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Effects of Sowing Date on Yield and Yield Components in Sweet Maize (*Zea mays* L.) Hybrids

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ABSTRACT: In order to determine the effects of sowing date on yield and yield components of nine sweet maize hybrids, an experiment was performed as factorial based randomized complete block design with three replicates. Sowing date in two levels (15 and 30 May) and nine sweet maize hybrids (Chase, Power house, Harvest gold, Temptation, Challenger, Basin, Ex08716636, Obsession and Ksc403su) were the treatments. Results of ANOVA revealed significant difference of sowing date and sweet maize hybrids on number of days to emergence tassel, number of days to anthesis, number of days to emergence spikelet, plant height, cob height, stem diameter, plant dry weight, cob dry weight, number of grain rows, cob diameter, 1000 kernel weight, cob length and net weight grain harvest per plant. Mean comparisons showed that the highest grain yield was for Ex08716636 variety and it was obtained on 15 May planting date.

Keywords: sowing date, sweet maize, hybrids, yield and yield components.

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; Walker, 2013). 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. One of the important cereal crops in the world and Iran after wheat and rice is Maize (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 various corn varieties for variant 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 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. 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 examining 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 *et al.,* 2008). The yield of maize in Iran is very little (Xue *et al.,* 2002). Maize undergoes three stages from pollen dissemination to physiological maturation (Cox *et al.,* 1998). The first stage is known as lag phase (slow growth). The cells start to divide (Abdul Rahman *et al.,* 2001).

At the end of this stage, grain weight slightly increases since endosperm cells play an important role in sink capacity (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 (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 at that time are focused more on breeding aspects rather than crop management (Xue *et al.*, 2002). The period from November to February is the best time for the highest dry matter production in the Khartoum area. It also was 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 1000 kernel weight (Cirilo and Andrade, 1996), where 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 as 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 cultivar had greater assimilated allocation to the grain than the taller cultivars (Benga *et al.*, 2000). Therefore present works 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 Varamin, Iran, 2014. 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 p.p.m and 81% respectively, and its pH was 7.61. The Meteorological information of Varamin has shown in Table 2. The previous crop was wheat. The soil was fertilized by 350 kg ha^{-1} Urea (during sowing, at six leaf stage and the remaining during tassel emergence as top-dressing), 180 kg ha^{-1} K_2O, and 150 kg ha^{-1} P_2O_5 after leveling and before making the furrows. Nine varieties namely Chase, Power house, Harvest gold, Temptation, Challenger, Basin, Ex08716636, Obsession and Ksc403su were sown in two dates 15 and 30 May 2014. Experiment was designed as a randomized complete block design with a factorial treatment arrangement replicated three times where planting dates and hybrids were factorial treatments. Spacing 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, and at four-leaf stage, one plant with the best condition was kept and the other were 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 at two planting dates were judged to be at optimum fresh market maturity. Measurements were made immediately after harvest. All morphological and yield component traits 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 growth in height and leaf number as a function of thermal time was 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 (Power Corn Cutter; A&K Development Co.).

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

Mn	Zn	Fe	K	P	N	Organic Matter	pH	EC	Soil texture
(mg kg^{-1})					(%)			(dS m^{-1})	
2.5	3.2	4.2	29	15	0.56	1.2	7.16	4	Silty-clay

Table 2: Meteorological information Varamin, Iran.

Month	Maximum relative humidity (%)	Minimum relative humidity (%)	Rainfall (mm)	Temperature (soil surface)	Total lighting (h)
May	59	23	13.9	18	249
June	55	21	10.6	24	329
July	49	15	-	31	351
August	49	17	-	30	356
September	49	14	-	26	340

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.

RESULTS AND DISCUSSION

Determination of sowing dates for maize varieties is very crucial for better crop yield. Sowing date and variety treatments were statistically significant on the days to emergence tassel, days to a thesis, plant height, cob height, stem diameter, plant dry weight, cob dry weight, number of grain rows, cob diameter, 1000 kernel weight, cob length and net weight grain harvested per plant (Table 3). Analysis of variance showed that sowing date and variety treatments on the number of leaves, leaves above the cob and diameter of the cob were not significant statistically (Table 3). Table three (analysis of variance) shows that variety on the days to emergence spikelet, length of male flowers, number of grains per row and dry weight of cob were significant statistically at 5% probability level. The highest cob height, plant height, number of leaves, days to emergence spikelet, days to anthesis, days to emergence tassel, number of grain rows, cob dry weight, plant dry weight, length of male flowers, stem diameter, number of leaves above the cob, 1000 kernel weight, dry weight of cob, diameter of the cob, net weight grain harvested per plant, cob length, number of grains per row were recorded in Obsession (126 mm), Obsession (159.8 cm), Chase (12.5), EX08716636 (54.0 days), EX08716636 (54.2 days), EX08716636 (50 days), EX08716636 (108.3), EX08716636 (117.7 g), EX08716636 (519.5 g), Temptation (42.1 cm), Obsession (20 mm), Chase (4.3), Challenger (199.3 g), Temptation (56.7 g), Chase (4.4 cm), EX08716636 (105.5 g), EX08716636 (21.9 cm) and Obsession (39.2) respectively (table 4).

