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Genotype and Plant Density Effects on Corn (*Zea mays* L.) Forage Yield

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Abstract: Corn forage is an important source of feedstuff for beef and dairy cattles. A two-year study was conducted in Eastern Mediterranean Region of Turkey to determine the optimum plant densities for forage yields of corn genotypes commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. The experimental design was a randomized complete block in a split-plot arrangement with three replications. Main plots were corn hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626 and Arifiye. Split-plots were plant densities of 143 000, 114 000, 95 000, 82 000 and 71 000 plant. Split-plot size was 2.8 m by 5.0 m with four rows per plot. The effects of corn genotypes and plant densities on the forage and dry matter yield and some agronomic characteristics were significant. The highest forage and dry matter yields were obtained from Dracma genotype (69.5 and 27.0 t ha^{-1}, respectively). The highest forage and dry matter yield obtained at 114000 and 143000 plant densities (64.4 and 62.3 t ha^{-1} forage yield and 24.8 and 23.1 t ha^{-1} dry matter yield, respectively).

Key words: Corn, genotype, plant density, forage yield

INTRODUCTION

Corn forage is an important source of energy for livestock animals. Whole plant corn silage is an excellent feedstuff for beef and dairy cattles (Perry, 1988). Many environmental, cultural and genetic factors affect corn forage yield and quality (Cusicanqui and Lauer, 1999). Plant densities can be increased to provide maximum dry matter production. Since grain moisture is not a great concern for silage, later hybrids that are more leafy and larger in size can be utilized. Plant density recommendations for silage production have often been essentially the same for grain production. Maximum grain production is important for higher dry matter yield and to optimize silage quality. Because, the grain is the most digestible fraction of silage (Olson and Sander, 1988).

Investigators found that higher plant densities are needed to maximize silage yields than for grain yields. Cusicanqui and Lauer (1999) reported that maximum dry matter yields observed at 97300 to 102200 plants ha^{-1}. Widdicombe and Thelen (2002) reported that the response of forage dry matter yield to plant density was linear, with the maximum dry matter yield observed at the highest plant density level of 88900 plants ha^{-1}.

Yield increases with increasing plant density up to a maximum for a corn genotype grown under a set of particular environmental and management conditions and declines when plant density is increased further (Tollenaar *et al*., 1994).

Hybrids developed in recent years are able to withstand higher plant density levels than older hybrids (Tollenaar, 1989) and the current hybrids were found to have decreased lodging frequencies at the higher plant populations (Nafziger, 1994). Soya *et al*. (2001) indicated that leaf ratio, stem ratio, ear ratio, green herbage yield and dry herbage yield significantly affected by corn hybrids. Turgut *et al*. (2005) reported that there were significant effects of corn hybrids and plant densities on corn forage and dry matter yields.

The objective of this study was to determine optimum plant densities for forage yields of corn genotypes commercially grown in Eastern Mediterranean Region of Turkey.

MATERIALS AND METHODS

Field experiments were conducted at Mustafa Kemal University, Agricultural Faculty research farm as a second crop of the year after wheat harvest in 2000 and 2001. The soil of experimental site was clay loam having a pH 7.7, with low concentration of available phosphorus (17.2 kg ha^{-1}) and low organic matter content (0.23%).

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The experimental field was prepared after wheat harvest in June and corn seeds experiments were hand-planted with 70 cm inter-row spacing at 26 June in 2000 and at 22 June in 2001. $N-P_2O_5-K_2O$ (90 kg ha^{-1} for each) was applied and mixed into soil before planting and N (180 kg ha^{-1}) was applied at knee-high stage as top dressing. Weed control and irrigation were performed as needed.

The experimental design was a randomized complete block in a split-plot arrangement with three replications. Main plots were corn hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 and Dekalb 626 and Arifiye. Split-plots were plant densities (143000, 114000, 95000, 82000 and 71000 plant ha^{-1}). Sub-plots size was 2.8 m by 5.0 m with four rows per plot.

Plant height, stem diameter, leaf ratio, stem ratio, ear ratio, forage yield and dry matter yield were determined in the center two rows of each sub-plot according to Soya *et al*. (2001).

Data were analyzed using standard analysis of variance (ANOVA) technique and means were separated using Least Significant Difference (LSD) comparisons.

RESULTS AND DISCUSSION

Plant height: Plant height was significantly affected by corn hybrids but not affected by plant densities. The tallest plants were measured from Arifiye genotype and the shortest plants were measured from P-3335 genotype (Table 1). The previous studies indicated that there were genotypic differences in plant height by Gozubenli *et al*. (2003 and 2001) and Konuskan (2000).

