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IMPROVING AGRICULTURAL PRODUCTIVITY THROUGH PLANT HEALTH CLINICS: INSIGHTS FROM COTTON GROWERS IN PUNJAB, PAKISTAN

APRIMORANDO A PRODUTIVIDADE AGRÍCOLA POR MEIO DE CLÍNICAS DE SAÚDE VEGETAL: PERCEPÇÕES DE PRODUTORES DE ALGODÃO EM PUNJAB, PAQUISTÃO

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Abstract
Present study was designed to determine the effectiveness and impact of Plant Health Clinics (PHC) on improving agricultural productivity of cotton in the Punjab Province of Pakistan. The study was conducted in two districts (Multan and Khanewal) of Punjab province of Pakistan being the leading cotton producing areas. Sample size of the study was 354 respondents using structured interview schedule for data collection. The collected data were analyzed through SPSS. Descriptive and correlational statistics were used for the interpretation of data. Results revealed that majority of the respondents were middle-aged. Most respondents had low educational attainment. The majority of respondents (58.2%) owned 11–15 acres of land. Most respondents (38.7%) relied on fellow farmers as their primary information source. Half of the respondents (50.3%) accessed the service fortnightly. Farmers largely agreed that Plant Health Clinics improve knowledge and awareness and make

Resumo
O presente estudo foi concebido para determinar a eficácia e o impacto das Clínicas de Saúde Vegetal (CSV) na melhoria da produtividade agrícola do algodão na província de Punjab, no Paquistão. O estudo foi realizado em dois distritos (Multan e Khanewal) da província de Punjab, no Paquistão, que são as principais áreas produtoras de algodão. A amostra do estudo foi composta por 354 respondentes, selecionados por meio de entrevistas estruturadas para a coleta de dados. Os dados coletados foram analisados utilizando o SPSS. Estatísticas descritivas e correlacionais foram utilizadas para a interpretação dos dados. Os resultados revelaram que a maioria dos respondentes era de meia-idade. A maioria dos respondentes tinha baixa escolaridade. A maioria dos respondentes (58,2%) possuía de 11 a 15 acres de terra. A maioria dos respondentes (38,7%) dependia de outros agricultores como sua principal fonte de informação. Metade dos

agricultural information more accessible, while the ability to diagnose pests and diseases and being a cost-efficient activity showed highly significant associations, whereas aspects like linking stakeholders and inclusivity were less strongly supported. Plant Health Clinics are progressive hub for information sharing among farmers to improve their productivity, therefore the government should initiate massive PHCs for agricultural productivity.

Keywords: Cotton Growers. Agricultural Productivity. Plant Protection Measures. Plant Health Clinics (PHCs).

respondentes (50,3%) acessava o serviço quinzenalmente. Os agricultores concordaram, em sua maioria, que as Clínicas de Saúde Vegetal melhoram o conhecimento e a conscientização, além de tornarem as informações agrícolas mais acessíveis. A capacidade de diagnosticar pragas e doenças e a relação custo-benefício da atividade apresentaram associações altamente significativas, enquanto aspectos como a articulação entre as partes interessadas e a inclusão receberam menos apoio. As Clínicas de Saúde Vegetal são centros progressivos para o compartilhamento de informações entre os agricultores, visando melhorar sua produtividade. Portanto, o governo deve implementar uma rede massiva de Clínicas de Saúde Vegetal para impulsionar a produtividade agrícola.

Palavras-chave: *Produtores de Algodão. Produtividade Agrícola. Medidas fitossanitárias. Clínicas de Saúde Vegetal (CSV).*

1 INTRODUCTION

Agriculture plays an important role in providing employment and income generating opportunities, reducing poverty, providing raw material to industries, food security and social stability (Pawlak and Kołodziejczak, 2020; Jerzak and Smiglak-Krajewska, 2020). This has been widely acknowledged and reported that plant pests and diseases are the common and important threat to livelihoods of farmers mainly in developing counties where agriculture is the major source of income and livelihoods (Silvestri *et al*., 2019). Effective plant health management is becoming ever more important in agriculture, not only for food security but also for increasing farm income. Pests and diseases may affect production through regular and severe occurrences leading to production losses if they are not properly managed (Bourne *et al*. 2017). Pest and diseases are always a challenge to small farmers because there is always variability in these problems and the pressure that comes with climate change and increasing human and goods traffic across the world (Bebber, *et al*., 2014). Nonetheless, relatively easy and timely source of plant health information and advice are often hard to come by or altogether unavailable in low-income zones (Smith et. al., 2008).

