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Effect of Some Novel Herbicides on the Controlling Weeds Associated with Maize Plants

F.A. Sharara, T.A. El-Shahawy and K.G. El-Rokiek
Department of Botany, National Research Center, Dokki, Cairo, Egypt

Abstract: Field experiments were conducted in two successive seasons to investigate the effect of some novel herbicides and/or hand hoeing treatments on controlling weeds and increasing maize (*Zea mays* L.) productivity. One pre-emergence herbicide (Gesaprim) and two post-emergence herbicides (Bentazone and Fluroxypyr) were applied at different concentrations either alone or followed by hand hoeing once treatment. Applying the three herbicides alone at different concentrations substantially reduced the weeds associated with maize as compared with controls. Gesaprim at 0.5 and 0.75 kg/feddan was the most effective herbicide for controlling both narrow and broad-leaved weeds as compared with the other two herbicides, irrespective of rate of application. Applying the three herbicides at lower concentrations, followed by one hand hoeing treatment gave, to a large extent, similar results to those herbicides applied alone at the highest and moderate concentrations for controlling a wide range of weeds and significantly increased the maize yield (52-74%) as compared with control. However, hand hoeing twice treatment was the most effective treatment for controlling the weeds and increasing the maize productivity (86-88%), either compared with control or other chemical treatments. Some difference was found between applying the three herbicides either alone or in combination with hand hoeing for increasing protein content in maize grain as compared with control. It has been suggested that applying the herbicides and/or hand hoeing for controlling weeds in maize must be considered in relation to the costs and environmental impact.

Key words: Gesaprim, Fluroxypyr, Bentazone, herbicide, phytotoxicity, selectivity, weeds, control, hand hoeing, maize, yield

INTRODUCTION

Maize (*Zea mays* L.) is considered one of the most important cereal crops all over the world and takes third place economically after rice and wheat. The maize crop gained its importance as a foodstuff for livestock and in the agricultural industry. Presently, maize grains are valued by the developing communities, in particular Egypt, to be used as a human nutrient, e.g. bread, to meet the rapid increase in growth population. Thus, great attention should be given to increase the productivity of maize crop as an area unit of the agricultural land. Increase in crop production should be achieved primarily through improved farming practices, employing merging technology, using modified cultivators and a suitable program of chemical inputs, e.g. fertilizers and pesticides, with regards to the environmental and health impacts[1,2].

Weeds are amongst many obstacles that determine the productivity and quality of maize yield. In Egypt, the farmers use little technology and possess soil with a heavy load of seeds, therefore, weeds represent a major management problem. The slow growth of maize plant at the early stage and the high fertilizers application during the successive period make the problem more serious. Much research showed that maize plants are known to be very susceptible to weed competition and yield losses are estimated at 35% to complete crop failure[3,4]. Today, labour for hand weeding is becoming too expensive and lack of time and facilities reduces the managerial weed control possibilities.

Herbicides used in maize production are increasing dramatically and traditional weed management strategies for maize are no longer applied in many areas[5-7]. However, in some cases the traditional methods were obligatory beside chemical methods to achieve maximum weed control as mentioned by Brendler[2] who suggested a promising model for using herbicides in a mixture with cultivation methods e.g. frost exposure, rotavator and crop rotation to control potatoes as a weed in maize, sugarbeet and cereals.

Over the past years, many pre-postemergence herbicides have been authorized for use in controlling weeds in maize crops, such as Fluroxypyr, Bentazone, Atrazine, Furamsulfuron, Rimsulfuron, Isoxaflutolo, S-metolachlor, Bromoxynil, Dicamba, Sulcotrione, Lentagran and Mesotrione[6,8-10]. Zaciragic and Grabo[4]

Corresponding Author: Dr. T.A. El-Shahawy, Department of Botany, National Research Center, Dokki, Cairo, Egypt

reported that the main herbicides for control of weeds infestation in maize were Motivell, Cambio (Bentazone+Dicamba), Frontier 900, Stomp and Bazagran. Salarzai[11] examined seven different herbicides for their herbicidal potential in controlling weeds in maize and found that these weedicides significantly affected the weed population, weed biomass and various yield components, however, the highest grain yield (5.16 t ha^{-1}) was obtained in a plot treated with Gesaprim and closely followed by Gramaxone 20 EC (3.12 t ha^{-1}) against 3.12 t ha^{-1} in the control plot. Rout and Satapathy[12] reported that Atrazine, Metalachlor and Alachlor were more than 90% efficient in reducing dry weight of weeds, thus increasing the yield and yield attributes. Research on Fluroxypyr and Bentazone showed that the compounds were functionally acting on broad-leaved weeds rather than grasses[11-15]. Post-emergence applications of Fluroxypyr, with regards to the date of application was highly effective when used at a rate of 0.2 L/feddan, meanwhile, Bentazone showed it's b est efficiency at 1 L/feddan[16-18]. However, the harmful effect of Bentazone and Fluroxypyr on maize growth was discouraging[19,20].

