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THE EFFECTS OF PREVIOUS PLANTS AND NITROGEN RATES ON SECOND CROP CORN

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ABSTRACT

The aim of this experiment was to investigate the effects of nitrogen (N) rates and previous crops on corn planted as second crops. This research was conducted in Kahramanmaraş condition of second crop growing in 2007 and 2008. Split-split plot experimental design was used with four replications. Vetch and wheat were used as previous crops and N rates were used at 0, 12.5 and 25 kg/da for P 35Y65 and P.3394 hybrid corns. Tasseling period, plant height, 1000 grain weight, protein rate and grain yield parameters were evaluated. Results indicated that effects of years for tasselling period, plant height, and protein rate and grain yield of corn varieties were highly significant. There were significant differences between previous (vetch and wheat) for tasseling period, protein rate and grain yield of corn. Effect of N rates was also significant for tasseling period, 1000 grains yield and grain yield. There were significant differences between corn cultivars for 1000 grains yield and plant height. The results also indicated that protein rate and grain yield of corn seed were 7.94% and 919.13 kg/da respectively, when previous crop was wheat. The previous crop was vetch, protein rate of corn seed were 9.15% and 1010.84 kg/da. It was reported that the least grain yield was 838.55 kg/da with 0 kg/da N manure, the highest grain yield was 1032.22 kg/da with 25 kg/da N. It was showed that the previous crop was significant for corn.

Keyword: corn, nitrogen rate, previous crop

INTRODUCTION

In today's world, the most prominent aim of human beings is to maximize the profit by increasing production. Higher inputs used in production in order to get maximum profit cause some economic losses since they pollute environment. Preventing environmental pollution and minimizing economic losses are gaining importance in sustainability concept. Sustainability would only be possible with the conservation of soil and plant. Rotation application for the plants grown in the field from which we obtain our basic food will not only increase the yield but also make remarkable contribution to sustainability (Avcı et al., 2005).

The aim of rotation is to determine the plants getting maximum contribution from environment by conserving soil and water existence and this also requires a series of investigations which would increase soil productivity and grain yield. Rotation studies starts with identification of the main crop group suitable for environmental and climate conditions. Most frequently used crop group for human and animal nutrition is cereal products and among them most widely grown ones are wheat, rice and corn. Corn has higher yield in unit area compared to rice plant and wheat. Apart from being used as cereal, corn is also widely used in industry, which has caused corn farming to grow and many studies to be carried out on this plant (Torun, 1984; Dok, 2005).

Corn is usually grown in temperate and tropical regions (Kırtok, 1998). Corn is also a leading plant to be subject of rotation studies. Since corn can use light effectively and has the ability to produce a great quantity of dry matter in a short time, it is an ideal rotation plant for irrigated conditions. From a grain weighing less than 1 g, 2-3 m plant height can be obtained in the first 2 months and 500-700 grains can be produced in a short vegetation period of 3-5 months under the normal conditions. Developments in corn improvement in recent years have enabled farmers to grow corn as both previous crop and second crop successfully (Cesurer, 1995).

Soil productivity is a dynamic event and is significantly affected from climate conditions and farming methods. In order to maintain soil productivity, mineral fertilizers are widely used but using fertilizers more than needed doesn't increase yield contrary to what is believed (Berenguer et al., 2009). Depending on the activities on field, a large amount of fertilizer might be used and as the amount of fertilizer increases, economic loss and environmental pollution increases, too (Romero Guzman et al., 2006). When use of excessive fertilizer combined with wrong applications such as tillage out of season and intensive farming, stubble firing, soil gets poorer in terms of organic matter content. Increasing organic matter content of soil is a vital and primary issue for prevention of environmental pollution related with excessive mineral fertilizer and sustainable yield by improving physical, chemical and biological properties of soil.

In order to increase the organic matter content of soil and meet nutrient need of plants, manure and plant waste are widely used in soil. Therefore, using low-cost and

environment friendly organic-based alternative fertilizers in field-agriculture is quite significant for a sustainable yield (Tunçsiper and Yılmaz, 2005). It is reported that with application of the plant wastes used in agricultural production and the wastes obtained from the usage of agricultural products in industry improved chemical, biological and physical properties of the soil (Calderon, 2000; Salgado, 2000; Tejeda et al., 2001).