The concept of Plant Health Clinics arose in response to challenges of the modern farming, including the increased frequency of plant diseases due to climate change, new destructive species, increased intensity of cropping (Smith, 2018). Plant Health Clinics (PHCs) refers to organizations that support farmers, agricultural personnel and rural populations in plant health concerns. PHCs offer easy access to farmers where plant health management embracing diagnostics, research and extension education are integrated (CABI, 2015). According to Tahat *et al*., (2020), PHCs help to address the problem of dependence on chemicals and to support the development of safe production practices. There are approximately 4500 plant clinics globally and approximately 34 countries are implementing plant health clinics. According to Boa, there are plant clinics in Asia, South America and Africa as listed by CABI (2015). Major functions of PHCs are Diagnostics & Analysis, Provision of advisory services, Provision of education and outreach facilities, Provision of research & development related activities and Policy Advocacy (Gouda & Ashwini, 2023)**.** The establishment of Plant Health Clinics provides valuable benefits for farmers, agricultural stakeholders, and the environment in the form of increase in crop yield, sustainable agricultural practices, farmer's empowerment, ensure food security and rural community and stakeholder's engagement (Zwart & Metz, 2020); Gurr *et al*., 2016).

The formation of PHCs is also consistent with a mission to boost the productivity in agriculture and food security in Pakistan (Luqman *et al*., 2020). Since these clinics give farmers proper information that is most relevant to them, it helps the farmers to manage diseases and pests that affect the plants hence increasing the yields and minimizing on economic returns (Wingfield *et al*., 2015). In case of Pakistan, majority of farmers have very small land holding. They also lack livelihood resources. Poor quality chemicals further damage the situation (World Bank, 2017). Plant Health Clinics in Pakistan provide a variety of services to address the challenges faced by farmers especially Diagnosis and Testing, Agricultural Advisory Services, Education and Training, Research and Development Services (Bourne et. 2017).

Cotton is among the world's most popular and widely used agricultural commodity affecting the lives of billions and the economies of many countries across the globe. Cotton is an example of a natural fiber and has been used for thousands of years with continuing importance as a raw material for the textiles trade (Najib *et al*., 2022). Oerke (2006) studied different potential losses due to insect pest a in case of wheat these potential losses were about 50% however for cotton it remained 80% whereas for soybean was affected to about 26 to 30%. Pakistan is among the top 5 cotton producing countries where Sindh and Punjab are the major contributors in cotton production (Baloch and Abbasi, 2020). Year wise cotton production in leading countries of the world is as under:

Table 1

Year wise cotton production in leading cotton production countries

Country	2021/22	2022/23	2023/24	2024/25 (est.)	2025/26 (forecast)
China	26,700	30,750	27,350	32,000	31,500
India	24,300	26,300	25,400	24,000	23,500
Brazil	10,820	11,720	14,570	17,000	18,250
United States	17,523	14,468	12,066	14,413	13,214
Pakistan	6,000	3,900	7,000	5,000	5,000
Australia	5,850	5,800	5,000	5,600	4,100
Turkey	3,800	4,900	3,192	3,950	3,600

Source: USDA, 2025

Cotton crop yearly suffers 10-15% losses due to pest and disease attack around the globe. In developing countries like Pakistan production losses due to disease attack exceed 50% (UIA, 2023). Region wise breakdown of actual losses in cotton production according to Husfarm (2024) is given in the following table:

Table 2

Region wise cotton production losses due to pest and disease attack

Region	% Losses
Africa	20%
Asia	13%
America	11%
Europe	11%

Advisory and suggestion services are offered to farmers by plant health clinics as main plant health services (Negussie *et al*., 2011). In terms of the services they provide, plant health clinics can be classified into two types, as stated by Boa *et al*. (2016): (1) "Institute-based plant clinics have laboratory facilities for identifying pests and pathogens" and (2) "Clinics that offer management advice through extension intermediaries" also known as mobile plant clinics. The majority of smallholder farmers probably aren't aware that these kinds of clinics exist (Musebe *et al*., 2018) which creates an awareness gap. Furthermore, as Boa *et al*. (2016) pointed out, the majority of smallholder farmers are unaware of the services offered by various types of clinics.