Differences among plant densities in plant height were not statistically significant (Table 1). Turgut *et al*. (2005) reported there were no intra-row spacing effects on plant height. Whereas, Konuskan (2000) found that plant height increased with increases in plant density up to 10000 plant ha^{-1}.

Stem diameter: Corn hybrids and plant densities significantly affected stem diameter. The highest stem diameter was measured at Dracma with 19.6 mm and the lowest one at Pioneer 3335 with 18.5 mm (Table 1). Many other researchers (Turgut *et al*., 2005; Gozubenli *et al*., 2003, 2001; Konuskan, 2000) also declined that there were genotypic variations in stem diameter of corn.

Stem diameter increased with decreases in plant densities and the highest stem diameter (20.53 mm) was determined at 71000 plant ha^{-1} and the lowest stem diameter (17.91 mm) was determined at 143000 plant ha^{-1} (Table 1). Stem diameter is strongly influenced by environmental conditions during stem elongation. Some researchers reported that stem diameters of corn hybrids were lower in higher plant densities (Turgut *et al*., 2005; Gozubenli *et al*., 2003; Konuskan, 2000; Ulger, 1998).

Leaf ratio: Leaf ratio is an important character for corn forage yield and quality. There were significant differences among corn genotypes and plant densities in leaf ratio (Table 2). The highest leaf ratio values were obtained from P 3335 and P 3223 genotypes with 16.7% and 15.9% ratio respectively. Iptas and Acar (2003) and Turgut *et al*. (2005) indicated that there were significantly differences among corn genotypes for leaf ratio and the late hybrids had more leaf number and ratio

Leaf ratio increased with increases in plant densities and the highest leaf ratio obtained at 143000 plant ha^{-1} with 16.5%. and the lowest leaf ratio obtained at 71000 plant ha^{-1} with 15.1%. Iptas and Acar (2003) and Turgut *et al*. (2005) reported that leaf ratio was

Table 1: Genotype and plant density effects on plant height, stem diameter, forage yield and dry matter yields of corn

	Plant height (cm)			Stem diameter (mm)			Forage yield (t ha^{-1})			Dry matter yield (t ha^{-1})		
Genotypes	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Dracma	216.9	219.9	218.4	19.68	19.56	19.62	72.1	66.8	69.5	27.0	26.9	27.0
P3223	218.1	220.9	219.5	18.33	18.72	18.53	63.3	60.7	62.0	23.0	24.2	23.6
P3335	209.2	205.6	207.4	18.36	18.64	18.50	57.5	61.4	59.5	19.9	23.6	21.8
DK711	217.1	218.8	218.0	18.94	19.04	18.99	58.3	57.3	57.8	23.4	21.5	22.5
DK626	227.3	224.7	226.0	19.63	19.19	19.41	59.7	52.0	55.9	22.3	20.9	21.6
Arifiye	227.1	233.8	230.4	19.71	19.49	19.60	51.3	61.7	56.5	19.0	25.5	22.2
LSD (0.05)	7.5	15.0	8.3	NS	NS	0.6	5.9	3.1	3.3	2.7	1.1	1.5
Densities (plant ha^{-1})												
143000	219.7	223.91	221.8	17.98	17.84	17.91	59.7	64.9	62.3	21.2	25.0	23.1
114000	220.0	222.17	221.1	18.86	18.43	18.65	65.1	63.6	64.4	24.3	25.2	24.8
95000	219.1	220.22	219.6	18.88	19.03	18.96	59.6	59.7	59.7	21.7	24.1	22.9
82000	219.9	218.67	219.3	19.39	19.61	19.50	58.2	56.6	57.4	21.1	22.4	21.8
71000	217.8	218.11	218.0	20.45	20.62	20.53	59.2	55.2	57.2	22.2	22.1	22.1
LSD (0.05)	NS	NS	NS	0.8	0.6	0.5	NS	2.8	3.0	1.0	NS	1.3

Table 2: Genotype and plant density effects on leaf ratio, stem ratio and ear ratio of corn

