Knowledge and practices of pesticide use among farm workers in the West Bank, Palestine: safety implications

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Abstract

Objectives The objectives of this study were to assess the knowledge and practices associated with pesticide use in an agricultural community in Palestine, and to determine the prevalence of self-reported health symptoms related to pesticide exposure.
Methods In this cross-sectional questionnaire study, agricultural farm workers in Nablus district, Palestine, were interviewed on their knowledge and practices of pesticide use. Comparisons of knowledge and practices of pesticide use between various groups were performed using the Mann–Whitney *U*-test or the Kruskal–Wallis rank test of variance. The program of the Statistical Package for Social Sciences (SPSS) version 15 was used for data analysis.
Results The questionnaire was completed by 381 farm workers. The mean age ± SD of the participants was 38.8 ± 11.8 years. The majority (97.9%) of the participants were male. The mean participant scores for knowledge and safety procedures were 2.8 ± 3.2 out of 8 and 9.8 ± 2.4 out of 15, respectively. There was a significant positive correlation ($r = 0.323$; $P < 0.001$) between the knowledge and safety procedure scores. Unsafe behaviors were identified as the storage of pesticide products at home, the preparation of pesticides in the kitchen, inadequate disposal of empty pesticide containers, eating and drinking during pesticide application, and using inadequate protective clothing. The most frequent self-reported toxicity symptoms associated with pesticide use were skin rash (37.5%), headache (37%), excessive sweating (24.9%), and diarrhea (21.3%). There was a strong significant negative correlation ($r = -0.83$; $P < 0.001$) between self-reported toxicity symptoms and scores for protective measures.
Conclusion The results of this study indicate that most farm workers in this district need more educational programs regarding the safety and use of pesticides. Legislation promoting the use of safer pesticides is also needed.

Keywords Pesticide - Knowledge - Practice - Symptom - Palestine

Introduction

Pesticides are widely used throughout the world, especially in agriculture for crop protection [1, 2]. According to the World Health Organization (WHO), 20% of pesticide use in the world is focused in developing countries, and this use is increasing [1]. Studies regarding pesticides are considered important in order to decrease pesticide risk and help to improve public health policies [2, 3]. Previous studies have indicated that the unsafe use of pesticides is common in developing countries [2, 4–6]. There are no previously published studies regarding pesticide knowledge and practice in the West Bank, Palestine. At present, Palestine is divided into two geographic areas: the West Bank and the Gaza Strip. Despite the small size of the West Bank and Gaza, these areas enjoy a diversity of climatic regions, which makes it possible to grow almost anything, all year round. Agriculture is the largest sector of the Palestinian economy, generating more than 22% of the gross domestic product of the West Bank and Gaza and providing employment to more than 15% of the population [7]. Furthermore, the agricultural sector is a major earner of foreign exchange and supplies the basic needs of the majority of the local population [7]. The total population in Palestine is 4,151,668 inhabitants. The Nablus district in the northern part of the West Bank, Palestine, is a well-defined area with a total population of 362,159 native Palestinian inhabitants [8].

We hypothesized that: (1) good knowledge is associated with the safe use of pesticides among farm workers; and (2) the unsafe use of pesticides is associated with acute health symptoms. To test this hypothesis, we carried out this study with the following objectives: (1) assessment of the knowledge of farm workers regarding the use of pesticides; (2) investigation of the determinants and predictors of poor or good knowledge; (3) evaluation of field practices with pesticides in relation to the farm workers knowledge; (4) evaluation of the practices for the storage, preparation, and disposal of pesticides in relation to the farm workers knowledge; and (5) determination of the prevalence of self-reported health symptoms related to pesticide exposure.

