

Assessment of Pest and Pesticide Trends in Vegetable Crops in the United Arab Emirates and Sultanate of Oman

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Abstract. A preliminary survey on pesticide uses in 40 vegetable-growing farms representing different agricultural areas in Oman and the UAE, twenty farms from each country, revealed that all the vegetable farms used pesticides for crop protection. Among the major insect-pests, whiteflies (*Bemisia tabaci*), leafminers (*Liriomyza trifolii*), melon fruit flies (*Bactrocera ciliatus*), aphids (*Aphis* spp.) and tobacco leafworm (*Spodoptera littoralis*) were recorded in Omani farms. In the UAE, whiteflies, leafminers, cutworms (*Agrotis ypsilan*), tomato fruitworms (*Helicoverpa armigera*) and eggplant fruitworms (*Leucinodes orbonalis*) were the 5 top insect-pests. Among the plant diseases, powdery mildew (*Erysiphe* spp.), blight (*Alternaria* spp.), damping off (*Pythium* spp.), leafspot (*Alternaria* spp.) and mosaic (CMV) were major cause of vegetable diseases in Omani farms; whereas, damping off (*Pythium aphanidermatum*), downy mildew (*Pseudoperonospora cubensis*), early blight (*Alternaria solani*), septoria leaf spot (*Septoria lycopersici*) and anthracnose rip rot (*Colletotrichum* spp.) were the most predominant diseases encountered in most UAE farms. Among the most commonly used pesticides, 29 insecticides, 16 fungicides and 3 herbicides were used by the vegetable farmers. Around 55% of Omani farms used routine application of pesticides, irrespective of the pest presence. Whereas, in the UAE, most farmers started to spray pesticides at 6-20% pest (insect, disease & weeds) infestation. Over 65% of the farms, in both the countries, received chemical pest management information from the sales representatives.

Keywords: insecticides, fungicides, herbicides, insect-pests, pesticide resistance, pesticide residues, Oman, UAE

Introduction

The Gulf's agricultural production has dramatically increased during the last 32 years. For example, the value of Omani agricultural and fisheries production has risen from 17 million Omani rials in 1970 to 156 million Omani rials by 1994. Due to increased farming intensities (i.e. addition of more lands to cultivation and increasing number of crops per land), agricultural production has an extraordinarily upward trend. Omani cereal yield increased from 0.90 tones/hectares in 1980 to 2.17 tones/hectares in 1998 (Thacker *et al.*, 2001). FAO reports showed that the value (cost) of pesticide imports to Oman increased more than 10 folds since 1960. Due to intensive modern farming practices and pest problems, Omani and the UAE crop producers used large amount of agrochemicals, especially pesticides for crop protection (Tivy, 1991). A total of 835 pesticides are registered in the UAE, among which 49.8%

are insecticides and 22% fungicides (Kaakeh *et al.*, 2004). The increased use of different pesticides in the Gulf countries caused serious concern, including the potential for lethal effects of some pesticides on certain species of birds and fish, the possibility of pesticide residues in food and the environment, potentially harmful effects in humans and domestic animals and the unintentional effects of pesticides on pollinating insects including the honeybee, beneficial predators and parasites (Perry *et al.*, 1998). A recent survey showed that for crop protection, 95% of the farms in Northern Oman used insecticides, 60% used fungicides and 20% used herbicides (Thacker *et al.*, 2001).

Worldwide reports show that insects, fungi and weeds have become resistant to major pesticide classes. Currently, around 500 species of insect pests are resistant to 14 major pesticide classes including the organochlorines, organophosphates, carbamates and pyrethroids (Clark and Yamaguchi, 2002). A recent report showed that tomato fruitworms (*Helicoverpa*

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armigera) one of the major crop insect-pests in the UAE and Oman, was found to be resistant to 32 different insecticides (Martin *et al.*, 2003). In another report, the sweet potato whitefly (*Bemisia tabaci*), another major insect in Oman, showed resistance to 36 different insecticides (Byrne *et al.*, 2003; Elbert and Nauen, 2000). On the other hand, more than 25 fungal pathogens have become resistant to more than 22 fungicides and fungicide groups (Agrios, 1997). The use of frequent and excessive amount of herbicides to control major weeds has also created serious herbicide resistance problems in targeted weeds. The International Survey of Herbicide Resistant Weeds (ISHRW) reported that there are 291 herbicide resistant weed biotypes exhibiting resistance to 18 herbicide chemical families (ISHRW, 2004). However, no published record is available on the resistance status of the weeds in Oman or UAE.

