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Full Length Research Paper

The effect of nitrogen levels on forage yield and some attributes in some hybrid corn (*Zea mays indentata* Sturt.) cultivars sown as second crop for silage corn

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This study was carried out to determine the effect of four nitrogen levels on forage yield and some attributes three corn cultivars under irrigated conditions in Mustafakemalpasa, Bursa, Turkey in 2005 and 2006. The field experiments were set up according to randomized complete block experimental design with three replications. Three varieties were used (LG 2687, PR34N43 and H 2547) and four rates of nitrogen (0, 150, 300 and 450 kg ha^{-1}) were applied. The plant height, first ear height, stem diameter, the number of leaf and ear per plant, ear percentage in green herbage, forage yield and dry matter yield were determined. The effects of different nitrogen levels were not significant on all attributes, except forage and dry matter yield. It was determined that 300 kg N ha^{-1} was suitable for high forage and dry matter yield. The forage yields of cultivar were obtained between 81457 and 92913 kg ha^{-1}.

Key words: Corn, forage, nitrogen, yield.

INTRODUCTION

The maize is a crucial source of nutrition in foraging and a widely used industrial plant in Turkey, as well as in other countries. The maize is third, following wheat and barley, in Turkey production of cereal crops (Anonymous, 2007). It is an important crop that is planted and consumed more and more the last years (Kara, 2001).

Maize has good adaptation ability and a lot of cultivars have been used for production as a main crop and the second crop in Turkey. Since it has multiple consumption areas, the land where maize are planted increased considerably in recent years in Turkey. About 35% of Turkish maize production was used for human consumption, 30% was used as animal feed and 20% was used in forage industry (Genctan et al., 1995).

The maize is used mainly to make silage to feed the cattle and sheep in the Marmara region, so it is the most

Maize forage is an important source of energy for live-
important alternative way to lessen the need of forage.
stock animals. Mustafakemalpasa is one of the most popular places of raising cattle in the Marmara region.

Farmers who do not practice suitable maize rotation, have not obtained high forage yields in the region. Yet they have continued to apply excessive fertilization on different levels of nitrogen and other nutrient elements in soil with the expectation of high yield in excessive irrigation conditions. Particularly, excessive fertilization provides no increase in both yield and income but promotes environmental pollution. Especially low-cost fer -tilizers for some years encouraged excessive fertilization.

Corn is the most important silage plants in the world, because it is the most proper plant for ensilage. In addition, it produces abundant amount of green herbage and its silage has high nutriment value and palatable (Acikgoz, 1991).

The soil of the experiment area was high nitrogen level and the fertility of the soil was high. Therefore, the aim of the research was to determine the nitrogen needs of various maize cultivars planted as a second crop on these

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Table 1. Monthly air temperature, precipitation and relative humidity in 2005 and 2006 with long term averages (1990-2007) at Mustafakemalpasa.

Months	Temperature (^{o}C)			Precipitation (mm)			Relative humidity (%)		
	2005	2006	1990-2007	2005	2006	1990-2007	2005	2006	1990-2007
June	21.6	22.4	22.5	20.8	62.8	33.9	58.3	59.0	58.8
July	24.9	24.2	24.9	54.8	2.0	18.2	62.3	56.0	57.8
August	25.4	26.8	24.8	3.4	3.3	24.8	63.9	58.9	60.4
September	20.4	20.0	20.2	94.1	91.0	59.9	68.8	70.9	66.0
October	13.2	15.9	15.8	33.0	25.8	72.9	72.2	73.6	71.4
November	9.3	7.2	10.2	109.3	101.1	83.5	74.6	74.3	67.9
Average	-	-	-				-	-	-
Total	-	-	-	315.4	286.0	293.2	-	-	-

ecological conditions.

MATERIALS AND METHODS

The experiment was conducted at the field of experimental plots of Mustafakemalpasa Vocational School in 2005 and 2006. The experimental fields are situated at a latitude of 40^{o} 02' North, and a longitude of 28^{o} 23' East, 80 km away from Bursa, Turkey, 22 m above sea level. This climatic zone is characterized as a Mediterranean type climate.

Temperature, rainfall and relative humidity during the experimental period (June-November) are shown in Table 1. The first year of the study was more rainy than long term (315.4 vs 293.2 mm). On the other hand, second year was driest and rainfall during the growing period was much lower than long-term (286.0 vs. 293.2 mm). The soil was a clay loam, slightly alkaline (pH 7.8), and rich in extractable K (142.3 mg kg^{-1} soil), poor in extractable P (7.9 mg kg^{-1} soil), medium in organic matter (2.5%) and high nitrogen level (0.165% total N).

