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Improving the Efficiency of Herbicides by Adding Mineral Oil on Maize (*Zea mays* L.) Crop and Associated Weeds

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A FIELD experiment was conducted during 2018 and 2019 seasons, at Sakha Agricultural Research Station, Kaferelshiekh, Egypt. To study the efficacy certain herbicides [Nicosulfuron (Shamshon 75%WG), Flumetsulam (Candy 80%WG), Bromoxynil+ Terbuthylazine (Monester 35%SE) and Nicosulfuron+ Bromoxynil (Scrop 75%WG)] at full rate (alone) (30g, 30g, 500cm^3 and 120g /fed.), respectively, and at used rate (75 or 50%) of full rate mixtures with mineral oil at 1 and 2%, beside, Maisterpower 4.53% OD (Foramsulfuron-sodium+ Iodosulfuron-methyl-sodium+ Thiencarbazone-methyl) at full rate (alone) 500cm^3/fed., (fed= feddan=0.42 hectare), hand hoeing (twice) and weedy check on weed control, productivity and grain quality. Each experiment was laid out a Randomized Complete Blocks Design.

Results revealed that both (Monester and Scrop) at used rate 75%+ min.oil 1% or Maister power at full rate gave more controlling effect on total weeds which was reflected to increase yield and its components, than other treatments in both seasons. Also, previous treatments gave increasing grain yield which was directly correlated with increasing vegetative growth traits, yield components and quality characters of grains compared to other treatments in both seasons.

Results indicated that the herbicide and adjuvants selected and relative amount used both of them must be tailored to specific condition of each application, therefore, it could replace the two herbicides (Monester or Scrop) at used rate 75% with min.oil 1% by Maister power at the full rate (alone), to avoid the appearance development weeds-resistant to herbicide, beside, without loosing weed control efficiency and grain yield, its components and quality in maize.

Keywords: Herbicide, Maize, Mineral oil, Reduce rates, Weed control, *Zea mays* L.

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop after wheat and rice in the world and as such, plays an important role in the global agricultural economy (Chandrasekaran et al., 2010; Hafez & Abdelaal, 2015). In Egypt, maize occupies a special position in the national economy, it is a multipurpose crop (used as a human food, animal and poultry feed; as well as for use in raw materials (e.g. for starch industry) and use in the preparation of other products. Maize bread is a staple food in most urban and rural areas in Egypt (Galal, 2002; Mohamed, 2020). The total cultivated area of maize in 2018 was about 2.5 million feddans (Agricultural Statistics, 2019). Its production is estimated to increase by 161 million ton to 1.2 billion ton by 2027 (OECDFAO, 2018). In spite of the high yield potential of maize, its yields in Egypt are still very low in comparison with advanced countries of the world. Although several high yielding varieties have been developed and released the required potential yield still cannot be achieved. This is significantly due to no or little importance being given to the weeds control practices by the farmers (Khaliq et al., 2004).

Weeds are among the serious constraints that limit maize production. The competition

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between weeds and maize is capable of reducing the quality and quantity of maize yield by over 30% (Mahmoodi & Ali, 2009). Weeds interfere with crop growth and yield through acquisition of required resources including light, water and nutrients (El-Sobky & El-Naggar, 2016). They are thus potentially a major constraint on crop production if not controlled (Ali et al., 2003). Thus, Pannacci & Onofri (2016) found that crop yield losses in the untreated treatment compared to the highest yield obtained with herbicides treatments, ranged from 33 to 91%. Other researchers mentioned that maize yield losses caused by weed competition have been 50% (Abouzinea et al., 2013) and 33.7 % (Saudy, 2013).

In this respect, Weed control in maize fields is essential for obtaining good yield. Different weed control methods have been used to manage weed control; mechanical and chemical methods are more frequently used for weed 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 management system because it is cheaper, faster and it gives better control.

Previous studies have shown that use of currently available single herbicides at the full rates did not give satisfactory results for weed control, especially if the weed community has high populations and many different species. Many of the herbicides contain an active ingredient which controls only some weed species. They thus provide only a narrow spectrum weed control (Amin et al., 2008). Also, the continuous usage of the same herbicides or similar group herbicides which have the same site of action year after year over several years caused changing weed flora, poor control and promoted the evolution of herbicide resistant weed biotypes. Hence, the choice of mixtures containing two or more active ingredients for weed control generally increases herbicide efficacy (Pannacci et al., 2007; Sulewska et al., 2012). This is due to a mix providing control of a broad spectrum of the target weed species and a slowdown of selection of herbicide-resistant weed biotypes (Zollinger, 2011).

