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ASSESSING AWARENESS AND ADOPTION LEVELS OF SUSTAINABLE COTTON PRODUCTION PRACTICES AMONG COTTON GROWERS IN PUNJAB, PAKISTAN

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ABSTRACT

The economy of Pakistan is intricately tied to the agriculture sector, with cotton playing a pivotal role in economic development. As a significant contributor to the textile industry, cotton accounts for over 50% of the country's total exports and 5.2% of agriculture's value addition. However, the reliance on conventional cotton production practices has led to environmental challenges due to the indiscriminate use of chemical pesticides and fertilizers. To address these issues and align with global sustainability initiatives, this study assessed the awareness and adoption levels of sustainable cotton production practices among cotton growers in Punjab, Pakistan. The primary objective of this research was to assess the awareness and adoption levels of Sustainable Cotton Production Practices among cotton growers in Punjab, Pakistan. To achieve this, a mixed-methods approach was employed, integrating both qualitative and quantitative data collection techniques. The study population consisted of Learning Groups (LGs) participating in sustainable cotton production under the Lok Sanjh Foundation (LSF) in selected districts. A multistage sampling technique was used, with purposive and random sampling ensuring a representative sample of 400 respondents. Quantitative data was gathered through semi-structured interviews guided by an interview schedule comprising Likert scale questions. These questions probed respondents' strategies for insect pest control, precautionary measures during pesticide application, fertilizer preferences, soil sampling awareness, and perceived barriers and enablers for sustainable cotton production practices. Additionally, qualitative data was collected through key-informant interviews and focus group discussions, offering deeper insights into the subject matter. Statistical analysis of quantitative data using the Statistical Package for Social Sciences (SPSS) software revealed the distribution of responses and levels of awareness and adoption among cotton growers. Content analysis of qualitative data highlighted recurring themes, shedding light on hindering and supportive factors that influence the adoption of sustainable practices. The findings of this study revealed that cotton growers employ diverse strategies for insect pest control, including the integration of techniques learned through Sustainable Cotton (SC) and Learning Group (LG) training. These strategies ranged from cultural practices to biological pest control methods, showcasing a willingness to explore alternatives to chemical pesticides. Respondents emphasized the importance of precautionary measures during pesticide application. The findings highlighted a significant awareness gap regarding the responsible use of chemical pesticides, indicating the need for targeted educational interventions to ensure safer pesticide handling. The research identified a preference for both chemical and organic fertilizers among cotton growers. However, respondents demonstrated limited knowledge of sustainable fertilizer management practices and soil sampling techniques, indicating a potential area for capacity building and training to enhance soil health. The study revealed a range of factors hindering the adoption of sustainable cotton production practices, including inadequate access to resources, limited technical know-how, and concerns about initial costs. On the positive side, cotton growers perceived supportive factors such as improved soil quality, reduced environmental impact, and potential economic benefits as incentives for adopting sustainable practices.

Keywords: Cotton farming, soil health, pest management, sustainable agriculture, Lok Sanjh Foundation (LSF), Better Cotton Initiative (BCI)

INTRODUCTION

The economy of Pakistan is mainly dependent on the agriculture sector and the livelihoods of the people living in rural areas are both directly and indirectly dependent on agriculture. (Govt. of Pakistan, 2021-22). In Pakistan, it contributes almost 60% to the country's exports and supports approximately 45% of the country's workers (Syed *et al.*, 2022). It also contributes to 22.7% to the GDP and provides employment around 37.4%. The major important crops wheat, sugarcane, maize, rice and cotton contribute 19.44% to value addition in agriculture sector and 4.41% to Pakistan's GDP which is the 5th largest producer of cotton in the world. Exports of cotton and textile products have a share of around 60 percent in overall exports of the country. It contributes around 0.6% to GDP and 2.4% of the value added in agriculture (Economic Survey of Pakistan, 2022-23).

The most extensively used natural fiber is cotton (Bedi and Cororaton, 2008). The cotton belt of Pakistan extends approximately 1200 kilometers along the Indus River between latitudes 27°N and 35°N and 27 to 155 meters altitudes. All Pakistani provinces produce cotton but Punjab and Sindh provinces contributes major share in production (Zulfiqar and Thapa, 2017). Cotton and textile exports are the backbone of Pakistan's economy (Ali *et al.*, 2022).

Cotton production is directly linked with cotton support price trend, prices of inputs and weather changes. These all have a significant impact on cotton production. Various inputs are used during the production process. Inputs required in the cotton production process include land preparation, labor, and inputs including labor, irrigation water, fertilizer, and pesticides. Every input in cotton cultivation is important to get maximum yield. Land preparation is an important step in cotton production. The remaining inputs include seed, irrigation water, fertilizer, and plant protection methods. All these inputs are vital to cotton production. The price of these inputs has affected Pakistan's cotton production (Ali *et al.*, 2012).

Cotton cultivation in Punjab, Pakistan, serves as a crucial economic activity, contributing significantly to the nation's textile industry and supporting the livelihoods of numerous farmers. However, the traditional practices employed in cotton production have raised concerns about their long-term sustainability, given their adverse environmental impacts and economic limitations. To address these challenges and promote a more sustainable cotton sector, the adoption of sustainable cotton production practices is becoming increasingly important.

