Current Research in Medical Sciences
p ISSN: 2538-6212
Student Research Committee
Babol University of Medical Sciences

Original Article

Knowledge, Attitudes, and Practices of Orchardists in Amol County Regarding Agricultural Pesticides and Their Adverse Effects

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Article Info.

Received: 22 Aug 2025
Revised: 18 Sep 2025
Accepted: 25 Sep 2025
Published: 15 Oct 2025

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Cite this article
Lonaji AR, Asgharnia H, Mehdinia SM, Shirmardi M. Knowledge, Attitudes, and Practices of Orchardists in Amol County Regarding Agricultural Pesticides and Their Adverse Effects
Curr Res Med Sci. 2025; 8: 87-97.

Abstract

Background: Global population growth has increased the demand for agricultural productivity and food security. In many countries, particularly developing regions, chemical pesticides remain the primary means of crop protection. This study aimed to assess the knowledge, attitudes, and practices (KAP) of orchardists in Amol County, Mazandaran Province, Iran, regarding chemical pesticides usage and their associated risks to human health and environmental sustainability.

Methods: A cross-sectional descriptive study was conducted in spring 2024 among orchardists in Amol County, selected via cluster sampling. Data were collected using a structured KAP questionnaire, partially derived from validated instruments in related studies.

Results: The mean ± SD scores for knowledge, attitude, and practice were 9.91 ± 2.88 (out of 15), 15 ± 3.07 (out of 20), and 12.30 ± 3.53 (out of 20), respectively. Significant correlations were observed between knowledge and attitude ($p < 0.05$) and attitude and practice ($p < 0.05$). Education level had a significant effect on all three KAP domains ($p < 0.05$). Farmers with higher education levels demonstrated better knowledge, attitudes, and safer practices compared to less-educated or illiterate participants. Notably, only 14.3% of respondents reported consulting agricultural extension services during their farming activities, while 85.7% relied on self-directed pesticide management, including procurement and dosage determination.

Conclusion: The findings highlight gaps in pesticide safety awareness and regulatory compliance among orchardists, underscoring the need for targeted educational interventions and enhanced extension services to mitigate health and environmental risks.

Keywords: Pesticides, Orchard Management, Sustainable Agriculture, Knowledge, Attitude, Practice

Introduction

The growing global population has intensified the demand for food and agricultural production, while pest infestations continue to cause substantial losses, both in fields and storage facilities. Worldwide, it is estimated that 20–30% of agricultural products are destroyed annually by pests, emphasizing the importance of crop protection strategies. Currently, in most countries—particularly developing nations—chemical pesticides remain the predominant tool for pest control [1,2]. However, pesticide use poses serious risks not only to human health but also to environmental components such as soil, water, ecosystems, and agricultural productivity [3].

In Iran, agriculture contributes significantly to the economy, accounting for about one-third of non-oil exports, one-third of employment, and roughly one-quarter of the gross domestic product (GDP), while also meeting the majority of the nation's food and agro-industrial needs. This sector therefore plays a pivotal role in economic development, employment, exports, research and technology advancement, and national food security [4].

Mazandaran Province plays a crucial role in Iran's agricultural sector, accounting for 7.26% of the national GDP and 23% of total employment. Each year, the province produces approximately 6 million tons of agricultural, horticultural, livestock, and fishery products, representing over 10.5% of the country's total agricultural value-added—a figure 4.5 times higher than the national average. With a cropping intensity index of 1.4, double the national average of 0.7, Mazandaran maintains over 600000 hectares of cultivated land annually. The province ranks first nationally in the production of 14 major agricultural, horticultural, and fishery commodities and also leads in agricultural mechanization, with a nominal mechanization coefficient of 1.6 horsepower per hectare [5].

Amol County is a key citrus-producing region within Mazandaran. It encompasses approximately 6850 hectares of citrus orchards, yielding an annual production of 120000 tons, primarily concentrated in the Dasht-e-Sar, Esko-Mahalleh, and Marandeh areas. Additionally, the county supports 122 hectares of ornamental plant cultivation, producing an estimated 123 million plants annually [5].

