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The effect of planting dates, plant density, and silicon spraying on the growth and yield of sweet corn

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Abstract
The experiment was carried out in private field in Abu Gharaq (10 km west of Hilla city) during the fall season 2019, to study the effect of planting dates (July 15, August 1 and 15) and plant density (40 and 80 thousand plants ha^{-1}, silicon spraying levels (0, 1.5, 3.0, and 4.5 ml l^{-1}) and their interactions on the growth and yield of sweet corn. Split-split-plot arrangement following a randomized complete block design (R.C.B.D) with three replications was used. The results were analyzed and the averages were tested according to the least significant difference at the 0.05 probability level. The most important results are summarized as follows: Planting on July 15 delayed the day's number to 50% silkinging to 53.21 days compared to August 1 (51.71 days), and decreased ripening single ear weight with sheaths to 104.3 g compared to August 15 which achieved 244,9 g. High plant density caused significant increase in 50% silking, and leaf area index to 53.75 days and 2.998, without significant effect on ripening single ear weight with sheaths. Silicon spraying levels caused significant effect on ear ripening weight, and 3 ml l^{-1} achieved high weight 174.8 g compared to 169.4 g from control treatment.

Keywords: Sweet corn, Silicon, Planting date, Plant density

Introduction
Sweet corn *Zea mays L. saccharata* is one type of yellow corn. Sweet corn is distinguished from yellow corn in containing its high sugar (14-20% sugar) seeds in the milky and early pasty stages (Rubatzky and Yamaguchi, 2000) [17]. Sweet corn has been cultivated in Iraq only as experimental scale, and due to the few studies, no field practices for its cultivation have been identified. Determining the appropriate date for planting is one of the important factors for crop growth and more efficient utilization of environmental factors that affect plant growth and yield (Azadbakht *et al*., 2010) [7]. The plant density plays an important role in plant growth and yield, through its influence in determining the degree of competition between plants on light, water, and available nutrients (Van Rokel and Coulter, 2012) [21]. Silicon increased plant's ability to exploit solar energy and absorb light, which leads to increase the photosynthesis, and thus increase growth and yield (Deshmukh *et al*., 2017) [9]. Silicon is one of the rare nutrients which takes an important role in bearing various types of stress and increases the rate of photosynthesis (Sahebi *et al*., 2015) [18]. Silicon is present in the soil in large quantities, but it is one of the rare nutrients of the plant that it is preferred to add, since most silicon sources in the soil are in the form of crystals of insoluble aluminum silicates, which is not directly available to plants (Richmond and Sussman, 2003 and Meena *et al*, 2014) [16, 14].

Materials and methods
A field experiment was carried out in Abu Ghark district, within 32.3146 degrees north latitude and 44.2217 degrees east longitude, in the autumn season of 2019 to study the effect of planting dates (July 15, August 1 and 15), plant density (40 and 80 thousand plants per hectare) and silicon spraying levels (0, 1.5, 3, and 4.5 mL l^{-1}) on growth and yield of sweet corn in silty clay loam soil (Table 1).

Table 1: Some physical and chemical field soil properties

characteristic	Value and unity	characteristic		Value and unity
Available N	8.41 mg kg^{-1}	Soil components	sand	186 g kg^{-1}
Available P	19.02 mg kg^{-1}		Silt	339 g kg^{-1}
Available K	191 mg kg^{-1}		clay	475 g kg^{-1}
EC	2.9 dSm m^{-1}	Soil texture		Silty clay loam
pH	7.5			

The experiment was carried as a factorial experiment according to split-split plots arrangement within a randomized complete block design with three replicates (3 * 2 * 4 * 3). The main plots contained planting dated, and the split plots contained plant density, while silicon levels were taken place in split-split plots. Each experimental unit included three ridges, 1 m widths 3 m length, planted in one side, or both sides in hills 25 cm apart to attain the plant density. Compound fertilizer (N-P-K, 20-20-20) was added at 200 kg ha^{-1} during soil preparation. The grain was seeded in the upper third of the ridge. The plants after two weeks thinned to one plant per hill. The data were analyzed and the means were tested according to the least significant differences at 0.05 probability.

Results and discussion

Table (2) shows that planting date had a significant effect on the number of days to 50% of tasselling, and planting on August 15 gave the highest number of days 43.12 days compared to July 15 that gave the lowest number 42.08 days. This may be due to day length high temperature during mid-July, which results in faster flowering (Oktem *et al*., 2004) [15]. The plant density had a significant effect on this trait, and the low density gave the lowest day number 42.39 days compared to the high density (43.08 days). This may be due to the deception that encouraged vegetative growth and delay of the transition period to reproductive growth. Or that increasing plant density led to a lack of light penetration inside the plant, that increasing ouxine and then prolonging the vegetative growth period and delaying the transition to reproductive status (Hashemi and Herbert, 1992) [10]. This result was agreed with Shrestha *et al* (2018) [20]. Silicon spraying had a significant effect and the level of 4.5, gave the highest days 43.33 days, while control treatment gave the lowest days number 42.22 days.