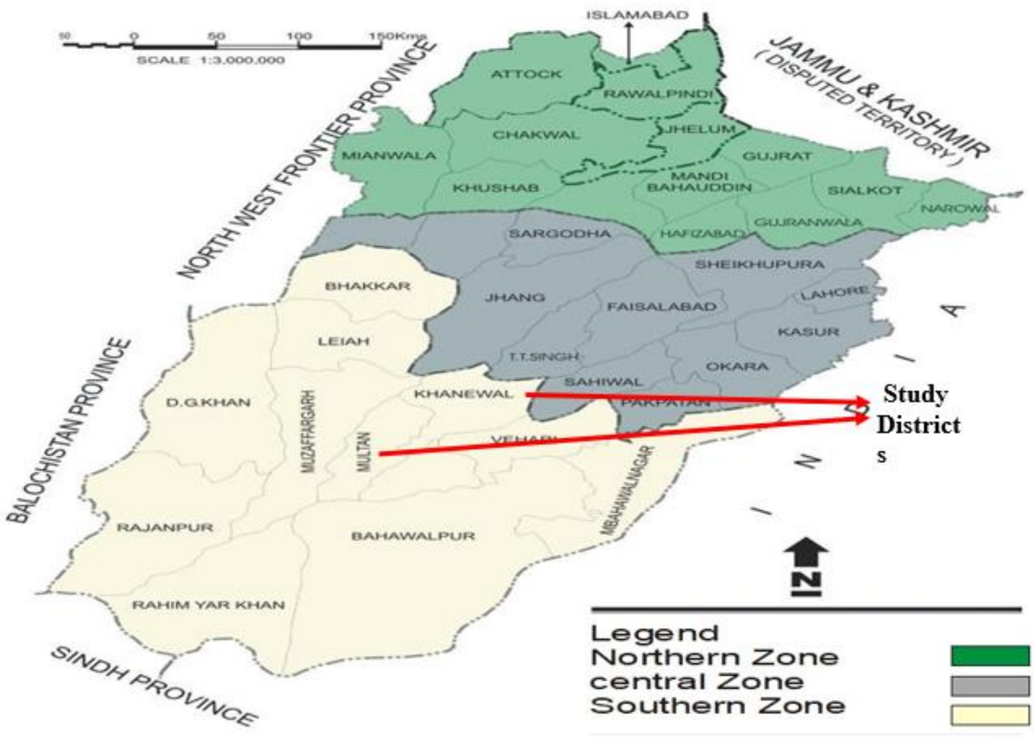
Economically this has been reported that pests and diseases responsible are for 40% of agricultural output losses (Oerke, 2006). Pests and diseases pose a threat to plant output for most smallholder farmers. Plant health clinics are crucial for diagnosing plant diseases and pests, which help smallholder farmers to overcome some of the obstacles they confront. Plant health clinics are a way for farmers to get advice on how to deal with pests that damage their crops and how to implement a control plan (Alokit *et al*., 2015). All types of farmers in developing nations have access to plant pest and disease advising services via one of the several plant health clinic projects (Boa *et al*., 2016). All this narration hovers around the issue that farmers are still unaware of the latest farm practices especially for cotton. This calls for a comprehensive note on the research problem related to effect of PHCs in improving agricultural productivity. With this background there is need to conduct a study to determine the effectiveness and impact of plant health clinics on improving agricultural productivity of cotton growers in the Punjab Province of Pakistan.

2 MATERIALS AND METHODS

The study was conducted in south Punjab due to being the main cotton producing areas. This area is also responsible for high usage of pesticides on cotton crop. District Khanewal and Multan were purposefully selected as the targeted research areas (Govt. of Punjab, 2021). Both are basically Agricultural Districts. More than 80% population derives its earnings from Agriculture in one way or the other.

Figure 1

Map showing study districts



The present study is descriptive and correlational in nature as it gives an opportunity to this social science researcher to describe research in question with utmost detail and necessary measures. A cross-sectional survey was used to conduct for the current research study. Primary data was collected through comprehensively developed and validated interview schedule prepared keeping in view the objectives of the study. Face and content validity of the instrument was checked by the panel of experts from the Department of Agricultural Extension & Rural Studies, University of Sargodha. A pilot study was conducted before full scale study to measure the reliability of the instrument and the value of Cronbach alpha was calculated. Sample size was calculated using online sample calculator website https://www.calculator.net/sample-size-calculator.html. Confidence level was kept at 95% whereas margin error was kept at 5.21% and keeping population proportion at 50%. The study sample was consisting of 354 respondents. A face-to-face interview schedule was employed for data collection. The data were very comprehensively analyzed for the study. Firstly, data were coded and entered into

Microsoft Excel. This software is helpful for data entry and data management. It is easy to handle and can be used for all types of editing and correction with ease. Secondly, the data were exported to SPSS.

3 RESULTS AND DISCUSSION

3.1 Age of the respondents

Age is the cumulative sum of a person's years since birth. The categories of age of the farmers include: up to 30 years, 31-40 years, 41 to 50 years and above 50 years. The data regarding the age of the respondents are presented in the following table.