Despite its agricultural importance, Mazandaran is also among the highest consumers of chemical pesticides in Iran. Nearly 4000 tons of pesticides are used annually in the province—five times the national average. Excessive pesticide use has been linked to increasing cases of gastrointestinal cancers in the region, in addition to other health problems such as respiratory disorders, neurological diseases, reproductive issues, and even fatal poisoning. Furthermore, pesticide misuse contributes to pest resistance and widespread contamination of soil and water resources [1,4,6,7].

Given the climatic conditions of Mazandaran and the extensive cultivation of crops—particularly citrus fruits—in both urban and rural areas such as Amol, the widespread use of pesticides and the subsequent leaching of contaminated agricultural runoff into water resources has become inevitable. This situation underscores the necessity of adopting urgent and effective strategies to reduce pesticide application in farms and orchards across the province.

Moreover, understanding farmers' knowledge, attitudes, and practices is essential in predicting and shaping their behaviors toward pesticide use. Although behaviors are influenced by multiple factors and contextual conditions, numerous theoretical frameworks suggest that attitudes are key determinants of behavior, implying that changing attitudes can potentially predict or even modify future behaviors [8,9].

Accordingly, this study was conducted to evaluate the knowledge, attitudes, and practices of citrus growers in Amol County regarding pesticide use, with the aim of identifying patterns of pesticide application and their potential implications for human health and the environment.

Methods

This descriptive cross-sectional study was conducted in spring 2024 among citrus farmers in Amol County, Mazandaran Province, northern Iran. The target population included both urban and rural farmers actively engaged in citrus cultivation. Participants in this study were assured that personal information from the responses would be used solely for the purpose of conducting the research and would not be made available to any individual, group, or organization, and that all information would be kept confidential.

Sampling Procedure

The minimum required sample size was calculated using the standard formula for estimating a single population proportion (Equation 1). The calculation assumed a 95% confidence level (Z = 1.96), a margin of error (d) of 0.08, and an anticipated proportion (p) of 0.25. This proportion was based on a previous study in which 25% of farmers demonstrated sufficient knowledge of pesticide risks [10]. The resulting sample size was 112 participants, which was considered feasible within the study's logistical constraints, including field accessibility and participant availability.

$$n = \frac{z^2_{1-\frac{\alpha}{2}}\, p(1-p)}{d^2}$$

$$n = \frac{1.96^2 \times 0.25 \times (1-0.25)}{0.08^2} \simeq 112 \qquad (1)$$

To achieve the required participants, a cluster sampling method was employed. Initially, Amol County was divided into four geographical clusters to capture the diversity in citrus cultivation patterns and population distribution (Figure 1). Subsequently, 28 farmers were randomly selected from each cluster, yielding a total sample size of 112 participants.

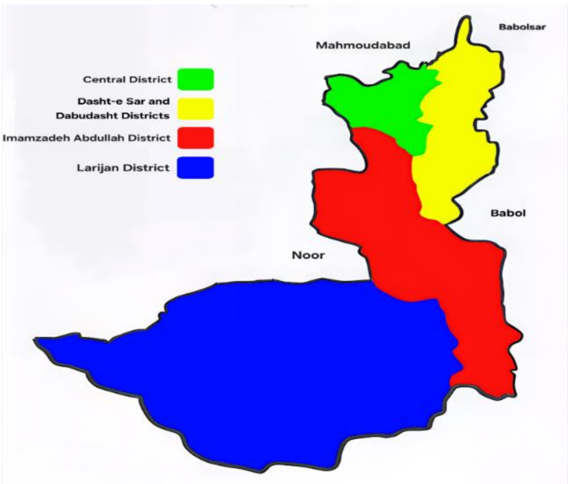

Figure 1. Map of Amol County, Mazandaran Province, Iran, showing the four geographical clusters used for stratified sampling in this study

Data Collection Instrument

A structured questionnaire was designed to assess Knowledge, Attitudes, and Practices (KAP) of farmers regarding pesticide based on the questionnaires used in previous studies [2,11] with some modifications. It was reviewed by academic experts to ensure content validity. Necessary revisions were made to improve clarity and minimize bias. The internal consistency of the questionnaire was evaluated using Cronbach's alpha. Based on the conceptual structure and item design, alpha values ranged from 0.72 to 0.81 across the three subscales (Knowledge, Attitudes, and Practices), suggesting satisfactory reliability. The questionnaire consisted of four sections:

Demographic characteristics: age, gender, education level, years of farming experience, orchard size, and contact with agricultural extension agents.

