Utilization of Herbicidal Treatments to Overcome Weed Problems in Peppermint (*Mentha piperita L.*) Cultivation under Egyptian Conditions

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Abstract---Two field trials were conducted on farrow-irrigated Peppermint (Mentha piperita L.) at Elhagger-Beheira governorate, during the growing winter seasons 2012 and 2013, to evaluate the efficiency of certain herbicidal treatments in controlling weeds associated with mint fields. Nine Herbicidal Treatments were applied post –cutting of mints beside the un-weeded check was also included in each of the two seasons to solve the weed problem in mints field. The effectiveness of the herbicidal treatments was depends upon the weed flora. The herbicidal treatment which effective against broad leaf weeds in mints was Bentazone, Oxadiargyl and Metribuzine. And the effective against grassy weeds was Oxadiargyl and Metribuzine. The recommended herbicidal treatments against total weeds grown in mints according to the results of this work were Oxadiargyl and Metribuzine which gave the highest weed control and increased the mints yield.

Keywords- Herbicides, Peppermint, Mentha piperita L, Weed problems, Egyptian conditions

1. INTRODUCTION

Peppermint (*Mentha piperita L.*) is a hybrid plant obtained by crossing spearmint (Mentha spicata L.) with water mint *(Mentha aquatica L.*) Peppermint raw material is used in medicine, cosmetics and food industry, therefore this plant is widely grown around the world [1]. Peppermint is grown in northeastern California for its oil. This perennial crop is established by transplanting either greenhouse-grown plants in spring or field-grown roots in fall. Greenhouse-grown plants are usually planted in spring in rows 40 inches apart with plant populations of about 10,000 per acre. Over the course of the first summer, stolons spread between rows to create an established stand. The wider rows allow limited cultivation for weed control before plants fill across rows. The crop is swathed, chopped, and distilled to extract the oil when it begins to bloom in August. Increases from nursery fields occur in November when field-dug roots are transplanted in 20-inch rows [2], [3]. In Egypt peppermint is perennial crop grown from roots parts in winter and leave to grow and chopped every 50-60 day, and transplanted in the big farms which produced the medicine and aromatic plants and oils.

The origin of peppermint species cannot be determined. Dried leaves were found in the Egyptian pyramids dating back to 1000 BC. Two species of mint were used by the ancient Greek physicians, however, some writers doubt whether one is the modern peppermint, though there is evidence that *M. piperita* was cultivated by the Egyptians. It is mentioned in the Icelandic pharmacopoeias of the thirteenth century, but only came into general use in the medicine of Western Europe about the middle of the eighteenth century, and then was first used in England.

Weeds are the key pest of mint in Wisconsin. Excessive weed populations compete with mint to reduce yields up to 40% in the case of pigweed, and may contribute off-flavors to the mint oil at harvest, resulting in lowered oil quality. Giant foxtail is the most problem annual grass weed, some weeds may contain volatile compounds which are extracted along with the mint oil during the distillation process [4].

Since mint is grown as a perennial crop, it is important to have the soil as weed-free as possible prior to planting. Excessive weeds compete with mint and reduce yields, and may contribute off-flavors to the mint oil at harvest, resulting in lowered oil quality [5]. Weed control is a substantial economic input for production of mints oil, the most commercially important of which are obtained from peppermint resistant to glufosinate herbicide which eradicate the weeds and without residues effect in the oils [6].

In Indiana, all mint acres use at least one herbicide application each year treated two or more times, depending on the problem. Most growers attempt to control annual weeds either with soil-applied pre-emergence or post-emergence herbicides [7].

[8] stated that herbicide application can provide the most effective and time-efficient method of managing weeds. Chemical weed control which is more rapid one could say that it provides longer time weed suppression than many mechanical methods. Besides, results of herbicidal weed control shows greater grass production in pastures as compared to clipping of weeds [9].

