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YIELD AND QUALITY OF FORAGE MAIZE AS INFLUENCED BY PLANT DENSITY AND NITROGEN RATE

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ABSTRACT

The producers of silage maize need more information on agronomic managements such as plant density and nitrogen fertilization. Field studies were conducted in Bursa to evaluate dry matter yield and forage quality responses of silage maize to plant density and nitrogen rate. Five densities of 60 000, 100 000, 140 000, 180 000 and 220 000 plants ha^{-1} and five rates of 0, 100, 200, 300 and 400 kg N ha^{-1} were applied with split block design of three replications. As plant density increased, dry matter yield, stem percentage and ADF increased, but leaf number plant^{-1}, stem diameter and ear percentage decreased with the highest dry matter yields of 180 000 plants ha^{-1} and 220 000 plants ha^{-1}. However, there were no effects of plant densities on plant height, leaf percentage, crude protein and NDF. The dry matter yield, plant height, leaf number plant^{-1}, stem diameter, leaf percentage, ear percentage, crude protein content and NDF responded linearly to nitrogen rates with the highest dry matter yields at 300 and 400 kg N ha^{-1}, respectively. However, stem percentage decreased and ADF did not change as nitrogen rates increased. In conclusion, 180 000 plants ha^{-1} and 300 kg N ha^{-1} may be recommended for cultivation of silage maize under drip irrigation at Southern Marmara Region.

Key words: Dry matter yield, forage quality, nitrogen rate, plant density, *Zea mays* L.

INTRODUCTION

Maize (*Zea mays* L.) is the most important silage plants in the world because of its high yield, high energy forage produced with lower labor and machinery requirements than other forage crops (Roth et al., 1995). Many environmental, cultural and genetic factors influence maize forage yield and quality. Maize forage producers require more information on how nitrogen fertilization and plant density practices affect dry matter yield and forage quality.

Forage maize responds differently to plant densities under different environmental and cultural factors which influence maize forage yield and quality. The relationship between maize forage yield and plant density is not well established. Total dry matter increases from 6 to 40 % when plant density increases from about 55 000 to 88 000 plants ha^{-1} in some studies (Rutger and Crowder, 1967; Karlen et al., 1985) and 79 000 to 165 000 plants ha^{-1} in some other studies (Sparks, 1988; Graybill et al., 1991; Cox and Otis, 1993; Turgut et al., 2005; Yandim, 2006; Yilmaz et al., 2007). Olson and Sander (1988) indicated that optimum plant density may differ between maize grain and forage production with higher plant densities favoring forage rather than grain yield. Cox and Otis (1993) reported maximum dry matter yield at 81 500 plants ha^{-1} and maximum grain yield at 74 100 plants ha^{-1}. Many other researchers also reported that plant density affected positively forage yield and most of its quality components (Kamel et al., 1983; Saglamtimur et al., 1989; Kara et al., 1999; Uslu and Karaaltın, 1999; Jiwang et al., 2004). However, Alexander et al. (1963), Cusicanqui and Lauer (1999) and Widdicombe and Thelen (2002) reported that crude protein content of forage maize was negatively associated with plant densities, but some of the reserchers found no statistical relation between crude protein content and plant densities (Cuomo et al., 1998; Patricio Soto et al., 2002). ADF and NDF, a good indicator of forage quality, were reported that their relations with plant densities were controversial. NDF was affected by plant densities in some studies (Iptas and Acar, 2006), but it was unaffected in other studies (Cox and Cherney, 2001; Widdicombe and Thelen, 2002). There were no significant relations found between plant densities and plant height (Bangarwa et al., 1993; Dogan et al., 1997; Turgut et al., 1997; Kara et al., 1999; Turgut et al., 2005; Iptaş and Acar, 2006; Azam et al., 2007; Yilmaz et al., 2007). Leaf number plant^{-1} values were affected by plant densities (Saruhan and Sireli, 2005) or not affected (Dogan et al., 1997; Iptas and Acar, 2003). Researches indicated that plant densities had no significant effects on leaf percentage (Cuomo et al., 1998; Iptas and Acar, 2006). Stem percentages increased as plant densities increased (Oktem and Oktem, 2005). The results of the studies on the effects of plant densities on ear percentage were controversial (Cummins and Dobson, 1973; Yilmaz et al., 2007).

