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TITLE OF PROJECT

Integrated Control Of Tetranychid Mites On Greenhouse Cucumbers
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C- Executive Summary

The ultimate goal of the project was developing an integrated pest management program for control of tetranychid injurious mites in cucumber greenhouses, while using the special technique of "Pest-in-First" method of the biological control strategy. In this technique instead of waiting for a natural infestation of spider mites to develop, the plants were inoculated with a few spider mites early in the growing season, then a few days later predators were introduced onto the same plants. The advantage of this method was that the presence of prey prevented the predators from dying out, so they can serve as a buffer against spider mite outbreaks occurring later in the season. Experiments showed that once prey and predators are established at low densities, the two species can coexist for an entire season without further introductions, and without any significant reduction in the yield.

A great success was achieved through this project to the benefit of both countries mainly to Jordan, since the results showed clearly and significantly that the use of the technique "Pest- in-First" as a method of the biological control strategy could replace the traditional use of synthetic chemicals for control of the tetranychid mites in cucumber greenhouses. This lead to less coastly production, less environmental pollution and healthier crops.

The bio-control agent, the predatory mite *Phytoseiulus persimilis*, was effective in reducing the level of the tetranychid mites to the same level the chemical treatment did, and did not reduce the size of the yield, which was very successful.

The study of population fluctuations and species composition was conducted in commercial and unsprayed cucumber greenhouses in the Jordan valley (Jordan) and at – the Jezriel valley (Israel). Over the entire observation periods, in both countries, no native predatory mites were found, and no other injurious tetranychid mite other than *Tetranychus cinnabarinus* (Boisd) was found.

In both countries pesticides were tested on two species of predatory mites that could be of use in cucumber greenhouses. The results showed selectivity. This means that farmers can use the appropriate chemical without serious damage to the beneficial organism.

The Jordanian principal investigator with his research engineer visited the Israeli investigator, observed all the facilities and techniques in the Israeli side and discussed all issues regarding the joint project. In addition, the Israeli partner visited the Jordanian investigator and guided him in each step of the study.

The start of the project in Jordan was delayed by one year due to the delay on the part of the collaboration institute "NCARTT" in signing the Grant Agreement and in addition to that there was a delay in transferring the budget needed to the Jordanian side (Feb. 2004) by the U.S administration.

D. Research Objectives:

During the last decade greenhouse vegetables, mainly cucumbers (*Cucumis sativus L.*), have become the major crop grown in the Jordanian agricultural areas. The mite *Tetranychus cinnabarinus* (Boisduval) (Acari: Tetranychidae), is a major pest of this crop, causing damage by sucking out leaf cells (2,13). Crop protection, most often by the use of pesticides, has been associated with a score of problems, including the resurgence of some pests, development of pest resistance to acaricides, and deleterious effects on beneficial organisms (6,9,11). Predacious mites of the Phytoseiidae family have been considered to be of major importance in the control of spider mites in greenhouse vegetables (3,4,5,12,14,15).

Cucumber is one of the most important vegetables grown in the Jordan valley (JV) under protected plastic houses. According to the Department of Statistics in the Ministry of Agriculture (2003), the total number of plastic houses planted with cucumber are 19850, out of these 9986 plastic houses were in the upland and 9859 in the JV, producing 56620 and 45934 tons in the upland and JV, respectively. However, 22% of this production were exported to different countries. (Ministry of Agriculture. Jordan).

This study is a pioneering one, since it was the first attempt to put a natural enemy into practice in developing an integrated mite management program. For this purpose, the following procedures were conducted for the first time in the Middle East: 1. Studying the phenology, population dynamics of the phytophagous tetranychid pest mite in cucumber greenhouses in the region 2. Identifying and recognizing the native predatory phytoseiid mite if it will be found in sprayed and in unsprayed CGH. 3. Studying the potential of the bio-control agent. 4. Investigating the susceptibility of the natural enemy to commonly used pesticides.

5. Choosing pesticides less harmful to the natural enemy, and 6. Utilizing it as a biological control agent (1,4,16). All these are key innovations which have never been tried either in the Jordan or in Israel. The outcome of the findings were pre-requisite and essential for developing integrated mite control schemes suitable for the hot dry weather that characterizes the region (1,7,8).

In addition we adapted the method "Pest-in-First" (16), that is to say: instead of waiting for a natural infestation of spider mites to develop and then applying predatory mites as "living pesticides", the plants are inoculated with a few spider mites "Pest-in-First" early in the growing season, then a few days later predators are introduced onto the same plants. The advantage of this method is that the presence of prey will prevent the predators from dying out, so they can serve as a buffer against spider mite outbreaks occurring later in the season.

In Jordan and in Israel spider mites are considered one of the most economically important (destructive?) pests; they attack cucumber plants grown under plastic houses, causing extensive damage and reducing the quality of the fruits. In addition, during the past few years, Jordanian and Israeli farmers have noticed frequent failure of various acaricides against spider mite infestations (personal information). It is evident that prolonged use of these acaricides has increased the degree of tolerance of spider mites populations.

E - Methods and Results

Israel (2003-2004)

In the Jezriel valley in Sandalah village, one third (750 m^2) of a commercial plastic house (2000 m^2) was rented to run two different experiments.

Experiment No. 1.: Biological control of the red spider mite *Tetranychus cinnabarinus* using the predatory mite *Phytoseiulus persimilis* (Pest-in-First) .

Materials & Methods: Seedlings of cucumber (variety: IV36) were planted and treated (Date of seedling Oct. 1, 2003) as customary for commercial use. Four rows, each 50 meters long were used, adding to a total area of 350 m^2. Each row was divided to 5 sections; in each section there were 10 plants, 8 of them were infested with phytophagous mites *T. cinnabarinus* and later with the predatory mites *Ph. persimilis* .

Each section was used as one replicate and there were 5 replicates for each treatment.

The strain of the mite *T. cinnabarinus* used in this study originated from infested cotton leaves at the Newe Yaar Research Center in 1991. Since then, new spider mites from different sources have been added three time a year to avoid inbreeding depression. Rearing was done on trifoliate leaves of 2-3 week-old kidney bean (*Phaseolus vulgaris l.*).

Plants were grown in 25x32x8 cm high pots. The mites were reared in a controlled climate room at 25°C-27°C. 60±5 % r.h. and 16 h of light supplied by a series of fluorescent lamps, providing a light intensity of ca 2000 Lux.
The bean leave pieces (2x2 cm) containing 10-20 adult mites were cut and placed (23.10.03) on each plant in each section when the cucumber plants were 3-week-old (ca 80 cm high).
Ten days later (3.11.03). Six standard plastic bottles of predatory mites=PM, (each bottle containing about 2000 PM) were bought and brought from Bio-Bee Biological Systems Sdde Eliyahu. Two were used for a dose of 80 PM/plant and four for a dose of 160 PM/plant. Spraying with Vertimic was done on the same day.
The following treatments were applied: 1=control ;2=spray with vertimic 0,1%; 3=spread of *Ph. persimilis* (*pers.*) at a dose of 80 per plant; *4*= spread of *Ph. persimilis* (*pers.*) at a dose of 160 per plant.
The experiment had a completely randomized design.
In order to examine the effects of the treatments, sampling was done each week as follows: in each section (8 plants in total) the third-forth leaf from the apex was taken from each plant (40 leaves from each treatment group) and the mites were washed away with Ethanol solution at a concentration of 80% and kept in plastic bottles (500 cm^3). These bottles were brought to the laboratory and the mites were counted under a stereomicroscope. The yield harvested from each treatment group (8 plants) was weighted twice a week in the greenhouse during the whole period of observation.
Experiment No. 2: Population fluctuations and species composition of mites in an unsprayed greenhouse cucumber 2003/4.
Materials & Methods: As in experiment 1; at the same plastic house, five rows 50 meters long each (total area about 350 m^2) were used to study natural infestation with mites, population fluctuations and species composition. These five rows since 3 week after seedling were divided to 10 sections. In each row there were two sections, and each section contained 50 cucumbers plants. Every week in each section, the third or fourth leaf was taken off each fifth plant. This means that from 10 plants from each section, a total 100 plants (100 leaves) were sampled and washed with Ethanol solution at a concentration of 80%, thus all live organisms including mites were dislodged and kept in plastic bottles, to be taken to the laboratory for observation and counting under a stereomicroscope.