Using tank mixtures of herbicides is highly recommended in controlling maize weeds, rather than applying herbicides alone. Carvalho *et al.*[21] recorded a significant activity of using Atrazine plus Metolachlor, Metolachlor+Nicosulfuron, or Nicosulfuron for controlling many aggressive weed infested maize, which was estimated by (91.8-100%). Under green house conditions, tank mixtures of CGA-248757 or Flumiclorac with Atrazine and Bentazone increased velvetleaf, common lambsquarters, redroot pigweed, or common ragweed control when compared with the control by Atrazine and Bentazone alone[8]. Rapparini *et al.*[22] found that Fluroxypyr+Sulcotrione+Nicosulfuron (0.5+1+1.2 kg ha^{-1}) applied at 5 to 6 leaf stage of maize controlled most of the weeds as compared with individual application of the same herbicides.

The aim of the present research was to study the effect of Gesaprim, Bentazone and Fluroxypyr herbicides, either alone or in combination with hand hoeing in controlling a wide range of weeds and increasing the productivity of maize plants.

MATERIALS AND METHODS

Two field experiments were conducted during two successive seasons (2003/2004) at the experimental station of National Research Center, Shalakan, Kalubia governorate, Egypt. The grains of maize (*Zea mays* L., Cv. Single cross 122) were sown during the first week of June in both seasons. Three seeds were planted per hill and the germinated seeds were thinned to one seedling/hill after 14 days from sowing. The plants were watered and fertilized as recommended. The experiments were set up in a Randomized Complete Block Design with four replicates for each treatment; the size of the experimental unit was 12 m^2 divided into five rows, each row was 3.45x0.7 m. The soil texture was a clay loam soil (pH=7.89; organic matter=1.89%) with medium fertility. Three individual herbicides at different rates and/or in combination with hand hoeing once were tested in comparison with hand hoeing twice and weedy check control treatments. The chemical structure, concentration, time and type of spraying of each treatment were shown in Table 1. The herbicides were applied by using a Knapsack sprayer equipped with one nozzle boam and water volume of 200 L/feddan.

Field samples and other observations were recorded, either with maize plants or weed population as follows:

Weeds development: After 15 days from spraying, weed samples were collected within the two experimental seasons by randomly hand pulling of grown weeds from one square meter of each plot. Weeds were identified and classified into grasses and broad-leaved weeds. The fresh and dry weights of shoot biomass (g m^{-2}) of both groups of weeds were determined individually.

Maize development:

Vegetative growth: Maize samples were taken simultaneously with weed samples. Samples of five plants of maize were taken randomly from each plot to determine several vegetative characteristics including the plant height, fresh and dry weights (g) and number of leaves per plant.

Yield and it's components: At harvest stage (120 days from sowing), random samples of ten guarded plants were taken from each plot to estimate ear length (cm), ear weight (g), number of rows/ear, number of grains/row, weight of grains/ear (g), weight of 100 grains (g) and the total grain yield by ardab/feddan (ardab=140 kg)

Chemical composition: The total nitrogen in grains of treated or untreated plants was determined colorimetrically according to the methods of Yeun and Follard[23].

Determination of the inhibitory and stimulatory effects of the three herbicides on the growth and development of weed and crop plants were accounted according to the equations of El-Shazly *et al.*[24] and Itokawa *et al.*[25]. The data on weeds and maize plants were subjected to standard analysis of variance and the means were combined using least significant differences at 0.05[26].

Percent of germination inhibition =

$$\frac{\text{Number of germinating grains in control} - \text{Number of germinating grains in treatments}}{\text{Number of germinating grains in control}} \times 100$$

Percent of growth inhibition =

$$100 - \left(\frac{\text{Average length after treatment of the sample}}{\text{Average length after treatment of the control}} \times 100\right)$$

RESULTS AND DISCUSSION

Effect of herbicide/hand hoeing treatment on the growth and development of weeds: It was found that the three herbicides of Gesaprim, Bentazone and Fluroxypyr at different concentrations significantly inhibited the growth and development of broad-leaved weeds such as (*Prtulaca oleracea*, *Chenopodium murale*, *Convolvulas arvensis* and *Corchorus olitorios*) and narrow leaves (i.e. *Solanum nigram*, *Cynodon dactylon*, *Sorgham halepensis* and *Echinochloa colonum*), either such herbicides applied alone or in combination with hand hoeing once within the two successive seasons (Table 2). It was obvious that applying Gesaprim, Bentazone and Fluroxypyr herbicides alone at different concentrations substantially inhibited the fresh (53.84-92.38%) and dry (45.52-92.19%) weights of shoot biomass of broad-leaved weeds in the two successive seasons, meanwhile in the narrow leave weeds by (5.35-92%) and (5.32-92%), respectively. The three herbicides were more effective in controlling the broad-leaved weeds rather than narrow leave weeds by significantly inhibiting the fresh and dry weights of shoot biomass, irrespective of the type and rate of application. However, Gesaprim showed wide spectra for controlling the narrow and broad-leaved weeds rather than Bentazone and Fluroxypyr, which were acting on broad leave only.

Applying the 3 herbicides at low concentrations followed by using hand hoeing once gave, to a large extent, similar results to those herbicides applied alone at moderate or higher concentrations for controlling the narrow and broad-leaved weeds grown with the maize plants.