Knowledge assessment: six items with response options "Yes", "No" and "I don't know", scored from 0 to 2 depending on correctness.

Attitude assessment: eleven items with response options "Agree" "Neutral" and "Disagree", also scored on a 0–2 scale.

Practice assessment: This section comprised nine questions, each with binary or multiple-choice responses scored according to appropriateness. The items pertained to practices related to pesticide use, including: use of personal protective equipment (PPE) during spraying, consumption of food or drinking water during pesticide application, and disposal of leftover pesticides and empty pesticide containers.

Variables

The dependent variables in this study were the farmers' knowledge, attitudes, and practices (KAP) concerning pesticide use. The independent variables encompassed a range of socio-demographic, and educational characteristics, including age, educational attainment, farming experience, and contact with agricultural extension services.

Data Analysis

Data analysis was conducted using SPSS version 24. Descriptive statistics are presented as frequencies and percentages for categorical variables, and as means with standard deviations for continuous variables. The normality of continuous variables was assessed using the Shapiro–Wilk and Kolmogorov-Smirnov test, Skewness, Kurtosis and Q-Q plot. Spearman's correlation coefficient was used to evaluate associations between quantitative variables. Due to the non-normal distribution of knowledge, attitude, and practice (KAP) scores, comparisons between groups were performed using the Mann–Whitney U test (for two groups) and the Kruskal–Wallis test (for more than two groups). A p-value below 0.05 was considered statistically significant.

Results and Discussion

Demographic Characteristics

Participants demographics and attributes are displayed in Table 1. The mean age of participants was 56.34 ± 13 years, with a range from 28 to 83. The majority were male (87.5%) and the remaining were female (12.5%), confirming that pesticide application in orchards is predominantly undertaken by men. Educational attainment was generally moderate; only 21.4% of farmers had any university-level education, while 11.6% had a high school diploma, 30.4% were illiterate and 36.6% had not completed high school. These findings indicate a limited formal educational background, which is known to influence safe pesticide handling and decision-making. Farming experience varied: 10.7% had less than 5 years of experience, 44.6% had 5–10 years, 30.4% had 11–20 years, and 14.3% had over 20 years. The mean farm size was 1,411.31 m^2. Notably, only 14.3% of participants had ever interacted with an agricultural extension officer or farm advisor, while 85.7% reported relying solely on personal judgment in pesticide selection and application. The absence of expert guidance creates a gap that pesticide retailers frequently fill, potentially prioritizing product sales over safety and integrated pest management (IPM) principles [12,13]. This limited contact with extension services mirrors findings from Ghasemi and Karami [11] and Sharafi et al. [13], underscoring a persistent gap in farmer support systems. For instance, Sharafi et al. [13] reported that the majority of farmers (52.7%) obtained their pesticide information from other farmers, while the smallest share (22.1%) came from books, the internet, and similar sources.

Table 1. Demographic characteristics and farming profile of citrus growers (N=112) participating in the study on pesticide use in Amol County, Mazandaran Province, Iran

Characteristic	Category	n	%	Mean ± SD
Age (years)				56.34 ± 13.0
Gender	Male	98	87.5	
	Female	14	12.5	
Educational Level	No formal education	34	30.4	
	Below high school	41	36.6	
	High school diploma	13	11.6	
	Associate degree	8	7.1	
	Bachelor's degree	14	12.5	
	Master's degree	2	1.8	
Farming Experience	< 5 years	12	10.7	
	5–10 years	50	44.6	
	11–20 years	34	30.4	
	> 20 years	16	14.3	
Orchard Size (m^2)				1411.31
Contact with Extension Services	Yes	16	14.3	
	No	96	85.7	