This research study aims to assess the levels of awareness and adoption of sustainable cotton production practices among cotton growers in Punjab, Pakistan. The study focuses on understanding the strategies used to control insect pests, the precautionary measures taken during pesticide application, the types of chemical and organic fertilizers utilized, the awareness and knowledge of soil sampling techniques, as well as the hindering and supportive factors influencing the adoption of recommended sustainable cotton production practices.

MATERIALS AND METHODS

Research Design

This study employs a mixed-methods research design to comprehensively assess the awareness and adoption levels of sustainable cotton production practices among cotton growers in Punjab, Pakistan. The study integrated both qualitative and quantitative data collection techniques to gain a holistic understanding of the subject matter.

Population

The population for this research consisted of all Learning Groups (LGs) participating in sustainable cotton production under the Lok Sanjh Foundation (LSF) in district Bahawalnagar and Toba Tek Singh of Punjab, Pakistan.

Sampling Technique

The multistage sampling technique was used to select the study sample. Purposive sampling was employed to select the cotton-growing districts with registered sustainable cotton growers trained by various implementing partners under the Better Cotton Initiative (BCI). Districts Bahawalnagar and Toba Tek Singh were purposively chosen due to their high number of registered sustainable cotton growers.

Selection of Learning Groups (LGs)

Two tehsils from each selected district were randomly chosen. Ten Learning Groups (LGs) were then selected from each tehsil, resulting in a total of 40 LGs for the study.

***Sample Size*:** To achieve a total sample size of 400 respondents, ten farmers were randomly selected from each Learning Group (LG), comprising a mix of small-scale, medium-scale, and large-scale cotton growers.

DATA COLLECTION

Quantitative Data

A semi-structured interview schedule was employed to collect quantitative data from the selected cotton growers. The interview schedule included Likert scale questions pertaining to various aspects of sustainable cotton production practices, such as strategies for pest control, pesticide application, fertilizer use, soil sampling, and adoption factors.

Qualitative Data

Qualitative data was collected through key-informant interviews and focus group discussions. Key-informant interviews were conducted with representatives from Lok Sanjh Foundation (LSF) and other relevant stakeholders. Focus group discussions were held with selected members from the Learning Groups (LGs) to delve deeper into their perspectives on sustainable cotton production practices and challenges faced.

DATA ANALYSIS

Quantitative Data

The collected quantitative data were analyzed using the Statistical Package for Social Sciences (SPSS) software. Descriptive statistics such as frequencies and percentages were used to analyze the responses to Likert scale questions, offering insights into the awareness and adoption levels of sustainable cotton production practices.

Qualitative Data

The qualitative data obtained from key-informant interviews and focus group discussions were analyzed using content analysis. Themes, patterns, and recurring narratives were identified to extract meaningful insights into the hindering and supportive factors affecting the adoption of sustainable cotton production practices.

Ethical Considerations

Ethical approval was obtained from the relevant research ethics committee before data collection. Informed consent was obtained from all respondents participating in the study, ensuring their voluntary participation, and understanding the purpose of research.

Limitations

The findings of study x were context-specific and may not be fully generalizable to other regions or countries. The self-reporting nature of the responses may introduce bias, despite efforts to minimize it through careful data collection.

RESULTS

Awareness and Adoption Levels

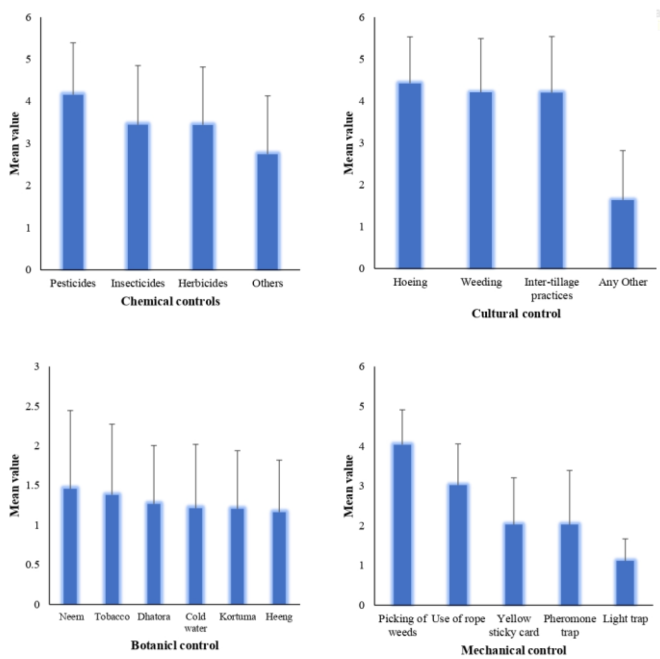
The results of the study revealed the current levels of awareness and adoption of sustainable cotton production practices among cotton growers in Punjab. The Likert scale responses were aggregated and analyzed to determine the percentage of respondents with high, moderate, and low levels of awareness and adoption.