Table 3

Frequencies of Age groups of the cotton growers

n=354

Age categories	Frequency	Percent
Up to 30 years	30	8.5
31 to 40 years	104	29.4
41 to 50 years	174	49.2
Above 50 years	46	13.0

The table presents the age distribution of cotton growers, categorized into four groups. The majority, comprising 49.2%, are aged between 41 to 50 years, indicating that middle-aged individuals dominate the cotton farming sector. The next significant group is between 31 to 40 years, accounting for 29.4%, followed by 13% who are above 50 years. The smallest segment, at 8.5%, is composed of farmers aged up to 30 years. This data suggests that most cotton growers are experienced adults, with younger generations representing a smaller portion, potentially highlighting a generational shift or lack of young entrants in cotton farming. The results are supported by Vaillant (2002).

3.2 Educational level of respondents

Education is a very important demographic feature in determining a person's behavior. The second important factor of the research tool was education. Hence the education of the farmers was categorized according to the level of schooling. The categories of education of the farmers include; no formal education, primary, middle, secondary, intermediate and above graduation. The data regarding the education level of the respondents are presented in the following table.

Table 4

Educational level of respondents

n=354

Educational Level	**Frequency**	**Percent**
No formal Education	55	15.54
Primary	141	39.8
Middle	97	27.4
Secondary	40	11.3
Intermediate	15	4.2
Graduation and above	6	1.69

This table outlines the educational background of cotton growers. The largest segment, 39.8%, has completed primary education, followed by 27.4% with middle-level education. A smaller group, 15.54%, has no formal education, indicating a potential challenge in accessing advanced agricultural knowledge. Secondary education accounts for 11.3%, while 4.2% have completed intermediate studies. Only 1.69% have attained graduation or higher levels of education. This distribution reflects a predominantly low to moderate educational attainment among cotton growers, which could influence their ability to adopt modern farming techniques or engage effectively with agricultural extension services. The results are supporting the results by World Bank (2018) whose report stated that surveys depicted limited access to higher education opportunities.

3.3 Size of landholding

Size of a landholding denotes the farm size of a farmer and his families for crops/plants and animal output. Concerning technology transfers a core assumption that innovation will occur in larger farms earlier than in smaller farms (USDA, 2007). The scale of land ownership plays a very important role in the application of new technologies or new methods. Hence, the categories of landholding of the farmers include; up to 5 acres, 6 to 12.5 acres, 13 to 25 acres and above 25 acres. The following table shows the distribution of respondents by size of their landholding.

Table 5

Frequency distribution of Land holding size of respondents

n=354

Land Holding Size (in acres)	Frequency	Percent
1-5	4	1.1
6-10	74	20.9
11-15	206	58.2
16-20	23	6.5
Above 20	47	13.2

This table categorizes cotton growers based on their landholdings. Most farmers (58.2%) own 11–15 acres of land, followed by 20.9% with holdings of 6–10 acres. A smaller group, 13.2%, holds over 20 acres, indicating a minority of large-scale farmers. Those owning 16–20 acres represent 6.5%, while the smallest segment, at 1.1%, comprises growers with 1–5 acres. This distribution highlights that the majority of farmers operate medium-sized farms, which may influence their capacity for mechanization and their reliance on labor-intensive practices. Large-scale operations are comparatively rare, pointing to a predominantly small to medium-scale farming community.

Table 6

Awareness about Plant Health Clinics

n=354

Information source	Frequency	Percent
Social media	78	22.0
Newspaper	58	16.4
Fellow farmers	137	38.7
Television	65	18.4
Other Media	16	4.5

This table explores how farmers learned about plant health clinics. Fellow farmers are the most common source, accounting for 38.7%, followed by social media (22%) and television (18.4%). Newspapers contribute 16.4%, while 4.5% cite other sources. This distribution underscores the importance of informal networks and digital platforms in disseminating information. Social media's significant role reflects its growing influence in rural areas. Enhancing communication through these preferred channels could further improve awareness and engagement, ensuring that more farmers benefit from the services offered by plant health clinics.

Table 7

Frequency to visit Plant Health Clinic

n=354

Frequency	Frequency	Percent
Weekly	83	23.45
Fortnightly	178	50.28
Monthly	93	26.27

This table examines how often farmers visit plant health clinics. Half of the respondents (50%) have never visited, while weekly visits account for 23.4%. Fortnightly and monthly visits represent 22% and 4.5%, respectively. These figures suggest that a significant portion of growers remains disconnected from regular consultations, which could hinder timely interventions for plant health issues. Promoting the benefits of consistent engagement with clinics and addressing barriers such as time, cost, or distance could lead to more frequent usage.