Knowledge, Attitude, and Practice (KAP) Scores

The knowledge, attitudes, and practices of farmers concerning pesticide use and disposal are essential for developing effective strategies and action plans to reduce overall pesticide use and promote safer application methods. It is also important to identify the factors that influence pesticide use and related health effects [13]. The mean knowledge score was 9.91 ± 2.88 (out of 15), attitude score 15 ± 3.07 (out of 20), and practice score 12.30 ± 3.53 (out of 20). Although 79.5% of farmers acknowledged the harmful effects of pesticides on human health and the environment, this awareness did not fully translate into safe practices. Most farmers (74%) agreed that protective equipment reduces health risks, however only 38.4% supported reducing pesticide use through integrated pest management (IPM). A significant proportion (58.1%) believed that "chemical pesticides are necessary", indicating a reliance on conventional methods. The vast majority of gardeners (93.8%) expressed a desire to grow crops using fewer pesticides for personal and family consumption. This study reveals a critical disconnect between knowledge, attitudes, and practices (KAP) among citrus farmers in Amol County. While farmers demonstrated moderate knowledge and generally positive attitudes towards pesticide safety, their actual practices were frequently suboptimal and hazardous. Consistent with thresholds used in similar KAP studies, scores falling below 15 (out of 20) were classified as suboptimal. This paradox highlights that knowledge alone is insufficient to drive behavioral change and highlights the urgent need for multi-faceted interventions that address the underlying socioeconomic and structural barriers to safe pesticide management.

Pesticide Handling and Disposal Practices

Improper pesticide container management was common. Only 1.8% buried containers safely, while 18.8% burned them, and 75.8% discarded them in the environment or public waste bins. Alarmingly, 3.6% washed and reused containers. Such practices pose significant environmental and public health risks and highlight the urgent need for structured training and waste management systems [1]. Mohanty et al. [14] reported that nearly half of the farmers buried leftover pesticides for disposal. About one third discarded leftovers in the field. Most farmers reported disposing of empty containers in an indiscriminate way. Farmers who buried or burned leftovers tended to have better knowledge. In the study conducted by Sharafi et al. [13], none of the empty pesticide containers were disposed of using environmentally safe methods. This is mainly because there are no facilities for safe collection and handling of empty pesticide containers. Throwing them into land or water bodies, disposing of them with regular waste, reusing them for other purposes, burning, burying, or selling them are not proper pesticide waste management practices and can create serious health risks for people and harm different parts of the environment.

Because many people lack education and guidance on how to manage small amounts of pesticide waste, hazardous chemicals are often left around in both rural and urban areas. Reusing contaminated empty containers for domestic purposes—common in many developing areas—poses a major health risk [13,15,16]. Although engineered landfilling or incineration are possible disposal options, farmers typically lack the knowledge and skills to use them [13].

Damalas et al. [15] reported that about 66% of farmers discard containers in the fields or in irrigation canals and streams. To ensure proper disposal of empty containers, a training program and a well-designed waste-management system should be provided in areas with extensive farming, such as Mazandaran Province.

Use of Personal Protective Equipment (PPE)

Nearly half of the respondents (47.3%) reported personally performing spraying activities. Among these, a full body PPE use was limited: 98.1% used masks, 94.3% gloves, and 73.6% boots, but only 32.1% used protective goggles (Figure 2). This partial use of protective gear indicates gaps between awareness and consistent and comprehensive protection. These gaps between knowledge and practice indicate the need for more practical training in the field of personal safety [7,17,18]. Previous studies carried out by Yassin et al. [3] and Damalas et al. [19] found similar deficiencies, suggesting this is a widespread challenge in developing agricultural systems. Sharafi et al. [13] found that roughly 18% of farmers wear full personal protective equipment (covering the face and hands) when applying pesticides, whereas more than 13% use no protection at all. Mohanty et al. [14] reported a wide range in the non-use of personal protective equipment during pesticide spraying, from about 40% to 78%. Rostami et al. [20] reported that about half of farmers wore basic protective items such as hats, gloves, masks, and rubber boots. In contrast, the use of spray-applied eye protection (spectacles) was relatively low. The suboptimal practice scores, particularly regarding PPE use is a primary concern. The near-universal use of masks and gloves suggests a baseline awareness of dermal and inhalation risks. However, the critically low adoption of goggles (32.1%) indicates a lack of understanding of specific exposure pathways, such as ocular splashing, which can lead to acute poisoning. This selective PPE use aligns with findings from agricultural communities in Nepal and Ethiopia, where practical barriers like cost, availability, comfortability, and inadequate training often override knowledge [21,22].