In the study, three hybrid maize cultivars, LG 2687, PR34N43 and H 2547 were used and four nitrogen levels (0, 150, 300 and 450 kg ha^{-1}) were applied. PR34N43 is short in height, it is widely grown as a second crop in Marmara region. The vegetation period is early in maturity (90 - 100 days) and it is resistant drought conditions. The interior of ear is red. Another cultivar H 2547 (Gold Daste) is short in height, it is used as both the main crop and a second crop in Marmara region. The vegetation period is middle early (112 - 115 days), it is resistant to the soils with high in pH. It has high tolerance to drought. The interior of ear is white. It's FAO group is 550- 590. LG 2687 is also advised as a second crop at the same region. The vegetation period is middle early (112 - 115 days) and it is resistant to drought conditions. It has no selectivity of soil. The interior of ear is red. It's FAO group is 550.

The experiment was laid out according to randomized complete block experimental design with three replications.

The experimental field was prepared after the rapeseed (*Brassica napus oleifera*) harvest in July and seeds were planted by hand with 70 cm inter-row spacing, 15 cm intra-row spacing with 4 rows for silage corn. The size of plots was 2.8 x 5 m = 14 m^{2} sowing made on July 8th, 2005 and July 10th 2006 as second crops.

Nitrogen doses were split up in two parts, one half was applied at sowing and the other half was applied when plants became 30 - 40 cm height as urea (46%N) . Besides, 100 kg ha^{-1} phosphorus was applied to each plot during sowing as triple super phosphate (46% P_2O_5). Weed control and irrigation were performed as needed.

For morphological measurements, ten plants were selected randomly from each plot and taken just before harvestig for silage. Plant height, first ear height, stem diameter, the number of ears per plant, ear percentage in the green herbage (%), and number of leaves per plant were measured. All sampled plants were divided into stover and ear fractions, and then weighed for their percentages. Two rows of the each plot were harvested for forage at the milk- to-dough stage. The sampled plants were dried at 70^{o}C for 72 h to calculate dry matter ratio than dry matter yield. Analysis of variance was performed on morphological measurements and forage yield data using MINITAB (University of Texas, Austin) and MSTAT-C (Version 2.1 Michigan State University, 1991) programs. Statistically significant means were separated by the LSD test at the 0.05 level.

RESULTS AND DISCUSSION

Some agronomic and yield characters of hybrids maize cultivars grown under different levels of N fertilization were shown in Table 2.

Plant height

Nitrogen fertilizer did not affect the plant height of maize significantly over control (Table 2). Control plots (0 kg N ha^{-1}) had lower plant height (278.5 cm) than other plots which applied N fertilizer doses (287.1, 287.2 and 297.1 cm). Similar results were reported by Turgut (1998) and Kara et al. (1999). But Keskin et al. (2005), Sahar et al. (2005) reported that plant height increased with increasing nitrogen application.

Although there were no significant differences among cultivars on the plant height, among the three maize cultivars. The plant height was changed from 279.5 to 301.4 cm. Results were similar to those of Iptas (1993), Sade (1994), Budak et al. (2005), Kusaksiz et al. (2005), and Yilmaz et al. (2007).

First ear height

Nitrogen fertilizer did not affect the first ear height significantly (Table 2). Control plots (0 kg N ha^{-1}) had lower ear height (132.7 cm) than other plots which applied N fertili-zer. 150, 300 and 450 kg N ha^{-1} had a little higher ear hei-ght than control (134.3, 132.3, 134.7 cm, respectively). These results were in accordance to

Table 2. Effect of hybrid and nitrogen levels on some morphological traits and forage yield (average of two years).