3.4 Effectiveness of plant health clinics (PHCs) for improving agricultural productivity

Table 8

Effectiveness of PHCs in improving agricultural productivity

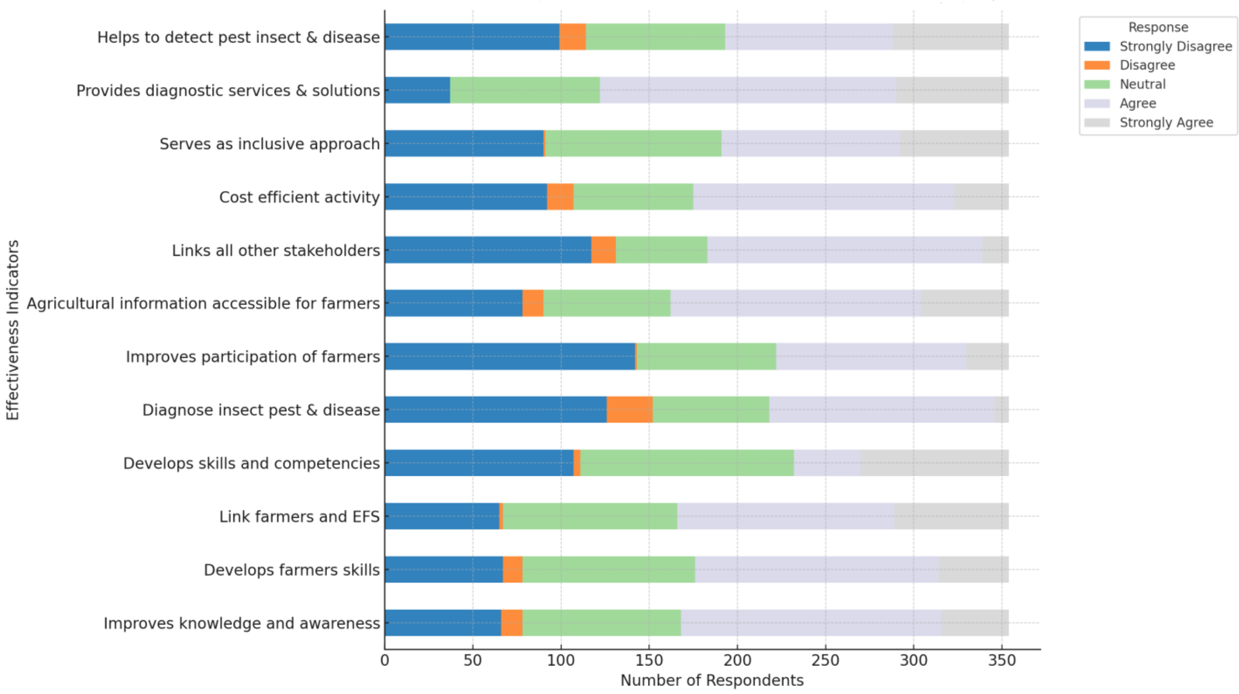
Effectiveness	S. Disagree	Disagree	Neutral	Agree	S. Agree	Chi square	P-value
Improves knowledge and awareness	66 (18.6)	12 (3.4)	90 (25.4)	148 (41.8)	38 (10.7)	9.9	0.041
Develops farmers skills	67 (18.9)	11 (3.1)	98 (27.7)	138 (39.0)	40 (11.3)	7.2	0.124
Link farmers and EFS	65 (18.4)	2 (0.6)	99 (28.0)	123 (34.7)	65 (18.4)	2.2	0.692
Develops skills and competencies	107 (30.2)	4 (1.1)	121 (34.2)	38 (10.7)	84 (23.7)	7.5	0.113
Diagnose insect pest & disease	126 (35.6)	26 (7.3)	66 (18.6)	128 (36.2)	8 (2.3)	26.1	0.000
Improves participation of farmers	142 (40.1)	1 (0.3)	79 (22.3)	108 (30.5)	24 (6.8)	12.1	0.017
Agricultural information accessible for farmers	78 (22.0)	12 (3.4)	72 (20.3)	142 (40.1)	50 (14.1)	22.1	0.000
Links all other stakeholders	117 (33.1)	14 (4.0)	52 (14.7)	156 (44.1)	15 (4.2)	6.9	0.142
Cost efficient activity	92 (26.0)	15 (4.2)	68 (19.2)	148 (41.8)	31 (8.8)	28.7	0.000
Serves as inclusive approach	90 (25.4)	1 (0.3)	100 (28.2)	101 (28.5)	62 (17.5)	2.3	0.681
Provides diagnostic services & solutions	37 (10.5)	0 (0.0)	85 (24.0)	168 (47.5)	64 (18.1)	0.3	0.944
Helps to detect pest insect & disease	99 (28.0)	15 (4.2)	79 (22.3)	95 (26.8)	66 (18.6)	2.4	0.655