Nitrogen fertilization is one of the most important agronomic practices and therefore there are numerous studies conducted with nitrogen fertlizer. Optimum rate of nitrogen fertilizer for forage maize cultivation depends on numerous variable factors such as environmental conditions, management systems and genotypes. Nitrogen fertilization of maize influences dry matter yield by influencing leaf area index, leaf area duration and photosynthetic efficiency (Muchow, 1988; Muchow and Davis, 1988). O'leary and

Rehm (1990) reported that forage dry matter yields of maize responded linearly to nitrogen rates at three sites and curvilinearly at five sites. Likewise, these researchers determined that forage quality traits such as NDF and ADF responded inconsistently to nitrogen rates. Some other researchers also reported that there were positive effects of nitrogen on dry matter yield and forage qualities (Cox et al., 1993; Mullins et al., 1998; Kara et al., 1999; Cox and Cherney, 2001; Hamid and Nasab, 2001; Patricio Soto et al., 2002; Bayram et al., 2004; Patricio Soto et al., 2004; Keskin et al., 2005; Sahar et al., 2005; Saruhan and Sireli, 2005).

Management studies on maize in Turkey in recent years have focused primarily on forage production for silage. Nitrogen fertilization and plant density studies were the centre of these studies. Results of these studies indicated somewhat differences due to different ecological conditions, cropping system and genotypes. The objective of this study was to evaluate dry matter yield and forage quality responses of silage maize to plant densities and nitrogen rates.

MATERIALS AND METHODS

Field studies were conducted during the 2006 and 2007 growing seasons on clay loam soil at the Agricultural Research and Experiment Center of Uludag University, near Bursa (40° 11′ N, 29° 04′ E). Soil test values indicated a pH of 7, none saline, low values in lime and organic matter and rich in potassium.

Precipitation patterns and amount differed markedly between the 2006 and 2007 growing seasons (Table 1). Although cumulative precipitation in 2006 was only 12.2 mm below the long-term mean, dry conditions existed in May, July and August. Precipitation in June and September was quite higher than the same mounths of long-term. Cumulative precipitation in 2007 growing season was 67.2 mm below the long-term mean, and all of the mounths of this year except June were very dry. There were almost no differences between mean temperatures and relative humudities of experimental years and the long-term means.

Table 1. Precipitation, mean temperature and relative humidity in 2006, 2007 and long-term (1929-2001) in Bursa.

	Precipitation (mm)			Mean temperature (ºC)			Relative humidity (%)		
Months	2006	2007	Long-term	2006	2007	Long-term	2006	2007	Long-term
May	9.2	31.8	50.0	16.6	19.9	17.6	61.4	62.0	69.5
June	43.5	46.6	30.4	21.5	24.4	22.1	64.2	57.1	62.9
July	3.6	13.6	24.0	23.8	26.1	24.5	52.3	52.2	58.1
August	3.7	1.0	18.9	26.4	26.5	24.1	50.6	53.8	60.5
September	91.2	3.2	40.1	19.9	20.9	20.1	65.9	59.8	66.4
Total/mean	151.2	96.2	163.4	21.64	23.56	21.68	58.88	56.98	63.48

The variety ADA-523 was used as plant material. Five plant densities (60 000, 100 000, 140 000, 180 000 and 220 000 plants ha^{-1}) and five nitrogen rates (0, 100, 200, 300 and 400 kg ha^{-1}) were evaluated. The experimental design was a randomized complete block in a split plot arrangement with three replications. Main plots consisted of plant densities and split plots consisted of nitrogen rates. Split plot size was 5 by 5.2 m with 8 rows. Split plots were planted at 0.65 m row spacing. Three-fold seeds for each plant density were sown at split plots and hand-thinned to target plant densities. Half of the nitrogen rates with the starter amounts of P and K each at 100 kg ha^{-1} were applied before planting. The rests of nitrogen rates were sidedressed when plants attained 40-50 cm heights. Weeds were controlled by a post-emergence application of 2,4-D at a rate of 2.0 l ha^{-1} and mechanical hoeing whenever it was needed.

