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Risk Factors among Greenhouse Farmers in Gaza Strip

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Abstract

Greenhouse farmers are exposed to many risk factors during work. This paper characterized the risk factors and discussed their health impacts among greenhouse farmers. Risk factors under greenhouse conditions emerged from pesticide application and greenhouse gas emission from soil during day. Risk factors among farmers were determined by recording toxicity symptoms, acute and chronic obstructive pulmonary disease (COPD). This study targeted 67 greenhouses in Gaza Strip and found 169 farmers doing many agricultural activities without protective clothes. We documented nine highly toxic insecticides and five moderately toxic fungicides being applied for insect and fungal control. A large number of farmers (55%) revealed that they visited respiratory health clinic quite two to three times a month immediately after insecticide application. About 8.88% (n = 15) of farmers stated that they had unrecoverable lung disease due to working in greenhouses during winter season. Personal health records of farmers showed variety of cholinergic symptoms, severe reduction on acetyl choline esterase activity (ACHE), many cases of COPD and some pneumonia cases. Classification of farmers according to risk factors indicates that 18% of farmers are at high risk due to extreme to insecticides. It is recommended to seasonally investigate the activity of ACHE of greenhouse farmers and to routinely check their chests and lungs to avoid any potential health risk factors due to works in greenhouse environment.

Keywords

Risk Factors, Insecticides, Acetylcholine Esterase, Chronic Obstructive Pulmonary Disease

1. Introduction

A large number of farmers are doing many agricultural activities in greenhouses in Gaza Strip to meet the population needs from vegetables and ornamentals.

Greenhouse construction in Gaza Strip is progressively increased due to ornamental and medical plant production. Farmers in greenhouses are doing the following agricultural activities: manure application, manual pesticide spray, fruit collection sorting and separation, storage and post-harvest activities. It has been shown that application of pesticides in greenhouse caused many environmental problems [1] [2] [3] [4]. Moreover, health risks such as cancer cases [5], health disabilities [6] and biochemical changes [7] have been documented with pesticides application. In addition, drinking of contaminated water [8] [9], ingestion of contaminated food [3], working with soil components [10] and inhalation of contaminated air [11] may become extreme health risk due to indirect exposure to pesticides. Application of pesticides was found to create risks to non-target organism such as cyanobacteria [12] [13] [14] [15], plant [16], fish [17] [18]. Many authors tried hard to reduce health risks associated with pesticide application. This included development of ecologically acceptable organoclay formulations of pesticides [19]-[29]. Health risk among farmers may be emerged due to occupational and/or accidental exposure to direct insecticide solution or vapor. In addition, misuse or violation with safety measures of insecticides may lead to appearance of health risk among farmers. So far, health risk among farmers may be indicated by measuring the toxicity symptoms, activity of acetylcholine esterase in blood serum, chest and pulmonary disease. Several authors [30] [31] [32] indicated the reduction of erythrocyte acetylcholinesterase as a potential health risk in greenhouse workers due to occupational pesticide exposure. Similarly, they found methamidophos-treated groups had significantly lower butyrylcholinesterase and paraoxonase activities. In a different study, Liu *et al.* [33] evaluated the prevalence of farmer's lung disease (FLD) and the potential risk factors for FLD among Chinese greenhouse farmers. They revealed that prevalence of FLD among these farmers was 5.7% (308/5,420) and the risk factors for FLD were years of age, shorter time interval for re-entry greenhouse, ventilation frequency of greenhouse. Earlier, Jurewicz *et al.* [34] reviewed the evidence on the association between working in greenhouses and the occurrence of and respiratory disorders. They indicated that greenhouse exposure was associated with an increased risk of respiratory disorders, sensitization to allergens and skin reactions. Previously, Terho *et al.* [35] studied the prevalence and incidence of chronic bronchitis and farmer's lung with respect to age and sex. They found that the prevalence of chronic bronchitis was 8.0%, and the mean annual incidence was 2017 per 100,000 farmers. So far, it is necessary to characterize the risk factors among greenhouse farmers in Gaza Strip. Accordingly, this study was initiated to answer the following questions: 1) what are risk factors among greenhouse farmers in Gaza? 2 what are health impacts of these factors? and 3) what can be done to reduce the impacts of risk factors?

