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Original Article

Effects of Sowing Date on Physiological Characteristics, Yield and Yield Components for Different Maize (*Zea mays* L.) Hybrids

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Abstract

In order to determine the effects of sowing date on physiological characteristics, yield and yield components of six sweet maize hybrids, an experiment was arranged in split plot based complete randomized block design with three replications. Sowing date in two levels (15 June and 1 July) and sweet maize hybrids in six variants ('Chase', 'Temptation', 'Challenger', 'Basin', 'Obsession' and 'Ksc403su') were the treatments. Results of ANOVA revealed significant difference of sowing date and sweet maize hybrids on the number of days for tassel emergence, number of days to anthesis, plant height, cob height, stem diameter, plant dry weight, cob dry weight, number of grain rows, length flowers, number of leaf above the cob, raffinose content of grain and grain yield. Mean comparisons showed that the highest grain yield was obtained for 'Basin' variety and it was obtained from the crop established on the 15th of June as planting date. In temperate regions, maize potential productivity seems to be more limited by the amount of solar radiation available around silking (determinant of grain set) than during grain filling (determinant of grain weight).

Keywords: physiological characteristics, sowing date, sweet maize, yield

Introduction

Fresh sweet corn (*Zea mays* L. var. *saccharata*) has been consumed broadly by boiling or by grilling since past times. Production and use of sweet corn has expanded rapidly in recent years. Sweet corn varies from other corns (field maize, popcorn and ornamental) since the grains have great sugar content in the milk on early dough stage. It is consumed in the immature stage of the crop. The taste of sweet corn kernels is 25-30% sweeter than normal corn. At optimum market maturity, sweet corn will contain 5 to 6% sugar, 10 to 11% starch, 3% water-soluble polysaccharides and 70% water. Sweet corn also has medium levels of protein, vitamin A (yellow varieties) and potassium (Najeeb *et al*., 2011). It can be consumed as fresh, frozen or conserved and also used particularly as garniture in the salads. Corn (*Zea mays* L.) is one of the most important cereal crops grown principally during the summer in Iran. Is one of the important cereal crops in the world after wheat and rice (Gerpacio and Pingali, 2007; Golbashy *et al*., 2010). The International Maize and Wheat Improvement Centre (CIMMYT) accompany with National Agricultural Research Systems (NARS) routinely conducted maize regional trials with the objective of evaluating, selecting high yielding and stable genotypes in a wide range of environments (Banziger and De Meyer, 2002). Grzesiak (2001) reported remarkable genotypic variability among corn varieties for several characteristics. Ihsan *et al*. (2005) also demonstrated considerable genetic differences for morphological variables for corn genotypes. This mutability is a clue to crop improvement (Welsh, 1981).

Environmental variations related with different sowing dates have an altering effect on the growth and development of corn plants. Each corn hybrid has a desirable planting date, and the larger the deflection from this favorite (early or late planting), the larger the yield loss (Sárvári and Futó, 2000; Berzsenyi and Lap, 2001). Sowing date was introduced to affect the growth and yield of corn significantly. To date, compete for corn growers is finding the thin window between cultivation too early and cultivation too late (Nielson *et al*., 2002). Either early cultivation or late cultivation can result in lower yield since the probability exists that unfair climatic conditions can happen after cultivation or during the growing season. Norwood (2001) suggested that farmers should plant on more than one sowing date in order to protect against unforeseen seasons. Short season hybrids can be cultivated early without harmful effects on their upmost yield potential. It can also minimize the risk of obtaining immature cobs and grains or sustaining early frost loss (Hicks *et al*., 1993).

