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STUDIES ON BROOMRAPE (OROBANCHE SPP.) AVOIDANCE ON CONTROL

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BROOMRAPE CONTROL WITH IMIDAZOLINONE HERBICIDES

Recent reports have indicated that the herbicide - Imazaquin (commercial formulation - Scepter) applied as a foliar spray resulted in considerable selective control of broomrape in broadbeans (Vicia faba L.) Lentiles (Lens culinaris Medik) and Chick Peas (Cicer arietinum L.)

We conducted several experiments to determine the effectiveness for broomrape control and phytoxicity of Scepter and another closely related compound - Imadazolinon (AC - 263499), both products of American Cyanamid company.

We had very little background information about those compounds as selective broomrape controlling agents. We spread our studies to several crops and relatively a wide range of rates. Those first experiments were conducted mostly in randomized blocks with two replications.

CARROTS

Materials and Methods

The experiment was conducted in a commercial field of carrots in Kibbutz Shluchot in the "Bet-Shean" Valley.

Hybrid carrot cav. Buro were planted on November 2, 1987. The experiment was devided into two experiments. In the first experiment, the plots were sprayed on Feb. 10 and March 18, 1988. In the second experiment, the plots were sprayed on March 18 and April 4, 1988. The plots were 5 m long and 2 m wide. Both experiments were harvested on May 4, 1988. The rates tested were equal for both compounds and are listed in Tables 1 and 2. The experiments were conducted in randomized blocks with two replications; spray volume was

250 l/ha. Surfactant triton x-100 at 0.1% was added to the spraying solution.

Results and Discussion

Only a few broomrape plants appeared in the field and no information was obtained regarding the potential of those two herbicides in controlling the parasite. Data regarding the effect of herbicides on the crops are presented in Table 1 and 2. It seems that Scepter was slightly more phytotoxic to root yield than AC 263499. Both compounds were phytotoxic at the highest rate of 80 gr/ha. AC 236499 seems safe at 40 gr/ha while that rate of Scepter caused some damage to the crop.

Table 1. Effect of two sprays of Scepter and AC 263499 applied on the 101 and 137 days after planting on carrot foliage and roots

Rate gr/ha a.i.	Foliage color	Root weight gr/m^2	Number roots per m^2	Foliage weight gr/m^2
a. Septer				
0	5.0	6700	173	970
5	5.0	6460	182	1370
10	4.7	6450	219	1450
20	4.7	5960	197	1150
40	3.0	6075	173	780
80	2.0	5450	188	480
b. AC 263499				
0	5.0	6900	208	1400
5	5.0	6815	208	1470
10	5.0	6780	200	1200
20	5.0	5950	187	1220
40	2.5	4850	173	660
80	1.0	5150	177	510

1. Figures represent visual observation

5 - normal green color

1 - yellowing

Table 2. Effect of two sprays of Scepter and AC 263499 application on the 137 and 154 day after planting on carrot foliage and roots.

Rate gr/ha a.i.	Foliage color	Root weight gr/m^2	Number roots per m^2	Foliage weight gr/m^2
a. Scepter				
0	5.0	6460	181	1130
5	4.5	6230	177	1020
10	4.0	6680	208	1150
20	3.0	6040	195	800
40	3.0	6450	178	630
80	2.0	6169	198	500
b. AC 263499				
0	5.0	6580	195	1020
5	5.0	6660	210	1100
10	4.0	7360	197	1290
20	3.0	5620	178	710
40	2.5	6560	179	650
80	1.5	5810	177	410

1. As in Table 1.

PERSLEY

Persley was grown in Israel in a small scale for many years. However, it is only recently that this crop (other varieties) is grown in rapidly increasing acrage for the dehydration industry. This crop proved to be very sensitive to broomrape as are other crops of the umbelliferae family (carrots, celery). There are two types of broomrape damage to the crop that have to be considered. First, and probably the less important - yield reduction. In order to observe yield reduction, infestation has to be relatively heavy. Second, and probably more important, broomrape stalks and flowers which are foreign material in the harvested foliage have to be (so far) manually removed from the line of production. The extent of broomrape contamination that renders the harvested foliage to be useless is by far less than that causes measurable yield reduction.