Ten plants from certain rows of each split plot were, just prior to forage harvest, cut to determine morphological charachters such as plant height, stem diameter and leaf number $plant^{-1}$. Five out of each 10 sampled plants were assorted into stem, leaf and ear fractions to determine their percentages in a whole-plant weight.

After removing border effects, two center rows of each split plot were harvested and fresh-weighed insitu to determine forage yield when kernel was dough. After harvest, 2 plants from forage material of each split plot were taken, dried at 78 ºC for 48 h, weighed and then ground in mill with a 1 mm screen. Data obtained from these procedures were used both for calculation of dry matter yield of split plots and for determination of total nitrogen, acid detergent fiber (ADF) and neutral detergent fiber (NDF). 1 g ground sample was used for the total nitrogen determination and 0.5 g for ADF and NDF. ADF and NDF were analyzed by sequential detergent analysis method (Van Soest et al., 1991) and total nitrogen by Kjedahl method. Crude protein content was calculated by multiplying total nitrogen by 6.25 constant.

Before variance analysis, all data of parameters of single years were averaged across years. Then, all data obtained from measurements or analyses of morphological characters, dry matter yields and forage quality components were subjected to analyses of variance by using MINITAB and MSTAT-C programs. The LSD was used to seperate means of plant densities, nitrogen rates and their interactions when the F-test was significant.

RESULTS AND DISCUSSION

Data obtained from the research work, averaged across years and subjected to variance analysis are given in Table 2. Results of variance analysis indicated that the effects of plant densities and nitrogen rates were of significance on most of the parameters. Also, the effects of interactions on some parameters were observed significant.

Table 2. Effect of plant densities and nitrogen rates on dry matter yield, some morphological traits and forage quality (across 2 years).

Plant Density plants/ha	Dry matter yield (kg/ha)	Plant height (cm)	Leaf number plant^{-1}	Stem diameter (mm)	Leaf percentage (%)	Stem percentage (%)	Ear percentage (%)	Crude protein (%)	ADF (%)	NDF (%)
60 000	18719 b[1]	285.08	15.01 a	24.50 a	26.47	49.68 d	24.03 a	5.27	25.90 c	64.84
100 000	19450 b	285.28	14.58 ab	20.75 b	25.31	54.75 c	20.07 b	4.91	27.15 bc	62.50
140 000	20261 ab	284.80	14.48 ab	19.06 c	25.22	55.98 bc	18.81 b	4.81	27.89 ab	63.68
180 000	21263 a	284.02	14.16 b	17.47 d	24.59	57.13 b	18.44 b	5.04	28.40 ab	62.61
220 000	20639 ab	277.84	14.16 b	16.69 e	25.00	59.35 a	15.81 c	5.19	28.50 a	61.47
Nitrogen Rate (kg/ha)										
0	14049 d	257.46 d	13.70 d	19.17 c	23.02 e	62.81 a	14.17 d	4.25 c	27.47	59.56 c
100	18340 c	279.22 c	14.14 c	19.44 bc	23.89 d	58.96 b	17.34 c	4.68 b	27.37	62.71 b
200	21204 b	289.50 b	14.53 b	19.78 ab	25.60 c	54.23 c	20.17 b	4.91 b	28.25	63.96 ab
300	22883 a	293.69 ab	14.97 a	20.00 a	26.49 b	51.22 d	22.43 a	5.62 a	27.75	64.19 ab
400	23855 a	297.16 a	15.05 a	20.07 a	27.59 a	49.68 d	23.06 a	5.76 a	27.01	64.68 a
Years	**	**	ns	**	**	ns	**	**	**	**
Density (D)	*	ns	*	**	Ns	**	**	ns	**	ns
Nitrogen (N)	**	**	**	**	**	**	**	**	ns	**
D x N	ns	ns	**	ns	Ns	ns	**	ns	ns	*

1: Means of the same column followed by the same letter were not significantly different at the 0.05 level using LSD test.
*, **: F-test significant at p≤ 0.05, and p≤ 0.01, respectively. ns: not significant

