Minufiya J. Agric. Res. Vol.39 No. 1(1): 169 - 180 (2014) "http://www.mujar.net"

EFFECT OF PLANT DENSITY ON GROWTH AND GRAIN YIELD OF SOME MAIZE HYBRIDS

M.A.G. Khalil
Maize Research Department, Field Crops Research Institute (FCRI),
Agricultural Research Center (ARC), Egypt

(Received : Dec. 12 , 2013)

ABSTRACT: *Four field experiments were conducted at Sakha (North Egypt) and Sids (middle Egypt) Agric. Res. Sta. during 2011 and 2012 seasons, to study the effect of four plant densities (21875, 26250, 30625 and 35000 plants fed^{-1}) on growth, grain yield and yield components for four maize hybrids, i.e. SC 10, SC 162, SC 166 and SC173. Experimental design was split-plot with four replications where plant density were allocated in main plots and hybrids were arranged in sub plots. Combined analysis for locations was used in both seasons. Results showed that Sakha location gave the highest values for plant and ear height, ear length, ear diameter, rows /ear, kernels / row,1000-kernel weight and grain yield in both seasons, whereas Sids location had the highest values for days to 50% silking and anthesis-silking interval in both seasons. Plant density significantly affected for days to 50% silking and anthesis-silking interval in the second season and ears/100-plants, ear length and diameter, kernels/row,1000-kernel weight and grain yield fed^{-1} in both seasons. The highest grain yield fed^{-1} was obtained by plant density of 30625 plants fed^{-1} in both seasons. The tested maize hybrids varied significantly in growth and grain yield traits, except for kernels /row in 2011 season. Hybrid SC173 reached flowering stage earlier than the other hybrids and it had the lowest value for ear height at both seasons. However, SC10 was the highest for plant height, ear diameter and 1000-kernel weight in both seasons. Hybrid SC166 had the highest rows/ear in both seasons, while, SC 162 gave the lowest means for anthesis-silking interval and the highest values for ears/100-plants, ear length, kernels/row, and grain yield in both seasons. Results of interaction was indicated that SC162 hybrid had the highest grain yield when it was planted in moderate densities (26250 and 30625) as an average of both locations and seasons.*

Key words: *Maize, Plant density, Locations, environmental condition, Growth, Yield and Yield components.*

INTRODUCTION

Plant density is one of the most important cultural practices, which determine grain yield in addition to other important agronomic factors of maize (Sangoai, 2001). Maximum crop production can be achieved by using of high yielding hybrids and suitable growing under environment and soil with optimum plant population fed^{-1}. Optimum plant population is the prerequisite for obtaining maximum yield (Trenton *et al.*, 2007). Plant density exerts a strong influence on maize growth and grain yield, because of its competitive effect both on the vegetative and reproductive development (Tetio-Kagho and Gardner, 1988). Grain yield increase linearly with plant density until some competitive effects become apparent (Abolhassan *et al.*, 2005). In dense population most plants remain barren ear and ear size remain small, crop become susceptible to lodging, disease and pest attack while plant population at sub-optimum level resulted lower yield per unit area because of lesser than optimum plants (Cardwell, 1982 and Nasir, 2000). In case of low plant density, days to 50% silking and anthesis-silking interval decreased, while rows per ear, kernel per row and 1000-kernel weight increased (Kalil, 2001; Sangoai *et al.*, 2002 and Shafi *et al.*, 2012). Modarres *et al.* (1998) found that total grain yield was higher at high plant density than at low plant density. The hybrids response differently to various agro management practices especially plant density. This variable response is mainly due to differences hybrids, in relative maturity

(Farnham, 2001), plant morphology (Benga *et al.*, 2001), vertical leaf area profile (Valentinuz and Tollenaar, 2006), short pollen-shed-to-silking interval (Smith *et al.*, 1982), grain filling duration (Echarte *et al.*,2006), intra-specific competition in maize plants (Maddonni and Otegui, 2006), prolificacy (Boris *et al.*, 2004), plant growth rate (Maddonni and Otegui, 2004), crowding stress tolerance (Tollenaar and Lee, 2002) and sink capacity (Borras and Westgate, 2006). The hybrids have the ability response with stand at high plant density due to more partitioning of assimilates to shoot as compared to root (Herbert *et al.*, 2001).

The objective of this study was to estimates the effect of plant density on growth, yield and yield components traits of some hybrids.

