Egypt. J. Plant Prot. Res. Inst. (2021), 4 (1): 1 –9

Egyptian Journal of Plant Protection Research Institute

www.ejppri.eg.net

Pest management practices in greenhouses producing vegetables in Egypt

Bruce, L. Parker[1]; Shaaban, Abd-Rabou[2] and Margaret, Skinner[1]

[1]*University of Vermont, Entomology Research Laboratory, 661 Spear Street, Burlington, Vermont, USA 05405-0105.*

[2]*Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.*

ARTICLE INFO

Article History

Received: 3 /1/2021

Accepted: 2/ 3 /2021

Keywords

Greenhouse survey, Egypt, Integrated Pest Management (IPM), whitefly (Hemiptera: Aleyrodidae) and thrips (Thysanoptera: Thripidae).

Abstract:

Greenhouse vegetable growers in 14 of the 26 Governorates in Egypt were surveyed from May through July 2016. The Governorates surveyed were selected because they were areas of intensive greenhouse vegetable production. All surveys were conducted with face-to-face interviews of the head grower or owner of the operation using a standard set of questions focused on the growers' experience with insect and disease pests, crop scouting and pesticide application practices. In general greenhouse operators surveyed were growing tomatoes, *Solanum lycopersicum* L. (Solanales: Solanaceae) and/or cucumbers, *Cucumus sativus* L. (Violales: Cucurbitaceae). A total of 123 growers were surveyed with between 2 - 16 growers from each governorate. Across all Governorates , 43% of growers report applying pesticides more than once per week. In five Governorates (32 sites), 100% of growers report applying pesticides more than once per week. In five other Governorates (42 sites), 100% of growers apply pesticides once per week. In 5% of sites, pesticides are applied once a month or less. The data gained will serve as the basis for further work designed to implement IPM practices and reduce use of chemical pesticides. Grower interviews clearly indicated that insecticide resistance was prevalent, and growers desperately need alternative management strategies.

Introduction

Vegetables are essential components of a healthy diet for humans throughout the world. Annual per capita consumption of vegetables averaged approximately 69.28 kg in Africa, 175.75 kg in Asia and 116.51 kg in the US (FAO, 2020). As of 2009 vegetable crops occupied 10.6% of arable land in Egypt (El-Nahrawy, 2011). This is very intensive agriculture as only 3% of Egypt's land is arable (FAO, 2016). In 2019 Egypt exported $1.1 billion in vegetable (UN ComTrade Database, 2019). The Russian Federation was Egypt's top partner for vegetable exports, followed by Saudi Arabia and Italy. Vegetable exports are a promising means of developing the Egyptian national economy and enhancing food security in-country. In the US, vegetable and fruit exports were estimated at $6 billion in 2015, while imports exceeded $18 billion, resulting in trade imbalance of $11 billion. Whereas the US in the

early 1970s was a net exporter of fruits and vegetables, it has now become a major importer (Johnson, 2016). Efforts are underway to increase vegetable production in both countries, which would significantly bolster agricultural revenues and contribute to stabilizing food security. Insect pests are a major factor reducing yields of vegetables (Kisha, 1984), and chemical insecticides remain the prominent means of control, despite their known negative impacts on the environment and human health. In fact, pesticides remain the primary means of pest management- 30% of all insecticides used worldwide are applied to vegetable crops for insect control (Shelton *et al.,* 2008). As of 2017 in Egypt, highly toxic pesticide residues were still detectible in the environment (Mansour *et al.,* 2017). While there is a shift toward biopesticide use in field crops, the use of indoor pesticides is widespread and generally inadequately managed (Mansour, 2008).

Materials and methods

To start implementing integrated pest management (IPM) strategies in greenhouses in Egypt, it was first necessary to determine what the insect pests were and how they are managed. Vegetable pests represent a broad range of plant types, production systems and pest problems. However, from a global perspective, two insect groups, whiteflies (Hemiptera: Aleyrodidae) and thrips (Thysanoptera: Thripidae), remain the more serious persistent and challenging problems facing farmers. Both feed by piercing the plant and sucking the sap from plant cells. They reduce crop yields, quality and shelf life by their direct feeding damage and also transmit viruses which can result in complete plant mortality. In the US, vegetable production areas yield losses ranging from 20 to 80% are often attributed to insect-borne viruses (Shelton *et al.*, 2008). While a large number of different whitefly and thrips species are known to attack vegetable crops, only relatively few represent a serious threat. For example, silverleaf whitefly, *Bemisia tabaci* (Gennadius), feeds on a wide variety of vegetables, including beans (Fabales: Fabaceae), tomatoes, *Solanum lycopersicum* L. (Solanales: Solanaceae), eggplant (Solanales: Solanaceae), cucumber, *Cucumis sativus* L. (Violales: Cucurbitaceae) and squash (Cucurbitales: Cucurbitaceae).