Materials and Methods

The field was sown on Sept. 25, 1987. The plots were sprayed twice with both Scepter and AC 263499 at various rates - the same as in carrots, on Feb. 26 and April 4, 1988. Spray volum was 300 L./ha and 0.1% of the surfactant triton x-100 was added to the spraying solution. In this experiment only visual observation of the herbicide affect was conducted.

Results and Discussion

Results are presented in Table 3.

Table 3. Visual evaluation of the condition of Persley foliage following foliage application of Scepter and AC 263499

Rate gr/ha a.i	1st Evaluation 18.3.88		2nd Evaluation 26.4.88	
	Growth[1)]	Color[2)]	Growth	Color
a. Scepter				
0	4.2	4.2	3.5	4.2
5	4.0	4.7	4.5	4.5
10	3.0	4.5	3.7	3.5
20	2.7	4.2	3.0	3.5
40	3.0	3.2	2.0	4.0
80	1.2	1.2	1.5	2.0
b. AC 263499				
0	4.2	4.2	4.2	4.5
5	4.0	4.7	4.5	4.5
10	3.0	4.5	4.0	4.0
20	2.5	3.5	4.0	4.5
40	2.7	3.2	2.0	3.5
80	1.5	1.2	1.7	2.0

1. Growth	5. unretarded	1. Retarded
2. Color	5. Dark green	1. Yellowing

Results indicate that the crop is relatively sensitive to those compounds. Mostly, the rate of 10 gr a.i/ha caused retardation of growth. Sensitivity was somewhat less as the crop grew older. There was very little broomrape in the field except on one end where rates of 20 and 40 gr a.i/ha of both compounds were applied. In those plots broomrape was clearly retarded but so was the crop.

As otherwise very little broomrape was observed, no clear indication is available regarding the compound effect on broomrape. Probably insufficient selectivity might also be inhibitory.

PEA

Peas are heavily infected by Crenate broomrape (only) (Orobanche crenata Forsk) Broomrape demage to Pea may be of three fold. First - reduce yield. Secondly, if used for hay production, the detached flowering broomrape stalks will mature viable seeds and contaminate the hay. It was alrendy demonstrated by Jacobsohn that at least some of the broomrape seeds will not be devitalized by the farm animal digestive system. In that way, broomrape infested hay may indirectly cause the spread of the pest in agricultural farm land. Third, broomrape stalks and mainly flowers may contaminate the green kernels in Pea fields grown for that purpose, demanding further inputs to remove them.

Materials and Methods

The experiment was conducted in an infested field with crenate broomrape belonging to Kibbutz Yad Mordechai in the south.

Peas (Pisum sativum) cv. "Tugat" were sown on January 3, 1988. The experiment was sprayed twice, namely March 24, and April 7, 1988 (Peas at flowering stage). The experiment was harvested on May 1, 1988. The sprayed plots were 5 meters long and two meter wide, while the harvested plots were 3 meter long and 1 meter wide. Foliage fresh weight was determined. The rates are the same as in the previous experiments. Spray volum was 250 l/ha. The treatments were replicated twice.

Results and Discussion

Visual observation was conducted on April 7. Some retardation of growth and flowering as well as discoloration was observed in plots treated

Table 4. Effect of two sprays of Scepter and AC 236499 of various rates on Pea foliage fresh weight.

Rate gr/ha a.i.	Scepter Fresh wt. gr/m^2	Scepter Number of Broomrape/m^2	AC 236499 Fresh wt. gr/m^2	AC 236499 Number of Broomrape/m^2
0	1417	6	1130	10
5	1120	6	1560	10
10	1350	7	1230	15
20	1100	3	1270	5
40	1500	0.7	1160	2
80	1160	0	1170	4

with 40 and 80 gr/ha a.i. of Scepter. The same rates of AC 236499 did not affect the crop. The experiment was harvested about one month later. The results as presented in Table 4 do not confirm the visual observation. Some trend of yield reduction can be observed in the data of the effect of AC 236499. It is interesting to note that the plots treated with the high rates Scepter were heavily affected by mildew. Both compounds reduced the number of emerging broomrape. Scepter was more effective than AC 236499.

