MANAGEMENT OF STRAWBERRY INSECTS IN FARMERS FIELD SCHOOLS WITH MICROBIAL INSECTICIDES

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Abstract

The present work was carried out to train (a) agronomists working as facilitators in IPM/FFS project, (b) farmers on microbial insecticides application and (c) evaluate the possibility of using of microbial insecticides compared to conventional chemical pesticides against major strawberry pests at Ismailia governorates. Three IPM/FFSs were selected, and then all tested material was sprayed according to the economic threshold after field's inspection. In these trials, five microbial insecticides namely Protecto (*Bacillus thuringiensis*), Viroset (*Spodoptera littoralis nuclear polyhedrosis* virus), Profect (*B.t. + S. littoralis NPV*), Biovar (*Beauveria bassiana*) and Bioranza (*Metarhizium anisoplae*) were used in comparison with Vertemic (Abamectin) pesticide. The results show that reduction percentage of *S. littoralis* larvae on strawberry canopy increased with increasing the time elapsed after spray. Reduction percentage was ranged between 13.6 - 53.8% after the first day of spray, while it was ranged between 23.2 - 53.9%, 55 - 80% and 81.4 - 93.8% after the 3rd, 5th and 7th day post spray. For aphids, results indicated that all tested compounds reduced significantly aphid nymphs and adults in treated plots in comparison with the untreated one. No significant differences were found between different compounds at different time's intervals. Regarding two spotted mite, *Tetranychus urticae*, the data showed that the efficacy of microbial, mineral oil and Vertemic against *T. urticae* increased gradually with increasing the time elapsed after spray, whereas mites individual sharply decreased to became lower than the economic threshold in most cases. So, it could be concluded that educating facilitators and farmers about biological control result in farmers using less chemical insecticides and becoming more efficient in their production activities.

Key words: FFS, Microbial Insecticides, Strawberry, *S. littoralis, T. urticae.*

INTRUDUCTION

Over the last decade, the Integrated Pest Management (IPM) Farmer Field School (FFS) has emerged as a robust approach to educate poor farmers to manage their crops more efficiently, not just in Asia but also in Africa and South America. The defining principles of an FFS have been clearly described by ter Weel and van der Wulp (1999) and Pontius *et al.* (2002). The FFS is the primary learning approach piloted in Indonesia (Dilts and Pontius 2000), Egypt (Impiglia *et. al.*, 2006). IPM/FFS is

a field-based activity that lasts a full cropping season. Biological control usually refers to "the action of parasitoids (parasites in the original definition), predators and pathogens in maintaining another organism's density at a lower average than would occur in their absence" (DeBach 1964). Based on educating the farmer, the development objective of the program was to reduce the existing and potential use of pesticides by increasing the capabilities of farmers to manage their crops and inputs more effectively, thereby improving food security and developing human resources in Egypt in a way that would be environmentally sustainable. Through the first and second phases of IPM/FFSs project, farmers' skills are going to be built for making decisions and taking action based on an open discussion of ideas through participatory training. In addition, the project interested to implement IPM program practically with farmers sharing by introducing the safely alternatives e.g. parasites, predators and entomopathogens in control strategy, as well as, studying economic impact in improving standard of living in rural area. So, project intended to go through the following activities:

- Establishment of IPM/FFSs for strawberry,
- Increasing extension service skills through TOT training,
- Development farmers skills and making decisions by participatory training,
- Reducing chemical insecticides hazards due to introducing safely alternatives such as microbial insecticides e.g. *B.t.,* insect fungi
- Impact of IPM/FFS

MATERIALS AND METHODS

For strawberry, the experimental area was divided into small plots (each 1/24 feddan) and the total area was ½ feddan. Completely randomized plot design was used for distribution of different tested materials.