Table 1: Chemical structure, rate, time and type of herbicides application

Treatments	Common name	Chemical name	Manufacture	Application rate	Type of application	Time of application	Physiological stage
Gesaprim (80% WP)	Atrazine	2-chloro-4-(ethyleamino)-6-isopropylamino-s-triazine	CIBA-Geigy Corn.	*0.375 kg/feddan 0.50 kg/feddan 0.75 kg/feddan	Pre-emergence	Sowing day	Seedling stage
Bazagran (48% EC)	Bentazone	3-isopropyl-1H-2,1,3-benzothiadiazin-(4)-3H-one 2,2-dioxide	BASF-AG Corn.	*0.375 kg/feddan 0.50 kg/feddan 0.75 kg/feddan	Post-emergence	Two weeks after sowing	Seedling stage
Starane (20% EC)	Fluroxypyr	4-amino-3,5-dichloro-6-fluoro-2-pyridyloxyacetic acid	Dow Chemical Corn.	*0.10 kg/feddan 0.15 L/feddan 0.2 L/feddan	Post-emergence	Two weeks after sowing	Seedling stage
Hand hoeing once	---	---	---	---	Post-emergence	Two weeks after sowing	Seedling stage
Hand hoeing twice	---	---	---	---	Post-emergence	Two weeks after sowing	Seedling stage
Unweeded check (control) (control)	---	---	---	---	---	---	---

* Followed by one hand hoeing after two weeks from herbicidal application

Table 2: Herbicidal effect on the developing of weeds infested maize within the two successive seasons

		1st year survey (2003)								2nd year survey (2004)							
		Fr. Wt. (g m^{-2})				Dr. Wt. (g m^{-2})				Fr. Wt. (g m^{-2})				Dr. Wt. (g m^{-2})			
Treatments	Conc. (Per feddan)	Broad leaf	Inhibition (%) of control	Narrow leaf	Inhibition (%) of control	Broad leaf	Inhibition (%) of control	Narrow leaf	Inhibition (%) of control	Broad leaf	Inhibition (%) of control	Narrow leaf	Inhibition (%) of control	Broad leaf	Inhibition of (%) control	Narrow leaf	Inhibition of (%) control
1	0.500	90.00	76.92	210.00	44.44	18.95	72.77	35.00	44.00	68.25	84.17	128.25	63.87	12.83	84.13	21.38	63.38
	0.750	48.00	87.69	30.00	92.00	10.11	85.47	5.00	92.00	45.25	89.50	37.00	89.57	8.50	89.50	6.18	89.55
2	0.500	165.00	57.69	335.00	10.66	34.74	50.09	55.83	10.67	109.50	74.60	323.25	8.94	20.58	74.59	53.88	8.90
	0.750	30.00	92.38	333.00	9.86	6.31	90.93	55.00	12.00	33.50	92.23	318.25	10.42	6.32	92.19	53.05	10.39
3	0.150	180.00	53.84	350.00	6.66	37.92	45.52	58.34	6.65	141.25	67.24	336.5	5.35	26.55	67.26	56.00	5.32
	0.200	32.00	91.79	340.00	9.33	6.74	90.31	56.37	9.80	34.00	92.11	330.00	7.04	6.38	92.12	55.00	7.01
4	0.375	107.00	72.56	60.00	84.00	22.63	67.49	10.00	84.00	82.00	80.98	66.50	81.24	15.40	80.98	11.08	81.26
5	0.375	40.00	89.74	90.00	76.00	8.42	87.90	15.00	76.00	38.00	91.18	94.75	73.30	7.15	91.17	15.80	73.28
6	0.100	42.00	89.23	107.00	71.46	8.84	87.30	17.92	71.32	41.75	90.31	110.00	69.01	7.85	90.30	18.35	85.88
7	---	240.00	38.46	120.00	68.00	50.53	27.40	20.00	68.00	198.75	53.39	218.00	38.59	37.38	53.85	36.45	38.37
8	---	36.00	90.76	15.00	96.00	7.58	89.11	2.50	96.00	36.00	91.65	22.00	93.80	6.78	91.62	3.67	93.79
9	---	390.00	--	375.00	--	69.61	--	62.50	--	431.25	--	355.00	--	81.05	--	59.15	--
LSD $_{0.05}$	---	19.82	--	19.5	--	10.67	--	3.25	--	8.89	--	12.97	--	1.68	--	2.16	--

1: Gesaprim; 2: Bentazone; 3: Fluroxypyr; 4: Gesaprim+ hand-hoeing once; 5: Bentazone + hand-hoeing once; 6: Fluroxpyr + hand-hoeing once; 7: Hand-hoeing once; 8: Hand-hoeing twice; 9: Unweedy check (control)

Table 3: Herbicidal effect on the shoot biomass of maize plants within the two successive seasons

