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Full Length Research Paper

Nitrogen rate and previous crop effects on some agronomic traits of two corn (*Zea mays* L.) cultivars Maverik and Bora

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A 2-year field study was conducted to evaluate effects of nitrogen (0, 12.5, 25 kg/da N) rates and previous crops on 2 hybrid corn cv Maverik and Bora varieties planted as second crop following either chickpea or wheat during 2004 and 2005. Split-split plot experimental design was used with 4 replications. Tasseling period, ear silk period, first ear height, plant height, stem diameter, ear length, 1000 seed weight, seed weight of each ear and seed yield parameters were evaluated. Results indicated that effects of previous crops for ear silk period, 1000 seed weight, seed weight of each ear and seed yield of corn varieties were highly significant during both years, while first ear height and ear length were significantly different during 2004, only. The N rates significantly affected tasseling period, ear silk period, first ear height, plant height and seed yield during both years. Effect of N rates was also significant for stem diameter and ear length during 2004 while 1000 seed weight was significant during 2005, only. There were significant differences between 2 corn varieties for tasseling period, ear silk period, first ear height, ear length, seed weight of each ear during both years whereas 1000 seed weight and seed yield showed significant differences during 2004 and stem diameter showed a significant difference during 2005, only. There was a previous crop x N rate interaction for seed yield during both years while significant previous crop x N rate interactions were determined for 1000 seed weight and seed weight of each ear in 2005. This study suggested that N rates and corn cultivars might result significant differences on tasseling period, ear silk period, first ear height, ear length and seed weight of each ear. The results also indicated that species of previous crops significantly affect corn seed yield and yield parameters and winter legumes such as chickpea might help to maximize corn yield in a crop rotation system.

Key word: Corn, chickpea, wheat, previous crop and nitrogen rate.

INTRODUCTION

Corn (*Zea mays* L.) is one of the most important crops all around the world. Monoculture of corn cropping systems has resulted in typical problems associated with intensive agriculture, including increased weeds and pest problems (Fischer et al., 2002), reduced soil fertility (Halvorson et al., 2001; Rice et al., 1987), deteriorate soil physico-chemical conditions (Vanlauwe et al., 2001) and N pool status and N availability (Dinnes et al., 2002). Therefore, choice of optimal crop rotations is the first step to design sustainable cropping systems. There are several management practices that can influence N dynamics of soil-plant system such as tillage and crop rotation with legume crops (Bremer and Kessel, 1992a; Haynes et al., 1993). Including legume plants in the crop rotation systems will result enhanced soil fertility, increased water use efficiency and decreased yield and quality losses from weeds and soil-borne diseases. Guy and Gareau (1988) also reported that mustard (*Sinapis alba* L.), dry

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Table 1. Some physicochemical compositions of research field soil (Tosun, 2005; Celep, 2006).

Parameter	Wheat	Chickpea
Saturaion (%)	41.15	41.10
pH	7.3	7.49
Lime (%)	21.8	22.19
Organic matter (%)	1.24	1.43
Salt (%)	0.05	0.04
P_2O_5 (kg/da)	4.86	4.86
K_2O (kg/da)	35.32	29.31

pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.) might be beneficial for crop rotation to increase yield of winter wheat. It was shown that wheat yields following both sunflower and soybean were less than those following corn and sorghum and yields following sunflower were less than those following soybean (Norwood, 2000).

Although green manure of legume crop residues is an effective source of N (Bremer and Kessel, 1992a; Haynes et al., 1993), N fertilizers such as ammonium sulfate might be more effective supplier of N to a crop system (Seo et al., 2006). Total N requirement for sorghum and a sustainable portion of N needed to maximize corn yield may be provided by legume cover crops (Hargrove, 1986; McVay et al., 1989; Touchton et al., 1982). Reinbott et al. (2004)) suggested that winter annual cover crops provide several distinct benefits to no-tillage corn and sorghum production systems and cover crops should be selected based on specific grower needs.