N is one of the most significant nutrients in plant development. Corn plant which has the ability of producing great amount of dry-matter in irrigated conditions and has hairy roots which needs high-doses of N. When excessive amount of N is applied in irrigated farming, plants cannot use the entire N and leaching with irrigation water occurs (Hall, 1992). As a result of leaching, N leaks into ground water and pollutes it and, naturally, the environment (Hills et al., 1983; Eck, 1984; Soltner, 1990; Eghball et al., 1996; Kırtok, 1998). Previously conducted studies show that the amount of N used in corn farming can be between 8-25 kg/da. However, optimum N level may vary depending on the corn types and environmental conditions (Keçeci et al., 1987; Sencar, 1988; Sezer and Yanbey, 1997).

Second crop farming is common in Kahramanmaraş which have the opportunity of irrigated farming. Since livestock is a developed sector in this region, fodder plant farming is also a great necessity. The rotation between legume plants and cereal plants make great contribution to both soil and yield. In our study, the effect of N rates and previous crops (vetch and wheat) on corn plant as second crop was investigated for two years.

MATERIAL AND METHOD

Experimental Place and Plan

The field experiment was carried out in Kahramanmaraş conditions with corn as second crop in 2007 and 2008 using split-split plot experimental design with four replications for a two-year-period. Soil and climate properties were shown in Table 1 and Table 2 respectively (Anon., 2007, 2008a and 2008b). As previous crop vetch and wheat and as second crop P35Y65 and P3394 hybrid corn types were used in the study. N-fertilizer rates were used at 0, 12.5 and 25 kg/da at two stages. The materials were planted with 70 x 20 plantation distance in four rows, each of which had a 5 m length, in 14 m^2 field. Just after the previous crop harvest, soil was prepared for plantation by disc harrow, rotary tiller and harrow.

Field Experiment and Data Collection

Previous crops were planted on November 18, in 2006 and on December 11 in 2007 year. In the experiment years (2007 and 2008), vetch and wheat were harvested in the last week of May and in the second week of June respectively. Corn as second crop was planted by grain drill in the first week of July in 2007 and in the last week of June in 2008. While phosphorous fertilizer was applied by drilling machine (10 kg/da), the first half of nitrogen was applied to the rows by hand. The other half of the N-fertilizer was applied to the rows by hand before tasselling period. Herbicide against weeds was applied twice a year. Pesticide was applied once in 2007 and twice in 2008. The field was irrigated seven times in 2007 and eleven times in 2008. Although the crop was ready for harvest at the end of October, it was harvested in the first week of November due to rainfall. In the experiment, tasselling period, plant height, 1000 grain weight, protein rate and grain yield parameters were studied (Ulger, 1986). The results were analyzed using SAS statistical program (SAS, 1997) and mean values were evaluated using LSD test.

As we see from Table 1, the soil of the experimental place was loamy, had neutral pH and had no salt problem, it was rich in lime and potassium but it was moderate in terms of organic matter content and phosphorous.

Table 1 Soil properties of experiment place in 0-20 cm depth.

Properties	Wheat Field		Vetch Field	
	2007	2008	2007	2008
Saturaion (ml)	44.2	40.9	48.1	40.8
Ph	6.8	7.02	7.19	7.53
Salt (%)	0.09	0.04	0.09	0.05
Lime (%)	20.45	25.92	22.61	25.59
Organic matter (%)	2.74	1.83	3.53	1.88
Phosphorous (ppm)	12.35	9.92	14.49	11.94
Potassium (ppm)	188.94	162.88	182.27	55.8

As it is shown in Table 2., the highest and the lowest temperatures, in July and August , during which active vegetative growing of corn continues, are 38.7 °C and 23.5 °C respectively and these values in September and October, during which generative growing of the plant continues, are 34.6 °C and 13.2 °C respectively. During the second crop growing season, relative humidity varied in the range of 46.0% - 65.9%.

Table 2 Average maximum and minimum temperature and relative humidity (%) parameters belonging to second crop corn growing season in Kahramanmaraş in 2007 and 2008.