Tested materials were sprayed using backpack type with 20 liter capacity tank at the rate of 200L/feddan under pressure 1.5 bar. Protecto and Viroset were applied at the rate of 714gm/ha, while Biovar and Bioranza were applied at the rate of 200 gm/100 l water. Vertemic and KZ Oil were used at the rate of 40 and 1,000 cc /100 l. water, respectively. For cotton leaf worm, *S. littoralis*, the average number of larvae was determined before spray and then after 1, 3, 5, and 7days post-treatment according to Ministry of Agriculture and Land Reform (MOALR) protocol. For aphid and red mites, leaves samples were collected randomly (10 leaves each) and replicated three times before and after spray at 1, 3, 5, and 7 day time intervals. After leaves samples collection, they were put in bag paper and transferred to laboratory for

examination under binuclear. To determine the efficacy of different tested materials, reduction percentage was calculated according to **Henderson and Tilton (1965).**

RESULTS AND DISCUSSION

Evaluation of Microbial insecticides against strawberry insects

To enhance knowledge and skills of farmers, it was important to establish some studies to evaluate microbial insecticides against strawberry insects using the IPM/FFS established by the FAO Regional IPM Programme in the Near East. At the beginning, some farmers after spraying microbial insecticides (e.g. *B.t.*) used to say that "They didn't work", because they used to the larval insects died soon after chemical insecticides application. While some insects such as caterpillars, they were still alive for 1 or 2 days after application. This study includes control of cotton leafworm, *Spodoptera littoralis* (Boised.), peach green aphid, *Myzus persicae* and two spotted red mites, *Tetranychus urticae* .

Cotton leafworm, *S. littoralis*

The cotton leaf worm, *S. littoralis* is the most destructive insects not only for strawberry but also for other vegetable, field and ornamental crops in Egypt, it attacks about 120 plant hosts and cause severe damage if not monitored and eventually controlled.

In this trial, microbial insecticides *B.t.*, *S. littoralis* nuclear polyhedrosis virus (SLNPV) and their mixture were used in comparison with Mineral Oil in strawberry nurseries to manage *S. littoralis*. It could be noticed that microbial insecticides were able to reduce the incidence of cotton leaf worm larvae on strawberry foliage. At the 1st day post spray, reduction per cent in microbial insecticides treated plots ranged between 13.1 % and 39.0%, but it was 92.0% in Mineral Oil treatment. Then, reduction percentage of *S. littoralis* larvae increased gradually to reach more than 80% after the 7th day of application (Table 1). During this experiment, it was important for the farmers to know that they have to use microbial insecticides at the 1st and 2nd larval instars, they should apply biocides early morning or before sun set. Looking for the efficacy of microbial insecticides against *S. littoralis* larvae, some farmers wanted to spray a chemical insecticide only one day after applying microbial insecticides because the larvae were still alive. However, only when looking more closely, they found that the caterpillars were actually hardly eating anymore, they were just sitting on leaves, not moving very much. Increasing time intervals after spray, farmers found that the larvae appeared sick and dying. Efficacy of *B. thuringiensis* against cotton leafworm was also studied under laboratory condition by Mabrouk *et.al.* (1995) and El-Husseini *et al.* (2000[a&b]).

In addition, farmers could observed that the caterpillars have stopped eating with *less damage to the leaf* and *less frass production.* At 24 hours after exposure to *Bt* and SLNPV, larvae are very sick. Also, farmers can see that the caterpillars are sick by measuring that the caterpillars *do not move much, even if touched.* They found that the caterpillars were actually hardly eating anymore. Then, larvae die after about 3 days. They were just sitting on leaves, not moving very much.

Table 1. Average cotton leaf worm, *S. littoralis* larvae and reduction percentage of larvae after spraying the different biological agents in strawberry IPM/FFS$_{13}$ at Ismailia summer 2005.

Compounds	No. Larvae **	No. of *S. littoralis* larvae /plant after spray				% Reduction of *S. littoralis* larvae			
		1day	3 days	5 days	7 days	1day	3 days	5 days	7 days
Protecto	25	20	18	10	5	20	33.0	62.8	82.0
Viroset	33	28	25	13	7	13.1	29.5	63.4	80.9
Profect	42	29	19	11	4	39.0	57.9	75.6	91.1
Mineral Oil	40	20	15	13	10	92.0	65.1	69.8	77.5
Control	30	29	32	28	27	-	-	-	-

Green peach aphids, *Myzus perscicae*

Aphids are known for their wide range of plant host and their rapid multiplication. They have the ability to reproduce through parthenogenesis (female cloning). Females give live birth to pregnant females. Each new female is capable of producing 50-100 young aphids that become reproductive within 7-10 days. In addition to the ability to transmit viruses, aphids cause direct damage by feeding on plant sap to acquire the proteins and sugars needed for their reproduction. Aphids secrete excess sugars in the form of sticky "honeydew". Honeydew supports the growth of black sooty mold that affects plant photosynthesis. So, effective and timely control of aphid populations in vegetable production is important due to their ability to develop into large populations quickly. In these experiments, entomogenous fungi compared to Abamectin and Mineral Oil were evaluated against green peach aphids, *M. persicae* in strawberry nurseries.