2. Materials and Methods

2.1. Data Collection

About 67 greenhouses were visited for data collection and 169 farm workers were interviewed in the field via direct contact, face to face interview. The data collection included knowledge of risk factors, working conditions under greenhouse, temperature of greenhouses, humidity, manure application and pesticide knowledge, toxicity symptoms and protective measures related to pesticide application in greenhouse.

2.2. Determination of Risk Factor Associated with Pesticide Application

The greenhouse farmers were convinced to donate blood samples (10 ml each) in a private clinic. Blood samples were collected in heparin containing tubes and analyzed in the same day for Acetylcholine esterase activity (ACHE) using a spectrophotometer according to previous method [36].

2.3. Analysis of Personal Health Records of Farmers

Personal health records of farmers having acute and chronic lung disease were collected and carefully summarized.

2.4. Statistical Analysis

Insecticides and fungicides applied in greenhouse were collected along with their properties and presented in a separate table. Toxicity symptoms were arranged according to locations, total and percentage values of symptoms were calculated. Risk factors according to toxicity among farmers were categorized into four cases according to the activity of Acetyl cholinesterase. Average and standard deviation of each group was calculated. These groups are extreme risk, high risk, and moderate risk.

3. Results

Risk Factors Emerged from Pesticide Application

The study targeted 67 greenhouses distributed in different governorate in Gaza Strip and found 169 farmers doing all agricultural activities. Moreover, about 20 non-farmer individuals were taken as control sample. It was found that majority of farmers (70%, n = 118) are male in the age group of 20 - 35 years old, having 12 - 14 years of education. Farmers indicated that they have about 5 years working experience with greenhouses. About 65% (n = 110) of farmers indicated that insecticides are not risky for human beings. In addition, 60% (n = 100) of farmers stated that they did not comply with safety measures such as wearing protective clothes, gloves, glasses or long shoes during pesticides application. Majority of greenhouse farmers revealed that insecticides and fungicides were applied while the greenhouse is totally closed and the application rate was 1.5 folds higher than the recommended rate. They also indicated that pesticide spray processes were applied mechanically using high volume techniques at the several cases of pest control whereas manual applications were occasionally applied by farmers using low volume technique. Farmers revealed that both techniques resulted in face and skin contamination. Some farmers (31%, n = 52) revealed that their internal clothes have the same odor of pesticide solution at the end of working day. We found about 11 insecticides are commonly used in greenhouses for insects, nematodes and mites control, with application rates ranged from 1 - 2.5 kg/ha (**Table 1**). The applied insecticides included Nemacur, Methomyl and Vertimic. These insecticides are extreme risky materials due to their high toxicity and low LD_{50} values (6 - 34 mg/kg) [37]. Moreover, Pirate, Malathion, and Pyrethrine are moderately risky insecticides due to higher LD_{50} values than Nemacur, Methomyl and Vertimic [38]. These applied insecticides belonged to organphosphorus compounds (OPs) carbamate compounds, and organo-chlorine compounds (OC). Application of OPs and carbamate compounds are the most risky compounds due to irreversible binding to ACHE. In addition fungicides with different chemical groups (diazole, and triazoles) were applied in greenhouses to control *Botrytis cinerca*, *Oidiumspp*, *Oidiopsissicula*, *Alternariacucamerina*, *Pseuduperonasporacubenis* of cucumber, melon and tomato. These fungicides y have LD_{50} values ranged from 700 - 5000 mg/kg and considered as unsafe materials [37]. More risk of pesticides application may be emerged from their water solubility which ranged from 0.1 - 2000 mg/l (**Table 1**). This factor enables applied pesticides to move quickly in soil profile and reach the ground water creating threats to human life. Leaching of pesticides in soil has been studied [39] [40] [41] [42]. These reports stated high risk to ground water. In addition, it was found that greenhouse temperature usually in the range of 23˚C - 35˚C and high relative humidity (50% - 65%) during winter season due to close

Table 1. List of insecticides and fungicides applied in greenhouses.