	Leaf ratio (%)			Stem ratio (%)			Ear ratio (%)		
Genotypes	2000	2001	Mean	2000	2001	Mean	2000	2001	Mean
Dracma	16.3	14.5	15.4	43.7	41.9	42.8	40.0	43.4	41.7
P3223	18.4	13.5	15.9	39.1	44.3	41.7	42.5	41.9	42.2
P3335	19.9	13.6	16.7	38.1	41.5	39.8	42.0	45.0	43.5
DK711	16.5	14.2	15.4	45.1	40.2	42.7	38.4	45.4	41.9
DK626	16.9	12.7	14.8	40.6	40.3	40.5	42.6	47.0	44.8
Arifiye	17.4	14.0	15.7	50.5	48.3	49.4	32.1	37.5	34.8
LSD	1.1	1.2	0.8	2.2	2.2	1.6	2.7	2.4	1.8
Densities (plant ha^{-1})									
143000	18.1	14.9	16.5	43.0	43.2	43.1	38.9	41.9	40.4
114000	17.5	14.1	15.8	42.7	42.0	42.4	39.9	43.6	41.7
95000	17.6	13.5	15.6	43.0	42.4	42.7	39.4	43.9	41.7
82000	17.4	13.4	15.4	43.4	42.7	43.1	39.2	43.8	41.5
71000	17.2	13.0	15.1	43.2	42.4	42.8	39.7	44.7	42.2
LSD (0.05)	NS	1.1	0.7	NS	NS	NS	NS	2.2	1.6

significantly affected by plant densities and high leaf ratio values obtained from dense plantings.

Stem ratio: Stem ratio differed according to hybrid and the highest value was obtained from Arifiye and the lowest values were from P-3335 and DK-626 varieties (Table 2). Soya *et al.* (2001) reported that variations in stem ratio effected by genotype and environmental conditions. Stem ratios slightly varied depend on plant densities and similar results obtained at different plant densities.

Ear ratio: Ear ratios varied among corn hybrids in both years, DK-626 and P-3335 had the highest average values with 44.8 and 43.5%, respectively (Table 2). Our results accordance with findings of Soya *et al.* (2001). The effect of plant densities on ear ratios was significant and the lowest ear ratio obtained at 143000 plant ha^{-1} with 40.4%, when the highest value obtained at the lowest density of 71000 plant ha^{-1} (Table 2). Cummins and Dobson (1973) reported that ear ratios decreased with increases in plant densities.

Forage yield: It was indicated that there were varietal differences among corn hybrids in respect to forage yield. The highest forage yield was obtained from Dracma followed by P-3223 and P-3335, when DK-626 had the lowest forage yield (Table 1). Varietal differences among corn genotypes was also reported by Soya *et al.* (2001) and Yilmaz and Saglamtimur (1996).

Forage yield differences among planting densities was statistically significant and consistently increased as the planting density increased up to 114 000 plant ha^{-1} and decreased at 143 000 plant ha^{-1} and the lowest planting density had the lowest forage yield (Table 1). Higher plant densities are needed to maximize silage yields than for grain yields (Cox, 1997). While single-plant yield decreased with increases in plant densities, total light interception by the canopy is increased (Karlen and Camp, 1985). Turgut *et al.* (2005) indicated that forage yields of corn increased up to 105000 plant ha^{-1} and insignificantly decreased at the highest density of 125000 plant ha^{-1}.

Dry matter yield : Similar to the forage yield, the dry matter yield of the hybrids was significantly different. The highest dry matter yield was obtained from Dracma followed by P-3223 and Dk-711, when Dk-626 had the lowest dry matter yield (Table 1). Similar results also reported by Graybill *et al.* (1991), Cusicanqui and Lauer (1999) and Turgut *et al.* (2005).

Dry matter yield was highly influenced by different planting densities and the highest dry matter yield was obtained from the 114 000 plant ha^{-1} planting density followed by 143 000 and 95 000 plant ha^{-1}. The lowest dry matter yields obtained from 82 000 and 71 000 plant ha^{-1} densities (Table 1). Present findings are in good agreement with the reports of William and Thelen (2002) and Turgut *et al.* (2005).

CONCLUSIONS

Genotype x plant density interaction were not observed for investigated traits in this study. This suggest that similar responses were given to plant densities by corn hybrids.

Our results showed that genotypic differences were significant and the highest forage and dry matter yields were obtained from Dracma.

Plant densities can be increased to provide maximum forage and dry matter production. Higher plant densities are needed to maximize silage yields than for grain yields (Cox, 1997). Forage and dry matter yields increased with increases in plant densities up to 114 000 plant ha^{-1} and decreased at 143 000 plant ha^{-1} and also lower yields obtained at lower planting densities. For corn silage, using Dracma hybrids with 114000 plant ha^{-1} planting density is suitable in Eastern Mediterranean Region of Turkey.

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