		1st year survey (2003)								2nd year survey (2004)							
Treatments	Conc. (Per feddan)	Plant height (cm)	Increasing (%) of control	No. of leaves/ plant	Increasing (%) of control	Fr. wt (g)	Increasing (%) of control	Dr. wt (g)	Increasing (%) of control	Plant height (cm)	Increasing (%) of control	No. of leaves/ plant	Increasing (%) of control	Fr. wt (g)	Increasing of (%) control	Dr. wt (g)	Increasing of (%) control
1	0.500	173.25	17.45	14.00	19.14	721.75	72.80	140.98	76.93	177.00	26.65	13.50	17.39	743.00	83.51	149.55	83.51
	0.750	192.75	30.67	15.00	27.65	740.00	77.16	144.55	81.41	195.00	39.89	14.75	28.26	900.00	122.22	181.10	122.20
2	0.500	170.75	15.76	13.25	12.76	651.75	55.82	125.65	57.69	169.25	21.10	13.75	19.50	698.25	72.40	140.48	72.36
	0.750	174.00	17.96	14.00	19.14	695.00	66.16	137.75	70.36	171.75	22.89	13.00	13.04	725.00	79.01	145.90	79.01
3	0.150	165.50	12.20	13.00	10.63	643.25	53.79	127.58	59.73	161.25	15.38	13.00	13.04	661.75	63.39	133.15	63.37
	0.200	172.00	16.61	13.50	14.89	653.25	56.18	127.58	59.73	171.25	22.54	13.25	15.21	703.25	73.64	141.48	73.59
4	0.375	180.25	22.20	14.25	21.27	723.25	72.92	141.25	77.27	178.00	27.37	14.25	23.91	746.75	84.38	150.25	84.35
5	0.375	187.00	26.77	14.25	21.27	740.00	76.92	144.50	81.35	186.25	33.27	14.50	26.08	823.25	103.27	165.65	103.25
6	0.100	180.75	22.54	14.25	21.27	731.75	74.95	142.99	79.40	183.75	31.48	14.50	26.08	768.25	89.69	154.60	89.69
7	---	155.75	5.59	12.25	6.38	543.25	29.88	106.10	33.03	146.25	4.65	12.75	10.86	620.00	53.08	124.73	53.04
8	---	211.50	43.38	15.25	29.78	768.25	83.68	150.08	88.53	206.00	47.93	16.00	39.13	916.75	126.35	184.45	126.31
9	---	147.50	--	11.75	--	418.25	--	79.68	--	139.75	--	11.50	--	405.00	--	81.50	--
$LSD_{0.05}$	---	14.69	--	1.42	--	77.07	--	16.55	--	9.51	--	1.24	--	71.55	--	15.08	--

1: Gesaprim, 2: Bentazone, 3: Fluroxypyr, 4: Gesaprim + hand-hoeing once, 5: Bentazone + hand-hoeing once, 6: Fluroxpyr + hand-hoeing once, 7: Hand- hoeing once, 8: Hand- hoeing twice, 9: Weedy check(control)

Table 4: Herbicidal effect on the yield components of maize plants within the two successive seasons

		1st year survey (2003)									
Treatments	Conc. (Per feddan)	Ear length (cm)	Increasing (%) of control	Ear weight (g)	Increasing (%) of control	Ear grain weight (g)	Increasing (%) of control	No. of row/ ear	Increasing (%) of control	No. of grains/ row	Increasing (%) of control
1	0.500	19.50	11.42	200.00	13.17	185.00	48.00	14.00	21.73	46.00	21.85
	0.750	21.33	21.88	237.75	34.51	205.75	64.00	16.00	39.13	47.75	26.49
2	0.500	19.00	8.57	193.00	9.33	166.75	33.40	13.00	13.04	43.00	13.90
	0.750	19.50	11.42	196.00	11.31	173.00	38.60	14.00	21.73	45.25	19.86
3	0.150	18.25	4.28	188.25	6.50	158.25	26.60	12.00	4.34	42.75	13.24
	0.200	19.25	10.00	196.00	10.89	170.00	36.00	13.00	13.04	45.00	19.20
4	0.375	21.18	21.02	228.25	29.13	199.00	29.20	15.00	30.43	47.00	24.52
5	0.375	20.83	19.02	220.00	24.46	190.00	52.00	14.50	26.08	46.25	22.51
6	0.100	20.25	15.71	215.00	21.64	191.75	53.40	14.50	26.80	46.00	21.85
7	---	18.50	5.71	181.75	2.82	135.00	8.00	12.00	4.34	40.25	6.26
8	---	21.33	21.88	261.75	48.09	215.00	72.00	16.00	30.43	49.00	29.80
9	---	17.50	--	176.50	--	125.00	--	11.50	--	37.75	--
$LSD_{0.05}$	---	2.13	--	17.63	--	14.43	--	2.01	--	4.56	--
		1st year survey (2003)									
Treatments	Conc. (Per feddan)	Ear length (cm)	Increasing (%) of control	Ear weight (g)	Increasing (%) of control	Ear grain weight (g)	Increasing (%) of control	No. of row/ ear	Increasing (%) of control	No. of grains/ row	Increasing (%) of control
1	0.500	20.00	17.64	211.75	46.03	190.50	42.96	14.00	16.66	45.25	16.77
	0.750	21.25	25.00	233.25	60.86	201.75	51.40	16.00	33.33	47.80	23.35
2	0.500	18.25	7.35	195.75	35.00	174.25	30.01	13.00	8.33	42.25	9.03
	0.750	19.88	11.05	203.25	40.17	190.00	42.58	14.00	16.66	45.25	16.77
3	0.150	17.75	4.41	193.25	33.27	171.75	28.89	13.00	8.33	42.00	8.38
	0.200	19.00	11.76	198.00	36.72	178.25	33.77	13.50	12.50	44.00	13.54
4	0.375	20.83	22.52	225.00	55.17	189.25	42.02	15.00	25.00	47.25	21.93
5	0.375	20.63	21.35	218.75	50.86	195.00	46.34	14.50	20.83	47.00	21.29
6	0.100	20.50	20.58	215.75	48.78	192.00	44.09	14.50	20.83	46.75	20.64
7	---	17.80	5.47	195.00	34.48	168.25	26.26	12.50	4.16	42.00	8.38
8	---	21.83	28.41	240.00	56.51	231.75	73.92	16.50	37.50	51.25	32.25
8	---	17.00	--	145.00	--	133.25	--	12.00	--	38.75	--
$LSD_{0.05}$	---	1.66	--	20.34	--	12.94	--	1.88	--	3.51	--