Results:

Experiment No. 1: The results of biological control of the tetranychid mites was evaluated in cucumber plants in greenhouses using the "Pest-in-First" method are shown in Table 1. Even when we summarizeed the sample values received on all dates of sampling (a measure of potential accumulating damage), all the treatment groups were significantly different than the control. The reducing effect of the number of injurious mites (TM) was as follows: Vertimec: 84%; *pers.* dose 80: 92%; and *pers.* dose 160: 96%;. The three treatments were not significantly different among themselves.
The effect on yield was as follows (Table 2): the use of the predatory mite *pers.* dose 160 gave the highest yield (1677.5 gr/sample) and was significantly different from the control group (1327 gr/sample); and *pers.* dose 80 (1325 gr/sampl); but not significantly different from treatment with Vertimec (1592 gr/sample). The yield in the control and *pers.* dose 80 treatments was 21% less than that of *pers.*dose 160.
Experiment No. 2: The results are shown in Fig. a. The tetranychid mites started to appear on the first week of November 2003 and peaked in mid December, reaching more than 150 mites/leaf (one sample = 100 leaves), and then declined when the plants were nearly destroyed. No predatory mites were found except for *Phytoseiilus persemilis,*

which immigrated from the plants that were infested early in the season in the second part of the greenhouse. They started to appear in mid Dec. and reached 0.2mite/leaf two weeks later.

Israel (2004)

In the Jezriel valley, in Sandalah village, one third (750 m²) of a commercial plastic house (2000 m²) was rented to run two different experiments.

Experiment No. 1.: Biological control of the red spider mite *Tetranychus cinnabarinus* using the predatory mite *Phytoseiulus persimilis* ("Pest-in First").

Materials & Methods: Seedlings of cucumber (variety: IV36) were planted and treated (Date of seedling Apr. 15. 2004) as customary for commercial use. Four rows 50 meters long each, were used, constituting a total area of 350 m². Each row was divided to 5 sections; in each section there were 10 plants, 8 of them were inoculated with phytophagous mites *T. cinnabarinus* and later with the predatory mites *Ph. persimilis*.
Each section was used as one replicate and there were 5 replicates for each treatment.
The strain of the mite *T. cinnabarinus* used in this study originated from infested cotton leaves at the Newe Yaar Research Center in 1991.
Bean leave pieces (2x2 cm) on which there were 10-20 adult mites were cut and placed (5.5.04) on each plant in each section when the cucumber plants were three week old (ca 80 cm high).
Eight days later (13.5.04), six standard plastic bottles of predatory mites=PM, (each bottle containing about 2000 PM) were bought and brought from Bio-Bee Biological Systems Sdde Eliyahu. Two were used at a dose of 80 PM/plant and four at a dose of 160 PM/plant. Spraying with Vertimec was done on the same day.
The following treatments were applied: 1=control ;2=spray with Vertimec 0,1%; 3=spread of *Ph. persimilis* at a dose of 80 per plant; *4*= spread of *Ph. persimilis* at a dose of 160 per plant.
The experiment had a completely randomized design.
In order to examine the effects of the treatments, sampling was done each week as follows: in each section (a total of 8 plants) the third-forth leaf from apex was taken from each plant (40 leaves from each treatment group) and the mites were washed away with ethanol solution at a concentration of 80% and kept in plastic bottle (500 cm³). These bottles were brought to the laboratory and the mites were counted under a stereomicroscope. Yields harvested from each treatment group (8 plants) were weighted twice a week in the greenhouse during the whole period of observation.

Experiment No. 2: Population fluctuations and species composition of mites in an unsprayed cucumber greenhouse 2004.

Materials & Methods: As in experiment 1; at the same plastic house, five rows 50 meters long each, (a total area of about 350 m²) were used to study natural infestation with mites, population fluctuations and species composition. These five rows were divided to 10 sections 3 week after the seedlings were planted. All procedures were the same as those described in Exp No. 2 in the previous year.

Results: Results are shown in Tables 1,2 and Figures 1 and 2

Experiment No. 1: The results of biological control of the (TM) evaluated in cucumber plants in greenhouses using the method of "Pest-in-First" are shown in Table 1, Fig 1. The overall average of cucumber yield (X gr. / 8plants) were compared by t-test (p=0.5). It was found that Vertimec treatment and the use of the predatory mite *Ph. p* at dose 80 caused a significant increase of 27% (X= 4379 gr. / 8 plants) and 30% (X= 4471 gr. / 8 plants) respectively as compared to the control group (X = 3372 gr. / 8 plants). The use of the predatory mite at the dose 160 caused a 6% increase in the yield (X= 3931 gr. / 8 plants), which was not significantly different from the control group. It seems that the

absence of phytophagous mites for a few days after the release of predaceous mites at dose 160 led to immigration of these mites to other sections in the plastic house.
Even when we summarize the values of all the samplings (starting 30.5 ending 4.7) (a measure for potential accumulating damage) the results (Table 2) in the control group were X= 4353; treatment *Ph. p.* 80, X=1940 (reduction effect, RE=55%) treatment *Ph. p.* 160, X=4063 (RE=6%) and Vertimec X=243 mites per 8 plants. (RE=94%). It should be emphasized that even at the highest percentage of reduction in mite numbers caused by Vertimec, the increase in yield caused by this treatment was equal to that of *Ph. p* 80.
When we compared between treatments using cumulative mite (MD) days (Table 3) for the injurious spider mite *T. cinnabarinus* (T.c. MD) and the predatory mite *Ph. Persimilis* (*Ph. p.* MD) it was found that only Vertimec treatment caused a significant reduction in TcMD and in *Ph. p.* MD, while the use of the predatory mite *Ph. p.* at dose 80 and *Ph. P.* at dose 160 caused certain non significant reduction, but despite this, the use of the predatory mite at dose 80 caused significant increase in the yields, as did the Vertimec treatment.
Experiment No. 2: The results are shown if Fig 2. The tetranychid mites started to appear on the first week of June 2004 and peaked at the end of June, reaching about 470 mites/leaf (one sample = 100 leaves), and then declined when the plants were nearly destroyed. No predatory mites were found except *Ph. persemilis*, which immigrated from those plants that were infested early in the season in the other parts of the greenhouse.

Effect of Pesticides on the predacious mite *Neoseiulus californicus* - 2005

In another experiment the predacious mite *N. californicus* was tested instead of *Ph. Persimilis*, since this mite has been recently imported to Israel, and is considered potentially effective for the control of tetranychid mites in greenhouse vegetables. In addition *Ph. Persimilis* has been subjected to the effect of pesticides as was done by Bio-Bee Biological Systems Sdde Eliyahu.

