: Zeki Mut, Department of Field Crops, Faculty of Agriculture, Bozok University, Yozgat 66100, Turkey

forage must have high intake, digestibility and efficiency of utilization. Plant cell walls, containing a digestible and an indigestible fraction are an important element fixing forage quality. ADF (acid detergent fiber) and NDF (neutral detergent fiber) are good indicators of fiber contents in forages. While Acid Detergent Fiber (ADF) content is a measure of the indigestible fraction, Neutral Detergent Fiber (NDF) content is a measure of the total cell wall fraction.

Oat genotypes that are low in NDF and ADF should have good forage quality because low NDF is associated with high forage intake and low ADF is associated with high digestibility. Protein content is an important feed factor per se, with high quality feed having high protein content. The chemical composition and nutritive value of green plant material can give useful information about the forage quality (Kjos, 1990). About 12 oat genotypes evaluated by Riveland *et al.* (1977) were similar in forage quality and nutritionally competitive with good-quality cool-season grass hay. Additionally, Stuthman and Marten (1972) found minimal variation for forage quality among 11 oat genotypes.

The differences regarding hay yield and quality of different oat genotypes sown in autumn and spring were investigated in this study.

MATERIALS AND METHODS

A field experiment was conducted for 4 years during the 2003-2007 growing seasons at the Experiment Farm of Ondokuz Mayis University in Samsun, Turkey. The altitude of experimental area was 195 m (41°21'N, 36°15'E). The experiment was established in a clay soil with pH 7.10, organic matter content 3.01%, available P content 25.40 ppm and K 305 ppm (0-30 cm depth). Climatic data during the four growing seasons of the experimentation were shown in Table 1. The genotypes were shown in a completely randomized block design with three replications. Names and origin of genotypes is used in the study were shown in Table 2. Each genotype was sown in 7.2 m^2 (1.2 by 6.0 m) plots consisting of 6 row with 20 cm row spacing at the beginning of November for the autumn sowing and at the beginning of March for the spring sowing in all years. Plots were fertilized with 60 kg N and 60 kg P ha^{-1} at sowing. Harvest dates were shown in Table 2. Maturity at harvest was determined using Zadoks's scale (Zadok *et al.*, 1974). Harvest was done at late milk dough (Zadok scale 77).

A sub-sample (800-1000 g) was randomly selected from each harvested plot to estimate hay yield and provide samples for forage quality analysis. The samples were weighed and dried for 72 h by forced-air drying oven at 65°C. The dried samples were reassembled and ground to pass through a 1 mm screen. Crude protein, Acid Detergent Fibre (ADF), Neutral Ddetergent Fibre (NDF) and Ca, K, Mg and P contents of samples were determined using Near Infrared Reflectance Spectroscopy (NIRS) (Hoy *et al.*, 2002; Poblaciones *et al.*, 2008). NIRS was calibrated using software program coded IC-0904 FE.

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:

$$TDN = (-1.291 \times ADF) + 101.35$$

$$DMI = 120/NDF\% \text{ dry matter basis}$$

$$DDM = 88.9-(0.779 \times ADF\% \text{ dry matter basis})$$

$$RFV = DDM\% \times DMI\% \times 0.775$$

Data were analyzed with Analysis of Variance (ANOVA) procedures using the MSTAT-C statistical software. The mean separation among treatment means

Table 1: Monthly total rainfall and mean air temperature during the four growing seasons of experimentation at Samsun, Turkey

	Total monthly rainfall (mm)					Mean monthly temperature (°C)				
Months	2003-2004	2004-2005	2005-2006	2006-2007	30-year average	2003-2004	2004-2005	2005-2006	2006-2007	30-year average
Autumn										
November	64.0	174.2	74.2	65.8	83.0	11.5	12.2	12.3	11.5	11.9
December	104.0	84.4	40.4	71.4	73.2	9.3	8.9	10.0	7.2	9.0
January	84.2	62.8	121.3	24.5	60.7	8.1	9.0	4.7	9.6	7.1
February	43.9	43.1	98.7	43.8	50.7	7.5	7.5	6.0	7.5	6.6
March	66.2	141.6	94.6	68.1	56.8	8.5	7.2	9.7	8.6	7.8
April	101.0	87.8	33.7	25.9	58.6	11.4	11.4	11.0	9.9	11.2
May	56.2	34.7	69.0	67.0	49.3	15.0	15.8	14.6	17.2	15.3
Sum	519.5	628.6	531.9	366.5	432.3	10.2	10.3	9.8	10.2	9.8
Spring										
February	43.9	43.1	98.7	43.8	50.7	7.5	7.5	6.0	7.5	6.6
March	66.2	141.6	94.6	68.1	56.8	8.5	7.2	9.7	8.6	7.8
April	101.0	87.8	33.7	25.9	58.6	11.4	11.4	11.0	9.9	11.2
May	56.2	34.7	69.0	67.0	49.3	15.0	15.8	14.6	17.2	15.3
June	77.6	51.1	36.3	38.0	48.6	20.0	20.2	21.3	23.0	20.0
Sum	344.9	358.3	332.3	242.8	264.0	12.5	12.4	12.5	13.2	12.2

