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Research Article

Knowledge Gaps and Training Needs of Date Palm Growers for Red Palm Weevil (*Rhynchophorus ferrugineus*) Management in Pakistan

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ABSTRACT

Red palm weevil (RPW), *Rhynchophorus ferrugineus*, is a major constraint to date-palm production; yet effective management depends on growers' knowledge, training, and adoption of recommended practices. This study assessed these dimensions among 120 date-palm growers from Dera Ismail Khan (Dhakki) and Sukkur (Aseel), Pakistan. A structured survey evaluated growers' knowledge of RPW, training needs, and adoption of management practices. Growers answered an average of 11.54 of 25 knowledge items correctly (46.2%), indicating a knowledge-gap index of 53.8%. Knowledge was strongest for larval damage, severe infestation symptoms, and pest recognition, but was particularly weak for reporting suspected infestations (4.2%), pheromone-trap use and monitoring (8.3%), prevention (8.3%), and integrated pest management (9.2%). The overall training-need score was 3.36/5 (67.1%), with greatest demand for approved management practices, integrated pest management, safe disposal of infested material, early-stage infestation management, and recognition of early symptoms. Adoption was highest for avoiding trunk injuries (74.2%), recommended pruning (71.7%), and use of healthy planting material (65.8%), but very low for pheromone trapping and monitoring (7.5%), RPW-related training (3.3%), and reporting suspected infestations (1.7%). Overall, growers showed substantial gaps in preventive, monitoring, integrated-management, and institutional aspects of RPW control. Targeted extension and practical training focused on early detection, pheromone-based monitoring, integrated management, safe disposal, and reporting could help strengthen field-level RPW management.

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Introduction

Date palm (*Phoenix dactylifera* L.) is an economically important fruit crop in Pakistan and plays a significant role in the rural economy of arid and semi-arid areas, providing income, employment, and food security to thousands of farming households. Dera Ismail Khan in Khyber Pakhtunkhwa and Sukkur in Sindh are important date-palm-growing areas representing distinct production systems and commercially important varieties. Dhakki is an economically important cultivar in Dera Ismail Khan, while Aseel is among the dominant commercial varieties grown in Sindh (Solangi et al., 2024). Among the major biotic threats to date palm, the red palm weevil (RPW), *Rhynchophorus ferrugineus*, is considered one of the most destructive pests of palms worldwide. The insect damages the internal tissues of the palm, and infestation frequently remains unnoticed during its early, concealed stages; delayed detection and

improper management can lead to severe structural damage and death of affected palms (Abraham et al., 1998; Faleiro, 2006). In Pakistan, RPW infestation has been documented across multiple geographical regions of date palm cultivation, including Sukkur and other districts of Sindh, confirming that the pest is now well established in the country's major date-growing areas rather than being confined to a single locality (Manzoor et al., 2020). Effective management of RPW depends heavily on growers' knowledge and their timely adoption of appropriate practices, including regular field surveillance, identification of early symptoms, proper pruning and field sanitation, avoidance of trunk injuries, safe disposal of severely infested palms, pheromone trapping, use of healthy planting material, and timely preventive or curative intervention based on approved recommendations (Elkahky and Faleiro, 2020). International guidance emphasizes that farmer awareness and training are essential components of RPW integrated pest management, since failure to detect infestations at an early stage allows the pest to spread within and between orchards. A comparable knowledge-attitude-practice survey of date palm growers in Saudi Arabia found a strong positive association between farmers' knowledge of RPW infestation symptoms and their adoption of integrated pest management practices (Kassem et al., 2020), underscoring that closing knowledge gaps is not merely descriptive but is directly linked to on-farm management behavior.

Previous research on date-palm production in Pakistan has reported weaknesses in agricultural extension services generally. Ata et al. (2012) identified extension and input-access constraints hampering date palm production in the Punjab. These reports are consistent with the low extension-contact and information-access levels observed in the present sample and motivate a focused assessment of growers' RPW-specific knowledge and training needs, rather than general production knowledge alone. Although general date-palm production and extension services have received some research attention in Pakistan, limited empirical work is available on growers' specific knowledge gaps and training needs regarding RPW prevention and management, particularly across two contrasting production systems studied within a single design.

The objective of this study was to assess the knowledge gaps and training needs of date palm growers across two production systems in Pakistan, Dera Ismail Khan (Dhakki) and Sukkur (Aseel), with a view to providing an empirical basis for demand-driven extension and training interventions. This is a descriptive needs assessment rather than a formal comparative study: findings are reported for the pooled sample and by district, but district-level differences were not tested statistically (see Materials and Methods). Specifically, the study aimed to (1) determine the socio-economic and farm characteristics of the selected growers; (2) assess growers' knowledge regarding identification, symptoms, and biology of RPW infestation; (3) quantify the knowledge gap regarding preventive and management measures; (4) identify and prioritize growers' training needs; and (5) assess current adoption of RPW-related management practices.

Materials and Methods

Research design and study area

A cross-sectional, descriptive survey design was employed to characterize date-palm growers' knowledge, perceived training needs, and adoption of red palm weevil (RPW) management practices. The study was conducted in two major date-palm-producing districts of Pakistan: Dera Ismail Khan, Khyber Pakhtunkhwa, representing the Dhakki production system, and Sukkur, Sindh, representing the Aseel production system. These districts were purposively selected because of their importance in the production of the respective date-palm types and their relevance to the study objectives. Date-palm-growing localities within each district were identified in consultation with the respective Agricultural Extension Departments and local agricultural officers.

Study population and sampling procedure

The target population comprised date-palm growers cultivating Dhakki in Dera Ismail Khan or Aseel in Sukkur who were actively involved in orchard management and maintained at least 20 date palms. Both criteria were applied as eligibility requirements.

A multistage sampling procedure was used. First, Dera Ismail Khan and Sukkur districts were purposively selected to represent the Dhakki and Aseel production systems, respectively, rather than being randomly selected from the population of date-palm-producing districts in Pakistan. Second, six major date-palm-growing localities were identified within each district. Third, a locality-wise sampling frame of eligible growers was prepared with assistance from local agricultural

extension personnel, and approximately 10 growers were selected randomly from each locality. Thus, 60 growers were included from each district, giving a total sample of 120 respondents.

All selected growers agreed to participate and completed the interview; consequently, no refusals, replacements, or non-response adjustments were required. The sample size was considered operationally adequate for describing item-level patterns in knowledge, perceived training needs, and management-practice adoption within the two study areas. However, no formal a priori statistical power calculation was performed. Comparable regional surveys have used similar approaches; for example, Kassem et al. (2020) surveyed 183 date-palm growers across a broader geographical area.