1: Gesaprim; 2: Bentazone; 3: Fluroxypyr; 4: Gesaprim+; 5: Bentazone + hand-hoeing once; 6: Fluroxpyr + hand-hoeing once; 7: Hand-hoeing once; 8: Hand-hoeing twice; 9: Weedy check (control)

Hand hoeing twice was the most effective treatment for controlling the narrow and broad-leaved weeds associated with maize as compared with other herbicidal treatments or weedy control. The hand hoeing twice treatment significantly inhibited the fresh and dry shoot biomass of such weeds by (90.67-96%). However, less response was obtained with hand hoeing once, which inhibited the weeds growth by (27.4-53.85%) as compared with control (Table 2).

Effect of herbicides/hand hoeing treatments on maize development

Vegetative growth: With regards to all investigated growth parameters, it was found that the three herbicides and hand hoeing treatments significantly increased the plant height, number of leaves and shoot biomass of maize plants. This response was more pronounced on the fresh and dry weights rather than on the plant height and number of leaves per plant, particularly in the second

Table 5: Herbicidal effect on the yield and protein content of maize plants within the two successive seasons

		1st year survey (2003)				2nd year survey (2004)			
				Increasing (%) of control				Increasing (%) of control	
Treatments	Conc. (Per feddan)	Grain yield (ardab/ feddan)	Protein content (%)	Grain yield	Protein content	Grain yield (ardab/ feddan)	Protein content (%)	Grain yield	Protein content
1	0.500	23.00	9.29	60.16	16.85	24.00	9.47	61.07	14.15
	0.750	26.65	9.40	85.58	18.23	27.00	9.65	81.20	16.68
2	0.500	20.17	8.28	40.38	4.15	22.15	8.50	48.65	2.78
	0.750	22.10	8.63	53.89	8.55	23.90	8.78	60.40	6.16
3	0.150	19.85	8.19	38.23	3.01	21.70	8.30	45.63	0.36
	0.200	21.90	8.49	51.81	6.79	23.70	8.68	59.06	4.95
4	0.375	25.12	9.20	74.93	15.72	26.00	9.35	74.49	13.05
5	0.375	24.60	8.91	71.30	12.07	25.70	9.22	72.48	11.48
6	0.100	24.11	8.70	67.89	9.43	25.10	9.28	68.45	12.21
7	---	17.20	8.11	19.77	2.01	18.15	8.27	21.81	Nil
8	---	27.12	9.06	88.85	13.96	27.80	9.28	86.52	12.81
9	---	14.36	7.95	---	---	14.90	8.27	---	---
$LSD_{0.05}$	---	0.92	0.29			0.99	0.39		

1: Gesaprim, 2: Bentazone, 3: Fluroxypyr, 4: Gesaprim + hand-hoeing once, 5: Bentazone + hand-hoeing once, 6: Fluroxpyr + hand-hoeing once, 7: Hand-hoeing once, 8: Hand-hoeing twice, 9: Weedy check (control)

season (Table 3). It was clear that hand hoeing twice has a potential effect on increasing the vegetative growth of maize rather than with the herbicidal treatments. Hand hoeing twice increased plant height by (43.38-47.93%), number of leaves per plant by (29.78-39.13%), fresh and dry weights by (83.68-126.31%) over weedy check. Hand hoeing once gave less response which resulted in increasing the fresh and dry weights by (29.88-53.08%) and slightly increased the plant height and the number of leaves per plant which were estimated at (4.65-10.86%). Applying the three herbicides alone significantly increased the plant height by (12.2-39.89%), number of leaves/plant by (10.6328.26%), fresh weight by (53.79-122.22%) and dry weight by (57.69-122.2%) of shoot biomass of maize as compared with control in the two seasons. No significant differences were found between applying the herbicides alone at high concentration and applying them at low dose, followed by hand hoeing once on the maize growth and development as compared with control in the two seasons.