Subjects, materials, and methods

Study area and sample size

The area where the study took place is in northern Palestine, 20 km east-north of Nablus city. For this study, Tammun, Tubas, EL-Far'a, Tayasir, and Nassariyah village were selected. These five regions are characterized by important agricultural activity. The major vegetables grown are potatoes (*Solanum tuberosum*), onions (*Allium cepa*), carrots (*Daucus carota*), tomatoes (*Lycopersicon esculentum*), cucumbers (*Cucumis sativa*), bitter gourds (*Momordica charantia*), cabbage (*Brassica oleracea* var. *capitata*), and cauliflowers (*Brassica oleracea* var. *botrytis*). The study was carried out in October and November, 2008.

This was a cross-sectional study that involved farm workers working in open or closed fields (greenhouses), or both, and using pesticides during the time of the study. The farms were selected randomly from within the study regions and one individual per farm (farm worker ≥18 years of age) was invited to participate in the study. As a result, a total of 440 farm workers were invited.

Study tool: the questionnaire

A structured questionnaire containing both open-ended and close-ended questions was developed for this study by the Poison Control and Drug Information Center (PCDIC) at An-Najah National University. The questionnaire was based on the United States Environmental Protection Agency's questions related to safe pesticide use, and on questionnaires used in similar published studies [*9*, *10*]. The questionnaire was piloted with 12 farm workers, who did not participate in the final study, and modified as necessary.

The questionnaire contained four sections. The first was the demographic section, which contained questions regarding age, gender, place of residence, education level, and type of agricultural field (open vs. closed fields). The second section of the questionnaire consisted of questions related to pesticide practices. Practice questions included: number of working hours in the field with pesticide; number of working days with pesticide per month; number of years of pesticide use; names of the most common pesticides used; pesticide concentration applied; pesticide preparation places; disposal of the empty pesticide containers; and self-reported toxicity symptoms associated with pesticide use.

The third section of the questionnaire consisted of questions related to correct procedures adopted by the farm workers. The following procedures were considered correct: wearing of protective clothes; reading and following label instructions; not eating, or drinking, or smoking during the application of pesticides; washing hands after pesticide application; and washing contaminated clothes separately. The final section was designed to assess participants' pesticide knowledge. Participants were presented with eight questions that could be answered by either 'yes', 'no', or 'I do not know'. One point was given for each correct answer, one point was deducted for each wrong answer, and selecting 'I do not know' did not affect the grade. The range of the knowledge score was −8 to 8 and was categorized as: <4 = poor knowledge; and ≥4 = good knowledge.

Statistical analysis

All data were coded, entered, and then analyzed using the Statistical Package for Social Sciences (SPSS; Chicago, IL, USA) program, version 15. Descriptive results were expressed as frequencies, and percentages for categorical variables, and as means ± SD for continuous variables. The χ^2 or Fisher's exact test, whichever was appropriate, was used to test the significance of differences between categorical variables. Multiple logistic regression analysis was used to identify significant predictors of knowledge. Variables included in the regression were those with significant *P* values (<0.05) in the univariate analysis. Knowledge scores were calculated as the summation frequency of correct responses to each question. Scores for protective procedures were calculated as the summation frequency of correct procedures adopted by the farm workers. Correlation between knowledge and practice scores was tested by Pearson's correlation coefficient. Comparisons of knowledge and practice between various groups were performed using the Mann–Whitney *U*-test or the Kruskal–Wallis rank test of variance. These analyses were used to test differences in the mean rank of practices among the participants. *P* values of less than 0.05 were accepted as statistically significant.

Results

Demographic characteristics of the participants

The response rate was 86.6% ($n = 381$). The mean age ± SD of the participants was 38.8 ± 11.8 years. The majority (97.9%) of the participants were male. Results related to the educational levels of the participants showed that 18 (4.7%) had a college education, while the remaining (95.3%) did not (Table 1).

Risk of pesticide exposure

The results showed that 109 (28.6%) participants were using pesticides in closed fields, 132 (34.6%) in open fields, and 140 (36.8%) in both. In this study, 325 farm workers (85.3%) stated that they had worked with pesticides for more than 1 year. Two hundred and twenty-seven (59.6%) of the participants reported working for more than 2 h/day during the growing season with pesticide application occurring for 2–10 days each month. A total of 192 (50.4%) participants used the recommended concentration of pesticides; 102 (26.8%) used less than the recommended concentration, and 87 (22.8%) used more than the recommended concentration. A total of 213 (55.9%) participants reported that they mixed two or more pesticides before application.

