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INFLUENCE OF INTER- AND INTRASPECIFIC COMPETITION BETWEEN MAIZE AND COMMON COCKLEBUR (*Xanthium strumarium)* WEED DENSITIES ON MAIZE PRODUCTIVITY

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ABSTRACT

Common cocklebur is considered a strong weed competitor to maize and distributed all over the world and Egypt. Knowledge about the nature of competition to maize is the key of planning weed management crop strategies in this crop. Then, the aim of this investigation was to determine the economic threshold of common cocklebur for maize. Where two field experiments was conducted in naturally heavily infested soil with common cocklebur at Mallawy Agriculture Research Station, Agriculture Research Centre, EL-Minia Governorate during 2014 and 2015 seasons.

A split-split-plot design with three replicates was used. These experiments included three factors, main plot included two maize hybrids i.e, SC 166 (Single cross 166) and SC 173 (Single cross 173) , the sub plot three corn densities of 20000, 24000 and 30000 plants feddan^{-1} and the sub sub plot were randomly to common cocklebur densities of 0, 2, 4, 6 and 8 plants m^{-2}.

The main finding of this research show that sown SC173 was high competitive than SC 166 to common cocklebur and reduce its dry weight and gave highest yield and yield component of maize.

Also, increasing maize density reduced in common cocklebur dry weight, ear length, ear weight, grains number ear^{-1}, 100- grain weight, plant height and LAI. Maize density at 24000 plant fed^{-1} gave the highest grain yield (ard fed^{-1}) in both seasons compared to other maize densities.

So, increasing common cocklebur density, decreased common cocklebur dry weight, maize grain yield and yield components such as plant height, leaf area index (LAI), ear length, ear weight, grains number ear^{-1}, 100- grain weight and grain yield of maize (ardab faddan^{-1}).

Maize yield losses at 1, 4 and 8 common cocklebur plants m^{-2} reached to 5.2, 22.0 and 44.4 %, respectively, as compared zero common cocklebur plants m^{-2} in the first season and calculated from regression equation by 4.9, 21.0 and 42.5 %, respectively, in the second season.

The main findings of this investigation refer that common cocklebur weed should be managed to avoid maize grain yield losses due to its competition through growing maize vigor hybrid such as SC173 with proper plant density at 24000 plant fed^{-1} and continues hand pulling any emerged common cocklebur seedling or to use selective recommended herbicides.

Keywords: Hybrids, weed competition, common cocklebur, maize .

INTRODUCTION

Common cocklebur (*Xanthium strumarium)* interference is considered a serious problem for maize crop, which cause yield losses in it (Baldoni *et al.* 2000), may be attributed to its high capacity to absorb large amounts of nitrogen, phosphorus and potassium for growth Shipley and Weise (1969). Cocklebur is an annual broadleaf weed and in other hand this weed species capable of growing more than 2 m tall which detrimentally affects crop growth and yield by competing effectively for light, water, space, and nutrients (Keeley *et al.,* 1987). Common cocklebur is a common, competitive and vigorous weed in most summer crops (Holm *et al.,* 1991). Bükün *et al.* (2005) reported that *X. strumarium* was the most prevalent weed species and produced the highest biomass. According to Rao (2000), an increase of one kilogram of weed growth corresponds to a reduction of one kilogram of crop growth. Little information are available about relationship between common cocklebur and maize densities was studied by El- nass *et al*. (2010) They found that common cocklebur densities at 1.43, 2.86, 4.29, 5.72 and 7.14 plants m^{-2} significantly decreased grain yield by 13.34, 37.86, 43.04, 66.17 and 65.59 % in the first season and 15.11, 28.97, 52.31, 68.54 and 70.35 % in the second season, respectively than zero plant m^{-2}. Economic threshold for common cocklebur in maize at 5 % acceptable yield losses were 1470 plants faddan^{-1} in the first season and 1344 plants faddan^{-1} in the second season. Abd El-Azeem and Mekky (2008) studies the relationship between cocklebur density biomass (ton fed^{-1}) and maize grain yield losses in Egypt. They mentioned that comparison of the regression coefficient suggested that the cocklebur competition led to significant yield losses, and increased linearly as density of weed biomass increased. Yield losses were 59 % obtained from the high competition rate of cocklebur (7.2 ton fed^{-1}). Plant height was decreased by increasing weed biomass density.

In spite of maize had a vigorous and tall growing plant, it is susceptible to competition from weeds (Rahman, 1985), especially during the early stage of its growth as it grows slowly during the first 3-4 weeks (Sandhu *et al.,* 1986). Plant density can play an important role in the competitive balance between weeds and maize and increasing crop density is one of the more efficient weed management strategies that allows for more soil surface coverage and more light capture to compete with weeds. Crop density may change the grains number per ear and grains weight (Pagano *et al.,* 2007). Crop competitive ability can be enhanced via its optimum population density, rapid root growth, leaf expansion rate, early root shoot biomass accumulation, canopy closure and plant height (Subhan-ud- Dan *et al.,* 2013). The greater height of maize could be the main reason for its competitiveness against the weeds (Cavero *et al.*, 1999). Began *et al.*(2001) proposed that hybrids and plant spacing could be used as integrated weed management program in maize.

There were slight decreases in weed growth with each changing in density pattern towards increasing density (El-Bially, 1995 and Mosalem and Shady (1996). Esmail (1996) concluded that increasing plant population from 20000 to 25000 and to 30000 plants fed^{-1} decreased yield components namely, ear length, ear weight, 100-grain weight and shelling percentage, but increased grain yield feddan^{-1}.

The percent reduction in grain yield was 5- 40 % and fit a quadratic relationship. Increasing densities of either crop or weed generally decreased yield components due to inter- and intra- specific competition, suggested that increasing crop density will likely not be effective in suppressing *X. strumarium* and making up for possible yield loss in corn Hussain *et al.* (2014).

Thus, the objective of this investigation was to evaluate the effect of maize and common cocklebur densities competition on some maize hybrids grain yield and its components.

MATERIALS AND METHODS

Two field experiments were conducted at clay loam soil Table 1 at Mallawy Research Station Farm at El-Minia Governorate, Egypt, during 2014 and 2015 summer seasons. Each experiment included combination of thirty treatments to evaluate the effects of maize and common cocklebur densities competition on maize grain yield and yield components of some maize hybrids. The preceding winter crop was sugar beet in both seasons.

The experiment design was split-split-plot design in three replications with plot area 8.4 m^2 as used in this study. The main plots included two maize hybrids, the sub-plots were assigned to three maize densities, while, the five common cocklebur (*X. strumarium* L.) densities were assigned in sub-sub-plots.