Strategies for Insect Pest Control

The interviews provided insights into the various strategies adopted by cotton growers to control insect pests, including the integration of SC and LG training. Common practices and their effectiveness were discussed. Sustainable cotton production has become increasingly important in recent years due to the need for environmental protection, social development, and economic sustainability. Insect pests are one of the major challenges facing cotton production, and their control is essential for achieving sustainable cotton production goals. One effective strategy for controlling insect pests is through participation in sustainable cotton LGs (Local Groups) training. LGs are community-based organizations that provide training, information, and support to farmers on sustainable cotton production practices. By participating in LG training, farmers can learn about integrated pest management (IPM) practices, such as the use of biocontrol agents, crop rotation, and intercropping, that reduce the need for synthetic pesticides and promote natural pest control. Results regarding strategies to control insect pests are given in Figure 1.

Figure 1.

Strategies to control insect pests by participating in sustainable cotton LGs trainings.



Results regarding strategies to control insect pest by participating in sustainable cotton (SC) and learning group (LG) trainings in Figure 1 show that in the chemical control, respondents ranked "pesticides" ($\bar{x}$=4.1600, 1.23215) at 1^{st} position followed by "insecticides" ($\bar{x}$=3.4475, 1.40434), "weedicides/herbicides" ($\bar{x}$=3.4450, 1.37357), "others" ($\bar{x}$=2.7500, 1.3831) at 2^{nd}, 3^{rd} and 4^{th} position respectively. In the botanical control, respondents ranked "extract of neem" ($\bar{x}$=1.4574, 0.98774) at 1^{st} position followed by "use of tobacco solution" ($\bar{x}$=1.3825, 0.89060), "extract of dhatora" ($\bar{x}$= 1.2675, 0.73641), "use of cold water" ($\bar{x}$=1.2125, 0.80558), " use of kortuma solution" ($\bar{x}$= 1.2050, 0.73439), "use of heeng solution" ($\bar{x}$=1.1650, 0.65486) at 2^{nd}, 3^{rd}, 4^{th} , 5^{th} and 6^{th} positions categorically. In the use of cultural control, respondents ranked "hoeing" ($\bar{x}$=4.4225, 1.28534) at 1^{st} position followed by "weeding" ($\bar{x}$=4.2050, 1.28534), "inter-tillage practices" ($\bar{x}$=4.1975, 1.34089), "other" ($\bar{x}$=1.6375, 1.17880) at 2^{nd}, 3^{rd} and 4^{th} position categorically. In the use of mechanical control, respondents ranked "hand picking of weeds" ($\bar{x}$=4.0350, 0.87790) at 1^{st} position followed by "use of rope" ($\bar{x}$=3.0225, 1.03182), "use of yellow sticky card" ($\bar{x}$=2.0275, 1.17695), "pheromone trap" ($\bar{x}$=2.0275, 1.36065), "light trap" ($\bar{x}$=1.1175, 0.55177) at 2^{nd}, 3^{rd}, $4^{th,}$ and 5^{th} positions categorically.

Strategies to control insect pests

To confirm the appropriateness of PCA a Bartlett Test of Sphericity (BTS) and a Kaiser–Meyer–Olkin (KMO) was employed to find out the strategies to control insect pests in sustainable production of cotton in this study. Results showed the value of BTS at 1669.9 and its level of significance, which indicates that the data were appropriate for Principal Component Analysis (PCA). The value of KMO is 0.54, indicating that there are enough items for each factor (Table 1). We have selected a total of 19 relevant variables for our analysis (Table 2). The eigenvalue of the first component of two items is 40.8 and accounts for the variance of 26.0% (Table 2).

It is evident in rotated component matrix (Table 3) that the first component consists of two items. The constraints included in this component are hoeing (0.69) and weeding (0.66). The sum of the factor loading of component 1^{st} is 1.35. Component one is labelled as "cultural control". The eigenvalue of the second component consists of two items is 18.8 and accounts for the variance of 81.0% (Table 2). It is apparent in RCM (Table 3) that the second component consists of two items. The constraints included in this component are weedicide/herbicide (0.68) and insecticides (0.59). The sum of the factor loading of component 2nd is 1.28. Component two is labelled as “chemical control”. The eigenvalue of the third component consists of two items is 13.1 and accounts for the variance of 110.5%. It is clear in RCM (Table 3) that the third component consists of two items. The constraints included in this component are light traps (0.74) and extract of neem (0.74). The sum of the factor loading of component 3rd is 1.49. Component three is labelled as “mechanical and botanical control”. The eigenvalue of the fourth component consists of two items is 10.6 and accounts for the variance of 132.4% (Table 2). It is obvious in RCM (Table 3) that the fourth component consists of two items. The constraints included in this component are the pheromone trap (0.73) and the use of cold water (0.69). The sum of the factor loading of component 4th is 1.43. Component fourth is labelled as “botanical and cultural Control”. Based on the above empirical findings, the most important strategies to control insect pests in the sustainable production of cotton by mechanical control with a value of (1.486) followed by botanical control (1.437), cultural control (1.359) and chemical control (1.28) including light trap, pheromone trap, extract of neem, hoeing, weeding. weedicide/herbicide and insecticide respectively. Because LSF is working in that area that is why registered cotton growers are using less chemical control method while they are using mechanical control, botanical control and control methods.

