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Effect of Plant Spacing and Weed Control Treatments on Maize Yield and Associated Weeds in Sandy Soils

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Abstract: The effect of plant spacing, weed control treatments and their interaction on maize yield and weed growth in sandy soils is not completely understood. Therefore, field experiments were conducted during 2005 and 2006 growing seasons to determine if management can improve maize competitiveness with weeds and thus achieve the yield potential of maize in sandy soils. The experiment included six plant spacing (two ridge width 60 and 70 cm with 3 constant spaced hills (20, 25 and 30 cm apart) on one side of ridge, at approximately 35000, 28000 and 23333 plants/fed for ridge 60 cm width and 30000, 24000 and 20000 plants/fed for ridge 70 cm width, respectively) and four weed control treatments, e.g., hand hoeing twice, fluroxypyr + one hoeing, one hoeing + sethoxydim and a nonweeded check. Plant spacing affected dry weight of weeds growing with maize. Biomass of weed species was decreased, in most cases, under narrow plant spacing. Weeds were controlled by all treatments compared with the nontreated check; however, herbicide treatments were not superior to hand-hoeing treatments. Using wide plant spacing favored growth of maize plant and weeds. Planting at wide spacing also improved most yield parameters of ear. The highest biological and grain yields of maize resulted at spacing of 60 x 25 cm (28000 plant population/fed). All weed control treatments improved grain yield up to two fold compared with the nonweeded check. The interaction between plant spacing and weed control treatments had significant effects on total weeds dry weight, as well as number of kernels/ear, grain index and biological yield parameters of maize. Grain yields were improved with fluroxypyr applied 2 wk after sowing (WAS) maize followed by one hand hoeing 6 WAS or hoeing at 3WAS followed by sethoxydim applied 6 WAS. However, the highest yields were obtained by hoeing two times during the growing season. Maize weeds control by the hoeing or herbicides treatments was enhanced in narrow- compared to wide-spacing maize 8 WAS. Application of the three weed control treatments resulted in less weed biomass and greater maize yield in narrow- compared to wide-spacing maize.

Key words: Hand hoeing · Integrated weed management · Plant population · Fluroxypyr · Sethoxydim

INTRODUCTION

Maize is one of the most important cereal crops of Egypt. Increasing grain yield per unit area and increasing the corn cultivatable area are recognized as a better solution to solve the gab between consumption and production. Therefore it's important to increase the maize yield in sandy soil. It has been shown that maize yields can be reduced if weeds are not controlled [1, 2]. Effective weed control often requires a combination of cultural, mechanical and chemical applications is one important component of integrated weed management. Different intensities of crop yield losses caused by weed competition have been observed: 21 % [3], 66% [4], 90% [5].

Plant spacing or plant density plays an important role in the competitive balance between weeds and maize. Singh and Singh [6] stated that the weed density and other measures of weed abundance usually decrease as crop density increases. They added that narrow row spacing affect the weeds and increases crop yield. Conversely, Teasdale [7] did not find any difference in the effect of row spacing on *Abutilon theophrasti* growth and survival. Common lambsquarters biomass and seed production were reduced when grown under canopies of corn planted in populations exceeding 72900 plants/ha [8]. Acciares and Zuluaga [9] reported that in the weedy treatment, the narrow row planting pattern registered a lower aboveground dry matter of weeds than the wide row arrangement, while corn grain yield was greater

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when crop was grown in narrow row rather than in wide row spacing.