Knowledge about pesticides

The results showed that 373 (97.9%) of the participants knew the names of the pesticides they were using. Table 2 lists the types, names, and toxicological classes of pesticides that were frequently used during the study. The most commonly used insecticides were carbamates and organophosphates (e.g., methomyl and methamidophos, respectively). Other types of agricultural pesticides used included fungicides and herbicides.

Table 3 shows the extent of the respondents' knowledge regarding pesticide effects on human health, livestock, and the environment; and the routes of pesticide entry into the body. The knowledge of the farm workers was assessed and showed that the total sum of the knowledge scores was 1,073; the mean knowledge score was 2.8 (SD: 3.2; range: [(−6)–(8)]. Information regarding pesticide knowledge was mostly obtained from product labels (36%) and from experience (29.4%).

Factors influencing pesticide knowledge

Good knowledge was significantly associated with: secondary education level ($P < 0.001$), college education level ($P = 0.01$), use of pesticides for more than 10 years ($P = 0.03$), experience ($P < 0.001$), and information from a pesticide seller ($P < 0.001$). Poor knowledge was significantly associated with primary education level ($P < 0.001$) and the use of pesticides for less than 1 year ($P = 0.001$). The other factors tested such as age and gender did not reach statistical significance (Table 4).

Multivariate logistic regression analysis showed that predictors of good pesticide knowledge were: secondary education level, college education level, using pesticide for more than 10 years, getting pesticide knowledge by experience, and getting pesticide knowledge from a pesticide seller. Detailed results are listed in Table 5.

Safety practices in relation to pesticide knowledge

The mean score for protective procedures was 9.8 (SD: 2.4; range: 3–14). There was a significant correlation ($r = 0.323$; $P < 0.001$) between the knowledge score and the protective measure score. Table 6 shows that 48.6% of the participants reported wearing special gloves, 63% reported wearing special clothes, 63.5% reported wearing a special face mask, 71.1% reported not smoking during application of pesticides, 82.7% reported washing their hands after each application, and 68.5% reported washing contaminated clothes separately. The majority (71.4%) of the participants stated that they read the labels on the pesticide containers, and 49.9% of the participants stated that they followed the label instructions. The majority (60.9%) of the participants indicated that they used leftover pesticide solutions on the same day, but 29.4% of the participants kept the leftover pesticide in a drinking container for later use. The mean knowledge scores and ranks of knowledge were significantly different between those who applied protective measures and those who did not (Table 6).

Pesticide knowledge was significantly associated with practices in the field. Farm workers with less than 2 h working in the field with pesticide had the highest knowledge score (mean score: 3.6 ± 3.1; mean rank: 218.3) compared to farm workers with more than 6 h working in the field with pesticide (mean score: 1.7 ± 2.7; mean rank: 152.7). Farm workers with less than 1 year experience had the lowest mean knowledge score (mean score: 1.5 ± 2.9; mean rank: 147.4) compared to farm workers with more than 10 years experience (mean score: 3.2 ± 3.2; mean rank: 200.9). Farm workers using the recommended concentrations of pesticides had the highest knowledge score (mean score: 4 ± 3.1; mean rank: 232.6) compared to farm workers who used less than the recommended concentration (mean score:

1.4 ± 2.6; mean rank: 142.9), and farm workers who used more than the recommended concentration (mean score: 1.8 ± 3; mean rank: 155.4). Detailed results are listed in Table 7.