Table 1
Bartlett test of Sphericity (BTS) and Kaiser–Meyer–Olkin (KMO) for strategies to control insect pests in sustainable production of cotton.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.540
Bartlett Test of Sphericity Approx. (Chi-Square)	1669.934
Df	171
Sig.	0.000

Table 2
Total variance explained by PCA for strategies to control insects’ pests in sustainable cotton production.

		Initial Eigenvalues	
Components	Total	% of Variance	Cumulative %
1	2.813	14.803	14.803
2	2.145	11.291	26.094
3	1.893	9.964	36.059
4	1.692	8.907	44.965
5	1.415	7.447	52.412
6	1.089	5.732	58.144
7	1.049	5.521	63.665
8	0.969	5.101	68.766
9	0.870	4.581	73.347
10	0.810	4.264	77.611
11	0.702	3.694	81.305
12	0.646	3.399	84.704
13	0.586	3.087	87.790
14	0.571	3.007	90.798
15	0.504	2.654	93.452
16	0.378	1.989	95.440
17	0.349	1.836	97.276
18	0.298	1.571	98.847
19	0.219	1.153	100.000

Figure 2
Screen plot of eigenvalues after Principal Component Analysis (PCA)

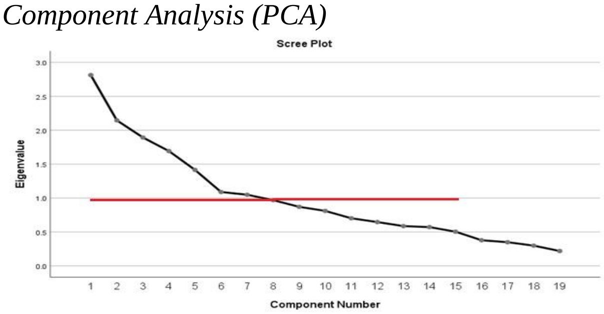


Table 3
Rotated Component Matrix (RCM).

	Components				
Factors	1	2	3	4	Labeling
Light trap			0.749		Mechanical control (1.486)
Pheromone trap				0.737	
Extract of neem			0.741		Botanical control (1.437)

Use of cold water			0.696	
Hoeing	0.693			Cultural control (1.359)
Weeding	0.666			
Weedicide/ herbicide		0.682		Chemical control (1.28)
Insecticides		0.598		

Precautionary Measures for Pesticide Use

Respondents' precautionary measures while spraying chemical pesticides were examined, highlighting safety practices and concerns regarding pesticide exposure. Based on the collected data regarding ranking of issues in use of pesticides and fertilizers weighted score, mean and SD were calculated. Results regarding awareness and adoption level of precautionary measures used while spraying chemical pesticides in the Table 4 show that in the precautionary measures, respondents ranked “direction of wind (should be opposite” ($\bar{x}$=4.4500, 1.07256) at 1st position followed by “keep chemicals out of reach of livestock” ($\bar{x}$=4.2850, 1.27783), “spray according to weather condition” ($\bar{x}$=4.2325, 1.11874), “keeping spray machine and raw pesticide out of reach of children” ($\bar{x}$=4.1275, 1.42700), “time of spray (morning and evening)” ($\bar{x}$=3.9850, 1.34696), “proper disposing bottles” ($\bar{x}$=2.8375, 0.93717), “precautions for spraying person (gloves, washing of mouth and hands with soap) ($\bar{x}$=2.3925, 0.89747) at 2nd, 3rd, 4th, 5th, 6th and 7th position respectively.

Table 4

Mean, standard deviation (SD), Weighted score and rank order regarding the awareness and adoption level of precautionary measures used while spraying chemical pesticides.

Precautionary measures	Mean value	Standard deviation	Weighted score	Rank order
Direction of wind	4.4500	1.07256	356	1
Keeping chemicals out of reach of livestock	4.2850	1.27783	342.8	2
Spraying according to weather condition	4.2325	1.11874	338.6	3
Keeping raw pesticide and spray machine out of reach of children	4.1275	1.42700	330.2	4
Time of spray (morning and evening)	3.9850	1.34696	318.8	5
Proper disposing bottles	2.8375	0.93717	227	6
Precautions for spray man (Washing of mouth, gloves and hands with soap)	2.3925	0.89747	191.4	7

Not at all 2. Rarely 3. Sometimes 4. Often 5. Always

Fertilizer Preferences and Soil Sampling Awareness

The study investigated the types of chemical and organic fertilizers used by cotton growers. Additionally, the extent of awareness and knowledge of soil sampling techniques among respondents were explored.

Use of Chemical fertilizer

Fertilizer is a vital input for crop productivity. Balanced use of fertilizers has a crucial role in increasing crop productivity, efficiency, and farm income. Table 5 shows that respondents ranked “Nitrogen (urea)” ($\bar{x}$=4.4850, 1.11485) at 1st position followed by “Phosphorus (DAP)” ($\bar{x}$=4.2725, 1.34825), “Potash (k)” ($\bar{x}$=2.8125, 0.78030), “Gypsum” ($\bar{x}$=2.3950, 0.88936), “Micronutrients” ($\bar{x}$=1.9500, 0.78997) at 2nd, 3rd, 4th and 5th position respectively.