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

		Mean Square (MS)						
Sources change	**df**	**Days to emergence tassel**	**Days to an thesis**	**Days to emergence spikelet**	**Number of leaves**	**Plant height**	**Cob height**	**Leaves above the cob**
Replication	3	4.0*	1.0	3.6	8.8	414.8**	287.4**	1.0
Sowing date (D)	1	687.3**	767.0**	760.5**	19.0	6206.8**	3780.2**	1.2
Variety (V)	8	3.8*	3.3**	7.7**	5.2	473.5**	283.4**	0.5
D×V	8	0.4	0.1	0.1	4.9	12.0	2.5	0.5
Error	51	1.4	1.0	1.6	5.0	62.4	42.9	0.6
CV		2.4	1.9	2.3	19.4	5.2	5.5	20.3

		Mean Square (MS)					
Sources change	**df**	**Length of male flowers**	**Stem diameter**	**Plant dry weight**	**Cob dry weight**	**Number of grains per row**	**Number of grain rows**
Replication	3	78.0**	10.8**	13856.1**	767.4**	19.9	504.8*
Sowing date (D)	1	34.0	68.6**	92133.5**	2001.3**	51.7	2453.3**
Variety (V)	8	44.9*	37.8**	22062.6**	1145.5**	40.8*	971.5**
D×V	8	5.8	0.1	145.0	3.2	19.3	4.0
Error	51	16.2	1.6	2797.0	148.2	16.0	121.8
CV		10.7	7.5	12.0	12.2	11.0	12.0

		Mean Square (MS)					
Sources change	**df**	**Diameter of the cob**	**Cob diameter**	**1000 kernel weight**	**Cob length**	**Net weight grain harvested per plant**	**Dry weight of cob**
Replication	3	0.2*	0.1	1064.7	6.8*	114.2	687.7**
Sowing date (D)	1	0.1	2.5**	14138.9**	15.1**	1816.8**	186.8
Variety (V)	8	0.3	0.2*	3417.6**	11.0**	1154.5**	150.6*
D×V	8	0.1	0.0006	829.6	14.1**	160.2	0.2
Error	51	0.8	0.1	841.5	1.9	259.9	59.9
CV		11.7	7.5	18.0	7.2	18.7	15.3

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

The lowest cob height, plant height, number of leaves, days to emergence spikelet, days to anthesis, days to emergence tassel, number of grain rows, cob dry weight, plant dry weight, length of male flowers, number leaves above the cob, stem diameter, 1000 kernel weight, dry weight of cob, diameter of the cob, net weight grain harvested per plant, cob length, number of grains per row were observed in Obsission (104.7 mm), Chase (132.6 cm), Harvest gold Chase (10), KSC043su (50.9 days), Challenger (52.1 days), Challenger (47.9 days), Power house (76.8), Power house (83.5 g), Power house (372.9 g), Chase (35.4 cm), Temptation (14.2 mm), Temptation (3.5), Power house (136.5), Power house (42.6 g), Power house and KSC403su (3.9 cm), KSC403su (71.1 g), Basin and KSC403su (18 cm) and Challenger (33) respectively.

There were no significant differences among power house Harvest gold, Temptation, Basin, EX08716636 and KSC403su for Plant height. Number of leaves was the same for all varieties except Temptation variety. KSC403su and EX08716636 were the most early and late maturity respectively among varieties (Table 4).

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

Sowing date	Days to emergence tassel	Days to anthesis	Days to emergence spikelet	Number of leaves	Plant height (cm)	Cob height (mm)
15 May	51.9 a	56.2 a	55.7 a	12.1 a	159.7 a	125.6 a
30 May	457.8 b	49.7 b	49.2 b	11.0 a	141.1 b	111.1 b
			Variety			
Chase	49.4 abc	53.4 ab	53.6 ab	12.5 a	132.6 d	104.7 d
Power house	49.5 ab	53.1 bc	52.9 abc	12.4 a	148.7 bc	117.4 bc
Harvest gold	49.1 abc	53.0 bc	51.9 cde	11.1 ab	153.6 abc	120.8 abc
Temptation	48.5 bcd	52.6 bc	52.2 cd	10.0 b	149.1 bc	117.2 bc
Challenger	47.9 d	1 c	51.6 de	10.9 ab	148.2 c	116.8 c
Basin	48.4 bcd	53.0 bc	52.0 cde	11.8 ab	150.9 bc	118.9 bc
EX08716636	50.0 a	54.2 a	54.0 a	11.8 ab	156.4 ab	123.4 ab
Obsission	48.6 bcd	52.6 bc	52.6 bcd	11.5 ab	159.8 a	126.0 a
KSC403su	48.2 cd	52.2 c	50.9 e	12.2 ab	154.2 abc	119.9 abc

