

## Improved Weed Control Methods in Maize (*Zea mays* L.) By Using Single Herbicides and Their Combinations at Reduced Rates with Mineral Oil Adjuvant

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### Abstract:

A field experiment was carried out in Mallawy Agricultural Research Station, Agricultural Research Center, El-Minia Governorate, during 2015 and 2016 seasons to evaluate the efficacy of certain single herbicides at full rate and their mixtures at reduced rate (50 % of full rate) with mineral oil on weed control and maize productivity. Each experiment comprised of fourteen treatments as follow: the first five treatments were pendimethalin, s-metolachlor, acetochlor, nicosulfuron and dicamba+topramizon used as single herbicides at full rate 682.5, 672, 840, 24 and 63 g a.i./fed., respectively, the next six treatments were the sequential application of the same previous herbicides at half of the rate plus mineral oil at 1 % v/v and the last three treatments were (foramsulfuron sodium 3.35 % + iodosulfuron-methyl sodium 0.11 + thien carbazonemethyl 1.07) used at full rate 22.65 g a.i./fed., hoeing twice and untreated treatment as control. Randomized Complete Block Design (RCBD) with four replications was used. The major weeds were *Euphorbia geniculata*, Ortega, *Xanthium strumarium* L., *Corchorus olitorius* L. and *Ipomoea eriocarpa* L. as broad-leaved weeds and *Echinochloa colonum* L. and *Brachiaria reptans* L. as grasses weeds.

The findings of this study showed that the sequential application of two herbicides with different site of action (pendimethalin or s-metolachlor or acetochlor combination with nicosulfuron or dicamba+topramizon) at reduced rate plus mineral oil at 1 % v/v gave better result in controlling broad-leaved and total weeds than applying the same previous herbicides alone at full rate, while, pendimethalin and s-metolachlor alone at full rate were the best in controlling grasses weeds.

The best total weed control efficiency (91.95 and 91.5 %) was achieved under treatment hoeing twice which was equal statistically with foramsulfuron sodium + iodosulfuron – methyl sodium + thien carbazonemethyl (91.48 and 90.05 %) and with acetochlor mixture with nicosulfuron at reduced rate plus mineral oil (87.19 and 85.37 %) controlling effect as compared with untreated treatment at first survey in both seasons, respectively. Moreover, those treatments also gave the significantly higher grain yield (28.14, 27.20 and 24.98 ardab/fed.) and (26.90, 25.44 and 23.36 ardab/fed. in the both seasons, respectively), as well as ear grains weight and 100-grain weight as compared with untreated treatment.

**Keywords:** Maize, weed control, herbicides, reduced rate, mineral oil.

### Introduction:

Maize (*Zea mays* L.) is one of the most important among the cereal

crops in the world's agricultural economy. Maize grains are used for human consumption, feed for poultry

and livestock, for extraction of edible oil and also for starch and glucose industry.

Weeds infestation is one of the serious pests that interfere with maize crop through competition and allelopathy resulting in direct loss to quantity and quality of the product. (Pannacci and Onofri, 2016) found that crop yield losses in the untreated treatment compared to the highest obtained yield with herbicides treatments, ranging from 33 to 91 %. Other researchers mentioned that maize yield losses caused by weed competition have been amounted by 50% (Abouzienna *et al.* 2013) and 33.7 % (Saady, 2013).

Weeds control in maize fields is, very essential for obtaining good yield. Different weed control methods have been used to manage the weeds, but mechanical and chemical methods are more frequently used for the weeds control than any other control methods. Mechanical methods including hand weeding and hoeing are still useful but are getting expensive; laborious and time – consuming. Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop because it is cheaper, faster and it gives better control.

Previous studies shown that use of currently single herbicides at the full rates did not give satisfactory results to weeds control, especially if weeds community has many and different species, whereas many of them containing active ingredient is activity only on some weed species without other, have relatively short time of action and provide only a narrow spectrum weed control (Amin *et al.*

2008). As that continuous usage of same herbicides or similar herbicides have same site of action year after year over several years caused changing weed flora, poor controlling and promoted the evolution of herbicides resistant weed biotypes. Hence, choice of mixtures two or more active ingredients for weed control generally increases herbicide efficacy (Pannacci *et al.* 2007) and (Sulewska *et al.* 2012). This is due to provide a broad spectrum of the target weed species and slowdown selection of herbicide-resistant weed biotypes (Zollinger, 2011).

Post-emergence herbicides must overcome a variety of barriers to their entry into plants in order to be effective. For example, herbicides applied to foliage must remain on the leaf instead of beading up and rolling off, then get past the leaf hairs and waxes on the leaf surface, then finally penetrate through the cell walls and cell membranes (DiTomaso, 1999). An adjuvant is any compound that is added to a herbicide formulation or tank mix to facilitate the mixing, application, or effectiveness of that herbicide. Adjuvants may also improve a herbicide's efficacy (Costa *et al.* 2005) so that the concentration or total amount of herbicide required to achieve a given effect is reduced (Naddem *et al.* 2008). Mineral oil adjuvant include paraffinic oil which can soften wax, or cause cracks in the cuticle, allowing increased herbicide penetration (Green, 2001).

Keeping in view the above mentioned thoughts, it was hypothesized that herbicides mixtures at reduced rate could be effect when applied with adjuvant; therefore, present

study was, objective to evaluate the efficacy of certain single herbicides at full rate and their mixtures at half of the rate; tank mix with mineral oil 1 % on weed control and maize productivity.