An earlier report showed that 3 out of 11 selected pesticides that are widely used in the UAE have the potential to leach to groundwater due to their water solubility exceeding threshold values (Kaakeh *et al.*, 2004). However, limited work has been conducted to investigate the fate of applied pesticides in the UAE and Oman. Existing studies, albeit significant, were mainly restricted to laboratory conditions. Thus, there is a need to collect information about major insect-pest status, pesticide uses, pesticide resistance and residues in crop products, as well as pesticide levels in sub-surface environment in both the UAE and Oman. As a first step in this direction, this research study was designed to carry out a pesticidal survey, in UAE and northern Oman, to determine the abundance of major pests (insects, diseases and weeds) in vegetable crops and pesticide uses for their control in both the countries.

Materials and Methods

Around 40 vegetable production farms representing differences in size, location and organizational structure, were selected for the proposed research study from the UAE and Sultanate of Oman (20 farms from each country). Through a standard set of questionnaires, the following detailed information was collected from each farm: (1) diversity of vegetable crops growing within the farm; (2) presence of different pests (insects, diseases and weeds) during the last 5 years within the farm; (3) pest and disease management techniques for the last 5 years including the names of all the pesticides, frequency of application and their doses; (4) pesticide application system including the equipment used for the application of pesticides, and (5) safety system regarding the handling, mixing, storage and disposal of pesticides.

Results and Discussion

1. Diversity of vegetable crops. The survey results show that most of the Omani vegetable farms (70%) are 5-10 years old, whereas, most of the UAE farms were 2-5 years old. Mostly, all farms use pesticides (90% or more) for crop protection in both the countries. The top five vegetables grown in Oman are tomato, melons, squash, eggplants and capsicum; whereas, tomato, cucumber, eggplant, squash and bean are the most cultivated vegetables in the UAE.

2. Major insect pests, fungal diseases, and weeds. The list of top five major pests (insects, diseases, and weeds) encountered in vegetable farms in the UAE and Sultanate of Oman are presented in Table 1. Among the major insect-pests, the whiteflies (*Bemisia tabaci*), leafminers (*Liriomyza trifolii*), fruit flies (*Bactrocera ciliatus*), aphids (*Aphis* spp.) and tobacco leafworms (*Spodoptera littoralis*) were recorded in Omani farms. Mites were also enlisted as one of the major pests in the vegetable farms in the Oman. In UAE, the whiteflies (*Bemisia tabaci*), leafminers (*Liriomyza trifolii*), cutworms (*Agrotis ypsilon*), tomato fruitworms (*Helicoverpa armigera*) and eggplant fruitworms (*Leucinodes orbonalis*), were the top 5 insect-pests. Whiteflies (*Bemisia tabaci*) and leafminers (*Liriomyza trifolii*) were encountered in both the countries and considered to be major insects. Among the plant diseases, powdery mildew (*Erysiphe* spp.), blight (*Alternaria* spp.), damping off (*Pythium* spp.), leafspot (*Alternaria* spp.) and mosaic (CMV) were the major cause of vegetable diseases in Omani farms, whereas, damping off (*Pythium aphanidermatum*), downy mildew (*Pseudoperonospora cubensis*), early blight (*Alternaria solani*), septoria leaf spot (*Septoria lycopersici*) and anthracnose rip rot (*Colletotrichum* spp.) were the five most important diseases encountered in most of the UAE farms. Damping off and leaf spot diseases were also encountered in both the countries at different levels of importance. Among the weeds, the common grass, foxtails, broadleaf weeds and cyperus grass were found as the major weeds in Omani vegetable farms, whereas, in the UAE vegetable farms, the presence of narrow and broadleaf weeds were recorded. Broadleaf weeds are thus common in vegetable farms in both the countries. Due to shortage of scientific resources for identification of weed plants in agricultural farms, most of the weeds were not named up to genus/species level.