A- Maize hybrids,

1. Single cross 166 (SC 166).

2. Single cross 173 (SC 173).

Maize hybrids SC 166 and 173 were obtained from Maize Department Field Crop Research Institute, Agriculture Research Center, Ministry of Agriculture, Egypt.

Table 1 : Physical and chemical properties of the experimental soil (before sowing) at 2014 and 2015 seasons.

physical and Chemical Properties	2014	2015
physical Properties		
Particle size distribution:		
Sand (%)	7.99	8.14
Silt (%)	53.32	54.35
Clay (%)	38.69	37.51
Textural grade	Silty clay loam	Silty clay loam
Chemical Properties:		
PH soil- water suspension (1:2.5)	8.01	8.14
E.C soil- water extract (1:5) .(dS/m\1)	1.31	1.35
Organic matter (%)	1.14	1.18
Soluble cations (meq\L)		
Ca++	6.97	7.15
Mg+	1.76	1.90
K+	0.26	0.24
Na+	3.85	3.45
Soluble anions (meq\L):		
CO3-	0.00	0.00
HCO3	2.92	3.59
Cl-	2.25	1.25
SO4-	3.85	2.40
Available N (ppm)	20.32	19.98
Available P (ppm)	8.15	7.85
Available K (ppm)	183	188

B-Maize hybrid densities,

1- 20000 plants fed^{-1} (4.8 plants m^{-2}).

2- 24000 plants fed^{-1} (5.7 plants m^{-2}).

3- 30000 plants fed^{-1} (7.1 plants m^{-2}).

These densities were obtained from sowing maize plants on 70 cm between ridges and 30, 25 and 20 cm distance between hills for the above mentioned maize hybrid densities, respectively on one side of the ridge with leaving one plant $hill^{-1}$.

C- Common cocklebur densities,

1- Zero plants m^{-2} (free from common cocklebur plant).

2- 2 common cocklebur plants m^{-2} (8400 plants $feddan^{-1}$).

3- 4 common cocklebur plants m^{-2} (16800 plants $feddan^{-1}$).

4- 6 common cocklebur plants m^{-2} (25200 plants $feddan^{-1}$).

5- 8 common cocklebur plants m^{-2} (33600 plants $feddan^{-1}$).

Both experimental sites in the two seasons of the present study are naturally heavily infested with the common cocklebur which thinned after the emergence (21 days after sowing) to the required common cocklebur density. All other weeds were removed regularly by hand weeding and weeds emerged after that was removed by hand weeding.

Each sub-sub- plots consisted of four ridges of 3.0 m long and 70 cm apart (area 8.4 m^2). The maize genotypes were sown on third week of May and harvested on third week of September for first and second seasons, respectively. Nitrogen was applied as urea (46.5% N) at the rate of 112 kg N fed^{-1} in two equal portions, just before the first and second irrigations. Phosphorus fertilizer was added as Super phosphate (15.5% P_2O_5) at the rate of 100 kg fad^{-1} before planting. Potassium was added at the recommended rate of 24 kg K_2O fad^{-1} after thinning.

Data recorded:

1- leaf area index

After 75 days from sowing leaf area index (LAI) on maize were calculated according to Brown (1984) as follows:

LAI = LA / GA

where LA is leaf area and GA is ground area.

2- At harvest, a random sample of 10 maize plants was taken from each plot to determine: plant height (cm), ear weight (g), number of grain ear^{-1}, grains weight ear^{-1} (g) and 100- grain weight (g). In addition, grain yield (ardab $feddan^{-1}$) was estimated on plot basis.

Statistical Analysis:

All obtained data were analyzed using the MSTAT-C software. Treatment means were separated using Fischer's Protected LSD at P= 0.05 level. For regression study data were plotted and regression analyses were conducted. Linear $\tilde{y} = a + bx$, quadratic $\tilde{y} = a + bx - cx^2$ and cubic $\tilde{y} = a + bx + cx^2 + dx^3$ models were estimated to describe the relationship between the measured dependent variable common cocklebur density (no. m^{-2}) and independent variables as common cocklebur dry weight (g m^{-2}), LAI and maize grain yield (ard $faddan^{-1}$). Whereas, $\tilde{y}$ = variables, X= common cocklebur density, a, b, c and d parameters represent intercept and slope of regression of variables and a regression models. The suitable model which fitted for prediction between mentioned above variables linear regression analysis according to Snedecor and Cochran (1989) which that the correlation coefficient (R^2) was greater than other studied models and standard estimate error (SE) were smaller than those of the models.

RESULTS AND DISCUSSION

1- Common cocklebur dry weight (g m^{-2}) and maize growth.

Effect of maize hybrids:

Results in Table 2 revealed that hybrids had significant influence on common cocklebur dry weight (g m^{-2}), plant height (cm) and LAI in both seasons except plant height in first season. SC173 significantly decreased cocklebur dry weight by 5.4 % in the first season and 5.3 % in the second season as compared to SC166. This might indicate that the studied SC173 had more vigorous vegetative growth and competed well with common cocklebur compared to SC166. These results may be attributed to the greater plant height of this hybrid and consequently canopy shading effect on weeds. SC173 increased plant height by 4.0 % in the second season only as compared to SC166. Concerning LAI, SC 173 increased this trait by 3.4 and 5.3 %, respectively, in the first and second season as compared to SC166. These results are in the same line with those obtained by Mekky (1998).

Effect of maize plant densities:

Data in Table 2 showed that maize plant density had significant influence on common cocklebur dry weight, plant height (cm) and LAI in both seasons except LAI in the first season. Increasing plant densities from 20000 to 30000 significantly decreased common cocklebur dry weight by 9.2 and 16.1 %, respectively, in the first season and by 9.0 and 15.9 %, respectively, in the second season.

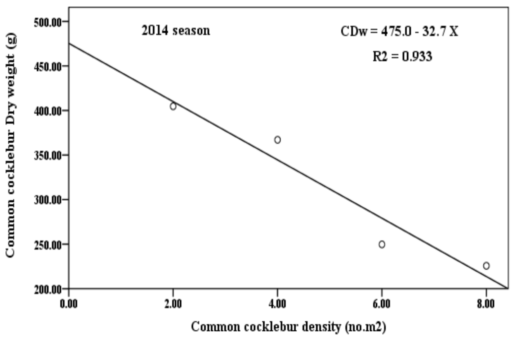
Increasing plant densities from 20000 to 30000 significantly increased plant height by 4.2 and 4.6 %, respectively, in the first season and by 3.7 and 4.6 %, respectively, in the second season. Concerning , increased maize plant densities from 20000 to 30000 plant fed^{-1}. increased LAI by 4.3 and 6.6 % , respectively, in the second season. The competitive effect of high maize densities for common cocklebur due to the increase plant height and LAI of maize. These results are in the same line with those obtained by Tollenaar *et al.* (1994) and Esmail (1996) they reported a substantial weed biomass reduction when the maize plant population density was increased, in association with a high corn leaf area index (LAI).

