Journal of Zankoy Sulaimani
Part-A- (Pure and Applied Sciences)
http://jzs.univsul.edu.iq

A survey study of Pesticide application pattern in selected plastic houses in Sulaimani governorate/ Iraq

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Article info

Original: 14 April 2020
Revised: 21 June 2020
Accepted: 23 August 2020
Published online: 20 December 2020

Key Words:
Pesticides; Insecticides; Fungicides; Herbicides; PPE; IMP.

Abstract

This study was conducted to determine the frequency and types of used pesticides in some plastic houses in Sulaimaniyah. The levels of perception and behavior of farmers regarding usage of pesticide; and farmer attitude towards the importance of pest management practice adoption are investigated. The study was quantitative research. Sources of data were collected from observation, questionnaire, and in-depth interview methods. The respondents were vegetable growers inside high tunnels plastic houses from October 2019 to February 2020, (n=102). The study found that different insecticides and fungicides were mostly applied by vegetable growers. Insecticides were applied by 55.95% of respondents compared to fungicides and herbicides 28.19%, 15.86% respectively. Abamectin insecticide was the most used active ingredient 54.90% among the farmers, followed by Cyflumetofen 45.10% of respondents. It was also found that 92.16%, 54.90%, 5.88%, and 43.14% of respondents followed retailer instruction, label instruction, government regulation, and past experiences respectively during pesticide usage. The data revealed that 100% of respondents have never received government support in terms of pesticide allocation. Only 11.76% of respondents have been regulated by the government. Immediate comprehensive intervention is recommended to prevent potential hazards and health risks through training programs on pesticide use for farmers, distributors, and retailers. Further laboratories pesticide residue analyses are needed to evaluate potential toxic effects of the most commonly used pesticides

Introduction

Since the mid-twentieth century average global crop production has exceeded by twofold worldwide, but crop yield has remained the same or even declined in some regions. At the same time, due to population growth and higher living standards, food demand has raised [1].

High tunnels plastic houses increased rapidly among the farmers who supply local market foods over the last two decades. Although high tunnels plastic houses are similar to greenhouses, high tunnels are not greenhouses [2],[4]. According to [2], China is on the top list countries, where 3600 km^2 of their crop production farms are covered with high tunnels plastic houses. Scientists and researchers implemented various applications to increase yield production through the use of fertilizers and pesticides. However, these applications might have an adverse effect on the environment [1], [5].

Mostly pesticides are a group of chemical mixture, which mainly classified into insecticides, fungicides, and herbicides, or any substances that used to control insects, fungus, and weeds [6]. Approximately 1500 active ingredients were registered worldwide, where 85% of all pesticides are used for agriculture. Due to their chemical nature, pesticides can pose serious environmental and health problems [7], [8]

The use of pesticides has increased many folds over the past few decades. According to [9] approximately 2.54 billion tons of pesticides were used worldwide each year. The production of pesticides in India, which is one of the top pesticide manufacturer's countries, has increased by 20.5 folds from 1958 to 1999 [10].

The main reasons for using pesticides are to increase productivity and reduce yield losses by protecting crops from weeds, diseases, and insects [11]. On the other hand, excessive use of pesticides results in health issues for both farmers and consumers [12], and environmental including water pollution ,[13], [14] soil contamination [15], and damage useful microorganisms, soil biomass, earthworms [16], [17].

Many studies reported that the excessive use of pesticides for agriculture production could lead to environmental pollutions [14], [18], [19]. One of the primary concerns of many international organizations due to lack of knowledge is the risks that face growers during incorrect chemical application techniques such as poorly maintained or totally inappropriate spraying equipment, inadequate storage practices, and poor use of personal protection equipment (PPE) [20], [21], and pesticide residue [22]

Very limited studies have been conducted in the study area, in particular those concerning the above-mentioned conditions, as well as the lack of data on the type of pesticides use and application pattern by farmers in Sulaimani. Therefore, this study aimed to determine the frequency and types of used pesticides in plastic houses in Sulaimaniyah, Secondly, levels of perception and behavior of farmers regarding usage of pesticide, finally, to explore farmer attitude towards the importance of pest management practice adoption.

Methodology

This research was conducted from October 2019 until February 2020 located at the Bazyan area Southwest of Sulaimani governorate. The location of the study was selected based on the rapid increase in numbers of the plastic house during the last decade, and it is one of the supply sources of the vegetable market at the Sulaimani governorate. This quantitative research was performed by collecting data from observation, questionnaires, and in-depth interviews. The respondents were farmers who planted vegetables in plastic houses during the last ten years (n=102). The plastic house owners were interviewed personally with a questionnaire to determine information about the use of agricultural pesticides. The questionnaire was composed of three sections. The first section included questions about the plastic houses managed by each respondent such as; the number of houses, size, and the pattern of vegetable planting in the study area, growing season per year, and the duration of houses run by respondents. The second section included questions regarding types of pest control for products, as well as application patterns. The third section related to pest management, which included farmers' knowledge in handling the excessive amounts, disposal of empty containers, awareness regarding health effects of pesticides use, the use of personal protection equipment PPE (gloves, goggles, face mask, coveralls, and boots), thoughts and feedbacks of respondents about pesticide effectiveness, and government support and monitoring. In addition, three pesticide retailers in the study area were interviewed, in order to verify the collected data from the respondents. The retailers were asked about: types, common names, cost of pesticides, trade names, and all information related to pesticide applications. The notebook and recorder were used during the questionnaire. The data collected were inputted to Microsoft Office Excel for descriptive analysis.

