SEMIANNUAL REPORT

Covering Period: 26\5\03 – 26\12\03

Submitted to the U.S. Agency for International Development; Bureau for Global Programs, Field Support and Research; Center for Economic Growth

Title: Integrated Broomrape Management in Legumes

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Project Number: (C20-043).
Grant Number: TA-MOU-00-C20-043

Project Duration: May 2002 – May 2005

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Executive Summary

The overall objectives of the current project are to eliminate legume devastation caused by the parasitic weed broomrape in the Middle East and other parts of the world.

Two criteria should be regarded as an ideal solution for broomrape control:

1. Development of efficient control methods (preferably environmentally friendly), which are absent at present and 2. Multi-regional effort to prevent dispersal of the parasite seeds between countries. Our approach will include integrating measures based on results and observations made during the last two decades at Neve Ya'ar Research Center aimed to control the parasitic weed broomrabe in legume crops in the Middle East.

In ISRAEL: The research plan for the second year of the project was focused on refine herbicidal methods for broomrabe control by using low rates of crop selective herbicides. Greenhouse screening for chickpeas and faba been selective herbicides for Orobanche crenata control was conducted in pots under greenhouse conditions. Imazapyr, imazapic (two formulations), imazethapyr, imazaquin, and dimethenamid, were tested at one or two split applications at three weeks interval. In chickpeas All treatments significantly reduced the number of inflorescences emerged above soil and the number of the total parasites counted on the roots at the end of the experiment. The most effective treatment was imazapyr at 1.25 + 1.25 and 2.5 gr a. i. /du. In faba been all herbicides tested (imazapic, imazethapyr and imazaquin) prevented completely inflorescences emergence above soil. Imazaquin, at the two concentrations tested, significantly reduced the total number of parasites counted on the roots. Overall, excellent progress has been made toward project objectives in selective herbicides for Orobanche control.

In HEBRON UNIVERSITY: The research plan for the second year was to identify legume species with resistance / tolerance to *Orobanche aegyptiaca* and isolation of pathogens diseased the broomrape.

Local cultivars of broad bean, soy bean, cow pea, chick peas, and common vetch, lentil and bean plants were screened for resistance / tolerance to Orobanche aegyptiaca in pots. The results indicated that some lines of soybean, cowpea and bean were resistant to broomrape since seeds of the broomrape have not germinated. Broad bean, chickpea, common vetch and lentils were susceptible to broomrape; they could germinate Orobanche aegyptiaca seeds.

Additionally, a field survey of broomrape pathogens was conducted. 84 samples of diseased broomrape spikes were collected. The identification of pathogens showed that most of them were Fusarium spp., and Rhizoctonia solani, in addition to other fungi which still are under investigation. There were 109 isolates of Fusarium and 14 isolates of R. solani.

A) Research Objectives

Our approach will be multi-disciplinary based on close collaboration between the two groups in order to achieve the following objectives:

1. We will screen for broomrape resistant or tolerant crop varieties, based on legume seed bank that exist in Israel and in the Palestinian Authority.
2. We will refine herbicidal methods - using low rates of crop selective herbicides for broomrape control.
3. Developing agronomic measures (catch crops, trap crops and planting time) to reduce broomrape seed bank in the soil.
4. We intend to use biological control methods including insects and fungi.

In such situation, a successful integrated pest management approach together with regulations of countries in the region can bring a gradual decrease in the soil seed bank over the years enabling the region to grow legumes without notable damage to the yield.

B) Research Accomplishments

Chickpea

Chickpea response to herbicides was tested in infested and non-infested broomrape soil. In the infested soil, Imazapyer at 1.25 gr active ingredient (a. i.) per dunam (du), imazethapyr at 5, 5 + 5 and 10 gr a. i., imazaquin 15 gr a. i./du, imazethabenz-methyl at 37.5, 37.5 + 37.5 and 75 gr a. i. and dimethenamid at 135 gr a. i./du had no significant effect on chickpea development as reflected in the visual estimation of plant vigor preformed at the end of the experiment (Table 1). The visual estimation of Imazethapyr and imazethabenz-methyl treatments was in complete agreement with the fresh and dry weight determination. Dry and fresh weight of the chickpea plants treated with imazapic (Oroban formulation) were the same as the control, as opposed to the significant difference in the visual estimation of the same treatments as compared with the untreated control (Table 1). The same experiment was repeated with broomrape non-infested soil (Table 2).