[10] mentioned that herbicide is the most powerful and effective single weapon towards weed control and management. It has the highest consumption, production and market share among all pesticides. Also they stated that most herbicides are more economical than mechanical & manual methods as they can substitute mechanical control of weeds in many situations and hence reduce mechanical damage to crops. They control weeds where other methods is difficult to execute, e.g. in wet & marshy soils under humid conditions, within or between narrow-rows of crops.

[11] mentioned that unrestricted weed growth significantly reduced mint oil yield in Japanese Mint (*Mentha arvensis* L.) by 58% and 73%, respectively in the first and second harvests. They also tested Pre-emergence applications of Terbacil (1.5 kg a.i./ha), Pendimethalin (1.0 kg a.i./ha) or Oxyfluorfen (0.25 kg a.i./ha) followed by application of Fluazifopbutyl (0.25 kg a.i./ha) after first harvest and found this to be effective in reducing weed density and dry weight and gave oil yield comparable to weed-free check. They also found that applications of Diuron (0.75 kg a.i./ha) or Oxadiazon (0.25–0.50 kg a.i./ha) were less effective in weed control. The mints oil and their components are affected by weeds competitive with the mints during the vegetative growth [12].

In Egypt there is no specific herbicide for controlling weeds in peppermint. Therefore, the objective of this research was undertaken to select and evaluate the efficacy of herbicidal treatments to overcome the weeds problems in peppermint and their effect on peppermint yield. Although the herbicides used in the experiment are not all registered for peppermint production in Egypt, producers may use these available and less expensive herbicides.

2. MATERIALS AND METHODS

A field experiment was carried out in Elhagger-Beheira governorate during the growing winter seasons 2012 and 2013 to control broad leaved weeds and grassy weeds in peppermint (menthe piperita). The experiment was designed as randomized complete block design with three replicates. All herbicides were applied post–cutting. The herbicidal treatments, names, time and rates of application are shown in table (1). The herbicides were applied by a CP3 knapsack sprayer, with red fan type nozzle. Unweeded check was also included in both seasons.

Table1: Trade, common ,chemical names, formulation and the rate of application of herbicidal treatments

Tr.No.	T.N	C.N	Chemical name	F	R/F
1	sencor	Metribuzin [1,2]	4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5 (4H)-one	70% WP	200 gm
2					60 gm
3	Sinal	Metosulam	*N*-(2,6-dichloro-3-methylphenyl)-5,7-dimethoxy[1,2,4]triazolo[1,5-*a*]pyrimidine-2-sulfonamide	10% SC	40 ml
4	Derby	Flumetsulam	N-(2,6-difluorophenyl)-5-methyl[1,2,4] triazolo[1,5-a]pyrimidine-2-sulfonamide	12% SC	30 ml
5	Harmony	Thifensulfuron- methyl	methyl 3-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl] amino] sulfonyl]-2-thiophenecarboxylate	75% DF	24 gm
6	Reglone	Diquat - dibromide	1,1'-Ethylene-2,2'-bipyridyldiylium dibromide	200 g/l	1.5 L
7	Topstar	oxadiargyl	5-tert-butyl-3-[2,4-dichloro-5-(prop-2-ynyloxy)phenyl]-1,3,4-oxadiazol-2(3H)-one	80% WG	250 gm
8	Basagran	Bentazone	3-Isopropyl-1-2, 1,3-benzothiadiazin(4) 3H-one 2,2-dioxide	48% SL	500 ml
9	Panther	Flumioxazin	2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2H-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1H-isoindole-1,3(2H)-dione.	55% SC	500 ml
10	Unweeded check	Control			

Tr.No.=Treatment Number, T.N=Tread Name, C.N=Common Name, F=Formulation, R/F=Rate/Feddan

All cultural practices e.g. fertilization, irrigation were applied as usual in peppermint plantation. Herbicidal efficacy was evaluated after 45 days after application by collecting all weeds grown each experimental plot and converted to weight per m^2. Weeds were sorted and weighted. Percentage of weed reduction of each weed species, broad leaf weeds, grassy weeds and total of all weeds were calculated. Also the effect of tested herbicides on yield was calculated.

