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Research Article

Understanding Citrus Growers Views on Protection Problems and Mitigation Strategies in Punjab, Pakistan

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ABSTRACT

Increasing population pressure necessitates greater food production for a sustainable future, yet the prevalence of insect pests and diseases intensifies competition for critical resources. Pakistan has recorded substantial losses due to disease infestations, particularly affecting citrus crops. Citrus fruits are among the most widely cultivated and economically important agricultural commodities globally. However, various pests, diseases, and environmental factors significantly impact the production and quality of citrus fruits. This study aims to comprehensively analyze the major insects, diseases, and other factors that affect the protection of citrus crops, as well as the strategies that growers employ to mitigate these challenges. Therefore, the present study explored the major diseases, insects, and other factors affecting citrus protection. One hundred fifty respondents were selected using a Multistage random sampling technique under a survey-based research design. Findings indicate that most of the respondents were above the age of 40, and a significant portion of the population has education above the matriculation level. Citrus fruit fly, citrus leaf miner and psylla were the major insects affecting citrus protection. Citrus white fly, citrus caterpillar, citrus red scale, and citrus black fly also harm the citrus orchards. Findings also indicate that the major diseases affecting citrus protection were Citrus Canker, Gummosis, Citrus Melanose and Citrus Scab. Moreover, the study revealed that awareness about advanced protection practices, incomplete knowledge regarding the identification of insects and diseases, high cost of chemicals, poor quality of pesticides and unwise application of spraying were the major factors affecting citrus protection. This study also identifies that the coping strategies adopted by the growers to protect citrus were IPM practices, chemical control, biological control, insect control nets, use of resistant varieties, crop rotation and crop insurance.

Keywords: Major Diseases, Major Insects, Citrus Protection, Citrus Varieties, Mitigation Strategies.



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Article History

Received: July 30, 2024

Accepted: September 10, 2024

Published: September 17, 2024



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Rawalpindi, Pakistan.

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INTRODUCTION

Pakistan's economy is deeply rooted in its agricultural sector, accounting for a significant 22.96% of its Gross Domestic Product. A diversity of diverse resources, well-irrigated plains, dramatic weather patterns, and a long history of cultivation

characterize the agricultural landscape. Citrus fruits, in particular, play a crucial role in Pakistan's horticulture sector, contributing to domestic and export markets (Shahid et al., 2022). However, the citrus industry in Pakistan faces numerous challenges, including poor harvesting practices, inadequate transportation facilities, insufficient orchard land, poor irrigation management, and the prevalence of major citrus diseases (Naheed et al., 2023). To address these issues, researchers have proposed several strategies to enhance the productivity and sustainability of citrus production in Pakistan.

One of the key recommendations is to strengthen the linkage between growers and farmers, promoting maximum production and establishing an accurate supply chain (Manzoor et al., 2020). This approach aims to improve the efficiency of the citrus industry by fostering collaboration and coordination among various stakeholders. Additionally, training growers in the latest citrus production, protection, and harvesting technologies can help improve the quality and quantity of citrus production (Naheed et al., 2023). Opportunities for the expansion of fruit production in Pakistan include increased market demand, the availability of improved inputs and land availability, access to water resources, and a skilled labor force. However, these opportunities are often hindered by a lack of market-oriented production, inefficient and costly transportation, the absence of fruit market information, and limited government interventions (Urgessa, 2020).

The citrus supply chain in Pakistan has experienced decreasing profits over time. This is due to several variables, including stressors for the supply chain, such as insufficient technical support, a lack of improved varieties, obsolete irrigation systems, disease infestation, and abrupt weather fluctuations. The national economy and growers' livelihoods are losing millions of dollars due to these circumstances (Usman et al., 2018). The quality and appearance of agricultural products are paramount in today's highly competitive markets. Produce with visible flaws or blemishes, often referred to as "cosmetic defects," can be subject to significant rejection rates by exporters. Many agronomic factors, including poor orchard cleanliness, excessive irrigation, dirty harvest equipment, and the movement of plant debris and soil, have been linked to the spread of these cosmetic issues (Kyriacou and Rouphael, 2018).