#### Materials and Methods:

A field experiment was carried out in Mallawy Agricultural Research Station, Agricultural Research Center, El Minia Governorate, during 2015 and 2016 seasons, each trial comprised of fourteen treatments as follow:

1. Pendimethalin [*N*-(1-ethylpropyl)-3, 4-dimethyl-2, 6 dinitrobenzeneamine] Known commercially as "Stomp extra 45.5 % SC" used at full rate 682.5 g a.i./fed. applied after sowing before irrigation as pre – emergence (PRE).

2. S – metolachlor [A mixture of (S)-2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide and (R)-2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide] known commercially as "Dual gold 96 % EC" used at full rate 672g a.i./fed. applied as pre-emergence.

3. Acetochlor[2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl)acetamide] known commercially as "Harness 84% EC" used at full rate 840g a.i./fed. applied as pre-emergence.

4. Nicosulfuron [2-[[[(4, 6-dimethoxy-pyrimidinyl) amino] carbonyl] amino] sulfonyl]-N, N-dimethyl-3-pyridinecarboxamide] known commercially as "Active 6 % SC" used at full rate 24 g a.i. /

fed. applied at 4-6 leaves stage of maize as post – emergence (POST).

5. Dicamba 16 % [3, 6-dichloro-2-methoxybenzoic acid.] + Topramezon 5 % [(3-(4, 5-dihydro-3-isoxazolyl)-2-methyl-4-(methylsulfonyl) phenyl) (5-hydroxy-1-methyl-1*H*-pyrazol-4-yl) methanone] known commercially as "Stellar star 21 % SL" used at full rate 63 g a.i./fed. applied as post-emergence.

6. Stomp extra used at 50 % reduced rate 341.25 g a.i./fed. as PRE + Active at 50 % reduced rate 12 g a.i./fed. as POST tank-mixed with mineral oil known commercially as Super misrona 94% EC added to the spray tank at 2 L/fed. (1% v/v) of the total spray volume.

7. Stomp extra at 341.25 g a.i. /fed. as PRE + Stellar star at 31.5 g a.i./fed. as POST tank-mixed with mineraloil at 1 %.

8. Dual gold at 336g a.i./fed as PRE + Active at 12g a.i./fed. as POST tank-mixed with mineraloil at 1 %.

9. Dual gold at 336g a.i./fed as PRE + Stellar star at 31.5 g a.i./fed. as POST tank-mixed with mineraloil at 1 %.

10. Harness at 420 g a.i./fed as PRE + Active at 12 g a.i./fed. as POST tank-mixed with mineraloil at 1 %.

11. Harness at 420 g a.i./fed as PRE + Stellar star at 31.5g a.i./fed. as POST tank-mixed with mineraloil at 1 %.

12. Foramsulfuron sodium 3.35 % [2-[[[(4, 6-dimethoxy-2-pyrimidinyl) amino] carbonyl]

amino] sulfonyl]-4-(formylamino)-*N*,*N*-dimethylbenzamide]+ Iodosulfuron-methyl sodium 0.11 % [methyl 4-iodo-2-[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino] carbonyl] amino] sulfonyl] benzoate, sodium salt] + Thiencarbazone-methyl 1.07 % [methyl 4-[[[(4,5-dihydro-3-methoxy-4-methyl-5-oxo-1*H*-1,2,4-triazol-1-yl) carbonyl] amino] sulfonyl]-5-methyl-3-thiophenecarboxylate] known commercially as "Maister power 4.53 % OD" used at full rate 22.65 g a.i./fed. applied as POST.

13. Hoeing twice at 20 and 40 days after sowing.

14. Untreated (control).

The experimental field was well prepared and calcium super phosphate (15.5 % P<sub>2</sub>O<sub>5</sub>) was applied during soil preparation at the rate of 200 kg/fed. Randomized Complete Block Design (RCBD) with four replicates was used. Each plot area was 10.5 m<sup>2</sup> (5 rows X 3.0 m length). The row-to-row and plant-to-plant distances were 70 cm and 25 cm, respectively. The maize cultivar "single cross 128" (*Zea mays* L.) was used in both seasons. Maize grains were sowing manually on one side in hills at the rate of 10 Kg/fed. during the 1<sup>st</sup> week of June in both seasons. The seedlings were thinned to one plant per hill before the 1<sup>st</sup> irrigation. Nitrogen and potassium fertilizers were applied in the form of urea (46 % N) and potassium sulphate (48 % K<sub>2</sub>O) at the rate of 120 kg N/fed. and 50 kg K<sub>2</sub>O/fed., respectively, in two equal doses before the 1<sup>st</sup> and 2<sup>nd</sup> irrigations. Herbicides were applied after

sowing and before irrigation as pre – emergence and at 3-6 leaves stage of maize as post-emergence using "Knapsack hand sprayer CP3 20 liter" equipped with one nozzle even flat fan calibrated to deliver spray volume of 200 L/fed. Harvested was done on the 1<sup>st</sup> week of October in the both seasons. The experimental field had been in a corn - Sugar beet (*Beta vulgaris* L.) rotation cycle for the last two years. All other agronomic practices for growing maize crop were remained constant and uniform for all treatments, except those under study.