All treatments significantly reduced the number of inflorescences emerged above soil and the number of the total parasites counted on the roots at the end of the experiment. The most effective treatments were imazapyr at 1.25 + 1.25 and 2.5 gr a. i. /du, imazapic (cadre formulation) at the three rates tested, imazaquin at 15 + 15 and 30 gr a. i. /du and dimethenamid at 135 + 135 and 270 gr a. i. /du. Unfortunately these treatments were not safe to the crop based on the visual estimation. More experiments are needed in order to establish an efficient and safe application method of these herbicides based on rate reduction, timing, and the number of repeated applications.

Faba been

All herbicides tested (imazapic, imazethapyr and imazaquin) prevented completely inflorescences emergence above soil (Table 3). Imazaquin, at the two concentrations tested, significantly reduced the total number of parasites counted on the roots. The most promising treatments, which need farther attention, were imazapic and imazethapyr (Table 3). More experiments are needed to optimize the use of these herbicides for broomrape control.

Table 1: Chickpea and Egyptian broomrape response to herbicides

Broomrape infested soil

Treatment		Chickpea			*O. aegyptiaca*	
Herbicide	Rate	Vigor[3]	Foliage weight Fresh	Foliage weight Dry	Shoots	Total parasites[1]
	g a. i /du	(0-100)	gr		No./plant	
Imazapyr	**1.25**	62 c-f[2]	10.9 c-e	2.0 b-e	5.2 b-d	12.2 bc
	1.25+1.25	63 c-f	5.1 ef	1.2 ef	0.0 e	0.2 e
	2.5	50 e-f	7.8 d-f	1.7 c-e	0.0 e	1.0 ef
Imazapic (Oroban)	**0.2**	80 a-c	13.9 cd	2.8 bc	6.6 bc	9.2 b-d
	0.2+0.2	80 a-c	14.4 cd	2.9 bc	4.8 b-d	11.4 bc
	0.4	80 a-c	12.2 c-e	2.3 b-d	4.8 b-d	10.2 b-d
Imazapic (Cadre)	**4.8**	60 c-f	8.6 c-f	1.9 c-e	1.6 de	3.2 d-f
	4.8+4.8	26 g	7.1 d-f	1.54 c-e	0.4 e	1.0 ef
	9.2	6h	1.7 f	0.8 e	0.0 e	0.0 e
Imazethapyr	**5**	74 b-d	16.4 bc	3.3 ab	4.2 b-d	12.0 bc
	5+5	100 a	20.3 ab	4.1 a	4.0 b-d	6.2 b-f
	10	88 ab	22.4 a	4.0 a	4.8 b-d	7.8 b-e
Imazaquin	**15**	100 a	13.3 cd	2.5 b-d	5.0 b-d	8.8 b-d
	15+15	64 c-f	12.9 c-e	2.4 b-d	0.4 e	3.2 d-f
	30	60 c-f	11.4 c-e	2.1 b-e	3.2 d-f	6.0 b-f
Imazethabenz-methyl	**375**	52 d-f	8.9 c-e	1.8 c-e	7.4 b	13.2 b
	375+375	100 a	13.5 cd	2.8 bc	2.8 c-e	8.4 b-d
	750	74 b-d	11.1 c-e	2.3 b-d	5.0 b-d	9.2 b-d
Dimethenamid	**135**	80 a-c	12.4 c-e	2.6 b-d	4.2 b-d	9.6 b-d
	135+135	70 b-e	11.4 c-e	2.4 b-d	1.4 de	3.6 d-f
	270	46 f	6.4 d-f	1.5 c-e	2.0 de	5.0 c-f
Control		58 c-f	6.9 d-f	1.5 c-e	11.0 a	20.2 a

[1] The number of the total parasites found attached to the roots after washing the soil from the roots at the end of the experiment.

[2] Means within a column followed by the same letter do not differ significantly at $P \leq 0.05$ according to Duncan's new multiple range test.

[3] Vigor evaluation scale from 0 = dead plants to 100 = vigorous plants.