The quality and yield of citrus fruits can be significantly improved by implementing specialized pruning and foliar application procedures. Recent studies have demonstrated that reducing the total biomass of citrus trees by 8-10% through improved pruning can substantially increase the percentage of high-quality "A" grade fruit and enhanced fruit diameter (Kumar et al., 2018). The fruit industry in Pakistan faces significant challenges in the post-harvest process, resulting in substantial losses and inefficiencies. Recent reports indicate that a staggering 40% of the country's fruit production is lost during the post-harvest stage. This loss is attributed to a combination of factors, including poor harvesting techniques, harvest delays, unfavorable weather conditions, and a lack of disease management. The post-harvest losses not only reduce the availability of fruits but also increase the per-unit cost of production and marketing, affecting both producers and consumers (Jadhav et al., 2020).

The citrus crop holds substantial economic importance, yet its current condition is under threat due to an array of issues, including reduced yields stemming from various diseases (Kumar et al., 2018). The low yield per hectare can be attributed to the ineffective control of pests such as citrus leaf miner, as well as diseases like root rot, and citrus canker (Cheng et al., 2020). These pests and diseases diminish citrus yield, also diminish citrus yield, and degrade fruit quality. Furthermore, the lack of knowledge among citrus growers regarding effective disease control and plant protection strategies compounds the challenges facing the citrus industry, as the inability to properly address these issues results in continued yield losses and quality degradation. Integrated disease management strategies, incorporating cultural practices, chemical applications, and natural plant defense mechanisms' exploitation offer promising solutions to address these challenges and optimize citrus yield and quality (Deng et al., 2020). This substantial difference highlights a significant production gap between current and potential yields. This gap is primarily attributed to various factors, with insect pests and diseases being the most prominent.

MATERIALS AND METHODS

The citrus industry in Pakistan is a significant contributor to the country's agricultural landscape, with the province of Punjab accounting for the majority of the nation's production. Sargodha, a region characterized by its flat and fertile plains, has emerged as the premier citrus-producing area in the country due to its favorable climatic conditions (Nadeem et al., 2022).

The climate in Sargodha and related regions is marked by extreme seasonal variations, ranging from scorching summer temperatures reaching up to 50°C (122°F) to freezing winters. This climate pattern has made this region an ideal location for citrus cultivation, as the crop thrives in these conditions. (Shahzad et al., 2021). Consequently, this study was conducted in Tehsil Mankera of District Bhakkar, which is in South Punjab nearly related to the Sargodha

Region, where citrus farming is the predominant occupation of the local Farmers.

Sampling Procedure and Sample Size

The current study employed a multistage random sampling technique due to time and financial resource constraints. District Bhakkar consist of four tehsils. Of these four tehsil, Mankera was selected as a study area because citrus is intensively grown here. There are total of 8 Union Councils (2 Urban and 6 rural) in tehsil Mankera, from 6 rural UCs three rural union councils were selected randomly. From each selected union Council 2 villages was selected randomly. From each selected village 25 citrus growers were selected randomly. Thus, a sample size of 150 respondents was obtained.

Instrumentation and Data collection

The structured interview schedule was used for the data collection from the study participants. The instrument was quantitative and a 5-point Likert scale was used for the collection of responses from the respondents. The five-point Likert scale used was 1: strongly disagree 2: disagree 3: undecided 4: Agree 5: Strongly agree. For validity checking the instrument was checked by one expert from the Institute of Agricultural Extension, Education and Rural Development University of Agriculture Faisalabad and one expert from the Institute of Horticultural Sciences, University of Agriculture Faisalabad. Based on their suggestion minor changes were incorporated in the paper. This improved instrument was pre-tested on 20 respondents who were not the part of sample size. The reliability of the instrument was checked using Cronbach alpha technique and the value appeared 0.742, endorsing the reliability of the instrument.