Scale: S. Agree=5, Agree =4, Neutral= 3, Disagree=2, S. Disagree=1 (Values in parenthesis are the percentages)

Above table assesses farmers' views on the effectiveness of plant health clinics (PHCs). Many believe PHCs improve knowledge and awareness, with 18.6% strongly agreeing. However, a large majority of the farmers i.e. 41.8% disagreed that PHCs improve knowledge and awareness. PHCs are also valued for enhancing skills in disease identification and promoting early diagnosis of pest issues. Although positive responses are significant, a large portion remains neutral or disagrees, indicating varying levels of satisfaction. Many of the cotton farmers strongly agreed that PHCs improves participation of farmers for crop protection. Strengthening clinic services and showcasing success stories may improve perceptions, helping farmers appreciate the benefits of engaging with PHCs to boost productivity. Findings of the study revealed that PHCs are particularly effective in improving knowledge level of cotton growers, reducing costs and also provide support to farmers in diagnosis of insects/pests and diseases as these factors are directly contribute towards agricultural production. These findings are similar to earlier research studies that described the role of PHCs in improving decision making and problem-solving capability of farmers (Danielsen *et al*., 2014; Bentley *et al*., 2016). Similar findings were also reported by Boa *et al*., (2019). In connection with findings of the present study (Tambo *et al*., 2020) reported that in Rawanda visitors of PHCs obtained significantly higher crop yield than non-visitors. The positive impact of Plant Health Clinics on farmer's decision-making capability was also pointed out by Danielsen *et al*., (2013). Role of PHCs in performance of agricultural farms and poverty alleviation was also described by Waibel and Harsa (2010). The effectiveness of PHCs in agricultural productivity of cotton growers on different parameters/statements regarding effectiveness is best depicted in the following bar chart:

Figure 2

Bar chart regarding effectiveness of PHCs in improving agricultural productivity of cotton growers



3.5 Changes in plant production & protection practices due to PHCs visit

Table 9

Changes in plant production & protection practices due to PHCs visit

Statements	S. Disagree	Disagree	Neutral	Agree	S. Agree	Chi square	P-value
Soil analysis practices improved	97 (27.4)	18 (5.1)	129 (36.4)	36 (10.2)	74 (20.9)	0.4	0.982
Laser land levelling uses encouraged	148 (41.8)	18 (5.1)	106 (29.9)	74 (20.9)	8 (2.3)	0.1	0.999
Adoption of early plantation time	54 (15.3)	0 (0.0)	166 (46.9)	83 (23.4)	51 (14.4)	0.2	0.985
Selection of recommended & certified seeds	54 (15.3)	0 (0.0)	166 (46.9)	107 (30.2)	27 (7.6)	0.6	0.898
Seed treatment improved	81 (22.9)	18 (5.1)	138 (39.0)	60 (16.9)	57 (16.1)	0.1	1.000
Seedbed preparation as recommended	141 (39.8)	34 (9.6)	110 (31.1)	52 (14.7)	17 (4.8)	0.1	0.999
Recommended plantation methods adopted	125 (35.3)	27 (7.6)	111 (31.4)	57 (16.1)	34 (9.6)	29.1	0.000
Fertilizer application as suggested by experts	147 (41.5)	14 (4.0)	99 (28.0)	88 (24.9)	6 (1.7)	0.2	0.997
Adopted pesticide insecticide application methods as suggested	51 (14.4)	0 (0.0)	172 (48.6)	73 (20.6)	58 (16.4)	0.6	0.899

Identification and adopted weed management methods	42 (11.9)	0 (0.0)	166 (46.9)	112 (31.6)	34 (9.6)	0	1.000
Adopted recommended irrigation application	100 (28.2)	23 (6.5)	135 (38.1)	43 (12.1)	53 (15.0)	0.632	0.959
Recommended harvesting methods adopted	136 (38.4)	39 (11.0)	104 (29.4)	64 (18.1)	11 (3.1)	0.146	0.997
Storage_& marketing practices improved	153 (43.2)	26 (7.3)	94(26.6)	76 (21.5)	5 (1.4)	0.3	0.990
Identification & management of insect pest and disease improved	154 (43.5)	17 (4.8)	101 (28.5)	71 (20.1)	11 (3.1)	0.4	0.986
Crop rotation & cover crop practices increased	62 (17.5)	0 (0.0)	169 (47.7)	67 (18.9)	56 (15.8)	0.9	0.812
Identification and management of beneficial insects	50 (14.1)	0 (0.0)	168 (47.5)	105 (29.7)	31 (8.8)	0.2	0.975