Mechanical and chemical analysis of the soil experimental site showed that the soil texture was silty clay loam and containing 21.3, 8.43 and 186 ppm for N, P and K, respectively.

#### Collected data:

##### A. Weed survey:

The weed species from one square meter chosen at random from each plot were hand pulled out and identified at the species level using the weed identification manual of (Täckholm 1974), then separated into two groups i.e. broad-leaved and grasses weeds. Thereafter, weeds were air-dried for three days and then were oven dried at 70°C for 48 hr., until a constant weight was reached. The dry weight of each group (g/m<sup>2</sup>) was recorded. Weed survey was carried out twice i.e. after 60 and 90 days after sowing. Weed control efficiency (WCE) was calculated as follow:  $WCE = \frac{DWC - DWT}{DWC} \times 100$ . Where, DWC = Dry weight of weeds from control plot and DWT = Dry weight of weeds from treated plot.

## B. Maize data:

At harvest, random samples of ten guarded maize plants were taken from the middle three rows of each plot to estimate the following traits: Ear grains weight g, 100-grains weight (g). And grain yield ar-dab/feddan (1ardab =140 kg) was calculated based on weight grains yield obtained from each plot, the weight were adjusted to 15.5 % moisture content.

### Statistical analysis:

All data were statistically analyzed according to technique of Analysis of Variance (ANOVA) for the randomized complete block design with four replications as mentioned by (Gomez and Gomez 1984), using "SAS" computer software package (SAS, 1999). Duncan's Multiple Range Test (DMRT) was used for compare among treatment means (Duncan 1955). Weed dry weight were square root transformed ( $\sqrt{x+0.5}$ ) prior to analysis to correct for normal distribution. Data in tables are reported as non- transformed (original data).

## Results and Discussion:

### A. Effect of weed control treatments on weeds:-

#### 1. Effect of weed control treatments on broad-leaved weed control at first survey (60 days after maize sowing).

Table 1 show the effect of various weed control treatments on the dry weight of broad-leaved weeds accompanied by their equivalent weed control efficiency at first survey in 2015 and 2016 seasons. Significant effect of different studied treatments on the dry weight of broad-leaved

weeds was observed as compared with untreated treatment. Presented data indicated that all studied treatments gave more than 60.92 and 52.51% weed control efficiency in 2015 and 2016 seasons, respectively, as compared with untreated (control).

The maximum broad-leaved weeds control efficiency was observed under treatment of hoeing twice 93.96 and 94.32% in the first and second seasons, respectively, which was statistically at bar with foramsulfuron sodium+iodosulfuron-methyl sodium+thiencarbazone-methyl as a ready formulated mixtures at full rate 22.65 g a.i./fed. which gave 93.05 and 93.66 % controlling effect in the first and second seasons, respectively.

All herbicides sequential application at reduced rate (PRE+POST + mineral oil) gave excellent control of broad-leaved weeds compared to the use of same herbicides alone at full rate without adjuvant exception of nicosulfuron alone at full rate in 2016 season.

Acetochlor or pendimethalin or s-metolachlor + nicosulfuron with mineral oil at reduced rate provided weed control efficiency by about 87.53, 83.24 and 82.31 % in 2015 season and 86.66, 79.38 and 76.97 % in 2016 season, respectively. Acetochlor or pendimethalin or s-metolachlor+ dicamba+topramizon with mineral oil at reduced rate ranked second and provided about 73.33, 71.65 and 72.61 % and 72.46, 70.87 and 69.93 % controlling effect in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

Among herbicides applied alone at full rate, nicosulfuron and dicamba+topramizon both being at

par with each other show the superiority over treatments pendimethalin, s-metolachlor and acetochlor alone at full rate. The maximum dry weight of broad-leaved weeds was found under untreated treatment in the both seasons.

Similar trend of results was observed during the second survey (at 90 days after maize sowing) in both seasons as shown in Table 2.

## 2. Effect of weed control treatments on grasses weed control at first survey (60 days after maize sowing).

Concerning the effect of various weed control treatments on the dry weight of grasses weeds recorded at first survey in both seasons, the data in Table 1 reveal that all weed control treatments significantly reduced the dry weight of the grasses weeds, compared to untreated (control).

**Table 1. Dry weight of broad-leaved, grasses and total weeds at first survey (60 DAS) as influenced by various weed control treatments.**