Table 5

Mean, Standard Deviation, weighted score and rank order regarding the awareness and adoption level of different chemical fertilizers used by respondents.

Chemical fertilizers	Mean value	Standard Deviation	Weighted score	Rank Order
Nitrogen (UREA)	4.4850	1.11485	358.8	1
Phosphorus (DAP)	4.2725	1.34825	341.8	2
Potash (k)	2.8125	0.78030	225	3
Gypsum	2.3950	0.88936	191.6	4
Micronutrients (Zinc, Boron)	1.9500	0.78997	156	5

Not at all 2. Rarely 3. Sometimes 4. Often 5. Always

Use of Organic Fertilizers

The use of organic fertilizer in agriculture is gaining popularity worldwide due to its potential to improve soil fertility, enhance crop productivity, and reduce environmental impacts. Organic fertilizers are derived from natural sources such as plant and animal waste, and they contain a range of nutrients that are essential for plant growth and development. In contrast to synthetic fertilizers, organic fertilizers release nutrients slowly, reducing the risk of nutrient leaching and increasing the availability of nutrients over a longer period. Results regarding the awareness and adoption level of different chemical fertilizers used by respondents in the Table 6 show that in the use of organic fertilizers, respondents ranked "compost (FYM)" ($\bar{x}$=2.2425, 1.07078) at 1st position followed by "green manure" ($\bar{x}$=1.9500, 0.78997), "fermentor" ($\bar{x}$=1.6850, 0.75644), "peat" ($\bar{x}$=1.7200, 0.77337) at 2nd, 3rd and 4th position respectively.

Table 6

Mean, standard deviation (SD), Weighted score and rank order regarding the awareness and adoption level of different organic fertilizers used by respondents.

Organic fertilizers	Mean value	Standard Deviation	Weighted score	Rank Order
Compost (FYM)	2.2425	1.07078	179.4	1
Green manure	1.9500	0.78997	156	2
Fermentor	1.6850	0.75644	134.8	3
Peat	1.7200	0.77337	137.6	4

1. Not at all 2. Rarely 3. Sometimes 4. Often 5. Always

Soil Sampling Technique

Table 7

Distribution of the respondents according to their awareness regarding how to take soil samples.

Response	Frequency	Percent
Yes	47	11.8
No	353	88.3
Total	400	100.0

Awareness Regarding Soil Sampling Technique

Table 8

Distribution of respondents according to their awareness level regarding soil sampling technique

Response	Frequency	Percent
Not at all	93	23.3
Rarely	264	66.0
Sometimes	25	6.3
Often	6	1.5
Always	12	3.0
Total	400	100.0

Not at all 2. Rarely 3. Sometimes 4. Often 5. Always

Hindering and Supportive Factors

Based on the Likert scale responses and interview data, hindering and supportive factors influencing the adoption of sustainable cotton production practices were identified and analyzed.

Table 9

Mean, Standard Deviation (SD), Weighted Score and Rank Order regarding the extent of hindering factors.

Hindering factors	Mean value	Standard Deviation	Weighted score	Rank Order
Lack of training	3.9550	1.19228	316.4	1
Lack of financial resources	3.4100	.99970	272.8	2
Lack of knowledge	3.3350	1.41342	266.8	3
Less production	3.1475	1.53023	251.8	4
Small land holding	3.1375	1.44354	251	5
Others (Specify)	3.0250	1.24831	242	6
Lack of labor	2.7525	1.51558	220.2	7
Lack of interest	1.9650	1.6799	157.2	8

1. Not at all 2. To Some Extent 3. Moderate Extent 4. High Extent 5. Very High Extent

Extent of Hindering Factors

Results regarding the extent of hindering factors in the Table 9 show that the respondents ranked "lack of training" ($\bar{x}$=3.9550, 1.19228) at 1st position followed by "lack of financial resources" ($\bar{x}$=3.4100, 0.99970), "lack of knowledge" ($\bar{x}$=3.3350, 1.41342), "less production" ($\bar{x}$=3.1475, 1.53023), "small land holding" ($\bar{x}$=3.1375, 1.44354), "others" ($\bar{x}$=3.0250, 1.24831), "lack of labor" ($\bar{x}$=2.7525, 1.51558) at 2nd, 3rd, 4th, 5th, 6th and 7th position respectively.

PCA of Hindering Factors in Adoption of Sustainable Cotton Production Practices

To confirm the appropriateness of PCA a Bartlett test of sphericity (BTS) and a Kaiser–Meyer–Olkin (KMO) was employed to find out the factors in adoption of sustainable cotton production practices in this study. Results showed the value of BTS at 1626.626 and its level of significance, which indicates that the data were appropriate for PCA. The value of KMO is 0.632, indicating that there are enough items for each factor (Table 10). We have selected a total of 17 relevant variables for our analysis (Table 11).

Table 10.

