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Research article

EFFECT OF THE PLANT DENSITY AND SOWING DATE ON KERNEL YIELD IN EARLY MATURING MAIZE

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ABSTRACT: In order to determine the best planting dates and plant densities of corn for kernel yield, two early and very early maturity corn cultivars (SC 108 and SC301) were planted separately on three planting dates (22 Jun ,1 Jul and11Jul) for two years (2009 – 2010) . Plant densities were 75000, 85000, 95000 and 105000 plants per hectar. A split plot design with three replications was used. Sowing dates and plant densities were alocated to main plots and sub plots, respectively. Two experiments were done in two locations, Qaemshahr and Neka, and with two cultivars (SC 301 and SC108). Kernel yield for each plot and each treatment were evaluated. The best planting date and plant density were determined for two years. In Bayekola location, for SC301 cultivar, the best density was 75000 plants per hectare with kernel average yield of 8.1 t/ha. For SC 108 cultivar, highest kernel yield was 7.3 t/ha with 85000 plants per hectare. In Qarakhyle, for SC301 cultivar, the best density was 75000 plants per hectar with kernel average yield of 7.7 t/ha. In this location, for SC108 the highest kernel yield was 7.2 t/ha and the best density was 85000 plants per hectar. In general, planting date and plant density affected on 1000 kernel weight Result showed that SC301 had higher yield than SC108 after wheat harvest.
Key words: Corn, kernel yield, plant density and sowing date.

INTRODUCTION

Corn (Zea mays L.) is the most important grain- forage crop in Iran [8]. The average grain yield of corn is more than 8 t/ha and it increase annually. Produce of new hybrids for each area will increase corn yield [1].Among of new produced hybrids ,can be named SC108 and SC301.These hybrids can be planted in total area of Iran as second crop. In order to optimize the use of moisture, nutrients and solar radiation, corn seeds must be planted under optimum density [7, 15]. Intensive production of field crops practiced until recently to achieve high yields required intensive tillage and application of other high-technology inputs. Farmers approach production in terms of the cost effectiveness of the applied system [10]. For 4500 years, corn has had a special and importance role in the lives, the religious rituals and customs, and the development of the cultural history of the peoples of South, Central, and North Americas [9]. Corn yield was affected by plant density [20].Plant density have notable effects on corn kernel yield [28].Only in suitable density, plant can be had highest yield [3, 13].In determine of density, hybrid type is high effective [24]. Kresovic et al. [11] reported that with an increase in plant density from 49300 to 59500 plants per hectare, grain yield went up from 11.14 to 15.02 tons per hectare. Nielson [14] reported that with an increase in plant density from 44444 to 88888 plants per hectare, corn yield rose by about 2.7 percent. Andrade et al [2] found that corn yield response to decreased row spacing was negatively correlated to radiation interception at pollination time with the wider spacing. Widdicombe and The len [28], 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. 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, and finally a yield plateau at some relatively high plant density [5, 17, 26]. Higher plant density combined with narrower row spacing results in a more equidistant planting pattern that is expected to delay initiation of intraspecific competition [5] while yearly 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 [23].Narrow-row corn has been advocated in recent years as a technique to enhance grain yield [16].

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 [23]. Paszkiewicz [18], 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. Crop row spacing can also influence soil water utilization [23]. For each cultivars in each area, suitable density can be produced highest yield [28].Sowing date also is very important in corn [12, 27]. Suitable sowing date increase corn yield [21].In each area determines of suitable planting date is very important in order to obtain highest corn yield [6].

MATERIALS AND METHODS

The study was conducted at the Agricultural Research station of Mazandran at Qaemshahr (31°28' N, 52°35' E) and Neka (36°42' N, 53°15' E) in 2010-2011 in Iran. Weather condition in the experiment site are summarized (Table 1).

Table 1. Weather condition in experiment site (Average) during corn growth stages in 2010-2011.

Variable	Qaemshahr	Neka
tem (°C)	24.3	25.5
Moisture (%)	75	68
Suny duration (day)	6.2	7.8
Precipitation (mm)	41.5	31.2

The soil type was classified as clay loam at two locations. Soil PH at Qaemshahr was 7.6 and at Neka were 7.1.
In order to determine the best planting dates and plant densities of corn for kernel yield, two early and very early maturity corn cultivars (SC 108 and SC301) were planted separately on three planting dates (22 Jun ,1 Jul and11Jul) for two years (2009 – 2010) . Plant densities were 75000, 85000, 95000 and 105000 plants per hectar. A split plot design with three replications was used. Sowing dates and plant densities were alocated to main plots and sub plots, respectively. Two experiments were done in two locations, Qaemshahr and Neka. Each treatment was planted in four rows. The previous crop at the site was wheat. NPK fertilizers were applied according to yield potentials and soil test level to the site. Fertilizer used as N. P. K (300-100-100kg/ha) were made from urea, ammonium phosphate and potassium sulfate. Hand weeding was practiced to control weeds. The site was irrigated with water using a sprinkler irrigation system. Plants from each plot harvested separately. Plants were cut at the surface from the two middle rows in the plots (area of 9 m^2). In harvest time, years in each treatment were separated, weighed and grain moisture adjusted to 14%. Number of grain row, number of row per year, 1000 seeds weight (g), ear height (cm), plant height (cm), ear diameter, cob diameter, were measured. Data were analyzed using the by MSTAT-C procedure to develop the ANOVA for a split plot 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