Treatments		Rate g a.i. / fed.	First survey at 60 days after maize sowing on 2015 and 2016 seasons.													
			Season 2015						Season 2016							
			Broad-leaved weeds		Grasses weeds		Total weeds		Broad-leaved weeds		Grasses weeds		Total weeds			
			Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %		
T <sub>1</sub>	Pendimethalin 45.5 % CS.	682.5	233.78 b	62.21	6.42 cd	88.98	240.21 b	64.52	293.89 b	55.10	6.28 gf	90.68	300.17 bc	58.42		
T <sub>2</sub>	S – metolachlor 96 % EC.	672	241.80 b	60.92	5.62 d	90.35	247.42 b	63.45	310.81 b	52.51	4.29 g	93.64	315.09 b	56.35		
T <sub>3</sub>	Acetochlor 84 % EC.	840	219.58 b	64.51	12.08 bcd	79.28	231.65 b	65.78	238.33 bc	63.59	14.50 c-f	78.49	252.82 bcd	64.98		
T <sub>4</sub>	Nicosulfuron 6 % SC.	24	181.07 b	70.73	12.26 bcd	78.96	193.34 b	71.44	196.15 cd	70.03	15.07 cde	77.63	211.22 de	70.74		
T <sub>5</sub>	Dicamba+Topramizon 21 % SL.	63	187.81 b	69.64	13.88 bc	76.19	201.68 b	70.21	209.43 cd	68.00	20.62 bc	69.40	230.04 cd	68.13		
T <sub>6</sub>	T <sub>1</sub> +T <sub>4</sub> + Mineral oil.	341.25 + 12+2L	103.69 d	83.24	8.37 bcd	85.64	112.06 c	83.45	134.95 ef	79.38	9.24 efg	86.29	144.19 fg	80.03		
T <sub>7</sub>	T <sub>1</sub> +T <sub>5</sub> + Mineral oil.	341.25 + 31.5+2L	175.42 b	71.65	8.01 bcd	86.25	183.43 b	72.90	190.67 cd	70.87	9.82 d-g	85.42	200.49 de	72.23		
T <sub>8</sub>	T <sub>2</sub> +T <sub>4</sub> + Mineral oil.	336 + 12+2L	109.42 cd	82.31	9.02 bcd	84.52	118.45 c	82.50	150.72 de	76.97	9.27 efg	86.24	159.99 ef	77.84		
T <sub>9</sub>	T <sub>2</sub> +T <sub>5</sub> + Mineral oil	336 + 31.5+2L	169.46 bc	72.61	7.09 cd	87.84	176.55 b	73.92	196.83 cd	69.93	8.65 efg	87.16	205.48 de	71.54		
T <sub>10</sub>	T <sub>3</sub> +T <sub>4</sub> + Mineral oil.	420 + 12+2L	77.14 de	87.53	9.58 bcd	83.56	86.73 cd	87.19	87.30 f	86.66	18.33 cd	72.79	105.63 gh	85.37		
T <sub>11</sub>	T <sub>3</sub> +T <sub>5</sub> + Mineral oil.	420 + 31.5+2L	165.00 bc	73.33	13.57 bc	76.72	178.56 b	73.62	180.22 cde	72.46	13.74 -f	79.60	193.97 def	73.13		
T <sub>12</sub>	Foramsulfuro sodium + Iodosulfuron–methyl sodium + Thiencazone–methyl 4.53 % OD.	22.65	43.02 ef	93.05	14.52 bc	75.09	57.53 d	91.50	41.51 g	93.66	30.35 b	54.95	71.86 hi	90.05		
T <sub>13</sub>	Hoeing twice at 20 - 40 DAS.		37.34 f	93.96	17.15 b	70.57	54.49 d	91.95	37.20 g	94.32	24.34 bc	63.88	61.54 i	91.48		
T <sub>14</sub>	Untreated (control).		618.70 a	0.00	58.28 a	0.00	676.97 a	0.00	654.52 a	0.00	67.38 a	0.00	721.89 a	0.00		
F test =			**		**		**		**		**		**			

Any two means in the same column sharing same letters did not differ significantly by Duncan at 5 % level of probability.

WCE= Weed control efficiency.

**Table 2. Dry weight of broad-leaved, grasses and total weeds at second survey (90 DAS) as influenced by various weed control treatments.**

Treatments		Rate g a.i. / fed.	Second survey at 90 days after maize sowing on 2015 and 2016 seasons.											
			Season 2015						Season 2016					
			Broad-leaved weeds		Grasses weeds		Total weeds		Broad-leaved weeds		Grasses weeds		Total weeds	
			Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %	Dry weight	WCE %
T <sub>1</sub>	Pendimethalin 45.5 % CS.	682.5	477.80 bc	54.20	14.91 de	82.35	492.70 bc	56.31	551.96 c	49.91	20.36 f	82.93	572.32 c	53.14
T <sub>2</sub>	S – metolachlor 96 % EC.	672	520.38 b	50.11	11.41 e	86.49	531.79 b	52.84	646.36 b	41.34	18.41 f	84.57	664.77 b	45.57
T <sub>3</sub>	Acetochlor 84 % EC.	840	437.47 bcd	58.06	23.26 b-e	72.46	460.73 bcd	59.14	487.55 cd	55.75	37.08 cde	68.92	524.63 cd	57.04
T <sub>4</sub>	Nicosulfuron 6 % SC.	24	392.1 bcd	62.41	29.43 bc	65.16	421.56 bcd	62.61	444.10 def	59.70	42.39 cde	64.47	486.49 cde	60.16
T <sub>5</sub>	Dicamba+Topramizon 21 % SL.	63	404.91 bcd	61.18	21.49 cde	74.55	426.40 bcd	62.19	455.71 de	58.64	40.29 cde	66.24	496.00 cde	59.39
T <sub>6</sub>	T <sub>1</sub> +T <sub>4</sub> + Mineral oil.	341.25 + 12+2L	324.19 d	68.92	19.68 cde	76.70	343.87 d	69.50	352.20 g	68.04	29.79 def	75.03	381.99 f	68.72
T <sub>7</sub>	T <sub>1</sub> +T <sub>5</sub> + Mineral oil.	341.25 + 31.5+2L	374.99 cd	64.05	25.67 bcd	69.61	400.66 cd	64.47	403.61 d-g	63.37	36.45 cde	69.45	440.06 def	63.97
T <sub>8</sub>	T <sub>2</sub> +T <sub>4</sub> + Mineral oil.	336 + 12+2L	348.44 d	66.60	19.46 cde	76.96	367.90 cd	67.37	362.89 fg	67.07	26.80 ef	77.54	389.69 f	68.09
T <sub>9</sub>	T <sub>2</sub> +T <sub>5</sub> + Mineral oil	336 + 31.5+2L	374.57 cd	64.09	17.20 cde	79.64	391.77 cd	65.26	430.89 d-g	60.90	26.95 def	77.41	457.85 def	62.51
T <sub>10</sub>	T <sub>3</sub> +T <sub>4</sub> + Mineral oil.	420 + 12+2L	197.79 e	81.04	21.13 cde	74.98	218.92 e	80.59	211.69 h	80.79	44.36 cde	62.82	256.05 g	79.03
T <sub>11</sub>	T <sub>3</sub> +T <sub>5</sub> + Mineral oil.	420 + 31.5+2L	346.28 d	66.80	18.36 cde	78.26	364.64 cd	67.66	395.33 efg	64.12	26.96 def	77.41	422.28 ef	65.42
T <sub>12</sub>	Foramsulfuro sodium + Iodosulfuron–methyl sodium + Thien carbazone–methyl 4.53 % OD.	22.65	157.86 ef	84.87	38.17 b	54.80	196.03 ef	82.62	145.79 i	86.77	69.51 b	41.74	215.31 gh	82.37
T <sub>13</sub>	Hoeing twice at 20 - 40 DAS.		100.30 f	90.38	38.25 b	54.71	138.55 f	87.71	120.69 i	89.05	52.00 bc	56.42	172.69 h	85.86
T <sub>14</sub>	Untreated (control).		1043.14 a	0.00	84.46 a	0.00	1127.60 a	0.00	1101.91 a	0.00	119.31 a	0.00	1221.23 a	0.00
F test =			**		**		**		**		**		**	