Management of corn (*Zea mays*) row spacing and populations has been used to increase corn productivity. Widdicombe and Thelen [10] recorded yield increases up to 10% with reducing row spacing. Murphy *et al.* [11] showed that corn planted at 50 cm rows intercepted about 8% more photosynthetically active radiation (PAR) at silking than crop at conventional rows, reducing biomass of late-emerging weeds. Shapiro and Wortmann [12] reported that corn grain yield typically exhibits a quadratic response to plant density, with a near-linear increase across a range of low densities, a gradually decreasing rate of yield increase relative to density increase and finally a yield plateau at some relatively high plant density [13, 14]. Matta *et al.* [15] reported that growing 20000 plants/fed in case of Giza-2 or 24000 plants/fed in case of D.C.-204 produced more grain yield per unit area. Porter *et al.* [16] reported that the maximum corn grain yield was recorded at 82000 to 89000 plants /ha and decreasing row spacing from 0.76 to 0.51 m resulted in 4% more grain yield. They added that grain yield was not affected by increasing plant density above 61800 plants/ha but it was greater with narrow row spacing. Row spacing did not affect harvest index [12]. While, Kumar and Walia [17] reported that plant population of 90000/ha resulted in lower dry matter accumulation of the weeds than 75000/ha. They added that plant population of 90000/ha resulted in higher leaf area index but lower grain yield compared to a plant population of 75000. Bavec and Bavec [18] reported that increased plant population from 4.5 to 13.5 plants per m^2 significantly changed the following cob characteristics, weight of 1000 kernels, cob length, number of kernel rows and number of kernels per row. Widdicombe and Thelen [10] reported that narrow row spacing for corn has been shown to increase yield in some environments. They added that it has been hypothesized that narrowing row spacing may increase crop access to available soil moisture because of the more equidistant distribution of crop plants [5, 19, 20]. A second hypothesis is that narrowing row spacing increases light interception by the crop, particularly in the early growing season, thereby leading to increased crop growth rates and earlier canopy closure [21-23]. This earlier canopy closure and increased shading of weeds has been associated with increased crop competitiveness and reduced weed growth in some situations [21, 23].

Several researchers have shown that fluroxypyr and bispyribac-Na can control weeds in maize [4, 24-27]. Jehangeri *et al.* [28] reported that application of selective herbicides provided 65 to 90% weed control and gave 100-150% more maize yield than weedy check. In addition to the high costs, hand-hoeing control is not always possible, due to labor shortage or excessive soil humidity.

Our objective was to evaluate the effect of plant densities and weed control treatments on maize yield and associated weeds under sandy soil conditions.

MATERIALS AND METHODS

Field experiments were conducted at Salhia district, Sharkia Governorate, Egypt, during 2006 and 2007 to evaluate the effect of plant spacing and weed control treatments on productivity of maize and growth of associated weeds. The soil was sandy with pH 7.8, organic matter 1.6%, E.C. 1.04 mmohs/cm, $CaCO_3$ 1.56%, total N 0.043%, total P 0.022% and total K 0.02%. Plot area was 21 m^2 (4.2 m wide by 5 m long). Plot width allowed for seven rows of corn when planted in 60 cm rows and six rows of corn when planted in 70 cm rows. Maize was sown in constant spaced hills (20, 25 and 30 cm apart) on one side of ridge, at approximately 35000, 28000 and 23333 plants/fed for ridge 60 cm width and 30000, 24000 and 20000 plants/fed for ridge 70 cm width, respectively. The experiment was established with a split-plot design having four replicates. The main plots included six plant population and subplots were assigned to four weed control treatments. Row (ridge) spacing (60 or 70 cm row widths) was the main plot.

Subplots were weed control treatments, which consisted of (1) un-weeded check (weeds were allowed to grow); (2) hand hoeing two times at 3 and 6 weeks after sowing (WAS) of maize; (3) fluroxypyr applied at 40 g ae/fed 15 days after maize sowing + one hoeing at 6 WAS of maize; and (4) one hoeing 15 days after maize sowing + sethoxydim (Nabu S 12.5%) applied at 1.5 l/fed i.e at 187.5 g ai/fed at 6 WAS.