Bartlett test of Sphericity (BTS) and Kaiser–Meyer–Olkin (KMO) factors in adoption of sustainable cotton production practices

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	0.632
Bartlett Test of Sphericity Approx. (Chi-Square)	1626.626
Df	28
Sig.	0.000

The objective of PCA is to find common factors, called principal components, in the form of linear combinations of the constraints under study and to rank them according to their importance. Results showed the eigenvalues of the components. There are 5 components whose eigenvalue is greater than one and they account for 92.60% of the total variance. It is worth mentioning that only factors that have eigenvalues greater than one along rotated component greater than 0.5 are retained. The plot of eigenvalues (Fig. 3) shows that eight factors are above the one eigenvalue along 0.5 Rotated components.

Table 11

Total variance explained by PCA factors in adoption of sustainable cotton production practices.

Components	Total	Initial Eigenvalues % of Variance	Cumulative %
1	2.982	37.281	37.281
2	2.062	25.773	63.054
3	1.079	13.491	76.545
4	0.727	9.090	85.636
5	0.557	6.964	92.600
6	0.282	3.526	96.126
7	0.204	2.555	98.681
8	0.106	1.319	100.000

Figure 3.

Scree plot of eigenvalues after PCA

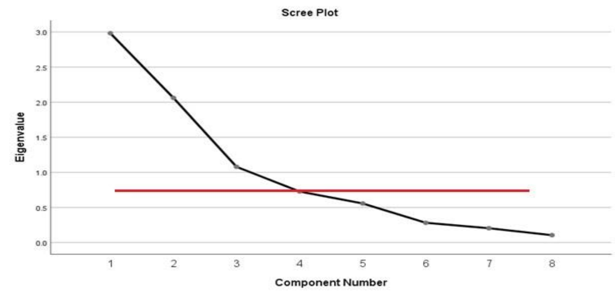


Table 12

Rotated Component Matrix (RCM).

Rotated Components	Component 1	Component 2	Labeling
Lack of interest	0.863		Hindering Factor (3.952)
Small landholding		0.850	
Lack of knowledge		0.799	
Lack of financial resources		0.744	
Lack of labor	0.696		

The eigenvalue of the first component of the two items is 63.054 and accounts for the variance of 100.33% (Table 11). It is evident in rotated component matrix (Table 12) that the first component consists of two items. The constraints included in this component are lack of interest (0.863) and lack of labor (0.696). The sum of the factor loading of component 1st is 1.559. Component one is labelled as "hindering factors". The eigenvalue of the second component consists of three items is 29.545 and accounts for the variance of 254.781% (Table 11). It is evident in RCM (Table 12) that the second component consists of three items. The constraints included in this component are small landholding (0.850), lack of knowledge (0.799) and Lack of financial resources (0.744). The sum of the factor loading of component 2nd is 2.393. Component two is labelled as "hindering factors". Based on the above empirical findings, the most important factors in adoption of sustainable cotton production practices are hindering factors including, lack of interest, small landholding, lack of labor, lack of knowledge, lack of financial resources etc.

Extent of Supporting Factors

Results regarding the extent of supporting factors in the Table 13 show that the respondents ranked "Training opportunity" (x̄=3.4225, 1.32982) at 1st position followed by " less input cost" (x̄=3.3825, 1.41109), "facilitation by LSF staff" (x̄=3.2725, 1.44689), "more yield of cotton" (x̄=2.9025, 1.61385), "support from other farmers of L.G" (x̄=2.7225, 1.56096), "unproblematic marketing" (x̄=2.6550, 1.39134), "water saving" (x̄=2.3075, 1.39024), "other factors" (x̄=2.3125, 1.41947) and "more profit" (x̄=2.3075, 1.00771), at 2nd, 3rd, 4th, 5th, 6th, 7th, 8th and 9th position respectively.

Table 13

Mean, standard deviation (SD), Weighted score and rank order regarding the extent of supporting factors.

Supporting factors	Mean value	Standard Deviation	Weighted score	Rank order
Training opportunity	3.4225	1.32982	273.8	1
Less input cost	3.3825	1.41109	270.6	2
Facilitation by LSF staff	3.2725	1.44689	261.8	3
More yield of cotton	2.9025	1.61385	232.2	4
Support from other farmers of L. G	2.7225	1.56096	217.8	5
Unproblematic marketing	2.6550	1.39134	212.4	6
Other factors	2.3125	1.41947	185	7
Water saving	2.3075	1.39024	184.6	8
More profit	2.3075	1.00771	184.6	9

1. Not at all 2. To Some Extent 3. Moderate Extent 4. High Extent 5. Very High Extent

DISCUSSION

This section presents a comprehensive analysis of the awareness and adoption levels among cotton growers in Punjab. It compares these findings with existing literature and highlights any disparities or trends.