Any two means in the same column sharing same letters did not differ significantly by Duncan at 5 % level of probability.

WCE= Weed control efficiency.

It is clear from recorded data on grasses weed control efficiency in Table 1 that all studied treatments gave 70.52 to 90.35 % and 54.95 to 93.64 % controlling effect in 2015 and 2016 seasons. Minimum dry weight of grasses weeds was recorded in treatment s-metolachlor 5.62 and 4.29 g/m<sup>2</sup> with 90.35 and 93.64 % and pendimethalin 6.42 and 6.28 g/m<sup>2</sup> with 88.98 and 90.68 % controlling effect both alone at full rate as compared with untreated treatment which gave higher weight 58.28 and 67.38 g/m<sup>2</sup> in the first and second seasons, respectively.

Use the same two herbicides at half of the rate in sequence combina-

tion with other herbicides (nicosulfuron or dicamba+topramizon) at reduced rate plus mineral oil found effective, ranked second and provided about 84.52 to 87.87 % and 85.42 to 87.16 % controlling effect in both seasons, respectively. Moreover, the other herbicidal treatments and hoeing twice were significantly higher than the untreated (control). The minimum control against grasses weeds was found under treatment hoeing twice 17.15 g/m<sup>2</sup> with 70.57 % in 2015 season and under treatment foramsulfuron sodium+iodosulfuron–methyl sodium+thien carbazone–methyl 24.34 g/m<sup>2</sup> with 63.88% in 2016 season as compared with un-

treated treatment. Similar trend of results was observed during the second survey (90 Days after sowing) in both seasons as shown in Table 2.

### 3. Effect of weed control treatments on total annual weeds control at first survey (60 days after maize sowing).

Table 1 show the effect of various chemical treatments and hoeing twice on the control of total annual weeds present at the site of application in comparison with the untreated treatment. Statistical analysis of the presented data in Table 1 shows that the dry weight of total annual weeds were significantly affected by various weed control treatments.

During the first survey the treatments of hoeing twice and foramsulfuron sodium + iodosulfuron-methyl sodium + thien-carbazone-methyl provided a consistent control of total weeds by 91.95, 91.48 % and 91.5, 90.05 % in the first and second seasons, respectively.

Applying post-emergence nicosulfuron or dicamba+topramizon at 50% reduced rate plus mineral oil in sequence with pre-emergence acetochlor or pendimethalin or smetolachlor at 50 % reduced rate gave excellent results in control total annual weeds and higher than use the same herbicides alone at full rate, where, 50 % acetochlor + nicosulfuron with mineral oil ranked second with 87.19 and 85.37 % controlling effect in the both seasons, respectively, without significantly different from treatments hoeing twice.

Other sequential application treatments plus mineral oil gave good results on control total annual weeds with 72.9 to 83.45 % and 71.54 to

80.03 % controlling effect in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. Post-emergence nicosulfuron, dicamba+topramizon and pre-emergence pendimethalin, smetolachlor and acetochlor both of them alone at full rate gave adequate control of total annual weeds with 63.45 to 71.44 % and 56.35 to 70.74 % controlling effect in 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. Similar trend of results was observed during the second survey (90 Days after sowing) in both seasons as shown in Table 2.