MATERIALS AND METHODS

Four field experiments were carried out to study effect of plant density on growth, yield and its components of four maize hybrids at two locations i. e. Sakha and Sids, Agric. Res. Stn. in 2011 and 2012 summer seasons. The tested four plant densities were 21875(D_1), 26250 (D_2), 30625(D_3) and 35000 (D_4) plant feddan^{-1} (fed^{-1}) obtained from planting at 25, 20, 17.5 and 15 cm between hills, respectively. The tested four hybrids, i.e. SC10 (white grains) as well as SC162, SC166 and SC173 (yellow grains). The experimental design was split-plot with four replications. Plant density was randomly assigned to the main plots, while maize hybrids were arranged at random in the sub-plots. Experimental plot included 4 rows, 80 cm in width and 6 m in length. The planting date at Sakha location was 8th and 10th May and at Sids location was 17th and 21th May in 2011 and 2012 seasons, respectively. However, the harvesting date at Sakha location was 6th and 8th September and at Sids location was 15th and 19th September in 2011 and 2012 seasons, respectively. Recommended doses of Calcium super- phosphate and potassium fertilizers (30Kg P_2O_5 and 24Kg K_2O fed^{-1}) were applied during land preparation. Nitrogen fertilizer (as urea 46%) was applied at the rate of 120 Kg fad^{-1}, in two equal doses before the first and second irrigations and other cultural practices were performed as recommended at the proper time. Air and soil temperature were recorded for April, May, June, July, August, September and October in both locations and seasons (Table 1). The physical and chemical analysis of soil for experimental sites are presented in Table (2) Recorded data were number of days to 50% silking (DTS), plant height (PHT) cm, ear height (EHT)cm, anthesis-silking interval (ASI) day, number of ears per 100-plant (EPP), ear length (EL)cm, ear diameter (ED)cm, number of rows per ear (REP), number of kernels per row (KPR), 1000-kernel weight (KWT) g and grain yield (GY) ardab/feddan adjusted to 15 % grain moisture (one ardab = 140kg grains and one feddan = 4200m^2). Combined analysis for all studied traits over the two locations at each year was done according to Steel and Torrie, 1980, after homogeneity test of residual variance for all trails according to Bartlett (1937).

RESULTS AND DISCUTION

A. Locations effects:

Significant differences were detected between Sakha and Sids locations for all characters studied of growth, yield and yield components in 2011 and 2012 seasons, except for EPP and RPE in both seasons, and KPR and KWT in 2012 season (Table 3, 4 and 5). The highest mean values were observed for PHT, EHT, EL, ED, RPE, KPR, KWT and GY at Sakha location in both seasons and KPR in first season, while DTS and ASI at Sids location in both seasons. The superiority of the most of characters and yield and yield components at Sakha location obtained herein may be attributed to the decrease in the air and soil temperature as shown in Table (1) as well as the increase in the dry matter and available N, P and K as shown in Table (2) for Sakha location compared to sids one. Fery (1964) and Fery and Maldonado (1967) defined the stressed environment as the one in which mean performance for a certain attribute is low and that stress for one trait does not mean stress for all traits under study. El-Shenawy (2005) and Motawei (2006) found that significant differences between Sakha and Sids locations for DTS, PHT, EHT, EL, ED, RPE, KPR, KWT and GY(ard./fed.). Mosa *et al*. (2009) stated that the environmental conditions at Sakha location were non stress, while Sids location was a stressed environment.

B. Effect of plant density:

B.1.Growth characters:

The tested treatments of plant density significantly affected DTS and ASI in 2012 season (Table 3). Significant lower DTS was found at D_1 and D_2 compared with the other plant densities (D_3, and D_4). Casini (2012) and Shafi *et al.* (2012) found that plant density had insignificant effect on DTS, while, Mahgoub and El-Shenawy (2006) stated that increasing plant density significantly increased DTS. Also, ASI was increased with increasing plant density up to 35000 plants fed^{-1} (D_4). Sangoai *et al.* (2002) reported a linear elongation of the ASI duration with increasing plant density from 2.5 to 10 plants m^{-2}. Edmeades and Daynard (1979) stated that the required time for pollen shedding was not influenced appreciably by plant density, however, time from planting to silking increased from 84 to 95 days as plant density increased from 5 to 20 plants m^2. Moreover, the obtained data herein for PHT and EHT did not affect significantly by varying the plant density in both seasons. In this respect, Mosalem (1998) and El-Zeir *et al.* (1998) found that plant density was not significant for PHT and EHT.

Table (1): Monthly maximum, minimum and mean of air temperature and soil temperature at Sakha and Sids locations in 2011 and 2012 growing seasons.

month	Air temperature °C						Soil temperature °C	
	2011			2012				
	Sakha location							
	Max.	Min.	Mean	Max.	Min.	Mean	2011	2012
April	26.5	10.4	18.6	27.5	13.0	20.3	18.5	21.5
May	32.4	16	24.0	30.5	16.0	23.3	23.5	23.0
June	32.3	18.5	25.4	33.0	20.0	26.5	24.8	25.8
July	34.5	20.7	27.6	34.3	21.0	27.7	27.2	27.0
August	34.0	19.4	26.7	35.0	21.7	28.4	27.5	28.5
September	32.2	17.2	24.7	34.7	19.3	27.0	25.4	26.7
October	26.8	12.3	19.5	28.7	16.0	22.4	20.3	22.5
	Sids location							
April	29.0	13.0	21.5	31.8	14.0	22.9	21.6	23.6
May	29.5	16.8	23.2	33.5	16.9	25.2	23.7	26.0
June	33.8	19.2	26.5	36.1	21.3	28.7	27.6	29.3
July	32.7	19.5	26.1	35.2	22.0	28.6	26.1	30.5
August	34.1	21.0	27.6	37.6	24	30.8	28.5	31.7
September	32.8	18.7	25.7	34.2	19.7	27.0	26.5	27.8
October	30.6	15.2	22.4	32.8	21.5	27.2	23.0	26.0