Because the districts were purposively selected and respondents were clustered within a limited number of localities, the sample should not be regarded as a probability sample representing all date-palm growers in Pakistan. Accordingly, the findings are interpreted as descriptive evidence for the two production systems investigated and should not be generalized to other date-palm-growing regions without additional probability-based sampling. The locality-level clustering was also not incorporated into the descriptive analyses.

Data collection instrument

Data were collected using a structured, interviewer-administered questionnaire comprising four sections. All items used fixed, closed-ended response categories to standardize administration, facilitate quantitative coding, minimize item non-response, and reduce the recall and reporting burden on respondents.

Section A recorded 15 respondent- and farm-level characteristics. These included district, date-palm variety, educational level, contact with agricultural extension services, previous training, farmer-organization membership, and primary source of agricultural information. Age, farming experience, farm size, orchard size, number of date palms, and annual income were recorded using predefined categorical intervals rather than open numerical responses.

Section B consisted of 25 knowledge statements covering RPW identification, symptoms, biology, and prevention and management. Responses were coded as 1 for correct and 0 for incorrect or no knowledge. All statements were formulated as factual statements for which agreement represented the correct response; therefore, the corresponding answer key was based on endorsement of each statement. The complete wording of the knowledge items and their answer key are provided in.

Section C assessed perceived training needs across 20 RPW-related topics using a five-point Likert-type scale ranging from 1 (very low need) to 5 (very high need). This scale measures growers' self-reported perceptions of their need for training and should not be interpreted as an independently verified or externally assessed training requirement.

Section D comprised 12 RPW management-practice adoption items. Each practice was coded as 0 (No) or 1 (Yes) to document whether the respondent currently reported using the specified management practice. These items were included to provide a descriptive indication of the extent to which reported knowledge was accompanied by field-level adoption.

Measurement and scoring

The total knowledge score (KNOWTOTAL) was calculated as the sum of correct responses across the 25 knowledge items:

$$\text{KNOWTOTAL} = \Sigma \text{ correct responses}$$

With a possible range of 0–25. The knowledge-gap score (KNOWGAP) was calculated as:

$$\text{KNOWGAP} = 25 - \text{KNOWTOTAL}$$

And expressed as a percentage using:

$$\text{Knowledge} - \text{gap index (\%)} = \frac{\text{KNOWGAP}}{25} \times 100$$

For the 20 training topics, each item was scored from 1 to 5, with higher values indicating greater perceived training need. This graded needs-assessment approach permits differentiation among training priorities rather than reducing responses to a binary need/no-need classification (Witkin and Altschuld, 1995).

For each training topic, the mean training-need score was calculated from the aggregated response frequencies as:

$$\text{Item mean} = \frac{\Sigma(f_i \times s_i)}{N}$$

Where f_i is the frequency of responses in category i, s_i is the corresponding scale value, and N is the total number of respondents. Topics were ranked in descending order according to their mean scores, with a maximum possible value of 5.

The aggregate training-need score (TN_TOTAL) was calculated as the sum of the 20 item means, giving a

theoretical maximum of 100:

$$TN_TOTAL = \Sigma \text{ item means.}$$

The overall mean training-need score (TN_MEAN) was calculated as:

$$TN_MEAN = \frac{TN_TOTAL}{20}$$

TN_TOTAL was also expressed as a percentage of the maximum possible score (TN_PERCENT). Because Table 3 presents aggregated item means without respondent-level observations, measures of dispersion such as standard deviations could not be reconstructed reliably and were therefore not reported.

Adoption of each RPW management practice was expressed as the percentage of respondents reporting "Yes" and ranked in descending order. The 12 practices differed substantially in cost, technical complexity, and institutional requirements; therefore, an overall adoption mean was not considered an equivalent measure of practice adoption. A simple mean across the 12 binary items was nevertheless calculated for Table 5 as a descriptive summary index and is interpreted cautiously. The item-specific adoption percentages presented in Table 4 constitute the primary evidence for practice adoption.

All 120 respondents provided responses to all closed-ended items. Consequently, no missing or not-applicable observations required imputation or other missing-data treatment.

For Figure 3, eight knowledge items were paired with eight conceptually corresponding training-need topics. Each pair represented the same underlying competency, for example, knowledge concerning identification of the adult RPW was paired with the corresponding training topic on RPW identification. The pairing was used solely as a descriptive visualization to compare reported knowledge with perceived training need for related competencies and was not subjected to statistical testing.

Instrument validity, reliability, and data quality assurance

The questionnaire was reviewed by specialists in agricultural extension, entomology, plant protection, and date-palm research to establish content validity. A pilot test involving 10–15 growers from outside the final study sample was subsequently conducted, and minor wording modifications were made to improve clarity and suitability for field administration.

The questionnaire was translated from English into Urdu for administration and independently back-translated into English to assess conceptual equivalence between the two versions. Enumerators received training on the questionnaire, interview procedures, response coding, and standardized administration before commencement of the survey.

Content-expert review, pilot testing, and translation/back-translation were used as the principal procedures for establishing content validity and ensuring consistency of administration. Internal-consistency reliability, such as Cronbach's alpha (Cronbach, 1951), could not be calculated because the dataset available for the present analysis contained aggregated item-level frequencies rather than respondent-level observations. Consequently, respondent-level reliability estimates could not be reconstructed from the available data.

Similarly, the original study framework included district-level comparative and association analyses, including independent-samples *t*-tests or Mann–Whitney *U* tests, chi-square tests, Pearson or Spearman correlation analyses, and multiple regression. These analyses were not undertaken because the respondent-level dataset required for such analyses was unavailable. Accordingly, no inferential statistics, standard errors, confidence intervals, or measures of association were calculated.

The study was therefore restricted to descriptive analysis. Frequencies, percentages, means, and ranks were calculated from the aggregated response counts for individual questionnaire items. The observed relationships among knowledge, perceived training needs, and reported management-practice adoption are consequently presented as descriptive patterns rather than statistically tested associations or predictive relationships.

Ethical considerations

Before each interview, verbal informed consent was obtained from the participating grower. Participation was voluntary, and respondents were informed that their responses would be recorded anonymously and used for research purposes. No personally identifying information was included in the analytical dataset.

The survey was administered with the involvement of local agricultural extension personnel; however, formal review and approval by an institutional research ethics committee was not obtained. This constitutes a methodological and reporting limitation and is clearly acknowledged. Future surveys within this research program should obtain prospective institutional ethical

approval, together with documented informed-consent procedures, before participant recruitment.