Dry matter yield was influenced by plant densities. Dry matter yield increased and reached maximum at 180 000 plants ha^{-1} and then declined as plant density increased further. These results indicate a close relationship between dry matter yield and plant density. Numerous workers have determined different plant densities for maximum dry matter yield changing from 79 000 to 165 000 plants ha^{-1} (Sparks, 1988; Graybill et al., 1991; Cox and Otis, 1993; Turgut et al., 2005; Yandim, 2006; Yilmaz et al., 2007). In our study, plants did not encountered with water stress in the growing seasons due to drip irrigation system used, and this case created a good medium to grow more plants per unit area. Of course, there are other reasons of these differences such as variety, ecology and agricultural systems. Plant densities had not affects on plant height ranging from 277.84 to 285.28 cm (Table 2). The similar studies were conducted and similar results were found by some other workers (Bangarwa et al., 1993; Dogan et al., 1997; Turgut et al., 1997; Kara et al., 1999; Turgut et al., 2005; Iptaş and Acar, 2006; Azam et al., 2007 and Yilmaz et al., 2007). Leaf number plant^{-1} significantly decreased with increasing plant density and the highest value was found at 60 000 plants ha^{-1}. Similar effects of plant density on leaf number plant^{-1} were reported by Saruhan ve Sireli (2005) in forage maize. However, Dogan et al. (1997) and Iptas and Acar (2003) observed that leaf number plant^{-1} was not affected by plant density. The stem diameter significantly decreased with increasing plant density, and therefore the highest value was recorded at 60 000 plants ha^{-1}. These results coincided with the findings of Turgut et al. (2005) and Yilmaz et al. (2007). The relationship between plant density and the leaf percentage was not significant. Similar results were reported by Cuomo et al. (1998) and Iptas and Acar (2006). Stem percentage significantly changed due to plant densities. Stem percentage increased as plant density increased. The highest stem percentage was obtanied at 220 000 plants ha^{-1}. These results were in agreement with those of Oktem and Oktem (2005). The effect of plant densities on ear percentage was significant. There was a negative relation between plant density and ear percentage. Therefore, the highest value was obtained at the lowest plant density (60 000 plants ha^{-1}). Cummins and Dobson (1973) and Yilmaz et al. (2007) reported that ear percentage decreased with increasing plant density, conforming to our results. However, Turgut et al. (2005) reported reverse results. Plant density effect on crude protein content of maize was insignificant. Cuomo et al. (1998) and Patricio Soto et al. (2002) reported similar results, but Alexander et al. (1963), Cusicanqui and Lauer (1999) and Widdicombe and Thelen (2002) observed that crude protein contents of forage maize decreased with increased plant density. On the other hand, JiWang et al. (2004) reported that crude protein contents increased with increased plant density. Significant impactions of plant densities on ADF concentration were determined in this study. Increasing plant densities increased ADF, the highest value was recorded at 220 000 plants ha^{-1} (Table 2). Iptas and Acar (2006) reported that plant density had no affect on ADF of forage maize. NDF did have no relation with plant density in this study (Table 2). These results agree with the findings of Cox and Cherney (2001) and Widdicombe and Thelen (2002). However, there were revers results reported by other workers (Iptas and Acar, 2006).