Table (2): Physical and chemical properties of the experimental soil at the tow locations in 2011 and 2012 seasons.

season	2011		2012	
location	Sakha	Sids	Sakha	Sids
Soil particles				
Coarse sand %	2.7	1.5	2.8	1.3
Fin sand %	22.11	14.7	23.21	20.3
Silt %	23.19	32.1	21.94	27.4
Clay %	52.00	51.7	52.15	51.0
Texture	Clay	Clay	Clay	Clay
Chemical analysis				
Available N ppm	130.5	116.5	125.5	112.6
Available P ppm	12.7	10.5	11.6	10.7
Available K ppm	291.5	275.3	290.3	263.3
PH	7.8	7.8	8.00	7.7
EC (m mohs/cm)	1.9	0.48	2.5	0.52
D.M %	1.84	1.52	1.76	1.53
$CaCO_3$ %	1.75	1.80	1.73	1.83

Table (3): Effect of plant density, hybrids and their interactions on days to 50% silking (DTS), plant height (PHT), ear height (EHT) and anthesis-silking-interval (ASI) over two locations in 2011 and 2012 seasons.

Trait	DTS (days)		PHT (cm)		EHT (cm)		ASI (days)	
Season	2011	2012	2011	2012	2011	2012	2011	2012
Location (L)								
Sakha	61.25b	59.96b	292.9a	269.2a	169.5a	160.6a	0.90b	0.92b
Sids	66.40a	62.17a	223.2b	246.6b	113.4b	137.7b	1.53a	1.59a
F test	**	**	**	**	**	**	**	**
Plant density (D) (plants /fed.)								
D1 (21875)	63.40	59.65c	256.2	257.0	138.8	149.9	1.07	0.53d
D2 (26250)	63.78	60.34c	257.1	257.3	139.8	149.9	1.22	0.97c
D3 (30625)	64.12	61.56b	258.0	260.4	142.5	150.2	1.28	1.47b
D4 (35000)	64.15	62.71a	261.0	261.0	144.7	150.8	1.28	2.06a
Ftest	ns	**	ns	ns	ns	ns	ns	**
Hybrid(H)								
SC10	66.3a	62.84b	273.9a	282.1a	156.2a	168.5a	0.87bc	1.43b
SC162	66.4a	64.12a	270.1a	275.3b	147.0a	166.5a	0.53c	0.47c
SC166	64.7b	62.03b	241.5b	230.6d	136.7b	134.4b	1.09b	1.34b
SC 173	57.8c	55.28c	246.8b	243.6c	125.8c	127.1c	2.37a	1.78a
F	**	**	**	**	**	**	**	**
Interaction								
L x D	ns	ns	ns	ns	ns	ns	ns	*
L x H	**	**	ns	**	**	**	*	*
D x H	ns	ns	ns	ns	ns	ns	ns	*
L x D x H	ns	ns	ns	ns	ns	ns	ns	ns

B. 2. Yield components:

The differences between four plant densities were significant for maize yield components (EPP, EL, ED, KPR and KWT) in both seasons. These traits were greater under lower plant density compared with the dense planting (Tables 4 and 5). This may be due to limitation of reproductive partitioning in highest plant density. At low plant population, the reproductive sink capacity of individual plant is greater as compared with high plant populations. This may be due to the fact that available nutrients, moisture, space and light are limited at high plant population due to high competition of soil resources between plants. High plant densities enhance intra-plant competition for assimilates particularly during flowering and grain filling period and consequently decrease yield per plant. These results agreed with Boris *et al.* (2004) for EPP, Hassan (2000), Khalil (2001), Anafjeh and Chaab (2012) and Shafi *et al.* (2012) for EL, EDand KPR and Reddy and Reddi (2004) for KWT.

B. 3.Grain yield fed.$^{-1}$:

Grain yield fed^{-1} was significantly increased as plant density increased up to D_2 and D_3 in the two seasons (Table 5). High ear parameters in both seasons, i. e. EPP, EL, ED, RPE, KPR and KWT did not overcome the decrease in grain yield fed^{-1}. imposed by reducing plant density from D_3 to D_1. However, increasing plant density up to D_4 led to significant reduction in grain yield fed^{-1}. Productivity of grain yield fed^{-1} is a function of the number of plants per unit area and grain yield attributes per plant. Khalil (2001) reported that increasing plant density from 20000 to 30000 plants fed^{-1} led to increasing grain yield fed^{-1}, while, increasing plant density from 30000 to 35000 plants fed^{-1} decreased grain yield fed^{-1}. Also, Shafi *et al.*(2012) found that grain yield increased as plant density increased from 45000 to 66000 ha^{-1}. Abolhassan *et al.* (2005) reported that grain yield increases linearly with plant density until some competitive effects become apparent . Grain yield per unit area is the product of grain yield per plant and number of plants per unit area.