Crop yield and it's components: Increasing the yield and yield constitutes, including ear length, ear weight, ear grain weight, number of row/ear and number of grains/row was clearly pronounced with hand hoeing twice rather than applying herbicides alone as compared with control. The hand hoeing twice treatment significantly increased ear length by (21.88-28.41%), ear weight by (48.09-65.51%), ear grain weight by (72.00-73.92%), number of row/ear by (30.43-37.5%) and number of grains/row by (30.43-32.25%) within the two seasons (Table 4). However applying the 3 herbicides alone significantly increased ear length by (4.28-25%), ear weight by (6.5-60.86), ear grain weight by (26.60-64.00%), number of row/ear by (4.34-39.13%) and number of grains/row by (8.38-26.49%) as compared with control.

The effect of applying herbicides either alone or by hand hoeing once was more effective on increasing the grain yield as shown in Table 5. Slight significant differences were found between the herbicidal treatments concerning the maize yield, irrespective of rate or type of application, in the two seasons. However, hand hoeing twice was the most effective treatment for increasing the maize yield as compared with other treatments. It was found that hand hoeing twice has a substantial effect on increasing the grain yield (86-88%) of maize as compared with herbicides applied alone (40-85%) or in combination with hand hoeing once (52-74%), irrespective of rates of application. Hand hoeing once gave the lowest increases in the grain yield, which was estimated by 19.77-21.8% as compared with other treatments and control (Table 5).

The three herbicides slightly increased the protein content in maize grains either applied alone or in combination with hand hoeing once as compared with control (Table 5). Applying Gesaprim alone at moderate and higher concentrations substantially increased the protein content in maize seeds by (14.51-18.23%) as compared with Bentazone (2.78-8.55%) and Fluroxypyr (0.36-6.78%). Not much difference was found between applying the three herbicides either alone or in combination with hand hoeing once and hand hoeing twice for increasing protein content of maize seeds. However, hand hoeing once did not show any response in increasing the protein content as compared with control within the two seasons.

Applying the three herbicides either alone or in combination with hand hoeing once gave promising results for controlling a wide range of narrow and broad-leaved weeds and increasing the yield and it's constitutes of maize plants in the two successive seasons. However, hand hoeing twice without using herbicides was the most effective method amongst other treatments for controlling such weeds and increasing the yield of maize and it's components. These findings have been supported by several studies which indicated that the efficiency of hand hoeing twice in controlling weed infested maize was equal to, or more than many of the recommended herbicides such as Atrazine, Fluroxypyr and Pyridate which are

considered the most popular chemical-weed control practice in maize field[14,17,27]. Similarly, El-Bially[28] and Ahmed[29] have confirmed that hand hoeing twice was the best weed control treatment used in maize as compared with several herbicides including Cianazin, Alakhlor, Dimethalin as well as Atrazin, Bentazone and Fluroxypyr[16].

It was obvious that applying Gesaprim (Atrazine) alone at moderate or high concentrations showed superiority in controlling the narrow and broad-leaved weeds rather than Bentazone, or Fluroxypyr which were effective only on broad-leaved weeds, irrespective of rate of application. However, applying the three herbicides at low concentration, followed by hand hoeing once gave, to a large extent, similar results to those chemicals applied alone at moderate or high concentrations on controlling weeds. The results were in conformity with those from Changsaluk and Changsaluk[30]. Who reported that Fluroxypyr had no deleterious effect on the growth of narrow leave weeds e.g. itchgrass (*Rottboellia cochinchinensis*), goosegrass (*Eleusine indica*) and running grass (*Brachiaria reptans*) that aggressively infested sweetcorn in Thailand, even used at the higher concentration (160 a.i./rai). Similarly, Moshtohry *et al.*[16] found that Fluroxypyr and Bentazone used separately by 1L/feddan have failed to suppress grass infested maize fields. On the mode of action of Fluroxypyr, Roushdy[31] described that, the compound significantly decreased the fresh and dry weights of jute (*Corchorus olitorius*), markedly decreased the content of growth promoters e.g. auxins, gibberellins and cytokinins, increased growth inhibitors and considerably reduced the total amount of photosynthetic pigments by 18.3% as compared with untreated jute plants. Research on maize-controlling weeds confirmed that Atrazine was a highly effective herbicide for suppressing grasses and broad leave weeds by more than 80% within 4 weeks of treatment without affecting target crop, in converse with Fluroxypyr, which besides it's selectivity on broad leave weeds the compound negatively affected the growth of maize treated plants[20,30]. Rout and Satapathy[12] declared that Atrazine was more than 90% efficient in reducing the dry weight of either narrow or broad-leaved weed infested maize in comparison with other chemical weed control methods. Sonaa[32] found that applying Atrazine as a post-sowing broadcast on the soil of maize field either alone or in combination with sulfur gave good weed control and resulted in significantly greater plant height, ear length and diameter, No. of ears/row, No. of grains/cob, 1000 grain wt., grain yield, grain protein, oil and carbohydrate content.