Scale: S. Agree=5, Agree =4, Neutral= 3, Disagree=2, S. Disagree=1 (Values in parenthesis are the percentages)

This table clarifies most of the cotton growers agreed that before PHCs people knew the use of laser land levelers (41.8%) whereas before PHCs cotton farmers also had knowledge of recommended seedbed preparation of different crops (39.8%). Cotton farmers also strongly agreed that before PHC the usage of recommended fertilizer application was also in practice (41.5%). Before Launching PHC project, farmers had knowledge of storage & marketing practices already adopted by the farmers (43.2%) along with successful Identification & management of insect/ pest and diseases (43.5%). Significant adoption of Recommended harvesting methods had also been in practice before PHCs in order to facilitate farmers in adopting improved practices (38.4%).

3.6 Change in farm expenses due to PHCs visit

Table 10

Change in farm expenses due to plant health clinics

Statements	**S. Disagree**	**Disagree**	**Neutral**	**Agree**	**S. Agree**	**Chi square**	**P-value**
Labor cost decreased	0 (0.0)	89 (25.1)	77 (21.8)	174 (49.2)	14 (4.0)	2.5	0.474
Seed cost decreased	0 (0.0)	32 (9.0)	59 (16.7)	232 (65.5)	31 (8.8)	0.1	0.979
Decreased pesticides application cost	0 (0.0)	51 (14.4)	89 (25.1)	152 (42.9)	62 (17.5)	5.9	0.113
Fertilizer cost decreased	0 (0.0)	54 (15.3)	66 (18.6)	193 (54.5)	41 (11.6)	17.3	0.001
Decreased cost of cultural practices	0 (0.0)	95 (26.8)	34 (9.6)	214 (60.5)	11 (3.1)	0.6	0.883
Irrigation cost decreased	0 (0.0)	48 (13.6)	111 (31.4)	125 (35.3)	70 (19.8)	1.5	0.687
Harvesting cost decreased	0 (0.0)	48 (13.6)	94 (26.6)	151 (42.7)	61 (17.2)	9.1	0.028
Storage cost decreased	0 (0.0)	69 (19.5)	54 (15.3)	205 (57.9)	26 (7.3)	2.6	0.465
Decreased transportation cost	0 (0.0)	62 (17.5)	62 (17.5)	211 (59.6)	19 (5.4)	1.7	0.632

Scale: S. Agree=5, Agree =4, Neutral= 3, Disagree=2, S. Disagree=1 (Values in parenthesis are the percentages)

Above table represents farmers' significant agreement towards change in farm expenses. However, many of the farmers strongly agreed that labor cost has decreased due to PHCs (48.6%) whereas 45.4% of the cotton farmers strongly agreed while 44.4% just agreed to the pint that PHCs have decreased the seed cost since their introduction. Mostly the farmers agreed that PHCs have decreased pesticide application cost (52.5%). Cotton farmers showed agreement in changed crop harvesting expenses (52.5%) and crop storage expenses (67.5%) due to Plant Health Clinics. However, majority of the cotton growers also showed strong agreement in decreased expenses in fertilizer application (53.7%), cultural practices (46.6%), irrigation expenses (51.1%) and crop transportation costs (54.8%).

3.7 Change in Staff competencies

Table 11

Change in staff competencies due to plant health clinics

Change Parameters	S. Disagree	Disagree	Neutral	Agree	S. Agree	Chi square	P-value
Experience	159 (44.9)	182 (51.4)	13 (3.7)	0 (0.0)	0 (0.0)	14.9	0.001
Highly trained	168 (47.5)	162 (45.8)	24 (6.8)	0 (0.0)	0 (0.0)	3.6	0.162
Highly educated	166 (46.9)	183 (51.7)	5 (1.4)	0 (0.0)	0 (0.0)	5.1	0.079
Problem identification skills	169 (47.7)	174 (49.2)	11 (3.1)	0 (0.0)	0 (0.0)	11.4	0.003
Problem solving skills	170 (48.0)	169 (47.7)	15 (4.2)	0 (0.0)	0 (0.0)	12.7	0.002
Communication skills	183 (51.7)	136 (38.4)	35 (9.9)	0 (0.0)	0 (0.0)	7.9	0.019
Time management skills	172 (48.6)	161 (45.5)	21 (5.9)	0 (0.0)	0 (0.0)	7.7	0.021

Scale: S. Agree=5, Agree =4, Neutral= 3, Disagree=2, S. Disagree=1 (Values in parenthesis are the percentages)

The table gives a percentage wise distribution of respondents on the scale set for data collection. Cotton farmers stated agriculture staff as highly competent as they are highly trained (47.5%), have high problem-solving skills (48.0%), communication skills (51.7%) and task management skills (48.6%) because of introduction of Plant Health Clinics. Similarly cotton farmers rated agriculture staff as fairly competent in their experience (51.4%), education (51.7%) and problem identification skills (49.2%) due to Plant Health Clinics.