C. Effect of hybrids:

C.1.growth characters:

Highly significant differences among the tested hybrids were found for DTS, PHT, EHT, and ASI in both seasons (Table 3). Hybrid SC 173 was the earliest in terms of DTS and lowest in EHT in both seasons. Hybrid SC10 was the tallest (PHT) in both seasons. Hybrid SC162 recorded the lowest ASI in both seasons. Thus, hybrid SC162 is the most tolerance for high plant density between hybrids under study because has the lowest ASI among tested hybrids. Sangoai *et al.* (2002) reported that high plant densities elongate the duration between pollen shedding and silking. Smith *et al.* (1982) noticed that density-tolerant genotypes were characterized by short pollen-shed-to-silking interval. Carcova and Otegui (2001) and Khalil (2001) found that the hybrids were differences for DTS, PHT and EHT. These differences among hybrids may be due to differences in the genetic make up of evaluated hybrids.

C.2 Yield components:

Significant or highly significant differences were detected among hybrids in EPP, EL, ED, RPE and KWT in both seasons, as well as for KPR in the second season (Tables 4 and 5). The hybrid SC162 had the highest EPP, EL and KPR. The hybrid SC 10 recorded the highest in terms of ED and KWT in both seasons and the hybrid SC166 had the highest RPE in both seasons. Differences among the tested maize hybrids for these traits may be due to differences in their genetic make up to stress condition and environmental factors affecting developmental processes and ability to thrive and uptake of the available nutrients. Results are in harmony with those obtained by Hassan (2000), Mohamed(2004), Al-Ahmed *et al.*(2004), El-Aref *et al.* (2004) and Khalil (2007).

Table (4): Effect of plant density, hybrids and their interactions on ears/100 plants (EPP),ear length(EL), ear diameter (ED) and rows/ear (RPE) over two locations in 2011 and 2012 seasons.

Trait	EPP		EL(cm)		ED(cm)		RPE	
season	2011	2012	2011	2012	2011	2012	2011	2012
Location(L)								
Sakha	94.54	94.23	22.98a	20.65a	4.75a	4.59a	13.44	13.83
Sids	95.67	96.71	21.00b	20.13ab	4.30b	4.22b	13.34	13.72
F test	ns	ns	**	*	**	**	ns	ns
Plant density (D) (plants /fed.)								
D1 (21875)	101.1a	101.2a	23.5a	22.0a	4.61a	4.53a	13.5	13.9
D2 (26250)	96.5b	97.7a	22.1b	20.2b	4.55ab	4.43b	13.3	13.8
D3 (30625)	92.8c	92.4b	21.6b	19.5c	4.51ab	4.35bc	13.3	13.8
D4 (35000)	89.8d	90.5b	20.7c	19.7bc	4.45b	4.31c	13.2	13.5
F test	**	**	**	**	*	**	ns	ns
Hybrid(H)								
SC10	91.25c	91.94c	21.0c	20.0b	4.62a	4.50a	12.4c	13.1c
SC162	97.31a	98.73a	22.7a	21.0a	4.43c	4.34b	13.5b	13.6b
SC166	97.06a	96.70a	22.2b	20.1b	4.54ab	4.43ab	14.2a	14.9a
SC 173	94.81b	94.52b	21.9b	20.3b	4.52b	4.36b	13.2b	13.4bc
F test	**	**	**	*	**	*	**	**
Interaction								
L x D	**	ns	**	**	ns	*	ns	ns
L x H	**	ns	ns	**	ns	ns	ns	*
D x H	ns	**	ns	ns	ns	ns	ns	ns
L x D x H	ns	ns	ns	ns	ns	ns	ns	ns

Table (5): Effect of plant density, hybrids and their interactions on number of kernel per row (KPR), 1000-kernel weight (KWT) and grain yield (GY) over two locations in 2011 and 2012 seasons.

Trait	KPR		KWT(g)		GY(ard./fed.)	
season	2011	2012	2011	2012	2011	2012
Location						
Sakha	44.89a	42.68	416.6a	349.8	39.77a	29.76a
Sids	40.91b	42.16	320.3b	329.6	24.55b	26.33b
F test	**	ns	**	ns	**	**
Plant density (D) (plants /fed.)						
D1 (21875)	45.8a	45.1a	380.2a	351.1a	31.58b	26.43b
D2 (26250)	42.7b	42.5b	368.4ab	341.5b	32.41ab	29.55a
D3 (30625)	42.2b	41.1c	367.3ab	337.1b	33.26a	29.55a
D4 (35000)	40.8c	40.8c	357.9b	329.1ab	31.40b	26.64b
F test	**	**	*	*	**	**
Hybrid(H)						
SC10	42.38	42.83a	408.1a	359.6a	31.29b	26.88b
SC162	43.23	43.56a	345.7c	329.7c	34.43a	29.71a
SC166	42.87	40.82b	356.7bc	348.ab	33.38a	28.03ab
SC 173	43.12	42.47a	363.3b	347.8b	29.55c	27.54b
F test	ns	**	**	**	**	**
Interaction						
L x D	*	**	*	**	**	**
L x H	**	**	ns	ns	**	**
D x H	ns	ns	ns	ns	*	ns
L x D x H	ns	ns	ns	ns	ns	ns

C. 3.Grain yield (ard/fed.):

Highly significant differences were detected amang maize hybrids in terms of grain yield fed^{-1} (Table 5). Hybrid SC162 had the highest grain yield averaged over locations and plant densities in both seasons. This superiority may be due to that hybrid recorded the lowest values of ASI and the highest values of EPP, EL and KPR. Differences between these hybrids may be attributed to the genetic differences among hybrids, which play important role for the uptake of the available nutrients as well as light interception, which reflected on the photothynthesis processes,that led to increasing dry matter production. These results were agreed with Costa *et al*. (2002), El-Aref *et al*.(2004), Waitrarak (2004) and Sadek and Barkat (2006).