Table 2. Effect of maize hybrids, maize plant and cocklebur densities on common cocklebur dry weight and maize growth traits in 2014 and 2015 seasons.

Treatments	Cocklebur dry weight (g m^{-2})	Plant height (cm)	LAI	Cocklebur dry weight (g m^{-2})	Plant height (cm)	LAI
	2014 season			2015 season		
A- Maize hybrids						
SC 166	256.3	236.8	4.66	216.9	239.3	4.72
SC 173	242.5	241.9	4.82	205.3	248.8	4.97
F- test	**	NS	**	**	**	**
B- Maize densities (plants $feddan^{-1}$)						
20000	272.4	232.5	4.62	230.4	237.6	4.68
24000	247.3	243.1	4.79	209.2	246.4	4.88
30000	228.6	242.3	4.81	193.6	248.1	4.99
LSD at $_{0.05}$	6.97	8.05	NS	4.95	2.13	0.19
C- Cocklebur densities (plants m^{-2})						
0	0.00	260.9	5.76	0.00	266.3	5.91
2	404.7	249.9	5.27	341.9	252.6	5.30
4	367.1	239.6	4.68	301.6	244.6	4.83
6	249.7	229.6	4.24	201.3	236.1	4.39
8	225.7	216.6	3.75	191.4	220.6	3.81
LSD at $_{0.05}$	12.86	6.59	0.23	8.44	3.12	0.20
Interaction						
A × B	NS	NS	NS	NS	3.01	NS
A × C	NS	NS	1.24	NS	8.40	1.13
B × C	22.27	NS	2.93	14.64	NS	2.23
A × B × C	NS	NS	NS	NS	NS	NS

Effect of common cocklebur densities:

Results in Table 2 indicated that common cocklebur density m^{-2} significantly decreased common cocklebur dry weight (g m^{-2}), plant height and LAI in both season. The relationship between common cocklebur density m^{-2} and common cocklebur dry weight (g m^{-2}) was negative and fit as a linear equation (CDW_{2014} = 475.0 – 32.7 X, R^2 =0.933 and CDW_{2015} = 397.0 – 27.6 X, R^2 =0.918) in both seasons. Increasing common cocklebur densities m^{-2} from 2 to 8 plants significantly decreased common cocklebur dry weight by 9.3, 38.3 and 44.2 % in the 2014season and by 11.8, 41.1 and 44.0 % in the 2015 season, respectively. Also, maize plant height tended to decrease significantly with the increase in common cocklebur densities m^{-2} from zero to 8 plants by 4,4, 8.9, 13.6 and 20.5 % in the first season and by 5,4, 8.8, 12.8 and 20.7 % in the second season, respectively. The results suggest that there was strong intra-specific competition between common cocklebur plants in one side or inter-specific competition between common cocklebur and maize plants in another side, meaning that both of maize and common cocklebur species combat strongly with each other.



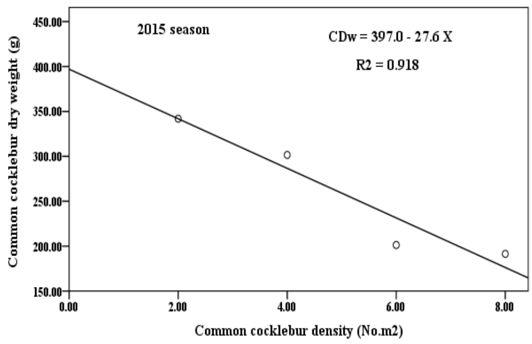
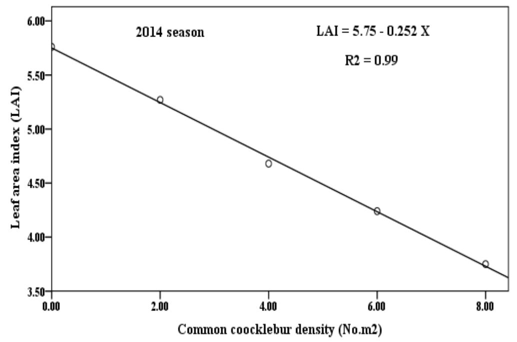


Figure 1. Relationship between common cocklebur densities (No m^{-2}) and common cocklebur dry weight (CDw) gram m^{-2} in 2014 and 2015 seasons.



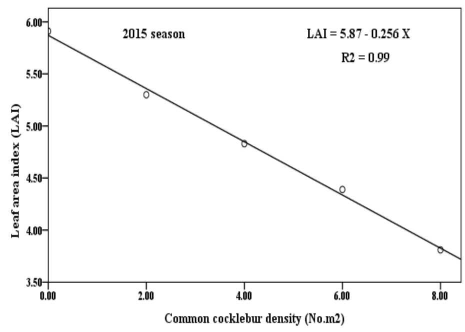


Figure 2. Relationship between common cocklebur density (No m^{-2}) and leaf area index (LAI) in 2014 and 2015 seasons.

These results are in line with those reported by David and kovacs (2007) they stated that higher common cocklebur density reduced maize plant height by 33% in weedy control plots as compared to weed free plots. Data in Table 2 and Figure 2 showed that increasing common cocklebur densities from 0 to 8 plants m^{-2} significantly decreased linearly LAI in fit a linear equations (LAI_{2014} = 5.75 – 0.252 X, R^2 =0.933 and LAI_{2015} = 5.87 – 0.256 X, R^2 =0.918) by 8.5, 18.8, 26.4 and 34.9 %, respectively, in the first season and by 10.3, 18.3, 25.7 and 35.5 %, respectively, in the second season with increasing common cocklebur at 2, 4, 6 and 8 plants m^{-2} than weed free treatment.