Table 2: Origin, harvest date and plant height of investigated oat genotypes

		Harvest date (days after 1st of April)*		Plant height (cm)*	
Genotype	Origin	Autumn sowing	Spring sowing	Autumn sowing	Spring sowing
Checota	USA	56	72	115.3	95.0
Peniarth	USA	63	76	106.0	86.9
Yesilkoy-330	Turkey	62	75	131.8	112.2
Yesilkoy-1779	Turkey	62	75	130.2	106.9
Faikbey	Turkey	63	76	130.0	111.0
Seydisehir	Turkey	63	76	134.5	113.7
Rize	Turkey-local population	59	74	122.7	103.6
Mugla	Turkey-local population	60	73	124.0	108.8
Samsun	Turkey-local population	61	74	121.7	105.2
Karaman	Turkey-local population	56	71	110.7	95.0
Kupa	Croatia	64	75	99.2	80.2
Baranja	Croatia	65	76	118.0	97.5
Samsun-Kavak	Turkey-local population	58	73	133.7	112.4
Ordu	Turkey-local population	58	73	113.0	97.0
Sivas	Turkey-local population	57	73	116.4	87.5
Bursa	Turkey-local population	62	76	116.7	96.2

*Means are averaged over four growing seasons (2003-2007) and three replicates

for years, sowing date and variety was obtained by using the Least Significant Difference (LSD) test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Precipitations and temperatures for the years under study are shown in Table 1. Cumulative precipitation both in autumn and in spring of 1st, 2nd and 3rd growing seasons was more than the normal yearly average. However, cumulative precipitation in autumn and spring of fourth growing season was less than the normal yearly average. Mean temperatures over 30 years were similar for the four growing season years (Table 1).

Variance analysis of the 4 years data showed that significant effect of genotype, sowing date, year and their interaction on hay yield and hay quality. As shown in Table 3-5 hay yield for both sowing dates in the growing seasons 2003-04 (first year) and 2004-05 (second year) was higher than 2005-06 (third year) and 2006-07 (fourth year). This may result from the fact that the rainfall between March and May was much higher in the first and second year compared with the third and fourth year (Table 1).

Hay yield: Maturity period for hay among genotypes in the autumn sowing was shorter than that of the spring sowing. Maturity period of Checota and Karaman were earlier than that of the others both in the autumn and in the spring sowing (Table 2). Plant height of genotypes in autumn sowing had taller than in spring sowing. Hay yield of the genotypes in the autumn sowing was higher than in the spring sowing.

Comparison of hay yields by the sowing time indicated a clear advantage of autumn sowing. Based on 4 years data autumn sowed oat resulted in 56.4% higher hay yield than the spring sowed crop (Table 3). This result could be due primarily to air temperature, precipitation and other factors. Similar findings were indicated by Maloney *et al*. (1999).

The hay yield of genotypes Yesilkoy-330, Yesilkoy-1779, Faikbey and Seydisehir (12.1, 12.2, 12.4 and 12.9 t ha^{-1}, respectively) were higher compared with the other genotypes in sowed in autumn. Genotypes Sivas and Karaman had the lowest hay yield (5.21 and 5.87 t ha^{-1}, respectively) (Table 5). The highest hay yield in spring sowing was obtained from Samsun and Kupa genotypes (8.25 and 7.77 t ha^{-1}, respectively). This study in the autumn sowing, hay yield of genotypes which had tall and late-maturing were generally higher than the other genotypes (Table 1, 3). Chapko *et al*. (1991) showed that tall, late-maturing genotypes were associated with high forage yield.