D. The interaction effects:

D.1. Location (L) x plant density(D) interaction:

The interaction effect of location(L) and plant density(D) was significant for EPP in 2011 season; ASI and ED in 2012 season; and EL, KPR ,KWT and, GY in both seasons (Tables 3, 4 and 5). In 2011 season the highest values for EPP, EL, KPR and KWT were associated with of D_1 at Sakha location, while the highest GY was recorded at D_3 at Sakha location (Table 6). In 2012 season, the highest values for EL, ED, KPR, and KWT were obtained by D_1 at Sakha loction. Also, the lowest plant density (D_1) at Sakha location had the lowest value of ASI, while the highest GY was resulted from D_2 at Sakha location. (Table 7).

Table (6): Effect of the interaction between locations and plant densities on ears/100 plants (EPP), ear length(EL), kernel per row (KPR), 1000-kernel weight (KWT) and grain yield (GY) in 2011 season.

location	Plant density	EPP	EL(cm)	KPR	KWT(g)	GY(ard./fed.)
Sakha	D1	101.6a	25.07a	48.96a	432.3a	39.89b
	D2	97.4b	23.43b	45.52b	423.8a	39.80b
	D3	92.5c	22.28c	43.45c	415.9a	41.50a
	D4	86.5d	21.15de	41.36cde	394.6b	37.90c
Sids	D1	100.7a	21.97cd	42.81cd	328.1c	23.21d
	D2	95.7bc	20.76e	40.96de	313.1c	25.03d
	D3	93.1c	20.97e	40.00e	318.7c	25.02d
	D4	93.1c	20.30e	39.90e	321.2c	24.90e

Table (7): Effect of the interaction between locations and plant densities on anthesis-silking-interval (ASI), length(EL), ear diameter (ED), kernel per row (KPR), 1000-kernel weight (KWT) and grain yield (GY) in 2012 season.

location	Plant density	ASI (days)	EL (cm)	ED (cm)	KPR	KWT (g)	GY (ard./fed.)
Sakha	D1	0.43f	22.77a	4.75a	47.07a	364.7a	27.27cd
	D2	0.69ef	20.20c	4.67a	42.57b	355.5ab	31.71a
	D3	0.81def	18.95d	4.53b	40.07c	345.8bc	30.56ab
	D4	1.00cde	18.62d	4.41bc	38.93d	333.1cd	29.48abc
Sids	D1	1.26bcd	21.26b	4.32cd	43.27b	350.0bc	25.59de
	D2	1.37bc	20.36c	4.18e	42.55b	337.5de	27.39cd
	D3	1.56ab	20.16c	4.17e	42.20b	318.7e	28.53bcd
	D4	1.94a	20.83bc	4.22de	42.70b	312.5abc	23.79e

D.2.Location (L) x Hybrid (H) interaction:

Location and hybrid interaction (Tables 3, 4 and 5) showed a significant effect on DTS, EHT, ASI, KPR and GY in both seasons, EPP in the first season and PHT, EI and RPE in the second season. The results in Tables 8 and 9 showed that, the lowest value of ASI was recorded by SC162 at Sakha location in both seasons. Hybrid SC173 gave the lowest values for DTS when it was growth at Sakha location and for EHT at Sids location in both seasons. However, SC162 hybrid at Sakha location had the highest values for EPP and GY in the first season and PHT and El in second season. Moreover, SC10 hybrid at the same location had the highest values for KPR in both seasons and GY in the second season, as will as SC166 hybrid had the highest values for RPE at Sakha location in seconed season.

Table (8): Effect locations x hybrid interaction on days to 50% silking (DTS), ear height (EHT), anthesis-silking-interval (ASI), ears/100 plants (EPP), kernel per row (KPR) and grain yield (GY) in 2011 season.

location	hybrid	DTS (days)	EHT (cm)	ASI (days)	EPP	KPR	GY (ard./fed.)
Sakha	SC10	63.5c	189.1a	0.68de	88.53c	45.8a	39.02b
	SC162	63.9c	175.6b	0.44f	98.41a	45.6ab	43.21a
	SC166	61.7d	162.0c	0.82cde	97.24ab	43.8b	41.43a
	SC173	55.8f	151.4d	1.50b	93.99b	44.2ab	35.43c
Sids	SC10	69.1a	123.4e	1.06bcd	93.96b	38.9c	23.55e
	SC162	68.8a	118.4e	0.62de	96.21ab	40.8c	25.65d
	SC166	67.7b	111.5f	1.37bc	96.85ab	41.8c	25.33de
	SC173	59.8c	100.3g	3.25a	95.63ab	42.0c	23.68e

Table (9): Effect of the interaction between locations and hybrids on days to 50% silking (DTS), plant height (PHT), ear height (EHT), anthesis-silking-interval (ASI), ear length(EL), rows/ear (RPE), kernel per row (KPR), and grain yield (GY) in 2012 season.