Maize (cv. single-cross 10) was sown in the second week of May in both seasons. Ammonium sulfate (21% N) was applied at 120 kg/fed at four times during the growing season; at planting (15% of the total amount) and at second, fifth and seventh irrigation in equal portions. Farmyard manure at 30 m^3/fed was added before plowing. P and K were applied at 56 and 60 kg/ha of P_2O_5 and K_2O, respectively, at the time of sowing maize. The preceding crop was berseem (*Trifolium alexandrinum* L.) in both seasons. The normal cultural practices for growing maize in sandy soil were applied as recommended, except for plant spacing and weed control measures. After 9 WAS, weeds were counted from one square meter (m^2) randomly taken from each plot. Weeds were identified and their dry weights were recorded. At harvest, 10 maize plants from each plot were taken to determine plant height, ear characters, i.e., length (cm), diameter (cm), number of rows/ear, number of kernels/cob, kernel weight, shelling percentage [(ear grain weight/cob weight) × 100], grain weight per ear (g), grain index (100- kernel weight) and harvest index (harvest index (percentage of grain to grain plus straw). Biological and grain yields per feddan (feddan = 4200 m^2)were determined by harvesting the whole plot area.

A combined analysis of data for the two seasons was carried out according to the procedure outlined by Gomez and Gomez [29]. For comparison between means, the LSD test at 5% level was used.

RESULTS AND DISSCUSSION

Weed Growth: The major weeds present on the experimental site included common purslane [*Portulaca oleracea,* L.] and nalta jute (*Sida alba* L.) as broadleaf weeds and barnyardgrass [*Echinochloa colonum* (L.) Link] and crowfootgrass [Dactyloctenium aegyptium (L.) Willd] as grass. The dry weight of broadleaf weed species was less than the grass species as shown in unweeded treatment (Table 1). The maximum biomass was recorded from Barnyardgrass and this was the most dominant weed species during both the years.

Effect of Plant Spacing: The response of weed growth to plant spacing differed according to the weed species (Table 1). Broadleaf weeds were not significantly affected by reducing the ridge width from 70 to 60 cm. While weed biomass of grass and total dry weight of weeds was reduced 17 and 10 % by reducing row spacing from 70 to 60 cm. Similar finding was reported by Tharp and Kells [8] and Begna *et al.* [30]. However, Teasdale [7] and Johnson *et al.* [32] found that reducing row spacing had no significant impact on weed biomass. One theory for the reduced weed growth in narrow rows is quicker row closure which reduces the light penetration to the weeds emerging below the crop canopy. Several studies have shown that narrow rows are more efficient (0 to 11%) at intercepting light than wide rows [8, 21, 30].

The lowest dry weight of broad, narrow and total weeds were recorded under 30000 plants (70 x 20 cm), 23333 (60 x 30 cm) and 28000 plants/fed (60 x 25 cm), respectively. According to Pallutt [32], the weeds are suppressed probably because of the enhanced competitiveness of the maize crop and increased shading.

Effect of Weed Control Treatments: As shown in Table 1, the three weed control treatments were effective in reducing the weed dry weight compared with weedy control plots. Insignificant differences were noticed between the two complementary treatments (herbicide + hoeing) and hoeing treatment (Table 1). In this respect, Zimdahl [33] stated that if human labor is abundant and labor cost is not high, hand hoeing can be an acceptable

Table 1: Effects of plant spacing and weed control treatments on dry weight of weeds (g/m^2) after 9 weeks from maize planting (combined analysis of the two seasons)

	Broadleaf weeds			Grasses			
	Common purslane	Nalta jute	Total	Barnyardgrass	Crowfootgrass	Total	Total
Treatments	(g/m^2)						
Plant spacing (cm):							
60 x20 (35000)	12.3	0.0	12.3	27.2	2.7	29.9	42.2
60 x 25 (28000)	10.1	0.0	10.1	25.3	1.4	26.7	36.8
60 x 30 (23333)	15.1	3.5	18.6	20.2	1.8	22.0	40.6
70 x 20 (30000)	8.0	1.2	9.2	25.3	1.7	27.0	36.2
70 x 25 (24000)	12.7	1.9	14.6	33.1	2.4	35.5	50.1
70 x 30 (20000)	14.2	1.1	15.3	27.6	4.0	32.6	46.9
LSD(0.05)	2.6	0.6	3.4	6.7	0.8	5.2	3.1
Weed control treatments:							
Unweeded check	34.2	4.7	38.9	103.6	2.5	106.1	145.0
Hand hoeing	5.7	0.0	5.7	0.4	1.4	1.8	7.5
Flur. + 1 hoeing	2.9	0.0	2.9	0.8	5.0	5.8	8.7
1 hoeing + Seth.	5.3	0.5	5.8	1.2	0.4	1.6	7.4
LSD at 5%	2.2	0.5	3.1	6.2	0.7	4.3	2.9
LSD at 5% for Int.	N.S	N.S	N.S	N.S	N.S	N.S	7.0