A great effort is also extended to reducing herbicide usage for environmental, crop damage reduction and economic reasons while maintaining weed control capabilities. One of these efforts is through decreasing the recommended rate of herbicide application with the addition of adjuvants enabling no loss in its control efficiency.

Therefore, the objective of this study was improving the efficacy of certain herbicides used at reduced rates in tank mixtures with mineral oil at 1 % or 2% on yield, its components and associated weed control of maize.

Materials and Methods

Field experiments were conducted during successive summer seasons, namely 2018 and 2019 (Latitude 30̊ 48̀ N, Longitude 31̊ 35̀ E), at the Sakha Agricultural Research Station at Kaferelsheikh Governorate, Agricultural Research Centre (A.R.C.) Egypt. Their goal was to study the efficacy of certain herbicides at full rate and at used rates (75% and 50% of full rate) in mixtures with mineral oil at 1% or 2%, on yield, its components, quality and associated weed control of maize cultivar “triple cross 321” (*Zea mays* L.).

Each field trial included the following treatments:

1- Nicosulfuron “Shamshon 75 % WG” used at full rate 30 g/fed, applied at 4-6 leaves stage of maize as post – emergence.

2- Nicosulfuron at 75% of full rate (22.5g/ fed) + Mineral oil at 1%.

3- Nicosulfuron at 50% of full rate (15g/ fed) + Mineral oil at 2%.

4- Flumetsulam “Candy 80 % WG” used at full rate 30 g/ fed, applied at two weeks after sowing date of maize as post – emergence.

5- Flumetsulam at 75% of full rate (22.5g/ fed) + Mineral oil at 1%.

6- Flumetsulam at 50% of full rate (15g/ fed) + Mineral oil at 2%.

7- Bromoxynil + Terbuthylazine “Monseter 35 % SE” used at full rate 500cm^3/ fed, applied at 10 -15 days after maize sowing as post – emergence.

8- Bromoxynil + Terbuthylazine at 75% of full rate (375cm^3/ fed) + Mineral oil at 1%.

9- Bromoxynil + Terbuthylazine at 50% of full rate (250 cm^3/ fed) + Mineral oil at 2%.

10- Nicosulfuron+ Bromoxynil "Scrop 75% WG" used at full rate 120 g/ fed, applied at two weeks after maize sowing as post – emergence.

11- Nicosulfuron + Bromoxynil at 75% of full rate (90g/ fed) + Mineral oil at 1%.

12- Nicosulfuron + Bromoxynil at 50% of full rate (60g/ fed) + Mineral oil at 2%.

13- Foramsulfuron sodium 3.35% + Iodosulfuron–methyl sodium 0.11% + Thiencarbazone–methyl 1.07 % "Maisterpower 4.53 % OD" used at full rate 500cm^3/fed, applied at 4-6 leaves stage as post – emergence..

14- Hand hoeing Twice: At 20 and 40 days after sowing (DAS).

15- Untreated (control).

The following table explains Trade, common and chemical names, family group and site of action of the herbicides according to the pesticide manual (2012) and number of group according to (WSSA, 2011) classification:

Trade name	Common name	Chemical name	Family group	Site of action	WSSA Group
Shamshon 75% WG"	Nicosulfuron	[2-[(4, 6-dimethoxy-pyrimidinyl) amino] carbonyl] amino] sulfonyl]-N, Ndimethyl-3-pyridinecarboxamide]	sulfonylurea	Inh. (ALS/ AHAS) synth.	2
Candy 80% WG	Flumetsulam	[N-(2,6-difluorophenyl)-5-methyl[1,2,4] triazolo[1,5-a]pyrimidine-2-sulfonamide N-(2,6-difluorophenyl)-5-methyl[1,2,4] triazolo[1,5-a]pyrimidine-2-sulfonamide]	triazolopyrimidine	Inh. (ALS/ AHAS) synth	2
Monseter 35% SE"	Bromoxynil + Terbuthylazine	[2,6-dibromo-4-cyanophenyl octanoate 2,6-dibromo-4-cyanophenyl octanoate] + [6-chloro-N-(1,1-dimethylethyl)-N′-ethyl-1,3,5-triazine-2,4-diamine]	Hydroxybenzonitrile + 1,3,5-triazine	Inh. Photosystem II	6 + 5
Scrop 75% WG"	Nicosulfuron + Bromoxynil	[2-[(4, 6-dimethoxy-pyrimidinyl) amino] carbonyl] amino]sulfonyl]-N,Ndimethyl-3-pyridinecarboxamide] + [2,6-dibromo-4-cyanophenyl octanoate 2,6-dibromo-4-cyanophenyl octanoate]	Sulfonylurea + Hydroxybenzonitrile	Inh. (ALS/ AHAS) synth + Inh. Photosystem II	2 + 6
Maister power 4.53% OD	Foramsulfuron sodium 3.35% Iodosulfuron–methyl sodium 0.11% Thiencarbazone–methyl 1.07%	[2-[[[[(4, 6-dimethoxy-2- pyrimidinyl) amino] carbonyl] amino] sulfonyl]-4-(formylamino)-*N, N* dimethylbenzamide] + [methyl 4-iodo-2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2yl)amino] carbonyl] amino] sulfonyl] benzoate, sodium salt] + [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]	sulfonylurea	Inh. (ALS/ AHAS) synth	2
El-Nasar Pure	Mineral oil	2% complex Boron from Boron Ethanol Amine + 98% carrier Material able to be Dissolved in water			

A Randomized Complete Block Design (RCBD) with four replicates was used. Each plot area was 10.5 m^2 (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 "triple cross 321" (*Zea mays* L.) was used in both seasons. Maize grains were sown manually on one side in hills at the rate of 10 Kg/fed, on the 28 May 2018 and 3 June 2019. The seedlings were thinned to one plant per hill before the 1st irrigation. Herbicides were applied as shown for each treatment, using a "Knapsack hand sprayer CP_3 20 liter" equipped with one even flat fan nozzle calibrated to deliver a spray volume of 200L/fed Harvesting was done on the 27 and 29 September in 2018/19, respectively. Cultural practices for Maize were applied according to local recommendations. Soil texture was clay in both seasons. The mechanical and chemical soil analyses for the experimental sites are presented in Table 1 according to Jackson (1967) and Black et al. (1965).

The following data were recorded:

Weed survey

The weed species from one square meter were chosen at random from each plot at 60 days after sowing. Weeds 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, grasses) and total weeds were counted. Weeds were then air-dried for three days and then oven dried at 70ºC for 48 hr., until a constant weight was reached. The dry weight of each group (g/m^2) was recorded. Weed control efficiency (WCE) was calculated as follow:

$$\text{WCE \%} = \frac{\text{DWC} - \text{DWT}}{\text{DWC}} \times 100$$

where, DWC= Dry weight of weeds from control plot and DWT= Dry weight of weeds from each treated plot.

Maize vegetative growth characteristics

1- Leaf Area Index: The samples were taken after 75 days from sowing were calculated according to (Daughtry & Hollinger, 1984) as follows: LAI= LA/GA

where, LA is leaf area and GA is ground area.

2- Measurements of plant pigments: The photosynthetic pigments chlorophyll (mg/g) a, b and total were estimated in samples of fresh leaves of maize according to Moran & Porath (1982)**,** The samples were taken 60 days after the application of herbicide treatments.

Yield and its components

At harvest, samples of ten plants were randomly taken from the central area of each plot to estimate the following traits: Ear diameter (cm), number of rows/ ear, ear grain weight (g), 100 grain weight (g) and grain yield ardab/feddan (1 ardab=140kg) was calculated based on the weight of grain yield obtained from each plot, the weights were adjusted to 15.5 % moisture content.

Maize grain quality

1- Determination of protein in maize grain: The total nitrogen was determined by micro-kjeldahl method according to A.O.A.C. (2000).

2- Determination of carbohydrates in maize grains: the total carbohydrate percentage was determined according to A.O.A.C. (2000).

Statistical analysis

All data were statistically analyzed according to technique of Analysis of Variance (ANOVA) for the randomized complete block design with four replicates as described by Gomez & Gomez (1984). Duncan (1955) multiple range tests were used for the comparison among means. All statistical analysis was performed using analysis of variance technique by means of MSTAT-C computer software package (Snedecor & Cochran, 1989).

TABLE 1. Some Mechanical and chemical properties of the soils (0-30cm), used in two seasons of study.