location	hybrid	DTS (days)	PHT (cm)	EHT (cm)	ASI (days)	EL (cm)	RPE	KPR	GY (ard./fed.)
Sakha	SC10	62.0c	285.3b	176.5b	1.12cd	20.27bc	13.08d	44.25a	31.19a
	SC162	63.2bc	301.8a	185.2a	0.31f	21.58a	13.51cd	43.46ab	29.46ab
	SC166	59.68d	227.1d	148.5d	0.87de	19.11d	15.40a	38.27d	29.24ab
	SC173	54.93e	255.8c	132.2e	1.37bc	20.57abc	13.32cd	42.67abc	29.14ab
Sids	SC10	63.68ab	279.0b	160.6c	1.75ab	19.85cd	13.12d	41.41c	22.57d
	SC162	65.0a	248.7c	147.8d	0.62ef	20.48ab	13.75c	43.66ab	29.97ab
	SC166	64.37ab	227.1d	122.4f	1.81ab	21.11ab	14.53b	43.37ab	26.83bc
	SC173	55.62e	231.5d	120.0f	2.18a	20.17bc	13.50cd	42.27bc	25.94c

E.3.Plant density (D) x Hybrid (H) interaction:

The interaction between D x H was not significant for all traits in both seasons except ASI and EPP in 2012 season and GY in 2011 season (Tables 3, 4 and 5). The lowest value of ASI was recorded by SC162 when it was planted at $D_1$and D_2 (Table 10). However, SC162 and SC166 hybrids had the highest EPP at D_2 (Table 11). Moreover, it can be noticed that the highest GY was recorded by SC162 hybrid when it was planted at D_2 (Table12).

E.4.Location (L) x Plant density (D) x Hybrid (H) interaction:

The interaction between L x D x H were not significant for all traits in both seasons, therefore the data were excluded.

CONCLUSION

From the obtained results, it can be concluded generally that the best hybrid in this study was SC162 (yellow hybrid) when it was planted in moderate densities (26250 and 30625) as an average of both locations and seasons.

Table (10): Effect of interaction between plant density and hybrids on anthesis-silking-interval (ASI) in 2012 season.

Plant density	Hybrids			
	SC10	SC162	SC166	SC173
D1	0.62ef	0.10f	0.75ef	0.75def
D2	1.38cd	0.12f	1.00cde	1.37cd
D3	1.50c	0.75def	1.50c	2.12b
D4	2.25b	1.00cde	2.13b	2.87a

Table (11): Effect of interaction between plant density and hybrids on ears/100 plants (EPP) in 2012 season.

Plant density	Hybrids			
	SC10	SC162	SC166	SC173
D1	99.56ab	103.01a	103.20a	99.26ab
D2	93.69def	101.55a	96.91bcd	98.73abc
D3	89.63fg	94.83bcde	91.03ef	94.12cdef
D4	84.87h	95.55bcde	95.55bcde	85.97gh

Table (12): Effect of interaction between plant density and hybrids on grain yield (GY) in 2011 season.

Plant density	Hybrids			
	SC10	SC162	SC166	SC173
D1	29.00fg	34.93ab	34.08abc	28.30g
D2	30.87defg	36.65a	32.41bcde	29.73efg
D3	33.35bcd	34.47abc	34.43defg	30.78cdef
D4	31.93cdef	31.67cdef	32.61bcde	29.41fg

REFERENCES

Abolhassan, M. H., S. J. Herbert and D. H. Putnam (2005). Yield response of corn to crowding stress. Agron. J. 97: 839-846.

Al-Ahmad, S. A., K. A. El-Shouny, Olfat H. El-Bagoury and K. I. M. Ibrahim (2004). Heterosis and combining ability in yellow maize (*Zea mays* L.) crosses under two planting dates. Annals. Agric. Ain Shams Univ., Cairo, 49:531-543.

Anafjeh, Z. and A. Chaab (2012). The effect of various plant densities on competitiveness of corn with natural population of weeds. Inter. J. of Agron. and Plant Production. 3 :207-212.

Bartlett, M.S. (1937). Properties of sufficiency and statistical tests. Prod. Roy Soc. London, Series A, 160:268-282.

Benga, S.H., R.I. Hamilton, L.M. Dwyer, D.W. Stewrart, D. Cloutier, L. Assemat, K. Foroutanpour and D.L. Smith (2001). Morphology and yield response to weed pressure by corn hybrids differing in canopy architecture. European J. Agron.14: 293-302.

Boris, V., Z. Svecnjak, M. Knezevic and D. Grbesa (2004). Performance of prolific and non prolific hybrids under reduced input and high input cropping systems. Field Crops Res. 90: 203-212.

Borras, L. and M.E. Westgate (2006). Predicting maize kernel sink capacity early in development. Field Crops Res. 95: 223-233.

Carcova, J. and M. E. Otegui (2001). Ear temperature and pollination timing effects on maize kernel set. Crop Sci. 49: 1809-1815.

Cardwell, V.B. (1982). Fifty years of Minnesota: corn production source of yield increase. *Agron.* J.74: 990-998.