Similar results were reported by other investigators (Anderson and Kaufmann, 1963; Stuthman and Marten, 1972). On the contrary, there is no such a relationship in the spring sowing. Maturity differences among the genotypes were much greater in autumn sowing than in spring sowing. These results agree with those of Smith (1974) and found that a change from warm to cool temperature delayed panicle emergence in oat while a change from cool to warm decreased time to reach this maturity stage.

Hay quality: Significant differences were found amongst years, the genotypes and sowing dates regarding crude protein, ADF, NDF, TDN, RFV and mineral contents of hay. Crude protein content of forage is one of the most important criteria for forage quality evaluation (Caballero *et al*., 1995; Assefa and Ledin, 2001). The highest CP content was obtained in autumn sowing in the third year and in the spring sowing in the second and third years (Table 4). CP concentrations for all oat genotypes were higher in spring sowing than in autumn sowing (104.0, 92.0 g kg^{-1} DM, respectively) (Table 3). Among genotypes, CP concentrations were

Table 3: Effects of sowing date on the parameters investigated in the study as 4 year average

Sowing date	HY (t ha^{-1})	CP (g kg^{-1})	ADF (g kg^{-1})	NDF (g kg^{-1})	TDN (g kg^{-1})	RFV (%)	Ca (g kg^{-1})	K (g kg^{-1})	P (g kg^{-1})	Mg (g kg^{-1})
Autumn	9.87^{a}	92.0^{b}	384.7^{a}	614.6^{a}	516.8^{b}	89.7^{b}	4.69	17.77	3.20^{b}	1.17^{a}
Spring	6.31^{b}	104.0^{a}	374.4^{b}	597.7^{b}	530.1^{a}	93.5^{a}	4.73	17.46	3.37^{a}	1.11^{b}

HY: Hay yield, CP: Crude protein, NDF: Neutral detergent fibers, ADF: Acid detergent fibers, TDN: Total digestible nutrients, RFV: Relative feed value, Ca: Calcium, K: Potassium, P: Phosphor, MG: Magnesium. Means within a column followed by the same lowercase letter are not significantly different ($p<0.01$)

Table 4: Effects of sowing date on the parameters investigated in the study as 4 year average

Sowing date	Years	HY (t ha^{-1})	CP (g kg^{-1})	ADF (g kg^{-1})	NDF (g kg^{-1})	TDN (g kg^{-1})	RFV (%)	Ca (g kg^{-1})	K (g kg^{-1})	P (g kg^{-1})	Mg (g kg^{-1})
Autumn	1	10.30^{ab}	89.4^{bc}	385.5^{b}	600.9^{b}	515.8^{a}	91.6^{ab}	4.53^{b}	17.16^{b}	3.17^{b}	1.24^{b}
	2	10.70^{a}	92.1^{b}	378.5^{b}	605.2^{b}	524.8^{a}	91.8^{a}	4.82^{a}	17.31^{b}	3.31^{a}	1.38^{a}
	3	9.65^{b}	99.2^{a}	380.3^{b}	623.1^{a}	522.5^{a}	89.1^{b}	4.63^{ab}	18.96^{a}	3.14^{b}	1.07^{c}
	4	8.80^{c}	87.3^{c}	394.5^{a}	629.2^{a}	504.2^{b}	86.5^{c}	4.81^{a}	17.66^{b}	3.19^{b}	1.02^{c}
Spring	1	6.77^{a}	101.8^{b}	387.4^{a}	610.7^{a}	513.4^{c}	90.1^{b}	4.21^{c}	18.28^{a}	3.28^{b}	1.08
	2	6.60^{ab}	105.7^{a}	358.1^{c}	563.3^{b}	551.2^{a}	101.3^{a}	4.43^{c}	16.11^{c}	3.41^{a}	1.11
	3	6.24^{b}	108.1^{a}	365.8^{b}	608.4^{a}	541.3^{b}	92.7^{b}	5.57^{a}	18.02^{a}	3.41^{a}	1.13
	4	5.64^{c}	100.5^{b}	386.3^{a}	608.3^{a}	514.8^{c}	90.0^{b}	4.74^{b}	17.47^{b}	3.37^{a}	1.11

HY: Hay yield, CP: Crude protein, NDF: Neutral detergent fibers, ADF: Acid detergent fibers, TDN: Total digestible nutrients, RFV: Relative feed value, Ca: Calcium, K: Potassium, P: Phosphor, MG: Magnesium. Means within a column followed by the same lowercase letter are not significantly different ($p<0.01$)

Table 5: Hay yield (HY), some quality characters and mineral concentration of oat genotypes in the autumn and spring sowing