Seasons	Mechanical analysis				Chemical analysis	Available nutrients (ppm)									
	Sand %	Silt %	Clay %	Texture	OM %	PH	N	P	K	Ca^{++}	Mg^{++}	K^+	Na^+	Cl	So_4
2018	20.7	31.5	47.8	Clay	1.30	7.5	32	2.42	244	4.0	5.2	0.38	15.3	8.0	7.78
2019	22.5	26.2	51.3	Clay	0.65	7.7	33	2.64	246	5.5	4.5	0.19	18.9	11.0	8.09

Results and Discussion

During both growing seasons of maize, the major dominant weeds were wild jute (*Corchorus olitorius* L.), cocklebur (*Xanthium brasilicum* L.), white goosefoot (*Amaranthus album* L.), common purslane (*Portulaca olerceae* L.), bladder hibiscus (*Hibiscus trionum* L.) and nightshade (*Solanum nigrum* L.), as broadleaved weeds and deccan grass (*Echionchloa colona* L.), penz (*Dinebra retroflexa* L.) and signal grass (*Branchiaria reptans* L.) as grassy weeds.

Effect of weed control treatments

On weeds

Data presented in Table 2 revealed that; in general, all herbicides applied at reduced rates of 50% of the full rate (Shamshon at 15g, Candy at 15g, Monester at 250 cm^3 and Scrop at 60g/ fed) mixed with mineral oil at 2% gave significantly lower efficiency of weed control than that which was obtained by the same herbicide when applied at full rate without adding mineral oil. The reduction in the weed control efficacy was substantial compared to the fully weeded control. WCE's were; 26.8, 40.8, 45.6 and 47.2%, respectively, in the first season. A similar but generally slightly higher WCE was observed in the second season where the WCE was; 37.8, 49.4, 45.4 and 49.2%, respectively. In all instances these WCE's were lower than for the full application rate and generally significantly so. The reduction in the efficacy of WCE obtained by the 50% reduced rate herbicide treatments indicates that the use of mineral oil did not fully compensate for the reduced rate. However, it is worthy of note that in some circumstances, adding adjuvants will not significantly improve control (Bunting et al., 2004a).

Potentially the total amount of herbicide required to achieve a given effect is lower than the full rate (WSSA, 1982; Bunting et al., 2004b), with an adjuvants (Nadeem et al., 2008).

TABLE 2. Effect of weed control treatments on Dry weight of total weed (g/m^2) at 60 DAS in 2018 and 2019 seasons.

Treatments	Rate/fed	Dry weight of total weed (g/m^2)					
		2018 season			2019 season		
		Mean		%	Mean		%
Shamshon 75% WG	30 g	78.3	cd	51.5	461.7	cde	53.8
Shamshon +Min. oil	22.5 g + 1 %	51.0	e	68.5	326.3	fg	67.4
Shamshon +Min. oil	15 g + 2%	118.3	b	26.8	621.7	b	37.8
Candy 80% WG	30 g	78.7	cd	51.3	427.7	cdef	57.2
Candy +Min. oil	22.5 g + 2%	58.3	de	63.9	373.0	efg	62.7
Candy +Min. oil	15 g + 2%	95.7	c	40.8	506.0	bcd	49.4
Monestar 35% SE	500 cm^3	52.7	e	67.4	402.3	def	59.8
Monestar +Min. oil	375 cm^3 + 1 %	31.0	f	80.8	185.7	h	81.4
Monestar +Min. oil	250 cm^3 + 2%	88.0	c	45.6	546.3	bc	45.4
Scrop 75% WG	120 g	51.7	e	68.0	381.3	efg	61.9
Scrop +Min. oil	90 g + 1%	30.3	f	81.2	176.7	h	82.3
Scrop +Min. oil	60 + 2%	85.3	c	47.2	508.3	bcd	49.2
Maister power 4.53% OD	500 cm^3	27.3	f	83.1	166.7	h	83.3
Hand hoeing		46.0	ef	71.5	272.7	gh	72.7
Untreated weed		161.7	a	0.0	1000.0	a	0.0