As the results of the present study are summarized, it can be suggested that hoeing twice treatment was the most effective treatment for controlling the total annual weeds associated with maize as compared with other herbicidal treatments and untreated (control). These results are in line harmony with those obtained by Sharara *et al.* (2005), Kandil and Kordy, (2013), Marzouk, (2013) and Saady, (2013) who found that treatment of hoeing twice at 25 and 40 DAS was the best treatment in controlling total weeds and caused reduction in weed dry weight reaching 90.5 % compared to untreated (control).

The best chemical treatments for controlling total annual weeds without significant different with hoeing twice was achieved under treatment foramsulfuron sodium + iodosulfuron-methyl sodium + thien-carbazone-methyl at full rate 22.65 g a.i. /fed., since this herbicide contain three active ingredient to broad spectrum of weed control and its new formulation OD was formed with oil and can be used without adjuvant.

Obtained resulted from this study show that total weed control



increased and was more consistent when two herbicide application (PRE + POST plus oil adjuvant) were used at reduced rate compared with a single-herbicide application (either PRE or POST) alone at full rate. Hence, use of two different chemicals with different site of action gave broad spectrum of weed control and enhanced the efficacy of weed control. In this respect, several research findings indicated that two herbicides applications increase weed control compared with a single herbicide Bogdan *et al.* (2007), Pannacii *et al.* (2007) and Amine *et al.* (2008). Some researchers also shown that two herbicides applications at reduced rate increase weed control compared with a single herbicide Kenezivic *et al.* (2003) and Sulewska *et al.* (2012). Also, Dogan *et al.* (2005), Kir and Dogan, (2009) and Sostarcic *et al.* (2015) shown that in the most cases effective weed control can be achieved with reduced rates of single herbicides with adjuvant addition. Idziak and Woznica, (2010) and Woznica and Idziak, (2015) who have shown that two herbicides applications at reduced rate with adjuvant increase weed control compared with a single herbicide.

The present finding from this study showed that due to at least two or more of the weed species flora in these study occur as dominating weed flora on the most of the growing maize fields in the region and none of herbicides application alone at full rate would do not provide acceptable broad spectrum weed control under this weed flora, therefore, it is important to use herbicides with different site of action in sequence at reduced

rate with mineral oil adjuvant to achieve broad spectrum weed control.

## **B. Effect of weed control treatments on maize yield and its components:-**

### **1. Ear grains weight (g).**

The mentioned data in Table 3 reveal that the weed control treatments had a significant influence on ear grains weight in both seasons. All weed control treatments significantly increased ear grains weight/g over the untreated treatment.

Thus, (acetochlor+ nicosulfuron+mineral oil) at reduced rate was the best and gave 219.6 and 212.84 g/ear higher than other sequential application of reduced herbicides plus oil adjuvant, but the higher of all the treatments in this respect 236.9 and 234.07 g/ear was achieved under treatment hoeing twice which was equal statistically with foramsulfuron sodium+iodosulfuron–methyl sodium + thiencarbazone–methyl 228.55 and 222.05 g/ear and with the above mentioned treatment (acetochlor+ nicosulfuron+mineral oil) at reduced rate in the first and second seasons, respectively. The average increased for ear grains weight/g in those treatments as compared with untreated treatment was 123.49, 115.61 and 107.17% and 125.04, 113.48 and 104.63% in the first and second seasons, respectively.

Other treatments of sequential application of pendimethalin or smetolachlor or acetolachlor + nicosulfuron or dicamba+topramezon at reduced rate + mineral oil provided good ear grains weight over same herbicides used alone at full rate and this herbicides which used alone at

full rate gave ear grains weight higher than untreated treatment.

These findings are in line with those observed by Sharara *et al.* (2005) who found that hoeing twice increase the ear grains weight by 72.00 - 73.92 % and chemical control increased ear grains weight by 26.60-64.00 % as compared with (control). The minimum value of ear grains weight 106 and 104.01 g/ear was obtained under untreated treatment. These results are in confirmatory with those reported by Abouziena *et al.* (2013) who found that weed competition caused significant reduction in the value of ear grains weight by 50.5% than hoeing twice.

## 2. 100-grain weight (g).

The data regarding 100-grain weight g are presented in Table 3 perusal of the data indicated that 100-grain weight was significantly affected by various studied weed control treatments.

Hoeing twice treatment produced the highest 100-grain weight (41.51 and 42.06 g) followed by treatment foramsulfuron sodium + iodosulfuron–methyl sodium + thien-carbazone–methyl (40.6 and 41.48 g) and treatment acetochlor+ nicosulfuron+oil mineral (40.1 and 40.26 g) in the first and second seasons, respectively. The above mentioned treatments increased parameter of 100-

grain weight by 39.16, 36.11 and 34.44 % in 2015 season and by 42.03, 40.07 and 35.96 % in 2016 season over the untreated treatment. Moreover, the other treatments applying sequential (PRE + POST + mineral oil) at reduced rate gave 100-grain weight higher than use these herbicides alone at full rate and these two groups gave 100-grain weight higher over untreated treatment and the average increased of those above treatments for 100-grain weight as compared with untreated treatment was 14.98 to 34.44 % and 13.04 to 35.96% in the first and second seasons, respectively. Saudy, (2013) found that treatment of hoeing twice was the effective practice for increasing 100-grain weight by 8.19% over control as well as Bashir *et al.* (2015) showed that the reduced rate of herbicides can be reduced up 50 % by addition adjuvant and increase 1000-grain weight of maize compared full dose without adjuvant and control. The minimum value of 100-grains weight (29.83 and 29.61 g) was obtained under untreated treatment. These results are confirmatory with those of Abouziena *et al.* (2013) who found that weed competition caused significant reduction in the value of 100-grains weight / g by 8.87 % than hoeing twice.