Genotype	HY (t ha^{-1})	CP (g kg^{-1})	ADF (g kg^{-1})	NDF (g kg^{-1})	TDN (g kg^{-1})	RFV (%)	Ca (g kg^{-1})	K (g kg^{-1})	P (g kg^{-1})	Mg (g kg^{-1})
Autumn sowing										
Checota	11.10^{bc}	84.1^{fg}	365.2^{e}	582.8^{f}	542.1^{a}	97.1^{a}	4.34^{de}	16.47^{ef}	3.17^{efg}	1.18^{b-e}
Peniarth	10.40^{cd}	102.3^{ab}	367.2^{c}-^{f}	603.1^{c}-^{f}	539.4^{a}	93.6^{abc}	4.54^{cde}	19.79^{a}	3.39^{ab}	1.20^{a-d}
Yesilkoy-330	12.10^{ab}	81.4g	404.0^{a}	634.2^{ab}	491.9^{e}	84.6^{fg}	4.95^{bc}	17.29^{c-f}	3.01^{hi}	1.29^{abc}
Yesilkoy-1779	12.20^{ab}	87.2^{d-g}	405.0^{a}	632.8^{ab}	490.6^{e}	84.6^{fg}	5.06^{b}	18.76^{abc}	3.13^{fg}	1.24^{abc}
Faikbey	12.40^{a}	86.0^{efg}	391.0^{a-d}	605.0^{c}-^{f}	508.7^{b-e}	90.1^{c-f}	4.66^{b-e}	15.80^{f}	3.15^{efg}	1.13^{c-f}
Seydisehir	12.90^{a}	82.5^{g}	401.5^{a}	625.6^{bc}	495.1^{e}	86.1^{efg}	4.52^{cde}	16.57^{def}	3.08^{gh}	1.16^{b-e}
Rize	10.10^{cd}	96.2^{bc}	393.7^{abc}	630.0^{ab}	505.2^{cde}	86.4^{d-g}	4.21^{e}	18.52^{abc}	3.27^{cde}	0.89^{g}
Mugla	10.40^{cd}	101.9^{ab}	376.9^{d-j}	603.6^{c}-^{f}	526.9^{abc}	91.9^{a-d}	4.67^{b-e}	15.96^{f}	3.15^{fg}	1.29^{abc}
Samsun	9.12^{de}	92.7^{cde}	382.0^{b-e}	621.9^{bcd}	520.3^{a-d}	88.8^{c}-^{f}	4.77^{bcd}	16.40^{ef}	3.12^{g}	1.36^{a}
Karaman	5.87^{g}	89.9^{c}-^{f}	395.2^{ab}	633.6^{ab}	503.3^{de}	85.6^{efg}	4.77^{bcd}	17.65^{b-e}	3.09^{gh}	1.21^{a-d}
Kupa	9.92^{cd}	103.5^{a}	369.0^{e}	598.7^{def}	537.1^{a}	94.1^{abc}	5.13^{b}	18.88^{ab}	3.38^{abc}	1.23^{abc}
Baranja	10.3^{cd}	94.7^{c}	389.1^{a-d}	616.8^{b-e}	511.2^{b-e}	88.6^{c-f}	4.54^{cde}	19.68^{a}	3.37^{abc}	1.05^{def}
Samsun-kavak	9.96^{cd}	92.8^{cde}	375.1^{de}	613.7^{b-e}	529.1^{ab}	91.1^{b-e}	4.20^{e}	18.12^{bc}	3.30^{bcd}	1.04^{efg}
Ordu	8.30^{ef}	94.2^{cd}	366.5^{e}	587.2^{f}	540.4^{a}	95.9^{ab}	5.69^{a}	16.31^{ef}	3.25^{def}	1.33^{ab}
Sivas	5.21^{g}	86.9^{efg}	402.2^{a}	649.4^{a}	494.2^{e}	82.8^{g}	4.67^{b-e}	18.06^{bcd}	2.93^{i}	0.98^{fg}