Material and Methods:

Maintenance of mite cultures and bean plants:
The predacious mite stock *N. californicus* were reared in the laboratory in a controlled climate room at 25-27^0 C, 60 ± 5 Rh. and 16 h light supplied by a series of fluorescent lamps yielding a light intensity of Ca 2000 Lux.
The predacious mite *N. californicus* strain originated from California and was reared on pollen of flowers of a *Pestacia atlantica* tree. From time to time it was fed with *T. cinnabarinus* from the laboratory colony.
Kidney bean *Phaseolus vulgaris* were seeded in pots (dept 8 cm; width; 25;length 32 cm) at 7 day intervals. A bioassay was done on a ca.2 week old kidney bean.

Toxicological tests

All pesticide formulations were diluted in water to obtain the required concentrations suggested for field applications. Water was used as control in all trials.
Bean leaves ca. 2 weeks old were dipped for 5 sec in the aqueous dilutions of the pesticide. Control leaves were dipped in water only.
The bean leaves were dried at room temperature and placed bottom side up on filter paper, floating on water in an aluminum pan (width ; 10 cm, length 15 ; depth 2 cm), and the upper side was placed on a plastic square (60 x 60 mm, 4 mm thick), with a 35 mm diameter hole, held in place with metal clips. Caster oil was applied Around the hole. Ca. one hour after dipping of the leaves in the diluted pesticide, 10 adult *N. californicus* were transferred from the colonies kept in the laboratory and placed on each leaf. Pollen of Tabor oak *Pistacia ithaburensis* (Anacardiacae) were placed on each leaf to serve as food.

The leaves with the mites were kept in a controlled climate room at 25^{0}C, 50-60% rh, 16 h light. Two days following the mite' exposure, the numbers of live, dead and/or repelled mites were recorded; mites which had left the leaves and were stuck to the caster oil were considered as repelled. Altogether 7 replicates were set up on 7 dates. The direct toxicity to *N. californicus* was evaluated in seven replicates of 10 mites per replicate.

Statistical analysis: The data were analyzed by analysis of variance and Duncan's multiple range test.

Pesticides Tested: The 11 pesticides employed were:

1. Abamectin (Vertimec® 18 g /l EC), 2. Neem Oil (Neemgard 97% Ol), 3. Tebufenpyrad (Masai® 20 20% WP), 4. Carbosulfan (Marshal 25 250 g /l EC), 5. Imidacloprid (Confidor® 350 g /l SC), 6. Triadimenol (Bayfidan 250 g /l EC), 7. Mefenoxam 4%, Mancozeb 64%, (Ridomil Gold MZ 68 WG), 8. Myclobutanil (Systhane 125 g /l EC), 9. Penconazole (Ofir® 200g /l EW), 10. Bupirimate (Nimrod 250 g /l EC), 11. Mancozeb 60%, Dimethomorph 9%, (Acrobat® 69 WP).

Results: Fresh, 1-h-old residues of the acaricides Vertimec, Massai and Marschal showed relatively strong to moderate acaricideal activity against the predatory mite *N. californicus* with mortality rates of 86%, 82%, and 77% respectively. All the other compounds were nearly equal in their effect (0-12%) (Table 4).

Regarding repellency rates, we can distinguish three levels of activity. One group includes: Systan (60%), Confidor (45%), Bayfidan (43%), Ofir (42%). The second group includes Acrobat (30%), Ridomil (27%), Nimrod (26%), Neemgard (18%), Marschal (17%). The third group includes Massai (12%), Control (7%), Vertimec (5%).

Table 1: Mean total no. of the Phytophagous mite *Tetranychus cinnabarinus* in three different treatments in comparison to control (40 leaves/treatment/week -8 weeks accumulative) – Sandala 2004

Treatment	Mean no. Of Tetra. mites	Effect of reducing (TM)
Control	375.5 a	
Vertimic	60.7 b	84% (6 fold)
Ph. pers. 80	32.6 b	92% (12 fold)
Ph. pers.160	15.4 b	96% (24 fold)

Levels not marked by same letter are significantly different (α = 0.05)0.

Table 2: The effect of treatments on yield (all dates – comparison of average yield per date, 17 samples (sample = yield from 8 plants) - Sandala 2004

Treatment	Mean weigh (gr)	Reduction in yield
Ph. pers.160	1677.5 a	-
Vertimic	1591.6 ab	5%
Control	1327.0 b	21%
Ph. pers. 80	1324.5 b	21%

Levels not marked by same letter are significantly different (α = 0.05)

Fig. a: Phenology of tetranychid and predatory mites in cucumber green house Sandala 2003/4

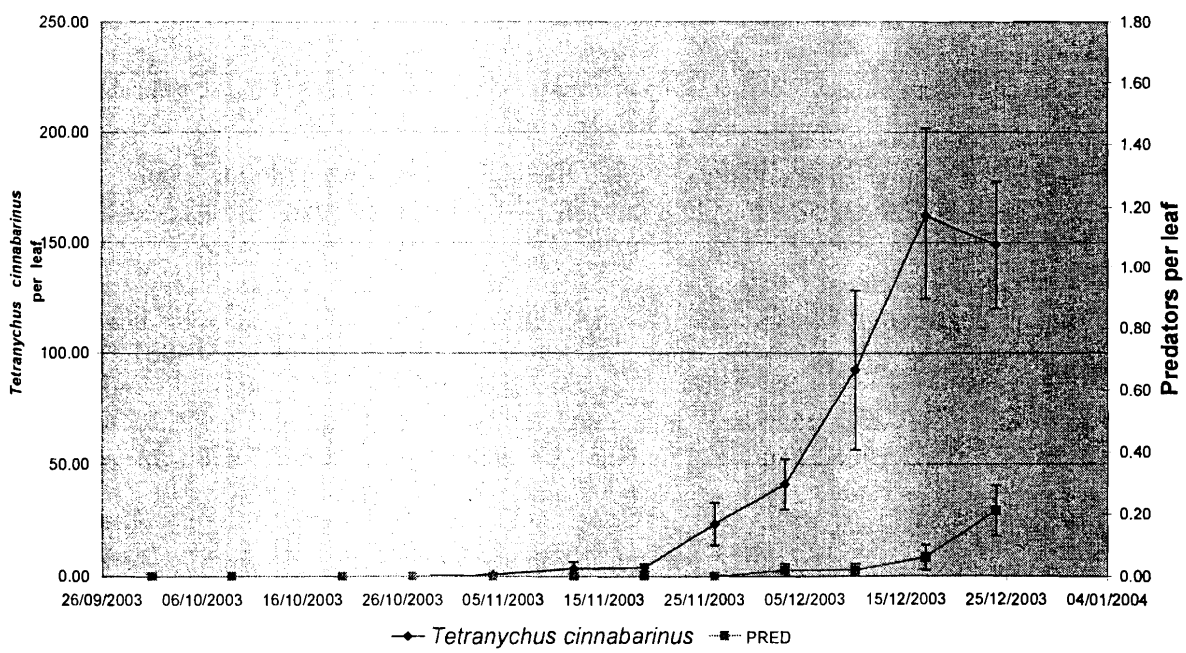

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Fig 1. Average yield of Greenhouse cucumber in 4 different treatments in each date of harvesting (13 samples; yield from 8 plants=sample)

