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Full Length Research Paper

Sowing date effect on growth and yield attributes of corn (*Zea mays everta* sturt) grown under different densities

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The effect of different sowing dates (June 5th, 20th and July 6th and 21th) and densities rates of 60000, 70000, 80000 and 90000 plant/ha on growth and yield components of Popcorn (*Zea mays everta* Sturt.) was investigated at a research field in Arak, Iran during 2009 and 2010 growing seasons. The experiment was carried out using split plots based on randomized complete block design (RCBD) with four replications. Results showed that sowing date effect was significant on number of grains per ear, number of nodes per stalk, ear height, ear diameter, husked green ear weight, 1000-grain weight, plant height and grain yield of pop corn. Densities significantly affected plant height, ear diameter, ear height, grain yield, husked green ear weight and 1000-grain weight. Interaction effect of sowing date × density was only affected by 1000-grain weight, grain yield and husked green ear weight, whereas the rest of the studied traits remained unaffected. The highest grain yield (7815.16 kg ha^{-1}) was that of July 6th coupled with 80000 plants/ha of density. It is concluded that optimum density/sowing date for popcorn crop is 80000 plant/ha. It is also suggested that further research should be done under different environmental conditions.

Key words: Sowing date, density, popcorn, yields.

INTRODUCTION

In Iran, especially in Markazi province, maize is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It contributes about 3.8% of the total food grain production in the country (Raghothama, 1999). It is a rich source of food and fodder (Reddy, 2006). Maize is also used in industries for the manufacture of corn sugar, corn oil, corn protein (Reed et al., 1988), corn-flacks and corn syrup etc (Minfal, 2009). The average yield of maize in Iran is very low as compared to other countries of the world (Roth, 1996). Maize is generally cultivated in wide spaced rows (SAS, 2001). Plant density per unit area is one of the important yield determinants of crops (Sener et al., 2004). Plant density is an efficient management tool for maximizing grain yield by increasing the capture of solar radiation within the canopy (Monneveux et al., 2005). An optimum plant population for maximum economic yield exists for all crop species and varies with cultivar and environment (Bruns and Abbas, 2005). New generations of maize hybrids are characterized by a better ability of plants to be grown in denser stand, as they were selected under such conditions (Anderson et al., 2000). The higher density results in the appearance modification of the maize genotype plant (Fathi, 1999). Old generations of maize hybrids selected in lower densities have, as a rule, more robust plants and less erect top leaves (Fontanetto, 1993). Newer generations of maize hybrids selected in higher densities have lesser robust plants and ears are placed lower, while the angle of top leaves in relation to the stalk is smaller (Gozobenli et al., 2004). Yield increases with increasing plant density up to a maximum for a corn genotype was grown under a set of particular environmental and management conditions and declines when plant density was further increased

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Table 1. The results of soil analysis.

Soil texture	Sand (%)	Silt (%)	Clay (%)	K (mg/kg)	P (mg/kg)	N (mg/kg)	Na (Ds/m)	EC 1:1.25	pH	Depth of sampling
Clay loam	38	33	32	140.5	4.3	35.2	0.04	0.19	8	0-30 cm

(Tollenaar, 1992). Nafziger (1994) suggested that newer hybrids have greater grain yield at higher plant densities than older hybrids. Newer hybrids seem to be more tolerant to plant stress at higher plant density than older hybrids (Tollenaar, 1992). Yilmaz et al. (2008) reported that yield and yield component of corn were significantly affected by planting patterns, plant densities and maize hybrids.

Corn hybrids respond differently to high plant density (Pinter et al., 1994). Long (1995) reported that though the generally adopted planting density for maize in China is 50000 plants/ha, the optimal population could be increased up to 75,000 plants/ha due to plant type improvement and increased fertilizer application under favorable irrigated conditions (Lynch et al., 1991).

Several researchers reported that the effects of row spacing and hybrids on maize dry matter (DM) yield and quality characteristics are variable (Scheible et al., 1997; Widdicombe and Thelen, 2002). Roth (1996) concluded a 9% DM yield increase for forage maize grown at 38 cm rows compared with 76 cm rows. Similarly, Cox et al. (1998) found that maize DM yield increased by 4% as row width lowered (Mirhadi, 2001). Soya et al. (2001) indicated that leaf ratio, stem ratio, ear ratio, green herbage yield and dry herbage yield was significantly affected by corn hybrids.