Bursa	7.61^{f}	95.8 ^{bc}	371.5^{e}	595.5^{ef}	533.9^{a}	94.3^{abc}	4.41^{de}	20.07^{a}	3.43^{a}	1.22^{abc}
Spring sowing										
Checota	6.29^{def}	89.0^{i}	372.6^{b-e}	592.4^{abc}	532.4^{a-d}	94.6^{ab}	4.33^{d-h}	16.86^{ef}	3.18^{gh}	1.03^{bc}
Peniarth	5.65^{fg}	106.5^{cde}	370.9^{b-e}	605.1^{ab}	534.6^{a-d}	92.6^{bc}	4.59^{cg}	18.06^{bcd}	3.60^{a}	1.12^{bc}
Yesilkoy-330	6.00^{efg}	107.7^{cd}	366.4^{cde}	579.7^{bc}	540.5^{abc}	97.4^{ab}	5.06^{bc}	18.57^{bc}	3.52^{ab}	1.42^{a}
Yesilkoy-1779	5.16^{g}	113.0^{b}	381.9^{abc}	598.5^{abc}	520.4^{cde}	92.5^{bc}	5.85^{a}	18.62^{bc}	3.47^{bc}	1.47^{a}
Faikbey	7.12^{bcd}	104.1^{def}	378.8^{bc}	58.6.7^{abc}	524.5^{cd}	94.8^{ab}	5.53^{ab}	17.34^{de}	3.33^{def}	1.04^{bc}
Seydisehir	5.87^{fg}	92.7^{hi}	374.3^{b-e}	613.4^{ab}	530.2^{a-d}	92.3^{bc}	5.03^{bc}	17.55^{cde}	3.29^{efg}	1.08^{bc}
Rize	6.00^{efg}	106.0^{cde}	383.2^{ab}	606.2^{ab}	518.7^{de}	90.8^{bc}	4.87^{cde}	19.73^{a}	3.48^{bc}	1.13^{bc}
Mugla	6.06^{efg}	111.7^{bc}	360.3^{e}	570.7^{c}	548.4^{a}	100.0^{a}	4.32^{dh}	14.37^{h}	3.39^{cde}	1.10^{bc}
Samsun	8.25^{a}	101.6^{efg}	376.9^{bcd}	610.3^{ab}	526.9^{bcd}	90.9^{bc}	4.94^{bcd}	15.94^{fg}	3.25^{fg}	1.05^{bc}
Karaman	6.81^{cde}	96.8^{gh}	368.0^{b-e}	593.5^{abc}	538.5^{a-d}	95.0^{ab}	4.19^{fgh}	15.43^{g}	3.09^{h}	0.95^{cd}
Kupa	7.77^{ab}	104.8^{def}	374.0^{b-e}	606.6^{ab}	530.7^{a-d}	92.3^{bc}	4.14^{gh}	18.58^{bc}	3.48^{bc}	1.11^{bc}
Baranja	7.22^{bc}	122.2^{a}	361.9^{de}	593.8^{abc}	546.2^{ab}	95.5^{ab}	5.67^{a}	17.50^{cde}	3.46^{bc}	1.17^{b}
Samsun- Kavak	6.38^{c}-^{f}	96.6^{gh}	395.9^{a}	616.4^{a}	502.3^{e}	88.1^{c}	3.80^{h}	18.52^{bcd}	3.43^{bcd}	0.82^{d}
Ordu	5.59^{fg}	100.4^{fg}	372.5^{b-e}	602.2^{abc}	532.6^{a-d}	92.6^{bc}	4.34^{d-h}	15.02^{gh}	3.21^{g}	1.04^{bc}
Sivas	5.27^{g}	105.7^{c}-^{f}	378.7^{bc}	601.5^{abc}	524.6^{cd}	92.1^{bc}	4.82^{c-f}	18.58^{bc}	3.25^{fg}	1.12^{bc}
Bursa	5.55^{fg}	106.6^{cde}	374.0^{b-e}	586.3^{abc}	530.7^{a-d}	95.0^{ab}	4.29^{eh}	19.03^{ab}	3.47^{bc}	1.08^{bc}

