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Research article

INFLUENCE OF PLANT POPULATION, PLANT PATTERNS AND TILLAGE SYSTEMS ON GRAIN YIELD AND YIELD COMPONENTS OF CORN (*ZEA MAYS* L)

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ABSTRACT: In order to investigate the effect of tillage systems and plant density in two plant pattern, on kernel yield and its component on corn (Zea mays L.cv.sc704), an experimental design , randomized complete block in a strip factorial was used, treatments arrangement with four replications in north of Iran in 2010. Main plot was subjected to tillage systems in three levels: 1. Rotary system (RS). 2. Disk system (DS) - 3. Plow and Disck system (PDS). Other factors were plant density in three levels (60000, 70000 and 80000 plant/ha) and plant pattern were conventional row (linear) and new two rows (zigzag).The results indicated that the grain yield and silage yield, which were affected by tillage systems did not show any significant difference,while the grain yield and silage yield, which were affected by plant density showed significant difference. With the increase of density from 60000 to 80000 plants/ha, grain yield and silage yield increased, an amount of from 9.793 to 10.92 and 62.68 to70.85 t/ha respectively. Grain yield and silage yield were not affected by plant pattern.

Key words: Corn, tillage system,plant density, sowing pattern, yield and yield component.

INTRODUCTION

Corn (Zea mays L.) is the most important grain- forage crop in Iran. The average grain yield of corn is more than 8 t/ha and it increase annually. In order to optimize the use of moisture, nutrients and solar radiation, corn seeds must be planted under optimum density and tillage system. Intensive production of field crops practiced until recently to achieve high yields required intensive tillage and application of other high-technology inputs. This concept, however, implies a number of problems, among which relationship between product quality and quantity are in the foreground, along with increase crop production which shows an important ecological sustainability. Above all, farmers approach production in terms of the cost effectiveness of the applied system [9].

Use of Agricultural mechanization is considered the main factor contributing to the total energy inputs in agricultural system. Tillage represents half of the operations carried out annually in the field. Consequently, there is a potential to reduce energy inputs and production costs by reducing tillage [13,15]. Tillage practices are needed to increase agronomic stability and productivity while enhancing the environment [8]. Since land preparation for double-cropping systems requires timeliness, especially when a moldboard plow is used, reduced tillage, mainly NT systems, are becoming widespread. Beneficial effects of the crop residue maintenance on the soil surface include a reduction of soil erosion and runoff, an increase soil water conservation and soil aggregation, and a less use of fossil fuel is not direct effect of crop residue management [11].

In order to compact soil loss and preserve soil moisture, a more attention has been focused on conservative tillage involving soil management practices that minimize the disruption of the soil structure [19].

Benefits of residue cover include improved soil water storage, enhanced soil organic matter content, nutrient recycling and protection against water and wind erosion [10].

So with the selection of desired plant density, appropriate yield can be produced. Corn is among the least tolerant of crops to high plant population density. Crop growth rate is directly related to the amount of radiation intercepted by the crop. Therefore, the response of grain yield to narrow rows can be analyse in terms of the effect on the amount of radiation intercepted at the critical periods for kernel set. In some cases, full radiation interception during these periods may not be achieved with wide rows. Andrade et al found that corn yield response to decreased row spacing was negatively correlated to radiation interception at pollination time with the wider spacing [2].

Widdicombe and The len, however, found that higher yields were attained for corn grown in narrow rows vs. wide conventional rows irrespective of hybrids and plant populations tested in Indiana and Michigan [28].Corn grain yield typically exhibits a quadratic response to plant density, with a near-linear increase across a range of low densities, a gradually decreasing rate of yield increase relative to density increase [5,14, 24]. Higher plant density combined with narrower row spacing results in a more equidistant planting pattern that is expected to delay initiation of intra specific competition [5] while early crop growth is increased [4]. Although the optimum row spacing varies among plant genus, yields will generally be maximized by sowing in rows that result in an equidistant spacing among plants [21]. Narrow-row corn has been advocated in recent years as a technique to enhance grain yield [12]. These differences in yield associated with row spacing appear to be accentuated for corn grown at more northerly locations within the U.S. Corn Belt [21]. Paszkiewicz, for example, found that corn grown in narrow rows to the north of Interstate 90 (44_ N latitude) resulted in an 8% higher grain yield while that grown in narrow rows to the south of Interstate 90 resulted in a 4% higher grain yield compared with corn grown in wide conventional rows[16].
Crop row spacing can also influence soil water utilization [21].

MATERIALS AND METHODS

The study was conducted at the Agricultural and Natural Resources Research Center of Mazandran, Qarakheil, Qaemshahr, Iran (31°28' N, 52°35' E) in 2010. The weather in this zone had an average temperature of 24.8°C per month and receives rainfall of 419 mm from May through October. Weather condition in the experiment site are summarized (Table 1).

Table 1. Weather condition in experiment site during corn growth stages.