Result and Discussion

1- Plastic house characteristic and planting pattern in the study area

High tunnels plastic houses are the majority of planting vegetables in the study area. The total numbers of houses run by respondents were 1238 houses (Table 1), where 37.3% of the vegetable growers are those who manage more than 10 houses. The size of each plastic houses managed by the respondents is between (405 - 450m^2), which covers around 52.94 ha in total.

The data presented in (Table 1) reflects that the life of plastic house management and the experience among respondents were varying. The majority of respondents 54.9% had 2-5 years of experiences, and respondents with 5-10 years account for 41.2%, followed by those have more than 10-year experiences 9.8%.

In addition, 54.90% of respondents were growing (2-5) products in plastic houses. According to [3] cultivation of a single crop has a negative impact on soil fertility and increases the problem of diseases and pests. Moreover, the farmers have two planting periods throughout the year, the first planting starts in

March, and the second planting starts at the beginning of July. Seventy-one percent of respondents are growing vegetables in both periods, while 25% of respondents plants only in March.

Table 1: The plastic house management informational run by the respondents (n=102).

Information	(1-2)	(2-5)	(5-10)	(+10)
Number of plastic houses run by respondents	11.76	13.73	37.25	37.25
Duration of the house management	13.73	54.90	41.18	9.80
Number of product(s)	37.25	54.90	19.61	N/A

The common types of protected cultivation in the study area were the high tunnels plastic houses. [3] reported that high tunnels plastic houses provide a suitable environment for plant growth. The present study shows that cucumber has the highest production 96% between the most common crops, while pepper, tomato, potato, eggplant, zucchini, and broccoli production are 41.18%, 29.41%, 13.73%, 9.80%, 5.88%, and 3.92% respectively (Figure 1). Tomato, pepper and cucumber are reported to be successfully grown in the high tunnel in many countries [2]. Moreover, the respondents reported that the reasons for cultivating cucumber and peppers rather than tomatoes, eggplants are due to the quick and high production amount, and commonly used by individuals. This crop cultivation patterns may be changed based on the vegetable price in the previous year.

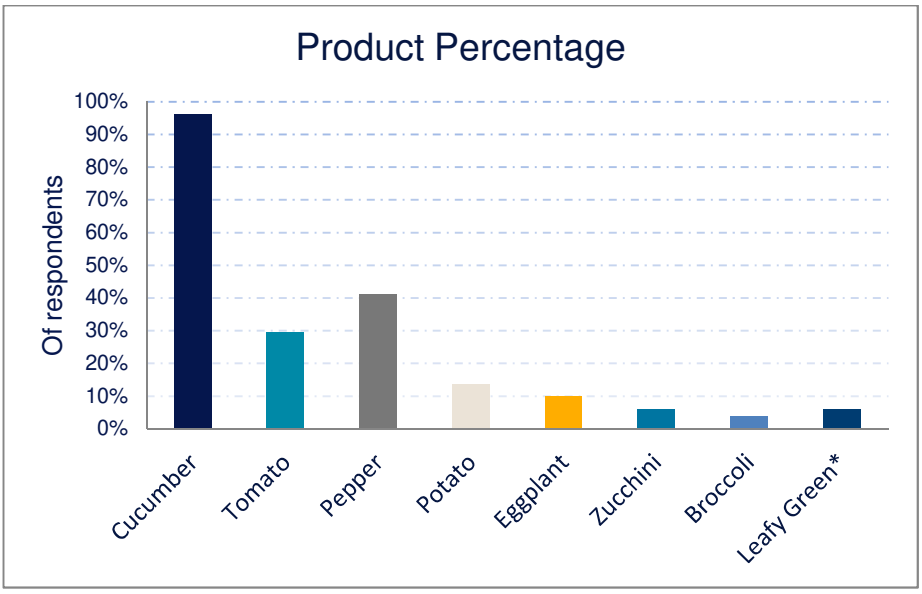

Figure 1: Production percentage among respondents in the study area (n=102). *** Leafy greens were mainly Arugula (*Eruca vesicaria ssp. sativa*), Celery (*Apium graveolens*), and Garden Cress (*Lepidium sativum*).**

2- Pesticides usage pattern among farmers in the study area

Pesticides are used extensively with various proportions due to damage caused by pests and disease on many crops. [11] reported that yield reduces by 55% in field crops as a result of weed infestations, insect/pest attacks, and disease outbreaks in field crops.