**Table 3. Effect of weed control treatments on yield and its components of maize.**

Treatments		Rate g a.i. / fed.	Season 2015			Season 2016		
			Ear grains weight g.	100 grains weight g.	Grain yield ard. / fed	Ear grains weight g.	100 grains weight g.	Grain yield ard. / fed
T <sub>1</sub>	Pendimethalin 45.5 % CS.	682.5	166.75 f	35.97 cde	16.25 ef	156.80 fg	35.39 ef	15.18 f
T <sub>2</sub>	S – metolachlor 96 % EC.	672	162.50 f	34.30 e	13.77 f	150.54 g	33.48 f	14.79 f
T <sub>3</sub>	Acetochlor 84 % EC.	840	173.10 ef	35.99 cde	18.89 de	164.85 efg	35.55 def	16.81 ef
T <sub>4</sub>	Nicosulfuron 6 % SC.	24	187.00 def	36.25 cde	21.25 cde	178.96 d-g	37.81 cde	19.72 cde
T <sub>5</sub>	Dicamba+Topramizon 21 % SL.	63	178.00 def	35.79 de	20.16 cde	175.99 d-g	36.93 cde	18.84 de
T <sub>6</sub>	T <sub>1</sub> +T <sub>4</sub> + Mineral oil.	341.25 + 12+2L	207.40 a-d	39.23 abc	22.97 bcd	202.63 bcd	39.43 abc	22.15 bcd
T <sub>7</sub>	T <sub>1</sub> +T <sub>5</sub> + Mineral oil.	341.25 + 31.5+2L	194.33 c-f	36.67 cde	21.54 cd	189.23 cde	38.41 b-e	20.90 cd
T <sub>8</sub>	T <sub>2</sub> +T <sub>4</sub> + Mineral oil.	336 + 12+2L	202.70 b-e	38.03 bcd	22.63 bcd	196.92 b-e	39.06 a-d	21.80 bcd
T <sub>9</sub>	T <sub>2</sub> +T <sub>5</sub> + Mineral oil	336 + 31.5+2L	186.55 def	36.38 cde	21.32 cde	183.60 c-f	37.86 cde	20.41 cde
T <sub>10</sub>	T <sub>3</sub> +T <sub>4</sub> + Mineral oil.	420 + 12+2L	219.60 abc	40.10 ab	24.98 abc	212.84 abc	40.26 abc	23.36 abc
T <sub>11</sub>	T <sub>3</sub> +T <sub>5</sub> + Mineral oil.	420 + 31.5 +2L	206.38 a-d	38.43 a-d	23.09 bcd	199.87 bcd	38.66 a-e	22.12 bcd
T <sub>12</sub>	Foramsulfuro sodium + Iodosulfuron–methyl sodium + Thien-carbazone–methyl 4.53 % OD.	22.65	228.55 ab	40.60 ab	27.20 ab	222.05 ab	41.48 ab	25.44 ab
T <sub>13</sub>	Hoeing twice at 20 and 40 DAS.		236.90 a	41.51 a	28.14 a	234.07 a	42.06 a	26.90 a
T <sub>14</sub>	Untreated (control).		106.00 g	29.83 f	9.04 g	104.01 h	29.61 g	7.41 g
F test			**	**	**	**	**	**

Any two means in the same column sharing same letters did not differ significantly by Duncan at 5 % level of probability.

### 3. Grain yield in ar-dab/feddan.

Data regarding the effect of weed control treatments on grain yield (ardab/fed.) are shown in Table 3 which clearly indicates grain yield (ardab/fed.) to be significantly affected by weed control treatments.

The significantly higher grain yield (28.14 and 26.90 ardab/fed.) was observed under treatment hoeing twice which was equal statistically at par with foramsulfuron sodium + iodosulfuron–methyl sodium + thien-carbazone–methyl (27.2 and 25.44 ardab/fed.) and with treatment acetochlor+ nicosulfuron+mineral oil (24.98 and 23.36 ardab/fed.). The average increased for grain yield in these treatments as compared with untreated treatment was 211.48, 201.02 and 176.48% and 263.22,

243.45 and 215.45% in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

There is a clear superiority of grain yield were found as a result of application herbicides in sequence combination (PRE + POST + oil mineral) at reduced rate from use the same herbicide alone at full rate. The average decreased of herbicides applied alone at full rate for grain yield ardab/fed. as compared with herbicides applied in combination sequence at reduced rate was 6.35 to 23.25 and 1.27 to 14.64% in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. While, the herbicide whether alone at full rate or in sequence at reduced rate plus mineral oil increased the grain yield of maize by 52.38 to 155.53 and 99.69 to 198.61% as compared with untreated treatment in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively.

Higher grain yield of maize under mechanical treatment (hoeing twice) and chemical treatments (foramsulfuron sodium + iodosulfuron-methyl sodium + thiencazone-methyl and acetochlor + nicosulfuron plus oil mineral may be due to the fact effective those treatments in control of weeds and reduced competition of weeds which lead to direct increase in uptake of nutrient, water and radiation which resulted in proper growth, development and increased photosynthetic efficiency of maize plants which resulted in ear grains weight and 100-grain weight ultimately resulting into increased grain yield.