	Year	June	July	August	Semtember	October	November
Maximum °C	2007	34.9	38.7	37.5	34.6	27.2	16.3
	2008	34.1	37.8	38.3	32.3	26.0	18.6
Minimum °C	2007	21.0	23.8	23.5	19.1	14.2	7.4
	2008	20.7	23.8	23.8	19.3	13.2	8.3
Humidity (%)	2007	49.8	46.0	62.8	54.5	54.2	65.9
	2008	49.8	58.3	59.7	61.4	54.6	64.1

RESULTS

The main values of some properties obtained from the studies carried out by planting P35Y65 and P3394 hybrid corns as second crop after the harvest of vetch and wheat and by applying 0, 12.5 and 25 kg/da N rates in Kahramanmaraş conditions are indicated in Table 3.

Tasselling Period

It is clear from Table 3 that years, previous crop and N rates ($P<0.01$) had significant effect on tasselling period. However, the effect of corn types on tasselling period was statistically insignificant. It was detected that there were

Table 3 Average data belog to tasselling period (TP), plant height (PH), 1000 grain weight (TGY), protein rate (PR) and grain yield (GY) of second crop corn in Kahramanmaraş conditions in 2007 and 2008 years.

	TP (day)	PH (cm)	TGY (g)	PR (%)	GY (kg/da)
Year (A)	**	**	ns	**	**
2007	54.12 a	182.23 b	347.21	8.99 a	879.27 b
2008	51.77 b	213.72 a	351.65	8.09 b	1050.69 a
LSD	0.351	3.360	10.549	0.35	55.38
Previous crop (B)	**	ns	ns	**	**
Corn after wheat	53.27 a	196.57	345.77	7.94 b	919.13 b
Corn after vetch	52.62 b	199.38	353.09	9.15 a	1010.84 a
LSD	0.351	3.360	10.549	0.35	55.381
Nitrogen rate (C)	**	ns	**	ns	**
0 (kg(da)	53.53 a	198.28	337.52 b	8.27	838.55 b
12.5 (kg/da)	52.34 c	197.77	348.63 b	8.82	1024.22 a
25 (kg/da)	52.96 b	197.87	362.14 a	8.53	1032.17 a
LSD	0.429	4.11	12.92	0.434	67.828
Variety (D)	ns	**	**	ns	ns
P 35Y65	52.89	195.94 b	358.67 a	8.56	963.23
P 3394	53.00	200.00 a	340.19 b	8.53	966.73
LSD	0.351	3.360	10.549	0.35	55.381
AXB	ns	*	*	ns	ns
AXC	**	**	ns	ns	ns
BXC	ns	**	ns	ns	**
AXD	**	**	ns	ns	*
CXD	ns	*	ns	ns	ns
AXBXD	*	**	ns	*	ns
AXCXD	ns	*	ns	ns	ns
AXBXCXD	**	ns	ns	ns	ns

*, ** Significant at the 0.05 and 0.01 level, ns : not-significant

significant differences among year x N rate, year x corn variety, year x previous crop x corn variety and year x previous crop x N rate x corn variety interactions in terms of their effect on tasselling period. The tasselling period in the second year was 51.77 days and it was 3 days earlier than that of the first year (54.12 days). When vetch was planted as previous crop for corn, tasselling period became 52.62 days and it was one day earlier than that of wheat as previous crop (53.27 days). The earliest tasselling period was recorded as 52.34 days at 12.5 kg/da N rate application and 25 kg/da and 0 kg/da N rate followed it with their tasselling period of 52.96 days and 53.53 days respectively. The earliest and the latest tasselling periods for year x N rate, year x corn variety, year x previous crop x corn variety and year x previous crop x N rate x corn variety interactions were 51.50 and 54.43, 50.62 and 55.16, 50.16 and 55.50, 49.75 and 56.00 days respectively.