TOMATO

Probably the most serious broomrape problem in Israel is in tomato, so any new herbicide for possible broomrape control will be tested on tomatoes. In Israel, tomatoes are mostly affected by Egyptian broomrape and secondly by nodding broomrape (Orobache cernua) and very rare, by crenate broomrape (O. crenata).

Materials and Methods

This experiment was conducted in 2 L. pots filled with a potting soil mixture [(1/3 clay soil, 1/3 sand and 1/3 tuff (grounded porrous volcanic stone)]. Each pot had 20 mg of Egyptian broomrape seeds.

Tomato plantlets (var M-82) were planted on April 20, 1988. The pots were placed into the ground in the field and irrigated with drip irrigation. The experiment was sprayed on May 10, 1988 with both herbicides at rates similar to the previous experiments. The experiment was terminated on June 9, 1988.

Results and Discussion

We observed no differences in growth between the plant sprayed with different rates. Also, no effect on broomrape was observed. All pots were infected.

BROOMRAPE CONTROL WITH FOLIARLY APPLIED GLYPHOSATE

Glyphosate is a systematic herbicide, generally used for non-selective weed control. It was one of the few herbicides that was effective against perennial and difficul-to-control weeds. Kasasias (1975) was the first one to report the glyphosate, at very low rates applied on the foliage of Faba beans may be used as a selective herbicide to control Crenate broomrape (Orobanche crenata) in this crop. Everesince, considerable amount of work was done worldwide attempting to control broomrape with this herbicide in various crops.

The present report describes various experiments which are a contribution to our earlier efforts to study the possibility to use glyphosate for broomrape control.

PERSLEY

The broomrape problem in Persley was already described earlier.

Materials and Methods

The experiment took place in Kibbutz Sede Eliyahu in the Bet Shean valley. The crop was planted on September 25, 1987. The sprays were inbetween the harvests which are in intervals of 25-40 days from one another, depending on the temperature.

Rates and dates of application are presented in table 5. Spray solutions applying 100 and 150 cc Round-up (commercial formulation containing 36% of acid equivalent glyphosate) per hectare received 0.1% of surfactant triton x -100. Rate of 200 cc Round-up/ha was applied without

surfactant. Data, as presented, were collected three times mainly on December 12, 1987, February 19 and March 15, 1988.

The experiment was conducted in randomized blocks with three replications.

Due to a mistake, the second harvest was lost. The field was commercially harvested before samples were taken.

Table 5. The effect of foliarly applied Round-up on foliage weight of Persley.

	Treatments				Foliage weight (gr/m^2)		
	Round-up sprays cc/ha				Harvest I	Harvest II	Harvest III
	9.12.87	5.1.88	28.2.88	5.4.88	18.12.87	14.3.88	28.4.88
1		100	100	100	-	800	700
2		200	200	200	-	570	400
3		100	150	200	-	1460	550
4	100	100	150	200	1530	970	630
5	check				1590	830	880

Table 6. Effect of foliarly applied Round-up on the color of persle foliage and number of emerging broomrape plants.

Treatments					18.12.87	19.2.88		15.3.88	
Round-up sprays cc/ha					Harves I	Harvest II		Harvest III	
	9.12.87	5.1.88	28.2.88	5.4.88	color1)	color	Broom-rape	color	Broom-rape
1		100	100	100		4	0	5	0
2		200	200	200		3	0	5	0
3		100	150	200		4	2.7	5	0
4	100	100	150	200	5	4	0.2	5	0
5	check				5	5	13	5	36

1. Visual observation 5- normal green 1-yellowish

2. Number of broomrape plant per plot: 20 m x 1.3 m

Results and Discussion

First observations and harvest were conducted only on plots of treatments 4 and 5 as the other treatments were not sprayed at that time. No negative effect was observed: Data of the third and fourth harvest indicate that treatment 2, namely 3 applications of 200 cc Round-up/ha caused yield reduction. Also, more discoloration was observed due to that treatment. Broomrape counts on February 19, namely after January 5 application in treatments 3 and 4 indicate that possibly 100 cc/ha is somewhat low and probable 150 cc should be prefered.