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The environmental and agronomic respond of corn hybrids recognize their adaptability and influence improvements in corn production through agronomy and breeding. Newly improved varieties usually need to be examined at several sowing dates or locations and for many years before being counseled for a given location. The basic environmental effects and genotype environment interaction have been introduced as the most important sources of alteration for the measured yield of crops (Dehghani *et al*., 2006; Yan *et al*., 2007; Sabaghnia and Sabaghpour, 2008). The yield of maize in Iran is very little (Xue *et al*., 2002). Maize undergoes three stages from pollen dissemination to physiological maturation (Johnson and Tanner, 1972; Cox *et al*., 1998). The first stage is known as lag phase (slow growth), the cells start to divide (Duvick, 1951; Abdul *et al*., 2001). At the end of this stage, grain weight slightly increases since endosperm cells play an important role in sink capacity (Outtar *et al*., 1987; Ahmad *et al*., 2001). The second stage is known as grain linear filling (log phase), the stage of sharp increase in grain dry weight due to the conversion of sugar to starch in endosperm, which commences 2-3 weeks after tassel emergence. Over 90% of grain dry weight is realized in this stage (Johnson and Tanner, 1972; Cox *et al*., 1998). During this stage, grains grow with a speed of 2-3% of final yield per day.

The most important effective factors on grain yield are application of optimal maize hybrids and suitable sowing dates. The research works focused more on breeding aspects rather than crop management (Xue *et al*., 2002). Under the optimum planting time for maize conditions, would be from the last week of September to the end of October in Khartoum area. High grain yield (2,952 kg ha^{-1}) was obtained during this period (Imam, 1966). The period from November to February is the best time for the highest dry matter production in the Khartoum area. It was also reported that the mean daily temperature is the major environmental factor that affects the crop development and yield (Elkarouri and Mansi, 1980; Begna *et al*., 2000). Grain yield maize was reduced when sowing time was delayed to the end of October (Mc Cormick, 1974). Delaying sowing date to mid-December reduced the individual 1,000 kernel weight (Cirilo and Andrade, 1996); the authors also indicated that maize varieties differed in their growth characters in Gainesville Florida (El-Koomy, 2005; Gardner *et al*., 1990). It has been shown that July 15 is an optimal sowing date for maize in Peshawar (Ahmad *et al*., 2001). In India, Sadek *et al*. (1994) and Zaki *et al*. (1999) reported that maize cultivars differed in yield and its components in the same region.

Variation in biological yield of corn varieties at different planting dates was associated with differences in the amount of intercepted radiation. Shorter cultivars had greater assimilated allocation to the grain than the taller cultivars (Benga *et al*., 2000). Grain growth rate is directly associated with dominant temperature and largely independent of dry matter accumulation in final crop (Duncan *et al*., 1965). If kernel growth outruns dry matter accumulation in the final crop, its required dry matter will be supplied and remobilized from stalks, leaves and cob covers (mostly from stalks). The third stage is accompanied with a decrease in dry matter accumulation in kernels and comes to an end with physiological maturation. Kernel weight is also determined in this stage. However, an important effect of temperature is that higher temperature (especially at night) shortens grain filling period and increases grain filling rate, while lower temperature have an inverse effect (Jones *et al*., 1981). Therefore, the present work was carried out to study the effect of sowing date and cultivar on grain yield of sweet corn.

Materials and Methods

The experiment was accomplished at Agricultural Research Center of Karaj, Iran. Soil preparation operations included plowing by moldboard plow, completing it by disc and leveling. Before carrying out the experiment, the soil was sampled from the depth of 0-30 cm. The experiment was carried out on clay-loam soil (Table 1). The results of soil analysis indicated that the absorbable phosphorus and carbon were 81.15 ppm and 81% respectively, and its pH was 7.61. The Meteorological information of Karaj is shown in Table 2. The previous crop was wheat. The soil was fertilized by 350 kg Urea/ha (1/3 during sowing, 1/3 at six leaf stage and the remaining during tassel emergence as top-dressing), 180 kg K_2O/ha, and 150 kg P_2O_5/ha after leveling and before making the furrows. Six varieties namely 'Chase', 'Temptation', 'Challenger', 'Basin', 'Obsession' and 'Ksc403su' were sown in two dates: 15 June and 1 July 2014. The experiment was arranged in split plot based complete randomized block design with three replications. Main factors were sowing date at two levels (15 June and 1 July) and sub plots were the six cultivars. Spacing of 75 cm row to row and 18 cm plant to plant spacing was maintained and two seeds were sown at the depth of 5 cm; at four-leaf stage, one plant with the best development, was kept and the other was eliminated. Plot size was 6 × 3.6 m, out of which 5 × 2.4 was used to assess final harvest. The furrow irrigation was applied twice a week. Data were collected when each cultivar, for both planting dates, was judged to be at optimum fresh market maturity.