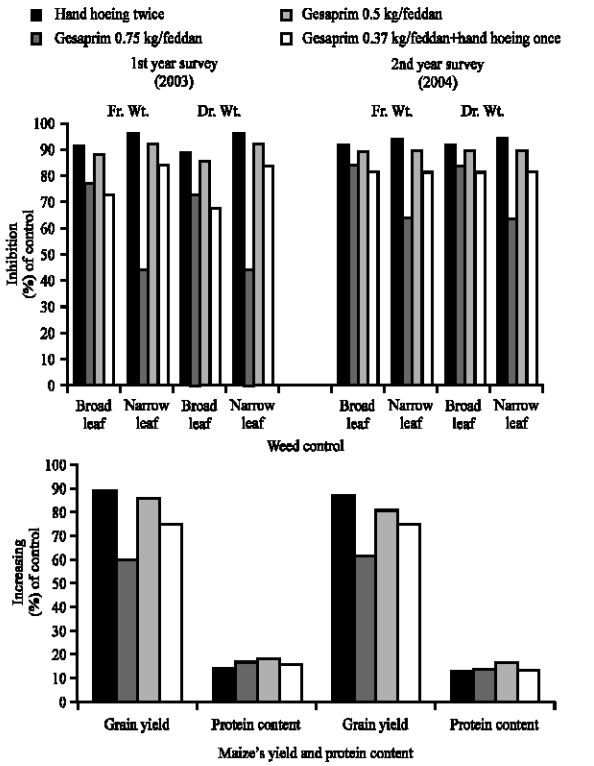

Fig. 1: The potancy of Gesaprim on weed control and maize productivity within the two successive seasons

Increasing the yield and it's components of maize and raising grain protein content, either by applying the herbicides alone or in combination with hand hoeing once could be explained in terms of suppressing growth and development of the associated weeds which, subsequently reflected in increasing ear length, ear weight, ear grain weight, weight of 100 grains, number of row/ear and number of grains/row. In this regard, Sharma *et al.*[3] recorded a promising result in increasing the total grain yield of maize and it's constitutes by using Atrazine and Metalacholr which totally attributed to the reduction which occurred in the density and dry matter accumulation of weeds. The results from Salarzai[11] referred to the efficiency of Atrazine in increasing maize yield, which was estimated at 5.16 t ha^{-1} against 3.12 t ha^{-1} in the control treatment. However, several researchers proved that hand hoeing twice was the most effective treatment which resulted in maximum improvement in yield of maize rather than using other chemical weed control treatments[33,34]. Mekky[27] indicated that the superiority of hand hoeing twice increased maize yield which accounted for 19.75 ardab/faddan as compared with several herbicides such as Pyredate, Fluroxypyr, or BAS635.

The important view, which might emerge from the present study, is that firstly, applying the Gesaprim, as a pre-emergence herbicide is the preferable treatment for controlling broad and narrow leave weeds in maize plants rather than the two other post-emergence herbicides (Bentazone and Fluroxypyr). Secondly, it would be better to use the hand hoeing twice treatment without using any chemicals or the herbicide Gesaprim either alone or combined with hand hoeing once for controlling the weeds and increasing the grain yield of maize (Fig. 1). However, much consideration should be given concerning the suitable costs of chemicals/labourers and/or environmental impacts.