Turgut et al. (2005) reported that there were significant effects of corn hybrids and plant densities on corn forage and DM yields. Several reports revealed that narrower rows produced higher grain yields than conventional rows (Andrade et al., 2002; Sharratt and McWilliams 2005; Yilmaz et al., 2008). Farnham (2001) reported that responses of six corn hybrids to narrowing the row space were different due to strong hybrid × row spacing interaction (Olson and Sander, 1988).

Keeping in view the importance of maize crop and the severity of damage caused by different planting date and densities, the re-search was carried out based on the following objectives:

1. To find out a proper sowing date for the popcorn hybrids in Arak.
2. To find out the link between the sowing date and densities to find out the highest yield components.
3. To achieve maximum yield.

The objectives of this research were to determine the most suitable plant density and sowing date on some hybrids for increased grain yield in popcorn grown under Arak conditions in Markazi province.

MATERIALS AND METHODS

This study was conducted on an experimental field of the Payam Noor University in Arak at Iran (36°15' N, 49°55' W; 1 700 m above sea level) from 5th June to 21th July, 2010, with clay loam soil (Table 1). The field experiments were planted on June 5th, 2010. The experimental design was split plot, using randomized complete block design (RCBD) with four replications. The treatments comprise four levels of corn hybrids: S1 = Jun 5th, S2 = Jun 20th, S3 = July 6th and S4 = July 21th in the main plot and four levels of plant density: 60000 plants/ha (D1) 70000 plants/ha (D2) 80000 plants/ha (D3) and 90000 plants/ha and (D4) in sub plot. Each plot sizes were 3 × 2 m, the distance between the middle plots was 1 m, and that of the main plots was considered as 2 m. The hybrid corn seeds were over seeded at a double rate and then thinned by hand after emergence to attain the desired target plant densities. First irrigation was accomplished immediately after the second and third plant irrigation, respectively during 4 days, and the last irrigation lasted for 6 days to the end of the experiment. In the experiments, weeds were controlled by hand and harrowing. Tasseling period (day), defined as 75% of the plants tasseled in a plot was measured as the number of days after planting. In this result, measuring, the parameters of yield and yield component of seed consist of: grain yield, the number of grain row in kernel, number of grain in kernel and 1000-grain weight. The center two rows of each plot were harvested by hand at maturity to determine yield and yield component.

RESULTS AND DISCUSSION

The data were analyzed using MSTATC software and mean comparison was done using Duncan multiple comparison at 5% probability level. It seems that an increase in the number of nodes caused an elevation in the plant stem due to the sowing date. The results are in conformity with the findings of Tsai et al. (1978), Grazia et al. (2003) and Normohammadi et al. (2001) that explained that plant height can be increased by sowing date. Application of 80000 plant/ha of density produced the tallest plant height at maturity (170.19 cm). The results of 80000 plant/ha and 90000 plant/ha of density were statistically at par with each other (Table 3). However, Grazia et al. (2003) found contradictory results. They found that density did not affect plant height.

The results in Table 2 indicated that, stalk diameter, was not significantly affected by different sowing dates, density and interaction thereof. However, the interaction between S3 and control produced maximum stalk diameter (1.698 cm). The effect of sowing date on

Table 2. The mean squares of ANOVA for plant height, stalk diameter, number of nodes per stalk, ear height and ear diameter of pop corn (*Zea mays* everta sturt).

S.O.V	df	Plant height	Stalk diameter	Number of nodes / stalk	Ear height
R	3	111.576ns	0.109ns	1.568ns	14.703ns
Sowing date	3	788.083**	0.013ns	5.141 *	28.797*
Ea	12	61.889	0.044	0.603	5.4
Density	3	88.229*	0.006ns	0.822ns	24.27**
S × D	6	62.458 ns	0.019ns	0.150 ns	1.399ns
Eb	27	28.104	0.034	0.6	4.691
CV%		4.48	11.75	7.2	10.43

S.O.V	df	Number of stalk	1000-grain weight	Grain yield
R	3	0.284ns	7.225	161007.748ns
Sowing date	3	0.947*	4491.063**	649430.143**
Ea	12	0.097	2.482	245129.536
Density	3	0.499**	38.356**	1754413.96**
S × D	6	0.109ns	5.445*	740025.126*
Eb	27	0.103	1.769	296239.989
CV%		6.75	0.78	8.59