Whereas much has been published in support of benefits attributed to annual winter crops, no research has been conducted concerning effects of chickpea and wheat on yield parameters of subsequent corn crop. Maize is generally planted after wheat as a second crop in Kahramanmaras-Turkey vicinity although annual legume crop planting such as chickpea is more than fit in a crop rotation and might provide several advantages to subsequent corn planting. Therefore, the objective of this research was to determine beneficial effects of chickpea and wheat on subsequent corn yield parameters of 2 corn cultivars.

MATERIAL AND METHODS

Side description and experimental design

Field experiments were conducted at Faculty of Agriculture, Sutcu Imam University, Kahramanmaras, Turkey during 2004 and 2005. The physico-chemical compositions of the soil of the research field were given in Table 1 and precipitation and average monthly air temperatures during 2004 and 2005 were reported in Table 2.

Split-split plot experimental design was used with three replications. Previous crops (wheat or chickpea) were main plots, corn cv (Maverik, Bora) were sub-plots and N (NH_4NO_3) rates (0, 125, or 250 kg/ha^{-1}) were sub-subplots. N rates were determined based on expected yield goal estimates for corn in the region (Oner, 2003). Sub-supplots were 2.8 m wide by 5 m long.

Field procedures and data collection

As previous crops, wheat was sown on 15 November during 2004 and 18 December during 2005 and chickpea was sown on 21 November 2004 and 12 December 2005.

The experimental sites were prepared after wheat and chickpea were harvested during June 2004 and 2005. Corn seeds were seeded by hand approximately 4 cm deep at 70 cm row spacing at first week of June 2004 and at second week of 2005. P_2O_5 (100 kg ha-^{1}) fertilizer was applied and mixed into soil before planting. Half of N rates was applied and mixed into soil before planting. Remaining doses of N rates were applied at knee-high stage as a top dressing. Weed control (4 - 5 times year^{-1}) and irrigation (8 - 9 times year^{-1}) were done when they were necessary.

Tasseling period, ear silk period, first ear height, plant height, stem diameter, ear length, 1000 seed yield, seed weight of each ear and seed yield were determined from the samples taken from the center 2 rows of each plot as described by Ulger (1986).

Data of each year were subjected to analysis of variance using SAS statistical software (SAS 1997) and mean separation was performed by Fisher's least significant difference (LSD) test if F test was significant at $P < 0.05$.

RESULTS AND DISCUSSION

Effects of previous crops

Including winter legumes crops in crop rotation systems might help to improve soil characters, organic matter and nitrogen (Clark et al., 1997; Clark et al., 1995; Meisinger et al., 1991). Significant yield increases could be achieved on production of subsequent crops if a proper previous crop is chosen (Abd-El-Samie, 1994) since soil N balance after legume crops can be positive or negative (Armstrong et al., 1994; Haynes et al., 1993). In this study, the previous crops showed no significant effect on tesseling period, plant height, stem diameter in both years while the effects of previous crops were significant ($P < 0.01$) for ear silk period, 1000 seed weight, seed weight of each year and seed yield in both years (Tables 3, 4 and 5). Uzun et al. (2005) reported no previous crop effect on ear lenght although results of this study showed significant ($P < 0.05$) effects of previous crops on the first ear height and ear length during 2005. Corn planted after chickpea provided a shorter ear silk period than corn planted after wheat for both years. Ear silk periods were 54.5 and 55.5 days and 42.1 and 44.3 days for corn planted after chickpea and wheat during 2004 and 2005, respectively. Ear silk period was also about 12 days shorter in 2004 than 2005. The cultivars planted after chickpea provided a longer first ear height (79.0 cm) and ear length (18.4 mm) than the cultivar planted after wheat in 2004 (Table 3) while the first ear height differences were not significant during 2005 for both parameters. The 1000 seed weight was significantly ($P < 0.05$) higher on the cultivars planted after chickpea in both years. Similarly, the cultivars planted after chickpea had a higher

Table 2. Precipitation and average monthly air temperatures for corn crop seasons of 2004 and 2005 in Kahramanmaraş-Turkey (Tosun, 2005; Celep, 2006).