3. Pest and disease management techniques. All the Omani farms use chemical pesticides as part of the crop protection. Over 75% farms use chemical methods as the main protection techniques, whereas, over 50% also use different types of cultural pest management techniques. Table 2 shows the most commonly used insecticides, fungicides, and herbicides in the

Table 1. The top five major pests recorded in the United Arab Emirates and Sultanate of Oman

Pest type	Common name (scientific name)	
	UAE	Oman
Insects	Whitefly (<i>Bemisia tabaci</i>), Leafminer (<i>Liriomyza trifolii</i>) Cutworm (<i>Agrotis ypsilan</i>) Tomato fruitworm (<i>Helicoverpa armigera</i>) Eggplant fruitworm (<i>Leucinodes orbonalis</i>)	Whitefly (<i>Bemisia tabaci</i>), Leafminer (<i>Liriomyza trifolii</i>) Fruit fly (<i>Bactrocera ciliatus</i>) Aphid (<i>Aphis</i> spp.) Tobacco leafworm (<i>Spodoptera littoralis</i>)
Diseases	Damping off (<i>Pythium aphanidermatum</i>) Downy mildew (<i>Pseudoperonospora cubensis</i>) Early blight (<i>Alternaria solani</i>) Septoria leaf spot (<i>Septoria lycopersici</i>) Anthracnose rip rot (<i>Colletotrichum</i> spp.)	Powdery mildew (<i>Erysiphe</i> spp) Blight (<i>Alternaria</i> spp.) Damping off (<i>Pythium</i> spp.) Leafspot (<i>Alternaria</i> spp.) Mosaic (CMV)
Weeds	Narrow leaf weeds Broadleaf weeds	Common (<i>Digitaria</i> spp.) grass Cyprus (<i>Cyperus</i> spp.) grass Foxtails (<i>Setaria</i> spp.) Broadleaf weeds

Table 2. The top five commonly used insecticides, fungicides, and herbicides in the United Arab Emirates and Sultanate of Oman

Pesticide type	Trade name (active ingredient)	
	UAE	Oman
Insecticides	Actellic 50 EC (Pirimiphos-methyl 50%) Hostathion 40 EC (Triazophos 40%) Action 50 EC (Phenthoate 40% + Cypermethrin 6%) Karate 2.5 EC (Lambdacyhalothrin 2.5%) Rocky (Deltamethrin 1.14% + Dimethoate 36.4%)	Malathion (Malathion) Salut (Chlorpyrifos + Dimethoate) Dursban (Chlorpyrifos) Diazinon (Diazinon) Omite (Propargite)
Fungicides	Tachigaren 30 L (Hymexazol 30%) Ridomil M Z 72 WP (Metalaxyl 8% + Mancozeb 64%) Prevex 72.2 SL (Propamocarb hydrochloride 72.2 g/l) Topsin M 40 WP (Thiophanate-methyl 40%) Ortiva (Azoxystrobin)	Derosal (Carbondazim) Dithane (Mancozeb) Topsin (Thiophanate-methyl 40%) Ridomil (Metalaxyl 8% + Mancozeb 64%) Maneb (Maneb)
Herbicides	Fusilade (Fluazifop-p-butyl) Touchdown (Glyphosate) Granstar (Tribenuron-methyl) Ronstar (Oxadiazon) Roundup (Glyphosate)	Roundup (Glyphosate) Dacthal (DCPA) Gamoxone (Paraquat)

UAE and Oman. Among the commonly used pesticides in Oman, around 29 insecticides, 16 fungicides and 3 herbicides were recorded which were used by the vegetable farmers. In the case of insecticides in Oman, malathion was the most commonly used by the farms (75%), followed by the salut (42%), dursban (42%), diazinon (33%) and omite (33%). Among the fungicides, most of the farms used derosal (84% farms),

followed by the dithane (50%), topsin (33%), ridomil (33%) and maneb. The use of herbicides was found less popular among the Omani vegetable farms; only 8% farms used Roundup, Dacthal and Gamoxone. In the UAE, the top 5 insecticides used by vegetable farms were actellic, hostathion, action, karate and rocky. Also, the top 5 used fungicides in UAE were tachigaren, ridomil, prevex, topsin and ortiva, while

the top 5 herbicides used were fusilade, touchdown, granstar, ronstar and roundup.