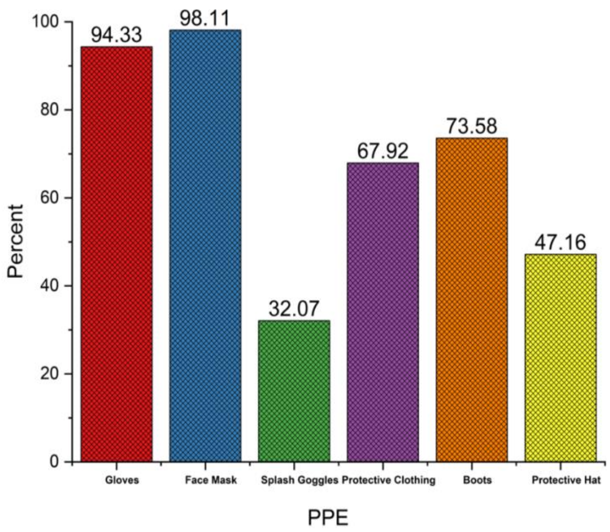

Figure 2. Personal Protective Equipment usage among citrus farmers in Amol County, Mazandaran Province, Iran

Risk Behaviors and Health Outcomes

While 90.2% of farmers avoided eating, drinking, or smoking during spraying, 33.1% still reported experiencing pesticide-related poisoning symptoms. In addition, 22.3% believed that using higher pesticide doses would improve crop quality and yield, a dangerous misconception that extends pre-harvest intervals and increases risks to consumers and the environment [1]. The study revealed a critical gap in information-seeking behavior: only 47% of gardeners had researched their purchased pesticides to understand their benefits and harms. Furthermore, a majority (52.7%) reported disregarding the instructional brochures and labels on pesticide containers, preferring instead to rely on habitual practices or personal preference. These findings underscore the persistence of risky behaviors despite moderate levels of knowledge. In fact, excessive and unprincipled pesticide use has been reported to be one of the contributing factors in the increase in the incidence of chronic diseases, including cancer, neurological disorders, and endocrine disruptions [23,24]. Karki et al. [25] conducted a cross-sectional study to assess the knowledge and practices related to safe pesticide use among farmers in the Bardiya District of Nepal. The findings indicated that, despite notable safety deficiencies, there were instances of admirable practices among the farmers. Notably, 76.3% of participants reported avoiding eating or chewing while applying pesticides, highlighting a positive aspect of their safety behavior.

Statistical Associations

As shown in Table 2 and Figure 3, no significant relationship was found between age and knowledge, attitude, or practices ($p > 0.05$), consistent with previous studies [4,19]. In contrast, education level had a significant effect on all three KAP domains ($p < 0.05$). Farmers with higher education levels demonstrated better knowledge, attitudes, and safer practices compared to less-educated or illiterate participants (Table 3 and Figure 4). It is obvious that the strongest predictor of comprehensive KAP was formal education level. Educated farmers are likely better equipped to comprehend complex pesticide labels, access and interpret information from diverse sources, and perceive long-term risks more accurately. This finding aligns with earlier reports highlighting education as a critical determinant of safe pesticide handling [2,4,11,26]. Farming experience showed no significant association with knowledge or attitude (p > 0.05), but significantly influenced practices (p = 0.032), as presented in Table 4. Farmers with over 10 years of experience exhibited safer practices than those with less experience. This suggests that while experienced farmers may develop techniques to protect themselves from immediate, obvious hazards through trial and error, they may not necessarily acquire the scientific rationale for broader safety protocols, such as environmental protection.

Correlation analysis revealed a strong positive association between knowledge and attitude (r = 0.756, p < 0.05), indicating that increased knowledge raises favorable perceptions toward safe pesticide use. However, the relationship between knowledge and practices was weaker (r = 0.284, p = 0.014), suggesting that while knowledge influences practice, other factors—such as economic constraints, availability of PPE, or ingrained behaviors—may limit behavioral change (Table 5). This knowledge–practice gap has been widely documented in agricultural health literature [27]. The findings of this study emphasize that to achieve sustainable and safe agriculture, it is necessary to focus simultaneously on education, supervision, and active participation of farmers. The use of behavioral models such as the Theory of Planned Behavior can be effective in designing educational interventions and reinforcing desired behaviors [28-30].