***** – p < 0.05, ****** – p < 0.01, ns – p > 0.05. R – Replication, S – Sowing date effect, D –Density effect. S × D represent interaction terms between the treatment factors.

number of nodes per stalk showed a significant difference (p<0.05), hence the application of S3 and S4 were placed at superior group with means of 11.12 and 11.08, respectively. Likewise, the lowest value of this trait was that of control in S1 (Table 3). Lastly, it must be mentioned that, density and interaction of S × D did not influence number of nodes per stalk. As regards ear height it should be noted that, ear height of pop corn is strongly affected by soil, water, nutrients and light situation and plant competition (intra-inter competition) due to plant density. Optimization of these conditions in order to maximize utilization of cultivars genetic potential is necessary. At full maturity stage, according to results in Table 2, ear height, was significantly/highly affected by sowing date rates and densities, respectively. Application of S2 with 22.01 cm ear height had the highest mean value, which was statistically at par with S3. The least ear height (19.23 cm) was also recorded for control. Data on Table 3 show that maximum ear height (22.208 cm) was recorded at higher densities (90000 plant/ha), in contrast, control produced minimum (19.02 cm). Sowing date and density interaction was not significant on this trait and all related means were on par (Tables 2 and 3). The result of 70000, 80000 and 90000 plant/ha respectively were statistically at par with each other.

One of evaluated traits in this study was ear diameter, which results of statistical analysis showed that this trait was significantly affected by sowing dates (p<0.05) and different densities (p<0.01) (Table 2). Earlier sowing date (Jun 6th) recorded significantly lower ear diameter by 5.01 cm over later sowing date (July 20th). The results of Table 3 showed that, among all applied densities, D3 (80000 plant/ha) was placed in superior group as compared to other density levels. Interaction of D × S revealed non-significant effect on produced ear diameter (Table 2). In this study, ear diameter followed similar trend as that of ear height in the interactions section (Table 3).

According to the results in Table 3, 1000-grain weight was highly significantly affected (p<0.01) by sowing dates and different density levels. Data on Table 3 showed that the 1000-grain weight increased with increasing in sowing date application rates (S1 to S4) as well as density rates (D1 to D3). Thus, the highest (173.46 g) and lowest (163.54 g) values of 1000-grain weight were obtained from S3 and S1, respectively. Maximum 1000-grain weight (171.02 g) was recorded at 80000 plant/ha against the minimum (167.05 g) at control (K=0 kg PS ha^{-1}). All density application levels (that is, 60000, 70000 and 80000 and 90000 plant/ha) were placed in superior group. In terms of this trait, it should be noted that, 1000-grain weight is a constituent of grain yield that is affected by genetic and environmental factors. The S2 × D3 interaction recorded significantly higher 1000-grain weight (175.8 g) as compared to rest of the interactions; whereas it was on par with S2 × D4 interaction (Table 3). Significantly lower 1000-grain weight of 162.80 g was recorded with S1 × D1 interaction.

The grain yield is an economical part of the plant, which is available to human and livestock consumption and is affected by environmental factors and genetic potential of plant. Finally, based on obtained results in Table 2, grain yield was also significantly affected by sowing date levels

Table 3. Effect of sowing date and density and interaction thereof on plant height, stalk diameter, number of nodes /stalk, ear height and ear diameter of pop corn in estimated means.