2- Maize yield and yield components

Effect of maize hyprids:

The difference between maize hybrids concerning maize yield and its components arrived to significant at 0.05 level except with ear length and grains weight ear^{-1} in the second season (Tables 3 and 4). SC173 gave the highest value of ear length, heaviest ear weight, grains weight ear^{-1}, 100- grain weight and maize grain yield by 5.0, 9.5, 8.5, 10.9 and 18.0 % , respectively, in the first season as compared to SC166 hybrid. The same trend was achieved with ear weight, 100- grain weight and maize yield which increased by 19.1, 3.0 and 7.5 % , respectively, in the second season. The increase in grain yield is owing to the increases in various yield component as plant height, LAI, ear weight, grains weight ear^{-1} and 100- grain weight. Mekky (1998) reported that single cross 10 (SC 10) hybrid was superior to three way cross 310 (TWC 310) and Giza 2 in plant height and grain yield. These resultrs are in the same line with Cavero *et al.* (1999) and Subhan- ud- Dan *et al.* (2013).

Table 3. Effect of maize hybrids, maize plant and cocklebur densities on maize yield and yield components in 2014 season.

Treatments	Ear length (cm)	Ear weight (g)	grains weight ear^{-1} (g)	100- grain weight (g)	observed yield observed (ard fed^{-1})	Predicted yield (ard fed^{-1})	Yield reduction %
Maize hybrids							
SC 166	17.9	172.8	157.2	26.5	15.71	--	0.0
SC 173	18.8	189.3	170.6	29.4	18.53	--	15.2
F- test	**	**	**	**	**	--	--
Maize densities (plants feddan^{-1})							
20000	18.9	202.8	168.7	28.7	14.77	--	29.9
24000	18.3	179.8	166.3	28.3	21.07	--	0.0
30000	17.8	170.5	156.6	26.8	15.52	--	26.3
LSD at $_{0.05}$	0.14	5.57	8.00	1.44	2.68	--	--
Cocklebur densities (plants m^{-2})							
0	21.1	207.4	182.6	30.4	21.96	21.96	0.0
2	20.0	195.0	174.6	29.2	19.63	19.63	10.6
4	18.6	181.2	165.5	28.2	17.16	17.21	21.9
6	17.0	168.8	154.7	26.8	14.76	14.70	32.8
8	15.2	152.8	142.0	25.2	12.09	12.11	44.9
LSD at $_{0.05}$	0.27	5.84	5.35	0.80	0.80	--	--
Interaction							
A × B	0.19	7.87	NS	NS	NS	--	--
A × C	NS	NS	NS	NS	4.27	--	--
B × C	NS	NS	NS	NS	4.65	--	--
A × B × C	NS	NS	NS	NS	NS	--	--

Effect of maize plant densities:

Data in Tables 3 and 4 indicated that the effect of maize density on yield and its components was statistically significant in both seasons. Increasing plant densities from 20000 to 30000 plant fed^{-1} decreased ear length by (3.2 and 2.7 %), ear weight by (11.3 and 15.9 %), grains weight ear^{-1} by (1.4 and 7.2 %) and 100-grain weight by (1.4 and 6.6 %) , respectively, in the first season. The same trend was achieved with ear length by (4.6 and 7.7 %), ear weight by (10.8 and 17.5 %), grains weight ear^{-1} by (4.6 and 10.2 %) and 100-grain weight by (4.0 and 7.2 %) , respectively, in the second season. For maize grain yield (ard fed^{-1}), it increased by 42.7 and 35.8 % , in the first season and by 46.8 and 30.1% in the second season, respectively, under medium plant density 24000 plants fed^{-1} as compared to the minimum plant density 20000 and maximum plant density 30000 plants $feddan^{-1}$. These results may be due to the increases in maize yield components namely ear weight and grains weight ear^{-1} (g) in these plant density. This may be due to intra-specific competition between maize plants in the higher maize plant density than lower and medium density which reduced significantly early maize growth and offset any gain in yield from reduced weed competition (Murphy *et al.,* 1996). These results are in the same line with those obtained by El-Bially (1995), Esmail (1996), Mosalem and Shady (1996) and Hussein *et al*.(2014).

Effect of common cocklebur densities:

Data in Tables 3 and 4 revealed that common cocklebur densities cause significant affects on ear length, ear weight, grains weight ear^{-1} and maize yield (ard fed^{-1}) in both seasons. Common cocklebur density at zero plants m^{-2} gave the highest value of these traits and the lowest value was recorded for the 8.0 plants m^{-2} in both seasons. Increasing common cocklebur densities from 0 to 8 plants/m^2 significantly decreased ear weight by 6.0, 12.6, 18.6 and 26.3 %, respectively, in the first season and by 8.1, 15.3, 21.1 and 27.1, respectively, in the second season.

Increasing common cocklebur densities from 0 to 8 plants m^{-2} decreased 100-grain weight by 3.9, 7.2, 11.8 and 17.1 %, respectively, in the first season and by 3.8, 7.6, 12.1 and 16.6 %, respectively, in the second season.

Estimation maize grain yield losses due to common cocklebur densities

It is evident from Table 3 and 4 and Figure 3 that relationships between common cocklebur densities and maize grain yield (ard fed^{-1}) was significantly decreased linearly according to the equations ($\acute{Y}_{2014}$ = 22.0 – 1.23 X, R^2 =0.99 and $\acute{Y}_{2015}$ = 21.7– 1.10 X, R^2 =0.99) due to the increasing common cocklebur densities from zero to 8 plants m^2 in both seasons. Increasing common cocklebur densities from zero to 8 plants m^{-2} significantly decreased grain yield (ard fed^{-1}) by 10.6, 21.9, 32.8 and 44.9 % in the first season and 12.3, 21.7, 32.7 and 43.9 % in the second season, respectively.

The relationship between grain yield losses % and common cocklebur densities declined in a linear regression with increasing common cocklebur density which revealed close correlation between grain yield losses % and common cocklebur densities in both seasons ($\acute{Y}_{2014}$ = 5.60 X – 0.36, R^2 =0.99 and $\acute{Y}_{2015}$ = 5.37 X – 0.48, R^2 =0.99). Maize yield losses at 1 and 4 and 8 common cocklebur m^{-2} were 5.2 and 22.0 and 44.4 %, respectively, in the first season and 4.9 and 21.0 and 42,5 %, respectively, in the second season.

Weed free treatment allow favorable conditions for maize growth by minimizing the competition between maize plants and the accompanied weed.

Table 4. Effect of maize hybrids, maize plant and cocklebur densities on maize yield and yield component in 2015 season.