Results and Discussion

Respondent and farm characteristics

Table 1 presents the respondent and farm characteristics of the study sample (N = 120). By design, the sample was evenly distributed between the two districts and date-palm production systems, with 60 growers each from Dera Ismail Khan (Dhakki) and Sukkur (Aseel). The largest proportion of respondents (44.2%) was 31–40 years of age, followed by 29.2% who were ≤ 30 years, while none was older than 60 years. Educational attainment was generally moderate: 45.0% had completed secondary education (Matric), 5.8% were illiterate, and only 2.5% had attained a graduate or postgraduate qualification. Both general farming experience and date-palm-specific experience were concentrated in the 11–20 and 21–30-year categories, which together accounted for approximately 80% of respondents for each experience measure (Figure 1).

Farm holdings were generally small. Overall, 76.7% of growers cultivated ≤ 5 acres, while 55.0% managed date-palm orchards of ≤ 2 acres. Approximately two-thirds (64.2%) maintained 101–200 date palms, and 65.0% reported an annual income of PKR 300,001–500,000 from date-palm production.

Access to agricultural extension services was markedly limited. Overall, 40.8% of growers reported that they had never been contacted by the extension department, while another 50.0% reported being contacted only rarely. Only 26.7% reported having access to agricultural information. Among the information sources identified, fellow farmers or progressive growers were the predominant source (56.7% of all respondents), whereas the extension department (3.3%) and media (0.8%) contributed minimally. Participation in formal training was also limited: only 4.2% of growers had previously attended any date-palm training, while 90.8% reported no prior RPW-specific training exposure, indicating that 9.2% had received some form of RPW-related training. Notably, all respondents (100.0%) reported previous occurrence of RPW in their orchards, confirming the widespread nature of the pest across both production systems and underscoring the relevance of assessing growers' RPW-related knowledge and training needs (Figure 1). These findings are consistent with earlier reports identifying inadequate extension support as an important constraint to date-palm production in Pakistan's major growing districts (Ata et al., 2012).

A discrepancy was observed between two training-related items reported in the study. The respondent-characteristics section (Section A) recorded 9.2% of growers as having had some prior exposure to RPW-related training, whereas the practice-adoption checklist (Table 4, "has attended any RPW-related training") recorded 3.3%. This difference reflects the distinct wording and scope of the two items rather than a contradiction: the Section A item assessed any previous exposure to RPW-related training sessions, whereas the Section D item specifically assessed attendance at a dedicated RPW training program as a current management practice. Accordingly, the two measures capture related but non-identical constructs and are reported separately within their respective sections.

Figure 2 summarizes the three key composite indicators assessed in this study, the mean knowledge score, mean training-need level, and mean practice-adoption rate, before presenting the corresponding item-level results in Tables 1–4.

Growers' Knowledge of Red Palm Weevil

Table 2 ranks the 25 knowledge items according to the percentage of correct responses. On average, growers answered 11.54 of the 25 items correctly (46.2%), corresponding to a mean knowledge gap of 13.46 items and a knowledge-gap index of 53.8%. Overall, growers' knowledge of RPW was therefore below the midpoint of the knowledge scale and indicated substantial gaps in key aspects of RPW management.

Knowledge was highest for items related to pest biology, damage symptoms, and recognition of severe infestation. All of the highest-scoring items exceeded 85% correct responses. All growers (100.0%; rank 1) correctly recognized that RPW larvae cause internal damage within the palm. Similarly, 92.5% correctly identified symptoms of severe or advanced infestation, while 91.7% correctly recognized both the appropriate management of severely infested palms and the risk of pest dissemination through improperly handled infested material. Recognition of the adult weevil was also high (90.8%), as was knowledge that RPW can spread through infested planting material (86.7%). These relatively high levels of knowledge likely reflect growers' direct field experience with RPW, consistent with the universal prior exposure to the pest reported above.

Table 1. Respondent and farm characteristics (N = 120).

Variable	Category	N	%
District	D.I. Khan	60	50.0%
	Sukkur	60	50.0%
Date variety	Dhakki	60	50.0%
	Aseel	60	50.0%
Education	Illiterate	7	5.8%
	Primary	18	15.0%
	Middle	21	17.5%
	Matric	54	45.0%
	Intermediate	17	14.2%
	Graduate	2	1.7%
	Postgraduate	1	0.8%
Contact with extension	Never	49	40.8%
	Rarely	60	50.0%
	Sometimes	7	5.8%
	Often	4	3.3%
Participation in date-palm	No	115	95.8%
	Yes	5	4.2%
Experience with red palm weevil	No	0	0.0%
	Yes	120	100.0%
Access to agricultural information	No	88	73.3%
	Yes	32	26.7%
Membership in farmer	No	106	88.3%
	Yes	14	11.7%
Main source of agricultural	Extension dept./agri. officer	4	3.3%
	Fellow farmersrs/ progressive growers	68	56.7%
	Media (TV/radio/social media/internet)	1	0.8%
	Input dealer/pesticide shop	30	25.0%
	NGO/private company	16	13.3%
	Other	1	0.8%
Age (years)	Up to 30	35	29.2%
	31 – 40	53	44.2%
	41 – 50	18	15.0%
	51 – 60	14	11.7%
	Above 60	0	0.0%
General farming experience	Up to 10	15	12.5%
	11 - 20	48	40.0%
	21 - 30	47	39.2%
	31 - 40	5	4.2%
	Above 40	5	4.2%
Date palm farming experience	Up to 10	16	13.3%
	11 - 20	49	40.8%
	21 - 30	47	39.2%
	Above 30	8	6.7%
Total farm size (acres)	Up to 5	92	76.7%
	6 – 10	17	14.2%
	11 - 20	11	9.2%
	21 - 50	0	0.0%
	Above 50	0	0.0%

Date-palm orchard area (acres)	Up to 2	66	55.0%
	3 – 5	26	21.7%
	6 – 10	17	14.2%
	Above 10	11	9.2%
Number of date palms	20 – 50	1	0.8%
	51 - 100	26	21.7%
	101 - 200	77	64.2%
	201 - 500	16	13.3%
	Above 500	0	0.0%
Annual income from date palm	Up to 100,000	1	0.8%
	100,001 - 300,000	12	10.0%
	300,001 - 500,000	78	65.0%
	500,001 - 1,000,000	17	14.2%
	Above 1,000,000	12	10.0%
Number of RPW trainings	None	109	90.8%
	1 – 2	9	7.5%
	3 – 5	2	1.7%
	Above 5	0	0.0%

Age, farming/date-palm experience, farm size, orchard size, number of palms, income, and RPW-trainings-attended were recorded as pre-set closed-ended class intervals.