Evaluation of crop tolerance to herbicides was done by using the European Weed Research Council (EWRC) rating scale [13]. Statistical analysis of data was carried out according to assistant software version beta [14].

3. RESULTS AND DISCUSSION

The data in table (2) showed that there was no severe phytotoxicity after 10 days of application according to EWRC, except in the case of Diquat-dibromide in both seasons which was recovered after that.

The opposite occurred in the case of Flumetsulam and Thifensulfuron-methyl as they showed moderate phytotoxicity compared to Diquat-dibromide but it reached complete crop damage at the end of experiment.

Table2: Evaluation of crop tolerance to herbicides by using the European Weed Research Council (EWRC) rating scale (adapted from Sandral et al., 1997), phytotoxicity rating scor (PRS).

Herbicide	PRS		Mean
	1st season	2nd season	
Metribuzin [1]	4	3	3.5
Metribuzin [2]	3	3	3
Metosulam	3	3	3
Flumetsulam	4	4	4
Thifensulfuron-methyl	3	4	3.5
Diquat dibromide	8	7	7.5
oxadiargyl	1	2	1.5
Bentazone	2	1	1.5
Flumioxazin	4	4	4

The data of weeds infestation in the experimental area was recorded in tables (3,4 and 5), the dominant weed in the first season was Portulaca Oleracea L. with a percentage of 44.87 followed by *Echinchloa Cololnum* 42.77% then *Setaria verticillata* (L.) Beauv. 12.36%, similarly in the second season the dominant weed was Portulaca Oleracea L. (48.93 %) followed by *Echinchloa Cololnum* (34.90 %) then *Setaria verticillata* (L.) Beauv. (16.18 %).

The efficacy of the herbicidal treatment as percentages of reduction in weed density against broad leaf weeds in the 1st season was ranged between 55-88%, but in the 2nd season 66-93%. The data in table (3) showed that the herbicide that gave best control for *Portulaca Oleracea* L. was Bentazone (88%) and Metribuzin 200 gm/fed (80.1 %) with no significant differences between them, the least control was found in the case of Diquat-dibromide (54.5 %) in the 1st season. Also, the same trend was noticed in the 2nd season the senior in this respect was Bentazone followed Oxadirgyl, Metribuzine and the last one was Diquat-dibromide. The values of weeds reduction were 93.0, 89.4, 86.5, and 66.1% respectively. According to this results, the herbicidal treatment which effective against broad leaf weeds in mints was Bentazone, Oxadiargyl and Metribuzine.

The dominant grassy weeds in this experiment were *Setaria verticillata* and *Echinchloa Cololnum*. In the case *of Setaria verticillata* (L.) Beauv., table (4), Metribuzin 200 gm/fed gave 100 % control while Metosulam was the least (20.6 % control), concerning with *Echinchloa Cololnum*, Oxadiargyl gave 100% control while Flumioxazin did not show good control with a percentage of 6.4% .

In the second season there were three herbicides gave reasonable results in controlling *Portulaca Oleracea* with no significant differences between them, these herbicides were Bentazone, Oxadiargyl and Metribuzin 200 gm/fed with percentage of control 93, 89.4 and 86.5 %, respectively, also Flumioxazin showed a good control for this weed (85.7%), the least herbicide was Diquat-dibromide with a percentage of control (66.1 %). This result agreed with Schmitt, 1996 who mentioned that Bentazone is used as an early post-emergence herbicide to control annual broadleaf weeds on up to 95% of the peppermint.

Concerning the *Setaria verticillata* (L.) Beauv., the treatments which gave the best weed control were Metribuzin 200 gm/fed and Metribuzin 60 gm/fed as they gave 94.1% and 93.1 %, respectively. While the least was Metosulam (54.2%),

also table (4) showed that the best herbicides in controlling *Echinchloa Cololnum* were Oxadiargyl and metribuzin 200 gm/fed as they gave 91.6 and 90.4 % of control, respectively.