Parameter		July	August	September	October	November	Average
Temperature (°C)	2004	29.3	28.0	26.3	21.0	11.5	22.7
	2005	28.6	28.7	24.9	17.1	10.8	22.0
Precipitation (mm)	2004	0.4	0.2	0.0	1.4	263.2	53.04
	2005	0.2	0.4	7.9	32.0	104.6	29.0

Table 3. Previous crop, nitrogen rates and cultivar effects on tasselling periot, ear silk period and first ear height of corn.

Parameter	Tasseling Period (day)		Ear silk period (day)		First ear height (cm)	
	2004	2005	2004	2005	2004	2005
Previous crops (A)	**Ns**	**Ns**	**	**	*	**Ns**
Corn after chickpea	51.62	40.66	54.50 b	42.16 b	79.00 [a]	76.99
Corn after wheat	52.33	40.91	55.58 a	44.33 a	75.58 b	78.92
LSD			0.62	1.68	2.53	
Doses of nitrogen (B)	**	**	*	**	*	**
0 (kg(da)	53.43 a	42.12 a	55.81 a	44.75 a	70.87 b	72.28 b
12.5 (kg/da)	51.43 b	40.37 b	55.06 ab	42.75 b	77.25 ab	78.28 ab
25 (kg/da)	51.06 b	39.87 b	54.25 b	42.25 b	83.75 a	83.31 a
LSD	1.34	0.716	1.43	0.716	7.87	6.728
Cultivars (C)	**	**	*	*	**	*
Maverik	53.20 a	43.50 a	55.58 a	45.66 a	81.25 a	79.32 a
Bora	50.57 b	38.08 b	54.50 b	40.83 b	73.33 b	76.59 b
LSD	0.87	0.41	0.86	0.45	4.68	2.69
AXB	**Ns**	**Ns**	**Ns**	**Ns**	*	**Ns**
AXC	Ns	Ns	Ns	*	Ns	Ns
BXC	Ns	Ns	Ns	Ns	Ns	Ns
AXBXC	Ns	Ns	Ns	Ns	Ns	*

*, ** Significant at 0.05 and 0.01 level, respectively. Ns: Non-significant.

seed weight of each ear as well as seed yield in both years (Table 5). Fischer et al. (2002) reported that corn after vetch with zero tillage yielded well. On the other hand, there are several researches indicating that legume cover crops could provide a sustainable portion of the N needed to maximize corn yield (Hargrove, 1986; McVay et al., 1989; Touchton et al., 1982). Estimates of N contribution associated with winter annual legume cover crops ranged 0 to 159 kg N ha^{-1}, depending upon year, location and legume cover crop (Hesterman et al., 1992; Oyer and Touchton, 1990; Touchton et al., 1982). For instance, Varco et al. (1989) used ^{15}N-depleted hairy vetch (HV) residues to estimate legume contributions to corn showed that corn recovered 32 and 20% of the HV-labeled N releases in moldboard-plow and no tillage treatments, respectively. It was also reported that ^{15}N releases from 4 different species of legume residues changed from 65 to 82% and succeeding barley used only 17 to 24% of the legume ^{15}N (Müller and Sundman, 1988). Although previous reports indicated that chickpea crop is incapable of meeting N demands by N fixation in its root nodules and does not even supply an equivalent quantity of 50 kg ha^{-1} of N fertilizer to the following wheat crop (López-Bellido et al., 2004a, 2004b), this study showed that residues of chickpea planted as a winter annual crop is able to make a significant contribution to maximize yield and some yield parameters of corn. Planting corn following chickpea significantly improved yield and yield parameters including 1000 seed weight and seed weight of each ear and provided a shorter ear silk period when we compare to corn planted after wheat.

Effects of N rates

Nitrogen fertilizer response of corn could vary among fields (Schmitt and Randall, 1994) as well as within same field (Blackmer and White, 1998; Manzer et al., 1996). This variation could be because of differences in soil N supply and corn N use efficiency (Meisinger, 1984). Soil

Table 4. Previous crop, nitrogen rates and cultivars effect on plant height, stem diameter and ear length of corn.