Regarding pesticide storage practices, Table 8 shows that farm workers who stored pesticides in a specific store had the highest mean knowledge score (mean score: 3.7 ± 3.2; mean rank: 220.6) compared to farm workers who stored pesticides at home (mean score: 1.3 ± 2.6; mean rank: 134), and compared to farm workers who stored pesticides in their animal house (mean score: 0.6 ± 2; mean rank: 115.4). Regarding the place of pesticide preparation, Table 8 also shows that farm workers who prepared pesticides in the field had the highest mean knowledge score (mean score: 5.6 ± 2.4; mean rank: 286.9) compared to farm workers who prepared pesticides in their home kitchen (mean score: 1.2 ± 2.1; mean rank: 137.9). Regarding the disposal of empty pesticide containers, Table 8 shows that farm workers who disposed of the containers by burning them had the highest mean knowledge score (mean score: 3.5 ± 3.4; mean rank: 216.4) compared to those who disposed of the containers by burying them (mean score: 1.7 ± 2.9; mean rank: 153).

Self-reported toxicity symptoms among the farm workers

Table 9 shows that the most frequent self-reported toxicity symptoms associated with pesticide use were skin rash (37.5%), headache (37%), excessive sweating (24.9%), and diarrhea (21.3%). The mean number of self-reported toxicity symptoms associated with pesticide use was 2.68 (SD: 1.4; range: 0–13). There was a strong significant negative correlation ($r = -0.83$; $P < 0.001$) between self-reported toxicity symptoms and scores for protective measures.

Discussion

In this study we sought to characterize factors related to work and home pesticide safety practices in a large sample of farm workers. We examined the participants' levels of knowledge in relation to demographics and interpersonal factors, such as practices of pesticide use among farm workers in Palestine.

The response rate of invited participants to the questionnaire interview in the present study was relatively higher than that in similar studies, indicating good intentions to participate. In the present study, 30.4% of the participants were aged between 30 and 39 years. Similar results were found by other researchers in other countries [10, 12]. The educational background of the farm workers in the study area was low. Similar results were also reported in other developing countries [5, 10, 13, 14]. Farm workers with little formal education might be at higher risk when using pesticides, possibly due to difficulties in understanding the use instructions and safety procedures included on the product labels.

A high level of knowledge was recorded among the participants who had a higher education level. The participants' knowledge of the effects of pesticides on human health was relatively accurate; this finding was consistent with other studies [12, 13]. The result that about half of the participants were not aware of inhalational and dermal absorption and entry of pesticides into the body agrees with other studies which have found that, although most occupational exposure to pesticides occurs from skin absorption and through inhalation, farm workers were not aware of this [15, 16]. These misconceptions still put the farm workers at risk.

Farm workers with good pesticide knowledge were more inclined to use pesticides according to the recommended guidelines for protective measures, a finding that was inconsistent with other studies. In Lebanon, assessments of pesticide use in farm workers were done by Salameh et al. [*11*], who reported high levels of knowledge of pesticide use, but the use of protective measures was poor.

The percentage of participants in the present study who grew their crops in closed fields beside open fields was higher than the percentage of those growing their crops in either open or closed fields. The nature of closed fields favors the appearance of hazards, and therefore the extensive use of pesticides in such fields exposes the farm workers to a higher risk [*17*]. The prevalence of mixing two or more pesticides, and using more than the recommended concentration of pesticides was high among our interviewed farm workers; this practice could put the farm workers at risk, due to the synergistic or potentiating effect of chemicals [*18*]. Also, the use of higher than recommended concentrations of pesticides was positively associated with the prevalence of self-reported toxicity among farm workers [*18*].

The present study showed that some of the interviewed farm workers tended to prepare and store the pesticides at home, a practice which might expose children and adults to hazardous risks. In addition, the high percentage of interviewed farm workers who disposed of empty containers in local waste containers or by washing and reusing the containers at home could expose the general population to hazardous risks. Such practices were considered to be one of the main problems associated with pesticide use in developing countries [*4*].