Sowing date	Leaves above the cob	Stem diameter (mm)	Length of male flowers (cm)	Plant dry weight (g)	Cob dry weight (g)	Number of grain rows
15 May	4.1 a	18.0 a	38.4 a	477.0 a	105.4 a	97.7 a
30 May	3.8 a	16.1 b	37.0 a	405.4 b	94.9 b	86.0 b
			Variety			
Chase	4.3 a	15.6 d	35.4 c	448.4 c	101.4 cd	89.4 bcd
Power house	4.2 ab	18.5 bc	36.5 bc	372.9 e	83.5 f	76.8 e
Harvest gold	3.9 ab	14.5 de	38.1bc	441.3 cd	100.3 cd	92.4 bc
Temptation	3.5 b	14. e	42.1 a	511.8 ab	116.7 ab	107.6 a
Challenger	3.8 ab	15.5 de	36.2 bc	440.9 cd	99.9 cde	92.1 bcd
Basin	4.0 ab	17.5 c	35.6 c	394.6 de	89.6 def	82.6 cde
EX08716636	4.0 a b	18.4 bc	39.1 abc	519.5 a	117.7 a	108.3 a
Obsission	3.9 ab	20.0 a	40.2 ab	460.8 bc	104.6 bc	96.3 b
KSC403su	4.2 ab	19.4 ab	35.9 c	380.6 e	87.8 ef	81.1 de

Sowing date	Number of grains per row	Cob length (cm)	Net weight grain harvested per plant	Diameter of the cob (cm)	Dry weight of cob (g)	1000 kernel weight (g)
15 May	37.1 a	19.8 a	91.4 a	4.3 a	52.1 a	146.4 b
30 May	35.4 a	18.9 b	81.4 b	3.9 b	48.8 a	174.4 a
			Variety			
Chase	35.9 abc	18.6 bc	86.0 bc	4.4 a	47.8bc	172.9 ab
Power house	34.5 bc	19.6 b	75.0 c	3.9 c	42.6 c	136.5 c
Harvest gold	38.6 a	19.8 b	84.6 bc	4.0 bc	50.6 ab	148.7 bc
Temptation	36.6 abc	19.5 b	99.6 ab	4.0 bc	56.7 a	185.1 a
Challenger	33.0 c	19.0 bc	85.9 bc	4.4 a	53.2 ab	199.3 a
Basin	33.5 c	18.0 c	73.9 c	4.3 ab	48.1 bc	148.0 bc
EX08716636	36.6 abc	21.9 a	105.5 a	4.0 bc	55.0 ab	151.3 bc
Obsission	39.2 a	19.8 b	96.0 ab	4.1 abc	52 1 ab	153.1 bc
KSC403su	38.4 ab	18.0 c	71.1 c	3.9 c	48.0 bc	148.7 bc

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

Other varieties in aspect of maturity located between two further mentioned varieties. There were no significant differences between Chase, Power house, Harvest gold, Challenger, Basin, and KSC403su for grain weight per plant (Table 4). The best sowing date for cultivation mentioned varieties was 15 May, because this time increased cob height, plant height, number of leaves, days to emergence spikelet, days to anthesis, days to emergence tassel, number of grain rows, cob dry weight, plant dry weight, stem diameter, diameter of the cob, net weight grain harvested per plant, cob length in cultivated varieties. Varieties had similar days to emergence spikelet, days to emergence tassel, length of male flowers and number of grain per row at two sowing dates. All varieties had similar dry weight of cob except Power house and Temptation (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 1000 kernel weight (Abdul Rahman *et al.*, 2001; Nielson *et al.*, 2002). In this study sowing date×cultivar interaction significant affected only cob length. Plants at optimum sowing date performed the high yield; EX08716636 produced a higher grain yield (about 7.4 t ha^{-1}), while KSC403su produced the lowest (5.3 t ha^{-1}). This result agree with finding by Otegui *et al.* (1995) that optimum planting date resulted in higher grain yield than early and late planting dates because of higher cob numbers and greater kernel numbers per plant). If kernel growth outruns dry matter accumulation in 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). As the overall the best planting date for 9 sweet corn was 15 May and the best variety was EX08716636.

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