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

The same herbicides at used rate 75% of full rate (Shamshon at 22.5g, Candy at 22,5g, Monester at 375cm^3 and Scrop at 90g /fed) with mineral oil at 1% gave significantly more control than the 50% rate reduction for total weeds for all herbicides in both seasons. Their WCE's were; 68.5, 63.9, 80.8 and 81.2% respectively, compared to the full control (Shamshon at 30g, Candy at 30g, Monester at 500cm^3 and Scrop at 120g/fed). The full rate without adjuvant gave WCE's of; 51.5, 51.3, 67.4 and 68.0%, respectively, in the first season. Similar results were found in the second season. Except for Shamshon used at 75% of full rate was significantly better than the full adjuvant free rate in both seasons. It thus appears that the use of an adjuvant can overcompensate for the reduced rate

Both of Monester at 375 cm^3 and Scrop at 90 g/fed, used at 75% of full rate with mineral oil at 1% gave significantly superior weed control to both Shamshon at 22.5g, and Candy at 22,5g at used 75% of full rate with mineral oil of 1% in both seasons. Monester and Scrop contain two active ingredients but Shamshon and Candy contain only one active ingredient. This may explain the greater broad spectrum weed control (Amin et al. 2008).

It can be concluded that the herbicide and adjuvants selected and relative amount used must be tailored to the specific conditions of each application. Therefore, the results from this study revealed that the concentration used both of adjuvants and herbicides must be tailored to the application to have/obtain significantly enhance and improve the herbicide efficiency (WSSA, 1982; Bunting et al., 2004b).

Also, the results from this study revealed that there were no significant differences in the efficiency of weed control between Maister power used at the full rate alone without adding mineral oil and Monester or Scrop used at 75% of full rate with added mineral oil at 1% Maister power is a ready-made formulated herbicide containing three active ingredients in OD formulation (Oil Dispersal). It therefore, provides a wide spectrum of weed control. These data suggest, it could be replaced the two previous herbicides used at 75% of full rate with mineral oil at 1% by Maister power at the full rate. Rotation of these chemicals could avoid repeated use of herbicides with the same mode of action (MOA), resulting in a delay in the development of herbicides-resistant weeds (Beckie, 2006; Norsworthy et al., 2012).

Moreover, there were no significant differences between Maister power at the full rate (500 cm^3/fed) and hand hoeing twice whereas the controlling effects were (83.1 and 71.5%) in the first season, while were (83.3 and 72.7%) respectively, in the second seasons.

Maize vegetative growth

The results in Table 3 revealed that there was a positive correlation between efficiency of herbicide on weed control and growth vegetative (plant height, LAI and total chlorophyll); whereas the (Monester at 375 cm^3 and Scrop at 90 g/fed) used at 75% of full rate with mineral oil at 1% and Maister power at the full rate (500 cm^3/fed) gave better weed control efficiency might attributed to the efficiency on weed elimination and consequently decreased weed competitive ability, also, enhancement of maize growth by plant height, consequently increased canopy shading of leaf area and containing greater amount of chlorophyll, so increase the efficiency of photosynthetic lead to increasing grain yield. these results are in the same line with those obtained by Soliman et al. (2011) who revealed that the favorable effects of control weeds on maize growth may gave more chance to better use the edaphic and aboveground environment resources and consequently stimulated growth of maize plants and minimized weed competition to a great extent. Confirming results in this respect were found by Tagour & Mosaad (2017) also, Fazal et al. (2009) that plant height is a key factor that contributes significantly to grain yield because taller plants capture more light and therefore had more photosynthetic available for grain filling, which, positively reflected on biological improvements and higher productivity of grain yield.

Grain yield and its components

Grain yield is an important parameter and function of an interaction among various yield components, which are affected differently by the growing conditions and crop management practices. Data in Tables 4, 5 revealed that the (Monester at 375cm^3 and Scrop at 90g/fed) used at 75% of full rate with mineral oil at 1% and

Maister power at the full rate (500cm^3/fed) gave significantly superiority on grain yield compared to other treatments whereas, the increasing were; 28.47, 29.51 and 31.50ardab /fed, respectively in the first season, the similar results were found in the second season.

TABLE 3. Effect of weed control treatments on maize vegetative traits in 2018 and 2019 seasons.