Sowing date	Densitiy	Seed yield t/ha	Stalk diameter (cm)	Number of nodes/stalk	Ear height (cm)
S1	60000	12.18^{a}	1.554^{a}	10.10^{b}	19.23^{b}
	70000	12.81^{a}	1.594^{a}	11.12^{a}	22.01^{a}
	80000	15.81^{b}	1.539^{a}	11.08^{a}	20.981^{ab}
	90000	14.2^{c}		11.02^{a}	20.25^{a}
S2	60000	12.6^{c}	1.592^{a}	10.37^{a}	19.02^{b}
	70000	13.69^{bc}	1.543^{a}	10.80^{a}	20.142^{ab}
	80000	14.19^{a}	1.546^{a}	10.97^{a}	21.625^{ab}
	90000	12.79^{ab}	1.568^{a}	10.87^{a}	22.208^{a}
S3	60000	13.06^{a}	1.550^{a}	9.75^{a}	17.875^{a}
	70000	14.12^{a}	1.555^{a}	10.35^{a}	18.425^{a}
	80000	16.2^{a}	1.530^{a}	10.20^{a}	19.750^{a}
	90000	13.2^{a}	1.580^{a}	10.10^{a}	21.250^{a}
S4	60000	12.62^{a}	1.698^{a}	10.75^{a}	19.8^{a}
	70000	13.5^{a}	1.495^{a}	10.92^{a}	21.125^{a}
	80000	12.37^{a}	1.610^{a}	11.55^{a}	23.625^{a}
	90000	11.75^{a}	1.555^{a}	11.17^{a}	23.375^{a}

Sowing date	Densitiy	Ear diameter (cm)	1000-grain weight (g)	Grain yield (kg ha^{-1})
S1	60000	4.525^{b}	163.54^{b}	5694.02^{b}
	70000	5.01^{a}	173.46^{a}	7001.08^{a}
	80000	4.703^{b}	171.71^{a}	6365.03^{ab}
	90000	4.256^{b}	172.46^{a}	6910.08^{a}
S2	60000	4.458^{b}	167.05^{b}	5853.62^{b}
	70000	4.792^{ab}	169.56^{a}	6285.78^{ab}
	80000	4.942^{a}	171.02^{a}	6773.88^{a}
	90000	4.787^{ab}	170.72^{a}	6444.23^{ab}
S3	60000	4.2^{a}	162.80^{f}	5254.85^{e}
	70000	4.550^{a}	163.20^{f}	5697.75^{de}
	80000	4.675^{a}	163.67^{f}	5864.37^{cde}
	90000	4.675^{a}	164.47^{f}	5959.10^{cde}
S4	60000	4.725^{a}	170.20^{d}	6086.42^{cde}
	70000	4.900^{a}	173.07^{bc}	6559.40^{bcd}
	80000	5.210^{a}	175.80^{a}	7781.10^{a}
	90000	5.2224^{a}	174.77^{ab}	7409.40^{ab}

(p<0.01), densities (p<0.01) as well as interaction thereof (p<0.05) (Table 2). Sowing date application at the S3 produced the highest grain yield (7001.08 kg ha^{-1}), but statistically at par with S4 (6365.03 kg ha^{-1}) (Table 3).The higher grain yield in sowing date application of S2 was mainly due to higher grain number in ear as well as achieving the most husked green ear weight in this study (Table 3).

Among the density levels, D3 produced highly significantly higher grain yield (6773.88 kg ha^{-1}) while D1 and D4 gave 6285.78 and 6444.23 kg ha^{-1}, respectively (Table 3). Among all treatment combinations, S3 coupled with S1 (S2D3) produced the highest grain yield (7781.10 kg ha-1). The higher grain yield in this interaction was due to significantly higher husked green ear weight (84.668 g) and 1000-grain weight (175.80 g). However, S2D3 and S2D4 interactions were on par. Clearly, for treatments treated with S2, density levels (D1 to D3) determined a significant increase in yield. Furthermore, the lowest grain yield (5254.85 kg ha-1) was that of the control treatment coupled with not applying density control (S1 × D1). On the other hand, within the S1 level, lower yields were measured with the decrease in density application. The results are in disagreement with the results of Grazia et al. (2003), who stated that the greatest yield of sweet corn belonged to S2 × D2 (S2=Jun 4th of pure sowing date and D2=70000 plant/ha) treatment combination.

Conclusion

The salient findings of the investigation are summarized. Significantly higher grain yield, thousand grain weights was recorded with June 20th and 90000 plants.ha^{-1} interaction over the rest of the interactions. The individual effects of sowing date (S3=July 6th) and density (D3=90000 plants ha^{-1}) were also significantly higher leading to considerably higher grain yield and thousand-grain weight. For treatments with level S2, a significant superiority was shown in estimated traits except for stalk diameter. Among the densities, (D3=90000 plants/ha), influenced the main yield components (thousand-grain weight, grain yield and husked green ear weight) yield related (ear height and ear diameter) and height of pop corn.

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