Table 2: Chickpea and Egyptian broomrape response to herbicides

Non infested broomrape soil

Treatment		Chickpea		
Herbicide	Rate gr a. i./du	Vigor[1] 0-100	Foliage weight Fresh	Foliage weight Dry
			gr	
Imazapyr	1.25	96 a-c[2]	14.8 a-g	2.8 b-e
	1.25+1.25	28 e	6.5 hi	1.6 e-h
	2.5	50 d	8.0 g-i	1.6 e-h
Imazapic (Oroban)	0.2	80 c	18.5 a-f	3.4 a-c
	0.2+0.2	84 bc	20.2 a-d	3.8 ab
	0.4	84 bc	16.4 a-f	3.1 a-d
Imazapic (Cadre)	4.8	50 d	4.7 i	1.0 gh
	4.8+4.8	32 e	6.7 hi	1.3 f-h
	9.2	22 e	2.3 f	0.9 g
Imazethapyr	5	100 a	22.2 ab	4.2 a
	5+5	100 a	22.6 a	4.1 a
	10	100 a	18.7 a-f	3.3 a-c
Imazaquin	15	98 a	13.8 c-h	2.3 c-f
	15+15	92 a-c	13.2 d-h	2.3 c-f
	30	80 c	11.0 hi	1.9 d-h
Imazethabenz-methyl	375	96 ab	21.3 a-c	3.7 ab
	375+375	100 a	16.5 a-f	3.2 a-d
	750	100 a	16.6 a-f	3.1 a-d
Dimethenamid	135	100 a	14.6 b-g	2.7 b-e
	135+135	80 c	13.6 c-h	2.5 b-f
	270	80 c	11.5 e-i	2.2 c-g
Control		90 a-c	19.2 a-e	3.8 ab

[1] Vigor evaluation scale from 0 = dead plants to 100 = vigorous plants. Observation made at harvest.

[2] Means within a column followed by the same letter do not differ significantly at $P \leq 0.05$ according to Duncan's new multiple range test.

Table 3: Faba been and *Orobanche crenata* response to herbicides

Treatment	Rate	Faba been		*Orobanche crenata*	
		Foliage Fresh Weight		Shoots	Total parasites[1]
	gr. a. i./du	gr		No./plant	
Broomrape[2]		-	+		
Imazapic	1.25 + 1.25	219a	183a	0.0b	34.8a
Imazapic	1.25 + 2.5	171a	196a	0.0b	19.8ab
Imazethapyr	1 + 1	233a	205a	0.0b	21.8ab
Imazethapyr	2 + 1	233a	222a	0.0b	17.6ab
Imazaquin	1.5 + 1.5	227a	149a	0.0b	14.2b
Imazaquin	3.0 + 1.5	226a	168a	0.0b	12.0b
Control[3]		191a	150a	3.6a	36.6a

[1] The number of the parasites recorded on the roots of the infected plant at the end of the experiment.

[2] Plants grown in non-infested broomrape soil (-); Plants grown in infested broomrape soil (+).

[3] Untreated plants grown in non-infested broomrape soil.

HEBRON UNIVERSITY

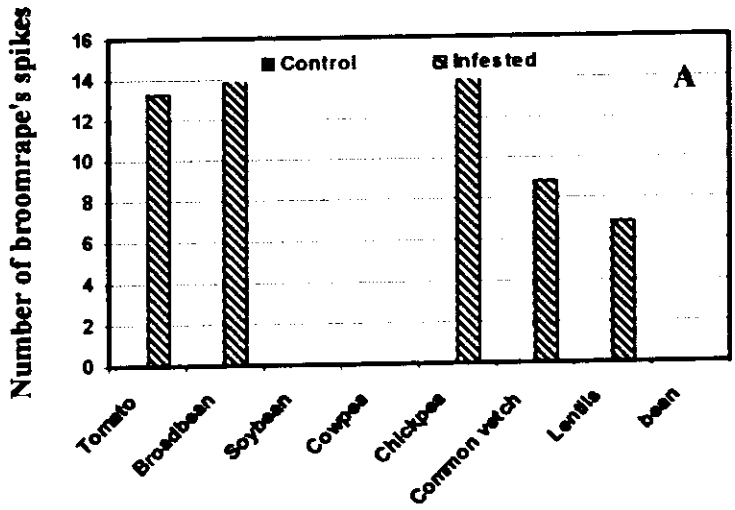
1. Identify legume species with resistance / tolerance to *Orobanche aegyptiaca*.