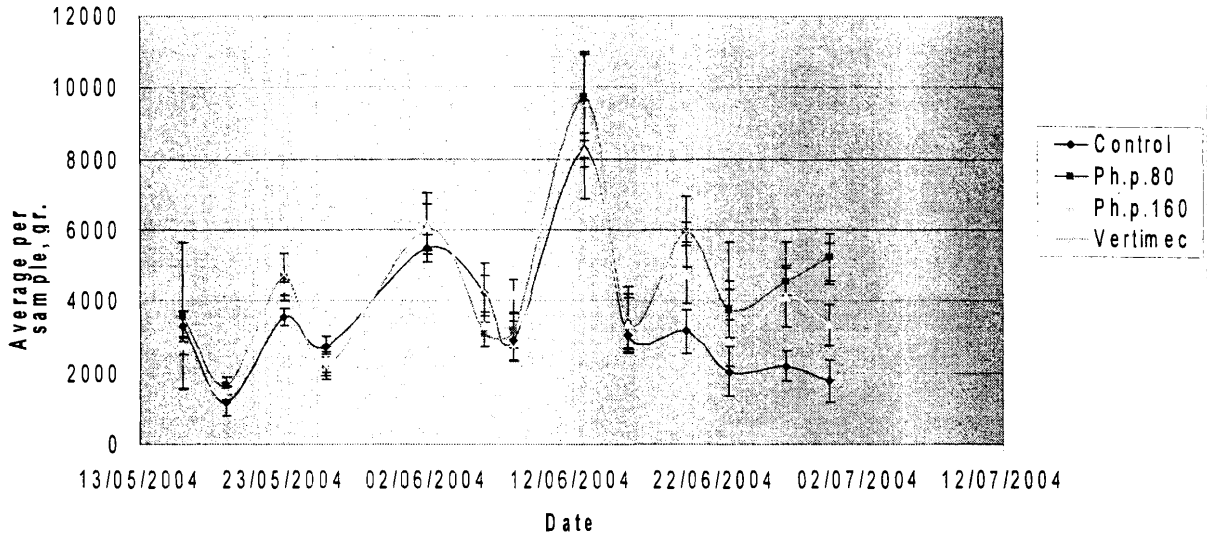

Fig 2. Mean number of motile stage per 10 leaves of *Tetranychuus cinnabarinus* in cucumber greenhouse at sandala 2004

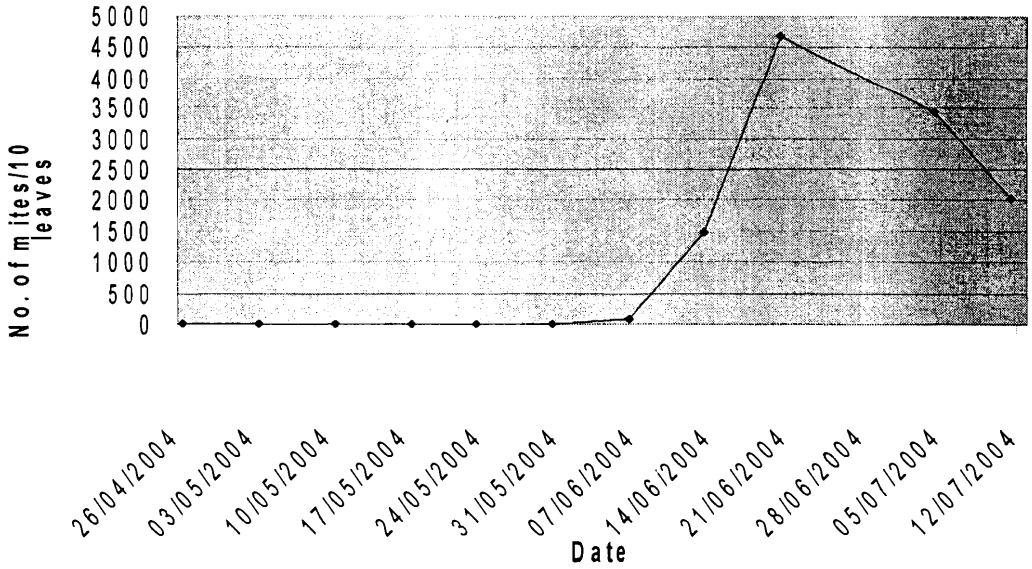

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Table1: The effect of different treatments on average total yield of greenhouse cucumber (t-test: α=5%) (13 samples; sample= yield from 8 plants) - Sandala 2004

TREATMENT	MEAN	STD DEV	STD ERR MEAN	INCREASE IN YIELD
Control	3372.1b	2019.4	250.5	-
Ph. pers. 80	4378.8a	2632.8	326.6	30%
Ph. pers. 160	3931.6ab	2137.2	265.1	6%
Vertimec	4471.5a	2561.6	317.7	27%

Means followed be the same letter do not differ significantly at P<0.05 (Tukey-Test).

Table 3. Mean number of cumulative mite days of the four treatments in greenhouse cucumber at Sandala, 2004.

TREATMENT	*T.C.* M MD		*Ph. pers.* MD	
Control	166499.9	a	2857.3	ab
Ph. pers. 80	76395.5	ab	49499.4	a
*Ph. pers.*160	15619.8	a	4337.1	a
Vertemic	8876.1	b	1007.8	b

Means followed by a common letters do not differ significantly at P<0.05 (Tukey-Test).

*T.C.*M MD: cumulative mite days of the spider mite, *Tetranychus cinnabarinus.*
Ph. pers. MD: cumulative days of the Phytoseiid mite, *Phytoseiulus persimilis.*

Table 2: Average no. of motile stage per 8 leaves of mixed population of phytophagous tetranychid (*T. cinnabarinus*) and predaceoius phytoseiid (*Ph. persimilis*) mites on greenhouse cucumber at Sandala 2004 (5.5.04 infestation with *T. cinnabarinus* (*T.c.*); 13.5.04 infestation with *Ph. pers.*; spraying with Vertimec 23/5,6/6,17/6,27/6)

Date / Treatment		Control	*Ph. pers.* 80		*Ph. pers.* 160		Vertimec	
	T.c.	*Fh. pers.*	*T.c.*	*Ph. pers.*	*T.c.*	*Ph. pers.*	*T.c.*	*Ph. pers.*
26/4/04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3/5/04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10/5/04	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0
17/5/04	0.0	0.0	2.4	1.4	0.0	3.0	0.0	0.2
23/5/04	4.2	0.2	4.0	2.0	0.2	0.0	4.0	0.2
30/5/04	45.0	0.6	49.0	1.6	92.6	1.4	1.2	0.0
6/6/04	658.0	8.6	301.0	16.6	1090.0	15.6	11.6	0.8
13/6/04	4386.2	23.8	2561.4	120.6	4307.6	46.6	21.0	3.0
20/6/04	8953.6	171.4	4423.4	244.2	6951.0	179.4	279.6	18.8
27/6/04	7402.0	165.6	2842.0	296.4	7805.6	350.4	758.6	117.6
4/7/04	4673.6	76.0	1461.8	49.0	4133.4	46.8	384.2	6.8
Total	26120		11644		24380		1459	
Mean	X=4352		X=1940		X=4063		X=243	
RE	-		55%		6%		94%	

Ph.Pers. : *Phytoseiulus persimilis*

T.c.: *Tetranychus cinnabarinus*

RE: Reduction effect

Table 4: Mortality, repellency and fecundity of adult predator mites *Neoseiulus californicus* exposed for 48 h-old spray residues from different pesticides on kidney bean leaves (10 predators/replicate; 9 replicates).