Broomrape counts in Mid-March indicate complete broomrape control in all treatments.

Glyphosate residue test.

Dried and grounded samples of all treatments were sent for residue tests to Monsanto laboratory in Brussels - Belgium

The tests were replicated twice. First replication of each treatment was analyzed twice and the results are average of two values and they are as follows:

Table 7. Glyphosate residue in dried and grounded persley after 3 or 4 foliar applications.

Glyphosate treatment number	Glyphosate (mg/kg)	
	Rep. I	Rep. II
1	0.2	0.1
2	0.2	0.2
3	0.4	0.2
4	0.4	0.2
5	<0.05	

Residue tolerance for pesticides differs from country to country. The U.S.A tolerance for glyphosate residues in leafy and root crops, seeds and pods are 0.2 ppm. The results reported in Table 7 indicate that in a few instances, above tolerance levels were found. However, it should be pointedout that dryed persley is consumed as a spice, Namely in very small quantities. Therefore it can be reasonably assumed that the consumers health is not endangered even when in some instances glyphosate residues are somewhat above the tolerance.

CELERY

Celery is an important export vegetable crop in Israel. As several other umbelliferae crops, celery is parasitized by at least two broomrape species, namely, Egyptian (Orobanche aegyptiaca) and Crenate broomrape (Orobanche crenata). In a few instances, heavy losses were recorded. Considerable research on broomrape control with foliarly applied glyphosate was conducted in the recent years with considrable success. We are suggesting now to try lower rates than in the past because of crop damage that was observed. The purpose of the present study was to verify the safety of the suggested rates (Table 8) and to determine the levels of glyphosate residues.

Materials and Methods

The experiment was conducted in a commercial field in Moshav Sharsheret in the Northern Negev. The field was planted on November 10, 1987 with plantlets obtained from a nursery sown on September 20. Four rates were tested (Table 8) applied twice with a motorized backpack sprayer. First application was on Jan. 20, 1988 and the second on February 9.
Spray volume was 300 l/ha and 0.1% surfactant Triton x-100 was add to the spraying solution. The experiment was terminated on March 10, 1988. Twenty celery heads were sampled from each plot and was weight before and after triming [1]. Plots were 10 m^2 and the experiment was designed in randomized blocks.

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1) Triming - preparing the head for marketing by removing the outer leaves and catting the tops 27 cm. above the base of the plant.

In addition, two 100 m^2 plots were sprayed twice with 15 cc Round-up. One trimed head from each plot was sampled for glyphosate residue test which was conducted at Monsanto Laboratories in Brussels, Belgium.

Results and Discussion

There were no broomrape plants in that field and the crop develope normally.

Table 8. Effect of foliarly applied Round-up on celery plants

	cc Round-up/ha				Glyphosate
	Spray I	Spray II	Weight of Heads gr		residues
	Jan. 20	Feb. 9	Whole	Trimed	mg/kg Fresh wt
1	100	100	1340 a	770 a	<0.05
2	150	150	1390 a	740 a	<0.05
3	150	200	1460 a	760 a	<0.05
4	check		1440 a	770 a	<0.05
	100 m^2 plots				
	15	15	1400	760	<0.05

1) Values followed by the same letters do not differ significantly (P = 0.05) according to Newman-Kells multiple range test.

Results presented in Table 3 indicate no harmful effect of non of the treatments to the crops.

Glyphosate residue tests indicate levels which are below detection of the method which is 0.05 mg/kg fresh weight, which is lower than the US tolerance (0.2 mg/kg).

Finalizing a study that lasted several years we feel that two foliar applications of 150 cc of Round-up/ha might be tested as a possible solution for the broomrape problem in celery. Timing of the application is critical for optimal results. Celery planted early (August) in a field suspected to be infested with broomrape will be sprayed earlier than if planted late in the fall.