Nitrogen fertilization had significant effect on dry matter yield. As nitrogen rates increased, so did the dry matter yield and reached a peak value at 300 kg N ha^{-1}, then stayed stable at further nitrogen rate. The 300 kg N ha^{-1} compared with the 0 kg N ha^{-1} treatment produced 63 % higher dry matter yield with a 30 kg dry matter per 1 kg N fertilizer. These results coincide with the finding of most workers (Hamid and Nasab, 2001; Kara et al., 1999; Keskin et al., 2005; Patricio Soto et al., 2002 and Sahar et al., 2005). Plant height responded significantly to nitrogen fertilization. Effects of nitrogen rates on plant height were linear. That is, as nitrogen amounts increased, then plant height increased, and the highest plant height was recorded at 400 kg N ha^{-1}. Plant height was 16 % higher at 400 kg N ha^{-1} than at 0 kg N ha^{-1} (Table 2). Leaf number $plant^{-1}$ significantly increased with increasing nitrogen rates up to 300 kg N ha^{-1}. After this rate, leaf number $plant^{-1}$ stood still. Similar results were reported by Bayram et al (2004). Response of stem diameter to nitrogen fertilization was statistically significant. Stem diameter increased up to 300 kg N ha^{-1} and then stayed stable at 400 kg N ha^{-1}. These results were in accordance to those of some workers (Kara et al., 1999 and Saruhan and Sireli, 2005). The differences in leaf percentage were markedly great and increased as nitrogen rate increased. Leaf percentage was the lowest (23.02 %) at 0 kg N ha^{-1} and the highest (27.59 %) at 400 kg N ha^{-1}. Keskin et al. (2005) reported positive correlation between nitrogen rates and leaf percentage in maize. Nitrogen fertilization had significant but negative effect on stem percentage. As nitrogen rates increased from 0 to 400 kg N ha^{-1}, stem percentage decreased from 62.81 % to 49.68 %. Similar results were reported by Keskin et al. (2005), but Saruhan and Sireli (2005) reported revers results. Ear percentage increased with increasing nitrogen rate until 300 kg N ha^{-1} at which maximum value was recorded and then stayed stable at 400 kg N ha^{-1}. Similar effects of nitrogen fertilization were reported by Keskin et al. (2005) and Saruhan and Sireli (2005) in forage maize. Crude protein content significantly increased as nitrogen rates increased with the exception of the highest rate. These results coincised to those findings of some workers (Patricio Soto et al., 2002; Patricio Soto et al., 2004). Nitrogen rates had no effcet on ADF concentration. But some workers reported meaningful results indicating that nitrogen fertilization decreased ADF concentration in maize (Keskin et al., 2005). NDF concentration was significantly impacted by nitrogen rate. Every rate of nitrogen produced NDF concentration higher than its previous rate, and therefore, the highest NDF concentration (64.68 %) resulted in the highest nitrogen rate (Table 2). However, there were researchers who reported results opposite to ours (Cox et al., 1993; Mullins et al., 1998 and Cox and Cherney, 2001).

CONCLUSION

Dry matter yield of forage maize responded positively to high plant densities with maximum dry matter yields occuring at 180 000 plants ha^{-1}. Leaf $plant^{-1}$, ear percentage and stem diameter decreased, stem percentage and ADF increased, plant height, leaf percentage, crude protein content and NDF did not change as plant densities increased. Increasing nitrogen rates increased the forage maize dry matter yield with a peak value occuring at 300 and 400 kg N ha^{-1}. On the other hand, as nitrogen rates increased, plant height, leaf $plant^{-1}$, stem diameter, leaf percentage, ear percentage, crude protein content and NDF increased, stem percentage was adversely affected and ADF was not influenced. The data from this study suggest that forage maize producers must carefully balance the potential benefits of higher dry matter yields and forage quality. 180 000 plants ha^{-1} and 300 kg N ha^{-1} may be practiced under drip irrigation system in Southern Marmara Region, provided that the variety ADA-523 must be grown.

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LITERATURE CITED

Alexander, R.A., J.F. Hentges, W.K. Robertson, G.A. Barden and J.T. Mccall. 1963. Composition and Digestibility of Corn Silage as Affected by Fertilizer Rate and Plant Population. J. Anim Sci., 22:5-8.

Azam, S., M. Ali, M. Amin, S. Bibi and M. Arif. 2007. Effect of Plant Population on Maize Hybrids. J. Agri. Biol. Sci., 2(1):13-20.

Bangarwa, A.S., W.S. Kairon and B.S. Mor. 1993. Effect of Plant Density and Levels of Nitrogen on the Growth Analysis of Winter Maize (*Zea mays* L.). Crop Res. Hisar., 6(1):5-16.

Bayram G., M. Turk, E. Budakli and N.Celik, 2004. The Effects of The Deficiency of Nitrogen, Phosphorus, Potassium and Zinc on The Development of the Root and Stem of The Corn Plant. S.U. J. Agri. Fac., 18 (33): 23-27.

Cox, W.J. and D.J. Otis. 1993. Grain and Silage Responses of Commercial Corn Hybrids to Plant Densities. p. 132. In Agronomy Abstract 1993. ASA, Madison, WI.

Cox, W.J. and D.J.R. Cherney. 2001. Row Spacing, Plant Density and Nitrogen Effects on Corn Silage. Agron. J, 93:597-602.

Cox, W.J., S. Kalonge, D.J.R. Cherney and W.S. Reid. 1993. Growth, Yield and Quality of Forage Maize Under Different Nitrogen Management Practices. Agron. J, 85:341-347.