This insect can easily be found in high densities across a large diversity of plants in many production landscapes (Macfadyen *et al.,* 2020). Several whitefly biotypes exist and are known to rapidly gain resistance to insecticides. Both adults and nymphs feed on the lower surfaces of leaves by sucking sap with their piercing-sucking mouthparts. Chlorotic spots then appear around feeding sites on the upper surfaces of the leaves. Whiteflies produce honeydew upon which sooty mold often grows that reduces light penetration, yield and quality of the crop. On squash whiteflies induce a condition known as silverleaf, *Chondrostereum purpureum* (Pers.) Pouzar (Agaricales: Cyphellaceae) in which the foliage becomes highly reflective and the fruit is pale in color. On tomatoes the pest causes irregular ripening of the fruit. Whiteflies are also vectors of geminiviruses (Geplafuvirales: Geminiviridae), such as the detrimental tomato yellow leaf curl virus (He *et al.*, 2020). Silverleaf whitefly is difficult to control with insecticides. Repeated applications make the situation worse by selecting strains of whitefly that are resistant to pesticides. Damage by the silverleaf whitefly in the US since 1991 is estimated to exceed $1 billion (Paine, 2016). Two common species of thrips plague vegetable production, western flower thrips, *Frankliniella*

occidentalis Pergande, which has a broad host range including cucumber, pepper (Solanales: Solanaceae) and beans, *Phaseolus vulgaris* L. (Fabales: Fabaceae), and onion thrips, *Thrips tabaci* Lindeman, a pest of onion, *Allium cepa* L. (Asparagales: Amaryllidaceae), garlic, *Allium sativum* L. (Asparagales: Amaryllidaceae) and peppers. Both are major insect pests worldwide and transmit several deadly viruses. In general, thrips have a relatively rapid reproduction rate allowing populations to increase quickly when conditions are favorable. For this reason, as for whiteflies, pesticide resistance develops rapidly and currently few conventional pesticides are effective against western flower thrips in the US. In 2016, a survey of greenhouse vegetable growers in Egypt was conducted to obtain current information on the pest and disease challenges they face, the IPM practices they use, and the common pesticides they apply. A copy of the survey is included in Appendix 1. Greenhouses were visited and owners or operators were met face to face and asked each of the questions in the survey. Answers were recorded and tabulated at a later date.

Results and discussion

Greenhouse vegetable growers in 14 of the 26 Governorates in Egypt were surveyed from May through July 2016 (Table 1 and Figure 1). The Governorates surveyed were selected because they were areas of intensive greenhouse vegetable production. All surveys were conducted with face-to-face interviews of the head grower or owner of the operation using a standard set of questions focused on the growers' experience with insect and disease pests, crop scouting and pesticide application practices (See grower survey in Appendix 1 and Table 2).

Table (1): Where growers were surveyed.

Region	Governorate	Area	# sites surveyed
Rashid	Beheira	North	8
Gharbia	Gharbia	Central	9
Beni Suef	Beni Suef	Central	7
Nubaria	Beheira	North	10
Dakahlia	Dakahlia	North	16
Sharqyia	Al Sharqia	North	8
Ismailia	Ismailia	North	4
Damietta	Damietta	North	8
Suez	Suez	Central	7
Luxor	Luxor	South	15
Qalyubia	Qalyubia	Central	4
Menoufia	Menoufia	Central	6
Faiyoum	Faiyoum	Central	2
Kafr El-Sheikh	Kafr El-Sheikh	North	9
Alexandria	Alexandria	North	10