Treat.	Rate/fed	Plant height (cm)		Total chlorophyll (mg/g)		LAI	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Shamshon 75% WG	30g	257 d	245 ef	5.147 ab	3.770 bcd	746.7 bcd	538.0 b-e
Shamshon +Min. oil	22.5g + 1%	294 ab	292 abc	5.370 ab	4.227 abc	808.3 abc	765.7 ab
Shamshon +Min. oil	15 g + 2%	233 e	230 f	4.063 bc	3.073 cd	616.0 de	429.3 cde
Candy 80% WG	30g	265 cd	253 de	5.080 ab	4.034 abc	739.3 cd	526.7 b-e
Candy +Min. oil	22.5g + 2%	286 b	283 bc	5.240 ab	4.220 abc	803.7 abc	654.0 a-d
Candy +Min. oil	15g + 2%	231 e	227 f	3.960 c	3.087 cd	585.0 de	421.7 de
Monestar 35% SE	500cm^3	283 bc	253 de	5.267 ab	4.177 bc	885.0 abc	665.7 a-d
Monestar +Min. oil	375cm^3 + 1%	308 a	303 ab	6.340 a	5.350 ab	930.3 ab	819.3 a
Monestar +Min. oil	250cm^3 + 2%	253 d	227 f	4.173 bc	3.133 cd	707.0 cd	482.3 cde
Scrop 75% WG	120g	278 bc	275 cd	5.570 ab	4.430 abc	893.0 abc	676.0 abc
Scrop +Min. oil	90g + 1%	310 a	307 a	6.510 a	5.783 a	938.7 a	825.0 a
Scrop +Min. oil	60 + 2%	256 d	230 ef	4.273 bc	3.167 cd	717.3 cd	501.3 cde
Maister power 4.53% OD	500cm^3	313 a	310 a	6.600 a	5.843 a	954.3 a	830.0 a
Hand hoeing		279 bc	275 cd	5.443 ab	3.987 abc	888.3 abc	661.7 a-d
Untreated weed		179 f	207 g	2.950 d	2.083 e	502.7 e	402.7 e

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

TABLE 4. Effect of weed control treatments on yield components in 2018 and 2019 seasons.

Treat.	Rate/fed	Ear diameter (cm)		Number of rows/ear		Weight of grains/ear (g)	
		2018 season	2019 season	2018 season	2019 season	2018 season	2019 season
Shamshon 75% WG	30g	4.00 d-h	4.00 d-g	13.3 c-f	13.2 b-e	184.3fgh	171.0 cd
Shamshon +Min. oil	22.5g + 1%	4.34 c-f	4.31 cde	14.0 bcd	14.1 ab	200.7 c-f	194.3 abc
Shamshon +Min. oil	15g + 2%	3.50 hi	3.40 hi	12.4 f	12.3 e	140.0 i	134.0 e
Candy 80% WG	30g	4.07 d-g	4.05 def	13.7 cde	13.7 bcd	186.0 e-h	175.0 bcd
Candy +Min. oil	22.5g + 2%	4.48 cd	4.36 cd	14.2 abc	14.2 ab	209.7 a-d	199.7 ab
Candy +Min. oil	15g + 2%	3.69 gh	3.53 gh	12.7 ef	12.5 e	153.3 i	166.7 d
Monestar 35% SE	500cm^3	4.67 bc	4.57 bc	13.8 cde	13.7 bcd	192.7 d-g	194.7 abc
Monestar +Min. oil	375cm^3+ 1%	5.74 a	5.71 a	15.1 ab	15.0a	216.7 abc	211.7 a
Monestar +Min. oil	250cm^3+ 2%	3.83 fgh	3.72 fgh	12.9 def	12.8 de	172.3 h	162.3 d
Scrop 75% WG	120g	5.14 b	5.02 b	13.9 cd	13.9 bcd	202.7 cde	198.0 ab
Scrop +Min. oil	90g + 1%	5.80 a	5.77 a	15.1 ab	15.3 a	220.3 ab	214.3 a
Scrop +Min. oil	60 + 2%	3.88 e-h	3.80 e-h	13.0 def	12.9 cde	180.3 gh	173.7 bcd
Maister power 4.53% OD	500cm^3	5.93 a	5.86 a	15.3 a	15.6 a	222.0 a	215.3 a
Hand hoeing		4.40 cde	4.30 cde	14.0 bcd	13.9 bc	208.3 bcd	198.3 ab
Uuntreated weed		3.05 i	3.01 i	10.9 g	10.5 f	98.7 j	97.0 f

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

TABLE 5. Effect of weed control treatments on weight 100-grains (g) and grain yield (ardab/fed.) in 2018 and 2019 seasons.