Before application, the average number per sample ranged between 10-15 adult/sample, while it ranged from 17 to 29 nymph/sample. One day after spray, both a live adults and nymphs were reduced. Increasing time intervals after spray, high reduction in aphid population appeared in different treated areas compared to untreated one. Reduction percentage was more than 70% for aphid adults but it was 80% for aphid nymphs after 7th days of treatment (Tables 2 and 3).

Entomopathogenic fungi are currently being investigated for the control of many important insect pests on various crops around the world, and some are commercially available. There are many studies on the efficacy of several entomopathogenic fungi on thrips Fransen (1990).

Table 2. Green peach aphid, *Myzus persicae* individuals before and after spraying the different biological agents in strawberry IPM/FFS_{12} at Ismailia summer 2005.

Compounds	Aphid individuals Before spray		Aphid individual/ plant at indicated days after spray							
			1 days		3 days		5 days		7 days	
	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs
Biovar	11	20	7	9	6	5	4	2	4	1
Bioranza	12	29	7	6	8	5	6	2	5	1
Mineral Oil	10	17	4	2	5	1	0	0	0	2
Vertemic	15	21	9	12	7	6	10	5	6	3
Control	11	18	15	20	19	17	21	17	18	22

Table 3. Reduction percentage of green peach aphid, Myzus persicae individuals after spraying the different biological agents in strawberry IPM/FFS12 at Ismailia summer 2005.

Compounds	Aphid individual/ plant at indicated days after spray							
	1 days		3 days		5 days		7 days	
	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs
Biovar	53.35	59.50	68.47	73.55	80.98	89.42	77.78	95.91
Bioranza	57.24	81.37	61.47	81.76	73.85	92.70	74.54	97.18
Mineral Oil	70.68	89.41	71.11	93.78	100.00	100.00	100.00	90.38
Vertemic	56.02	28.00	73.03	69.71	65.13	74.80	75.56	88.31

Two spotted red mite, *T. urticae*

Spider mites rasp away leaf surfaces to feed on plant sap, causing mottling, speckling, or bronzing of foliage. Severely damaged leaves die and drop. Hot, dry weather favors spider mite outbreaks, and problems occur most often in new fields where spider mites are carried in by winds before predaceous mites have reached the field or in older plantings where insecticides have eliminated predators. In the present study, entomogenous fungi compared to Abamectin and Mineral Oil were evaluated against two spotted red mite, *T. urticae* in strawberry nurseries.

Data in table (4) indicate that all tested compounds reduced significantly the average number of mites on strawberry. After the third day of spray, in treated plots, both adults and nymphs were lower than the economic threshold of mites, while the mites in the untreated plots were increased continuously. Reduction percentage after the 1st day of application ranged between 48.73 and 67.95 for mites adults, but it ranged between 48.18 and 62.90% for nymphs. Reduction mites increased with increasing time intervals after spray. After one week of application, both M. anisopliae and Mineral Oil revealed almost 100% reduction in mites (Table 5).

Generally, according to farmers discussion, it could concluded that good culture practices (GAP) through learning and participating the farmers improved their skills decision making about insect inspection, spray time and microbial insecticides management. They have thus demonstrated that they can eliminate highly toxic compounds from their production system and substantially reduce pesticide use and production costs while not adversely affecting production per area. Many investigations of using entomopathogenic fungi to control *T. urticae* have been carried out. (Chandler *et al.* 2000 & 2005). *Alves et al. (2002)* demonstrated that the yeast-like structures of *B. bassiana* produced on MacConkey agar are effective as inoculum for applications against arthropod pests, and possibly superior to conidia against some species. Yeast-like cells and conidia had similar virulence against *T. urticae*, the average mortalities with yeast-like cells and conidia were, respectively, 42.8 and 45.0%, with10^7 cells/ml, and 77.8 and 74.4%, with 10^8 cells/ml.

Table 4. Two spotted red mite, *Tetranychus urticae* individuals before and after spraying the different biological agents in strawberry IPM/FFS at Ismailia summer 2005.