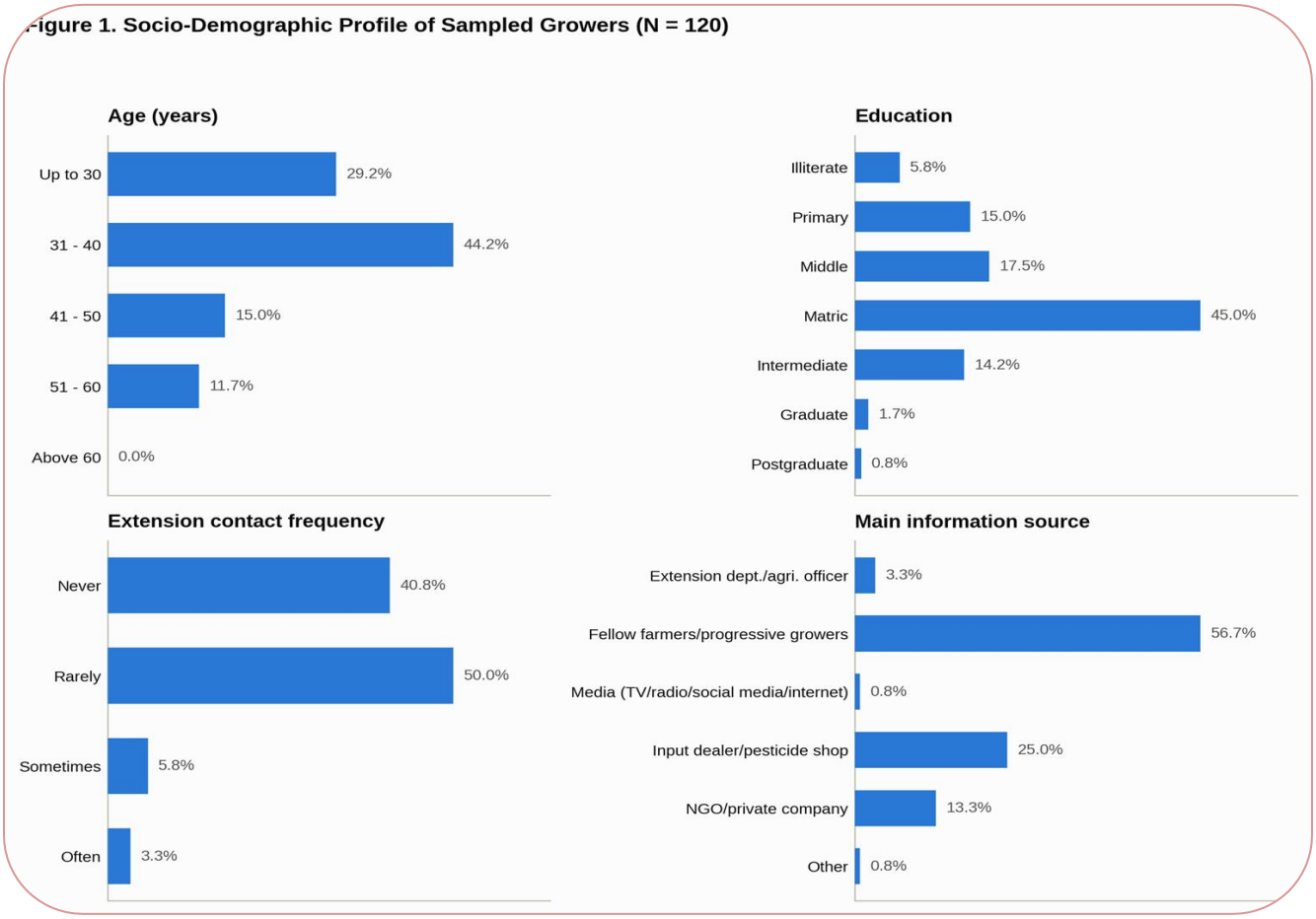


Figure 1. Socio-demographic profile of sampled growers (N = 120): age, education, extension-contact frequency, and main information source.

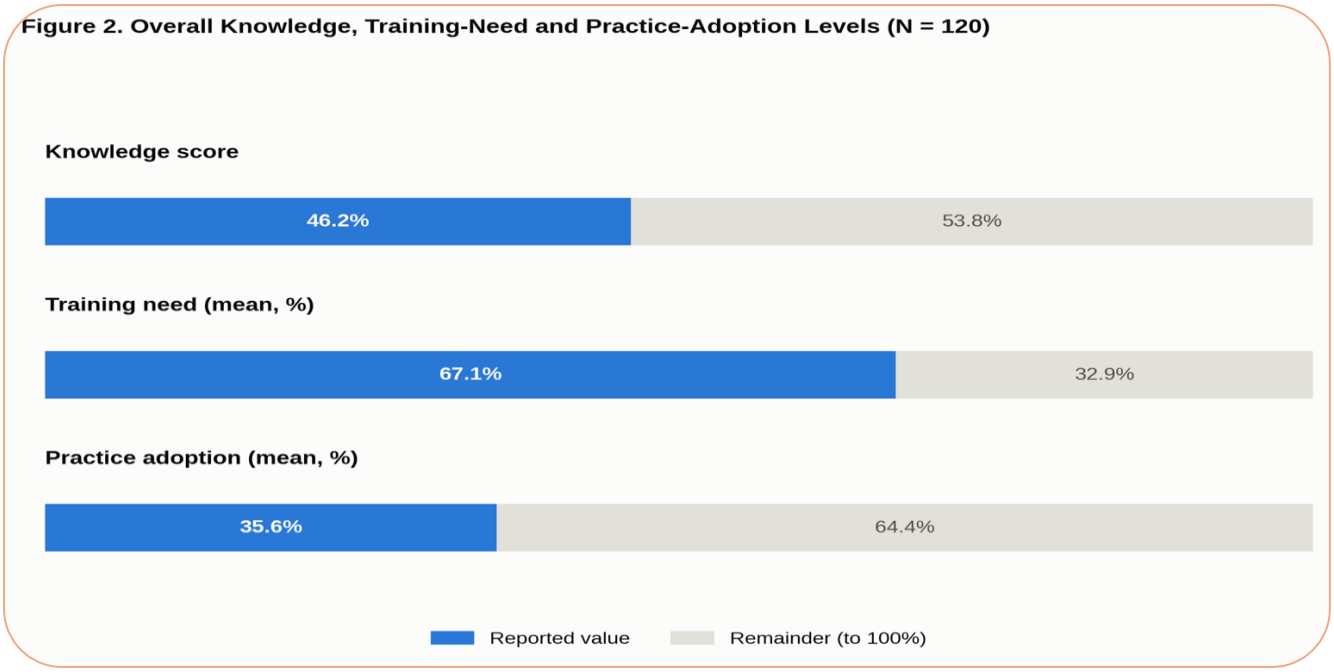


Figure 2. Overall knowledge, training-need and practice-adoption levels (N = 120).