Parameter	Plant height (cm)		Stem diameter (mm)		Ear length (mm)	
	2004	2005	2004	2005	2004	2005
Previous crops (A)	**Ns**	**Ns**	**Ns**	**Ns**	*	**Ns**
Corn after chickpea	206.95	173.32	18.13	16.01	18.44 a	17.85
Corn after wheat	197.00	178.51	16.33	16.32	17.34 b	17.83
LSD					0.75	
Doses of nitrogen (B)	*	*	*	**Ns**	*	**Ns**
0 (kg(da)	193.00 b	164.37 b	16.00 b	15.73	16.82 b	17.02
12.5 (kg/da)	198.81 b	180.92 a	17.45 ab	16.31	17.86 ab	17.53
25 (kg/da)	214.12 a	182.44 a	18.25 a	16.46	18.98 a	18.96
LSD	14.48	8.29	1.57		1.33	
Cultivars (C)	**Ns**	**Ns**	**Ns**	**	**	**
Maverik	202.33	177.21	17.16	15.51 b	18.62 a	18.49 a
Bora	201.62	174.62	17.30	16.82 a	17.16 b	17.19 b
LSD	9.7	4.04	0.49		0.68	0.56
AXB	**Ns**	*	**Ns**	**Ns**	**Ns**	**Ns**
AXC	Ns	Ns	Ns	*	Ns	Ns
BXC	Ns	*	Ns	Ns	*	Ns
AXBXC	Ns	Ns	Ns	*	Ns	*

*, ** Significant at 0.05 and 0.01 level, respectively. Ns: Non-significant.

Table 5. Previous crop, nitrogen rates and cultivars effect on 1000 seed yield, seed weight of each ear and seed yield of corn.

Parameter	1000 seed weight		Seed weight of each ear		Seed yield	
	2004	2005	2004	2005	2004	2005
Previous crops (A)	*	*	**	**	*	*
Corn after chickpea	378.66 a	359.46 a	183.16 a	255.10 a	761.67	794.84 a
Corn after wheat	335.37 b	321.56 b	152.12 b	193.36 b	698.79	622.21 b
LSD	24.09	25.05	16.34	29.46	49.58	142.51
Doses of nitrogen (B)	**Ns**	*	*	**Ns**	**	**
0 (kg(da)	349.18	359.99 a	151.50 b	200.03	620.69 b	568.41 b
12.5 (kg/da)	351.00	343.30 ab	164.06 b	217.92	677.50 ab	726.13 a
25 (kg/da)	370.87	318.26 b	187.37 a	209.73	892.50 a	831.03 a
LSD		25.05	22.62	20.47	223.1	160.30
Cultivar (C)	*	**Ns**	**	*	**	**Ns**
Maverik	348.45 b	333.90	158.04 a	220.10 a	793.42 a	733.08
Bora	365.58 a	347.12	177.24 b	198.36 b	667.04 b	683.97
LSD	13.24	17.46	13.93	16.71	89.20	87.22
AXB	**Ns**	**	**Ns**	**	*	**
AXC	Ns	Ns	Ns	Ns	Ns	Ns
BXC	Ns	Ns	Ns	Ns	Ns	Ns
AXBXC	Ns	Ns	Ns	Ns	Ns	Ns

*, ** Significant at the 0.05 and 0.01 level respectively. Ns : Non-significant.