Table3: Effect of herbicidal treatments on *Portulaca oleracea* Fresh weight g/m^2. (F.wt. g./m^2) and the percent in weed reduction (%R).

Herbicide	1st season		2nd season		Mean	
	F.wt. g./m^2	%R	F.wt. g./m^2	%R	F.wt. g./m^2	%R
Metribuzin [1]	303.3	80.1	276.7	86.5	290.0	83.8
Metribuzin [2]	470.0	69.2	613.3	70.0	541.7	69.7
Metosulam	450.0	70.5	526.7	74.3	488.4	72.7
Diquat dibromide	693.3	54.5	693.3	66.1	693.9	61.1
oxadiargyl	350.0	77.1	216.7	89.4	283.4	84.1
Bentazone	183.3	88.0	143.3	93.0	163.3	90.9
Flumioxazin	373.3	75.5	293.3	85.7	333.3	81.3
Control	1525.0	-	2047.0	-	1786.0	-
$LSD_{0.05}$	139.50		139.99		139.7	
Infestation %	44.88		48.93		46.91	

Table4: Effect of herbicidal treatments on narrow leaf weeds (*Setaria verticillata* (L.) Beauv. and *Echinchloa Cololnum*) Fresh weight g/m^2. (F.wt. g./m^2) and the percent in weed reduction (%R).

Herbicide	*Setaria verticillata* (L.) Beauv.				*Echinchloa Cololnum*			
	1st season		2nd season		1st season		2nd season	
	F.wt. g./m	%R	F.wt. g./m^2	%R	F.wt. g./m^2	%R	F.wt. g./m^2	%R
Metribuzin [1]	0.0	100	40.0	94.1	303.3	79.1	140.0	90.4
Metribuzin [2]	83.3	80.2	46.7	93.1	486.7	66.5	716.7	50.9
Metosulam	333.3	20.7	310.0	54.2	1080.0	25.7	1123.3	23.1
Diquat dibromide	310.0	26.2	243.3	64.0	1293.0	10.8	983.3	32.7
oxadiargyl	133.3	68.3	150.0	77.8	0.0	100	123.3	91.6
Bentazone	263.3	37.3	163.3	75.9	683.3	52.9	1096.7	24.9
Flumioxazin	330.0	21.4	243.3	64.0	1360.0	6.4	1246.7	14.6
Control	420.0	-	676.7	-	1453.0	-	1460.0	-
$LSD_{0.05}$	103.4		109.02		122.9		133.64	
Infestation %	12.36		16.18		42.76		34.90	

The herbicidal efficiency against narrow leaf weeds was recorded in table 5. The data showed that, Oxadiargyl gave the highest narrow leaf weeds control with a percentage of 92.9 % followed by Metribuzin 200gm/fed with a percentage of 83.8 % in the 1st season, while in the 2nd season, Metribuzin 200 gm/fed as well as Oxadiargyl showed no significant differences in controlling narrow leaf weeds with percentage of control 89.2 and 87.2 %, respectively. According to these results, the herbicidal treatment which effective against narrow leaf weeds in mints was Oxadiargyl and Metribuzine.

Table5: Effect of herbicidal treatments on total narrow leaf weeds Fresh weight g/m^2. (F.wt. g./m^2) and the percent in weed reduction (%R).