Table 2. Growers' knowledge of red palm weevil, ranked by percentage correct (N = 120).

Knowledge item	n correct	% correct	Rank
Knows that RPW larvae cause damage inside the palm (K2)	120	100.0%	1
Can identify severe or advanced symptoms of infestation (K5)	111	92.5%	2
Knows the importance of safe management of severely infested palms (K16)	110	91.7%	3
Knows that severely infested palm material can spread the pest if improperly handled (K17)	110	91.7%	3
Can identify the adult red palm weevil (K1)	109	90.8%	5
Knows that RPW infestation may spread through infested planting material (K3)	104	86.7%	6
Knows that regular inspection of date palms is important (K6)	75	62.5%	7
Can identify early symptoms of RPW infestation (K4)	69	57.5%	8
Knows the importance of rapid action after suspected infestation (K15)	68	56.7%	9
Knows that internal feeding may produce unusual sounds or other hidden symptoms (K7)	59	49.2%	10
Knows the importance of orchard sanitation in RPW prevention (K8)	57	47.5%	11
Knows the importance of using pest-free planting material (K10)	53	44.2%	12
Knows that pruning wounds may increase the risk of pest entry if improperly managed (K9)	49	40.8%	13
Knows the importance of preventing unnecessary injuries to palm trunks (K25)	47	39.2%	14
Knows the importance of approved/recommended management practices (K18)	40	33.3%	15
Knows the importance of early detection (K13)	39	32.5%	16
Knows that palms should be monitored even when no visible symptoms exist (K24)	38	31.7%	17
Knows basic safety precautions during pesticide application (K19)	29	24.2%	18
Knows that preventive practices are important in reducing RPW risk (K14)	27	22.5%	19
Knows that a single method alone may not provide complete control of RPW (K22)	25	20.8%	20
Knows the importance of integrated pest management (K21)	11	9.2%	21
Knows the purpose of pheromone traps (K11)	10	8.3%	22
Knows that pheromone traps require regular monitoring (K12)	10	8.3%	22
Knows that prevention is generally better than late management of severe infestation (K23)	10	8.3%	22
Knows that suspected infestation should be reported to relevant experts/authorities (K20)	5	4.2%	25

Overall knowledge score: mean 11.54/25 (46.2%). Overall knowledge gap: mean 13.46/25 (knowledge gap index = 53.8%).

In contrast, knowledge was markedly lower for preventive, monitoring, procedural, and institutional aspects of RPW management. Only 4.2% of growers correctly knew that suspected RPW infestations should be reported to the relevant authorities, making this the lowest-scoring item (rank 25). Only 8.3% correctly understood the purpose of pheromone traps, recognized that traps require regular monitoring, or identified prevention as preferable to attempting to manage severe infestations after they have become established. Furthermore, only 9.2% recognized the importance of integrated pest management (IPM), and 20.8% understood that reliance on a single management method may not provide complete control.

Overall, the findings indicate that the principal knowledge deficit was not a lack of awareness of RPW as a serious pest, but rather insufficient knowledge of the preventive, monitoring, integrated-management, and institutional measures required for timely intervention. This distinction is important because recognition of infestation and damage does not necessarily translate into effective preventive action. Strengthening growers' knowledge of early detection, pheromone-trap deployment and monitoring, integrated management, safe disposal or handling of infested palms and planting material, and mandatory or recommended reporting procedures could therefore help convert existing awareness of RPW into more effective pest-management practices.

Training needs of growers

Table 3 ranks the 20 training topics according to their mean weighted need scores on a 5-point scale. The overall mean training need across all topics was 3.36 out of 5 (TN_PERCENT = 67.1%), indicating a moderately high to high overall demand for training. The five highest-priority topics were the use of approved/recommended management practices (mean = 3.98), integrated pest management (3.97), safe disposal of infested palm material (3.95), management of early-stage infestations (3.89), and recognition of early infestation symptoms (3.88). These topics corresponded closely with those on which growers demonstrated the lowest knowledge levels in the preceding assessment. However, this correspondence represents a descriptive pattern based on aggregated item rankings and was not subjected to statistical testing.

Table 3. Training needs of growers, ranked by mean weighted need score (1-5 scale, N = 120).

Training topic	Mean need score	Rank
Use of approved/recommended management practices (T16)	3.98	1
Integrated pest management (T15)	3.97	2
Safe disposal of infested palm material (T14)	3.95	3
Management of early-stage infestation (T12)	3.89	4
Recognition of early infestation symptoms (T2)	3.88	5
Prevention of RPW infestation and pest spread (T5)	3.60	6
Field-based practical demonstration (T19)	3.53	7
Regular refresher training on RPW (T20)	3.53	7
Proper pruning and management of palm wounds (T7)	3.51	9
Safe movement of offshoots and planting material (T11)	3.50	10
Selection and use of healthy/pest-free planting material (T10)	3.48	11
Pheromone trapping (purpose, placement and monitoring) (T9)	3.47	12
Management of severely infested palms (T13)	3.38	13
Orchard sanitation (T6)	3.29	14
Orchard inspection, monitoring and surveillance techniques (T4)	3.25	15
Prevention of trunk injuries (T8)	3.12	16
Safe pesticide handling and application (T17)	3.06	17
Reporting suspected infestation and coordination with plant protection authorities (T18)	2.46	18
Identification of red palm weevil (adult and larvae) (T1)	2.27	19
Recognition of advanced/severe infestation symptoms (T3)	2.01	20

Overall training-need summary: item mean = 3.36/5; TN_TOTAL = 67.12 (of max. 100); TN_MEAN = 3.36; TN_PERCENT = 67.1%.

The lowest-ranked training needs were recognition of advanced/severe infestation symptoms (mean = 2.01; rank 20) and identification of the weevil itself (mean = 2.27; rank 19), which were also the two competency areas in which growers demonstrated the highest knowledge scores. This inverse pattern is consistent with the interpretation that growers perceive less need for training in areas where they already possess greater knowledge, while prioritizing areas in which their knowledge is comparatively limited. Nevertheless, because the analysis was based on aggregated item-level data, the strength or statistical significance of this relationship could not be formally evaluated.