Information and understanding of the crop-ecosystem reduces the need of pesticides while simultaneously increasing productivity and economic profit, especially in the cotton production system (Godtland *et al*., 2004; Khan *et al*., 2005). Similarly, it is evident from the data that farmers' employment of pesticides to manage insect pests and disease infestation has altered somewhat. Therefore, farmers gradually shifted towards alternative approaches such as botanical and mechanical management. Similar results were found by Togbe *et al*. (2015), who reported that control farmers did not use neem on their fields. A negligible fraction of farmers (4.6%) used neem oil to protect cotton. Lack of availability, the difficulty of efficacy, and the expense of neem oil were the primary reasons for its low acceptance, and similar explanations were discovered during talks with farmers for this study. Vasantha and Buchareddy (2006) cited restricted availability to pheromone traps as one of the primary reasons for slowed adoption and diminished effectiveness. Vasantha and Buchareddy (2006) also documented that the majority of farmers in India, including small, medium, and large farmers, cited a lack of inputs, high inputs costs, a low likelihood of net profit, and erratic consistency in profits; labor-intensive and dwindling financial positions were the cause of limited impact.

The effectiveness of different strategies for insect pest control is discussed, along with their alignment with sustainable cotton production practices. According to qualitative interviews, the LSF advocated prudent use of chemicals rather than outright prohibition. Farmers were becoming more conscious of the need for prudent pesticide use. Information and understanding of the crop-ecosystem reduces the need of pesticides while simultaneously increasing productivity and economic profit, especially in the cotton production system (Godtland *et al*., 2004; Khan *et al*., 2005). Similarly, it is evident from the data that farmers' employment of pesticides to manage insect pests and disease infestation has altered somewhat. Therefore, farmers gradually shifted towards alternative approaches such as botanical and mechanical management.

The discussion delves into the significance of adopting precautionary measures during pesticide application and the implications of using chemical versus organic fertilizers for sustainable cotton production. In production of cotton, several problems on health resulted from the application of pesticide in the field (Yasin *et al*., 2021). Pesticide applicators without covering their face and heads work in the field and they face different problems like stomach pain, body weakness, high fever, flu and cough, nausea and irritation (Tahir and Anwar, 2012; Memon *et al.*, 2019, Damalas and Koutroubas, 2019). The majority of farmers in Pakistan is illiterate and use imprudent insecticides and pesticides. Agricultural extension services provide training to cotton growers regarding selection and application of pesticides. Similarly, Ajayi and Akinnifesi (2007) reported that more than half (53%) of the pesticide applicators during spraying did not wear any clothing, gloves etc., and claimed that in core cotton-producing areas where pesticides have been used for a long period, the farmers used more disposal methods of pesticide containers as compare to non-core areas of cotton where pesticides have been used by the farmers more recently. They further suggested that training and awareness programmes should be launched to give awareness to farmers regarding the negative effects of pesticides on human health.

Inefficient use of fertilizers is not only an environmental hazard but has substantial economic loss in term of efficiency of crop and profit of farmers (Elahi *et al*., 2015). Excessive use of fertilizers causes serious environmental issues i.e., soil acidification, air pollution, water eutrophication and degradation (Steffen *et al*., 2015; Wang *et al*., 2018; Sha *et al*., 2020; Li *et al*., 2020). Elahi *et al.* (2015) study results indicate that with the balanced use of fertilizers, the technical efficiency of the crop improved by 14% in the wheat-cotton cropping pattern. One of the key informants said, "*Before BCI, we were using a lot of fertilizers in our fields and that was the main reason our soil became addicted and now we are using recommended fertilizers in our field*". Garg et al. (2020) also found that the use of organic fertilizer significantly improved soil fertility and crop yield in Indian agriculture.

The extent of awareness and knowledge of soil sampling techniques is evaluated in the context of its impact on sustainable cotton production. The discussion section critically examines the hindering and supportive factors reported by the respondents, providing insights into potential strategies for overcoming barriers and leveraging supportive factors to promote sustainable practices.

CONCLUSION

The research concluded by summarizing the key findings of the study and their implications for sustainable cotton production in Punjab, Pakistan. It highlighted the significance of addressing awareness gaps and promoting the adoption of sustainable practices to ensure a more sustainable and resilient cotton industry in the region. The research findings contributed valuable insights to the existing body of knowledge on sustainable agriculture, specifically in the context of cotton production in Punjab. This study provided valuable recommendations for policymakers, agricultural organizations, and stakeholders to design targeted interventions and policies that can facilitate the widespread adoption of sustainable cotton production practices.

Authors Contributions Statement

M. K. Ullah completed the research and prepared the draft; R. M. Amir, B. Shahbaz, F. Rasul reviewed and finalized the draft.

Conflict of Interest

The authors declare no conflict of interest.

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Ethical Statement

Ethical considerations were upheld throughout the study, ensuring informed consent and confidentiality in data collection from all participants.

Availability of Data and Material

We declare that the submitted manuscript is our work, which has not been published before and is not currently being considered for publication elsewhere?

Code Availability

Not applicable.

Consent to Participate

All authors participated in this research study.

Consent for Publication

All authors submitted consent to publish this research article in IJCISS.

REFERENCES

Ajayi, O.C. and F.K. Akinnifesi. 2007. Farmers' understanding of pesticide safety labels and field spraying practices: a case study of cotton farmers in northern Côte d'Ivoire. Journal of Scientific Research in Science Essay. 2:204-210.