Concentration of the aqueous dilution of the tested pesticide	Mean No. Of live	Mean No. Of Dead	(%)	Mean No. Of Repelled	(%)	Mean No. Of eggs After 48 h.
Control	9.0 A	0.2 B	(2%)	0.7 D	(7%)	4.5 A
Neemgard (1%)	8.1 A	0.0 B	(0%)	1.8 CD	(18%)	1.6 BC
Acrobat (0.3 %)	6.8 AB	0.1 B	(1%)	3.0 BCD	(30%)	2.0 B
Ridomil (6 gr./liter)	6.5 AB	0.6 B	(6%)	2.7 BCD	(27%)	1.3 BC
Nimrod (0.04%)	6.5 AB	0.5 B	(5%)	2.6 BCD	(26%)	1.3 BC
Bayfidan (0.1%)	5.3 BC	0.3 B	(3%)	4.3 ABC	(43%)	1.6 BC
Confidor (0.05%)	4.8 BC	0.5 B	(5%)	4.5 AB	(45%)	1.2 BC
Ofir (0.1%)	4.4 BC	1.2 B	(12%)	4.2 ABC	(42%)	0.5 BC
Systan (0.05%)	3.8 C	0.1 B	(1%)	6.0 A	(60%)	1.0 BC
Vertmic (0.1%)	0.7 D	8.6 A	(86%)	0.5 D	(5%)	0.7 BC
Massai (2 gr. /liter)	0.5 D	8.2 A	(82%)	1.2 D	(12%)	2.1 B
Marschal (0.15 %)	0.4 D	7.7 A	(77%)	1.7 CD	(17%)	0.0 C

Means followed by the same letter do not differ significantly at $P<0.05$

JORDAN (2004-2005)

Materials and Methods.

This research was carried out in the years 2004 and 2005, at the Deir Alla Experimental Station, Jordan Valley, in two plastic houses (each 400m^2).

1. Population dynamics – (conducted in first plastic house)

Twenty cucumber plants (Variety 189) were selected randomly from the first plastic house (control treatments) and sixty apex leaves were checked once a week in order to count the total numbers of adults and nymphs of the carmine spider mite (CSM) *Tetranychus cinnabarinus*. Temperature and relative humidity were recorded using the thermo-hygrograph inside the plastic house.

2- Evaluation of the predatory mite as a biological control agent (conducted in the second plastic house)

When cucumber plants reached 60 cm height they were artificially infested with CSM (20m/plant), Two weeks later *Phytoseiulus persimilis* was introduced.

In 2004 four treatments were set up in a complete randomized design replicated five times and in 2005, four treatments were replicated four times.

Weekly random samples of twelve and ten leaves per treatment were taken, in 2004 and 2005 respectively. Spider mites and predatory mites were counted using a magnifying lens.

The treatments were:-

2004: 1. control, 2. Masai 20WP (tebufenpyrad), 10gm/20lt. water. BASF- Italy. 3. *P. persimilis* rate 80/ m^2, 4. *P. persimilis* 160/m^2.

2005: 1. control, 2. Vertimec 1.8EC (Abamectin: 80% avermectin B1a and 20% avermectin B1b), 10ml/20lt. water. Syngenta – Bazel, Switzerland. 3. *P. persimilis* 50/ m^2, 4. *P. persimilis* 100/m^2 5. *P. persimilis* 150/m^2.

The total weight of fruits from each treatment was recorded from the beginning to the end of the seasons for the two years. For presentation Yield data was converted to tons/1000m^2 plastic house.

Results:

1. Population dynamics

CSM started to appear in mid February reaching 5 mites per leaf (Fig.1). Populations levels escalated from mid March until early May peaking at 280 mites per leaf, when average temperatures were ca. 26C^0. Populations then declined to ca. 39 mites per leaf in late May early June.

2. Evaluating the biological control of CSM using *P. persimilis*

In 2004 CSM populations were significantly higher in the control treatment than in the others. In the second week mean CSM levels reached 1750/12 leaves, While in the fourth week 190/12 leaves (Fig. 2). The Masai treatment yielded the lowest number of CSM arriving at 665 /12 leaves during first week and 128 /12 during fourth week (Fig.2). Predatory mite treatments at rate1 and rate2 provided comparable control to the Masai treatment. The number of CSM /12 leaves four weeks post release were 146 for rate 1 and 151 for rate 2. These numbers are significantly lower than that of the control, but did not significantly differ from the Masai treatment. The number of CSM was the lowest after the fifth week for the Masai treatment, as the numbers decreased to 72/12 leaves. This number was significantly lower than the levels attained in the other treatments. The numbers of CSM in the release rates 1 and 2 also decreased in the fifth week to 123,142 /12 leaves,

respectively, with no significant differences between release rates but differing significantly from the control (Fig.2).

Phytoseiulus persimilis were found in the Masai and control treatments, even though these treatments didn't receive any predatory mites. Predatory mite/ 12 leaves after one week for the Masai and control treatments were 25 and 30, respectively, which did not differ significantly from rate1 that reached 49 / 12 leaves (Fig.3). Two weeks post release, predatory mite levels in the control treatment were significantly higher than those of other treatments which reached 241/12 leaves, an indication of the searching ability of this predator, as this treatment had the highest number of CSM. The same trend was found three weeks post release, where the numbers of predatory mites were also significantly higher than those of the other treatments (164/12 leaves) (Fig.3). Four and five weeks post release predatory mite levels dropped following the decrease in CSM. In general we could not found clear differences between rate1 and rate2 of predatory mites.

Yields in the treatments Masai (8.2 tons/1000m^2) and predatory mite release rate2 (7.7 tons/1000m^2) were similar and significantly differed from the yields of release rate1 (6.5 tons/1000m^2) which in turn differed from the control (5.1 tons/1000m^2) (Fig.4).

The effects of *P. persimilis* on CSM populations in the second year of our trials (2005) are presented in Figures 5 through 9. In the second week post release population levels on release treatments ranged between 610-680 spider mites/10 leaves while it averaged 50-120 spider mites /10 leaves for the Vertimec treatment. From the fourth to the sixth week CSM numbers decreased substantially on release treatements, the lowest number being recorded in the fifth week of release rate3 with 50 spider mites/10 leaves. CSM populations were significantly lower on the Vertimec treatment for the first three weeks in comparison with the release treatments with 50/10 leaves in first week and 100/10 leaves in the third week. Whereas from the fourth week to the sixth week there were no significant differences between Vertimec and the other treatments, but rate2 and rate3 showed the lowest CSM number during the last three weeks with 48 and 45 in the fourth week, respectively. In the same period the Vertimec treatment showed slightly higher numbers in the fourth and fifth weeks, with 85, 110/10 leaves, respectively. Predatory mite levels were highest on release rate2 from the first to the fourth week, peaking at the fourth week with 365/10 leaves, in comparison to 276 and 286 during the same period for release rate1 and release rate3 , respectively (Fig.10). The numbers of predatory mites started to decrease during the last two weeks. The lowest number of predatory mites was recorded in the sixth week and reached 41/10 leaves at rate1, which was not significantly different from release rate2 and release rate3 with 48, and 49/10 leaves, respectively. All three rates reached very high predatory mite numbers compared to the Vertimec treatment. Predatory mites did move into the Vertimec plots in search of CSM.

In general in 2005, there were no significant different between the three rates of predatory mites, but rate2 (with an initial release of 100/m^2) had higher levels of *P. persimilis* and lower numbers of spider mites. In the first year release rate1 (with 80/ m^2) did not differ from release rate2 (with 160/ m^2). Indicating that the grower can introduce the predatory mites at the rate of 80-100/ m^2 on hot spots only, following up with supplementary releases in the case that additional hot spot appear. In 2005 there were no significant differences between the yields of the three release rates and the Vertimec treatment, but rate1 and Vertimec showed slight increases in yield with 7.8 and 7.7 tons/1000m^2, respectively, (Fig.11).