A related knowledge–practice relationship was reported by Kassem et al. (2020) among date-palm growers in Saudi Arabia, in whom greater knowledge of infestation symptoms was associated with higher adoption of integrated pest management practices. Although this evidence does not establish causality, it supports the rationale for prioritizing training on the topics identified as knowledge gaps. Such targeted capacity-building may enhance growers' ability to recognize infestations at an early stage and implement appropriate management practices, thereby increasing the potential for improved field-level pest management.

Figure 3 makes this alignment clear for eight topics that can be directly matched between the knowledge and training-need scales. For weevil identification and recognition of advanced symptoms, existing knowledge was high (91% and 92% correct, respectively), whereas the reported training need was comparatively low (45% and 40% of the maximum score, respectively). In contrast, pheromone trapping, integrated pest management, and reporting to authorities showed the opposite pattern, with very low knowledge levels (8%, 9%, and 4% correct, respectively) but relatively high training needs (69%, 79%, and 49% of the maximum score, respectively). This crossover pattern, high knowledge accompanied by lower reported training need and low knowledge accompanied by higher reported training need across the same matched topics, is a descriptive feature of the aggregated item-level data. It should not be interpreted as evidence that all topics were uniformly perceived as high-priority training needs or as a statistically tested association between individual growers' knowledge and their perceived training needs.

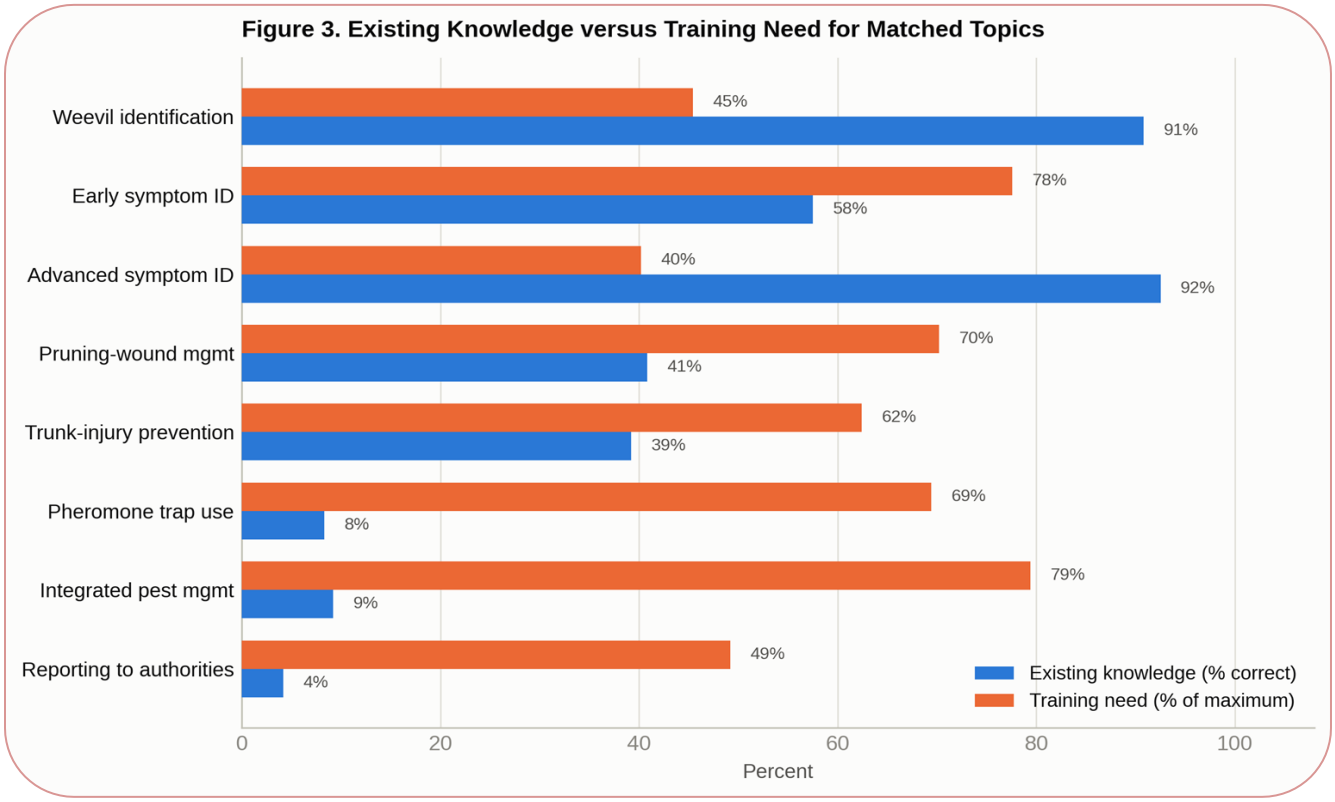


Figure 3. Existing knowledge (% correct) versus training need (% of maximum) for eight matched topics.

Adoption of RPW management practices

Table 4 ranks the 12 pest-management practices according to the percentage of growers who reported currently adopting each practice. Adoption was relatively high for practices involving physical protection of palms and requiring no specialized inputs, including precautions against trunk injury (74.2%; rank 1), recommended pruning practices (71.7%), and the use of healthy or pest-free planting material (65.8%). In contrast, adoption was markedly lower for practices requiring specialized inputs, technical knowledge, or interaction with relevant authorities. Only 7.5% of growers reported using pheromone traps or checking them regularly, 3.3% had attended RPW-related training, and only 1.7% reported suspected infestations to the relevant authorities, making this the least-adopted practice in the survey (Figure 4).

Table 4. Adoption of RPW management practices, ranked by percentage adopting (N = 120).