The present survey study showed that insecticides were applied mainly 55.95% among the respondents compared to fungicides and herbicides 28.19% and 15.86% respectively. (Table 2) presents the list of pesticides used by the respondents to prevent crop loss from pest attack, 34 pesticides with 42 different trade names were found to be used by the farmers during the study period. The World Health Organization [23], recommended guidelines for classification of pesticides by hazard, where only one of the pesticide belonged to the Class Ia (Extremely hazardous), 12 belonged to the Class II (Moderately hazardous), 8 belonged to Class III (Slightly hazardous), 8 belonged to class U (Unlikely to present acute hazard in normal use), and 1 belonged to class O (Obsolete as a pesticide, not classified).

Table 2: List of pesticides used by farmers in studied locations, classified using the WHO Hazard Class and health effects, 2010

Pesticide Type	Common Name	Active Ingredient	Class *
Insecticide	Danisaraba 20 SC	Cyflumetofen SC	NC
	Solution		
	Vertimec 018EC	Abamectin	III
	Transact 18 EC		
	Milbeknock 1%EC	Milbemectin	NC
	Oberon 240 SC	Spiromesifen	NC
	Master 11 EC	Abamectin + Acetamiprid	III
	D - Sect EC	Deltamethrin	II
	Alpha Chlore	Alpha-Cypermethrin	II
	Effector		
	Alpha-power		
	Afanti		
	Radiant 120 SC	Spinetoram	U
	Filap - 20% EC	Ethoprophos	Ia
	Vantex 6% CS	Lambda Cyhalothrin	II
	Matador 50		
	Levozan	Levamisole- HCL + Oxyclozanide	NC
	Zoro Super	Abamectin	II
	Aldrin	Aldrin	O
	Halek Super	Lambda-Cyhalothrin + Chlorpyrifos	II
	Applaud 20% SC	Buprofezin	III
	Orizon SL	Acetamiprid + Abamectin	II
	PropargiteAria	Propargite	III
	Acaronein 15% EC	Pyridaben	II
	Super mega	Chlorfenapyr	II
Herbicide	Halex 10.8% EC	Haloxyfop-p-methyl	II
	Oriental 40% SC	Bispyribac-Sodium	III
	Tiller 480 SL	Glyphosate IPA	III
	Glyphost plus	Glyphosate Acid	III
Fungicide	Ridoxyl	Metalaxyl	II
	Azox	Azoxystrobin	U
	Stellar		
	Elite Express	Fosetyl Aluminum	U
	Fosbel 80		
	Moncut	Flutolanil	U
	Mandate	Thiophanate-methyl	U
	Pristine WG	Pyraclostrobin + Boscalid	U
	Othello top 32.5% SC	Azoxystrobin + Difenoconazole	II
	Akrobeat 57	Dimethomorph + Propineb	U
	Thriam	Thriam	II
	Topas 100 EC	Penconazole	III
	Goldazim 50% SC	Carbendazim	U

*** II = Moderately hazardous; III = slightly hazardous; U = Unlikely to present acute hazard in normal use; Ia = Extremely hazardous; O = Obsolete as pesticide, not classified; NC = not classified.**

Insecticides mostly used by respondents to control pests of plants in their plastic houses such as Spiders, Thrips, and nematodes (Figure 2).

Nematodes constitute a big problem in the study area; this might be the reason for using insecticides extensively by the farmers. Probably the respondents have applied internationally prohibited insecticides to protect their products. Previous studies reported that nematodes caused damage nearly by 90% of plant products, in particular by the root-knot nematodes [24], [25], also an estimation of 118b US Dollars annually lost to world crops because of nematode parasites [26].