Disposal of the empty containers in the field or by throwing them near or into local waste containers is a totally unsafe practice and has been reported as a major problem in a number of studies [5, 10, 19, 20]. In addition, burning empty pesticide containers in open fires or burying empty containers should not be used as a method of management and disposal of empty pesticide containers. Distributors and suppliers and even local authorities often recommend these practices, but they are potentially hazardous to human health and the environment and should be discouraged and appropriate management encouraged. Safe burning procedures require a good understanding of pesticide chemistry, while safe burial requires adequate knowledge of local hydrology as well as of the environmental behavior of pesticides. Many users do not have such knowledge or cannot apply it properly to their particular circumstances. In many developing countries, empty pesticide containers are highly valued and used or exchanged as storage containers for other materials such as fuel, other chemicals, and sometimes even drinks or food, as we found in our study. Such practices are dangerous and should be prevented; for example, by puncturing any empty pesticide containers that cannot be returned to the supplier, in accordance with WHO recommendations [3].

Regarding self-reported toxicity symptoms associated with pesticide use, our results showed that common symptoms among the farm workers were skin rash, headache, excessive sweating, and diarrhea. Most of the reported symptoms of pesticide use are considered to be common manifestations of acetylcholinesterase-inhibiting insecticides [21–23]. These findings require urgent prevention, intervention, and protection to prevent the risk of these symptoms. The present study showed that organophosphate and carbamate insecticides such as methamidophos and methomyl were commonly used. These insecticides are classified as highly hazardous [24]. Restriction in the use of highly toxic pesticides has been considered by some scientists in order to decrease intoxication events [6, 25]. Researchers have concluded that farm workers in developing countries will continue to use pesticides in increasing quantities because of the lack of alternatives to pesticides, ignorance of the sustainability of pesticide use, and the weak enforcement of regulations and laws on pesticide use [4, 26, 27]. Workers' knowledge of hazards, which must be correct, is important for the prevention of acute and chronic poisoning: erroneous beliefs can seriously impair workers' capacity to protect themselves against the risks of pesticides [28].

Basic objectives of education are to ensure that farm workers understand the health hazards of relevant pesticides, use protective equipment properly, practice personal hygiene measures, become familiar with and adopt proper work practices, recognize early symptoms of overexposure to pesticides, and obtain first aid at the earliest time possible. The WHO has recommended the use of pesticides only by trained people [3]. For most pesticides, using protective measures results in a decrease of exposure to pesticides. Similar reductions are seen for farm workers using gloves compared to those not using gloves [29]. The use of protective measures could contribute to decreasing the health effects of pesticides. Also, this would lead, as expected, to a decrease in poisoning prevalence parallel to the reduction in exposure. Among Chinese farm workers, a safety educational program decreased the prevalence of pesticide poisoning from 1.05% to 0.25% [30].

A limitation of the present study was the inability to differentiate between the seriousness of the intoxications experienced within certain periods or with certain types of pesticides. The symptoms mentioned by the farm workers, such as headache, tiredness, vomiting, and muscular weakness, were not specific and might, in some of the cases, have been due to causes other than pesticide exposure. Also, this study did not assess treatment for these normally less serious intoxications with symptoms lasting for hours to days. Nevertheless, the results of this study support the hypothesis that farm workers with good knowledge of pesticides might show good practice in pesticide use. Also, farm workers who used pesticides without protective measures could be exposed to pesticides at levels sufficient to be associated with acute health symptoms.

Conclusion and recommendation

Most Palestinian agricultural workers in the study area had a low level of knowledge regarding pesticide use. In particular, the farm workers seemed to be unaware of real pesticide risks and they lacked safety education. In addition, the farm workers did not take enough protection measures, which may have exposed them to higher intoxication risks. Therefore, it is strongly recommended to initiate special educational programs, legislation promoting the use of safer pesticides, and the implementation of personal protective measures; such approaches are necessary to decrease the pesticide exposure of farm workers in Palestine.

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Conflict interest statement

No conflict of interest.