N supply of corn could be provided by either legume crops planted as a annual winter crop which could be an effective source of N (Bremer and Kessel, 1992b; Haynes et al., 1993), or by giving N fertilizers such as ammonium sulfate that might be more effective supplier of N to a crop system (Seo et al., 2006). Previous report showed that corn commonly recovers 30 to 55% of the ^{15}N in the above ground crop and about 15 to 30% of N retained in the soil, mostly as organic N (Timmons and Baker, 1992; Timmons and Cruse, 1990). Results of this 2 year study revealed that rates of N significantly affected all measured parameters with some exceptions (Tables 3, 4 and 5). The first ear height, stem diameter, ear length and seed weight of each ear and seed yield did not show any significant differences during 2005. While tesseling period was significantly ($P < 0.01$) affected by N rates, control plants showed a longer tasseling period than plants received N for both years. Tesseling period might be very based on variety, climate and environment (Kirtok, 1998; Tufekci, 1999). It was previously shown that tasselling period of corn was decreased when rates of N were increased (Gozubenli, 1997; Tufekci, 1999). However, results of this study revealed that increasing N rate from 125 to 250 kg h^{-1} did not show any significant difference on tesseling period (Table 3). Tesseling period was about 12 days shorter in 2005 than 2004 possible due to climatic differences. Similar effects were also present for ear silk period and the first ear height. The N rates showed significant ($P < 0.01$) effect on ear silk period of corn in both years, but differences were more present in 2005 than in 2004 when it was compared to control plants in terms of N rate. The 250 kg ha^{-1} N rate in 2004 and 2005 resulted 1 and 2 days shorter ear silk period than control plants that N fertilizer was not applied. The control plants had the longest tasseling period (55.8 and 44.7 days in 2004 and 2005, respectively). 125 kg h^{-1} (164.0 g) and 250 kg h^{-1} (187.3 g) of N in 2004 showed significant differences on seed weight. Previous report indicated that number of seeds ear^{-1}, 1000-seed weight and seed weight increased significantly up to 180 kg N ha^{-1} and seed yield $plant^{-1}$ up to 240 kg N ha^{-1} (Sanjeev et al., 1997). Gokmen et al. (2001) also reported that plant height, 1000 seed weight and seed weight ear^{-1} increased significantly with 100 kg N ha^{-1} while tasseling period generally decreased with increasing N rate. Increased N rate resulted in increased plant height in 2004 while plant height differences were not significant for N applications of 125 and 250 kg h^{-1} in 2005. It was previously reported that plant height of corn was increased when application of N rates were increased (Gozubenli, 1997; Tufekci, 1999) which is in agreement with the result of this study. Biomass and seed yields of corn crop increased with increasing N rate (Nunes et al., 1996; Oner, 2003). Oner (2003) reported that the maximum seed yield can be obtained from 250 kg ha^{-1} N application in Kahramanmaras conditions which is in agreement with the result of this study.

Effects of corn cultivars

The cultivars showed highly significant differences for tesseling period, ear silk period, first ear height, ear length and seed weight of each ear in both years (Tables 2, 3 and 4). On the other hand, stem diameter, ear length, 1000 seed weight and seed yield gave significant differences during 2004, only. The cv. Bora had a shorter tesseling period than cultivar Maveric in both years (Table 3). The results showed significant differences between corn varieties for ear silk period. The cultivar Bora had a shorter ear silk period than the cultivar Maverik (Table 3). Cultivar Maverik gave a longer first ear height and ear length in both years. However, conflict results were reported for the effects of N rates on ear length. For instance, Gozubenli (1997) and Tufekci (1999) reported a significant effect of N rates on ear length while Yilmaz (2005) has found that the effects of N rate were not significant. The results sowed that culti-var effects were significant ($P < 0.05$) on seed weight of each ear in both years (Table 5).

In general, previous crops by N rate interactions significantly ($P < 0.05$) occured for seed yield in both years while significant ($P < 0.01$) previous crop x N rate interactions were determined for 1000 seed weight and seed weight of each ear in 2005 (Table 5). Gozubenli (1997) reported a significant interaction between varieties and N rates for seed yield, although Tufekci (1999) showed that varieties x N rate interaction for seed yield was not significant.

In conclusion, rates of N significantly affected tesseling period of the cultivars used and significant differences were detected between cutivars for tesseling period, ear silk period, first ear height, ear length and seed weight of each ear. The results also revealed that species of previous crops significantly affect corn seed yield and yield parameters, including 1000 seed weight and seed weight of each ear and winter legumes such as chickpea might help to maximize corn yield in a crop rotation system.

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