*Abbreviations: Flur, fluroxypyr; Seth, sethoxydim; Int, interaction

Table 2: Effects of the interaction between plant densities and weed control treatments on the total dry weight of weeds (g/m^2) after 9 weeks from maize planting. (Combined analysis of the two seasons)

	Weed control treatments			
	Un-weeded check	Hand hoeing twice	Fluroxypyr + one hoeing	One hoeing + sethoxydim
Plant spacing	g/m^2			
60 x20 (35000)	140.5	6.6	9.1	12.6
60 x 25 (28000)	135.3	1.3	2.9	7.7
60 x 30 (23333)	139.3	4.4	14.7	4.1
70 x 20 (30000)	129.5	5.5	5.2	4.4
70 x 25 (24000)	175.4	12.6	8.6	3.9
70 x 30 (20000)	150.0	14.4	11.6	11.6
LSD(0.05)		7.0		

method for weed control. However, if human labor is not abundant and expensive, then mechanical hoeing will be costly for weed control. Fluroxypyr reduced biomass of common purslane 91.5%, but hand hoeing (twice) reduced it by 83.3 %. Bispyribac - Na at 6 WAS reduced the dry weight of grasses 98.5% relative to nonweeded check (Table 1). McDonald and Dernoeden [27] reported that bispyribac-Na can selectively control annual grasses. Similar findings were reported by Abouziena *et al.* [4], Dalley *et al.* [5], El-Metwally *et al.* [25], Sharara *et al.* [26] and Begna *et al.* [30].

Effect of Interaction Between Weed Control Treatments and Plant Spacing: Interaction effects of row spacing with plant density and weed control treatments were not significant for dry weights of common purslane, nalta jute, barnyardgrass or crowfootgrass (data not shown). However, the total dry weight of weeds was significantly affected by the interaction (Table 2). Maize weeds control by the hoeing or herbicides treatments was enhanced in narrow- compared to wide-spacing maize 8 WAS. The lowest dry weight of weeds resulted from hand hoeing twice at the plant spacing of 60 x 25 cm (28000 plants/fed). At ridge 60 cm when the spacing between maize plants was reduced from 30 cm to 25 cm, Fluroxypyr plus one hand-hoeing at 6 WAS treatment significantly reduced the total weed dry weight by 80 %. Similar trend was observed under ridge width 70 cm, where the control treatments exhibited the least weight of weeds under plant distance of 20 cm, while at 30 cm recorded more dry weight (Table 2). Earlier canopy closure and increased shading of weeds has been associated with increasing crop competitiveness and reducing weed growth in some situations [21, 23].

The results show the potential that planting corn in narrower rows may aid weed control. Similar observation was reported with Singh and Singh [6], Tharp and Kells [8] and Murphy *et al.* [11]. They reported that the weed density and other measures of weed abundance usually decrease as crop density increases. Murphy *et al.* [11] showed that corn planted at 50 cm rows intercepted about 8% more photosynthetically active radiation (PAR) at silking than crop at conventional rows, reducing biomass of late-emerging weeds. Acciares and Zuluaga [9] reported that in the weedy treatment, the narrow row planting pattern registered a lower aboveground dry matter than the wide row arrangement and the differences between planting pattern were highly significant. They added that narrow row corn was equally successful in reducing aboveground dry matter in early and later emerging weeds.