Local cultivars of tomato, broad bean, soy bean, cow pea, chick peas, common vetch, lentil and bean plants were screened for resistance / tolerance to *Orobanche aegyptiaca* in pots. The results indicated that soybean, cowpea and bean were resistant to broomrape since seeds of the broomrape have not germinated. Tomato, broad bean. chickpea, common vetch and lentils were susceptible to broomrape. Seeds of the parasite germinated, attached to the host roots and established the spikes over the soil. The mean of established spikes were 13.3, 14.5, 14, 8.8, and 6.8 for tomato, broad bean, chickpea, common vetch and lentils respectively (Fig.1A). Furthermore the mean weight of spikes was the highest on tomato (2.1g) and the lowest on broad bean and

lentils (1.3g) (Fig.1B). The effect of broomrape on the fresh and dry weight of the hosts was significant. The reduction of fresh weight was 65.8%, 48.6%, 83.1%, 58.6%, and 55.8%, and the reduction of dry weight was 76.4%, 48.6%, 81.8%, 70.5% and 55.6% for tomato, broad bean, chickpea, common vetch and lentils, respectively compared to the control (Fig.2A&B).

2. Isolation of the broomrape pathogens:

In summer 2003 during field survey of broomrape, 84 samples of diseased broomrape spikes were collected. Most of the samples were collected from naturally-infested tomato plants growing under rain fed conditions. Suspected pathogens were isolated on semi-selective medium, purified and sub-cultured on PDA medium. The identification of pathogens showed that most of them were *Fusarium* spp., and *Rhizoctonia solani*, in addition to other fungi which still are under investigation. There were 109 isolates of *Fusarium* and 14 isolates of *R. solani*. The pathogenicity of the strains in polyethylene bags and in pots will be investigated.



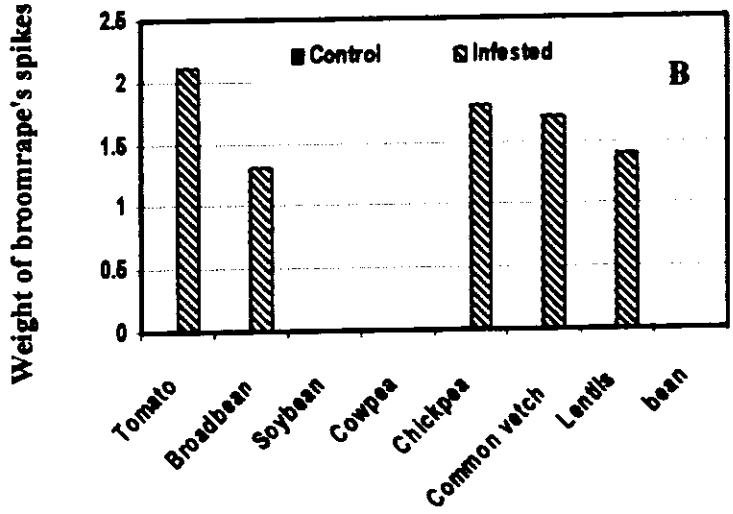


Fig.1 Crop resistance for broomrape in pot experiments; (A)-The number of broomrape spikes attached to the crop, and (B)- weight of broomrape spikes.