Compounds	Red mite individuals Before spray		Red mites individual/ plant at indicated days after spray							
			1 days		3 days		5 days		7 days	
	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs
Biovar	10	14	6	8	5	5	4	3	3	1
Bioranza	12	19	5	8	4	5	3	1	0	0
Mineral Oil	13	12	7	6	4	1	1	0	0	0
Vertemic	12	17	8	10	6	5	4	4	3	2
Control	10	15	13	17	15	21	19	20	19	20

Table 5. Reduction percentage of two spotted red mite, Tetranychus urticae individuals after spraying the different biological agents in strawberry IPM/FFS at Ismailia summer 2005.

Compounds	Red mite individuals Before spray		Red mites individual/ plant at indicated days after spray							
			1 days		3 days		5 days		7 days	
	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs
Biovar	10	14	53.86	49.65	61.55	74.50	78.96	83.93	84.22	94.46
Bioranza	12	19	67.95	62.90	74.37	81.21	84.22	96.05	100.00	100.00
Mineral Oil	13	12	58.59	55.95	76.33	94.05	95.95	100.00	100.00	100.00
Vertemic	12	17	48.73	48.18	61.55	79.00	82.47	82.35	86.85	91.18

Changes in insecticide application:

At the beginning of the project, during the 2004 cropping season, most of the strawberry growers did not have enough information on microbial insecticides and other alternatives to chemical pesticides to control major pests, they used to spray their fields with chemical insecticides to "protect" their crop from insect and diseases occurrence. The percentage of farmers using chemical insecticides was about 73.47% followed discendingly by macronized sulfur (51.94%), mineral oil (21.74%) and predaceous mites (0.4%), respectively.

Continuous training and field experiments conducted by the Regional IPM Programme of FAO in Egypt resulted in increasing farmer's skill about the proper way of dealing with pests, microbial insecticides and other control methods, farmers became more convinced that the use of microbial insecticides not only could control pests and diseases, but also, could reduce health hazards for themselves, their farm animals, protect the natural enemies of insect pests and reduce environmental contamination due to chemical insecticides. So, after the second year of the project, the total number of farmers using chemical insecticides reduced down to 13.09% and 7.94% through 2005 and 2006 seasons, respectively. In contrast, farmers using microbial insecticides and other pest control alternatives increased to be ranged between 63.49 - 80.56% and 71.43 -100% for 2005 and 2006 strawberry growing seasons, respectively (Table 6).

On the other hand, not only the behavior of farmers toward chemical insecticides has been changed, but also, their decision on the time of application according to insect population which revealed reducing the total number of applications. Before the FAO Regional IPM project in Egypt, strawberry growers at Ismailia used to spray their fields against insect pests from 5.3 to 6.7 times per

season. Now (after training), the number of insecticide sprays ranged between 1 and 3 times per season (Table 7). Furthermore, farmers participating at the FAO Regional IPM project in Egypt have been able to understand the positive results of using the entomopathogens e.g. *Bacillus thuringiensis*, nuclear polyhedrosis virus (NPV) of *Spodoptera littoralis* (Boised). Lepidoptera: Noctuidae) and insect pathogenic fungi (*Beauveria bassiana* and *Metarihizium anisopliae*) in reducing the incidence of insect pests on crops and decreasing the chemical insecticides usage. Similarly, farmers in Dalat, Vietnam have been able to carry out studies to better understand the action of *Bt* to replace the use of chemical insecticides and hence give an opportunity for *D. semiclausum* a chance to impact on the populations of DBM (Ooi *et al.* 2001).

In addition, for crop management, farmers used to apply high amount of fertilizers while they prefer high vigor of plants but they did not knew that increasing nitrogen could help in increasing infestation with some insects such as aphid , Also, using higher rates of fertilizers resulted in increasing the alkalinity in their soil which affect on plant growth

Table 6. Changes percentage of strawberry farmer's behavior during the period from 2004-2006 growing seasons

	% Usage of different alternatives		
	2004	2005	2006
Chemical insecticides	73.47	13.09	7.94
Microbial insecticides	1.19	63.49	93.25
Micronized sulfur	51.94	80.56	100.00
Mineral Oil	21.70	64.68	75.40
Sulfur Lim mixture	0.00	0.00	3.97
Insecticidal soap	0.00	0.00	99.21
Predacious mites	0.40	68.25	71.43

Table 7. Number of application and reduction % of pesticides used to control S. littoralis in IPM/FFS strawberry nurseries* and conventional insecticides treated fields