Measurements were made immediately after harvest. All morphological and yield component traits were measured on 10 randomly selected plants of each plot. Ten ears per replication were randomly selected and husked for the length, width and ear tip fill measurements. The number of days until 50% crop tasseling, 50% silking and 5% pollination were recorded. Sweet corn growths in height and leaf number, as a function of thermal time, were determined for each plot. To evaluate the effect of planting date on sweet corn establishment, growth and yield, the additional variables measured after crop emergence, near silk emergence and at harvest were subjected to ANOVA and means separation. Yield was measured in 3 m^2 for each treatment. Fresh ears were immediately husked with a husking bed (Sweet Corn Husker; A&K Development Co., Eugene, OR) and kernels were removed from the cob with an industry-grade corn cutter. Husked mass and kernel mass were recorded and adjusted to 15% moisture level. Ten ears per replication were randomly selected and husked for the length, width and ear tip fill measurements. The data statistical analysis was done by SAS statistical software (SAS, 2002) and the comparison of mean was also done by LSD test at 5% probability level.

Table 1. Physical and chemical properties of soil (0-30 cm)

Soil texture	Clay	Silt	Sand	Organic matter	pH	EC	Total nitrogen
	%	%	%	%		(dS m^{-1})	%
Clay -loam	36	34	30	81	7.61	4	0.079

Table 2. Meteorological information of the study area

Month	Maximum relative humidity (%)	Minimum relative humidity (%)	Rainfall (mm)	Temperature (soil surface)	Total lighting (h)
May	50	26	24.1	19	252
June	44	22	12.8	22	332
July	40	16	-	30	355
August	40	18	-	30	361
September	40	12	-	27	338

Results and Discussion

Determination of sowing dates for maize varieties is crucial for better crop yield. Sowing date and variety treatments were statistically significant on the days to emergence tassel, days to anthesis, number of leaves, plant height, cob height, leaves above the cob, length of male flowers, stem diameter, plant dry weight, weight cob with pod, weight cob without pod, number of grain rows, number of grain per rows, grain yield, grain glucose, grain fructose, grain saccharose, grain raffinose and grain carbohydrates (Table 3). Table 3 (analysis of variance) shows that variety on the days to emergence tassel, days to anthesis, number of leaves, plant height, cob height, leaves above the cob, length of male flowers, stem diameter, plant dry weight, weight cob with pod, ear weight without pod, number of grain rows, number of grain per rows, grain glucose, grain fructose, grain saccharose, grain raffinose and grain carbohydrates were significant statistically at 1% probability level. Also, the obtained data (Table 3) shows that sowing date on days to anthesis, days to emergence tassel, plant height, cob height, leaves above the cob, length of male flowers, stem diameter, plant dry weight, weight cob with pod, ear weight without pod, number of grain per rows and grain raffinose were significant statistically at 1% probability level. In addition, it was noted that sowing date × variety on days to anthesis, leaves above the cob, length of male flowers, grain yield, grain glucose and grain glucose were significant statistically at 1% probability level (Table 3).

The highest days to emergence tassel, days to anthesis, number of leaves, plant height, cob height, number of leaves above the cob, length of male flowers, stem diameter, plant dry weight, weight cob with pod, weight cob without pod, number of grain rows, number of grains per row, grain yield, grain glucose, grain fructose, grain saccharose and grain raffinose were recorded in 'KSC403su' (57.50), 'KSC403su' (62.25), 'KSC403su' (12.64), 'Obsession' (145.99 cm), 'Obsession' (55.89 mm), 'Obsession' (7.80), 'Challenger' (44.68 mm), 'Chase' (17.52 mm), 'KSC403su' (457.42 gr), 'Chase' (329.49 gr), 'Temptation' (256.76 gr), 'Obsession' (18.61), 'Obsession' (39.16), 'Basin' (9.77 mg/gr), 'KSC403su' (26.90 mg/gr), 'Obsession' (13.86 mg/gr), 'KSC403su' (49.88 mg/gr) and 'Chase' (0.71 mg/gr) respectively (Table 4).