Practice	n Yes	% Yes	Rank
Takes precautions to prevent trunk injuries (P8)	89	74.2%	1
Uses recommended pruning practices (P7)	86	71.7%	2
Uses healthy/pest-free planting material (P9)	79	65.8%	3
Regularly inspects trunk injuries or wounds (P2)	59	49.2%	4
Regularly inspects date palms for RPW symptoms (P1)	58	48.3%	5
Seeks expert advice when RPW is suspected (P10)	47	39.2%	6
Uses preventive management practices (P3)	41	34.2%	7
Maintains orchard sanitation (P6)	29	24.2%	8
Uses pheromone traps (P4)	9	7.5%	9
Regularly checks pheromone traps (P5)	9	7.5%	9
Has attended any RPW-related training (P12)	4	3.3%	11
Reports suspected infestation (P11)	2	1.7%	12

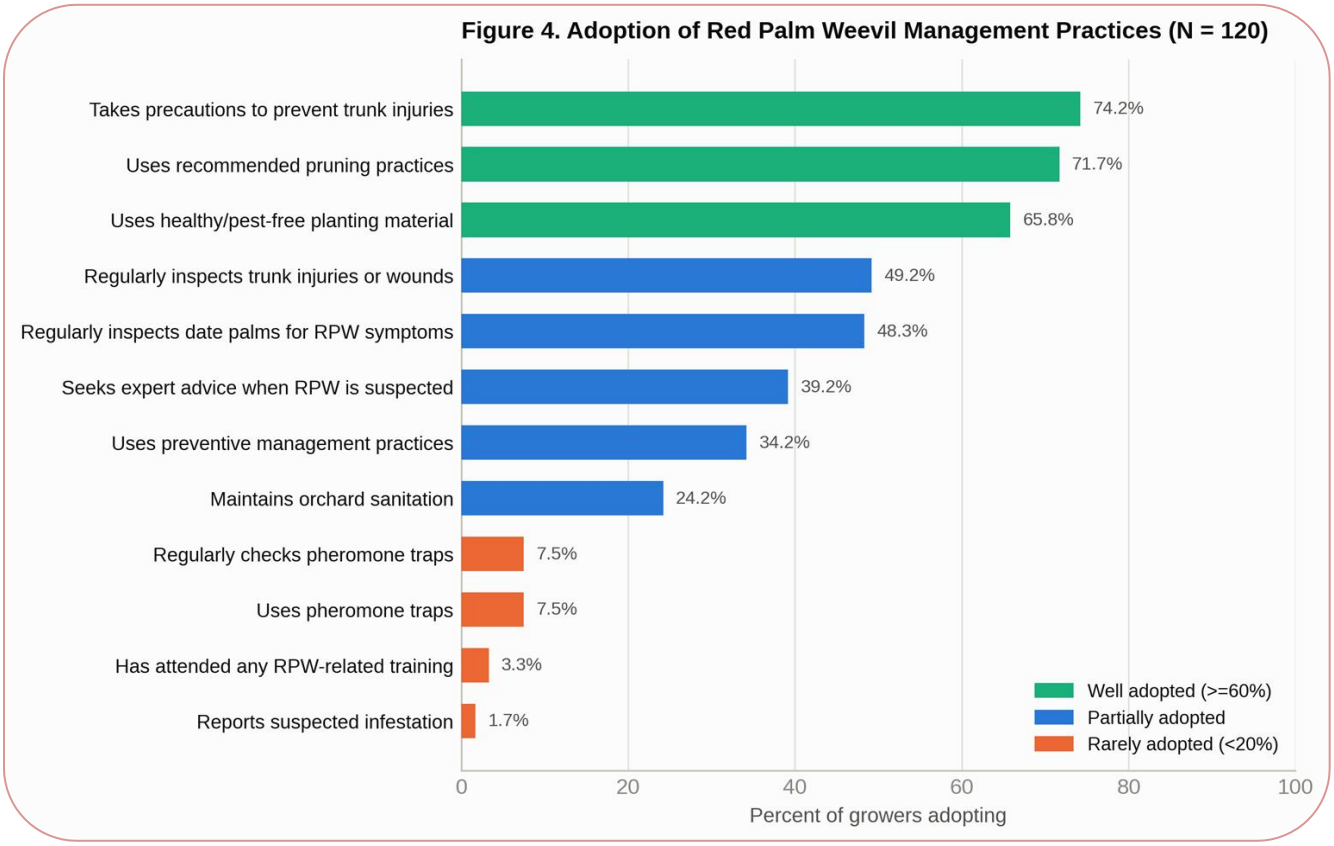


Figure 4. Adoption of RPW management practices (N = 120), grouped by adoption tier. See Table 4 for details.

The very low uptake of pheromone trapping is noteworthy because field trials using the Ferrolure + pheromone lure in date-palm-growing areas of Sindh have demonstrated substantial RPW captures and field efficacy under local conditions (Soomro et al., 2022). Thus, the low adoption observed in the present study may reflect limitations in growers' access to, awareness of, or practical knowledge regarding an intervention whose effectiveness has already been demonstrated locally, rather than an absence of evidence for its efficacy. This adoption pattern closely parallels the knowledge findings: trapping, reporting, and formal training were among the least-adopted practices and corresponded to domains in which growers demonstrated weaker knowledge and expressed greater training needs. The findings are therefore consistent with the possibility that knowledge and training gaps contribute to limited adoption, particularly in the context of very limited extension contact. However, the item-level data describe an association rather than establish causality; determining the relative contribution of knowledge, training, and other factors would require case-level multivariable analysis.

Knowledge and access to training, however, are unlikely to fully explain the observed adoption pattern. The present survey did not measure several structural, economic, and institutional factors that could independently constrain adoption of the least-used practices. Pheromone traps and lures involve recurring costs and depend on local availability, neither of which was assessed. Similarly, access to recommended pesticides, proximity to extension offices and field personnel, orchard characteristics such as planting density and palm age, availability and cost of labor for pruning and the safe disposal of infested material, and the level of RPW infestation experienced on individual holdings could all influence adoption independently of growers' knowledge or training.

The particularly low rate of reporting suspected infestations to plant-protection authorities may also reflect institutional and procedural barriers rather than lack of awareness alone. Potential barriers may include uncertainty about the appropriate authority or reporting procedure, limited confidence that reports will receive a timely response, or concerns about possible regulatory or quarantine-related consequences. These explanations were not directly assessed by the present instrument and should therefore be regarded as reasonable hypotheses rather than established determinants. Overall, the findings indicate substantial variation in the adoption of RPW management practices, with the greatest gaps occurring in practices requiring specialized inputs, technical support, training, or institutional engagement. Future studies should directly measure input affordability and availability, extension access, institutional trust, perceived costs and benefits, labor availability, infestation history, and other farm-level constraints to identify the factors most strongly associated with adoption.

Summary of composite indices

Table 5 summarizes the four composite indices calculated in this study, providing a concise reference for interpretation and facilitating comparisons with findings from other knowledge–attitude–practice (KAP) surveys on red palm weevil (RPW).