The interaction between the dates of planting and plant density had a significant effect and August 15 with high density gave the highest days number of days 43.50 days, while July 15 and the low density gave the lowest number 41.67 days. The interaction between planting date and silicon had a significant effect, and August 15 with silicon 4.5 ml l^{-1} gave the highest days number 44.00 days, while July 15 without spraying silicon gave the lowest number (40.67 days). The interference between plant density and silicon had a significant effect, and 1.5 ml l^{-1} silicon with high density gave the highest number 43.56 days compared to the low density without silicon (41.89 days). The interaction between the study factors had a significant effect and the lowest days number (40.33 days) achieved from July 15, low density, and without spraying silicon.

Table 2: Effect of seeding dates, plant density and Si spraying on tasselling (days)

Seeding dates	Plant Density	Silicon treatments				Interaction of dates* density
		0	1.5	3	4.5	
July 15	40000	40.33	42.33	41.33	42.67	41.67
	80000	41.00	44.00	42.67	42.33	42.50
August 1	40000	42.67	41.67	42.67	44.00	42.75
	80000	43.33	43.33	43.33	43.00	43.25
August 15	40000	42.67	41.67	42.67	44.00	42.75
	80000	43.33	43.33	43.33	44.00	43.50
Si mean		42.22	42.72	42.67	43.33	
$LSD_{0.05}$		Si= 0.688		T=2.186		1.420
Interaction of dates * silicon						Dates average
July 15		40.67	43.17	42.00	42.50	42.08
August 1		43.00	42.50	43.00	43.50	43.00
August 15		43.00	42.50	43.00	44.00	43.12
$LSD_{0.05}$		1.720				0.773
Interaction of density * silicon						Density average
40000		41.89	41.89	42.22	43.56	42.39
80000		42.56	43.56	43.11	43.11	43.08
$LSD_{0.05}$		1.438				0.631

Table (3) shows that planting date had a significant effect on the number of days to 50% of silking, and planting on July 15 gave the highest number of days 53.21 days compared to August 1 that gave the lowest number 51.71 days. This may be due to high temperature during mid-July, which results in faster flowering (Baker and Ahmed, 2002) [8]. This result was agreed with Al-Zuhairy (2005) [6]. The plant density had a significant effect on this trait, and the high density gave the highest day number 53.75 days compared to the low density (51.44 days). This may be due to the deception that increasing ouxine and then prolonging the vegetative growth period (Al-Taee, 2007) [5]. This result was agreed with Shrestha *et al* (2018) [20].

The interaction between the dates of planting and plant density had a significant effect and July 15 with high density gave the highest days number 55.25 days, while August 1 and the low density gave the lowest number 50.92 days. The interaction between planting date and silicon had a significant effect, and July 15 without silicon gave the highest days number 53.83 days, while August 1 without spraying silicon gave the lowest number (51. days). The interaction between plant density and silicon had a significant effect, and 1.5 ml l^{-1} silicon with high density gave the highest days 54.11 days compared to the low density without silicon (51.11 days). The interaction between the study factors had a significant effect and the highest days number (56.00 days) achieved from July 15, 1.5 ml l^{-1} silicon, and high density, while August 1, low density, and without spraying silicon gave the lowest days 50.00 days.

Table 3: Effect of seeding dates, plant density and Si spraying on silking (days)

Seeding dates	Plant density	Silicon treatments				Interaction of dates* density
		0	1.5	3	4.5	
July 15	40000	52.00	51.33	51.00	50.33	51.17
	80000	55.67	56.00	54.33	55.00	55.25
August 1	40000	50.00	51.33	51.33	51.00	50.92
	80000	52.00	53.00	53.00	52.00	52.50
August 15	40000	51.33	52.00	52.67	53.00	52.25
	80000	52.33	53.33	54.00	54.33	53.50
Si mean		52.22	52.83	52.72	52.61	
$LSD_{0.05}$		Si=n.s T=1.555				1.050
Interaction of dates * silicon						Dates average
July 15		53.83	53.67	52.67	52.67	53.21
August 1		51.00	52.17	52.17	51.50	51.71
August 15		51.83	52.67	53.33	53.67	52.88
$LSD_{0.05}$		1.194				1.019
Interaction of density * silicon						Density average
40000		51.11	51.56	51.67	51.44	51.44
80000		53.33	54.11	53.78	53.78	53.75
$LSD_{0.05}$		0.848				0.535

Table (4) shows that plant density caused a significant effect on the plant leaf area index, and high density gave the highest value 2.998, while low density gave the lowest value 1.494. This result was agreed with Abd Salama *et al.* (2007). The interaction between the dates of planting and plant density caused a significant effect, and August 1 with high density was superior by giving the highest value 3.068, while the July 15 and low density gave the lowest value (1.442). The interaction between planting dates and silicon levels caused a significant effect, and August 1 without spraying silicon gave the highest value 2.372, compared to July 15 without spraying silicon, which gave the lowest value 2.095. The highest leaf area index (3.243) achieved from August 1 with high density and without silicon.