Data Analysis

The data collected were analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistical methods, such as frequencies, percentages, Mean and Standard deviation, were employed for analysis. Based on the data collected using a 5-point Likert scale, means and standard deviations were calculated. The obtained mean value explained where the respondents rated their responses on a scale.

RESULTS AND DISCUSSION

Demographic attributes of respondents

The data in in Table 1, provides a detailed snapshot of the population under study, encompassing various aspects such as age, education, farming experience, tenancy status, land holdings, and citrus area.

The data in the Table indicates that most of the respondents (72%) falls within the 41-60 age range, with the remaining 28% in the 20-40 age group. This age distribution aligns with a study by the World Bank, which identified the 46-year-old average age group as the effective workforce among Asian countries (Sivatharshika and Thayaparan, 2019). According to the data in the table, the population's educational attainment is diverse, with a significant proportion (46%) having an educational level above matriculation, while 12% are illiterate. Previous research has shown that demographics, including educational level, play a role in representing and defining a country, especially when identifying and redefinition food heritage toward national identity (Ramli et al., 2020). The farming experience of the population is also varied, as shown in the table majority (42%) have 10-20 years of experience. This finding is consistent with research on small-holder farmers in Sri Lanka, which revealed an average farming experience of 15 years (Sivatharshika and Thayaparan, 2019). Regarding tenancy status, the data shows that the majority are landowners, with a smaller proportion being tenants or owner-cum-tenants. The land holdings of the population are predominantly in the 6-15 acre range, with a smaller percentage having larger holdings. Regarding the citrus-cultivated area, the data indicates that the majority of the population cultivates between 1-15 acres of citrus, with a smaller proportion of the respondents having larger citrus cultivated area areas.

Major Insects/pest of Citrus

The Table 2 comprehensively analyzes the insect commonly found in citrus crops, highlighting their respective mean values, standard deviations, and overall rankings. The Citrus fruit Fly emerges as the most prominent pest, ranking first with a mean value of 4.91 and a standard deviation of 0.407, indicating its significant impact on citrus crops. The citrus leaf miner follows closely, ranking second with a mean value of 3.93 and a standard deviation of 0.642, suggesting it is also a major threat to citrus protection. The citrus psylla, with a mean value of 2.99 and a standard deviation of 0.384, ranks third, highlighting its relatively lower impact than the top two pests. The citrus white fly, with a mean value of 1.94 and a standard deviation of 0.508, ranks fourth. In contrast, the Citrus Caterpillar occupies the fifth position with a mean value of 1.45 and standard deviation of 0.808.

The current study shows that citrus fruit fly have the worst impact on citrus, and these findings aligns with Gandarilla-

Pacheco et al. (2013) they found that Citrus Fruit Fly was a major threat to citrus crop, causing significant damage to fruit yields and quality. As studies of Chithambarathanu and Jeyakumar (2023) showed that the Citrus leaf miner can severely impact citrus trees, reducing photosynthetic capacity and ultimately, diminishing crop yields.

Table 1. Demographic attributes of respondents.

	<i>f</i>	%
Age		
20-40	42	28.0
41-60	108	72.0
Total	150	100.0
Education		
Illiterate	18	12.0
Middle	38	25.3
Matriculation	25	16.7
above Matriculation	69	46.0
Total	150	100.0
Farming Experience		
less than 10	53	35.3
10-20	63	42.1
21-30	20	13.3
more than 30	14	9.3
Total	150	100.0
Tenancy Status		
Owner	115	76.6
Tenant	10	6.8
Owner cum tenant	25	16.6
Total	150	100.0
Land Holdings		
less than 5 acres	23	15.3
6-15 acre	96	64.0
16-25 acre	20	13.3
above 25 acre	11	7.3
Total	150	100.0
Citrus Cultivated Area		
1-5 acres	47	31.3
6-10 acres	38	25.3
11-15 acres	44	29.3
16-20 acres and above	21	14.0
Total	150	100.0