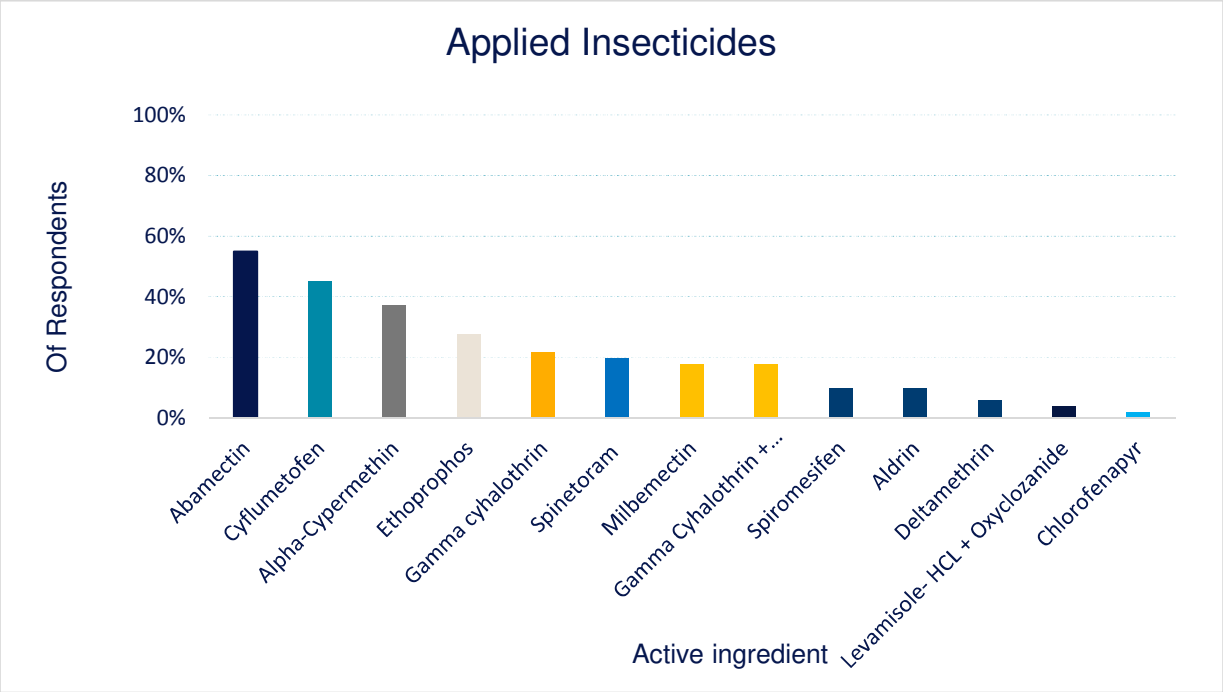

Figure 2: Most focused insecticides applied by respondents in the study area (n=102).

Figure 2 show that 54.90% of respondents apply Abamectin active ingredient. Low acute toxicity of Abamectin on non-target beneficial arthropods has revealed, which resulted to be accepted quickly by Integrated Pest Management (IPM) programs. Also, Abamectin application showed no adverse effect on man and environment during agricultural practices [25], [27].

However, United State Environmental Protection Agency [28] reported that Abamectin has high acute toxicity to sensitive invertebrates such as water flea (*Daphnia magna*) living in freshwater with a 48-h EC50 value of 0.34 µg ai/L, as well as Honey Bee with an acute dermal LD50 of 0.41 µg /bee, and very highly toxic with an acute 96-h LC50 value of 3.2 µg ai/L to freshwater fish (total form) such as rainbow trout (Oncorhynchus mykiss).

Besides, 45.10% of respondents were applied Danisaraba trade named insecticide, which contains Cyflumetofen 20 SC active ingredient. Very low acute toxicity of Cyflumetofen was found to mammals, birds, bees and beneficial insects, including predatory mites. Also, due to its degradability in water and soil, Cyflumetofen has some toxicity to fish and aquatic invertebrates [29], [30]. Although Cyflumetofen has not been evaluated by WHO yet (Table 2), the joint FAO/WHO meeting of pesticide residues (JMPR), which met during September 2014, reported the potential hazards to fetuses, infants and children of Cyflumetofen based on the existing database [31].

The study reveals that 31.37% of respondents were used Alpha-Cypermethrin active ingredient with various trade names. Alpha-Cypermethrin is an active pyrethroid, which intensively controls a wide range of pests in agriculture and animal breeding. Also, Alpha-Cypermethrin has low acute toxicity in humans and animals [32], highly toxic to fish and aquatic invertebrates [33], [34]. Alpha-Cypermethrin was classified by WHO as (II) class (Table 2).

Fungicides come in the second-order, which used by respondents to control plant diseases (Figure 3). During in-depth interviews farmers mentioned that after 2 days of planting, fungicides are applied to each seedling.

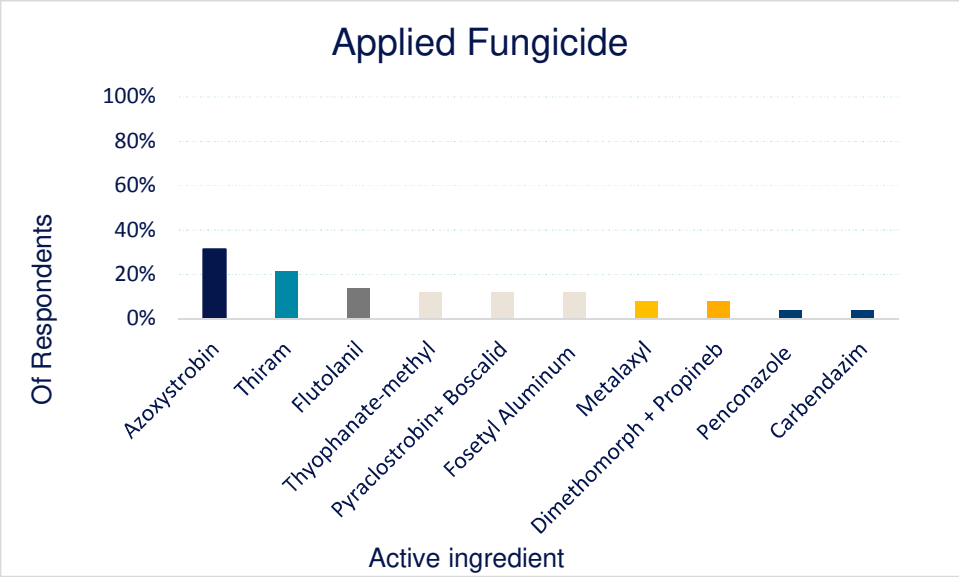

Figure 3: Most focused fungicides applied by respondents in the study area (n=102).