Maize Yield and its Components

Effect of Plant Spacing: Plant spacing had insignificant effect on ear diameter, number of rows/ear and shelling percentage criteria. However, Bavec and Bavec [18] reported that increased plant population from 4.5 to 13.5 plants per m^2 significantly changed the following cob characteristics, weight of 1000 kernels, cob length, number of kernel rows and number of kernels per row. The highest values of ear length, number of grains/ear, ear weight, grain weight/cob and grain index were recorded when sowing maize plants at wider spacing (70 x 30 cm) i.e. the lowest plant population (20000 plants/fed). This result may be attributed to decrease the intraspecific competition on the resources. Similar results were obtained with Maddonni *et al.* [34] who reported that the highest grain yields and kernel numbers were recorded at plant population densities 9≥

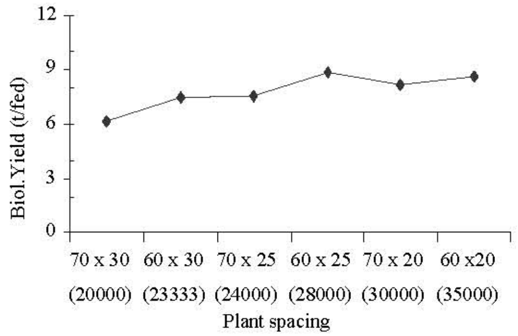

Fig. 1: Biol. yield of maize plants as affected by plant spacing. Average of two seasons. LSD 0.05 = 0.777

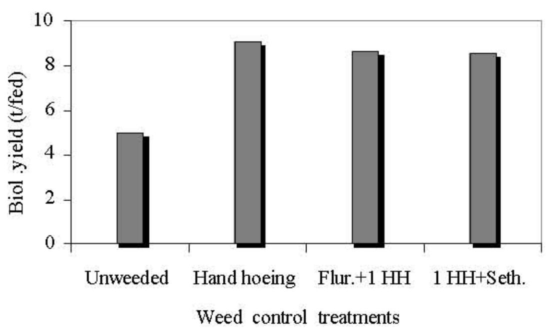

Fig. 2: Biological yield of maize as affected by weed control treatments. Average of two seasons. LSD 0.05= 0.327. HH: hand hoeing

plants m^{-2} while the largest kernel weights were obtained at low plant densities (3–4.5 plants m^{-2}). Ali *et al.* [35] reported that the competition between maize plants for light, soil fertility and other environment factors was markedly increased in case of the highest population. In addition, Dalley *et al.* [5] reported that soil moisture was greater in the 76 cm row spacing than at 38 cm.similar results were obtained with Maddonni *et al.* [34], Barbieri *et al.* [36] and Azam *et al.* [39]. Hamayun [37] reported that plant height, grains per cob and 1000 grain weight were maximum at 1.5 feet spacing followed by 1.0 and 0.5 feet spaced treatments.

The results in Fig.1 indicated that the biological yield/fed increased as plant population increased up to 28000 plant/fed that produced the maximum biological yield then the yield was declined at denser planting of maize at 60 x 20 cm (35000 plants/fed). This result may be due to the highest plant population per unit area. Grain yield per feddan take the same trend of biological yield criteria. The highest grain yield resulted from sowing maize at spacing of 60 x 25 cm (28000 plants/ fed) followed by 70 x 20 cm (30000 plants) and 60 x 25 cm (35000 plants /fed with insignificant differences between the three densities, as shown in Table 3. However the density of 28000 plants /fed exhibited increments of grain yield than the densities of 30000, 35000 and 24000 plants/fed by 4.6, 6.1 and 22.0 %, respectively. Similar finding was reported by Acciares and Zuluaga [9] and Zeidan *et al.* [38]. Shapiro and Wortmann [12] found that decreasing row spacing from 0.76 to 0.51 m resulted in 4% more grain yield and grain yield was not affected by increasing plant density above 61800 plants ha^{-1} but it was greater with narrow row spacing. Matta *et al.* [15] found insignificant deference of grain yield /fed obtained from growing maize at 24000 and 30000 plant/fed. While Porter *et al.* [16] reported that the maximum corn grain yield at 82000 to 89000 plants ha^{-1}. Previous studies indicated that corn grain yield typically exhibits a quadratic response to plant density, with a near-linear increase across a range of low densities, a gradually decreasing rate of yield increase relative to density increase and finally a yield plateau at some relatively high plant density [12-14, 36]. Results in Table 3, showed that the wider spacing (lowest plant population) recorded the lowest value of harvest index. Same trend was obtained by Abo-Shetaia *et al.* [40].