Cummins, D.G., and J.W. Dobson, 1973. Corn for Silage as Influenced by Hybrid Maturity, Row Spacing, Plant Population, and Climate. Agron. J. 65:240–243.

Cuomo, G.J., D.D. Redfearn and D.C. Blouin. 1998. Plant Density Effects on Tropical Corn Forage Mass, Morphology, and Nutritive Value. Agron. J, 90:93–96.

Dogan, R., I. Turgut and N. Yurur. 1997. The Effect of Plant Density on the Silage Yield and Quality of Some Dent Corn Varieties (*Zea mays indentata* sturt.) Grown under Bursa Conditions. II. Field Crops Congress in Turkey, 22-25 September, 467-471, Samsun.

Graybill, J.S., W.J. Cox and D.J. Otis. 1991. Yield and Quality of Froge Maize as Influenced by Hybrid, Planting Date and Plant Density. Agron. J, 83:559-564.

Hamid, A. and A.D.M. Nasab. 2001. The Effect of Various Plant Densities and N Levels on Phenology of Two Medium Maturity Corn Hybrids. Iranian J. Agri. Sci., 32:857-874.

Iptas, S. and A.A. Acar. 2003. Genotype and Row Spacing Influence on Corn Silage Yield and Some Agronomic Characters. V. Field Crops Congress in Turkey, 13-17 October, 458-462.

Iptas, S. and A.A. Acar. 2006. Effects of Hybrid and Row Spacing on Maize Forage Yield and Quality. Plant Soil Environ, 52(11):515-522.

Jiwang, Z., Ho. Changhao, W. Kongjun, D. Shuting and L. Peng. 2004. Effects of Plant Density on Forage Nutritive Value of Whole Plant Corn. Agricultural Sci. in China, 3(11):842-848.

Kamel, M. S., A. Rauf, M. S. Mahmood, and S. Amer. 1983. The Effect of Plant Population on Local “Roumi” Maize Grain Yield When Grown Under Irrigation. Ann. Agri. Sci., 19:79-93.

Kara, S.M., M. Deveci, O. Dede and N. Sekeroglu. 1999. The Effects of Different Plant Densities and Nitrogen Levels on Forage Yield and Some Attributes in Silage Corn. III. Field Crops Congress in Turkey, 15-18 Nowember, 172-177, Adana.

Karlen D.L., C.R. Camp and J.P. Zublena. 1985. Plant Density, Distribution, and Fertilizer Effects on Yield and Quality of Irrigated Corn Silage. Commun. Soil Sci. Plant Anal., 16:55-70.

Keskin, B, H. Akdeniz, I.H. Yilmaz and N. Turan. 2005. Yield and Quality of Forage Corn (*Zea mays* L.) as Influenced by Cultivar and Nitrogen Rate. J. Agron., 4(2):138-141.

Muchow, R.C. 1988. Effect of Nitrogen Supply on the Comparative Productivity of Maize and Sorghum in a Semi-arid Tropical Environment: I. Leaf Growth and Leaf Nitrogen. Field Crops Res., 18:1-16.

Muchow, R. C. and R. Davis. 1988. Effect of Nitrogen Supply on the Comparative Productivity of Maize and Sorghum in a Semi-arid Tropical Environment: II. Radiation Interception and Biomass Accumulation. Field Crops Res. 18:17-30.

Mullins, G.L., S.E. Alley and D.W. Reeves. 1998. Tropical Maize Response to Nitrogen And Starter Fertilizer Under Strip and Conventional Tillage Systems in Southern Alabama. Soil & Tillage Research, 45:1-15.

Oktem, A. and A.G. Oktem. 2005. Effect of Different Intra Row Spaces to Forage Value of Three Silage Corn (*Zea mays* L. indentata) Genotypes. III. National Animal Nutrition Congress in Turkey, 7-10 September, 523-527, Adana.

O’leary, M. J. and G. W. Rehm 1990. Nitrogen and Sulphur Effects on the Yield and Quality of Corn Grown for Grain and Silage. J Prod Agric 3:135–140.