Combined analyses of yield in two years (2009–2010) was shown in table1.Year and location effect was not significant on kernel of SC301 while Year effect was significant on kernel of SC108 (table 2). In Neka, best planting time for SC301 and SC108 was 22 Jun that was obtained most kernel yield. Planting date had not significant difference in 1 Jul in compare of 11Jul on grain yield .Plant density had a significant effect on grain yield at 0.05 probability levels (Tables 3and4). The highest grain yield of SC301 (8.1t/ha) was produced in 75000 plant/ha and the lowest grain yield (6.6 t/ha) was produced in 105000 plant/ha. Plant density had not significant difference in 85000 in compare of 95000 density on grain yield , 1000 kernels weight, ear diameter,cob diameter and kernel number in row(Table 4). With an increase of density to 85000, 1000 kernels weight and kernel yield decreased (table 4 and 5).
In Neka the highest grain yield of SC108 (7.28 t/ha) was produced in 85000 plant/ha and the lowest grain yield (6.28 t/ha) was produced in 105000 plant/ha. Plant density had not significant difference in 95000 in compare of 105000 densities on grain yield (Table 4).
In Qaemshahr, also best planting time for SC301 and SC108 was 22 Jun that was obtained most kernel yield. Planting date had not significant difference in 1 Jul in compare of 11Jul on grain yield .Plant density had a significant effect on grain yield at 0.05 probability levels (Tables 3and4). The highest grain yield of SC301 (7.94 t/ha) was produced in 75000 plant/ha and the lowest grain yield (6.39 t/ha) was produced in 105000 plant/ha. Plant density had not significant difference in 85000 in compare of 95000 density on grain yield, 1000 kernels weight, ear diameter,cob diameter and kernel number in row(Table 4). With an increase of density to 85000, 1000 kernels weight and kernel yield decreased (table 4 and 5).

Table 1. Combined analysis of variance of kernel yield for SC301 in different years and locations

S. O. V.	DF	M.S
Year(Y)	1	0.21 ns
Location(L)	1	0.571ns
Y x L	1	4.402ns
R(L x Y)	8	2.071ns
Factor A(Sowing date)	2	19.237**
Y x A	2	3.816ns
L x A	2	1.263ns
Y x L x A	2	5.344ns
Error	16	1.699
Factor B(Density)	3	17.736**
Y x B	3	1.927*
L x B	3	0.789ns
Y x L x B	3	1.047ns
A x B	6	1.821**
Y x A x B	6	1.184*
L x A x B	6	0.735ns
Y x L x A x B	6	0.838ns
Error	72	0.500
Total	143	

C.V%=9.71

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

Table 2. Combined analysis of variance of kernel yield for SC108 in different years and locations

S. O. V.	DF	M.S	
Year(Y)	1	26.423**	
Location(L)	1	5.173ns	
Y x L	1	3.122ns	
R(L x Y)	8	3.751ns	
Factor A(Sowing date)	2	0.575ns	
Y x A	2	4.324ns	
L x A	2	1.647ns	
Y x L x A	2	1.700ns	
Error	16	1.472	
Factor B(Density)	3	9.548**	
Y x B	3	1.293ns	
L x B	3	2.62**	
Y x L x B	3	4.284**	
A x B	6	1.111ns	
Y x A x B	6	0.303ns	
L x A x B	6	1.887**	
Y x L x A x B	6	0.513ns	
Error	72	0.511	
Total	143		

C.V%=10.67

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

In Qaemshahr, also best planting time for SC108, plant density had a significant effect on grain yield at 0.05 probability levels (Tables 3). The highest grain yield of SC108 (7.22 t/ha) was produced in 85000 plant/ha and the lowest grain yield (6.00 t/ha) was produced in 105000 plant/ha. Plant density had not significant difference in 95000 in compare of 105000 densities on grain yield (Table 4). SC301 had more yield than SC108 in two locations.

In Neka kernel yield of cultivars was better than Qaemshahr. Sowing in suitable date and density were obtained highest yield of corn [12].Each cultivar of corn only in suitable density have best yield [20].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 [19]. Shakarami and partners [22], 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 m^2 and the highest biological yield obtained from 13 plant m2. Kisic et al [10] 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. Tetio-Kagho and Gardner [25] reported that plant density is affected on kernel yield.