Experiment No.	No. Insecticides application	No. biocides application	Total application	% Reduction of insecticides
IPM/FFS_{12}	1**	2	3	60
IPM/FFS_{13}	3	2	5	40
IPM/FFS_{19}	3	1	4	25
Control field	6	0	6	0

**The farmer applied field border only with Profenofose

Costs and Benefits of IPM field schools

Comparison groups consisting of FFS participants and non participants were used to evaluate the impact of FFS on product expenditure, yield quantity and quantity, and farmers' income. A comparison of 512 farmers across four districts (Fig. 1), showed that fertilizer cost has reduced by 36.42 per cent (414.79 US$/ha) in IPM/FFS fields, while insecticides and fungicides reduced to 68.78 and 83.49 per cent, respectively. In addition, learning about biological control achieved in Ismailia, lead to an understanding of the selective action of the microbial insecticide *Bacillus thuringiensis* in managing the cotton leaf worm, *Spodoptera littoralis* on strawberry. With the information collected by the farmers' experimentation and pilot studies, farmers were able to take the correct decision of using different control measures. These resulted in a consistent reduction of chemical insecticide use, good saving on production cost and reduce the risk of investments due to reducing the number of chemical applications. In addition, the trained farmers have used more balanced fertilizer application (reduction of nitrogen and increase of phosphate and potassium). This is considered another benefit obtained by the IPM/FFS program to reduce the total expenditure of yield production in the different localities. In IPM/FFS fields, the total production cost ranged between 2,999.2 5,803.6 US$/ha, while it ranged from 4,045.9 to 6,203.7 US$/ha in fields out IPM/FFS project used as control (Fig. 2).

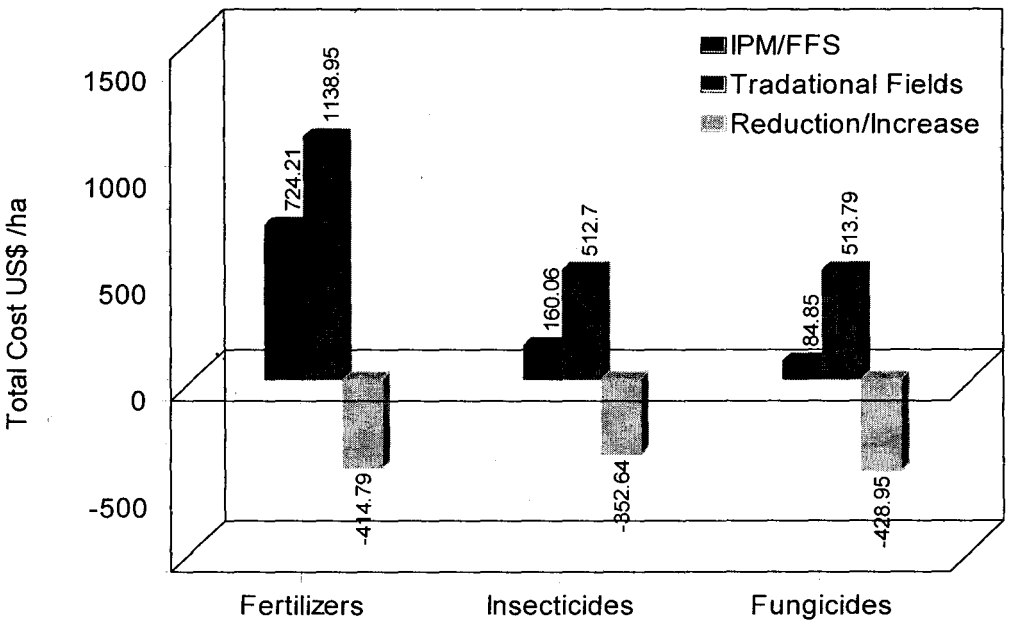

Fig. 1. Comparison the total cost of fertilizers, insecticides and fungicides between IPM/FFS fields and farmers practices.