Treatments	Ear length (cm)	Ear weight (g)	Grains weight ear^{-1} (g)	100- grain weight (g)	Observed yield (ard fed^{-1})	Predicted yield (ard fed^{-1})	Yield reduction %
Maize hybrids							
SC 166	18.6	170.6	144.2	26.4	16.35	--	0.0
SC 173	18.7	203.1	162.6	27.2	17.58	--	7.0
F- test	**NS**	**	**NS**	**	**	--	--
Maize densities (plants $feddan^{-1}$)							
20000	19.4	206.3	161.4	27.6	14.15	--	31.9
24000	18.5	184.0	153.9	26.5	20.77	--	0.0
30000	17.9	170.2	144.9	25.6	15.97	--	23.1
LSD at $_{0.05}$	0.43	9.35	8.00	0.73	3.70	--	--
Cocklebur densities (plants m^{-2})							
0	21.4	218.1	172.7	28.9	21.79	21.71	0.0
2	20.1	200.5	160.5	27.8	19.10	19.27	12.4
4	18.7	184.8	152.1	26.7	17.06	16.80	21.7
6	17.5	172.0	144.4	25.4	14.60	14.30	33.0
8	15.6	159.0	137.2	24.1	12.22	11.77	43.9
LSD at $_{0.05}$	0.36	7.18	6.74	0.73	0.86	--	--
Interaction							
A × B	NS	NS	NS	NS	NS	--	--
A × C	NS	NS	NS	NS	3.78	--	--
B × C	NS	NS	NS	NS	4.22	--	--
A × B × C	NS	NS	NS	NS	NS	--	--

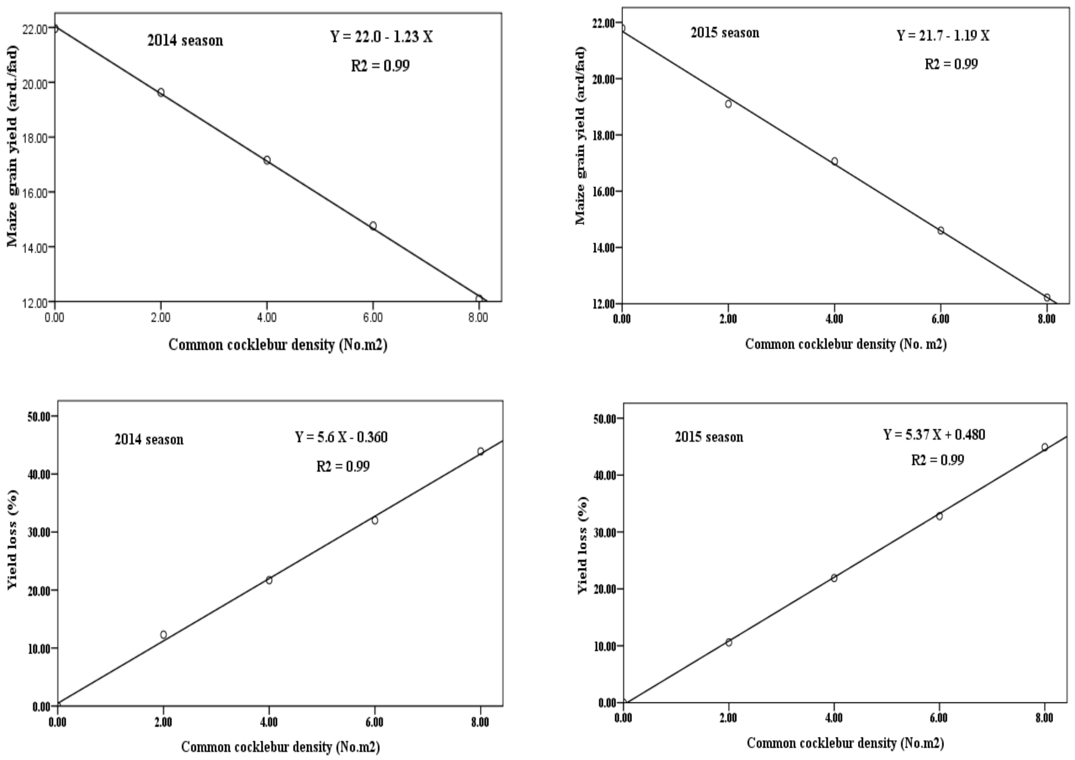


Figure3. Relationship between common cocklebur densities (No m^{-2}), maize grain yield (ard fad^{-1}) and percent yield loss (relative to weed- free) in 2014 and 2015 seasons.

On contrary, the severe reduction in maize grain yield (ard fed^{-1}) with increasing common cocklebur densities was due to the competition with the crop for light, water, nutrients and space. The competition negatively affected the vegetative growth of plants particularly leaf area as well as, dry matter accumulation and so yield components. Moreover, weed shaded the crop plants and reduced the radiation that would fall on foliage of the crop. Consequently, this negatively affected the photosynthesis efficiency and translocation of syntheses to be stored in grain. Beckett et al. (1988) found that common cocklebur density caused maize yield to decrease curvilinear with maximum predicated yield loss of 27 % at density 4.7 plants m^{-1} and yields decreased linearly at 6.6 plants m^{-1} of row, where 10 % yield loss was observed. These results are in general agreement with those of Abd el-Azeem and Mekky (2008) and El- Naas *et al*. (2010).

3- The interactions:-

Effect of the interaction between maize hybrids × maize densities.

The interactions between maize hybrids and maize densities on yield and its components were statistically significant on ear length and ear weight in the 2014 season and plant height in the 2015 season (Table 5). Planting SC173 with 20000 plant fed^{-1} gave the highest values of ear length and ear weight which increased by 10.3 and 35.3 %, respectively, as compared to SC166 and plant density 30000 plant fed^{-1} in the 2014 season. Meanwhile, planting SC173 with plant density 30000 plant fed^{-1} gave the tallest plant (252.0 cm) in the 2015 season. These results are in general agreement with those obtained by Began *et al.*(2001) proposed that hybrids and plant spacing could be used as integrated weed management program in maize.

Effect of interaction between maize hybrids × common cocklebur densities:

The effect of integration between maize hybrids × common cocklebur densities m^{-2} were statistically significant on LAI and maize grain yield ard fed^{-1} in 2014 and 2015 seasons and plant height in 2015 season (Table 6). The effect of integration between SC173 with zero cocklebur gave the tallest plant height of maize which increased by19.2 %, in the second season as compared to SC166 under 8 plants of common cocklebur m^{-2}. Data in Table 6 and Figure 4 revealed that the interaction between maize hybrids and zero common cocklebur was linear equation (G_1LAI_{2014} = 5.63 – 0.24 X, R^2 =0.993 and G_2LAI_{2014} = 5.87 – 0.26 X, R^2 =0.997 (G_1LAI_{2015} = 5.69 – 0.24 X, R^2 =0.980 and G_2LAI_{2015} = 6.05 – 0.27 X, R^2 =0.998) on LAI. The interaction between SC173 and plant density 24000 gave the highest LAI (5.83 and 6.04), respectively, in 2014 and 2015 seasons as compared with SC166 and 8 plant of common cocklebur m^{-2}. This may be owing to effect of integration between the role of hybrids with controlling weeds in maize or genetic potential of maize SC173.