CP: Crude protein, NDF: Neutral detergent fibers, ADF: Acid detergent fibers, TDN: Total digestible nutrints, RFV: Relative feed value, Ca: Calcium, K: Potassium, P: Phosphor, MG: Magnesium. Means within a column followed by the same lowercase letter are not significantly different ($p<0.01$), Means are averaged over four growing seasons (2003-2007) and three replicates

greater in Kupa, Peniart, Mugla than in the other genotypes in autumn sowing. But, in spring sowing, Baranja had greater CP concentration than the other genotypes (Table 5). Some researchers pointed out that crude protein content of hay changed among oat genotypes significantly (Ericson *et al*., 1977; Kim *et al*., 2006). Same researchers also showed that CP content of late-maturing oat varieties was higher than the early-maturating varieties. The results were consistent with the findings of Ericson *et al*. (1977) and Kim *et al*. (2006).

Other important quality characteristics for forages are the concentrations of ADF and NDF (Caballero *et al*., 1995; Assefa and Ledin, 2001). In this experiment, the values for ADF and NDF in spring sowing were lower than those in autumn sowing (Table 3). The values for ADF in the fourth year were greater than those in the first, second and third in autumn sowing. In spring sowing, however, these values in the first and fourth years were greater than those in the second and third (Table 4). The NDF values were in autumn sowing greater in the third and fourth years compared with the first and second year in spring sowing the NDF values were in the first, third and fourth years greater than second year (Table 4). The ADF and NDF values significantly differed with oat genotypes. Checota, Peniarth, Mugla, Kupa, Samsun-Kavak, Ordu and Bursa had lower the ADF and NDF values than those of the other genotypes in autumn sowing (Table 5). In spring sowing, much smaller differences were observed regarding the ADF and NDF values among genotypes and Mugla showed the lowest the ADF and NDF values (360.3 and 570.7 g kg $^{-1}$ DM, respectively) (Table 5).

The TDN refers to the nutrients that are available for livestock and are related to the ADF concentration of the forage. As ADF increases there is a decline in TDN which means that animals are not able to utilize the nutrients that are present in the forage. TDN value was higher in spring sowing than in autumn sowing (530.1 and 516.8 g kg^{-1} DM, respectively) (Table 3). The values for TDN in the 4th year were lower than those in the 1st, 2nd and 3rd in autumn sowing.

In spring sowing, however, these values in the first, third and fourth years were lower than those in the second. Genotypes Checota, Peniarth, Mugla, Kupa, Ordu and Bursa had the highest values for TDN during both season (Table 5). Additionally to these genotypes, the highest TDN values was obtained from the genotypes Samsun and Samsun-Kavak in autumn sowing and from the genotypes Yesilkoy-330, Seydisehir, Karaman and Baranja in spring sowing. Kim *et al*. (2006) showed that TDN value has significant differences among oat varieties (Table 5).

The RFV is an index that is used to predict the intake and energy value of the forages and it 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 fewer than 75 are considered as prime, premium, good, fair, poor and reject, respectively. In the present experiment, the RFV value was higher in the spring sowing than in the autumn sowing. Genotypes Checota, Mugla and Bursa were higher in RFV value than the other oat genotypes in both autumn and spring sowing (Table 5). Since RFV value was calculated from ADF and NDF, the observed differences were reflective of previously described ADF and NDF differences. Thus, a more comprehensive assessment on forage quality should be done for the different oat varieties in the different regions and at different seasons. This conclusion is consistent with the findings of Kim *et al*. (2006) who studied yield and quality of oat varieties.

There were significant differences amongst genotypes and years regarding their mineral content. Differences in Ca contents were not significant between sowing dates. Ca contents of the genotypes varied from 4.20 (Samsun-Kavak) to 5.69 (Ordu) g kg^{-1} DM in the autumn sowing, while Ca contents of the genotypes varied from 3.80 (Samsun-Kavak) to 5.85 g kg^{-1} DM in the spring sowing (Table 5). Tajeda *et al*. (1985) reported that forage crops should contain at least 3.0 g kg^{-1} of Ca for ruminants. The American National Research Council (NRC, 1984) recommended that forage crops should contain 3.1 g kg^{-1} Ca concentration for beef cattle. Results obtained for Ca concentration in this study were more than these recommended values. In the autumn sowing, K contents of the genotypes varied from 15.80 (Faikbey) to 20.07 (Bursa) g kg^{-1} DM while K contents of the genotypes changed between 14.37 (Mugla) and 19.73 (Rize) g kg^{-1} DM in the spring sowing (Table 5). Differences in K contents of sowing date were not significant. This conclusion is consistent with the findings of Mut *et al*. (2006) who studied yield and quality of triticale, barley, rye and barley varieties. These results were higher than suggested values of 8.0 g kg^{-1} by Tajeda *et al*. (1985). But high K concentration may cause Mg deficiency (Loreda *et al*., 1986).

P content was higher in spring sowing (3.37 g kg^{-1}) than in autumn sowing (3.20 g kg^{-1}). In the autumn 1.05 concentrations of 1.8-3.9 g kg^{-1} for forage crops are recommended for ruminants (National Research Council, 2001). Results obtained for P concentration in this study were adequate for ruminants.