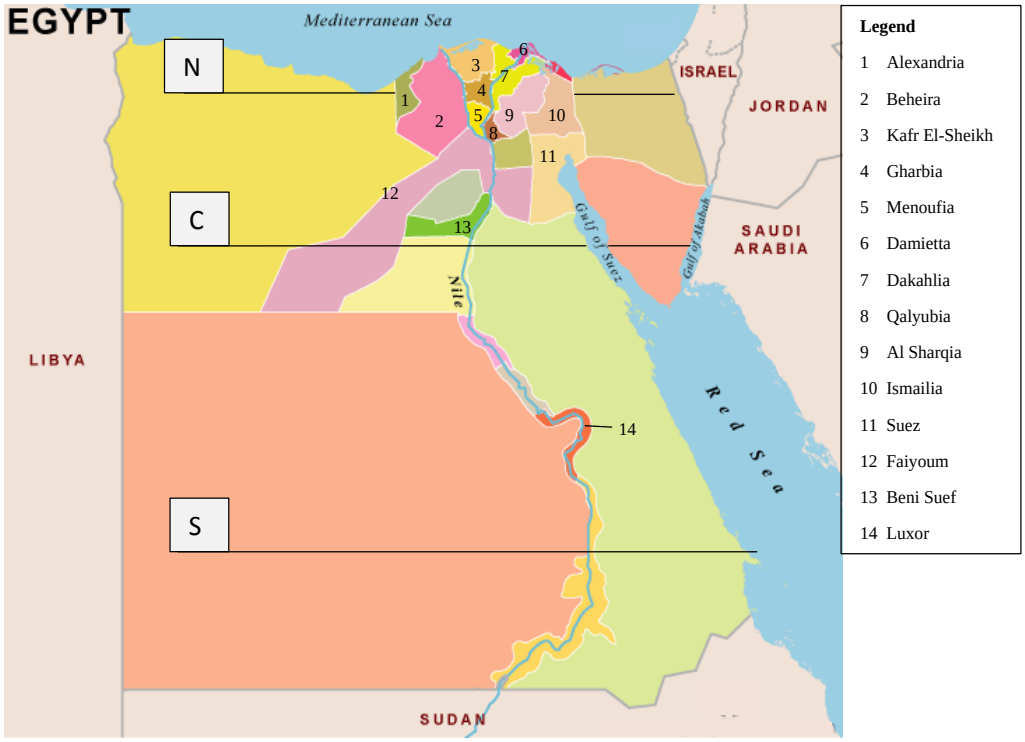

Figure (1): Map of Egyptian Governorates .
Complete map of Egypt showing individual Governorates , surrounding countries and water bodies. N = northern area, C = central area, S = southern area.

Table (2): Frequency of applying pesticides over the growing season.

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
1-2 times	2.4	0	16.7	0	0	0	0	0	0	0	0	0	0	0	0
1 time/wk	48.8	0	22.2	0	0	75	100	100	100	100	100	0	16.7	0	11.1
1 time/mo	2.4	0	5.6	0	0	0	0	0	0	0	0	0	0	0	22.2
Over 1 time/wk	43.1	100	38.9	100	100	25	0	0	0	0	0	100	83.3	100	66.7

Values represent percent of survey responses. A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

1. Vegetables grown:

Of all growers surveyed, 41-43% grow cucumbers and/or tomatoes, 36% grow peppers and 16% grow eggplant (Table S1). In Luxor and Faiyoum 100% of those surveyed grow tomatoes. Between 50-62% of the growers in Al Sharqia, Ismailia and Damietta grow tomatoes. Peppers are a common crop in Beheira (55%), Beni Suef (57%), Al Sharqia (62%), Menoufia (50%), Faiyoum (100%) and Kafr El-Sheikh (88%). Between 50-100% of the growers in Alexandria, Beheira, Al Sharqia, Damietta, Qalyubia, Menoufia, Faiyoum and Kafr El-Sheikh grow cucumbers. Crops grown less commonly include melon (Cucurbitales: Cucurbitaceae), strawberry, *Fragaria x ananassa* Duschene (Rosales: Rosaceae), onion, wheat (Poales: Poaceae), cabbage, *Brassica oleracea* L. (Brassicales: Brassicaceae), cilantro, *Coriandrum sativum* L. (Apiales: Apiaceae), garlic, lettuce, *Lactuca sativa* L. (Asterales: Asteraceae) and dill, *Anethum graveolens* L. (Apiales: Apiaceae).

2. Insect pests:

All regions reported multiple common arthropod pests (Table S2). Of those surveyed in Alexandria, Gharbia, Beni Suef, Al Sharqia, Damietta, Suez and Menoufia, 100% of growers reported whiteflies and thrips as

important pests. In all Governorates , mites were the most common pest, with 93% of regions reporting problems with the arthropod. Common arthropod pests across all regions include whiteflies (91%), aphids (Hemiptera: Aphidoidea) (78%) and thrips (78%). All Governorates reported whiteflies, aphids, and spider mites (Trombidiformes: Tetranychidae) as common arthropod pests. *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) (40.7%) and nematodes (39%) were fairly common among the regions. Other arthropod pests reported include jassid bug, *Amrasca biguttula* (Ishida) (Hemiptera: Cicadellidae), mealybugs (Hemiptera: Pseudococcidae) and leaf miners.