The lowest days to emergence tassel, days to anthesis, number of leaves, plant height, cob height, number of leaves above the cob, length of male flowers, stem diameter, plant dry weight, weight cob with pod, weight cob without pod, number of grain rows, number of grains per row, grain yield, grain glucose, grain fructose, grain saccharose and grain raffinose were recorded in 'Challenger' (47.00), 'Challenger' (51.50), 'Challenger' (8.59), 'Challenger' (116.58 cm), 'Temptation' (32.30 mm), 'Challenger' (6.06), 'KSC403su' (38.78 mm), 'KSC403su' (16.44 mm), 'Challenger' (288.12 gr), 'KSC403su' (279.55 gr), 'KSC403su' (199.51 gr), 'Temptation' (16.20), 'Chase' (35.25), 'KSC403su' (7.25 mg/gr), 'Challenger' (13.35 mg/gr), 'Challenger' (7.65 mg/gr), 'Challenger' (24.13 mg/gr) and 'Challenger' (0.00 mg/gr) respectively (Table 4). There is no significant difference among 'Chase' (9.27 t/ha), 'Temptation' (9.34 t/ha), 'Challenger' (9.52 t/ha) and 'Basin' (9.77 t/ha) for grain yield.

The best sowing date for cultivation mentioned varieties in the hereby experiment was 15 June, because this time increased the number of leaves, days to anthesis, days to emergence tassel, stem diameter, leaves above the cob, grain yield, grain glucose, grain fructose, grain saccharose and grain raffinose. Varieties had similar grain yield, grain glucose, grain fructose, grain saccharose, grain raffinose, number of grains row and number of leaves at the two sowing dates. All varieties had similar grain yield except 'Obsession' and 'KSC403su' (Table 4).

Applying the optimum sowing date for maize cultivars has a positive effect on a grain yield and physiological index in maize. The study revealed that both sowing date and cultivar had significant effect on grain yield in applied sweet maize varieties under the field conditions. Similar results have been obtained where seeding dates and varieties significantly influenced on physiological characteristics, yield and component yield (Quayyum and Raquibullah, 1987; Abdul Rahman *et al*., 2001; Nielson *et al*., 2002). In the current study sowing date × cultivar interaction significant affected days to anthesis, leaves above the cob, length of male flowers, grain yield, grain glucose, grain raffinose. Plants at optimum sowing date (15 June) performed higher yield; 'Basin' produced a higher grain yield (about 9.77 t/ha), while 'KSC403su' produced the lowest quantity (7.25 t/ha). Plants at optimum sowing date (15 June) performed the high grain raffinose; 'Chase' produced a higher grain raffinose (about 0.71 mg/gr), while 'Challenger' produced the lowest (0.00 mg/gr). This result is in agreement with findings of Otegui *et al*. (1995), saying that optimum planting date resulted in higher grain yield compared with early and late planting dates because of higher cob numbers and greater kernel numbers per plant.

In conclusions, overall, the best planting date for the six sweet corn varieties tested was 15 June and the height yield was obtained for the variety 'Basin'.

Table 3. Analysis of variance for physiological characteristics, yield and component yield traits in the sowing date and variety treatments

Mean Square (MS)								
Sources change	df	Days to emergence tassel	Days to anthesis	Number of leaves	Plant height	Cob height	Leaves above the cob	Length of male flowers
Replication	3	3.13*	5.02	0.95	115.46**	5.38	0.10	3.95
Sowing date (D)	1	111.02**	85.33**	0.73	6295.21*	1428.99**	26.70**	135.34*
First error	3	0.24	0.39	0.63	333.99	40.92	0.15	7.07
Variety (V)	5	94.12**	106.43**	90.92**	1340.50**	726.77**	3.16**	74.88**
D×V	5	0.72	5.48*	1.50	61.70	16.48	0.22**	13.32**
Error	30	1.12	1.89	0.58	101.98	23.88	0.06	2.72
CV		2.01	2.41	6.98	7.92	11.72	3.45	3.96