Mg content was higher in autumn sowing than in spring sowing and this difference was statistically significant. In both sowing dates, Mg concentration in the all genotypes was between 0.82 and 1.47 g kg^{-1} (Table 5). Mg concentrations for forage crops are recommended as 2.0 g kg^{-1} for ruminants by Tajeda *et al.* (1985) and 1 g kg^{-1} for beef cattle by the NRC (1984). Grass tetany or hypomagnesemic tetany in cattle is caused by an imbalance of K, Ca and Mg in the diet. Mineral imbalances, deficiencies or excess and low bio-availability of essential minerals result in negative economic impacts when animal performance and health are compromised (Van Soest, 1982). Magnesium deficiency may lead to a reduction in weight gain, milk production and conception rate (Stuedemann *et al.*, 1983).

Osman and Nersoyan (1986) pointed out that monocultures of common vetch or cereals do not provide satisfactory results for forage production. Similarly, Lithourgidis *et al.* (2006) indicated that forage quality of cereal hay is usually lower than that required to meet satisfactory production levels for many categories of livestock. On the other hand, Lawes and Jones (1971) showed that small grain cereals provide high yields in terms of dry weight.

CONCLUSION

The study showed that sowing date had great effect on hay yield and quality potential of oat genotypes. Comparison of hay yields by the sowing date indicated a clear advantage of autumn sowing. Based on 4 years data autumn sowed oat resulted in 56.4% higher hay yield than the spring sowed crop. However, in spring sowing, oat genotypes had higher quality values than in autumn sowing. This study also showed that late-maturing and tall genotypes like Yesilko-330, Yesilkoy-1779, Faikbey and Seydisehir performed better hay yield in autumn sowing but showed lower hay quality. On the contrary, there is no such a relationship in the spring sowing. With regard to low forage quality of cereals, forage yield and quality could be increased by growing suitable oat genotypes with legume forage crops.

REFERENCES

Anderson, L.J. and M.L. Kaufmann, 1963. A study of oat varieties for use as ensilage. Can. J. Plant Sci., 43: 157-160.

Assefa, G. and I. Ledin, 2001. Effect of variety, soil type and fertilizer on the establishment, growth, forage yield, quality and voluntary intake by cattle of oats and vetches cultivated in pure stands and mixtures. Anim. Feed Sci. Technol., 92: 95-111.

Braunwart, K., D. Putnam and G. Fohner, 2001. Alternative annual forages-now and in the future. Proceedings of 31st California Alfalfa Symposium, Dec. 12-13, University of California, Davis, pp: 38-44.

Caballero, A.R., E.L. Goicoechea-Oicoechea and P.J. Hernaiz-Ernaiz, 1995. Forage yields and quality of common vetch and oat sown at varying seeding ratios and seeding rates of vetch. Field Crops Res., 41: 135-140.

Celik, N. and V. Bulur, 1996. Tahillarin yem olarak kullanimi ve gelecekteki potansiyeli. Turkiye 3. Cayir-Mera ve Yembitkileri Kongresi, 17-19 Haziran, Erzurum. pp: 513-519.

Chapko, L.B., M.A. Brinkman and K.A. Albrecht, 1991. Genetic variation for forage yield and quality among grain oat genotypes harvested at early heading. Crop Sci., 31: 874-878.

Cherney, C.H. and G.C. Marten, 1982. Small grain crop forage potential: I. Biological and chemical determinants of quality and yield. Crop Sci., 22: 227-231.

Ericson, D.O., N.R. Riveland and E.W. French, 1977. The nutritional value of oat hay harvested at several stages of maturity. North Dakota Farm Res., 35: 13-16.

Fohner, G., 2002. Harvesting maximum value from small grain cereal forages. Proceedings Western Alfalfa and Forage Conference, Dec. 11-13, California, pp: 28-33.

Folkins, L.P. and M.L. Kaufmann, 1974. Yield and morphological studies with oats for forage and grain production. Can. J. Plant Sci., 54: 617-620.

Hoy, M.D., K.J. Moore, J.R. George and E.C. Brummer, 2002. Alfalfa yield and quality as influenced by establishment method. Agron. J., 94: 65-71.

Juskiw, P.E., J.H. Helms and D.F. Salmon, 2000. Competitive ability in mixtures of small grain cereals. Crop Sci., 40: 159-164.

Kaufmann, M.L., 1961. Yield-maturity relationships in oats. Can. J. Plant Sci., 41: 763-771.