Treat.	Rate/Fed.	Weight 100-grains		Grain yield (ardab/fed)	
		2018 season	2019 season	2018 season	2019 season
Shamshon 75% WG	30g	31.19 f	28.85 fg	21.01 ef	20.68 fg
Shamshon +Min. oil	22.5 g + 1%	34.66 de	32.44 de	23.73 de	22.73 def
Shamshon +Min. oil	15 g + 2%	24.09 h	23.55 i	16.09 h	14.09 i
Candy 80% WG	30g	33.01 def	31.34 fg	21.89 fg	21.30 efg
Candy +Min. oil	22.5 g + 2%	35.63 d	33.97 d	24.76 def	25.50 bcd
Candy +Min. oil	15 g + 2%	25.88 gh	24.55 hi	17.55 h	16.22 hi
Monestar 35% SE	500cm^3	38.97 c	36.80 c	25.33 cd	25.43 cd
Monestar +Min. oil	375 cm^3 + 1%	42.40 ab	40.55 ab	28.47 ab	28.47 ab
Monestar +Min. oil	250cm^3 + 2%	27.80 g	25.63 hi	18.47 gh	19.47 fgh
Scrop 75% WG	120g	40.34 bc	38.67 bc	26.43 bcd	26.33 bc
Scrop +Min. oil	90g + 1%	43.70 a	41.58 a	29.51 a	29.22 a
Scrop +Min. oil	60 + 2%	28.08 g	26.80 gh	20.75 fg	18.42 gh
Maister power 4.53% OD	500cm^3	44.48 a	42.81 a	31.50 a	29.57 a
Hand hoeing		31.86 ef	30.86 ef	25.67 cd	24.67 cde
Untreated weed		18.63 i	17.30 j	9.63 i	10.63 j

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level

Similar trend was observed in Tables 4 and 5 on yield components (ear diameter (cm), number of rows/ear, weight of grain/ear and weight 100 grains (g)) in both seasons. The increasing in grain yield and its components may attribute to minimizing weed competition. So, the positive effect of weeded control practices on maize yields and its components have been conformed with Sharara et al. (2005), El-Metwally et al. (2006), Hussein et al. (2007), Ali et al. (2014), Hargilas (2016), also, Noor et al. (2012) and El-Sobky & El-Naggar (2016) who concluded that the increasing in grain yield was directly correlated with increase in yield components and decrease in density and dry biomass of weeds.

Maize grains quality

Data presented in Table 6 showed that controlling maize weeds increased the concentrations of carbohydrate and protein percentage in maize grains compared with untreated treatment. The (Monester at 375cm^3 and Scrop at 90g/fed) used at 75% of full rate with mineral oil at 1% and Maister power at the full rate (500cm^3/fed) gave superiority carbohydrate and protein percentages were exceeded the rest of other treatments, whereas the values of carbohydrate; 97.2, 102.2 and 104.8%, while protein were; 10.71 , 11.16 and 11.74%, respectively, in the first season and in the second season similar results were found. While, the lower values of carbohydrate and protein percentages in grains were recorded at the reduced 50% rates (Shamshon and Candy) with added mineral oil at 2% whereas, carbohydrate were; 71.8 and 71.7% and protein were; 8.0 and 7.8%, respectively, in the first season, and a similar were observed in the second season. The higher carbohydrate and protein percentage may be due to the less competition for nutrients, water and light through limiting weeds infestation by effective weed control by using combination of different herbicides with adding mineral oil. In this respect, Hussein (1996) reported that, controlling weeds in maize field could save 75, 11 and 54kg/ha of N, P and K and 90, 1029 and 99g/ha of Zn, Fe and Mn, respectively. Similar results were obtained by Sinha et al. (2005), Ahmed et al. (2008) and El-Metwally et al. (2009).

TABLE 6. Effect of weed control treatments on grain quality characters in 2018 and 2019 seasons.