Mean Square (MS)							
Sources change	df	Stem diameter	Plant dry weight	Weight cob with pod	Ear weight without pod	Number of grain rows	Number of grain per rows
Replication	3	2.03	3179.58	1540.89	388.17	0.86	2.90
Sowing date (D)	1	59.83**	6290.91*	9080.86**	4497.04**	1.30	320.85**
First error	3	0.44	2810.59	220.29	91.21	2.25	2.72
Variety (V)	5	4.09**	3222.91**	3049.93	2900.82**	5.83**	29.04**
D×V	5	0.39	2484.66	1635.36	507.53	0.43	8.92
Error	30	0.54	3913.54	904.78	634.51	0.44	5.01
CV		4.27	16.53	9.76	10.84	3.90	3.15

Mean Square (MS)							
Sources change	df	Grain yield	Grain glucose	Grain fructose	Grain saccharose	Grain raffinose	Grain carbohydrates
Replication	3	0.351	0.700	0.065	1.200	0.0006	0.06
Sowing date (D)	1	0.006	0.333	0.025	0.460	0.0075*	0.08
First error	3	0.157	0.167	1.948	0.255	0.0003	0.03
Variety (V)	5	0.198	186.647**	42.388**	676.173**	0.8466**	2090.15**
D×V	5	0.143**	12.933**	1.617	12.570	0.0275**	14.03
Error	30	0.286	2.037	0.472	5.156	0.0008	7.00
CV		6.04	7.229	6.907	6.632	9.5752	3.86

*,**: Significant at 5% and 1% probability levels, respectively and ns: Non-significant

Table 4. Mean comparison of physiological characteristics, yield and component yield traits in interaction effect of sowing date and variety treatments

Sowing date	Days to emergence tassel	Days to anthesis	Number of leaves	Plant height (cm)	Cob height (mm)	Leaves above the cob
15 June	54.17a	58.29a	10.79a	116.05b	36.25b	7.88a
1 July	51.12b	55.62b	11.04a	138.95a	47.17a	6.39b
			Variety			
'Chase'	52.75c	55.87d	10.82b	116.18b	35.70d	7.19b
'Temptation'	51.75c	55.50d	10.02c	119.10b	32.30d	7.01b
'Challenger'	47.00d	51.150e	8.59d	116.58b	34.04d	6.06c
'Basin'	52.62c	57.37c	11.02b	126.37b	42.30c	7.01b
'Obsession'	54.25b	59.25b	12.39a	145.99a	55.89a	7.80a
'KSC403su'	57.50a	62.25a	12.64a	140.79a	50.04b	7.72a
Sowing date	Length of male flowers (cm)	Stem diameter	Plant dry weight (gr)	Weight cob with pod (gr)	Weight cob without pod (gr)	Number of grains row
15 June	39.95b	18.41a	342.22b	254.53b	201.65b	16.86a
1 July	43.30a	16.18b	414.62a	351.52a	262.88a	17.19a
			Variety			
'Chase'	39.15c	17.52a	353.86b	329.49a	240.85ab	16.94b
'Temptation'	45.38a	17.45b	337.80bc	326.19a	256.76a	16.20c
'Challenger'	44.68a	16.04c	288.12c	292.54bc	227.77b	16.55bc
'Basin'	38.88c	17.44b	400.07ab	315.47ab	238.70ab	17.22b
'Obsession'	42.90b	17.11b	433.27a	304.89abc	230.00b	18.61a
'KSC403su'	38.78c	18.22c	457.42a	279.55c	199.51c	16.61bc
Sowing date	Number of grains per row	Grain yield (t/ha)	Grain glucose (mg/gr)	Grain fructose (mg/gr)	Grain saccharose (mg/gr)	Grain raffinose (mg/gr)
15 June	33.80b	8.86a	24.34a	10.05a	38.23a	0.023a
1 July	38.98a	8.84a	24.26a	10.10a	38.12a	0.020a
			Variety			
'Chase'	35.25cd	9.27a	22.78b	9.15c	38.13b	0.71a
'Temptation'	35.96bcd	9.34a	16.35e	8.90c	28.30d	0.47c
'Challenger'	33.70ab	9.52a	13.35f	7.65d	24.13e	0.00d
'Basin'	37.70ab	9.77a	18.18d	8.61c	29.39d	0.00d
'Obsession'	39.16a	7.93b	20.92c	13.86a	35.62c	0.00d
'KSC403su'	36.56bc	7.25c	26.90a	11.49b	49.88a	0.54b

Means followed by same letters in each column have not significant difference at 5% probability

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