Effect of Weed Control Treatments: The grain yield decreases due to the weed infestation throughout the whole vegetation period by 90% [5] and 66 % [4]. Our results also show (Table 3) the significant decrease of yield in the check variant (50 % decrease in comparison with the hoeing treatment). The reduction in grain yield due to weeds may be attributed to several factors, e.g., competition between maize and weeds for water and nutrients, especially under sandy soil and allelopathic effects of weeds. Hussein [3] reported that controlling weeds in maize field could save 75, 11 and 54 kg/ha of N, P and K and 90, 1029 and 99 g/ha of Zn, Fe and Mn, respectively. Also, Zimdahl [33] mentioned that competition for water is often considered the most important source of weed–crop competition. Weeds growing with a crop have been shown to reduce soil moisture, although the depth of additional water extraction depends on the specific combination of crop and weeds present. The reductions in soil moisture have been related to increases in weed density or the length of time weeds remain present with the crop [5]. The application of the two complementary treatments (Fluroxypyr 2 WAS followed by hand hoeing 6 WAS or hand hoeing 3 WAS followed by sethoxydim 6 WAS) significantly increased the grain yield/fed by 78 or

Table 3: Effects of plant spacing and weed control treatments on maize yield and its components (Combined analysis of the two seasons)

Treatments	Plant height (cm)	Ear characters L.(cm)	D.(cm)	No. of rows	No.of kernels	Weight(g)	Shelling(%)	kernel weight(g)	Grain index(g)	HI	Grain yield (t/fed)
Plant spacing (cm)											
60 x20 (35000)	271	18	3.6	12.0	458	117.5	84.6	99.4	21.7	43.0	3.720
60 x 25 (28000)	268	18.9	3.8	12.3	511	134.5	84.3	113.4	22.2	44.5	3.948
60 x 30 (23333)	261	20.1	4.0	12.4	516	142.7	84.6	120.7	23.4	42.7	3.182
70 x 20 (30000)	265	19.1	3.8	12.0	511	135.8	84.3	114.5	22.4	46.3	3.776
70 x 25 (24000)	256	20.1	4.0	12.3	518	148.8	84.6	125.9	24.3	43.0	3.235
70 x 30 (20000)	243	20.8	4.1	12.2	521	157.1	81.6	128.2	24.6	41.9	2.571
LSD(0.05)	12	1.3	N.S	N.S	69	17.9	N.S	24.8	1.4	1.2	0.291
Weed control treatments											
Unweeded check	243	17.8	3.5	11.5	398	98.1	83.6	82.0	20.6	42.4	2.048
Hand hoeing twice	264	20.4	4.0	11.7	529	155.1	83.6	129.6	24.5	45.9	4.064
Flur. + 1 hoeing	267	19.5	4.0	12.8	544	154.7	84.4	130.6	24.0	43.3	3.639
1 hoeing + Seth.	268	20.2	4.1	12.7	552	153.8	84.0	129.2	23.4	42.4	3.588
LSD at 5%	10	1.1	N.S	N.S	56	14.7	N.S	20.2	1.1	1.0	0.238
LSD at 5% for inter.	N.S	N.S	N.S	N.S	139	N.S	N.S	N.S	2.7	N.S	N.S

*Flur.: fluroxypyr; Seth.: sethoxydim; L.: length; D.: diameter; HI: harvest index; inter.: interaction