Ali, H., M. Aslam and H. Ali. 2012. Economic analysis of input trend in cotton production process in Pakistan. Asian Economic and Financial Review 2:553-561.

Ali, M.A., M. Hassan, M. Mehmood, D.H. Kazmi, F.A. Chishtie and I. Shahid. 2022. The Potential Impact of Climate Extremes on Cotton and Wheat Crops in Southern Punjab, Pakistan. Sustainability 14:1609.

Bedi, J.S. and C.B. Cororaton. 2008."Cotton-textile-apparel sectors of India: Situations and challenges faced.". International Food Policy Research Institute (IFPRI). pp:70-75.

Damalas, C.A., S.D. Koutroubas and G. Abdollahzadeh. 2019. Drivers of personal safety in agriculture: a case study with pesticide operators. Agricultural systems. 9:34.

Economic Advisor's Wing, Ministry of Finance Pakistan. (2023). Pakistan Economic Survey 2022-23. Islamabad: Economic Adviser's Wing, Finance Division Government of Pakistan. Retrieved from . Accessed 10 July 2023.

Elahi, E., L. Zhang, M. Abid, O. Altangerel, K. Bakhsh, B. Uyanga, U.I. Ahmed and H. Xinru. 2015. Impact of balance use of fertilizers on wheat efficiency in cotton wheat cropping system of Pakistan. International journal of agriculture innovations and research. (IJAIR). 3:1369-1373.

Garg, P., Yadav, A., Yadav, R. L., & Tomar, O. S. 2020. Use of organic fertilizers in Indian agriculture: Benefits and limitations. In Environmental Concerns and Sustainable Development: Issues and Challenges. Springer. pp.123-138.

Godtland, E. M., E. Sadoulet, A. De Janvry, R. Murgai, and O. Ortiz. 2004. The Impact of Farmer Field Schools on Knowledge and Productivity: A Study of Potato Farmers in the Peruvian Andes." Economic Development and Cultural Change. 53: 63–92.

Government of Pakistan. 2021-22. Economic Survey of Pakistan. Economic advisor 's wing, Ministry of Finance, Pakistan.

Khan, M. A., I. Ahmad and G. Walter-Echols. 2005. Impact of an FFS-based IPM approach on farmer capacity, production practices and income: Evidence from Pakistan. In P.A.C. Ooi, S. Praneetvatakul, H. Waibel, & G. Walter-Echols (Eds.), The Impact of the FAO-EU IPM Programme for Cotton in Asia (pp. 45-60). Hanover, Germany: Pesticide Policy Project Publication Series, Special Issue No. 9.

Li, N., C. Wei, H. Zhang, C. Cai, M. Song and J. Miao. 2020. Drivers of the national and regional crop production-derived greenhouse gas emissions in China. Journal of cleaner production. 257:120503.

Memon, Q.U.A., S.A. Wagan, D. Chunyu, X. Shuangxi, L. Jingdong and C.A. Damalas. 2019. Health problems from pesticide exposure and personal protective measures among women cotton workers in southern Pakistan. Science of The Total Environment. 685:659-666.

Sha, Z., X. Ma, J. Wang, T. Lv, Q. Li, T. Misselbrook and X. Liu. 2020. Effect of N stabilizers on fertilizer-N fate in the soil-crop system: A meta-analysis. Agriculture, Ecosystems & Environment. 290:106763.

Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, I. Fetzer, E.M. Bennett, R. Biggs, S.R. Carpenter, W. De Vries and C.A. De Wit. 2015. Planetary boundaries: Guiding human development on a changing planet. Science. 347:1259855.

Syed, A., T. Raza, T.T. Bhatti and N.S. Eash. 2022. Climate Impacts on the agricultural sector of Pakistan: Risks and solutions. international journal of environmental research and public health. 6:100433.

Tahir, S., & Anwar, T. 2012. Assessment of pesticide exposure in female population living in cotton growing areas of Punjab, Pakistan. Bulletin of environmental contamination and toxicology, 89, 1138-1141.

Togbé, C. E., E. T. Zannou, S. D. Vodouhê, R. Haagsma, G. Gbèhounou, D. K. Kossou, and A. van Huis. 2015. "Technical and Institutional Constraints of a Cotton Pest Management Strategy in Benin." NJAS-Wageningen. Journal of life science. 63:67–78.

Vasantha, R. and B. Buchreddy. 2006. Perceptions on attributes of IPM technologies by cotton farmers of Guntur District. The Journal of Research ANGRAU. 34:53- 61.

Wang, M., L. Ma, M. Strokal, Y. Chu and C. Kroeze. 2018. Exploring nutrient management options to increase nitrogen and phosphorus use efficiencies in food production of China. Agricultural systems. 163:58-72.

Yasin, M.A., K. Bakhsh, R. Ali and H.I. Hussain. 2021. Impact of better cotton initiative on health cost and pesticide exposure of women cotton pickers in Punjab, Pakistan. Environmental Science and Pollution Research. 28:2074-2081.

Zulfiqar, F. & G. B. Thapa. 2017. Agricultural sustainability assessment at provincial level in Pakistan. Land use policy. 68:492-502.