3. Diseases encountered:

The most important disease reported throughout all the regions was powdery mildew (Erysiphales: Erysiphaceae), with 80% of growers surveyed reporting it a problem (Table S3). Every grower surveyed in Gharbia, Dakahlia, Al Sharqia, Ismailia, Suez, Qalyubia, Menoufia, Faiyoum and Kafr El-Sheikh reported powdery mildew as a common disease in their crops. Other diseases reported include downy mildew (Erysiphales: Erysiphaceae), which was the most common in Qalyubia (100%) and Al Sharqia (75%) but relatively mild across all regions (29%) and grey mold (Helotiales: Sclerotiniaceae), which was reported by only 4% of growers surveyed. Growers also report problems with blight, white mold *Sclerotinia sclerotiorum* (Lib.) de Bary (Helotiales: Sclerotiniaceae), fusarium wilt, *Fusarium oxysporum* Schlecht (Hypocreales: Nectriaceae), stem rot and rust (Puccinales).

4. Scouting:

All growers surveyed report scouting their fields for pests (Table S4). Across all regions 78% report daily scouting and 18% report weekly scouting. Every grower surveyed in Beni Suef, Ismailia, Damietta, Suez, Luxor, Qalyubia, Faiyoum and Kafr El-Sheikh report scouting daily. Only in Al Sharqia are growers more likely to report scouting weekly (62%) than daily (37%).

5. Soil fertility:

All growers identified at least one other production problem in their greenhouses (Table S5). Most growers report problems with soil fertility on their sites (83%). Soil fertility was a problem with 100% of growers in Alexandria, Ismailia, Suez, Luxor, Qalyubia and Menoufia. Across all Governorates 12% report high salt as a production problem. This was most common in Beheira (55%), Beni Suef (42%) and Faiyoum (50%).

6. Employees:

On average across all Governorates growers have 9 employees per site (Table S6). The most common number of employees in all Governorates was 6—10 (40%), followed by 1-5 employees (32%). Just 8.7% of growers surveyed had more than 20 employees. Smaller growers with 1-5 employees were common in Gharbia (77%) and Beni Suef (71%) and growers with 6-10 employees were common in Ismailia (100%), Damietta (62%), Suez (57%) and Kafr El-Sheikh (87%). Growers with more than 20 employees were uncommon across the region but made up 50% of growers surveyed in Faiyoum and 25% of growers in Qalyubia.

7. Greenhouses:

There is a mean of 50 greenhouses per site surveyed across all regions (Table S7). Among all Governorates 41% of growers have between 11-40 greenhouses and 41% of growers have between 41-100 greenhouses. Between 1-10 greenhouses was common at sites in Beheira (53%) and Ismailia (100%). Many growers in Beni Suef (85%), Gharbia (77%), Kafr El-Sheikh (77%)

and Qalyubia (100%) had between 11-40 greenhouses while many growers in Dakahlia (68%) and Damietta (75%) had between 41-100 greenhouses per site. In Al-Sharqia 37% of growers have more than 100 greenhouses, the highest percentage among all Governorates .

8. Marketing:

Most growers (76%) across all regions sell their crops to the local market (Table S8). Regions where growers reported growing vegetables for export include Beheira (44%), Beni Suef (42%), Ismailia (100%), Luxor (33%) and Qalyubia (50%).

9. Pesticides:

The most common forms of pest control across the Governorates are abamectin (56%), microbials (33%), thiamethoxam (27%) and copper/sulfur (24%). Less common pest control products include biological control (10%), spinosad (7%) and cypermethrin (6.5%). Biological control methods include using *Trichogramma* wasps (Hymenoptera: Trichogrammatidae), *Metarhizium anisopliae* (Metchnikoff) Sorokin (Hypocreales: Clavicipitaceae) fungus, the predatory mite *Phytoseiulus persimilis* Athios-Henriot (Mesostigmata: Phytoseiidae) and the predaceous lady beetle *Coccinella undecimpunctata* L. (Coleoptera: Coccinellidae).

It is concluded that growers list whiteflies and thrips as prominent pests in many regions of Egypt. A vast majority of growers also report powdery mildew as a problem in their crops. To battle pests growers often turn to abamectin, a highly toxic insecticide. Some components of IPM were reported, such as the use of biological control agents and frequent scouting for pests. However, frequent insecticide applications were common. More than 40% of those surveyed report applying insecticides more than once per week to crops including tomatoes, cucumbers and peppers. Insecticide resistance by the major pests is common and growers desperately need alternative management options.