	Components							
	Plant height (cm)	First ear height (cm)	Stem diameter (mm)	Leaf number/ plant	Ear number/ plant	Ear Ratio (%)	Forage yield (kg ha^{-1})	Dry matter yield (kg ha^{-1})
Hybrid								
LG 2687	301.4	144.1 a	17.7	13.7 a	1.01	37.0	92913 a	27165 a
PR34N43	279.5	124.9 b	17.4	12.5 b	1.02	36.0	81457 c	24522 b
H 2547	281.6	131.5 b	17.6	12.8 b	1.05	35.8	85042 b	24539 b
Nitrogen levels (kg ha^{-1})								
0	278.5	132.7	17.0	12.8	1.00	35.4	80965 c	23768 bc
150	297.1	134.3	17.4	13.2	1.01	37.0	89428 b	25873 b
300	287.1	132.3	18.1	12.9	1.03	36.6	95625 a	29164 a
450	287.2	134.7	17.9	13.1	1.06	36.0	79865 c	22828 c
Hybrid x nitrogen levels								
0xLG 2687	293.0	145.8 ab	17.4	13.3	1.00	37.1	88070 c	25402
0xPR34N43	269.0	152.8 a	17.6	14.1	1.02	35.8	96120 b	28556
0xH 2547	273.5	133.6 bcd	17.7	13.5	1.00	36.3	107030 a	32185
150xLG 2687	306.6	144.3 abc	18.2	13.8	1.03	38.8	80440 de	22516
150xPR34N43	298.4	121.5 de	17.2	12.2	1.00	33.9	77260 e	23449
150xH 2547	286.4	125.3 de	17.4	12.6	1.00	38.6	84490 cd	23841
300x LG 2687	309.0	118.5 e	17.5	12.7	1.03	38.3	86240 c	28656
300xPR34N43	284.1	134.3 bcd	17.5	12.6	1.03	32.9	77840 e	22142
300xH 2547	268.1	130.8 cde	16.3	12.8	1.00	35.2	77580 e	22455
450xLG 2687	296.9	124.8 de	17.2	12.8	1.02	36.7	87680 c	25222
450xPR34N43	266.2	144.7 abc	18.9	12.5	1.05	35.2	93600 b	26652
450xH 2547	298.4	125.6 de	17.9	12.9	1.12	36.2	81320 de	23827
F test								
Years	**	**	**	*	ns	**	**	**
Hybrid (H)	ns	**	ns	**	ns	ns	**	**
Nitrogen levels (N)	ns	ns	ns	ns	ns	ns	**	**
HxN	ns	**	ns	ns	ns	ns	**	ns

1:Means of the same column followed by the same letter was 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.

those of Turgut (1998).

There were significant differences between cultivars on the ear height (Table 2). Among three maize cultivars, LG 2687 had the higher first ear height (144.1 cm) than H 2547 (131.5 cm) and PR34N43 (124.9 cm) cultivars (Table 2). Results were similar to those of Turgut (1998).

The interaction between genotypes and nitrogen levels was found to be significant. While PR34N43 cultivar had the highest first ear height at 0 kg Nitrogen dose (152.8 cm) and 450 kg N ha^{-1} doses (144.7 cm), the lowest was obtained from LG 2687 cultivar (118.5 cm) at 300 kg N ha^{-1} dose.

Stem diameter

Nitrogen fertilizer did not affect the stem diameter of maize significantly (Table 2). Control plots (0 kg N ha^{-1}) had slightly lower stem diameter (17.0 mm) than other plots which applied N fertilizer (respectively 17.4, 18.1, 17.9 mm). On the contrary, Kara et al. (1999), Saruhan and Sireli (2005) reported that stem diameter increased with increasing nitrogen rate.

Although there were no significant differences between cultivars on the stem diameter, among the maize cultivars, stem diameter changed from 17.4 (cv PR34N43) to 17.7 mm (cv LG 2687). Maximum stem diameter (17.7 mm) was observed in cv "LG 2687", cv "H 2547" (17.6 mm) and cv "PR34N43" (17.4 mm) followed it. Results were supported by finding of Avcioglu et al. (2001), Yilmaz et al. (2003) and Yilmaz et al. (2007).

The number of leaf per plant

Nitrogen fertilizer did not affect the number of leaf per plant of maize significantly (Table 2). Control plots had slightly lower the number of leaf per plant (than other plots which applied N fertilizer. These results were in agreement with those of Kara et al. (1999), Saruhan and Sireli (2005).

There were significant differences between cultivars on the number of leaf per plant. Among three maize cultivars, cv "LG 2687" had the highest leaf number per plant (13.7 number) than PR34N43 (12.5 number) and H 2547 (12.8 number) cultivars (Table 2). Similar results were reported by Sade (1994), Geren (2000), Budak and Soya (2003), Kusaksiz and Kaya (2005) and Turgut et al. (2005).

The number of ear per plant

Nitrogen fertilizer did not affect ear number of per plant of maize significantly over control (Table 2). Control plots had lower ear number of ear per plant (1.00 number / plant) than other plots where N fertilizer was applied (1.01, 1.03, 1.06 number/plant, respectively). Results were in line to those of Turgut (1998), but in the contrary, Keskin et al. (2005) and Saruhan and Sireli (2005), reported ear number increased by increasing nitrogen rate.