Conclusion

This study assessed the knowledge, training needs, and current management practices of 120 date-palm growers concerning RPW across two contrasting production systems in Pakistan. Growers demonstrated substantial experiential knowledge of RPW occurrence and its associated damage; however, a considerable knowledge gap (53.8%) was evident in preventive, monitoring, and institutional aspects of RPW management required for early detection and intervention. The most prominent gaps concerned pheromone-trap use, systematic orchard inspection, IPM, and reporting mechanisms involving plant-protection authorities. These knowledge gaps were broadly reflected in growers' management practices and self-reported training priorities, which converged on a relatively small set of high-priority topics.

Table 5. Summary of composite indices (N = 120).

Index	Value	Interpretation
Mean knowledge score (KNOWTOTAL/25)	11.54 (46.2%)	Just below the moderate midpoint
Mean knowledge gap index (KNOWGAPPCT)	53.8%	Substantial, concentrated in preventive/institutional items
Mean training-need score (TN_MEAN, of 5)	3.36 (67.1%)	Moderately-high to high overall need
Mean practice-adoption rate (12 items)	35.6%	Good for low-input practices; poor for institutional practices

Given the limited contact with formal extension services and the predominant reliance on informal farmer-to-farmer information exchange, a demand-driven, RPW-specific training program is warranted. Priority areas should include: (i) approved management practices and safe disposal of infested plant material; (ii) IPM principles and implementation; (iii) recognition of early infestation symptoms and appropriate early-stage management; (iv) pheromone trapping, including its purpose, placement, and monitoring; and (v) procedures for reporting infestations to plant-protection authorities. Field-based practical demonstrations should constitute a central component of such training, as this was identified as a high-priority training need. A farmer-to-farmer or lead-farmer training-of-trainers approach may also provide an effective mechanism for disseminating RPW management knowledge in production communities where fellow farmers currently constitute the principal information source.

These priorities should, however, be interpreted as evidence-informed guidance derived from the descriptive patterns observed in this study rather than as demonstrated causal relationships. Because the study employed a cross-sectional descriptive design, the findings cannot establish that limited extension contact caused low adoption of recommended management practices, nor can they demonstrate that the proposed training interventions would reduce RPW infestation or spread. These are reasonable, literature-consistent expectations that require direct evaluation through appropriately designed intervention studies, such as pre- and post-training assessments or controlled training trials.

Limitations and future research

Several limitations should be considered when interpreting the findings. First, the study was descriptive by design, and the dataset available for analysis consisted of item-level frequency counts rather than a case-level respondent matrix. Consequently, formal district-wise comparative and correlational analyses, including independent-samples *t*-tests or Mann–Whitney *U* tests, chi-square tests, Pearson or Spearman correlations, and multiple regression, could not be conducted. Similarly, internal-consistency reliability testing, such as Cronbach's alpha, was not possible. Future surveys should retain case-level data for each respondent, thereby enabling formal testing of the associations identified at the descriptive level in this study. Second, the class-interval boundaries applied to continuous respondent characteristics were selected as part of the fully closed-ended survey design; these categories should be validated against the underlying empirical distributions in future studies using continuous measurements. Finally, as with other self-reported survey research, the reported knowledge and management-practice measures may be affected by recall error and social-desirability bias.

Future research should therefore combine case-level survey datasets with longitudinal or intervention-based designs to determine the factors associated with RPW-management adoption and to evaluate whether targeted, field-based training produces measurable improvements in growers' knowledge, surveillance practices, reporting behavior, and adoption of recommended management measures.

Author's Contributions

The author conceived and designed the study, collected and analyzed the data, interpreted the results, formulated the conclusions, reviewed and verified all AI-assisted outputs, and wrote the manuscript, assuming full responsibility for its accuracy, integrity, and content.

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Conflict of Interest

The authors declare no conflict of interest.

Sustainable Development Goals Targeted

SDG 2: Zero Hunger
SDG 8: Decent Work and Economic Growth
SDG 12: Responsible Consumption and Production

Policy Addressed

Integrated Pest Management (IPM); agricultural extension and farmer training; plant pest surveillance and early warning; pest reporting and regulatory coordination; date-palm health and biosecurity; pheromone-based pest monitoring; sustainable crop protection; and participatory agricultural extension.

References

Abraham, V.A., Al Shuaibi, M.A., Faleiro, J.R., Abozuhairah, R.A., Vidyasagar, P.S.P.V., 1998. An integrated management approach for red palm weevil, *Rhynchophorus ferrugineus* Oliv., a key pest

of date palm in the Middle East. Journal of Agricultural and Marine Sciences 3, 77-83.

Ata, S., Shahbaz, B., Ahmad, M., Khan, I.A., 2012. Factors hampering date palm production in the Punjab: A case study of D.G. Khan district. Pakistan Journal of Agricultural Sciences 49, 217-220.

Cronbach, L.J., 1951. Coefficient alpha and the internal structure of tests. Psychometrika 16, 297-334.

Elkahky, M., Faleiro, J.R., 2020. Red palm weevil: Guidelines on management practices. Food and Agriculture Organization of the United Nations, Rome.

Faleiro, J.R., 2006. A review of the issues and management of the red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Rhynchophoridae) in coconut and date palm during the last one hundred years. International Journal of Tropical Insect Science 26, 135-154.

Kassem, H.S., Alotaibi, B.A., Ahmed, A., Aldosri, F.O., 2020. Sustainable management of the red palm weevil: The nexus between farmers' adoption of integrated pest management and their knowledge of symptoms. Sustainability 12, 9647.

Manzoor, M., Ahmad, J.N., Ahmad, J.N.A., Naqvi, S.A., 2020. Population dynamics, abundance and infestation of the red palm weevil, *Rhynchophorus ferrugineus* (Olivier), in different geographical regions of date palm in Pakistan. Pakistan Journal of Agricultural Sciences 57, 381-391.

Solangi, N., Abul-Soad, A.A., Jatoi, M.A., Mirani, A.A., Markhand, G.S., 2024. Date palm cultivation, consumption and export: Current status and future challenges - A review. Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences.

Soomro, M.H., Mari, J.M., Nizamani, I.A., Gilal, A.A., 2022. Performance of Ferrolure + pheromone in the red palm weevil, *Rhynchophorus ferrugineus* (Coleoptera: Dryophthoridae), management in date palm growing areas of Sindh, Pakistan. Journal of the Saudi Society of Agricultural Sciences 21, 114-124.

Witkin, B.R., Altschuld, J.W., 1995. Planning and Conducting Needs Assessments: A Practical Guide. Sage Publications, Thousand Oaks, CA.

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