The survey results also showed that vegetable crops were monitored in all the farms for the infestation of insects and diseases, while only 10% of the farmers monitored for weed presence. Farmers in both the countries monitor insects before insecticide application (65% and 80% in the Oman and UAE, respectively), and most farmers identify damaging insects before insecticide application farmers also monitor plant pathogens (80% and 65% in the Oman and UAE, respectively), and many farmers identify plant pathogens before fungicide application. Manual weed control is the main weed management system used by most of the farms. Hoeing or hand-pulling weed control is the main weed management system used in 55% of the UAE farmers; some used mulches (wood chips, plastic cover, etc.). In Oman, 65% of the surveyed farms used hoeing or hand-pulling techniques for weed management.

In Oman, majority farmers (65%) scout daily for the pest (insects, diseases and weeds) presence. On the other hand, 80% of the UAE farmers scout daily for pest presence, while the remaining 20% farmers scout twice a week or once a week (10% each) (Table 3). It was interesting to find that 65% of the UAE farmers use the routine application of pesticides, irrespective of the pest presence, whereas 20% and 15% of farmers use chemicals after detecting 1-5% and 6-10% pest infestation, respectively. In Oman, 55% farmers use routine pesticide technique, but 40% farmers use pesticide after finding 1-5% pest infestation. Regarding the source of obtaining chemical pest control information, in Oman, 65% of the farmers received pesticide information from the sales representatives of the chemical company/distributors, 95% through the pesticide labels, and only 30% of farmers received this information from the extension service. On the other hand, over 70% of the UAE farmers received pest control information from the selling agents, 60% through the pesticide labels, 40% from their employers, and only 30% from the extension service (Table 3).

The survey further showed that 50% of the farms applied pesticides (insecticides, fungicides and herbicides) only into the infested fields/areas, whereas the remaining 50% farms applied pesticides, in all the fields, irrespective of pest infestation. In the UAE, it was found that most farmers start to spray pesticides to control pests when there was a 6-20% pest (insects, diseases and weeds) infestation. Most of the farmers obtained chemical pest control information from their extension officers and then from pesticide selling agents. Farmers decide to apply pesticides when pest damage is light to moderate and they also apply pesticides in all the fields.

4. Pesticide application decision. The decision of farmers to apply pesticides was mainly based on the advice/order from the owner/employer (45% both in Oman and UAE). Few farmers made their decisions based on an advice from the extension officers (15%), or from neighboring farm supervisors (10%). In the UAE, 65% of the farmers applied pesticides as preventive method and 35% applied pesticides on the basis of the pest (insect, disease and/or weeds) presence. In Oman, preventive applications of pesticides are made by 35% of the farmers. The survey further showed that, in both the countries, 45% of the UAE farmers applied pesticides only into the infested areas of the field, whereas the rest (55%) applied pesticides in all the fields, irrespective of pest infestation. In Oman, 60% farmers applied pesticides only in the infested areas, whereas 35% applied in all the fields.

5. Pesticide safety system. Regarding the application and post-application use of pesticides, farms of both the countries had similar approaches. Most farmers usually apply pesticides more than the recommended dose; some make an estimated guess on the proper dose. Farmers apply a higher dose of application to kill pests faster. Some farmers find label instructions too confusing. Most farmers poured unused-left-over pesticides on ground, and few of them used pesticides completely. Old pesticides were usually poured on ground, and then used containers were discarded. Most farmers left empty containers on the ground in the field; few placed empty containers in trash or dumpster. Manual weed control is the main weed management system used by most of the farms. Most farms in Oman were not interested in non-chemical or least toxic pest control methods, whereas the UAE farms opted for the reverse.