REFERENCES

1. Anonymous, 1992. Minya agricultural development project. 114-EG Interim Evaluation.
2. Brendler, F., 2002. Potato-a difficult weed to control. Cartoffelbau, No. 9-10: 401-404.
3. Sharma, V., D.R. Thakur and J.J. Sharma, 1998. Effect of metachlor and its combination with atrazine on weed control in maize (*Zea mays*). Indian J. Agron., 43: 677-680.
4. Zaciragic, C. and D. Grabo, 2003. Herbicides of BASF-AG Company with emphasis on the protection of major crops wheat and maize. Proc. 2nd Weed Conf., Sarajevo, Bosnia and Herzogovina, 6-7 June, Herbologia., 4: 213-219.
5. Lepiece, D., J.F. Salembier and A. Thompson, 2001. Primus (florasulam 50 g^{-1}), a new triazolopyrimidine sulfonanilide herbicide to control broad-leaved weeds in maize when applied in early postemergence (1 to 6 leaf stage of maize). Preliminary results. Proc. 53rd Intl. Symp. Crop Protection, Gent, Belgium, 8 May, Part II. Mededelingen, 66: 681-704.
6. Decoin, M., 2003. Weed control in large scale-farming, what's new? New authorized herbicides, registered mixes, withdrawals, reduction in doses of urea. Phytoma, No., 564: 27-31.
7. Isaacs, M.A., H.P. Wilson and J.E. Toler, 2003. Combinations of sethoxydim with postemergence broadleaf herbicides in sethoxydim-resistant corn (*Zea mays*). Weed Technol., 17: 224-228.
8. Fausey, J.C. and K.A. Renner, 2001. Broadleaf control in corn (*Zea mays*) and soybean (*Glycine max*) with CGA-248757 and flumiclorac alone and in tank mixtures. Weed Technol., 15: 399-407.
9. Okazov, P.N. and Z.P. Okazova, 2002. Protection of maize crops from weeds. Kukuruza-I-Sorgo. No. 2: 18-21.
10. Rapparini, G., 2002. Weed control in maize and sorghum. Informatore-Agrario, 58: 73-90.
11. Salarzai, A., 2001. Effect of different herbicides on weed population and yield of maize (*Zea mays* L.). Pak. J. Agric. Sci., 38: 75-77.
12. Rout, D. and M.R Satapathy, 1996. Chemical weed control in ranted maize (*Zea mays*). Indian J. Agron., 39: 166-167.
13. Rola, J. and H. Rola, 1990. Control of triazine-resistant weeds in maize in southwest Poland. Zeitschrift fure Pflanzenkrankheiten und Pflanzenschutz, 12: 509-514.
14. Yehia, Z.R., H.R. El-Wekil, G.M. Mkhial and M.S. Tewfik, 1992. Control of atrazine-tolerant broad-leaved weeds in maize by fulrxypyre. Assiut J. Agric. Sci., 23: 159-170.
15. MacDonald, R.T., J.C Hall, J.J. O'-Toole and C.J. Swanton, 1993. Field binweed (*Convolvulus arvensis*) control with fluroxypyre. Weed Technol., 7: 966-971.
16. Moshtohry, M.R., M.A Brhoma, M.W. Habib and Z.R. Yehia, 1995. The influence of interaction between weed control methods N fertilization levels on maize (*Zea mays* L.). Annals of Agric. Sci., Moshtohor, 33: 579-587.
17. Hassanein, A.M., 1996. Studies on the biological activity of some new low rate herbicides. M.Sc Thesis, Fac. Agric., Minia Univ., Egypt, pp: 119.
18. Wahab, M.F. and S.I. Attala, 1998. Effect of weed control and soil moisture regime on maize production. Fayoum J. Agric. Res. Dev., 12: 1-10.
19. ChihMing, W., W.C. Yuh, C.M Wu and C.Y. Wang, 2003. Differential tolerance in inbred corn (*Zea mays*) in response to bentazone. Plant Protection Bulletin Taipei, 45: 53-64.
20. Vettakkorumakankav, N.N., S. Deshpande, T.A. Walsh and J. C. Hall, 2002. Physiological effect of clopyralid on corn as determined by bioassay and light-scattering spectroscopy. Weed Sci., 50: 713-720.
21. Carvalho, F.T., J. Pupim-O, M.A. Cavazzana and A.L Melhoranca, 1999. Effeciency of pre and post-emergence herbicides for the control of weeds in maize. Controle quimico de plantas daninhas nos cerrados: Ata e anais . XII reumiao de Pesquisadores em Controle de plantas daminhas nos cerrados, 23 e 24 de junho de1999, Corumba, MS, brazil. Documentos-EMBRAPA-Agropecuaria-Oeste No. 3. pp: 84-87.
22. Rapparini, G., G. Campagna and F. Paci, 2001. Control of *Abutilon theophrasti* in maize. Informatore Agrario, 57: 69-74.

23. Yeun, S.H. and R. Follard, 1952. The determination of nitrogen in agricultural materials by Nessler reagent. J. Sci. Food Agric., 3: 442-448.
24. El-Shazly, A.M., M.A. Khalifa and A.H. El-Sebae, 1980. Toxic extracts of weeds. II. The effect of interaction between aqueous weed extracts and herbicides on wheat seedling. Alex. J. Res., 28:1695-703.
25. Itokawa, H., Y. Oshida, A. Ikuta, H. Inatomi and T. Adachi, 1982. Phenolic plant growth inhibitors from the flower of *Cucurbita pepo*. Phytochemistry, 21: 1935-1937.
26. Snedecor, G.W. and W.G. Cochran, 1967. Statistical Methods. The Iowa State Univ., USA Press, pp: 593.
27. Mekky, M.S., 2001. Control of broadleaf weeds in maize (*Zea mays* L.). Minia J. Agric. Res. Develop., 21: 387-399.
28. El-Bially, M.E., 1995. Efficiency of atrazine with other herbicides used alone in sequence or as tank mix in maize. Annals Agric. Sci., Ain Shams Univ., Cairo, 40: 709-721.
29. Ahmed, S.A., 1999. Effect of plant population and some weed control treatments on maize and its associated weeds. J. Agric. Sci. Mansoura Univ., 24: 5605-5625.
30. Changsaluk, S. and S. Changsaluk, 2003. Proceedings of 41st Kasetsart University Annual Conference, 3-7 February, Subject: Plants and Agricultural Extension and Communication, pp: 532-538.
31. Roushdy, S.S., 1997. Differential response of *Zea mays* and *Corchorus olitorius* to postemergence application of fluroxypyr. Egyptian J. Physiol. Sci., 21: 395-408.
32. Sonaa, H.E., 1993. Effect of gesaprimalone or in combination with sulphur in controlling weeds as well as the yield and chemical composition of maize plants. Bulletin of Faculty of Agricultural, University of Cairo, 44: 71-94.
33. Hussein, H.F., 1997. Effect of the stimulative nitrogen-dose and weed control treatments on maize plants and associated weeds. Egypt. J. Applied Sci., 12: 8-22.
34. Abd-El-Samie, F.S., 2000. Efficiency of metribuzin application methods in five maize varieties. Proc. 9th Conf. Agron., Minufiya Univ., 1-2 Sept, pp: 211-222.