Azoxystrobin active ingredient was among the most applied fungicides (31.37%) used by respondents. Azoxystrobin was mixed with Metalaxyl and Difenoconazole active ingredients during the applications, as reported by pesticide retailers. Azoxystrobin was firstly introduced to market sales in 1996 [35], which are derived from the naturally-occurring strobilurins [36]. It was classified by WHO as (U) class (Table 2). Azoxystrobin has shown low acute toxicity to humans, birds, mammals, and bees but high to very high acute toxicity to freshwater fish, freshwater invertebrates and estuarine/marine invertebrates respectively [37]. Also, it has proved that Azoxystrobin has a chronic effect on Amphipods, Midges, Cladocerans, and Mussels invertebrates. The possible change of the ecological rate process is observed on aquatic invertebrates through a noticeable alteration of biomass and reproduction [38].

Practical studies on Azoxystrobin reported that its soil persistence to be moderate in the absence of light and moderately mobile in soil profile [39]. In addition, [40] reported that the leaching of Azoxystrobin via loamy soils can take a long time after the applications, which most probably cause a potential risk to sensitive aquatic environments and drinking water recourses.

Moreover, 21.57% of respondents applied Thiram. Thiram is a kind of fungicide extensively used in agriculture [41]. According to [42] Thiram shows a low to moderate severe toxicity by ingestion, but it is moderately toxic if inhaled. Also, when administered to mice at the highest dose possible, Thiram was not carcinogenic. Moncut is also one of the top three applied fungicides (13.73%) by respondents, which has Flutolanil active ingredient content. In the present study, fungicides are used in preventive forms, where an amount of 350-500ml was applied to each seedling after the 2 days of planting.

The data in (Figure 4) illustrates applied herbicides by vegetable growers. One of the most used herbicides is Glyphosate active ingredient, with various trade names such as Tiller and Glyphost plus, which applied 37.25% of respondents to control weeds. Glyphosate is the most extensively used herbicides between weed control products worldwide. The Glyphosate properties were found since 1970, and in 1974 was introduced as the first commercial formulations for nonselective weeds [43].

The Toxicity of Glyphosate formulations were reported as low or non-toxic to birds and mammals, and non-toxic to moderately toxic to aquatic invertebrates [44]. In addition, it was concluded that Glyphosate is probably carcinogenic to humans [45]. Whilst, Glyphosate was reported as non-carcinogen to animals in the laboratory during an expert panel [46].

The data reveals that 17.65% of respondents were applied Halex. The active ingredient of Halex is

Haloxyfop-p-methyl. The last herbicide applied by the respondent was Oriental (15.65%), which has Bispyribac-Sodium active ingredient content.

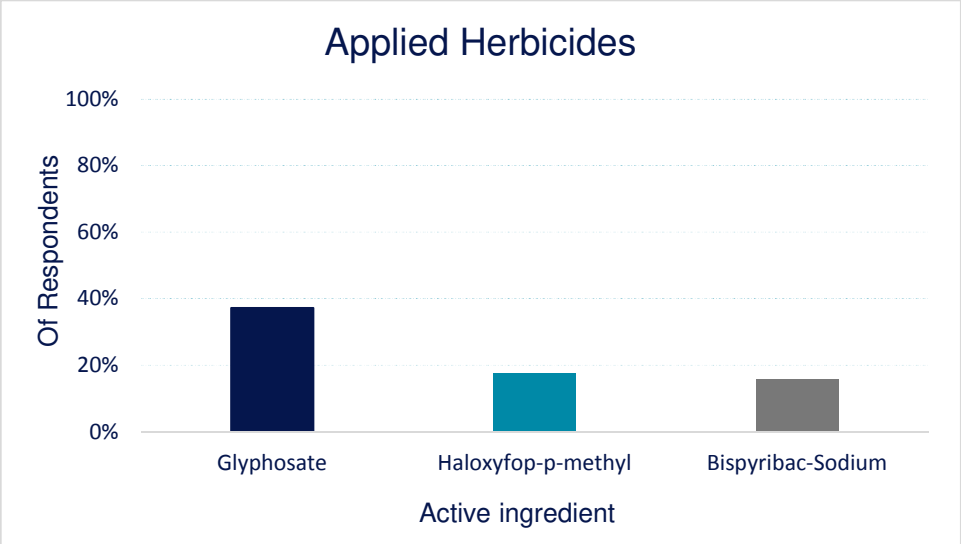

Figure 4: Most focused herbicides applied by respondents in the study area (n=102).

3- Farmers knowledge of pesticide application and effectiveness

Despite extensive use of pesticides in the study area, there is still relatively little knowledge about the fate and toxicity of pesticides on the environment. On the other hand, the respondents have not received any training on the choice of safe pesticide usage, apply, mix, store, and toxicity.