Table 2. Relationship between age and knowledge, attitude, and practice (KAP) among citrus farmers in Amol County, Mazandaran Province, Iran

Group	r	P- value*
Knowledge	-0.198	0.067
Attitude	-0.168	0.076
Practice	-0.159	0.095

***Spearman's rho correlation test result**
r: correlation coefficients

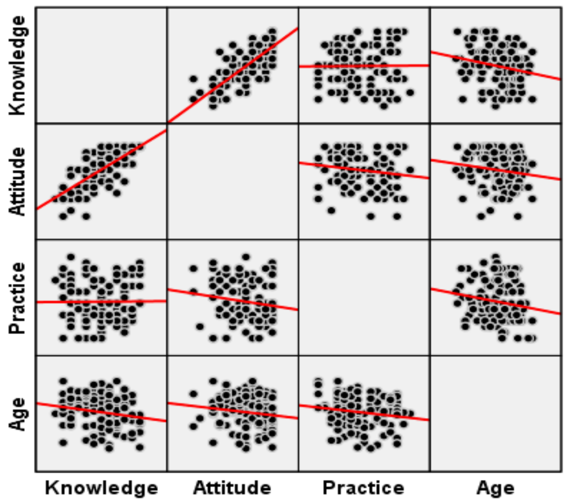

Figure 3. Relationship between age and knowledge, attitude, and practice (KAP) among citrus farmers in Amol County, Mazandaran Province, Iran

Table 3. Comparison of knowledge, attitude, and practice (KAP) scores regarding pesticide use across different educational levels among citrus farmers in Amol County, Mazandaran Province, Iran

Group	Illiterate Mean ± SD	Uncompleted high school Mean ± SD	Diploma Mean ± SD	University level Mean ± SD	P- value (Kruskal-Wallis)
Knowledge	9.558±2.732	9.073±2.473	8.864±2.733	12.458±2.466	0.000
Attitude	14.382±2.741	14.512±2.907	14.000±3.316	17.250±2.754	0.000
Practice	11.794±3.453	12.219±3.496	12.384±3.948	13.125±3.579	0.044

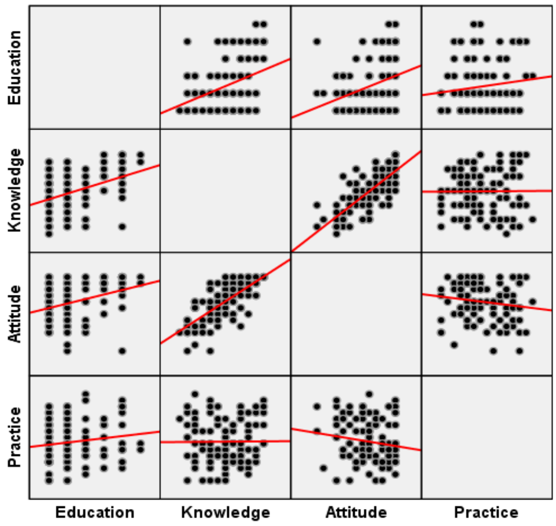

Figure 4. Comparison of knowledge, attitude, and practice (KAP) scores regarding pesticide use across different educational levels among citrus farmers in Amol City, Mazandaran Province, Iran

Table 4. Comparison of knowledge, attitude, and practice (KAP) scores regarding pesticide use based on farming experience (≤10 years vs. >10 years) among citrus growers in Amol County, Mazandaran Province, Iran

Group	Under 10 years Mean ± SD	Over 10 years Mean ± SD	P- value (Mann-Whitney)
Knowledge	10.000±3.213	9.820±2.335	0.936
Attitude	14.919±3.255	15.100±2.866	0.863
Practice	13.193±3.561	11.200±3.213	0.032