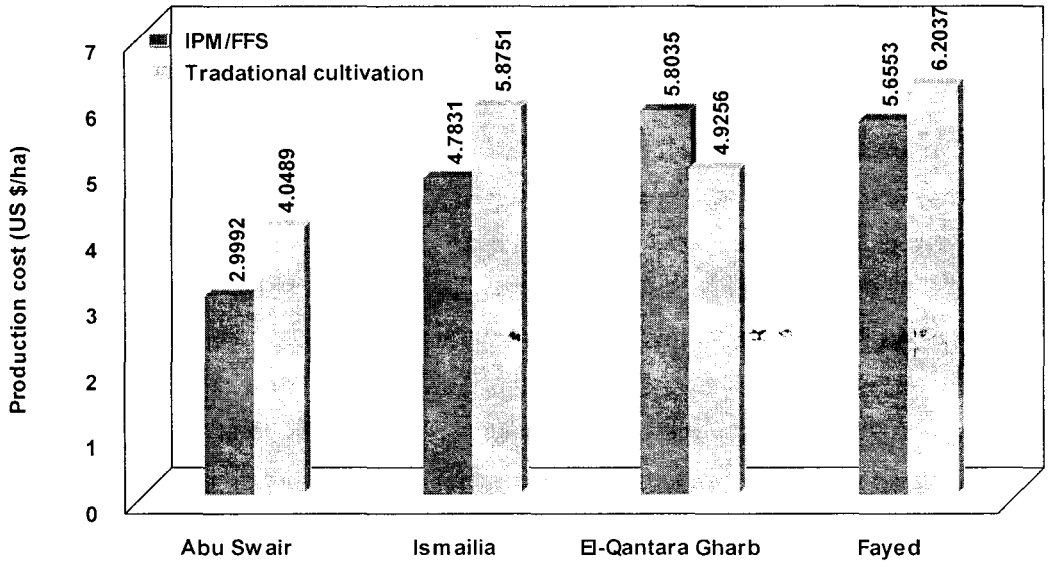

Fig. 2. Comparison production expenditure between IPM/FFS fields and farmers practices

Impact of IPM/FFS on farmer's income

Another important impact of the IPM/FFS project in Egypt on strawberry is the yield quantity and quality increase. The data in Fig. 3 show the adoption of IPM practices by farmers obtaining good yields. For example, at El-Qantara Gharb, some farmers used to keep their crop in the field for the second year to have an early production catching high market price. It was important to keep those farmers to do what they wanted, but at the end of the season, their harvest was low yielding (9.52 ton/ha) compared to 30.5 (ton/ha) of their neighbors participating at IPM/FFS programme. Even the farmers growing their crop like the IPM/FFS farmers using their traditional practices obtained a lower yield if compared to the farmers participating at the IPM schools. The average yield in IPM/FFS ranged between 9.52 -32.1 (ton/ha), while it was ranged from 20.5 to 37.6 ton/ha in IPM/FFS (Fig. 3).