It is most advisable not to spray before early broomrape infections have been found on the roots. The sampling of a field for presence of soil pathogens (Broomrape might be considered as one) was considered elsewhere. In case that farmers will find it difficult to do, preventive spraying may be considered.

PEA

The broomrape problem in peas was described earlier.

A. Broomrape control in pea (Pisum sativum arvense) var "Dan" for hay.

Materials and Methods

The experiment was conducted in Kibbutz Yad Mordechai. The field was planted late December 1987. First application of glyphosate took place on March 24, 1988 when the plants were at the early flowering stage. Second application was on April 7, when the field was at full flowering stage. The rates tested are described in Table 9. Spray volume was 300 l/ha and 0.1% of surfactant Triton x-100 was added to the spraying solution. The experiment was harvested on April 28. The sprayed and harvested plots were 8 m^2 and 3 m^2 respectively.

The experiment was designed in randomized blocks with four replications.

Results and Discussion

Results are presented in Table 9. Some discoloration was observed about two weeks following the first application. However, the plots gained color shortly thereafter. The herbicide had no negative effect on the crop and even some yield increase could be observed due to the treatments, seemingly, as a result of the effect on the broomrape.

Considerable, although not complete broomrape control was achieved. As previously mentioned, the remaining broomrape stalks in the hay impose a major quality problem due to the potential risk of spreading the pest. It is therefore, that unlike in most other weed problems, complete broomrape

control should be the goal. In order to achieve that, further research with glyphosate and other herbicides is needed. The main reason for testing also other herbicides is the fact that the safety margin of glyphosate is narrow and crop sensitivity to the herbicide may be affected and altered by environmental conditions, which are mostly unknown as yet.

Table 9. Effect of foliarly applied glyphosate on Peas (Pisum sativum arvense) and number of emerged broomrape plants

Treat.	Round-up cc/ha		Visual evaluation	green	%	Number
	Spray I	Spray II	7.4.88	material	dry	broomrape
no.	24.3.88	7.4.88	Leaf color(1-5)	gr/m^2	matter	plants/m2
1	100	100	4.1	1240 a	30	2
2	100	150	4.0	1220 a	31	0.7
3	150	150	3.1	1210 a	30	0.4
4	150	200	3.5	1190 a	31	0.2
5	check		5.0	920 a	32	12.0

1. Visual evoluation 1-yellow 5-normal green
2. Values followed by the same letter do not differ significantly ($P = < 0.05$) according to Newman kells multiple range test.

Broomrape control in peas for green kernels

Materials and Methods

The experiment was conducted in a field near Kibbutz Yad Mordechai. Peas of the variety "Fugat" were planted early December and started by irrigation. The plots were sprayed twice, on February 5 and 25. Spray volum was 250 l/ha. Each treatment consisted of two sprays.
The experiment consisted of 7 treatments ranging from 70 cc to 200 cc Round-up/ha. The experiment was designed in randomized bloocks with six replications.

Results and Discussion

Two weeks after the second spray, it was evident that the crop was seriously damaged by all rates, and the experiment was therefore discontinued.

We arrived to the conclusion that Round-up might be a suitable herbicide for broomrape control in peas for hay in which the variety "Dan" is grown. Additional research is needed to achieve complete broomrape control. However, the present varieties of peas used for green kernels are too sensitive to Round-up to allow safe useage.

RACES WITHIN OROBANCHE AEGYPTIACA

The existance of at least two races of O. aegyptiaca was suspected for some time. One, parasitizing "Winter crops" like carrots, vetch cabbage etc. The second, parasitizing "Summer crop" like tomato eggplant and sunflowers. A prelimlnary experiment to ascertain that hypothesis was

conducted with the assistance of Dr. Pramud Jha from Nepal during his training period in Israel.