Table 5. Correlation matrix of knowledge, attitude, and practice (KAP) scores regarding pesticide use among citrus growers in Amol County, Mazandaran, Iran

Variable	Correlation Coefficient	P- value
Attitude	0.756	0.000
Practice	0.284	0.014

Implications for Policy and Practice

The challenges identified in Amol County are similar to those seen in many developing regions with pesticide misuse. Policymakers should prioritize educating farmers, enforcing safety regulations, and encouraging the use of integrated pest management (IPM) strategies. International collaboration and knowledge exchange can enhance local capacities to address these issues. Strengthening agricultural extension services and improving farmers' access to protective equipment should be prioritized. In addition, stricter regulations on the sale and disposal of pesticides, along with the promotion of environmentally friendly alternatives, are essential to protect farmers' health and environmental sustainability.

Limitations

This study presents valuable insights into the knowledge, attitudes, and practices of citrus growers regarding pesticide use in Amol County. However, several limitations should be acknowledged to contextualize the findings and guide future research.

First, the cross-sectional design inherently restricts causal inference. While associations between knowledge, attitudes, and practices were identified, the temporal directionality of these relationships remains uncertain. Longitudinal studies are needed to establish causality and assess behavioral changes over time.

Second, the reliance on self-reported data particularly for practice-related behaviors introduces the potential for social desirability bias. Participants may have overreported safe practices or underreported risky behaviors, which could affect the accuracy of the practice scores.

Third, the sampling strategy, although based on geographical clustering, limits the generalizability of the findings beyond the citrus-growing population of Amol County. Regional agricultural practices, access to training, and socioeconomic conditions may differ significantly across other provinces in Iran.

Fourth, while efforts were made to ensure adequate sample size, the margin of error (0.08) reflects practical constraints in fieldwork and participant recruitment. This may slightly affect the precision of estimates and should be considered when interpreting the results.

Finally, potential non-response bias cannot be ruled out. Farmers who declined participation may differ systematically from those who responded, particularly in terms of pesticide awareness or compliance with safety protocols.

Despite these limitations, the study offers a robust foundation for targeted interventions and policy development aimed at improving pesticide safety and environmental health in agricultural communities.

Conclusion

This study demonstrates that while orchard farmers had moderate levels of knowledge and generally recognized the hazards of pesticides, their actual practices remained suboptimal. Improper disposal of pesticide containers, inconsistent use of PPE, and risky behaviors such as overdosing were prevalent. Education level emerged as the most consistent determinant of safer KAP, while farming experience mainly influenced practices. Importantly, a strong correlation between knowledge and attitude but only a weak link between knowledge and practices indicates that knowledge alone is insufficient to change behavior. To address these gaps, integrated interventions are urgently required. These should include structured training programs, expansion of agricultural extension services, provision of affordable PPE, and the establishment of safe pesticide container collection and disposal systems. By bridging the knowledge–practice gap, such measures can enhance farmer safety, protect environmental quality, and promote sustainable agricultural production.

Declarations

Ethical approval for this study was granted by the Ethics Committee of Babol University of Medical Sciences (Code: IR.MUBABOL.HRI.REC.1403.283). As this was a Knowledge, Attitude, and Practice

(KAP) survey based on an anonymous questionnaire, participant consent was implied by the voluntary completion and return of the survey. Farmers were informed of the study's purpose and their right to decline or withdraw at any time.

Acknowledgment

This paper is derived from the results of a research project approved by the Student Research Committee of Babol University of Medical Sciences (Project Code: 724136089). The authors would like to express their deepest gratitude to the Student Research Committee and the Vice-Chancellery for Research and Technology of Babol University of Medical Sciences for their invaluable financial and spiritual support, which made this study possible.

Conflicts of interest: There are no conflicts of interest.

Availability of data and material: Not applicable.

Author's contribution: Conceptualization: M.SH., A.R.L.; Methodology: M.SH., A.R.L., H.A., S.M.M.; Sampling: A.R.L.; Statistical analysis and investigation: A.R.L, M.SH., H.A.; Writing – original draft preparation: A.R.L., M.SH.; Writing - review and editing: A.R.L., M.SH., H.A, and S.M.M.

Consent for publication: Not applicable.

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