Table 5. Effect of interaction between maize hybrids and densities on ear length, ear weight and plant weight in 2014 season.

Maize hybrids	Maize densities (plant fed^{-1})	2014 season		2015 season
		Ear length (cm)	Ear weight (g)	Plant height (cm)
	20000	18.4	187.1	230.8
SC 166	24000	18.0	168.2	242.9
	30000	17.5	163.3	244.2
	20000	19.5	218.6	244.3
SC 173	24000	18.6	171.5	249.9
	30000	18.1	177.7	252.0
LSD at $_{0.05}$		0.19	7.87	3.01

Table 6.Effect of interaction between hybrids and common cocklebur densities on ear length and plant height, LAI and maize grain yield in 2014 and 2015 seasons.

Maize hybrids	Cocklebur densities (plant m^{-2})	2014 season		2015 season		
		LAI	Maize grain yield (ard fed^{-1})	LAI	Plant height (cm)	Maize grain yield (ard fed^{-1})
	0	5.70	20.92	5.78	262.3	21.46
	2	5.11	18.50	5.08	247.9	18.58
SC166	4	4.57	15.84	4.71	239.1	16.43
	6	4.21	13.07	4.30	228.9	13.93
	8	3.73	10.23	3.76	218.3	11.34
	0	5.83	23.00	6.04	270.2	22.12
	2	5.42	20.77	5.53	257.2	19.62
SC173	4	4.79	18.47	4.95	250.1	17.70
	6	4.28	16.46	4.48	243.3	15.38
	8	3.77	13.94	3.86	222.9	13.09
LSD at $_{0.05}$		1.24	4.27	1.13	8.40	3.78

Also, the effect of the interaction between maize hybrids and zero common cocklebur was linear equation (G_1Y_{2014} = 21.07 - 1.34 X, R^2 =0.970 and G_2 Y_{2014} = 23.01 - 1.12 X, R^2 =0.980 (G_1 Y_{2015} = 21.35- 1.25 X, R^2 =0.990 and G_2 Y_{2015} = 23.04 - 1.12 X, R^2 =0.983) on maize grain yield. The interaction between SC173 and plant density 24000 gave the highest values of grain yield (23.00 and 22.12 ard fed^{-1}), respectively, in 2014 and 2015 seasons compared with SC166 and 8 plant of common cocklebur m^{-2}. These results mean that SC173 hybrid had more photosynthesis capacity than SC166 hybrid which reflected on parallel increases in maize yield (ard fed^{-1}).

Interaction between maize × common cocklebur densities.

Results in Table 7 show that the effect of interactions between maize densities (plant fed^{-1}) and common cocklebur densities (plant m^{-2}) was statistically significant on common cocklebur dry weight m^{-2} and maize grain yield in both seasons.

Data in Table 7 and figure 5 revealed that the mathematical models which govern the relationships between maize and common cocklebur densities was significant and the correlation between them was linear equation on common cocklebur dry weight m^{-2} (D_1 CDW_{2014} = 584.6 - 41.6 X, R^2 =0.900, D_2 CDW_{2014} = 452.0- 28.6 X, R^2 =0.954, D_3 CDW_{2014} = 425.6 - 28.0 X, R^2 =0.935 and D_1 CDW_{2015} = 563.3- 35.0 X, R^2 =0.898, D_2 CDW_{2015} = 381.7 - 24.0 X, R^2 =0.954, D_3 CDW_{2015} = 359.7 - 23.5 X, R^2 =0.933) in both seasons.

Sowing high maize densities with 8 common cocklebur densities m^{-2} gave high reduction of common cocklebur dry weight (g m^{-2}) in both seasons as compared to lowest maize densities with 2 common cocklebur densities m^{-2}. The differences between middle maize density was higher significantly in maize grain yield (ard fed^{-1}) than both lower or high plant densities under common cocklebur densities from 2 to 8 plants m^{-2} in both seasons. Where both lower and high plant densities did not differ significantly in their effects on this trait.

The trend lines show that grain yield decreased linearly (D_1 $Ý_{2014}$ = 19.27 - 1.32 X, R^2 =0.997, D_2 $Ý_{2014}$ = 26.26 - 1.30 X, R^2 =0.994, D_3 $Ý_{2014}$ = 20.60 - 1.27 X, R^2 =0.998 and D_1 $Ý_{2015}$ = 18. 71 - 1.14 X, R^2 =0.993, D_2 $Ý_{2015}$ = 26.13 - 1.34 X, R^2 =0.996, D_3 $Ý_{2015}$ = 20.19 - 1.05 X, R^2 =0.988) in all plant densities with increasing common cocklebur densities (Figure 5).The interaction between maize density 24000 and zero common cocklebur gave the highest grain yield (26.02 and 26.0 ard fed^{-1}) as compared with maize density 20000 and 8 common cocklebur density m^{-2} (10.33 and 9.87 ard fed^{-1}), respectively, in the first and second seasons.

Interaction among maize hybrids, maize and cocklebur densities

The effect of interaction among maize hybrids, maize plant densities and common cocklebur densities were statistically significant on ear length (Table 8).

The integration between SC173 and plant density 20000 plant fed^{-1} and zero common cocklebur level gave the maximum values of ear length (22.4 cm) as compared to SC166 and plant density 30000 plant fed^{-1} with 8 plant m^{-2} common cocklebur (14.2 cm) or increased by 57.7 %.