Major diseases of citrus

Table 3 shows that Citrus Canker, with the highest mean severity of 4.83 and a relatively low standard deviation of 0.471, is ranked as the most severe disease in citrus orchards in South Punjab region. Citrus Canker further indicates a high significance level in the observed disease severity. Gummosis, the second-ranked disease, exhibits a mean severity of 4.01 and a standard deviation of 0.259, suggesting a lower but still significant level of disease impact compared to Citrus Canker. Citrus Melanose and Citrus Scab, with mean severities of 2.37 and 2.34, respectively, are ranked as the third and fourth most severe diseases. The high mean and standard deviation for Citrus Canker and Gummosis suggest that they are more prevalent and destructive citrus fruit diseases than Citrus Melanose and Citrus Scab. The current study's findings align with those (Roistacher, 2004), who stated that the Citrus Canker, in

particular, is known to be a major threat to citrus production in warmer and drier regions.

Table 2. Major Insects/pest of citrus

Insects/pests	Mean	S. D.	Rank
Citrus fruit Fly	4.91	.407	1
Citrus Leaf miner	3.93	.642	2
Citrus psylla	2.99	.384	3
Citrus White Fly	1.94	.508	4
Citrus Caterpillar	1.45	.808	5
Citrus Red scale	1.21	.591	6
Citrus Black Fly	1.16	.368	7

1: strongly disagree 2: disagree 3: undecided 4: Agree 5: Strongly agree

Table 3. Major diseases of citrus.

Diseases	Mean	S.D	Rank
Citrus Canker	4.83	.471	1
Gummosis	4.01	.259	2
Citrus Melanose	2.37	.756	3
Citrus Scab	2.34	.622	4

1: strongly disagree 2: disagree 3: undecided 4: Agree 5: Strongly agree

Table 4. Constraints that are affecting the protection of citrus.

Protection Problems	Mean	S.D	Rank
Awareness of advanced protection Practices	4.08	.790	1
Incomplete knowledge regarding the identification of insects and diseases	3.92	.276	2
High Cost of Chemicals	3.67	.471	3
Poor quality of pesticides	3.63	.639	4
Unwise application of spraying	3.11	.677	5
Extension Advisory Services	3.08	.271	6
Lack of finance	1.05	1.253	7
Lack of labor	.77	1.419	8
Incomplete knowledge regarding the calibration of spray machines	.42	1.171	9
Availability of Equipment	.35	1.112	10
Availability of insect-resistant varieties	1.00	1.622	11

1: strongly disagree 2: disagree 3: undecided 4: Agree 5: Strongly agree

Constraints that affect the protection of citrus

Data given in Table 4 reveals that the top constraint farmers face is the "Awareness about advanced protection Practices," with a mean score of 4.08 and a standard deviation of 0.790. This shows that the farmers of this region were less aware about advanced protection practices. The second-ranked constraint is "Incomplete knowledge regarding identification of insects and diseases," with a mean score of 3.92 and a standard deviation of 0.276. The third-ranked constraint is "High Cost Of chemicals," with a mean score of 3.67 and a standard deviation of 0.471. The fourth-ranked constraint is "Poor quality of pesticides," with a mean score of 3.63 and a standard deviation of 0.639. The fifth-ranked constraint is "Unwise application of spraying," with a mean score of 3.11 and a standard deviation of 0.677. The remaining constraints, such as "Extension Advisory Services," "Lack of finance," "Lack of labor," "Incomplete knowledge regarding calibration of spray machines," "Availability of Equipment's," and "Availability of insect resistant varieties," also present significant challenges for farmers in implementing effective protection practices.