Therefore, the interviewees reported that 92.16% of them use pesticides according to retailer instructions (Figure 5). This result is somehow in agreement with a previous study conducted by [11] who reported that more than 75% of farmers are receiving information from the pesticide distributors. But, it contradict with the findings of [47], where 34.5% of farmers dependent on retailers. Although, pesticide label is an important source of pesticide information [48], [49], the present study reveals that 54.90% of respondents followed label information on the pesticide container (Figure 5). This might because of farmers' education or the instructions are too long as well as its written in foreign languages as reported by [17], [50]. The results of studies conducted in Kuwait and Pakistan by [51], [52] reported that over 70% of farmers did not read the instructions on pesticide containers. Whilst over 88% of farmers in Adana-Turkey read the instructions before pesticide use [53].

In addition, 43.14% of respondents reported that they use pesticides based on the self-experiences, which gained from the duration of their plastic houses' management (Table 1). According to [54] farmer attitudes in pesticide uses are influenced by experiences.

Governmental monitoring has the most important rules in term of safe pesticide use as well as environmental protection. However, in the present study, only 5.88% of respondents followed governmental instructions and regulations during the pesticide uses (Figure 5). Many studies supporting the effectiveness of Integrated Pest Management-IPM technology implementation by farmers [18]. The IPM was established since 1970, which is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides,[55], [56]. According to [57] governmental monitoring and farmer education are very important, however, based on their survey 34% of respondents knew about IPM and only14% of the farmers have been adopting some forms of IPM.

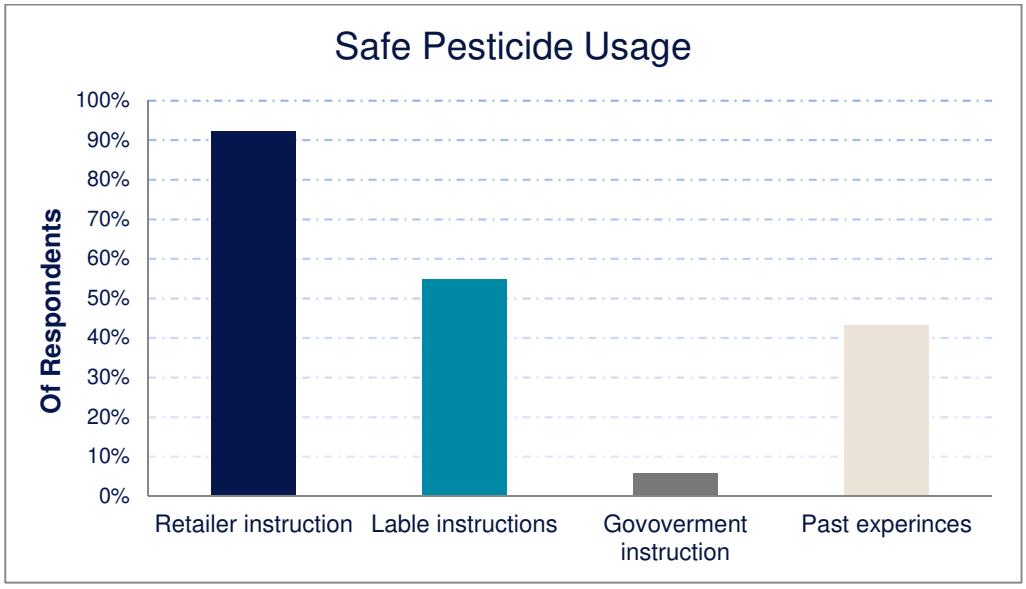

Figure 5: Percentage of respondents using different information sources in the study area (n=102).

Respondents were also asked about governmental support in term of pesticide allocation and monitoring in term of safe application of pesticides. The data revealed that 100% of respondents have never received government support in term of pesticide allocation. Alternatively, the only source of pesticides was pesticide retailers. In addition, only 11.76% of respondents have been regulated by the government. Therefore, pesticide applicators may be face errors like under-dose or overdose applications during the vegetable treatment.

Regarding farmers' thoughts and feedback on pesticide effectiveness, 54.9% of respondents have medium scale measurements on the effect of pesticide application (Figure 6).