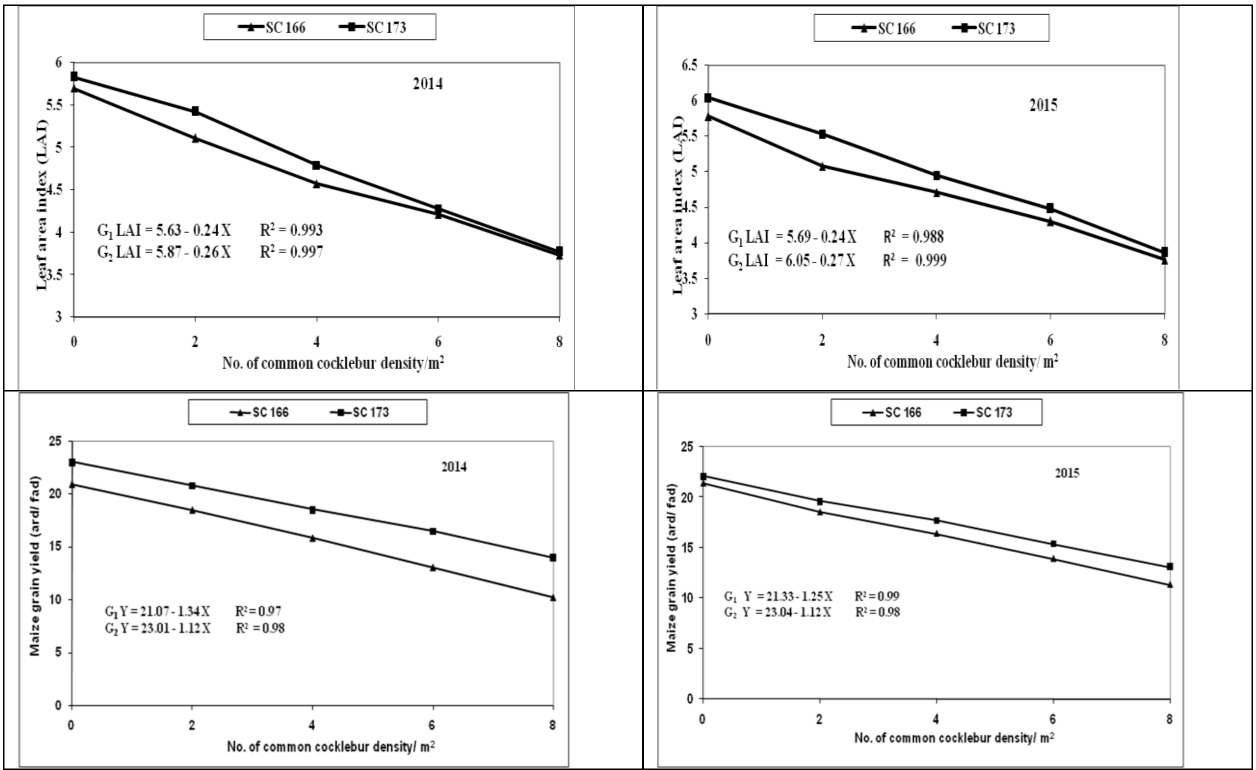


Figure 4. Relationship between common cocklebur densities (No/ m^2), LAI and maize grain yield under two genotypes in 2014 and 2015 seasons.

Table 7. Effect of interaction between maize densities and cocklebur densities on cocklebur dry weight, LAI and maize yield in 2014 and 2015 seasons.

Maize densities (plant fed^{-1})	Cocklebur densities (plant m^{-2})	2014 season		2015 season	
		Cocklebur dry weight (g m^{-2})	maize yield (ard fed^{-1})	Cocklebur dry weight (g m^{-2})	maize yield (ard fed^{-1})
20000	0	0.00	19.43	0.00	18.98
	2	448.4	16.97	378.7	16.40
	4	426.6	14.45	361.0	13.67
	6	260.5	12.68	220.5	11.85
	8	226.3	10.33	191.9	9.87
24000	0	0.00	26.02	0.00	26.00
	2	396.6	23.67	335.1	23.33
	4	346.7	21.38	293.1	21.25
	6	257.2	18.80	217.8	17.98
	8	235.9	15.47	199.9	15.25
30000	0	0.00	20.43	0.00	20.36
	2	369.1	18.27	312.0	17.56
	4	327.9	15.63	277.8	16.28
	6	231.2	12.80	195.7	14.14
	8	214.9	10.47	182.5	11.53
LSD at $_{0.05}$		22.27	4.65	14.64	4.22

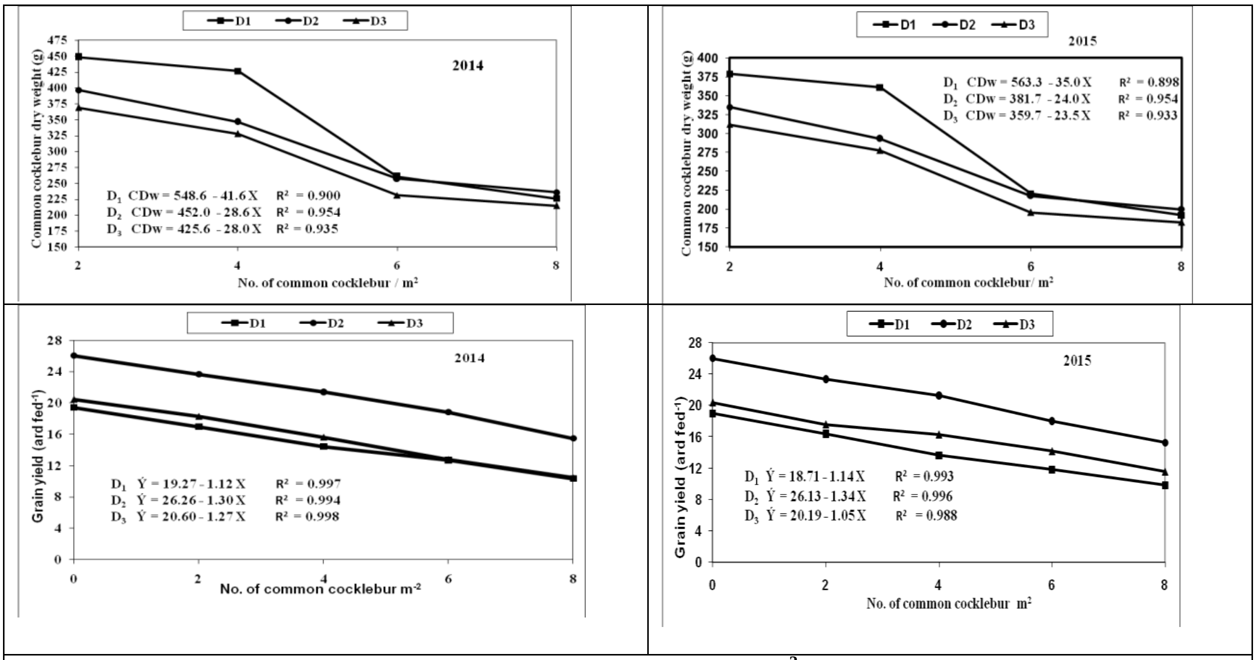


Figure 5. Relationship between common cocklebur density (No.m^2), common cocklebur dry weight and maize grain yield (ard fed^{-1}) under maize density in 2014 and 2015 seasons.