Ear number per plant of cultivars was found between 1.01 ear/plant (LG 2687) and 1.05 ear/plant (H 2547) and there was no significant difference among cultivars. These results were supported by finding of Turgut (1998) Keskin et al. (2005) and Turgut et al. (2005).

Ear ratio in forage

Nitrogen fertilizer did not affect ear ratio significantly over control (Table 2). Control plots had slightly lower ear percentage (35.4%) than other plots which applied N fertilizer. 150, 300, 450 kg N ha^{-1}, give respectively ear ratio values; 37.0, 36.6 and 36.0%. On the contrary, Keskin et al. (2005) reported that ear ratio increased by increasing nitrogen rate.

Ear ratio of cultivars was found to be between 35.8% (H 2547) and 37% (LG 2687) and there was no signi-ficant difference among cultivars. The results were sup-ported by finding of Budak et al. (2005) and Yilmaz et al. (2007).

Forage yield

Forage yield significantly changed depending on cultivars and nitrogen doses. LG 2687 produced greatest amount of forage yield (92913 kg ha^{-1}) and H 2547 followed (85042 kg ha^{-1}) it. PR34N43 had the lowest forage yield (81457 kg ha^{-1}). Results were supported by finding of Avcioglu et al. (2001), Geren et al. (2003) and Turgut et al. (2005).

The dose of 300 kg N ha^{-1} had the greatest amount of forage yield (95625 kg ha^{-1}) and 150 kg N ha^{-1} followed (89428 kgha^{-1}) it.

The dose of 450 kg N ha^{-1} and control plots (0 kg N ha^{-1}) had the lowest forage yield (79865 and 80965 kg ha^{-1}, respec-tively). The previous studies demonstrated that the lowest green herbage yields were obtained from the unfertilized plots and nitrogen applications increased forage yield (Torun and Koycu, 1996; Kara et al., 1999).

The interaction between genotypes and nitrogen levels was found to be significant for forage yield. The difference might be due to difference in nitrogen uptake and/or utilization by genotypes. H 2547 had the highest forage yield (10703 kg ha^{-1}) at 0 kg ha^{-1} nitrogen dose, PR34N43 cultivar followed it also 0 kgha^{-1} nitrogen dose (96120 kg ha^{-1}) and 450 kg ha^{-1} nitrogen dose (93600 kg ha^{-1}). This result shows that the amount of optimum nitrogen level which were applied to maize varies with respect to cultivar, soil structure and ecological conditions.

The soil of the experimental area had high nitrogen content and the fertility of the soil was well. These results indicate that higher forage yield obtained from some maize cultivars without application of nitrogen fertilizer may be in these ecological conditions.

Relatively high yield for some cultivars with no nitrogen application demonstrates that the adequate level of exploitable nitrogen is present in the soil. Kececi et al. (1987), Sencer (1988), Sezer and Yanbeyi (1997) reported that the amount of optimum nitrogen level varies depending on the cultivars and ecological conditions. But Hils et al. (1983), Eck (1984), Soltner (1990) and Kirtok (1998) reported that the amount of nitrogen might vary form 80 to 250 kg ha^{-1}.

Dry matter yield

Dry matter yield significantly changed depending on cultivars and nitrogen doses like forage yield. LG 2687 cultivar had the greatest dry matter yield (27165 kg ha^{-1}) and H 2547 (24539 kg ha^{-1}) and PR34N43 (24522 kg ha^{-1}) cul-tivars followed it. These results are in accordance to those of Konak (1994), Yilmaz et al. (1996), Avcioglu et al. (2001), higher than other previous researcher results (Budak and Soya, 2003; Keskin et al., 2005; Kusaksiz and Kaya, 2005; Sahar et al., 2005).

The dose of 300 kg ha^{-1} nitrogen applications had the greatest amount of dry matter yield (29164 kg ha^{-1}) and followed by 150 kg N ha^{-1} application (25873 kg ha^{-1}) it. There was no significant difference between control plot and 450 kg N ha^{-1} dose. Control plots and 450 kg N ha^{-1} yielded 22828 and 23768 kg ha^{-1}, respectively. The previous studies demonstrated that the lowest dry matter yields were obtained from the unfertilized plots and nitrogen applications increased dry matter yield (Torun and Koycu, 1996; Kara et al., 1999; Keskin et al., 2005; Sahar et al., 2005).

Conclusion

Like the soils with high level nitrogen and high fertility in these ecological conditions, enough forage yields are obtained from no nitrogen application. It has been noticed that the amount of optimum nitrogen might vary among the maize cultivars.

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