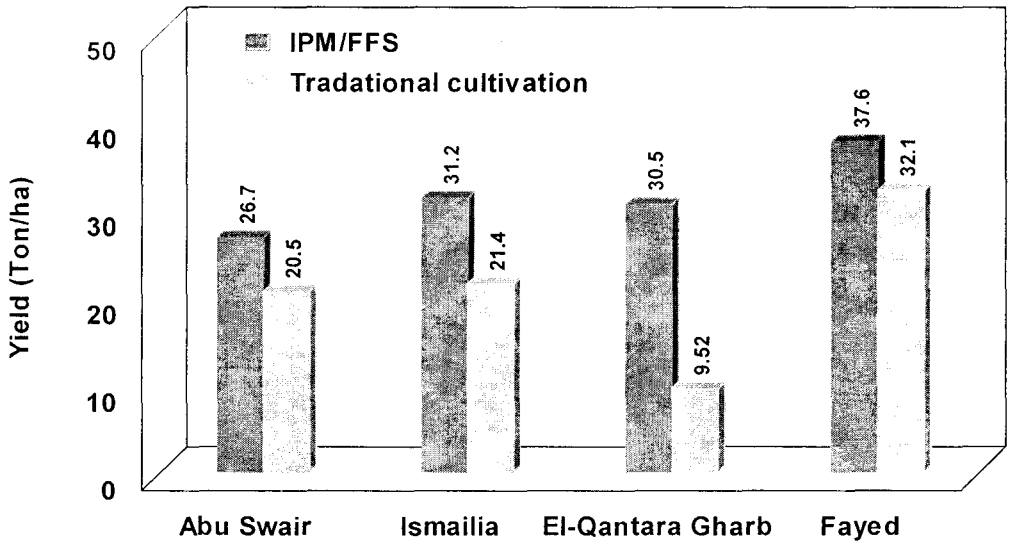

Fig. 3. Impact of IPM-FFS on strawberry yield in four districts, Ismailia, Egypt

Improving yield quantity and quality

The results from strawberry fields in IPM plots indicated that the total income of strawberry yields was 30.24% (yielding 1.897 ton/hectare) higher than farmers practice plots at Abu Swair District. While increase percent in strawberry yield was 45.79%, 220.37% and 17.13% at Ismailia, El-Qantra Gharb and Fayed districts, respectively (Fig. 4). The benefit from economic analysis data on strawberry production in IPM plot showed a 38 % or US$ 695/hectare earning capacity over farmers practice plots which could be attributed to yields as well as savings from lower use of pesticides, fertilizers and labour costs in pesticide repeating application.

Generally, the decrease in strawberry input with increasing the net profit in IPM/FFS plot is considered good impact of the training strategy for both facilitators and farmers. In Egypt, the government has increased the investment for extension programs, but extension activities do not reach small land – holding farmers in the most remote area. Possibly, lack of manpower at the extension services and difficulties in reaching farmers in remote area are the limiting factors for farmers to access information in order to improve crop and pest management. Thus, it will affect the exporting opportunities for the farmers and their sustainable agricultural practices including IPM tactics (Rola, *et al.* 1998).

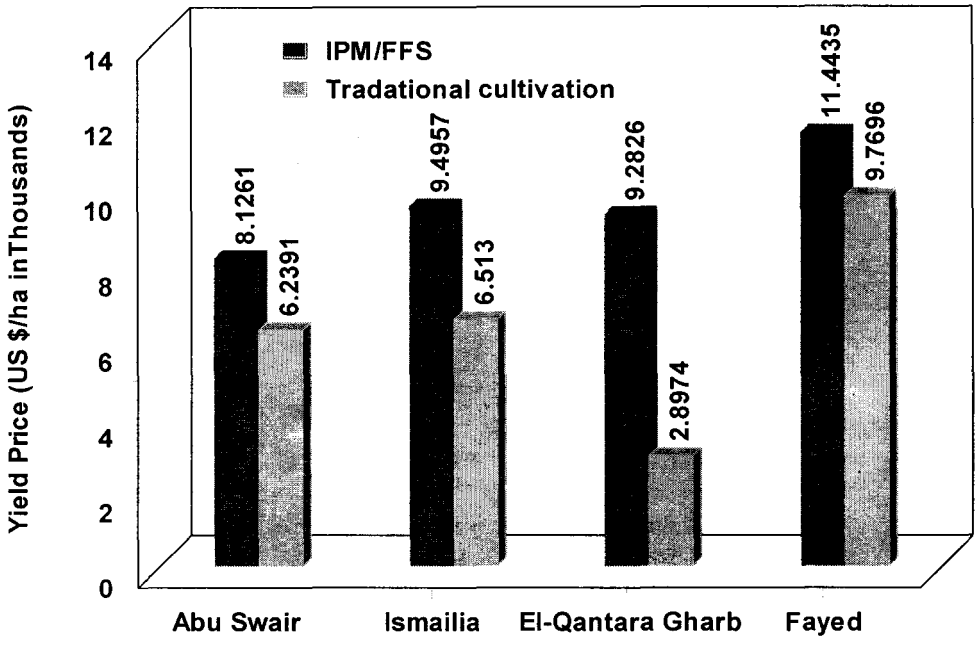

Fig. 4. Impact of IPM-FFS on Farmer Income in four districts, Ismailia, Egypt

Furthermore, the benefit from economic analysis data on strawberry production in IPM plot at Abu Swair district showed a more than 50 per cent or US$ 1,677/hectare earning capacity over farmers practice plots which could be attributed to yields as well as savings from lower use of pesticides, fertilizers and labour costs in pesticide repeating application. In contrast, farmer out the project at Ismailia and El-Qantara Gharb lost 1,229.3 and 3,268.2 US$/ha, respectively (Fig. 5).