Plant Height

It is clear from Table 3 that years and corn variety had ($P<0.01$) significant effect on plant height but the effects of previous crop and N rates on it were statistically insignificant. There were significant differences among year x previous crop, year x N rates, year x corn variety, previous crop x N rate, N rate x corn variety, year x previous crop x corn variety, year x N rate x corn variety interactions in terms of effect on plant height. The plant height parameter of 2008 was 31 cm greater than that of 2007 (182.23 cm) with its 213.72 cm value. It was detected that P3394 hybrid corn had greater height parameter than P35Y65 (195.94 cm) variety with its 200.00 cm height. The lowest and the highest height parameters of year x previous crop, year x N rate, year x corn variety, previous crop x N rate, N rate x corn variety, year x previous crop x corn variety, year x N rate x corn variety interactions were 181.50 cm and 217.21 cm, 177.63 cm and 218.11 cm, 181.96 cm and 218.05 cm, 193.41 cm and 203.15 cm, 193.53 cm and 202.01 cm, 175.68 cm and 218.08 cm, 192.15 cm and 204.25 cm respectively.

1000 Grain Weight

It is clear in Table 3 that N rates and corn variety ($P< 0.01$) had a significant effect on 1000 grain weight but the effect of years and previous crop was statistically insignificant. It was detected as a result of the study that years x previous crop interaction showed great difference in terms of 1000 grain weight. The highest 1000 grain weight parameter was recorded at 25 kg/da N rate application with 362.14 g parameter. Whereas, the lowest 1000 grain weight

was obtained from 0 kg/da N application with 337.52 g parameter and they were followed by 12.5 kg/da N application with its 348.63 g parameter and there was no statistically significant difference between them in terms of 1000 grain weight. P 35Y65 hybrid corn had 18 g greater 1000 grain weight than P 3394 hybrid (340.19 g) with its 358.67 g parameter. The highest and the lowest 1000 grain weight parameters in years x previous crop interaction were 360.80 g and 342.50 g respectively.

Protein Rate (%)

It was detected that there was a great statistical difference in protein rate depending on years and previous crop but the difference was statistically insignificant in N rates and corn varieties (Table 3). The protein rate parameter in the first year was 0.90% greater than that of the second year with its 8.99% parameter. The protein rates of corn grains for vetch and wheat as previous crops were 9.15% and 7.94% respectively. The protein rate varied by 1.21% between the previous crops rates didn't have any statistically significant effect on protein rate but the highest parameter was obtained at 12.5 kg/da N rate application and the lowest one at 0 kg/da N rate application. Although there was no statistically significant difference between corns hybrids in terms of protein rate, P 35Y65 type had greater parameters. Only year x previous crop x corn variety interaction had statistically significant difference in terms of protein rate and the highest and the lowest protein rate parameters were observed to be 10.37% and 7.02% respectively.

Grain Yield

It is clear in Table 3 that years, previous crops and N rates had affected grain yield significantly ($P< 0.01$) but the effect of corn varieties on grain yield was not statistically significant. There were significant differences in year x corn variety and previous crop x N rate interactions in terms of grain yield. The grain yield parameter of the year 2008 was 171 kg/da greater than that of the year 2007 (879.27 kg/da) with its 1050.69 kg/da. When vetch was used as previous crop, the grain yield parameter was seen to be 91 kg/da greater than that of the other previous crop (919.13 kg/da) with its 1010.84 kg/da yield. No statistically significant difference was observed between 25 kg/da N rate (1032.17 kg/da) and 12.5 kg/da N rate (1024.22 kg/da) in terms of grain yield. The lowest grain yield parameter was recorded at 0 kg/da N rate application with its 838.55 kg/da value and it stated a significant difference between 0 kg/da N rate and the other N rate applications. The highest and the lowest grain yield parameters of years x corn variety and previous crop x N rate interactions were 1083.23 kg/da and 850.22 kg/da, 1123.27 kg/da and 733 kg/da respectively.