Acknowledgments.

This survey was supported in part with funding from the US Department of Agriculture, Agricultural Research Service, Project #59-0210-5-006, University of Vermont College of Agriculture and Life Sciences and Egyptian Agricultural Research Center. We are grateful to the many scientists of the Egyptian Agricultural Research Center who helped with this work and the technicians at the University of Vermont who assisted with compiling the data. Special thanks to Miss Erin White for revision and editing.

References

El-Nahrawy, M.A. (2011): Egypt. Country Pasture/Forage Resource Profile. http://www.fao.org/ag/AGP/AGPC/doc/Counprof/Egypt/Egypt.html.

FAO (2016): AQUASTAT Country profile – Egypt. Food and Agriculture Organization of the United Nations (FAO). Rome, Italy.

FAO (2020): New Food Balances. http://www.fao.org/faostat/en/#data/FBS.

He, Y.; Wang, Y.; Yin, T.; Olivé, E.; Liu, Y.; Hanley-Bowdoin, L. and Wang, X. (2020): A plant DNA virus replicates in the salivary glands of its insect vector via recruitment of host DNA synthesis machinery. PNAS, 117(29), 16928-16937. DOI: 10.1073/pnas.1820132117.

Johnson, R. (2016): The US Trade Situation for Fruits and Vegetable Products. Congressional Research Service Report.

https://fas.org/sgp/crs/misc/RL34468.pdf

Kisha, J. (1984): Insect Pests of Vegetables – Approaches Used for Their Control. Acta Hort. (ISHS), 143:375-386.

Macfadyen, S.; Tay, W.T.; Hulthen, A.; Paull, C.; Kalyebi, A.; Jacomb, F.; … and Barro, P. (2020): Landscape factors and how they influence whitefly pests in cassava fields across East Africa. Landscape Ecol,

Mansour, S.; Soliman, S. and Soliman, K. (2017): Biomonitoring of persistent organic pollutants in Egypt using *Taphozous perforates* (Chiroptera: Emballonuridae). Sciendo, 48: 109-124.

Mansour, S.A. (2008): Environmental Impact of Pesticides in Egypt. In: Whitacre D. (eds) Reviews of Environmental Contamination and Toxicology , 196:1-51.

Paine, T.; Bellows, T. and Hoddle, M. (2016): Silverleaf Whitefly. UC Riverside Center for Invasive Research, University of California. cisr.ucr.edu/invasive-species/silverleaf-whitefly.html.

Shelton, A.M.; Romeis, J. and Kennedy, G.G. (2008): IPM and GM, insect-protected plants: thoughts for the future. *In* Integration of insect-resistance, genetically modified crops within IPM programs. Eds. J. Romeis, A.M. Shelton and G.G. Kennedy. pp. 419-430. Springer Dordrect, The Netherlands.

UN ComTrade Database (2019): Trade Statistics, Egypt Partner, 07 Vegetable Exports. http://comtrade.un.org/data.

Appendix 1

Table (S1): Crop type grown in greenhouses (% of survey responses).

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
Tomatoes	41.5	20	33.3	33.3	0	43.8	62.5	50	62.5	28.6	100	0	16.7	100	11.1
Eggplant	16.3	0	16.7	0	0	37.5	37.5	0	12.5	28.6	0	0	50	50	11.1
Peppers	36.6	30	55.6	33.3	57.1	12.5	62.5	0	37.5	28.6	0	0	50	100	88.9
Cucumbers	43.1	60	61.1	44.4	42.9	25	50	0	50	28.6	0	50	50	50	100
Melons	0.8	0	5.6	0	0	0	0	0	0	0	0	0	0	0	0
Ornamentals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	14.6	0	38.9	0	0	0	0	50	0	0	0	50	0	100	55.6

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S2): Most important arthropod pests (% of survey responses)

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
Whitefly	91.1	100	77.8	100	100	62.5	100	100	100	100	100	100	100	100	88.9
Thrips	78	100	72.2	100	100	100	100	50	100	100	0	50	100	50	77.8
Tuta absoluta	40.7	0	33.3	33.3	0	56.3	62.5	50	62.5	28.6	100	0	16.7	100	0
Aphids	78.9	100	66.7	55.6	85.7	93.8	75	100	87.5	100	86.7	50	100	50	33.3
Spider mite	93.5	100	83.3	100	100	93.8	100	100	100	71.4	93.3	100	100	100	88.9
Other mite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	39.0	20	61.1	100	0	87.5	37.5	50	12.5	42.9	0	50	0	50	0
Other	41.5	0	22.2	0	42.9	75	37.5	50	0	14.3	100	50	33.3	50	66.7