These findings are in line with those observed by Hassan and Ahmed, (2005) and Saady, (2013) who reported that treatment of hoeing twice was the effective practice for increasing maize grain yield t/ha by 33.71 %. Moreover, Patel *et al.* (2006) and Sikkema *et al.* (2008) showed that mixture herbicide at different mode of action application at the 50% reduced rate versus an untreated check still allowed for increased corn yield (8.3 vs. 4.9 t/ha). On the other hand, the minimum values of grain yield (9.04 and 7.41 ardab/fed.) was obtained under untreated treatment. These results are confirmatory with those of Tesfay *et al.* (2014) who found that weed interference with maize crop in the treatment weedy check caused a relative yield loss by (63.66 and 75.71 %) in the both seasons, respectively, compared to the treatment of hand weeding and hoeing. Other researchers mentioned that maize yield losses caused by weed competition have been amounted by 8.87% Abouziena

*et al.* (2013) and 33-91% Pannacci and Onofri, (2016).

#### **Conclusion:**

Based on the findings emerged out from the present investigation, use of sequence herbicides with different site of action at reduced rate plus oil adjuvant rather than single herbicides at full rate is more effective in weed control and increased grain yield in maize. Also hoeing twice at 20 and 40 days after sowing maize was found to be effective for weed control and increased grain yield if laborers are available easily.

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## طرق مكافحة الحشائش المحسنة في الذرة الشامية باستخدام المبيدات المنفردة وتوليفاتها بالمعدلات المخفضة مع مادة مضافة الزيت المعدنى

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### الملخص

إجريت تجربة حقلية في محطة البحوث الزراعية بملوى، مركز البحوث الزراعية، محافظة المنيا، خلال موسمي ٢٠١٥ و ٢٠١٦. لتقييم فعالية بعض مبيدات الحشائش المنفردة بالمعدل الكامل وتوليفاتها بالمعدل المخفض (٥٠% من المعدل الكامل) مع الزيت المعدنى على مكافحة الحشائش وإنتاجية محصول الذرة الشامية. وإشتملت كل تجربة على ١٤ معاملة كالتالى: المعاملات الخمسة الأولى كانت (بنديميثالين، إس-ميتولاكلور، اسيتوكلور، نيكوسلفيرون ودايكмба+توبراميزون) استخدمت كمبيدات منفردة بالمعدل الكامل (٦٨٢,٥، ٦٧٢، ٨٤٠، ١٢ و ٦٣ جم مادة فعالة/ فدان)، على التوالي، كانت المعاملات الستة التالية هي التطبيق المتسلسل لنفس المبيدات السابقة بنصف المعدل مع إضافة زيت معدنى ١% حجم/حجم وكانت المعاملات الثلاث الأخيرة هي مبيد فورامسلفيرون الصوديوم+ ايودوسلفيرون ميثيل صوديوم +ثينكاربازون ميثيل بالمعدل الكامل، معاملة العزيق مرتين ومعاملة المقارنة. وكان التصميم التجريبي المتبع هو تصميم القطاعات الكاملة العشوائية مع استخدام أربع مكررات وكانت الحشائش الرئيسية في التجربة هي الشربة، الشبيط، الملوخيه والعليق الحولى كحشائش عريضة الأوراق و أبو ركة وحشيشة الأرناب كحشائش نجيلية.

أظهرت نتائج هذه الدراسة أن التطبيق المتتابع لمبيدتين مختلفين فى موقع التأثير (بنديميثالين أو إس-ميتولاكلور أو اسيتوكلور مع نيكوسلفيرون أو دايكمبا+توبراميزون) بالمعدل المخفض مع زيت معدنى ١% أعطى نتيجة أفضل في مكافحة الحشائش الكلية وعريضة الأوراق عن تطبيق نفس المبيدات السابقة منفردة وبالمعدل الكامل، بينما أعطى بنديميثالين وإس-ميتولاكلور منفردا وبالمعدل الكامل نتيجة أفضل في مكافحة الحشائش النجيلية.

تم تحقيق أفضل كفاءة في مكافحة الحشائش الكلية تحت معاملة العزيق مرتين (٩١,٩٥ و ٩١,٥%) وهى متساوية إحصائيا مع معاملة فورامسلفيرون الصوديوم+ايودوسلفيرون ميثيل+ثينكاربازون ميثيل (٩١,٤٨ و ٩٠,٠٥%) ومع معاملة أسيتوكلور + نيكوسلفيرون بالمعدل المخفض مع زيت معدنى (٨٧,١٩ و ٨٥,٣٧%) مقارنة مع معاملة الكنترول وذلك في الحصر الأول في كلا الموسمين، على التوالي. علاوة على ذلك، أعطت تلك المعاملات أيضا محصول الحبوب الأعلى معنويا (٢٨,١٤، ٢٧,٢٠ و ٢٤,٩٨ أردب / فدان) و (٢٦,٩٠، ٢٥,٤٤ و ٢٣,٣٦ أردب/ فدان في كلا الموسمين على التوالي) وكذلك وزن حبوب الكوز بالجرام ووزن ١٠٠- حبة بالجرام وذلك مقارنة بمعاملة المقارنة.

**الكلمات المفتاحية:** الذرة الشامية، مكافحة الحشائش، المبيدات، المعدل المخفض و زيت معدنى.