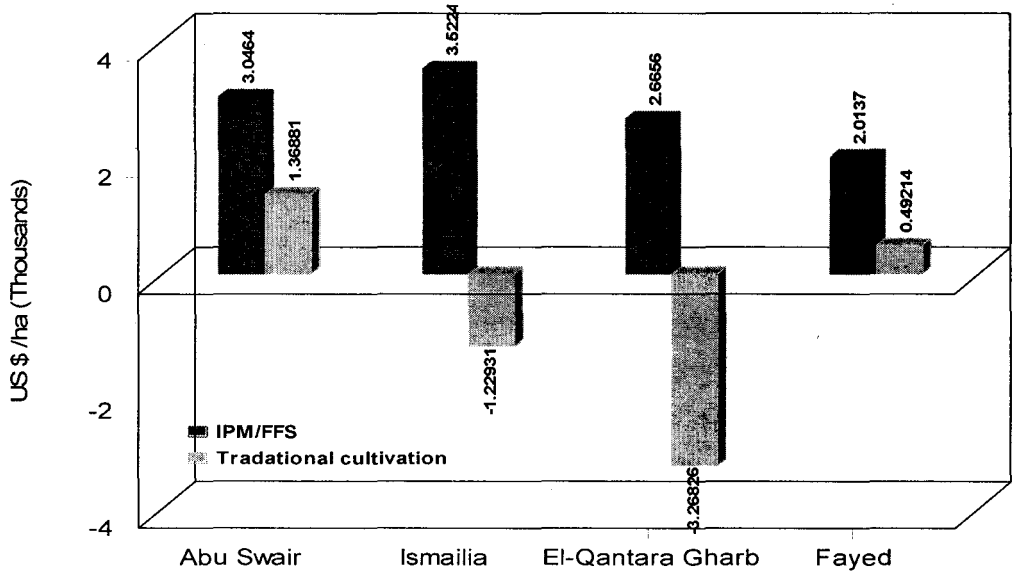

Fig. 5. Total benefits of IPM-FFS Farmers compared to traditional farmer practices

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الادارة المتكاملة لمكافحة آفات الفراولة فى المدارس الحقلية للمزارعين بإستخدام المبيدات الميكروبية

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١- معهد بحوث وقاية النباتات – مركز البحوث الزراعية – الدقى – الجيزة – مصر
٢- منظمة الاغذية والزراعة (الفاو)

اجرى هذا العمل فى محافظة الاسماعيلية لتدريب وإرشاد

أ- العمال الزراعيين المشتغلين ببرامج المكافحة المتكاملة للآفا والمدارس الحقلية للمزارعين

ب- المزارعين الذين يطبقون استخدام المبيدات الحشرية والميكروبية

ج- تقييم استخدام المبيدات الحشرية الميكروبية مقارنة بالمبيدات الكيماوية المستخدمة ضد آفات الفراولة بمحافظة الاسماعلية

وقد تم اختيار ثلاث برامج للمكافحة المتكاملة والمدارس الحقلية وتقييم واختبار هذه المواد التى تم رشها طبقا للحد الاقتصادى الحرج بعد الفحص الحقلى

وقد تم فى هذه التدريبات والارشادات استخدام خمسة مركبات ميكروبية هى (البروتكتو – فيروست – بروفكت – بيوفار+ بيورانزا) مقارنة بالمركب الكيماوى فيرتمك

وقد أوضحت النتائج ان النسبة المئوية للخفض فى تعداد يرقات دودة ورق القطن على الفراولة المغطاه قد زادت باختصار او نقص الوقت بعد الرش وقد تراوحت نسبة الخفض بين ١٣,٦ – ٥٣,٨% بعد اليوم الاول من الرش – بينما تراوحت بين ٢٣,٢ – ٥٣,٩% و ٥٥-٨٠% و ٨١,٤ – ٩٣,٨ بعد ٣،٥،٧ أيام بعد الرش .

أوضحت النتائج لكل المركبات المختبرة نقص معنوى لافراد المن الغير بالغة والحشرات الكاملة فى القطع المعاملة مقارنة بالقطعة الغير معاملة ولا توجد فروق معنوية بين المركبات المختلفة بالنظر الى العنكبوت الاحمر فقد سجلت النتائج كفاءة المركبات الميكروبية والزيت المعدنى والفيرتمك ضد العنكبوت الاحمر وقد زاد التاثير تدريجيا بزيادة عدد الرشات وتقليل الفترة ما بين الرشات حتى نقص التعداد واصبح اقل من الحد الحرج للضرر .

كما تم توضيح وتفسير نتائج المكافحة البيولوجية فى المزارع التى تستخدم اقل ما يمكن من المركبات الكيميائية حتى اصبحت اكثر فاعلية فى حماية انتاجهم.