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S3): Table (S3): Most important diseases (% of survey responses)

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
Powdery mildew	80.5	90	77.8	100	57.1	100	100	100	87.5	100	0	100	100	100	100
Grey mold	4.9	0	16.7	0	0	0	0	0	0	0	0	0	0	50	22.2
Downy mildew	29.3	10	44.4	0	42.9	6.3	75	50	37.5	57.1	0	100	0	0	44.4
Other	6.5	0	27.8	0	0	0	0	0	0	0	0	0	0	50	22.2

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S4): Frequency of scouting for pests (% of survey responses)

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
1-2 times over the season	0.8	0	5.6	0	0	0	0	0	0	0	0	0	0	0	0
Daily	78	60	44.4	77.8	100	75	37.5	100	100	100	100	100	66.7	100	100
Weekly	18.7	40	33.3	22.2	0	25	62.5	0	0	0	0	0	33.3	0	0
Monthly	0.8	0	5.6	0.0	0	0	0	0	0	0	0	0	0	0	0
Never	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S5): What other production problems are common (% of survey responses)?

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
High salt	12.2	0	55.6	0	42.9	0	0	0	0	0	0	0	0	50	11.1
Soil fertility	82.9	100	88.9	77.8	57.1	87.5	87.5	100	87.5	100	100	100	100	0	11.1

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S6): Employees per site (% of survey responses).

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
1-5 employees	32.5	40	44.4	77.8	71.4	37.5	12.5	0	25	42.9	40	25	16.7	0	0
6-10 employees	40.7	40	33.3	11.1	28.6	43.8	25	100	62.5	57.1	33.3	50	50	0	87.5
11-20 employees	17.1	20	11.1	11.1	0	18.8	50	0	12.5	0	26.7	25	33.3	50	12.5
>20 employees	8.7	0	11.1	0	0	0	12.5	0	0	0	0	25	0	50	0

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Table (S7): Mean greenhouses per site (% of survey responses).

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
1-10 greenhouses	7.7	10	53.8	0	14.3	0	0	100	0	0	0	0	0	0	0
11-40 greenhouses	41	60	15.4	77.8	85.7	18.8	25	0	25	57.1	26.7	100	33.3	50	77.8
41-100 greenhouses	41	30	15.4	22.2	0	68.8	37.5	0	75	42.9	53.3	0	50	0	22.2
>100 greenhouses	10.3	0	15.4	0	0	12.5	37.5	0	0	0	20	0	16.7	0	0

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh

Table (S8): Market used for selling crops (% of survey responses).

	All	A.	B.	G.	Be.	D.	Al.	I.	D.	S.	L.	Q.	M.	F.	K.
Local market	76.4	100	44.4	100	100	100	100	0	100	100	66.7	50	100	50	22.2
Export market	17.9	0	44.4	0	42.9	0	0	100	0	0	33.3	50	0	0	0

A: Alexandria B. Beheira G. Gharbia Be. Beni Suef D. Dakahlia Al. Al Sharqia I. Ismailia D. Damietta S. Suez L. Luxor Q. Qalyubia M. Menoufia F. Faiyoum K. Kafr El-Sheikh.

Grower survey:

Date: **Governorate:**

Grower Name:

Grower Address:

How many greenhouses do you have?

How many square meters of greenhouse space do you have?

What crops do you grow?

Tomatoes Melons

Eggplant Ornamentals

Peppers Other (Specify):

Cucumbers

What are your major insect/mite pests?

Whitefly Spider mite

Thrips Other mites

Tuta absoluta Other (Specify):

What are your major disease pests?

Powdery mildew Downy mildew

Grey mold (Botrytis) Other (Specify):

Other problems: High salts Soil Fertility

How often do you scout your crop?

Never Weekly

1-2 times/growing season Monthly

Daily

How often do you apply chemical pesticides?

Never 1 time/month during the growing season

1-2 times/growing season More than 1 time/week during the growing season

Do you ever use biological control?

If yes, what do you use?

This survey was supported in part with funding from the US Department of Agriculture, Agricultural Research Service, Project #59-0210-5-006, University of Vermont College of Agriculture and Life Sciences and Egyptian Agricultural Research Center.