Table 3. Comparison of two years average of kernel yield (t/ha) in different years and locations

			Cultivars	
Planting date	Single cross	301	Single cross	108
	Neka	Qaemshahr	Neka	Qaemshahr
22 Jun	7.905a	7.865a	7.218a	7.064a
1 Jul	7.359b	7.250b	6.389b	6.193b
11Jul	6.757b	6.749b	6.253b	6.066b
			Cultivars	
Density	Single cross	301	Single cross	108
Plant/ha	Neka	Qaemshahr	Neka	Qaemshahr
75000	8.097a	7.947a	6.247b	6.063b
85000	7.438b	7.300b	7.283a	7.221a
95000	7.338b	7.279b	6.435b	6.243b
105000	6.605c	6.393c	6.281b	6.003b

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

Table 4. Comparison of average characteristic for SC 301in Qaemshahr

Planting date	Ear diameter	Cob diameter	Row number	Kernel number in row	1000Kernel Weight	Plant height	Ear height	Cob percentage
22 Jun	5.133a	a3/312	18.0a	30.15a	372.5a	199.5a	86.79a	22.95b
1 Jul	4.913b	a3/202	17.4a	30.05a	342.2b	194.9a	85.72a	24.73a
11 Jul Density Plant/ha	4.972b	a3/223	17.8a	28.02b	318.0c	192.5a	85.49a	24.79a
75000	5.980a	3.300a	18.2a	28.64a	353.1a	194.4b	84.39b	22.68b
85000	5.053b	3.200b	18.0a	29.36a	333.0b	195.0b	85.11b	23.77b
95000	5.011b	3.210b	17.1b	29.47a	330.0b	196.1a	86.94a	25.00a
105000	4.073c	3.076c	17.0b	29.76a	318.8c	197.3a	87.56a	25.18a

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

Table 5. Comparison of average characteristic for SC108 in Qaemshahr

Planting date	Ear diameter	Cob diameter	Row number	Kernel number in row	1000Kernel Weight	Plant height	Ear height	Cob percentage
22 Jun	4.513a	2.547a	15.87a	30.62a	303.8a	168.1a	54.50a	21.54c
1 Jul	4.398b	2.750a	15.30b	26.97b	265.8b	167.9a	53.3a	23.18b
11 Jul Density Plant/ha	4.390b	2.755a	15.21b	27.45b	260.3b	166.5a	50.67a	24.83a
75000	4.519a	2.74a	15.42b	28.64b	278.2b	164.2c	55.22a	23.2b
85000	4.450a	2.73a	15.84a	30.49a	290.3a	166.0b	53.67b	21.9c
95000	4.320b	2.610b	15.42b	28.04b	275.0b	168.6b	52.83b	23.56a
105000	4.221b	2.603b	15.20b	26.07c	264.4c	171.9a	50.67c	23.8a

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

Table 6. Comparison of average characteristic for SC 301in Neka

Planting date	Ear diameter	Cob diameter	Row number	Kernel number in row	1000Kernel Weight	Plant height	Ear height	Cob percentage
22 Jun	5.25a	3.30a	18.4a	30.32a	355.6a	198.4a	86.56a	22.46b
1 Jul	5.20a	3.29a	17.9a	30.25a	334.5b	195.2a	85.12a	24.63a
11 Jul Density Plant/ha	4.98a	3.25a	17.6a	28.13b	318.6c	192.1a	84.55a	24.65a
75000	6.11a	3.410a	18.8a	30.85a	365.2a	193.9b	84.22b	22. 58b
85000	5.343b	3.220b	18.5a	29.35b	334.1b	194.0b	84.52b	23.66b
95000	5.200b	3.210b	17.3b	29.22b	331.2b	195.5a	85.56a	24.80a
105000	4.410c	3.009c	17.2b	29.10b	319.1c	196.4a	85.83a	25.15a

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

Table7. Comparison of average characteristic for SC108 in Neka

Planting date	Ear diameter	Cob diameter	Row number	Kernel number in row	1000Kernel Weight	Plant height	Eer height	Cob percentage
22 Jun	4.613a	2.85a	15.9a	30.66a	294.1a	168.5a	54.20a	21.6c
1 Jul	4.360b	2.75a	15.40b	26.90b	275.2b	168.0a	53.73a	23.20b
11 Jul Density Plant/ha	4.350b	2.71a	15.30b	27.55b	265.1b	166.1a	51.7a	24.9a
75000	4.59a	2.83a	15.40b	28.70b	278.5b	164.0b	52.42b	23.1b
85000	4.550a	2.80a	15.90a	30.55a	290.3a	164.3b	52.55b	22.1c
95000	4.300b	2.650b	15.55b	28.10b	276.2b	166.8b	52.02b	23.6a
105000	4.200b	2.555b	15.30b	26.11c	264.5c	172.5a	55.71a	23.7a

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

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