Casini, P. (2012). Maize production as affected by sowing date, plant density and row spacing in the Bolivian Amazon. J. of Agri. and Env. for Inter. Develo. 106: 75-84.

Costa, C., L.M. Dwyer, D.W. Stewart and D.L. Smith (2002). Nitrogen effects on grain yield and yield components of leafy and non leafy maize genotypes. Crop. Sci. 42: 1556-1563.

Echarte, L., F.H. Andrade, V.O. Sadras and P. Abbate (2006). Kernel weight and its response to source manipulations during grain filling in Argentinean maize hybrids released in different decades. Field Crops Res., 96: 307-312.

Edmeades, G. O. and T. B. Danyard (1979). The developmental of plant to plant variability in maize at different planting densities. Can. J. Plant Sci. 59: 561- 576.

El-Aref, Kh.A.O., A.S. Abo El-Hamed and A.M. Abo El-wafa (2004). Response of some maize hybrids to nitrogen and potassium fertilization levels. J. Agric. Sci. Mansoura Univ., 29:6063-6070.

El-Shenawy, A.A. (2005). Estimation of genetic and environment parameters for new white inbred lines of maize (*Zea mays* L.). J. Agric. Res. Tanta Univ. 31:647-662.

El-Zeir, F.A., A.A. El-Shenawy, E.A. Amer and A.A. Galal (1998). Influence of narrow row spaing (high plant density) and nitrogen fertilization on two maize hybrids. J. Agric. Sci. Mansoura Unvi. 23:1855-1864.

Farnham, D.E. (2001). Row spacing, plant density, and hybrid effects on corn grain yield and moisture. Agron. J. 93:1049-1053.

Fery, K.J. (1964). Adaptation reaction of oat strains selected under stress and non stress environmental conditions. Crop Sci. 4:55-58.

Fery, K.J. and M. Maldonado (1967). Relative productivity of homogeneous and heterogeneous oat cultivars in optimum and sub optimum environments. Crop Sci.7:532-535.

Hassan, A.A. (2000). Effect of plant population density on yield and yield components of 8 Egyptian maize hybrids. *Bull. Faculty Agric. Uni. Cairo.,* 51: 1-16.

Herbert, Y., E. Guingo and O. Loudet (2001). The response of root/shoot partitioning and root morphology to light reduction in maize genotypes. Crop Sci.16:162- 211.

Khalil, M.A.G. (2001). Response of some yellow and white maize cultivars to plant densities and nitrogen fertilization. M.Sc. Thesis, Fac. Agric., Kafer El-Sheikh, Tanta Univ., Egypt.

Khalil, M.A.G. (2007). Response of some white maize promising hybrids to planting dates and nitrogen fertilization. Ph.D. Thesis, Fac. Agric., Kafer El-Sheikh Univ., Egypt.

Maddonni, G.A. and M.E. Otegui (2004). Intra specific competition in maize: early establishment of hierarchies among plants affects final kernel set. Field Crops Res. 85:1-13.

Maddonni, G.A. and M.E. Otegui (2006). Intra-specific competition in maize: Contribution of extreme plant hierarchies to grain yield, grain yield components and kernel composition. Field Crop Res. 97: 155-166.

Modarres, A.M., R.I. Hamilton, M. Dijak, L.M. Dwyer, D.W. Stewart, D.E. Mather and D.L. Smith (1998). Plant population density effects on maize inbred lines grown in short-season environment. Crop Sci. 38: 104–113.

Mohamed, N. A. (2004). Principal component and response curve analyses of some maize hybrids to different nitrogen fertilization levels and plant density.Bull. Fac. Agric., Cairo Univ., 55: 531-461.

Mahgoub, G.M.A. and A. A. El-Shenawy (2006). Response of some maize hybrids to row spacing and plant density. First field crops conference. 1: 285-294.

Mosa, H.E., A.A. Motawei and A.A. El-Shenawy (2009). Genotype x environment interaction and stability of grain yield and late wilt resistance in some promising maize hybrids. Egypt. J. Plant Breed. 13:213-222.

Mosalem, M.E. (1998). Effect of plant density and nitrogen fertilization level on growth and Yield of maize. Adv. Agric. Res.3 : 389-394.

Motawei, A.A.(2006). Gene action and heterosis in dialel crosses among ten inbred lines of yellow maize across varios environments. Egypt. J. Plant Breed. 10: 407-418.

Nasir, M. (2000). The effects of different plant population on yield and yield components of different maize varieties. M.Sc. (Hons) Thesis, Dept. of Agron. KPK Agric. Univ, Peshawar, Pakistan.

Reddy, T.H. and G.H.S. Reddi (2004). Principles of Agronomy, In: Plant population, chapter VIII, Kalyani Pub., Hyderabad, India, 193-203.

Sadek, S. E. and A.A. Barkat (2006). Chemical analysis of photosynthates partition and migration of dry matter in same new maize genotype. Minufia J. Agric. Res.31: 49-59.

Sangoai, L. (2001). Understanding plant density effects on maize growth and development: An important issue to maximize grain yield. *Cienc. Rural,* 31: 159-168.