Variable	May	June	July	August	September	October
Minimum tem. (°C)	16.4	21.7	23.7	22.4	19.1	17.3
Maximum tem. (°C)	25.1	31.7	32.9	33.5	30.7	25.3
Evaporation (mm)	128.4	180.9	189.6	167.2	122.5	71.7
Precipitation (mm)	17.6	9	7.6	61	6.9	53.7

The soil type was classified as silty clay loam. Some of its properties are as fallows: 25, 25 and 50 g kg-1, clay, silt and sand, respectively, organic matter, 4.3 g kg-1; pH, 7.2.
Available N, P and K, were 0.21, 28.1 and 64 respectively. Before seeding, soil available N, P, and K were determined for depths (0 to 30 cm).
This experiment was laid out in strip-factorial on the basis of randomized completely block design with four replication. Tillage system in three levels 1. Rotary system (RS). 2. Disk system (DS) - 3. Plow and Disck system (PDS). Other factors were plant density in three levels (60000, 70000 and 80000 plant/ha) and plant patterns were conventional row (linear) and new two rows (zigzag).The previous crop at the site was canola. NPK fertilizers were applied according to yield potentials and soil test level to the site. Fertilizer used as N. P. .K (200-100-100kg/ha) were made from urea, triple super phosphate and potassium sulfate. Hand weeding was practiced to control weeds. Plants from each plot harvested in an area of 9 m^2 and the moisture content was adjusted to 14%. Cultivar corn was a single cross hybrid (*Z. mays* L. cv. singel cross 704) that was popular among growers in Iran. Plots were seeded 31rd May. The site was irrigated with water using a sprinkler irrigation system. Plants were cut at the surface from the central of the four middle rows in the plots (area of 9 m^2). All plots were harvested, on 3th October, 2010. Ears were separated, weighed and the plant dry weight of forage were measured, grain corn moisture content was determined. Data were analyzed using the by MSTAT-C procedure to develop the ANOVA for a factorial design. The DMRT procedure was used to make tests of simple and interaction effects by MSTAT-C, all differences reported are significant at P< 0.05 unless otherwise stated.

RESULTS AND DISCUSSION

Tillage system

Tillage systems had a significant effect on leaf yield, and root weight at 0.05probability level (Tables 2 and 4). Also tillage system had significant effect on leaf area index at 0.01probability level (Table 4). The highest leaf yield was obtained in rotary system (RS) (Table 3). The highest leaf area index also obtained in rotary system (RS) (Table 5). The highest root weight was obtained in plow and disk (PDS) (Table 5). Ahmad, in an experiment on the barley plant, reported that the maximum barely plant yield resulted from minimum tillage [1]. Wang and partners, in an experiment on wheat during 6 years with three tillage system concluded that average grain yield under minimum tillage system was at least 8% more than the grain yield under conventional tillage system at 5% probability level[26].

Effect of plant pattern

Plant pattern had not significant effect on all traits (Exept leaf erea index) in this study (Tables 2 and 4).Ottman and Welch, have reported a positive response in yield to growing corn in narrower rows [14]. Pedersen and Lauer found an 11% lower yield for corn grown in 0.19-m rows vs. 0.38- and 0.76-m rows in Wisconsin [17] while Farnham found a 2% lower yield for corn grown in 0.38-m rows vs. 0.76-m rows in Iowa. Farnham observed significant hybrid row spacing interaction among six hybrids grown in narrow and wide conventional rows in Iowa [6].

Westgate et al, however, reported that light interception was not affected by corn row spacing; they found no yield advantage to growing corn in narrow (spacing of 0.38 m) rows vs.conventional (spacing of 0.76 m) rows over two growin seasons in Minnesota [27].

Glen and Daynard reported that plant density was affected on kernel yield but row spacing was not affected on kernel yield [7].

Plant density

Plant density had a significant effect on grain yield, silage yield, leaf yield, biological yield and leaf area index at 0.05 probability levels (Tables 2and4). The highest grain yield (10.92t/ha) and biological yield (20.74t/ha)were produced in 80000 plant/ha. Plant density had not significant difference in 60000 and 70000 densities on grain yield and biological yield (Table 3). With an increase of density, 1000 seeds weight decreased , however increase of density from 70000 to 80000 plants/ha, the grain yield ,silage yield and biological yield had 6.3% , 2.5and 4.7 %increasing respectively (table 3). The highest stem yield and leaf yield were obtained from the density of 80000 Plant/ha (Table 3). With the increase of density, the leaf area index increased so the highest leaf area index was obtained from the density 80000 plants/ha (Table 5).Yield and yield component of corn varieties in 2 densities of 55.000 and 110.000 plants/ha of 21 Hybrid single cross and 13 Inbreed line with a commercial witness were significantly affected by plant density [18].Shakarami and partners, in investigating three plant density (7, 10 and 13 plant m2) of corn recognized that the highest grain yield, harvest index, number of grain row and number of grain ear was produced in 10 plant m2 and the highest biological yield obtained from 13 plant m2[20]. Kisic et al in the study of crop yield and plant density under different tillage systems found that the plant density and yields of maize, soybean, oilseed rape, winter wheat and spring barley point to the conclusion that high density crop (winter wheat, spring barley and oilseed rape) are suitable for growing under reduced tillage systems. Yield of low density spring crops (maize and soybean) obtained under the no tillage system are not satisfactory, especially in climatically extreme years [9].