Serial #	Pest	Pesticides	Rate g/ha	Freq.	LD_{50} mg/kg	Sol. mg/l	K_{ow}logP
1	*Tetranychus urtica*	[1]Smash (quinalphos)	150 - 200	57	71	17.8	4.44
		[2]Pirate (chlorfenapyr)	40	18	441	Ins	4.83
2	*Aphidoidae*	[1]Malathion	200	66	1375	145	2.75
		[3]Methomyl (lannate)	50	56	34	*57.9	0.093
3	*Bemisia tabaci*	[4]Pyrethrins	60 - 100 ml		1030	0.2	5.9
4	*Trips tabaci*	[1]Nemacur (fenamiphos)	200	10	6	400	3.3
		[4]Cymbush (cypermethrin)	150	37	250	0.004	6.6
5	*Spodoptra littoralis*	[1]Dursban (chlorpyrifos)	200	56	135 - 165	1.4	4.7
		[5]Vertimic (abamectin)	150	29	10	7-10	4.4
		[1]Dimethoate	200	37	387	*23.3	0.704
6	*Botrytis cinerca* Oidium spp. *Oidiopsis sicula*	Rovral (iprodione)	100	12	2000	13	3
		Antracol (2-naphthyloxyacitic acid)	250	25	1000	-	-
7	*Pseudoperonaspora cubensis* *Pseudomonas syringae*	Daconil (chlorothalonil)	150	25	5000	0.81	2.92
		Bayfidan (triadimenol)	50	100	700	33	3.28
8	*Alternaria cucumerina*	Copper sulfate (tribasic)	10	12	100	Ins	-

1= Organo-Phosphorus compounds; 2= Organo-Chlorine compounds; 3= Oxim carbamate compounds; 4= Pyrothriods; 5= Bio-pesticides; *= g/l.

conditions. Under this condition the applied pesticides tend to evaporate and attacking the respiratory enzymes in farmer's lung creating lung disease. This suggestion can be supported by our results which indicated about 26% (n = 36) farmers revealed that they had acute respiratory disease immediately after long working day under greenhouse condition. Farmers also stated that they recovered after medical treatment. In addition 27.3% (n = 38) of farmers revealed that they have unrecoverable disease during winter season whereas the symptoms disappeared in summer time. Investigation of clinical health records indicated that 18% (n = 25) farmers have pneumonia and 11.5% (n = 16) farmers have chronic obstructive pulmonary disease (COPD). More support to our results can be obtained from the results of Jurewicz *et al.* [34] who reviewed the evidence on the association between working in greenhouses and the occurrence of and respiratory disorders and indicated that greenhouse exposure is associated with an increased risk of respiratory disorders, sensitization to allergens and skin reactions. Further supports to our hypothesis come from the work of Liu *et al.* [33] who evaluated the prevalence of farmer's lung disease (FLD) and revealed that prevalence of FLD among these farmers was 5.7% (308/5420) and the risk factors for FLD were years of age, shorter time interval for re-entry greenhouse, ventilation frequency of greenhouse. In addition, the risk factors emerged from insecticide application can be classified to four cases according to ACHE activity: case 1, extreme risk group included farmers got slight ataxia and having the lowest ACHE activity (538 ± 302), case 2, high risk, included farmers got convulsions tremors and having ACHE activity (1829 ± 1048), case 3, moderate risk, included farmers got dizziness, and headache and having ACHE activity (6000 ± 1414) case 4, Low risk, included farmers got vomiting, and diarrhea, Nozai and having (8389 ± 1622) whereas the normal range of ACHE activity was (14100 ± 2798) included farmers not exposed to pesticides in greenhouse (control sample) more details are shown in **Table 2**.

Further risks in greenhouse may be emerged from the biochemical degradations of applied manures or from the organic matter that originally exists in soil. This process may result in excess emission of greenhouse gases such as NO_x, SO_2, CO_2 and CH_4. It can be suggested that at winter season where the greenhouse windows are usually closed and air exchange between outside and inside are not usually done at a suitable way. This may result in accumulation of

Table 2. Cholinergic and non-cholinergic symptoms among framers exposed to insecticides in greenhouse.