Sangoai, L., M.A. Gracietti, C. Rampazzo and P. Bianchetti (2002). Response of Brazilian maize hybrids from different ears to changes in plant density. Field Crop Res. 79: 39-51.

Shafi, M., J. Bakht, S. Ali, H. Khan, M. A. Khan and M. Sharif (2012). Effect of planting density on phenology, growth and yield of maize (*Zea mays* L.) Pak. J. Bot. 44: 691-696.

Smith, C.S., J.J. Mock and T.M. Crosbie (1982). Variability for morphological and physiological traits associated with barrenness and grain yield in maize population, Iowa Upright Leaf Synthetic 1. Crop Science, 22: 828-832.

Steel, R. G. D. and J. H. Torrie (1980). Principles and procedures of Statistics: A biometrical approach. 2nd (ed). Mc Graw-Hill Book Co., New York, USA.

Tetio-Kagho, F. and F. P. Gardner (1988). Responses of maize to plant population density: II Reproductive development, yield and yield adjustments. Agron. J. 80: 940-945.

Trenton, F.S. and G.L. Joseph (2007). Corn stalk response to plant population and the Bt–European corn borer trait. Agron. J, 99: 657-664.

Tollenaar, M. and E.A. Lee. (2002). Yield potential, yield stability and stress tolerance in maize. Field Crop Res.,75:161-169.

Valentinuz, O.R. and M. Tollenaar (2006). Effect of genotype, nitrogen, plant density, and row spacing on the area per leaf profile in maize. Agron, J. 98: 94-99.

Witatrak, P.G., R.L. Wright, J.J. Marios and R. Sprenkel (2004). Corn hybrids for late planting in southeast. Agron. J. 96:1118-1124.

Minufiya J. Agric. Res. Vol.39 No. 1(1): 169 - 180 (2014) "http://www.mujar.net"

تأثير الكثافة النباتية على نمو و محصول بعض هجن الذرة الشامية

محمد عطوه جمال الدين خليل

مركز البحوث الزراعية – معهد بحوث المحاصيل الحقلية – قسم بحوث الذرة الشامية

الملخص العربي

أقيمت أربعة تجارب حقلية بموقعين(الأول بمحطة بحوث سخا في شمال مصر والثانى بمحطة بحوث سدس في مصر الوسطى) خلال موسمي 2011و 2012 لدراسة تأثير الكثافة النباتية(21875, 26250, 30625, 35000 نبات للفدان) على صفات النمو و المحصول و مكوناته لأربعة هجن من الذرة الشامية وهى هـ.ف-10 (حبوب بيضاء), هـ.ف-162 , هـ.ف-166 , هـ.ف-173 (حبوب صفراء).

وقد استخدم تصميم القطع المنشقة في أربعة تكرارات, حيث وضعت الكثافة النباتية في القطع الرئيسية و وضعت الهجن في القطع المنشقة. وتم عمل التحليل المشترك بين الموقعين في كل من السنتين.

ويمكن تلخيص أهم النتائج المتحصل كما يلى:

1- حقق موقع سخا أعلى النتائج في ارتفاع النبات و الكوز ،طول و قطر الكوز ،عدد الصفوف في الكوز ،عدد الحبوب بالسطر ، وزن الألف حبة ، محصول الحبوب/ الفدان، بينما حقق موقع سدس أعلى النتائج لصفات عدد الأيام للوصول إلى 50% حريرة و الفترة بين ظهور النورة المذكرة و النورة المؤنثة.

2- أثرت الكثافة النباتية تأثيرا معنويا على صفات عدد الأيام للوصول إلى 50% حريرة و الفترة بين ظهور النورة المذكرة و النورة المؤنثة في الموسم الثاني ،عدد الكيزان لكل 100نبات ،طول و قطر الكوز ،عدد الحبوب بالسطر،وزن الألف حبة ،محصول الحبوب/ الفدان في كلا الموسمين. و قد تحقق أعلى محصول عند الكثافة النباتية 30625 نبات للفدان في كلا الموسمين.

3- أوضحت النتائج وجود اختلافات معنوية بين الهجن المختبرة فى كل من صفات النمو و المحصول و مكوناته في كلا الموسمين عدا عدد الحبوب بالسطر في موسم 2011. هذا وقد كان هـ.ف- 173 أسرع الهجن في التزهير و الأقل في ارتفاع الكوز في كلا الموسمين, بينما كان هـ.ف-10أعلى الهجن في ارتفاع النبات ،قطر الكوز،وزن الألف حبة فى كلا الموسمين كما كان هـ.ف-166 الأعلى فى عدد السطور بالكوز فى كلا الموسمين , بينما كان هـ.ف-162 الأقل في الفترة بين ظهور النورة المذكرة و النورة المؤنثة والأعلى قيمة في صفات عدد الكيزان لكل 100نبات ، طول الكوز ،عدد الحبوب بالصف، محصول الحبوب فى كلا الموسمين.

4-تشير نتائج التفاعل الى أن هـ.ف-162 كان أعلى الهجن فى محصول الحبوب للفدان فى كلا الموقعين كمتوسط لموسمى الزراعة و خاصة عند زراعته بالكثافات المتوسطة (26250، 30625 نبات للفدان).