Herbicide	1st season		2nd season		Mean	
	F.wt. g./m^2	%R	F.wt. g./m^2	%R	F.wt. g./m^2	%R
Metribuzin [1]	303.3	83.8	230.0	89.2	266.7	86.7
Metribuzin [2]	570.0	69.6	763.3	64.3	666.7	66.7
Metosulam	1413.0	24.6	1433.0	32.9	1423.0	29.0
Diquat dibromide	1603.0	14.4	1227.0	42.6	1415.0	29.4
oxadiargyl	133.3	92.9	273.3	87.2	203.3	89.9
Bentazone	946.7	49.5	1260.0	41.0	1103.4	45.0
Flumioxazin	1690.0	9.8	1490.0	30.3	1590	20.7
Control	1873.0	-	2137.0	-	2005.0	-
$LSD_{0.05}$	142.2		158.5		150.4	
Infestation %	55.13		51.07		53.10	

Concerning to the all weeds narrow and broad leaves grown in mints, the data was recorded in table 6, from which, Oxadiargyl and Metribuzin 200 gm/fed were the best in both seasons. They gave 85.8, 82.2 % of control, respectively in the 1st season and 88.3, 87.9 % of control in the 2nd season with no significant differences between them. Meanwhile, the other herbicidal treatments may be used also for weed control in mints such as Metribuzin at low dose, Bentazone, Metosulam, and Flumioxazin when the dominant weeds grown in mints is broad leaf like *Portulaca oleracea*, this type of weed effectively control by these herbicides.

Table6: Efficacy of herbicidal treatments on total mint weeds Fresh weight g/m^2. (F.wt. g./m^2) and the percent in weed reduction (%R).

Herbicide	1st season		2nd season		Mean	
	F.wt. g./m^2	%R	F.wt. g./m^2	%R	F.wt. g./m^2	%R
Metribuzin [1]	606.7	82.2	506.7	87.9	556.7	85.0
Metribuzin [2]	1040.0	69.4	1377.0	67.1	1208.3	68.2
Metosulam	1863.0	45.2	1960.0	53.1	1911.5	49.2
Diquat dibromide	2297.0	32.3	1920.0	54.1	2108.5	43.3
oxadiargyl	483.3	85.8	490.0	88.3	486.7	87.0
Bentazone	1130.0	66.8	1403.0	66.5	1266.7	66.6
Flumioxazin	2063.0	39.3	1783	57.4	1923.2	48.3
Control	3398.0	-	4183.0	-	3790.7	-
$LSD_{0.05}$	197.3		206.7		202.0	

The yield of mints may affect by their associated weeds, this reported by many researchers in this field [15], although the determination of total yield of mints was assessed after control of these weeds. Table 7 illustrated that, the best yield was obtained from areas treated with Oxadiargyl and Metribuzin 200 gm/fed as they gave 883.4 and 856.8 dry kg/fed, respectively with no significant differences between them in the 1st season, and 879.84 and 967.4 dry wt. kg/fed in the 2nd season. The main effect of these herbicidal treatments was increasing mints yield about 82 and 88.7% resp. meanwhile, the other herbicidal treatments such Metosulam, Diquat dibromide, bentazone and Flumioxazin showed no significant differences between them and the unweeded check.

Table7: Effect of herbicidal treatments on Mint yield (kg/fed) in both seasons

Herbicide	1st season	2nd season	Mean
Metribuzin [1]	856.8	967.4	912.1
Metribuzin [2]	740.04	799.12	769.6
Metosulam	547.4	507.64	527.5
Diquat dibromide	588	529.2	558.6
oxadiargyl	883.4	875.84	879.6
Bentazone	546	613.2	579.6
Flumioxazin	521.92	605.08	563.5
Control	504.84	462	483.4
$LSD_{0.05}$	109.21	117.98	113.6

4. CONCLUSION

In conclusion, the percentages of broad leaf weeds reduction due to herbicidal treatments was between 61 to 91%, the superiors in this respect were Bentazone, Oxadiargyl, and Metribuzin. But against grassy weeds, the Oxadiargyl and Metribuzine were more efficacy than other herbicidal treatments. The recommended herbicidal treatments against total weeds grown in mints according to the results of this work were Oxadiargyl and Metribuzine which gave the highest weed control and increased the mints yield. And these herbicides can be used within the integrated weed management program [10]. Sometimes more than one herbicide is needed to control combinations of weeds. However, mixing herbicides should be approached with caution as occasionally either poor performance of the products or injury to the crop can occur [2], [3].

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