Treat.	Rate/Fed.	Carbohyd rate %		Protein %	
		2018 season	2019 season	2018 season	2019 season
Shamshon 75% WG	30g	82.7 bcd	70.8 c	9.24 bcde	8.02 de
Shamshon +Min. oil	22.5g + 1%	88.0 abc	73.5 bc	9.77 abcd	8.91 abcd
Shamshon +Min. oil	15g + 2%	71.8 cd	60.5 d	8.04 de	7.81 de
Candy 80% WG	30g	78.7 bcd	68.5 c	9.52 bcd	8.60 bcd
Candy +Min. oil	22.5g + 2%	87.3 abc	71.6 c	10.02 abcd	9.20 abcd
Candy +Min. oil	15g + 2%	71.78 cd	60.5 d	7.84 de	7.51 de
Monestar 35% SE	500cm^3	88.1 abc	74.2 bc	9.86 abcd	9.23 abcd
Monestar +Min. oil	375cm^3 + 1 %	97.2 a	96.6 ab	10.71 abc	10.67 abc
Monestar +Min. oil	250cm^3 + 2%	76.9 bcd	66.3 c	8.41 de	8.0 de
Scrop 75% WG	120g	89.5 abc	75.3 bc	9.87 abc	9.10 abcd
Scrop +Min. oil	90g + 1%	102.2 a	98.2 a	11.16 ab	11.0 ab
Scrop +Min. oil	60 + 2%	75.0 bcd	69.3 c	8.62 cde	8.22 cde
Maister power 4.53% OD	500cm^3	104.8 a	101.5 a	11.74 a	11.41 a
Hand hoeing		85.0 abc	74.1 bc	8.81 cde	9.14 abcd
Untreated weed		64.6 d	53.4 e	7.23 e	6.00 e

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

Conclusion

From the previous results it can concluded that the herbicide and adjuvants selected and relative amount used both of them must be tailored to specific condition of each application, therefore, it could replace the two herbicides (Monester or Scrop) at used rate 75% with mineral oil 1% by Maister power at the full rate (alone), to avoid the appearance development weeds-resistant to herbicide, beside, without loosing weed control efficiency and grain yield, its components and quality in maize.

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تحسين كفاءة مبيدات الحشائش بإضافة الزيت المعدنى وتأثيره على محصول الذرة الشامية والحشائش المصاحبه

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اقيمت تجربة حقلية فى موسمى 2018 و 2019 بالمزرعة البحثية بمحطة البحوث الزراعية بسخا- محافظة كفر الشيخ, مركز البحوث الزراعية, مصر. لدراسة فعالية بعض مبيدات الحشائش بالمعدل الكامل (شمشون75%WG, كاندى 80%WG, مونستر35%SE وسكروب 75%WG) (منفردا) (30جم، 30 جم، 500 سم^{3} و120 جم/فدان) على التوالي، وبالمعدلات المستخدمه (75 و50% من المعدل الكامل) مع اضافتهما زيت معدنى بنسبة 1و2% على التوالى، بجانب مبيد ماستر باور 4.53%OD بالمعدل الكامل (500 سم^{3}/فدان), عزيق مرتين (20 و40 يوم من الزراعة) وبدون معامله (كنترول) وتأثير ذلك على المحصول، مكوناته، وصفات الجودة والحشائش المصاحبه للمحصول واشتملت كل تجربة على المعاملات السابقة. التصميم الإحصائى المستخدم فى كل تجربة القطاعات كاملة العشوائيه فى اربع مكرارات.

اوضحت النتائج ان المبيدات ذات المعدل المستخدم 75% من المعدل الكامل (مونستر وسكروب) مع اضافة زيت معدنى 1% لكلا منهما أو ماستر باور بالمعدل الكامل اعطت تاثيراُ معنوياً لمكافحة الحشائش الكلية وهذا ينعكس لزيادة المحصول ومكوناته مقارنة بالمعاملات الاخرى, فى كلا الموسمين. وايضاً تلك المعاملات السابقة اعطت زياده معنويه لمحصول الحبوب وهذه الزيادة ذات ارتباط موجب مع صفات النمو ومكونات المحصول كذلك صفات جودة الحبوب مقارنة بالمعاملات الاخرى, فى كلا الموسمين.

اوضحت النتائج انه: يجب عند اختيار المبيد والمواد المضافة اليه يؤخذ فى الاعتبار المعدل المناسب لكلاً منهما لان ارتباطهما يخضع لشروط خاصه، لذلك يمكن احلال المبيدين (مونستر وسكروب) بالمعدل المستخدم 75% من المعدل الكامل مع اضافة زيت معدنى 1% لكلا منهما بدلاً من مبيد ماستر باور بالمعدل الكامل (منفرداً)، لتجنب تطور ظاهرة مقاومة الحشائش للمبيدات وبدون فقد الفاعلية فى مكافحة الحشائش مع المحافظه على انتاجية المحصول، مكوناته وصفات جودة الحبوب فى الذرة الشامية.