Kim, J.D., S.G. Kim, S.J. Abuel, C.H. Kwon, C.N. Shin, K.H. Ko and B.G. Park, 2006. Effect of location, season and variety on yield and quality of forage oat. Asian-Aust. J. Anim. Sci., 19: 970-977.

Kjos, N.P., 1990. Evaluation of the feding value of fresh forages, silage and hay using near infrered reflectance analysis (NIR). I.A comparison of different methods for predicting the nutritive value. Norwegian J. Agric. Sci., 4: 305-320.

Lawes, D.A. and D.I.H. Jones, 1971. Yield, nutritive value and ensiling characteristics of whole-crop spring cereals. J. Agric. Sci., 76: 479-485.

Linn, J.G. and N. P. Martin, 1989. Forage Quality Tests and Interpretation. University of Minnesota, St. Paul.

Lithourgidis, A.S., I.B. Vasilakoglou, K.V. Dhima, C.A. Dordas and M.D. Yiakoulaki, 2006. Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. Field Crops Res., 99: 106-113.

Loreda, C.M.A., G.A. Ardilla and V.J. Alvarez, 1986. Variation in mineral concentrations in grasses in the cattle farming area of the coribbean herb. Abstract, 56: 928-929.

Maloney, T.S., E.S. Oplinger and K.A. Albrecht, 1999. Small grains for fall and spring forage. J. Prod. Agric., 12: 488-494.

Moreira, N., 1989. The effect of seed rate and nitrogen fertilizer on the yield and nutritive value of oat-vetch mixtures. J. Agric. Sci., 112: 57-66.

Mut, Z., I. Ayan and H. Mut, 2006. Evaluation of forage yield and quality at two phenological stages of triticale genotypes and other cereals grown under rainfed conditions. Bangladesh J. Bot., 35: 45-53.

NRC. (National Research Council), 1984. Nutrient Requirements of Domestic Animals: Nutrient Requirements of Beef Cattle. 6th Revised Edn., NAS/NRC., Washington DC., USA.

National Research Council, 2001. Nutrient Requirements of Dairy Cattle. 7th Rev. Edn., National Academy of Sciences, Washington, DC.

Osman, A.E. and N. Nersoyan, 1986. Effect of the proportion of species on the yield and quality of forage mixtures and on the yield of barley in the following year. Exp. Agric., 22: 345-351.

Poblaciones, M.J., S. Rodrigo, N. Simoes, M.M. Tavares-de-Sousa, A. Bagulho and L. Olea, 2008. Instantaneous determination of chemical composition of *Festuca* sp. and *Dactylis* sp. at two different cut times using near infrared spectroscopy (NIRS). Options Mediterraneennes Ser. A, 79: 227-230.

Riveland, N.R., D.O. Erickson and E.W. French, 1977. An evaluation of oat varieties for forage. N.D. Farm Res., 35: 19-22.

Smith, D., 1974. Influence of temperature on growth of Froker oats for forage. I. Dry matter yields and growth rates. Can. J. Plant Sci., 54: 725-730.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. McGraw Hill Co., New York, USA.

Stuedemann, J.A., S.R. Wilkinson, H. Cioria and A.B. Caudle, 1983. Effect of levels of nitrogen fertilization of Kentucky-31 tall fescue (*Festuca arundinacea* Schreb.) on brood cow health. Proceedings of the International Grassland Congress, (IGC'83), Westwiev Press, Lexington, pp: 728-732.

Stuthman, D.D. and G.C. Marten, 1972. Genetic variation in yield and quality of oat forage. Crop Sci., 12: 831-833.

Tajeda, R., L.R. Mcdowell, F.G. Martin and J.H. Conrad, 1985. Mineral element analyses of various tropical forages in Guatemala and their relationship to soil concentrations. Nutr. Rep. Int., 32: 313-324.

Van Soest, P.J., 1982. Nutritional Ecology of the Ruminant. O and B Books Inc., Corvalis.

Waldo, D.R. and N.A. Jorgensen, 1981. Forages for high animal production: Nutritional and effects of conservation. J. Dairy Sci., 64: 1207-1229.

Zadok, J.C., T.T. Chang and C.F. Konzak, 1974. A decimal code for growth stages of cereals. Weed Res., 14: 415-421.

Zhang, Y.S., X.M. Zhou and Q.J. Wang, 1998. A preliminary analysis of production performance of Oat at alpine meadow pasture. Acta Agrestia Sin, 6: 115-123.