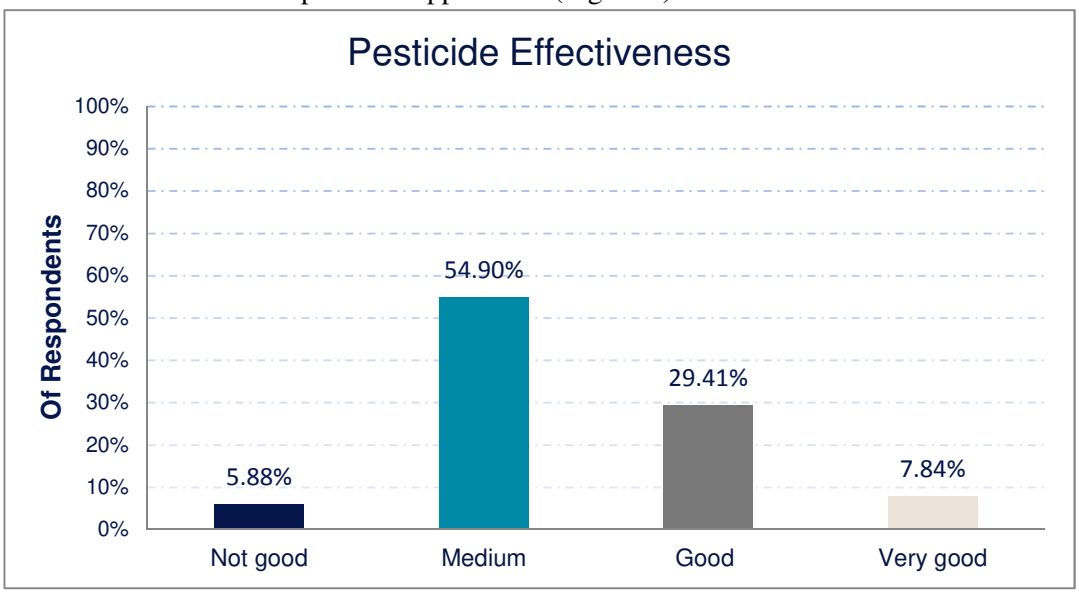

Figure 6: Respondents' thoughts and feedback on pesticide effectiveness in the study area (n=102).

Also, they have been asked whether they annually need to purchase an excessive amount of pesticides (Figure 7). Almost 75% of respondents purchase additional amount of pesticides compared to previous years. These findings are in agreement with [58], who reported that excessive usage of pesticides will increase vegetable production costs on consumers. (Figure 8) represents the additional amounts of pesticides purchased by respondents compared to previous years. The purchase excessive amount of pesticides annually may be due to misuse application by the farmer. This misuse of pesticide application could lead pesticide to resist and would increase further application of pesticides by growers to increase their yield [48], [59].

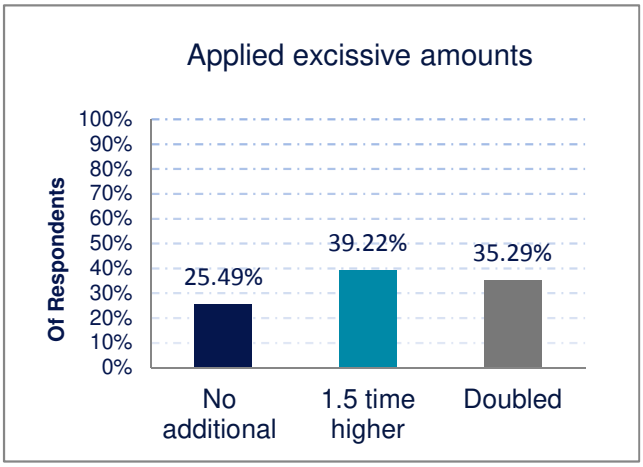

Figure 7: Annual additional amount of pesticides applied by respondents in the study area (n=102).

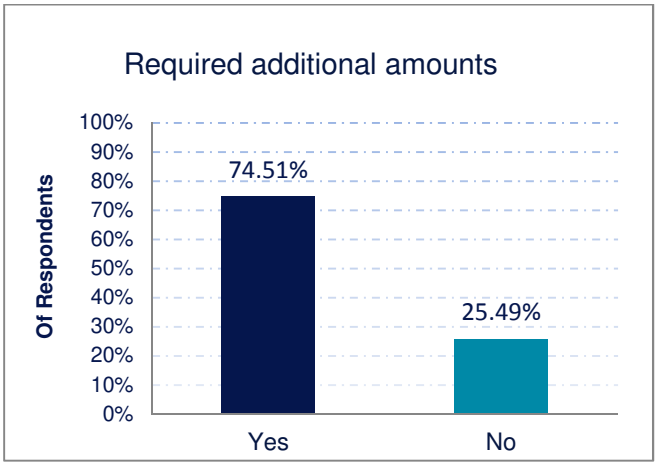

Figure 8. Additional amounts of pesticides applied by respondents compared to previous years (n=102).

4- Farmers exposure to pesticides

There is a potential adverse effect on farmers' health during the transportation of pesticides, preparation of spray solution, during cleaning the spraying equipment, and before during or after pesticide application [49], [60], [61]. Hence, the use of appropriate personal protective equipment (PPE), which includes (Gloves, Goggles, Face mask, Boots, Clothing), during and after pesticide application are important to reduce exposure to pesticides [51], [62].

The respondents of this study were questioned about the use of the specific set of PPE (Figure 9); the most often used PPE was gloves 88.24%. [60] reported that Gloves decrease the risk of pesticide exposure among citrus farmers in the United State by 27%. Also, it protected Danish greenhouse farmers effectively. Furthermore, Several researchers recommended that farmers must wear goggles, as eyes could absorb pesticide considerably by spills or splashes during mixing and loading the pesticides [60], [61]; However, goggle for eyes were used by 9.80% of those interviewed.