Table 4: Effects of the interaction between plant densities and weed control treatments on grain index and biological yield of maize plants (Combined analysis of the two seasons)

	No. of kernels/ear				Grain index (g)				Biological yield (t/fed)			
Treatments	Unw	HH	Flu.+1 HH	1 HH + seth	Unw	HH	Flur. + 1 HH	1 HH+seth.	Unw.	HH	Flur.+1 HH	1 HH+seth.
Plant spacing												
60 x20	360	484	492	496	19.9	22.7	22.6	22.2	5.869	9.407	8.447	10.875
60 x 25	398	555	538	552	18.3	23.4	22.8	24.2	5.843	10.196	9.273	10.180
60 x 30	432	541	562	529	20.0	24.8	25.1	23.8	4.637	7.873	8.338	8.963
70 x 20	427	535	532	549	21.0	24.4	22.1	22.2	4.322	9.659	9.750	8.938
70 x 25	378	537	588	567	23.1	26.6	25.3	22.4	4.344	10.557	8.610	6.603
70 x 30	394	520	552	617	21.5	25.2	26.0	25.7	4.625	6.552	7.032	6.336
LSD(0.05)	139				2.7				0.777			

*Unw.; unweeded, HH; hand hoeing, Flur: fluroxypyr, Seth.: sethoxydim

75 %, respectively in comparison with the un-weeded check, but did not reach the yield levels of hoeing treatment (Table 2). Similar result was obtained by El-Metwally *et al.* [25]. It is evident that the cultivation supported more favorable conditions for the development of maize root system and thus a better water and nutrient use [41]. The highest value of harvest index was obtained in the mechanical treatment, which significantly exceeded those of the two complementary treatments by 5.8 and 5.3 % respectively. This result explain the significant differences between the two complementary treatments and mechanical treatments in grain yields, however there is no significant differences between the three treatments in biological yield (Table 3). The weed infestation caused the significant decrease in the total plant height, ear characters except ear diameter, number of rows/ ear and shelling percentage which were not significantly influenced by the weed control treatments, while numbers of grains per cob and grain index were significantly increased by weed control treatments (Table 3). These results are agreement with Abouziena *et al.* [4], Sharara *et al.* [26] and Douan *et al.* [42]. The decrements in the previous criteria may be due to that weeds growing with a crop have been shown to reduce soil moisture, although the depth of additional water extraction depends on the specific combination of crop and weeds present [43]. Dalley *et al.* [5] reported that season -long weed competition in corn reduced soil moisture and reduced soil moisture contributed to reduced grain yield in the weedy treatment.

Effect of Interaction Between Weed Control Treatments and Plant Spacing: The interaction between plant spacing and weed control was not significant with most yield parameters except number of kernels/ear; grain index and biological yield (Table 4). Narrow-spacing maize averaged 23% higher biological yield than wide-row maize for all weed control treatments. Narrow-spacing maize (60 x 20 cm) with one mechanical hoeing + sethoxydim provided the highest biological yield. The possible explanation for the increase in biological yield could be that weed control by different methods in this study diverted the nutrients to the crop, which in turn resulted in increased grain yield. These results are also confirmed by Ali *et al.* [35] and Subhan *et al.* [44]. Sowing maize at wide spacing (70 x 30 cm) and weeds controlled by hand hoeing resulted in the highest grain index while, the treatment of one mechanical hoeing + sethoxydim produced the maximum kernels number/ear. While at dense planting (60 x 20 cm) the previous two treatments produced lower values of grain index and number of kernels/ear. The decrease in grain number/ear and grain index under narrow plant spacing may be due to the lowest amounts of metabolites in leaves as a result of high competition for light, water and minerals [34, 37, 38, 45].

CONCLUSION

Sowing maize in ridge 60 cm width and 25 cm between plants (28000 plants/ fed) and controlled weeds mechanically or by complementary between chemical and mechanical treatments produced the highest grain yield/fed.

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