Table 8. Effect of interaction between hybrids, maize densities and cocklebur densities on ear length of maize in 2015 season.

Maize densities (plant fed^{-1})	Cocklebur Densities (plant m^{-2})	Maize hybrids SC166	SC173
	0	21.0	22.4
	2	19.8	20.9
20000	4	18.4	19.8
	6	16.7	18.6
	8	15.9	16.0
	0	20.5	21.6
	2	19.7	19.8
24000	4	17.8	19.3
	6	17.0	17.0
	8	15.2	15.3
	0	20.3	20.5
	2	19.5	20.0
30000	4	17.2	18.9
	6	15.9	16.9
	8	14.2	14.3
LSD at $_{0.05}$		1.67	

V- Correlation analysis

Data presented in Table 9 indicated that common cocklebur density (No m^2) and common cocklebur dry weight (g m^{-2}) were negatively and highly significantly correlated with LAI, ear weight, ear length, grains weight ear^{-1}, 100- grain weight and grain yield ard. fad^{-1}. in both seasons. While, LAI and grain yield (ard fed^{-1}) were positively and highly significantly correlated with ear weight, ear length, grains weight ear^{-1} and 100-grain weight and negatively and highly significantly correlated with common cocklebur dry weight (g m^{-2}) in both seasons. Suggesting that maize grain yield can be affected strongly by common cocklebur competition.

Table 9. Correlation analysis between some studies traits in maize in under 2014 and 2015 season.

Traits	Cocklebur dry weight ($g\ m^{-2}$)	LAI	Ear Weight (g)	Ear Length (cm)	Grain weight ear^{-1}	100- grain weight (g)	Grain yield (ard fed^{-1})
2014 season							
Cocklebur number m^{-2}	0.287**	-0.917**	-0.689**	-0.931**	-0.778**	-0.634**	-0.722**
Cocklebur dry weight ($g\ m^{-2}$)	-	-0.302**	-0.119	-0.182	-0.156	-0.159	-0.237*
L.A.I	-0.302**	-	0.607**	0.854**	0.685**	0.624**	0.738**
Grain yield (ard fed^{-1})	-0.237*	0.738**	0.382**	0.705**	0.712**	0.650**	-
2015 season							
Cocklebur number m^{-2}	0.290**	-0.915**	-0.641**	-0.924**	-0.612**	-0.769**	-0.731**
Cocklebur dry weight ($g\ m^{-2}$)	-	-0.327**	-0.199	-0.207*	-0.233*	-0.167	-0.269*
L.A.I	-0.327**	-	0.587**	0.804**	0.544**	0.685**	0.727**
Grain yield (ard fed^{-1})	-0.269**	0.727**	0.445**	0.609**	0.480**	0.554**	-

CONCLUSION

The previous results suggest that both common cocklebur and maize plant densities can be adversely affect significantly the growth each other owing to the inter and intra- specific competition inside and between each species. Maize grain yield can be affected strongly by common cocklebur competition. The main findings of this investigation refer that common cocklebur weed should be managed to avoid maize grain yield losses due to its competition through growing maize vigor hybrid such as SC173 with proper plant density at 24000 plant fed^{-1} and continues hand pulling any emerged common cocklebur seedling or to use selective recommended herbicides.

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تأثير التنافس البينى و النوعى بين كثافات حشيشة الشبيط و نباتات الذرة الشامية على إنتاجية محصول الذرة الشامية

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تعتبر حشيشة الشبيط منافس قوى لمحصول الذرة الشامية وتنتشر على مستوى العالم ومصر. دراسة طبيعة التنافس بينهما هو مفتاح رسم استراتيجيات المكافحة للشبيط فى الذرة الشامية. كان الهدف من هذه الدراسة هو تحديد العتبة الاقتصادية لحشيشة الشبيط وكثافاتها المختلفة على محصول الذرة الشامية. لهذا السبب أجريت تجربتين حقليتين بأرض مصابة طبيعيا وبغزارة بحشيشة الشبيط بمحطة البحوث الزراعية بملوى، مركز البحوث الزراعية, محافظة المنيا ، مصر خلال الموسم الصيفى ٢٠١٤ و٢٠١٥. استخدام فى هذه الدراسة تصميم القطع المنشقة مرتين مع ثلاثة مكررات. أشتملت هذه الدراسة على ثلاثة عوامل ، العامل الرئيسى على هجينين من الذرة الشامية (هجين فردى ١٦٦ و ١٧٣) والعامل الشقى الأول على ثلاثة كثافات نباتية من الذرة الشامية (٢٠٠٠٠، ٢٤٠٠٠ و ٣٠٠٠٠ نبات/ فدان) والعامل الشقى الثانى على خمسة كثافات من حشيشة الشبيط (صفر، ٢، ٤، ٦ و ٨ نبات / م٢).

أشارت النتائج إلى أن زراعة هجين فردى ١٧٣ كان أكثر قوه فى المنافسة لحشيشة الشبيط وخفض الوزن الجاف لها وأعطى أفضل صفات محصولية للذرة الشامية مقارنة بالهجين الفردى ١٦٦.

أدت زيادة كثافات الذرة الشامية الى انخفاض الوزن الجاف للشبيط ، طول ووزن الكوز، عدد حبوب الكوز، وزن ١٠٠ حبه وزيادة طول النبات، دليل مساحة الورقة. أعطت كثافة الذرة الشامية ٢٤٠٠٠ نبات/ فدان أعلى محصول من الذرة الشامية (أردب/ فدان) فى الموسمين مقارنة بباقى الكثافات الاخرى.

خفضت زيادة كثافة الشبيط الوزن الجاف للشبيط والمحصول ومكوناته فى الذرة الشامية مثل طول النبات، دليل مساحة الورقة، طول ووزن الكوز، عدد حبوب الكوز، وزن ١٠٠ حبه ومحصول الذرة الشامية (أردب/ فدان).

كانت الخسارة فى محصول الذرة الشامية عند كثافة ١، ٤ و ٨ نبات شبيط /م٢ هى ٥,٢ ، ٢٢,٠ و ٤٤,٤ % فى الموسم الأول و٤,٩ ، ٢١,٠ و ٤٢,٥ % فى الموسم الثانى على التوالى.

يجب مكافحة حشيشة الشبيط لتجنب الخسارة فى محصول الذرة الشامية الناتجة من منافستها لها من خلال زراعة هجين قوى مثل هجين فردى١٧٣ مع استخدام كثافة نباتية مناسبة ٢٤٠٠٠ نبات/ فدان والاستمرار فى نقاوة بادرات الشبيط أو استخدام مبيدات الحشائش الموصى بها.

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