Olson, R. A. and D. J. Sander 1988. Corn Production. In: Sprague, G. F.; Dudley, J. W. (Ed.). Corn and Corn Improvement. Madison: American Society of Agronomy/Crop Science Society of America/Soil Science Society of America, 639-686.

Patricio Soto, O., B. Ernesto Jahn and S. Susana Arredondo. 2002. Planting Density and Nitrogen Fertilization of Hybrid Corn for Silage in the Irrigated Central Valley. Agricultura Tecnia, 62(2):255-265.

Patricio Soto, O., B. Ernesto Jahn and S. Susana Arredondo. 2004. Improvement of Protein Percentage in Corn Silage with an Increase in and Partitioning of Nitrogen Fertilization. Agricultura Tecnia (Chile), 64(2):156-162. Podolak et al., 1984;

Roth, G., D. Undersander, M. Allen, S. Ford, J. Harrison and C. Hunt. 1995. Corn Silage Production, Management, and Feeding. ASA, Madison, WI. NCR574.

Rutger, J.N., and L.V. Crowder. 1967. Effect of High Plant Density on Silage and Grain Yields of Six Corn Hybrids. Crop Sci. 7:182–184.

Saglatimur, T., M. Okant, V. Tasni and H. Baytekin. 1989. Güneydogu Anadolu Bölgesi Sulu Kosullarında Ikinci Urun Olarak Yetiştirilen Uc Mısır Ceşidinde Bitki Sıklıgının Verim ve Bazı Tarımsal Karakterlere Etkisi Uzerinde Bir Arastırma, Cukurova Universitesi Ziraat Fakultesi Dergisi, 4 (2), 10-20.

Sahar, A. K., S. Zorer, R. Celebi and A.E. Celen. 2005. The Effect of Different Forms and Doses of N Fertilizer on the Silage Yield of Maize (*Zea mays* L.). 5th Field Crops Congress in Turkey, 5-9 Semptember, 1001-1004, Antalya.

Saruhan, V. and H.D. Sireli 2005. An Investıgatıon on the Effect of Plant Densities and Nitrogen Doses on Ear, Stem and Leaf Yields of Maize (*Zea mays* L.). J.Agric.Fac.Hr.U., 9 (2): 45-53.

Sparks T.H., 1988. An Examination of the Effect of Plant Population on Dry Matter Yield in UK Variety Trials of Forage Maize. Plant Var. Seeds, 1:147-151.

Turgut, I., A. Duman, U. Bilgili and E. Acikgoz. 2005. Alternate Row Spacing and Plant Density Effects on Forage and Dry Matter Yield of Corn Hybrids (*Zea mays* L.). J Agron. Crop Sci., 191(2):146-151.

Turgut, I., R. Dogan and N. Yurur. 1997. The Effect of Plant Population on the Yield and Yield Components of Some Dent Corn Varieties (*Zea mays indentata* Sturt.) Grown under Bursa Conditions. 2th Field Crops Congress in Turkey, 22-25 September, 143-147, Samsun.

Uslu, O. And S. Karaaltin. 1999. Effect of Different Levels of Nitrogen on Physiological Growth, Yield Component and Yield of Second Crop Maize (*Zea mays* L.) under Kahramanmaras Condition III. Field Crops Congress in Turkey, 15-18 Nowember, 434-439, Adana.

Van Soet, P.J., J. B. Robertson and B.A. Lewis. 1991. Methods for Dietery Fiber, Neutral Detergent Fiber, and Non Starch Polysaccharides in Relation to Animal Nutrition. J. Dairy Sci. 74:3583-3597.

Widdicombe, D. and K.D. Thelen. 2002. Row Width and Plant Density Effect on Corn Forage Hybrids. Agron. J, 94:326–330.

Yandim, E. 2006. İkinci Ürün Mısırda (*Zea mays* L.) Bitki Sıklıgının Verim ve Bazı Tarımsal Karakterler Uzerine Etkisi. Yuzuncu Yıl Universitesi Fen Bilimleri Enstitusu Tarla Bitkileri Anabilim Dalı (Yayınlanmamış), Van, 27 p.

Yilmaz, S., H. Gozubenli, O. Knuskan and I. Atis. 2007. Genotype and Plant Density Effects on Corn (*Zea mays* L.) Forage Yield. Asian J Plant Sci, 6(3):538-541.