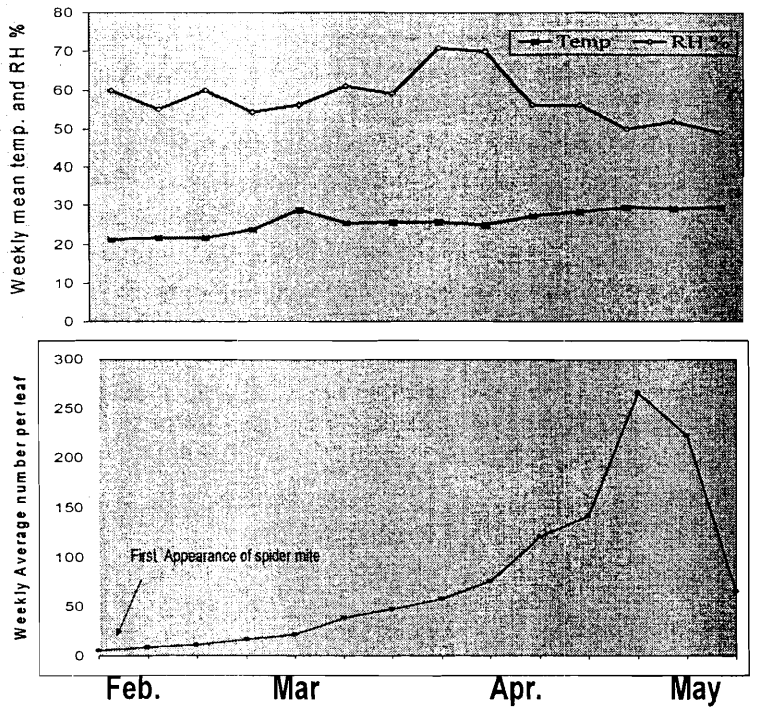

Fig.(1): Population dynamic of spider mites during , 2004.

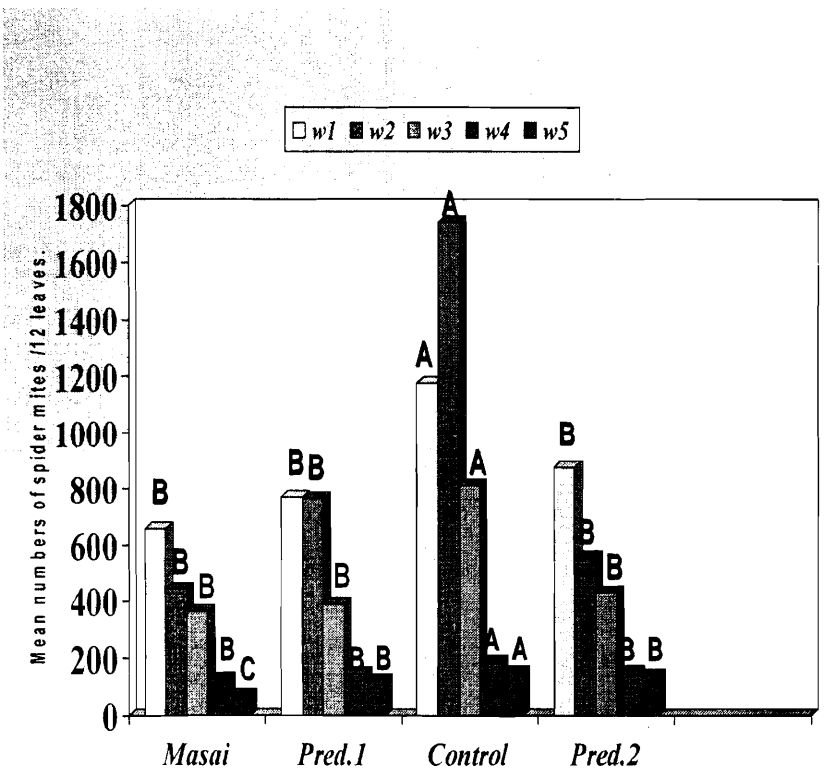

Fig.(2): Mean numbers of alived spider mites for the successive five weeks after applying the different treatments,2004.

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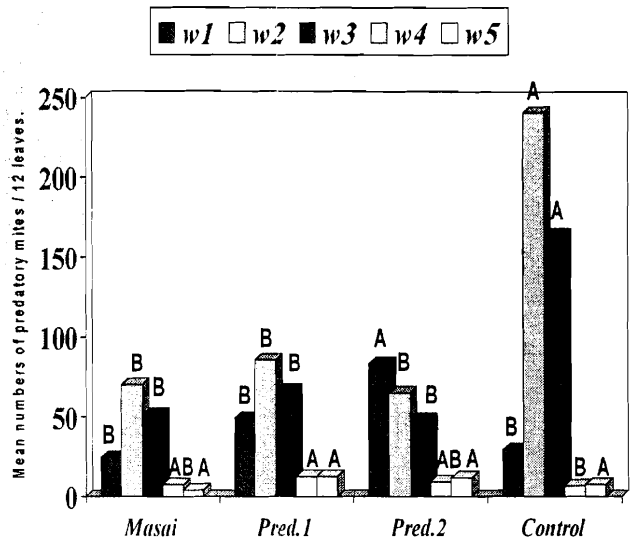

Fig.(3): Mean numbers of alived predatory mites for the successive five weeks after applying the different treatments,2004.

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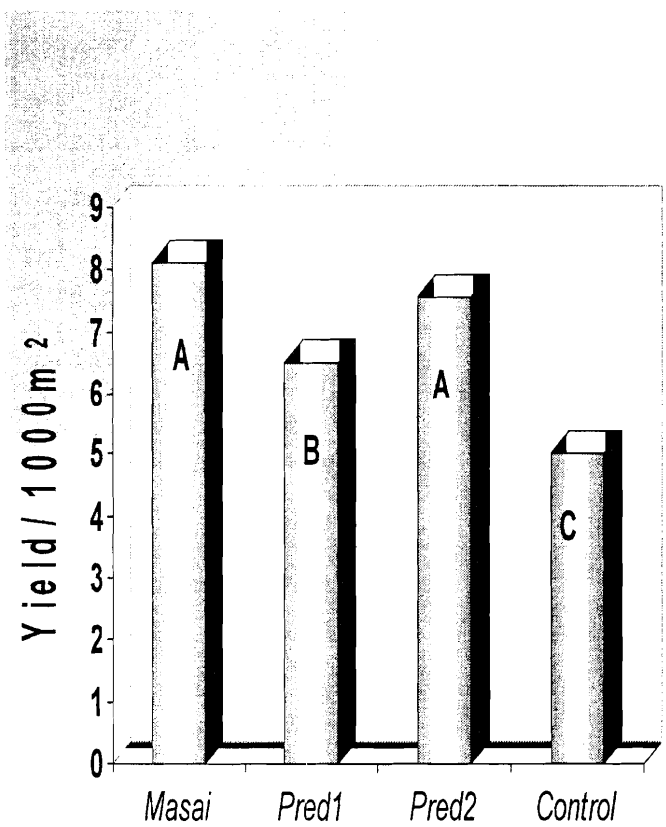

Fig.(4): Yield of evaluating the biological control of the spider mites Tetranychus cinnabarinus using the predator mites Phytoseiulus persimilis ,2004.