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Table 1 Demographics of the farm workers who participated in the study (*n* = 381)

Variable	**No. of participants (*n* = 381)**	**Percentage of participants per total sample**
Age		
<20	3	0.8
20–29	87	22.8
30–39	116	30.4
40–49	98	25.7
50–59	49	12.9
≥60	28	7.3
Education levels		
Primary (Grades 1–6 years)	250	65.6
Secondary (Grades 7–12 years)	113	29.7
College (Grades >12 years)	18	4.7
Gender		
Male	373	97.9
Female	8	2.1

Table 2 Pesticides most commonly used by farm workers; and thetoxicological classes of the pesticides

Type and name of pesticides	**No. of individuals**	**Toxicological class**
Insecticides		
Organophosphates		
Methamidophos	31	Ib
Dimethoate	19	II
Carbamates		
Carbofuran	44	II
Methomyl	10	Ib
Methiocarb	1	II
Other groups		
Abamectin	140	O

Type and name of pesticides	No. of individuals	Toxicological class
Propargite	73	III
Imidaclopride	45	II
Bromopropylate	29	U
Fenazaquin	24	II
Acetamiprid	24	II
Amitraz	20	III
Indoxacarb	14	O
Pyriproxyfen	14	U
Thiocyclam	13	II
Dicofol	12	III
Fungicides		
Difenconazole	84	U
Penconazole	76	U
Lufenuron	65	U
Triadimenol	37	III
Mefenoxam	12	III
Propamocarb	2	U
Pencycuron	2	U
Herbicides		
Glyphosate	38	U
Triazine	29	II
Oxyfluorfen	14	U
Paraquat	4	II

Ib highly hazardous; *II* moderately hazardous; *III* slightly hazardous; *U* unlikely to present acute hazard in normal use; *O* not classified [24]

Table 3 Knowledge of participants about the health impact of pesticides

	Correct *n* (%)	**Incorrect *n* (%)**	**Did not know *n* (%)**
Pesticides affect human health	327 (85.8)	48 (12.6)	6 (1.6)
Pesticides affect livestock	220 (57.7)	127 (33.3)	34 (8.9)
Pesticides affect the environment	162 (42.4)	93 (24.4)	126 (33.1)
Thinks that duration of effect is <24 h	134 (35.2)	64 (16.8)	183 (48)
Chose the time for application (during raining time)	223 (58.5)	33 (8.7)	125 (32.8)
Route of pesticide entry into body by inhalation	204 (53.5)	91 (23.9)	86 (22.6)
Route of pesticide entry into body by skin	201 (52.8)	94 (24.7)	86 (22.6)
Route of pesticide entry into body by mouth	224 (58.8)	71 (18.6)	86 (22.6)

Table 4 Comparison between participants with poor and good pesticide knowledge

Variable	**No. of participants (%)**	**Poor knowledge [a] (*n* = 165)**	**Good Knowledge [a] (*n* = 216)**	***P* value**
Gender				
Male	373 (97.9)	211 (97.7)	162 (98.2)	0.738
Female	8 (2.1)	5 (2.3)	3 (1.8)	
Age				
<40 years	206 (54.1)	116 (53.7)	90 (54.5)	0.870
≥40 years	175 (45.9)	100 (46.3)	75 (45.5)	
Education levels				
Primary	250 (65.6)	178 (82.4)	72 (43.6)	<0.001
Secondary	113 (29.7)	33 (15.3)	80 (48.5)	<0.001
College	18 (4.7)	5 (2.3)	13 (7.9)	0.010
Years of pesticide use				
<1 year	56 (14.7)	43 (19.9)	13 (7.9)	0.001
1–5 years	189 (49.6)	107 (49.5)	82 (49.7)	0.975
6–10 years	73 (19.2)	38 (17.6)	35 (21.2)	0.374
>10 years	63 (16.5)	28 (13)	35 (21.2)	0.032
Source of pesticide knowledge				
By experience	112 (29.4)	43 (19.9)	69 (41.8)	<0.001