Materials and Methods

The experiment was conducted by innoculating tomato and carrot roots in a soilless system. This system consists of two glass plates with a layer of 1 cm thick rubber foam and a piece of synthetic cloth of equal size (10 cm x 13 cm) in between the glass plates. Those components are tied together with two rubber bands, and placed into a container with nutrient solution (Hoagland no. II, 1/2 strength). Young tomato and carrot seedling were planted into that system and allowed to grow under continuous artificial light and 23-25°C. After about 2-3 weeks, when sufficient roots developed, the roots in each growing unit were innoculated with 200 broomrape seeds which were placed on the roots or close as possible. The broomrape seeds were of Egyptian broomrape that parasitized tomatoes (lot 25) and of Egyptian broomrape that parasitized carrots (lot 17). We set all possible combinations as described in table 7. After the inoculation, the experiment was set for another 4 weeks for attachments to form. Nutrient solution was replaced weekly.

Another small experiment was conducted in pots that were placed into the ground in the field to a depth equal to the level of the soil in the pots. In this experiment we used two litter pots filled with a soil mixture made of equal volume of sand, clay soil and tuff (grounded porous volcanic stone). 20 mg of broomrape seeds per pot were mixed into the soil. Tomatoes were planted on March 4, 1988 and the experiment was terminated two month later by damping the soil from each pot and counting the number of

broomrapes attached to the roots. Each treatment had eight pots.

Carrots were not introduced into this experiment because they are not parasitized by broomrape in spring planting.

Results and Discussion.

Both experiment indicate considerable difference between the two broomrape lots (Tables 7 and 8). The Egyptian broomrape grown on tomato (lot 25) parasitized both tomato and carrots, The difference between the number of infections on tomato and carrot may reflect difference in sensitivity or may be a result of the interaction between the soilless conditions and the plant species, being less favorable in the case of carrot compared to tomatoes.

In any case, carrots proved sensitive to Egyptian broomrape produced on tomato roots. The broomrape seeds produced on broomrape plants parasiting carrot may be less virulent, due age (collected in 1977 compared to lot 25 collected in 1981, but kept at 4°C) or they are naturally so. However, their germination capability was lately tested. lot 17 germinated about 55-60% while lot 25 germinated above 90%. Although infection by lot 17 was low, yet, in the soilless system, tomato were infected six times less than carrots. Similarly, lot 17 caused only very few infections on tomato and sunflowers in the pot experiment.

Table 10. Number of broomrape attachments found on tomato and carrot plants in a soilless system by Egyptica broomrape seeds collected from a tomato (lot 25) and carrot (lot 17) fields.

Broomrape		Egypt./Tomato	Egypt./Carrot	Egypt./Tomato	Egypt./Tomato
Host		Tomato	Tomato	Carrot	Carrot
Growing	1	26	0	4	0
units	2	28	0	10	2
	3	26	0	8	1
	4	33	0	5	1
	5	20	1	7	7
	6	15	2	16	4
	7	24	0	11	
	8			5	
$\bar{x}$		24.6	0.4	8.3	2.5

Table 11. Infection of tomato and sunflower plants grown in pots containing soil infested with Egyptian broomrape seeds collected from plants that parasitized carrots (lot 17) and tomatoe (lot 25).

Broomrape	Egyptian/Carrot		Egyptian/Tomato	
Host	Tomato	Sunflower	Tomato	Sunflower
Broomrape attachments	1.8	0.9	18.4	51.5

1) Egyptian broomrape grown on carrot and tomato respectively.

2) Include emerged and non-emerging

In spite of the data presented above, the results remain unconclusive as the possibility that the seeds of Egyptian broomrape produced on carrot (lot 17) are less virulent due to age or other unknown reasons, can not rejected. Further research on that subject is therefore required.

Visit to Nepal

The visit took place from May 16 to June 1, 1988. The activities in that visit are described by Dr. Agrawal in his part of the progress report. It was unfortunate that the visit did not take place in February because that is the time when broomrape can be seen in the field. Otherwise the visit was an absolutely essential, mainly because I could contribute both my general experience in conducting agricultural field experiments as well as my experience with the broomrape problem in particular. We visited the various experiment stations in which the experiments will be conducted, saw the fields and could adjust our plans accordingly.