Toxicity symptoms	Locations				Total	%	Ave ± Std (u/L)	State of risk
	Rafah	Kh Y	Gaza	North				
Tremors, Convulsions, Slight ataxia	9	7	13	10	39	23.1	538 ± 302	Extreme
Dizziness, Headache,	14	18	25	23	80	47.35	1829 ± 1048	high
Diarrhea, Vomiting	7	8	11	12	38	22.48	6000 ± 1414	Moderate
Nozai	3	3	3	3	12	7.07	8389 ± 1622	Low
Control group	5	5	5	5	20	00	14100 ± 2798	Normal range

humidity, under this condition NO_x, SO_2 and CO_2 tended to react with water molecules (accumulated humidity) and form corresponding acids that may reach farmer's body and make some damages to them. Furthermore, at low relative humidity NO_x, SO_2, and CO_2 may reach the lung and react with the blood producing corresponding acids that increase the acidity in lung. This situation may result considerable inhibition of respiratory enzymes and creating lung disease. These results agree with previous report [43] who found increased acidity in lung due to accumulation of acid gas in human building. This disease may not be recovered by medical treatment as farmers revealed. In summer time the windows of greenhouses are usually opened and air exchange between inside and outside of greenhouse would be at most. Under this condition there are no accumulations of greenhouse gas and farmers do not expose to high risk.

4. Discussion

The presented results in **Table 1** clearly shows the applied insecticide or fungicides have different solubility limits in water, different K_{ow}, different vapor pressure (Hunry constant), different application rate and frequency. These data indicate that applied pesticides have different behavior under greenhouse conditions. Moreover, risk factors emerged from toxicity symptoms (**Table 2**) showed cholinergic and non- cholinergic effects. The explanation of these results is that applied insecticides contained OP and oximcarbamate compounds that regard as strong acetylcholine esterase inhibitors as indicated by WHO [37] and fungicides have high LD_{50} values, indicating non- cholinergic effects. Moreover, toxicity symptoms associated with ACHE levels (**Table 2**) indicated that farmers exposed to extreme risk due to toxic substances. The explanation of these results is that under greenhouse conditions, high temperature and humidity, farmers may be exposed to pesticides in different ways such as inhalation, ingestion and/or skin absorption. Moreover, farmers revealed that they used high and low volume techniques during pesticides spray process. Under high volume technique, farmers may ingest few drops of spray solution whereas at low volume technique farmers may become in contact with micro-droplets of pesticides active ingredients that penetrate the skin and adipose tissues according to K_{ow} and reach the active site in the body faster than usual and make toxic symptoms as in **Table 2**. These multi-exposure techniques may enhance the toxicity of pesticides. Moreover, application of insecticides followed by fungicides may expose farmers to binary mixture toxicity. This agrees with recent reports [7] [16] [30] [31] [32] [44] [45] [46] who found decreased levels of acetyl cholinesterase in greenhouse workers due to pesticide exposure. Nevertheless, it can be suggested that greenhouse conditions enhance the evaporation of pesticides due to high temperature and exposing farmer lungs to toxic vapors. This situation might enhance appearance of oxidation stress accordingly elevated levels of liver enzymes were observed. Some authors found elevated liver enzyme in farmers worked in greenhouse condition. Moreover, recent published work [7] found elevated levels of liver enzymes in farmers having long term exposure to pesticides. Nevertheless, exposure to insecticides under greenhouse condition elevated the oxidation stress in liver [47] [48] [49] and result in elevation of ALT and AST levels. It can be suggested that irregular metabolic reaction of amino acid may occur resulting in accumulation of uric acid in the blood.

5. Conclusion

Working at greenhouse conditions exposes farmers to different types of health risk. This includes risks from pesticides application and their vapors. More risk factors emerged from greenhouse gas emission and exposing lungs to acidic gas such as NO_x, SO_2 and CO_2 which generate corresponding acids when reacting with blood, lowering its pH and creating lung diseases. Application of pesticides generates 4 types of healthy risks due to level of ACHE activity. Lung disease was the 2nd type of risk factors in greenhouse conditions.

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Ethical Statement

This study was not funded by any organization.

Compliance with Ethical Standards Conflict of Interest: Author declares that he has no conflict of interest.

The study complies with the international ethics issues. Consent form was filled by each farmer participating in the study. Helsinki human right ethics were received before conducting the study.

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