Conclusion

The knowledge gained from the current assessment of pesticide uses on vegetable farms in the UAE and Oman will aid in future suggestions within the scope of a management programme for pesticide application and handling. The suggestions, resulted from the current surveys in different vegetable farms, might be related to the selective use and application of pesticides that may lead to a reduction in pesticide use. Development of registration and legislation procedures for pesticides are based on subjective, expert-oriented assessment; risk assessment procedures for pesticide evaluation; evaluation of the possible risks of pesticide application; and development of a monitoring program after the implementation of the pesticide application. In addition to enlisting the current pesticides used for vegetable production, the outcome might help to enquire the pesticide resistance status in the mentioned pests, and the residual levels in soil and water.

Table 3. Farmers' response on pest management, pesticide application and safety in UAE and Omani vegetable farms

Desired information	Percentage (%)	
	Oman	UAE
A. Pest Management Information/Techniques:		
Monitoring vegetable crops in the farms for:		
- Insect-pests	95	100
- Diseases	95	100
- Weeds	95	10
Number of scouts:		
- Daily	65	80
- Twice a week	-	10
- Once a week	35	10
- Twice a month	-	-
Type of pest control method used in the farms:		
- Chemical control	95	95
- Biological control	5	0
- Cultural control	55	60
B. Pesticide Application Decision & Pesticide Safety:		
Percentage of crop attacked before spraying pesticides to control pests in the farms:		
1-5%:	40	20
6-10%:	5	15
11-15%:	-	-
16-20%:	-	-
21-25%:	-	-
Routine application	55	65
Sources of obtaining chemical pest control information (some farmers selected more than one option):		
- From pesticide label	95	60
- From your employer	5	40
- From Extension officer/worker	30	30
- From pesticide selling agents	65	70
Decision to apply pesticides based on:		
- An order from the Owner / Employer	45	45
- Prevention (no damage yet observed)	35	65
- Presence of a few pests	50	35
- When pest damage is light to moderate	5	35
- Advice from the extension office)	5	15
- Advice from neighboring farm supervisors	10	10
Spraying pesticides in infested area in the field or all areas in the field:		
- Only in the infested areas of the field	60	35
- Applying pesticides in all field	45	55
The way farmers determine the amount of pesticides to apply. (some farmers selected more than one option):		
- Follow label exactly	65	10
- Follow professional pest management guide	15	10
- Make an estimated guess on the proper dose	10	5
- Usually apply more than recommended dose	15	80
- Follow advice of employer	30	20
- Follow advice of farm supervisors	10	15

Reasons of applying amount of pesticide other than that specified on the label:

- Not applicable - follow label exactly	60	10
- Want a faster kill	30	18
- Dissatisfied with the result of following label instructions	-	50
- Label instructions too confusing	5	10
- No label on container	-	-

Status (fate) of the unused, leftover (mixed, diluted) pesticide: (some farmers selected more than one option):

- Pour on ground	-	45
- Pour down in farm drain	5	-
- Pour in street or storm drain	-	-
- Use completely or apply elsewhere	15	75
- keep for next use	65	60

The status (fate) of old pesticides (expired, no plan to use): (some farmers selected more than one option):

- Pour on ground, then discard empty container	-	10
- Pour down in farm drain, then discard empty container	-	-
- Pour in street/storm drain, then discard empty container	-	-
- Place container (with little pesticides) in a dumpster	15	-
- Use completely, have no old pesticides	40	80

The status of all empty containers after pesticide use: (some farmers selected more than option):

- Discard empty container in the field	60	80
- Throw empty container into drain	-	-
- Throw empty container into soil pit	-	-
- Throw empty container outside the farm	10	10
- Place in special trash or dumpster	-	10
- Sell containers	15	-

The expected outputs from the overall investigation might be vital for the future pesticide management strategies in the UAE and Oman. The current findings might also help the educational institutes such as SQU and UAEU to develop certain type of training or practical programmes for the local farmers for developing correct pesticide application, monitoring pesticide resistance and pesticide container disposal habits.

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