Table 4: Effect of seeding dates, plant density and Si spraying on leaf area index

Seeding dates	Plant density	Silicon treatments				Interaction of dates* density
		0	1.5	3	4.5	
July 15	40000	1.453	1.417	1.480	1.417	1.442
	80000	2.737	3.240	2.790	3.003	2.943
August 1	40000	1.500	1.463	1.613	1.417	1.498
	80000	3.243	3.083	2.870	3.073	3.068
August 15	40000	1.503	1.577	1.573	1.517	1.543
	80000	2.960	2.943	2.963	3.063	2.983
Si mean		2.233	2.287	2.215	2.248	
$LSD_{0.05}$		Si=n.s T=0.241				0.162
Interaction of dates * silicon						Dates average
July 15		2.095	2.328	2.135	2.210	2.192

August 1	2.372	2.273	2.242	2.245	2.283
August 15	2.232	2.260	2.268	2.290	2.263
$LSD_{0.05}$	0.187				n.s
Interaction of density * silicon					Density average
40000	1.486	1.486	1.556	1.450	1.494
80000	2.980	3.089	2.874	3.047	2.998
$LSD_{0.05}$	0.129				0.076

Table (5) shows that planting dates caused a significant effect on the marketable ear weight with sheath (g), and August 15 was significantly distinguished by giving the highest weight 244.9 g, while July 15 gave the lowest weight 104.3 g. This result was due to the optimum temperatures during the flowering period that affected the fertilization process and increases ear grains number (data not publish), which is reflected positively in increasing yield (Ahmed, 2001 and Al-Hassani, 2015) [1, 3]. This is consistent with the findings of Al-Hadidi (2007) and Al-Mashhadani (2010) [2, 4]. Silicon spraying caused a significant effect and the level 3.0 ml l^{-1} gave the highest weight of 183.3 g, while control treatment gave the lowest weight of 169.4 g. This is due to the role of silicon in improving the activity of photosynthesis and the efficiency of its representation in the plant, thereby increasing the dry matter (Jawahar and Vaiyapuri, 2010. 2013 and Xie *et al*, 2014) [12-13, 22]. These results are consistent with Zhiming *et al* (2014) and Idan (2016) [23, 11].

The interaction between planting dates and plant density had a significant effect August with low density gave the highest weight 260.8, while July 15 with high density gave the lowest weight 101.9. The interaction between planting dates and silicon levels caused a significant effect, and August 15 with 3 ml l^{-1} silicon gave the highest weight 251.7 g, while July 15 at all-silicon spraying levels gave the lowest weight. The interaction between plant density and silicon spraying levels caused a significant effect and low density with 3.0 ml l^{-1}silicon gave the highest weight 185.8 g, while the high density without silicon spray gave the lowest weight 164.8 g. The highest weight achieved from August 15 with low density and sprayed silicon at 1.5 - 4.5 ml l^{-1} reached to 266.0 - 269.3 g, while July 15 with high density at all levels of silicon gave the lowest ripening ear weight with sheath.

Conclusion

It was concluded from this experiment, that delayed planting date of sweet corn to 15 August improved the weight of ripening single ear with sheaths. Planting high density 80 000 plants ha^{-1} had no significant effect on the weight of ripening single ear with sheaths, but of corse dubled the ear numbers per unit area. Silicon spraying caused an increase in the weight of ripening single ear with sheaths.

Table No 5: Effect of seeding dates, plant density and Si spraying on harvesting ear wt

Seeding dates	Plant density	Silicon treatments				Interaction of dates* density
		0	1.5	3	4.5	
July 15	40000	103.0	111.7	109.0	103.0	106.7
	80000	98.3	107.7	98.7	103.0	101.9
August 1	40000	179.3	183.7	182.3	176.7	180.5
	80000	175.3	171.3	206.0	164.0	179.3
August 15	40000	240.0	268.0	266.0	269.3	260.8
	80000	220.7	224.7	237.3	232.7	228.9
Si mean		169.4	181.2	183.3	174.8	
$LSD_{0.05}$		Si= 9.42 T=24.8				17.2
Interaction of dates * silicon						Dates average
July 15		100.7	109.7	103.8	103.0	104.3
August 1		177.3	177.5	194.5	170.3	179.9
August 15		230.3	246.4	251.7	251.0	244.9
$LSD_{0.05}$		19.8				17.4
Interaction of density * silicon						Density average
40000		174.1	181.1	185.8	176.3	179.3
80000		164.8	181.2	180.7	173.2	177.5
$LSD_{0.05}$		12.8				n.s

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