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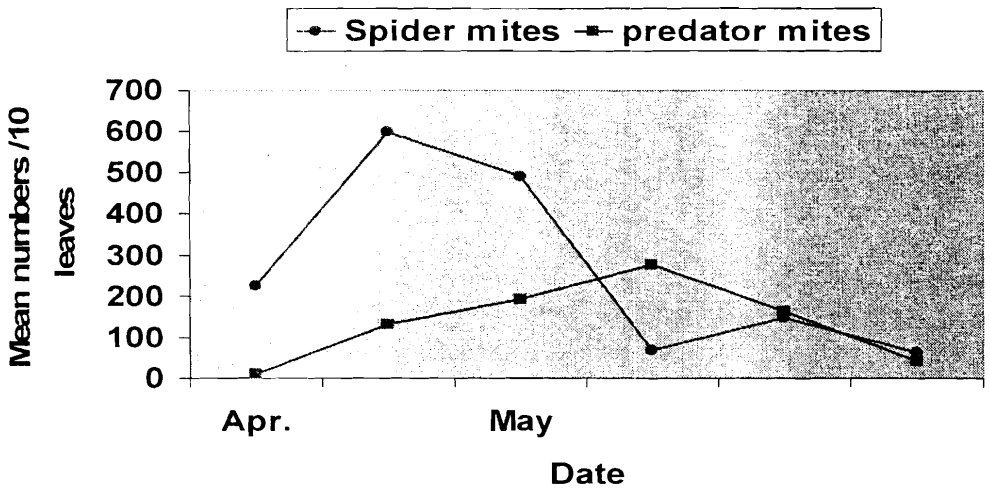

Fig.(5):The effects of introduction of predatory mites (*Phytoseiulus persimilis)* into a cucumber plants infested with spider mite (*Tetranychus cinnabarinus* and) at the rate(50/m²) of predatory mites , 2005.

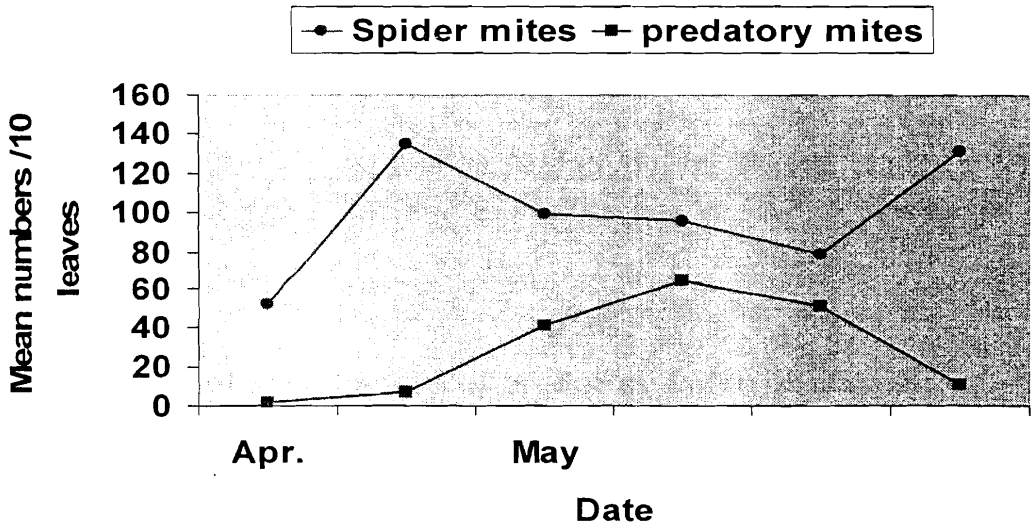

Fig.(6): The effects of Vertimec on the Spider mites (*T. cinnabarinus)* and predatory mites (*P. persimilis)*, on cucumber plants , 2005.

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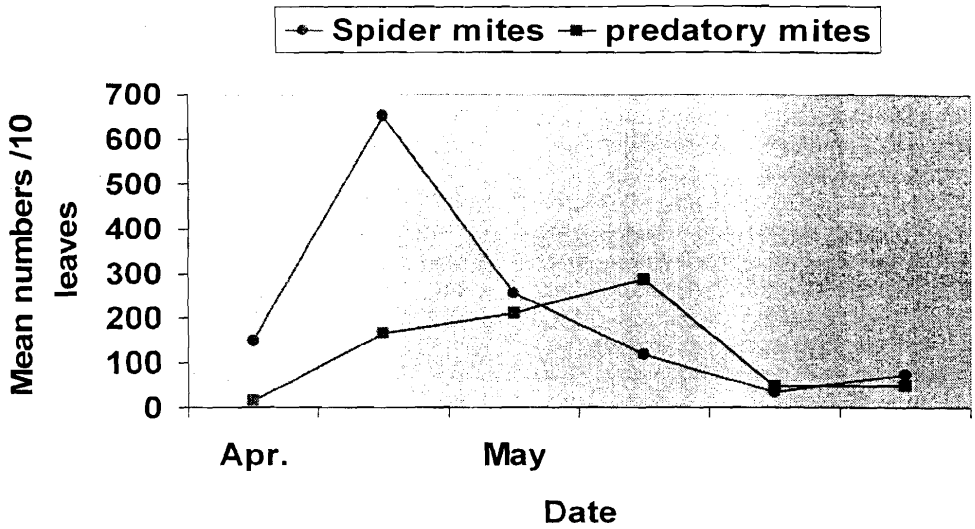

Fig.(7):The effects of introduction of predatory mites (*Phytoseiulus persimilis)* into a cucumber plants infested with spider mite (*Tetranychus cinnabarinus* and) at the rate of (150/m²) of predatory mites , 2005.

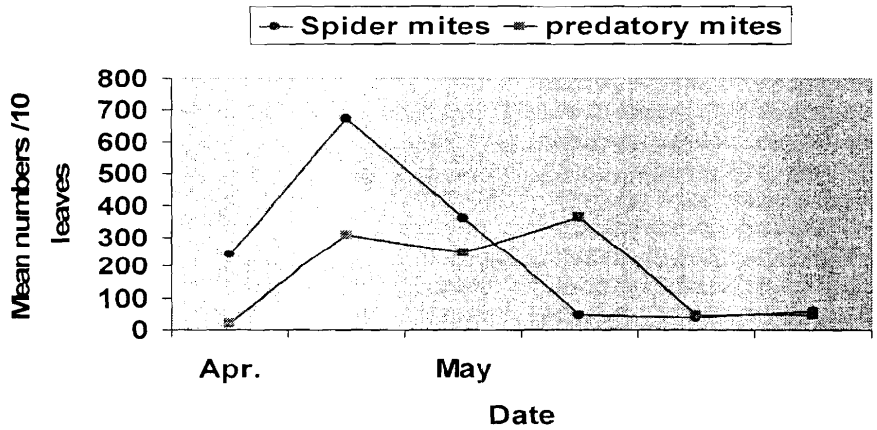

Fig.(8):The effects of introduction of predatory mites (*Phytoseiulus persimilis)* into a cucumber plants infested with spider mite (*Tetranychus cinnabarinus* and) at the rate of (100/m²) of predatory mites , 2005.

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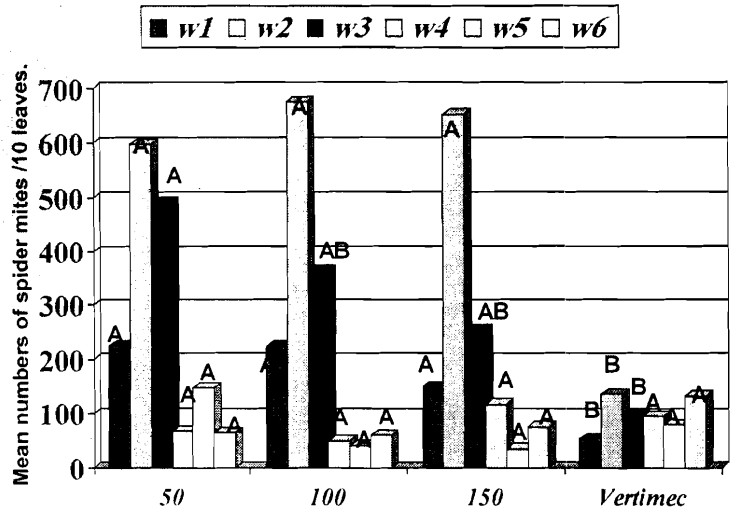

Fig.(9): Mean numbers of alived spider mites for the successive six weeks after applying the different treatments,2005.