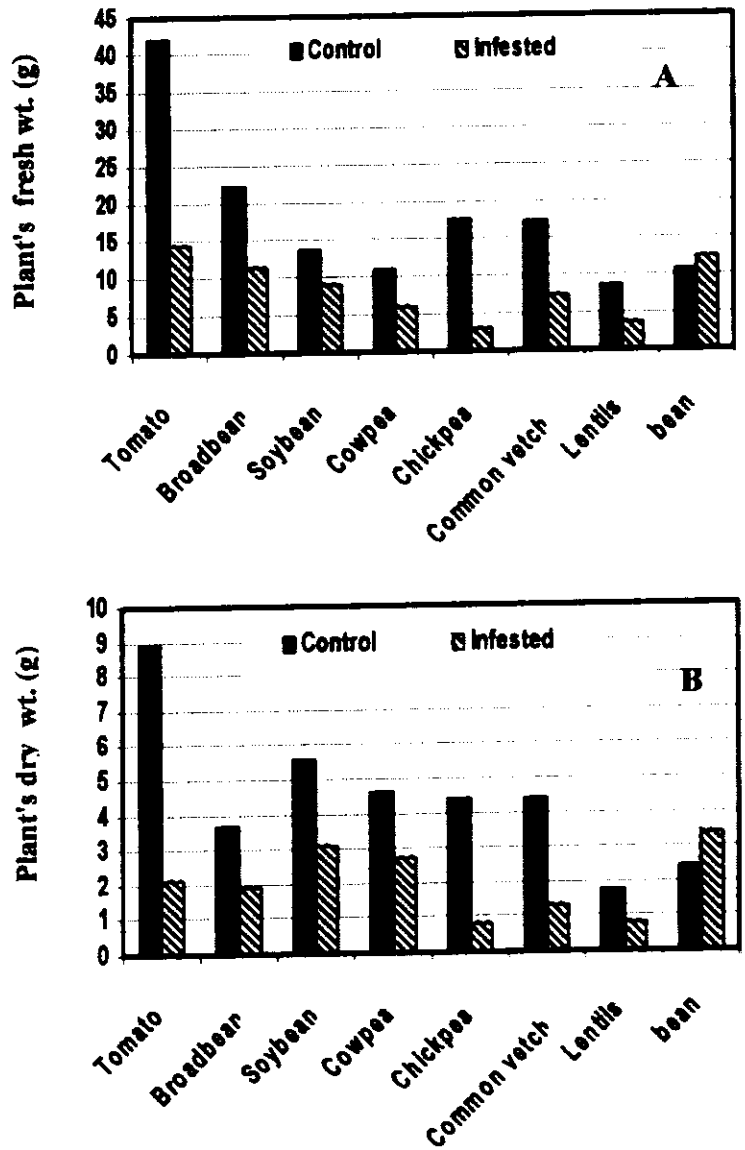


Fig. 2 Effect of broomrape's infestation on fresh weight (A) and dry weight of plants (B).

Overall, excellent progress has been made toward project objectives in the aspects of screening for resistance in both countries. We have already demonstrated that the research plan for the second year of the project was constructed together with our Palestinian partners during the visit of our collaborator Dr. Radwan Barakat to Newe Ya'ar Research Center during June 2003.

C) Scientific Impact of Collaboration

Despite the political situation and many obstacles prevailed in the area, cooperation has been established during the second year of the project. Initially, the collaborating partners communicated by email to discuss science and coordinate the project, but on June 2003, Dr. Radwan Barakat Co-PI visited Dr. Radi Ali lab. At Newe Yaar Research Center. This visit has been enormously valuable, allowing exchange of ideas and information, and providing a close link with the Newe Ya'ar group, where work continues on screening for legumes resistance and refinement of herbicides against broomrape. In the first year of the project, Dr. Barakat, has studied methods that are used in the laboratory, greenhouses and field experiments at Newe Ya'ar and he was responsible to deliver those techniques to Palestinian partners, students and technicians. Efforts of the Israeli team were concentrated in the second year on refine herbicidal methods for broomrabe control by using low rates of crop selective herbicides. Once this approach will be proved as efficient it will be transferred to our partners in the Palestinian Authority.

D) Project Impact

Our planned objectives for the second year were completed as outlined in the proposal: The Israeli team focused on refinement of herbicide application techniques for legume crops according to our systems which were previously achieved for controlling broomrape in crops such as tomato, potato, parsley etc. Where is, our Palestinian partner screened legume species for resistance / tolerance to broomrape and tested biological organisms for use as specific bioherbicides using techniques were adapted at Newe Yaar research center. Any potentially resistant lines identified or any tools will be proved as efficient against broomrape will be shared during this year between the two groups.

E) Strengthening of Developing Country Institutions

The Israeli Weed Science Department at Newe Yaar Research center is involved in various aspects of broomrape biology and control. The Israeli group acquired considerable experience in developing, testing and applying methods for broomrape control. This knowledge and techniques were recently transferred to Palestinian scientists during Dr. Radwan visit to Newe Yaar Research center on June, 2003 for training and adapting it to Palestinian students and technicians. Additionally, our partner was provided with some Israeli legume species, resistance or tolerant to broomrape and some isolates of fungi to use them as biocontrol agents to conduct biological control experiments for broomrape control in the Palestinian Authority. On the other hand some Palestinian legume species, resistance or tolerant to broomrape will be provided to the Israeli partner to test them under local conditions.

F) Future work

In Israel, the few herbicides were tested prevented completely inflorescences emergence above soil and some of them significantly reduced the total number of parasites counted on the roots. More experiments are needed to optimize the use of these herbicides for broomrape control. The Israeli team will also develop agronomic measures such as planting time to reduce broomrape seed bank in the soil.

The Palestinian team will continue screening the other legume species for resistance / tolerance to broomrape using polyethylene bags technique and pots.
Test the pathogenicity of *Fusarium* spp., and *Rhizoctonia solani* strains previously isolated from diseased broomrape using polyethylene bags technique and pots.
Test the potential of the herbicides (Round up, Glean, Amber, Pursuit, and Sulfonylurea) in controlling broomrape on legume species.