The data presented in the Table 4 provides insights into the key constraints faced by farmers. The top-ranked constraint is the lack of awareness about advanced protection practices. This suggests a need for more effective extension and training programs to disseminate information and knowledge to farmers. As suggested by Mpandeli and Maponya (2014), farmers have limited knowledge and understanding of advanced protection practices, which hinders their ability to manage pests and diseases effectively. Additionally, incomplete knowledge regarding the identification of insects and diseases and the calibration of spray machines indicate gaps in technical expertise that need to be addressed (Begho et al., 2022). The high cost of chemicals and the poor quality of pesticides are also significant barriers, highlighting the importance of ensuring the availability of affordable and reliable plant protection solutions. As stated in the previous studies by (Kadango et al., 2020) the high cost of chemicals used for protection is a significant barrier for farmers, potentially limiting their ability to invest in necessary protection measures. The unwise application of spraying, which can lead to ineffective pest management and environmental concerns, further underscores the need for farmer education and the promotion of sustainable pest control methods. This constraint suggests that farmers may not be effectively applying pesticides and other protection measures, leading to suboptimal results and potential negative impacts on the environment and non-target organisms (Das and Pattanayak, 2020).

Table 5. Mitigation strategies adopted by citrus growers regarding the protection of citrus

Mitigation Strategies	Mean	S.D	Rank
IPM Practices	4.73	1.003	1
Chemical Control	4.01	.306	2
Cultural control	3.84	.368	3
Value addition	3.94	.231	4
Mechanical Control	3.02	.511	5
Land Leveling	1.83	.809	6
Loaning	1.34	.826	7
Forward contract	1.32	.790	8
Insect Controlling Nets	1.08	.393	9
Use of Resistant varieties	1.79	1.352	10
Biological Control	1.06	.438	11
Crop Insurance	1.00	.000	12

1: strongly disagree 2: disagree 3: undecided 4: Agree 5: Strongly agree

Mitigation strategies adopted by citrus growers regarding the protection of citrus

Punjab smallholder farmers often face significant challenges due to climate variability, crop failures, and economic hardships. In response, they have developed a range of Mitigation strategies to ensure their livelihoods and food security. Table 5 indicates that the most widely used coping strategy is IPM Practices, with a mean score of 4.73 and a standard deviation of 1.003, suggesting a high level of adoption among the farmers. Chemical Control and Cultural control are the next two most commonly employed coping strategies, with mean scores of 4.01 and 3.84, respectively. The main reason behind high adaptability of these coping strategies is that the farmers want quick and good results so they apply IPM and chemical control (different pesticides) to their crops. On the other hand, the table shows that some coping strategies, such as resistant varieties, crop rotation, and biological control, have relatively lower mean scores, suggesting a lower level of adoption among the farmers.

The findings of the current studies align well with a recent study in semi-arid regions of Northern Ghana, which emphasized the importance of integrated pest management practices as a key coping strategy for smallholder farmers (Boansi et al., 2023). The present study's findings are consistent with observations made in a study conducted in East Hararghe Zone, Ethiopia, where smallholder farmers reported using a combination of chemical and cultural methods to mitigate the impacts of climate change-induced shocks. Findings of the current study indicate the need for further research and extension efforts to promote the adoption of these more sustainable and environmentally-friendly coping strategies also highlights the importance of resource management and diversification as key adaptation strategies for farmers.

CONCLUSIONS

Based on the findings it is concluded that the majority of the respondents are above the age of 40 and a significant portion of the population have education above the matriculation level. Citrus fruit fly and citrus leaf miner are the major insects of citrus, while Citrus canker and gummosis are the major diseases of citrus. The main protection problems of the citrus are the Awareness of advanced protection Practices, Incomplete knowledge regarding the identification of insects and diseases, High Cost Of chemicals, and Poor quality of pesticides. On the other hand, the coping strategies the farmer uses are IPM Practices, Chemical Control, Cultural control, Value addition, and Mechanical Control.

To improve their technical skills, growers need comprehensive training, access to investment funds, and high-quality chemicals for better protection. Introducing affordable micro-credit schemes in the area would support technology adoption for this vital fruit. Many growers rely on expensive chemicals and would benefit from education on biological control methods. Regular monitoring of pest populations, particularly during peak infestation times, is crucial to promote the use of bio-control methods over chemicals. Extension workers and experts in plant protection will be essential to this initiative. Additionally, research in specialized laboratories should be initiated to identify the most effective strategies for controlling infestations on a detailed level.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

The authors declare no competing interests.

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