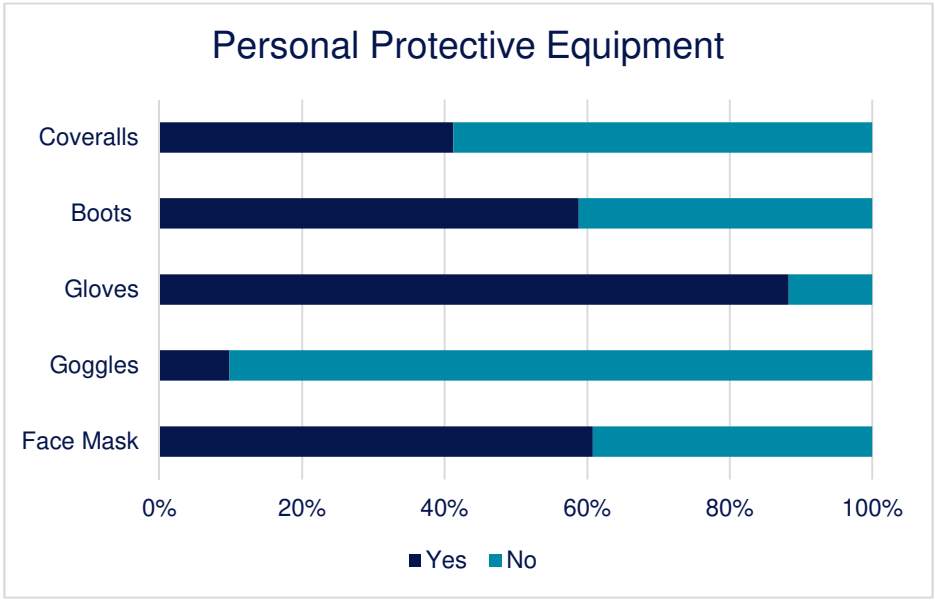

Figure 9: Use of PPE among respondents in the study area (n=102).

Many studies reported that educational level plays an important role in the use of PPE [11], [63], [64]. While [65] reported that incomplete PPE follow is not linked with different demographic participants.

During the field observations, respondents were asked about handling and storing the exceeded amounts of

pesticides that not used during a season. Almost all of the respondents 98.04% were kept the pesticides for the next following season. Although farmers have stored the pesticides within a designated room for their agriculture equipment, it was easy to reach by children. The potential health effect is reported during pesticide exposure to users and non-users like children due to improper storing of pesticides [66].

In addition, discarding pesticide containers were also observed among the respondents. Fortunately, all the farmers were discarding the empty pesticide containers, and they were conscious about poisoning the pesticide containers. Many studies reported that traces of the pesticides might retain and cause a severe health risk to farmers and their families when pesticide containers are reused for storing food [51], [66], [67]. Alternatively, the respondents of the present study were disposing of the empty containers in various ways such as throwing it into the garbage in the street, or burning of the containers, or dumping it under the ground. This random disposal was most probably due to a lack of policy guidelines. According to [49], [67] Discarding empty containers to the street has health risks and causes environmental pollution.

[60] reported that cleaning the equipment after pesticide applications could also be a significant source of exposure. The study respondents were asked about the places of washing pesticide spraying equipment, 100% of respondents clean-up their equipment after the pesticide applications outside their plastic houses. During the observation study, it was noticed that most of the farmer herding livestock near their plastic houses. According to [68] the discharge of pesticide waste may harm livestock through contaminated feed and water by pesticides residual.

Conclusion

The study showed that different pesticides were used in plastic houses. Insecticides and fungicides were mainly applied by vegetable growers in the study area. 55.95% of respondents have used Insecticides, while, fungicides and herbicides 28.19%, 15.86% were applied by farmers respectively. The most used active ingredient used by respondents was Abamectin followed by Cyflumetofen. Furthermore, lack of knowledge among the respondents has led them to adopt bad attitudes. The farmers do not use pesticides in accordance with regulation laws, where only 5.88% of respondents have followed government regulations. Besides, the respondents do not take protective measures during spraying. The result of the current study found that 88.24% of respondents used gloves, and goggles for eyes were used by 9.80% of those interviewed. Also, the respondents have faced a problem with manipulating empty containers of pesticides and washing equipment. The respondents also have not received any training on the choice of safe pesticide usage, apply, mix, store, and toxicity. Alternatively, 92.16%, 54.90%, and 43.14% of respondents followed retailer instruction, label instruction, and past experiences respectively during pesticide usage.

Based on the outcomes of this study, immediate comprehensive intervention is recommended to prevent potential hazards and health risks to farmers, their families, surrounding animals, and ecosystems. An urgent introduces educational training programs on pesticide uses for farmers, distributors, and retailers in the study areas are very crucial. This program could include providing information about pesticide hazards to enhance their knowledge and skills of pesticide usage, as well as the allocation of personal protective equipment (PPE) to encourage farmers to adopt safety measures. Moreover, donor funding programs such as Farmers Field Schools (FFS) of integrated pest management (IPM), and NGOs can have also an important intervention through training in pesticide usage in terms of preparation, application, disposal, and washing of equipment. Further research studies are recommended in pesticides application within plastic houses, and laboratories pesticide residue analysis are needed to evaluate potential toxic effects of the most common pesticides used to control vegetable pests as Abamectin and Cyflumetofen.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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