Variable	No. of participants (%)	Poor knowledge [a] (*n* = 165)	Good Knowledge [a] (*n* = 216)	*P* value
Product label	137 (38.4)	83 (38.4)	54 (32.7)	0.251
From a specialist	80 (21)	45 (20.8)	35 (21.2)	0.928
From a pesticide seller	91 (23.9)	14 (6.5)	77 (46.7)	<0.001
Ministry of agriculture	57 (15)	31 (14.4)	26 (15.8)	0.703

[a]The knowledge score was categorized as: <*4* poor knowledge; and ≥*4* good knowledge

Table 5 Predictors of good pesticide knowledge as found by multiple logistic regression analysis (enter method)[a]

Variable	*β*	SE	Wald test	*P* value	Exp(*β*) [95% CI for Exp(*β*)]
Secondary education level	1.12	0.29	15.33	<0.001	3.1 [1.47–15.32]
College level	1.56	0.6	6.8	0.009	4.75 [1.47–15.32]
More than 10 years of pesticide use	0.78	0.32	5.76	0.016	2.18 [1.15–4.1]
Source of pesticide knowledge by experience	0.86	0.27	9.9	0.002	2.36 [1.38–4.03]
Source of pesticide knowledge from a pesticide seller	2.24	0.34	42.62	<0.001	9.37 [1.75–5.36]

[a]Enter method means that all variables entered the analysis at the same step
CI confidence interval; *β* the coefficient of the predictor variables; *SE* standard error

Table 6 Safety procedures adopted by the farm workers and the correlations with the mean rank of their knowledge

Variable	No. of participants *n* (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Wears an eye mask				
Yes	143 (37.5)	2.9 ± 3.2	195.9	NS
No	238 (62.5)	2.7 ± 3.2	188.0	
Wears special gloves				
Yes	185 (48.6)	3.3 ± 3.3	207.4	0.005
No	196 (51.4)	2.3 ± 3	175.5	
Wears special shoes				
Yes	225 (59.1)	2.9 ± 3.2	194.8	NS
No	156 (40.9)	2.7 ± 3.2	185.5	

Variable	No. of participants *n* (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Wears special clothes				
Yes	240 (63%)	3 ± 3.2	200.2	0.03
No	141 (37)	2.3 ± 3.1	175.3	
Wears a special face mask				
Yes	242 (63.5)	3.1 ± 3.2	202.1	0.009
No	139 (36.5)	2.2 ± 3.2	171.6	
Clothing facilities on work site				
Yes	174 (54.7)	2.7 ± 3.1	188.8	NS
No	207 (45.3)	2.8 ± 3.2	192.9	
Does not eat during application				
Yes	361 (94.8)	2.8 ± 3.2	157.5	NS
No	20 (5.2)	1.9 ± 3.2	192.8	
Does not drink during application				
Yes	357 (93.7)	2.9 ± 3	192.6	NS
No	24 (6.3)	2 ± 3.4	166	
Does not smoke during application				
Yes	271 (71.1)	3.2 ± 3.2	205.5	<0.001
No	110 (28.9)	1.7 ± 3	155.2	
Washes hands after application				
Yes	315 (82.7)	3.1 ± 3.2	201.12	<0.001
No	66 (17.3)	1.3 ± 2.6	142.7	
Separates clothes when washing				
Yes	261 (68.5)	3.3 ± 3.2	206.6	<0.001
No	120 (31.5)	1.8 ± 2.9	157.1	
Reads labels on pesticide containers				
Yes	272 (71.4)	3.4 ± 3.3	206.7	<0.001
No	109 (28.6)	2.2 ± 2.9	151.9	
Follows the product label				
Yes	190 (49.9)	3.4 ± 3.3	211.1	<0.001
No	191 (50.1)	2.2 ± 2.9	171	
Does not use leftover pesticide solution				
Yes	232 (60.9)	3.4 ± 3.2	211.8	<0.001
No	149 (39.1)	1.8 ± 2.9	158.6	

Variable	No. of participants *n* (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Does not store leftover pesticide in drinking containers				
Yes	269 (70.6)	3.3 ± 3.3	209.3	<0.001
No	112 (29.4)	1.5 ± 2.6	147	