DISCUSSION

Tasselling period occurred 3 days earlier in the year 2008 than the previous year. The plantation was made a week earlier in the second year than the previous year. The experiment was carried out by planting to dry soil by grain drill and irrigating later in both years (2007 and 2008). Since the plant took the advantage of long daytime duration earlier during vegetative growth period in the second year, tasselling occurred earlier. When vetch was used as previous crop instead of wheat, tasseling occurred earlier, too. Of all N rates, the earliest and the latest tasselling were observed at 12.5 kg/da and 0 kg/da N rates respectively. It was also stated by Gokmen et al. (2001) that when N was not applied to corn types, tasselling was observed to delay. The finding that tasselling period varies depending on corn types, climate and environmental conditions (Kirtok, 1998; Tufekci, 1999) confirms our findings. Plant height parameter was recorded to be 31 cm greater in the second year and P 35Y65 corn type was 4 cm shorter than the other type P3394. Also, Kuşaksız (2010) reported that it was significant between plant height differences. The experimental field was irrigated more frequently in the second year compared to the previous year. Because of the shortage of water supply in the first year, irrigation interval was relatively longer. This problem was solved in the second year and since more frequent irrigation increased the ambient humidity, a greater plant height parameter was obtained. Cakir (2004) stated that additional irrigation applied to corn plant during its flowering period leaded to increase in plant height. The effect of N rates on 1000 grain weight was quite remarkable. Because 1000 grain weight parameter at 25 kg/da N rate was 25 g greater than that of at 0 kg/da N rate. It was determined that as N rate increased, 1000 grain weight and grain yield increased (Sanjeev et al., 1997; Gokmen et al., 2001). P35Y65 hybrid type had 18 g greater 1000 grain weight parameter than the other hybrid type. As for grain yield, we obtained more yield in the second year compared to the first year with 171 kg/da. In the second year, irrigation was applied more frequently compared to the first year in order to avoid adverse conditions of water shortage. It was stated by Dahmardeh (2011) that dry weather conditions caused N mineralization to decrease, which affected N uptake and changed grain yield in years. Eck (1984) stated that drought stress in each day of grain-filling period decreased grain yield by 1.2%. Protein rate of the first year was determined to be higher than that of the second year. There was an inverse relation between grain yield and protein rate (Kahraman et al., 2008). In our study, too, when the protein rate was low, grain yield was observed to be high. When vetch was used as previous crop instead of wheat, 91 kg/da yield and a 1.21% protein rate increase were observed. Uzun et al. (2005) stated that the grain yield of corn in rotation with wheat was lower than that of corn in rotation with vetch. Ohland et al. (2005) found that when vetch was used as previous crop, 1000 grain weight, grain yield and N content of corn increased was consistent with our own results. With the increase in N rate, grain yield was observed to increase. However, the difference between 12.5 kg/da N rate and 25 kg/da N rate in terms of grain yield was about 6 kg/da and it didn't have a statistical significance. Similar findings were determined by Liang and MacKenzie (1994); Tükel et al. (1996); Sanjaev et al. (1997); Oner (2003), too. It was stated by Özyazıcı et al. (2009) that when corn had a rotation with legume plants, some part of N needed by corn plant was met by legume plant residues. Therefore, using relatively less N than needed, desired crop level could be reached. Some other researchers (Meisinger et al., 1991; Clark et al., 1995; Clark et al., 1997) also stated that corn rotation with legume plants made significant

contribution to soil properties, organic matter content and N content. It was stated by Abd-El Samie, (1994) that legumes might have positive or negative effects on N balance in soil and by Haynes et al. (1993), Amstrong et al. (1994), Fischer et al. (2002) that choosing the suitable previous crop increased the yield and zero-tillage after vetch harvest affected corn growth positively. Touchton et al. (1982), Hargrove (1986), McVay et al. (1989) stated that some part of N needed for maximum corn yield was met by legume plants.

Year x previous crop interaction had a significant effect on plant height and 1000 grain weight; year x N rate interaction on tasselling period and plant height; year x corn variety interaction on tasselling period, plant height and grain yield (Sanjaev et al., 1997; Dahmardeh, 2011) N rate x corn variety interaction and, year x N rate interaction on plant height; years x previous crop x corn variety on tasselling period and plant height; years x N rate x corn variety interaction on plant height; years x previous crop x N rate x corn variety interaction on tasselling period (Gozubenli, 1997; Tufekci, 1999; Idikut et al., 2009). It was determined from the study that corn yield was affected by years, previous crops and N rates. The other interactions weren't significant. Hence, they are not showed in Table 3. According to numerous studies made previously (Touchton et al., 1982; Oyer and Touchton, 1990; Hesterman et al., 1992), annual and winter legumes made about 159 kg/ha N contribution depending on year, region and type of legume plant.

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