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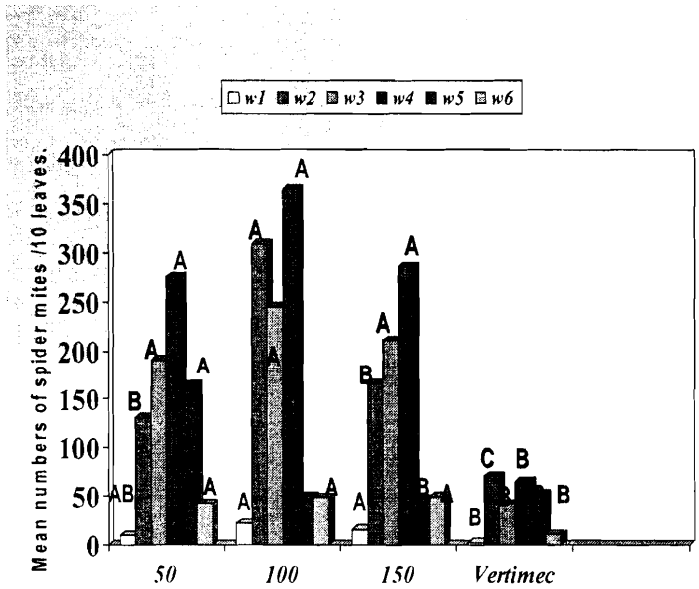

Fig.(10): Mean numbers of alived predatory mites for the successive six weeks after applying the different treatments,2005.

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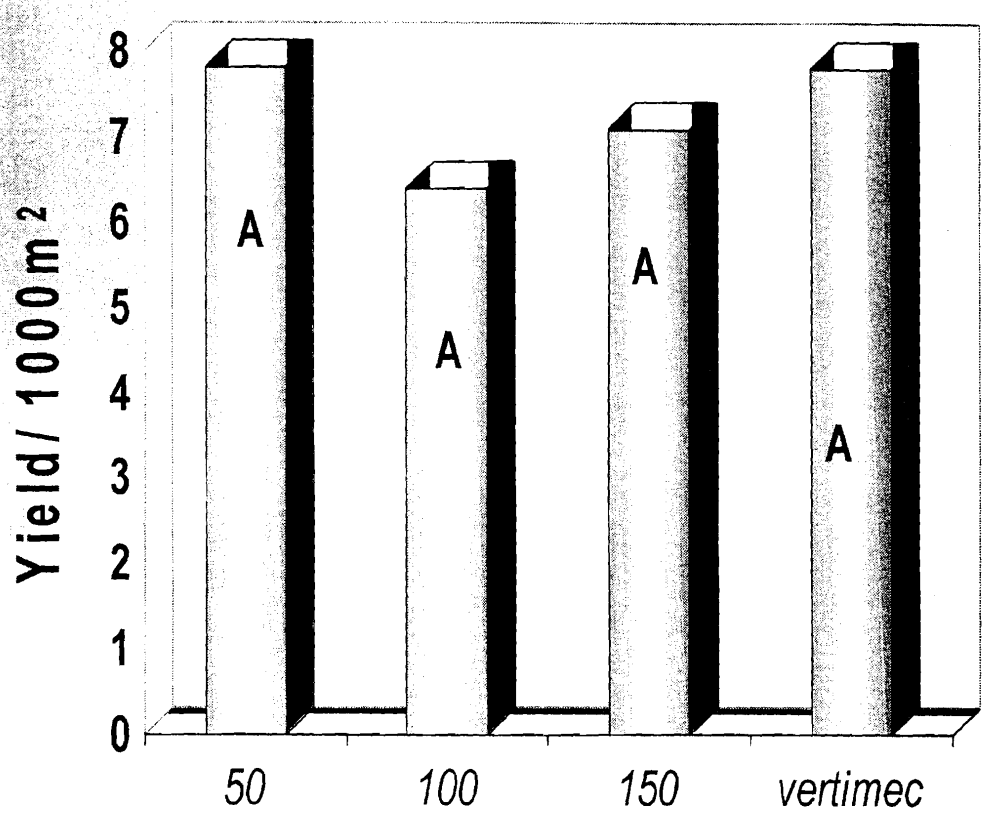

Fig.(11): Yield of evaluating the biological control of the spider mites Tetranychus cinnabarinus using the predator mites Phytoseiulus persimilis,2005 .

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F- Impact, Relavence, and Technology Ttansfer

The findings are very useful in the developing country considering the following facts. Spider mites are major cosmopolitan pests of many annual and perennial crops. Th control is becoming increasingly difficult due to the development of multi-facett resistance to pesticides, the increasing prices of agrochemicals, and the new awareness the ecological effects of the extensive use of pesticides.
Cucumber, a major crop in Jordanian areas and Israel, suffers annual losses due to mite In the last five years, cucumber production in greenhouses increased remarkably in th Jordanian areas. As of today, there are more than 19850 units which sustain a simil number of Jordanian families. In addition, thousands of farmers grow cucumber in walk-i tunnels. To ensure good yield and high quality products, acaricides are widely used fc control of injurious mites, with the well-known disadvantages. The results of this projec proved the ability to use natural enemy of injurious mites utilizing the technique of "Pest in-First" which lead to fewer pesticide applications, lower production costs, reduction o environmental pollution and the production of vegetables with substantially reduce chemical residues. Successful integrated pest management (IPM) or integrated mit management will encourage other farmers in the Jordanian areas to grow greenhouse vegetables and will help to raise their standard of living. The results with cucumber crops has serve as a model for other greenhouse vegetables and will also benefit the Israeli farmers, especially those of the Arab minorities who maintain the largest quantity of cucumber greenhouses. The results will also be of great significance to other developing countries in the region.

G - Project Activities / Outputs

1: Meetings were held in Israel and in Jordan during the project study. First visit to Jordan was accomplished during August 2003, 17-22, when the Israeli principal investigator (Mansour) visited NCARTT. He discussed all points regarding the project and guided the Jordanian partners, Dr. Marwan Abdelwali and his engineer Jihad Haddean. Once again the Israeli P.I. visited Jordan and held meetings with the Jordan partners from 30/11/03 to 2/12/03. Dr. M. Abdelwali and the engineer J. Haddean visited Israel and held meetings with the Israeli researcher. They observed, experiments, facilities and trained in all procedures related to the project. The Israeli P.I. visited Jordan once more during August 2005, 8/8/ - 10/8 and hold meetings with the Jordanian partners, summarizing results and how to put them into practice and how to cooperate in the future. In addition to that consultations were done by telephone.

H - Project Productivity

The project accomplished nearly all of the proposed goals by determining species presence, population dynamics of the pest, toxicity of commonly and pesticides to the natural enemy integration of biological and chemical control while using the "Pest-in-First" method of the biological control strategy and putting all these into practice to the benefit of farmers of both countries.

I - Future Work

During the period of the project excellent relations has been developed between the researchers from both countries. Problems of plant protection have been raised and

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discussed so as how to face these problems in order to make progress. On basis of this understanding the Jordanian partner has asked the Israeli one to cooperate in another USAID-CDR program for Integrated Mite Management in apple orchards especially that the Israeli partner (Mansour) has developed such a program for Israeli apple growers. Because of the serious problem that have been developed in apple orchards mainly failure of miticides to control spider mites, the Israeli and the Jordanian researchers have submitted a preproposal entitled: Integrated Control Of Tetranychid Mites On Apple Trees.

This research will enable scientists to develop basic ongoing research program for dealing with other arthropod pests and aid in establishing cooperative links between scientists working with problem in similar environments.

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