Table 7 **Farm workers practices with regard to the use of pesticides, and correlations with the mean rank of their knowledge**

Variable	No. of participants (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Type of agricultural field				
Closed field	109 (28.6)	3.1 ± 3.3	199.3	NS
Open field	132 (34.6)	3 ± 3.3	196.5	NS
Closed and open fields	140 (36.8)	2.5 ± 3	179.3	NS
Hours working in the field with pesticide				
<2 h	154 (40.4)	3.6 ± 3.1	218.3	<0.001
2–6 h	171 (44.9)	2.5 ± 3.2	179	NS
>6 h	56 (14.7)	1.7 ± 2.7	152.7	0.005
Days, per month, working with pesticide				
1 day	111 (29.1)	3.4 ± 3.3	210.4	0.027
2–10 days	195 (51.2)	2.8 ± 3.3	190.9	NS
11–20	48 (12.6)	2 ± 2.6	163.1	NS
>20	27 (7.1)	1.7 ± 2.6	152.4	NS
Years of pesticide use				
<1 year	56 (14.7)	1.5 ± 2.9	147.4	0.001
1–5 years	189 (49.6)	3 ± 3.2	196.7	NS
6–10 years	73 (19.2)	3 ± 3.2	201.1	NS
>10 years	63 (16.5)	3.2 ± 3.2	200.9	NS
Pesticide concentration applied				
Recommended	192 (50.4)	4 ± 3.1	232.6	<0.001
Less than recommended	102 (26.8)	1.4 ± 2.6	142.9	<0.001
More than recommended	87 (22.8)	1.8 ± 3	155.4	0.001

Variable	No. of participants (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Mixing pesticides				
Mixing 2 or more	213 (55.9)	3.5 ± 3.2	216.2	<0.001
Not mixing	168 (44.1)	1.9 ± 2.9	159.1	<0.001

Table 8 Storage, preparation, and disposal of pesticide products by the farm workers and correlations with the mean rank of their knowledge

Variable	No. of participants *n* (%)	Mean knowledge score	Mean rank of knowledge	*P* value
Storage of pesticide products				
Home	73 (19.2)	1.3 ± 2.6	134	<0.001
Specific store	202 (53)	3.7 ± 3.2	220.6	<0.001
Animal house	33 (8.7)	0.6 ± 2	115.4	<0.001
Farm site	45 (11.8)	3.1 ± 3.5	202.6	NS
Buy and use it immediately	28 (7.3)	2.5 ± 3	180.9	NS
Pesticide preparation places				
Home kitchen	31 (8.1)	1.2 ± 2.1	137.9	<0.001
Home garden	98 (25.7)	1.3 ± 2.6	139.3	<0.001
Animal house	82 (21.5)	1.4 ± 2.7	141	<0.001
The field	124 (32.5)	5.6 ± 2.4	286.9	<0.001
Already prepared	46 (12.2)	2.25 ± 3	173	NS
Disposal of empty pesticide containers				
Local waste containers	67 (17.6)	2.5 ± 3	178.8	NS
Burning	192 (50.4)	3.5 ± 3.4	216.4	<0.001
Burying	29 (7.6)	1.7 ± 2.9	153	NS
Washing and reusing at home	38 (10)	1.8 ± 2.8	158.5	NS
Reuse for storage of other pesticide	55 (14.4)	1.9 ± 2.6	159.7	0.02

Table 9 Symptoms related to pesticide use reported by 381 farm workers

Symptoms	**No.**	**Percentage**
Skin rash	143	37.5
Headache	141	37
Excessive sweating	95	24.9
Diarrhea	81	21.3
Redness of skin	72	18.9
Fatigue	66	17.3
Rhinorrhea	64	16.8
Abdominal pain	60	15.7
Eyes itching	58	15.2
Dry cough	56	14.7
Vomiting	42	11
Shortness of breath	41	10.8
Convulsion	37	9.7
Salivation	34	8.9
Vision disturbance	31	8.1