Plant density is affected on kernel yield [3, 22, 23].

Interaction effects

The statistical analysis of the data shows that there were no significant differences in all traits (Exept leaf erea index) due to different tillage system × plant density × plant pattern interactions in this study(Tables 2 and 4).

Table 2.Mean square effects of tillage systems, Plant pattern and plant densities on Grain yield, Biological yield, Stem yield, Leaf yield and Harvest index

Source of variation	DF	Grain yield	Silage yield	Stem yield	Leaf yield	Biological yield
Replication	3	12907251^{ns}	315.5^{ns}	5674697^{ns}	193522^{ns}	38273842^{ns}
Tillage system(A)	2	2786849^{ns}	128.0^{ns}	2660479^{ns}	1762162*	23101085^{ns}
Error	6	4108302	154.0	2868284	260433	18087193
Plant pattern(B)	1	63847^{ns}	72.8^{ns}	7459^{ns}	51835^{ns}	757770^{ns}
A x B	2	7056718^{ns}	76.2^{ns}	3556665^{ns}	115124^{ns}	28550542^{ns}
Plant density(C)	2	6385433^{ns}	443.7*	1559629^{ns}	217463^{ns}	16290906^{ns}
Error	17	12510615	140.1	3310817	328732	33855453
A x C	4	691679^{ns}	167.5*	1745626^{ns}	529621*	5256868^{ns}
B x C	2	15764593*	117.4^{ns}	5848843*	650374*	55497750*
Ax B x C	4	7098679^{ns}	35.0^{ns}	1444734^{ns}	240342^{ns}	14198282^{ns}
Error	28	4072230	64.6	1365520	105527	9488303
C.V%5..		19.55	11.9	18.77	13.56	15.11

*,** and ns significant at the 5% , 1% and non significant respectively.

Table 3. Means comperison effects of tillage systems, Plant pattern and plant densities on Grain yield, Biological yield, Stem yield, Leaf yield and Harvest index

Source of variation	Grain yield(Kg/ha)	Silage yield (T/ha)	Stem yield(Kg/ha)	Leaf yield(Kg/ha)	Biological yield(Kg/ha)
Tillage system					
Rotary	10410a	65.3a	6576a	2624a	21084a
Disck	9954a	67.4a	5914a	2096b	19260a
Plow and Disck	10620a	69.9a	6186a	2465a	20800a
Plant pattern					
1 Row	10359a	68.6a	6236a	2368a	20277a
2 Row	10299a	66.5a	6215a	2422a	20482a
Plant density					
60000Plant/ha	9793b	62.7b	6060a	2305a	19600b
70000Plant/ha	10270b	69.1ab	6098a	2385a	19800b
80000Plant/ha	10920a	70.8a	6519a	2494a	20740a
Tillage system					

Different letters in each colum shows significant difference at %5 probability (DMRT).

Table 4.Mean square effects of tillage systems, Plant pattern and plant densities on Number of grain row, Number of row per ear, 1000seeds weight, Plant height and Eear height

Source of variation	DF	Leaf area Index	Root weight	1000seed weight	Harvest index
Replication	3	2.59**	216848 ns	2153.16 ns	26.1 ns
Tillage system(A)	2	0.331**	1003384*	723.85 ns	26.5 ns
Error	6	0.006	192232	2399.5	9.72
Plant pattern(B)	1	0.169*	616869 ns	17.01 ns	6.2 ns
A x B	2	0.490**	720075 ns	998.76 ns	2.79 ns
Plant density(C)	2	5.955**	696023 ns	3254.22 ns	7.85 ns
Error	17	0.041	253606	1618.65	26.39
A x C	4	0.589**	237502 ns	873.91 ns	17.7 ns
B x C	2	0.182**	75477 ns	754.05 ns	5.7 ns
Ax B x C	4	0.080**	86316 ns	140.49 ns	33.04 ns
Error	28	0.004	182359	711.88	23.7
C.V%		1.23	21.3	7.58	9.66

*,** and ns significant at the 5% , 1% and non significant respectively.

Table 5.Means comperison effects of tillage systems , Plant pattern and plant densities on Number of grain row, Number of row per ear, 1000seeds weight, Plant height and Eear height

Source of variation	Leaf area Index	Root weight (Kg/ha)	1000seeds weight(Gr)	Harvest index
Tillage system				
Rotary	5.187a	2057ab	356.6a	49.3a
Disck	4.977b	1779b	353.0a	51.3a
Plow and Disck	4.990b	2178a	345.8a	51a
Plant pattern				
1 Row	5.003b	2097a	352.3a	50.7a
2 Row	5.100a	1912a	351.3a	50.1a
Plant density				
60000Plant/ha	4.577c	2074a	358.7a	49.7a
70000Plant/ha	5.007b	2129a	358.4a	50.7a
80000Plant/ha	5.570a	1810a	338.4b	50.8a

Different letters in each colum shows significant difference at %5 probability (DMRT).

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