3.8 Impact of Plant health clinics on extension-farmer linkage

Table 12

Impact of Plant health clinics on extension-farmer linkage

Statements	1	2	3	4	5	Chi square	P-value
Extension services become farmers needs demands driven	136 (38.4)	71 (20.1)	147 (41.5)	0 (0.0)	0 (0.0)	8.6	0.014
Existence of extension through PHCs has improved	71 (20.1)	81 (22.9)	202 (57.1)	0 (0.0)	0 (0.0)	0.2	0.897
PHCs trained field staff to diagnose plants heath issues	115 (32.5)	53 (15.0)	186 (52.5)	0 (0.0)	0 (0.0)	5.8	0.056
PHCs improved farmers knowledge regarding plants health problems	116 (32.8)	24 (6.8)	200 (56.5)	14 (4.0)	0 (0.0)	14.6	0.002
Provision of more extension services for farmers through PHCs	127 (35.9)	48 (13.6)	170 (48.0)	9 (2.5)	0 (0.0)	25.1	0.000
PHCs are providing capacity building opportunities for field staff of other stakeholders	81 (22.9)	75 (21.2)	186 (52.5)	12 (3.4)	0 (0.0)	12.9	0.005
Active and improved participation of farmers through PHCs	132 (37.3)	47 (13.3)	173 (48.9)	2 (0.6)	0 (0.0)	4.1	0.247
PHCs increased opportunities for public-private partnerships	114 (32.2)	53 (15.0)	167 (47.2)	20 (5.6)	0 (0.0)	32.2	0
PHCs encourage adoption of cost-effective & eco-friendly practices for crop productivity	122 (34.5)	65 (18.4)	156 (44.1)	11 (3.1)	0 (0.0)	15	0.002
PHCs increased opportunities for local extension agencies to collaborate with international organizations	90 (25.4)	82 (23.2)	174 (49.2)	8 (2.3)	0 (0.0)	11.6	0.009
PHCs approach is integrating in public extension systems	117 (33.1)	42 (11.9)	188 (53.1)	7 (2.0)	0 (0.0)	8.8	0.033

Scale: V. High=5, High=4, Moderate= 3, Low=2, V. Low=1 (Values in parenthesis are the percentages)

The table suggests that PHCs have strengthened the linkages between extension staff and farmers. Cotton farmers view moderate impact in all the major factors responsible for strengthening extension-farmer linkage. Most of the farmers reported that PHCs have moderate impact on agricultural extension and advisory services as they have become farmer’s needs/demands driven (41.5%). Similarly, most of the farmers also declared that there is moderate impact of existence of PHCs on rural areas improvement (57.1%) whereas more than half of the farmers also view that PHCs staff trained has moderate impact on extension-farmer-linkage (52.5%). The results reflect that while respondents acknowledge certain positive effects, the overall impact of PHCs on extension services is encouraging. The study results are also supporting the findings by

CABI report 2017 who reported that there has been improved impact of plant clinic users on various aspects of their farming practices.

3.9 Challenges to plant health clinics

Table 13

Challenges to Plant Health Clinics as perceived by the respondents

Challenges	S. Disagree	Disagree	Neutral	Agree	S. Agree	Chi square	P-value
Too expensive inputs	69 (19.5)	266 (75.1)	19 (5.4)	0 (0.0)	0 (0.0)	6.9	0.031
Cultural constraints	18 (5.1)	302 (85.3)	34 (9.6)	0 (0.0)	0 (0.0)	2.1	0.351
Farmer's lack of interest	14 (4.0)	303 (85.6)	37 (10.5)	0 (0.0)	0 (0.0)	30.6	0.000
Lack of expertise	25 (7.1)	289 (81.6)	40 (11.3)	0 (0.0)	0 (0.0)	11.8	0.003
Lack of awareness	71 (20.1)	243 (68.6)	40 (11.3)	0 (0.0)	0 (0.0)	16.3	0.000
Limited resources for conduction	20 (5.6)	299 (84.5)	35 (9.9)	0 (0.0)	0 (0.0)	0.3	0.879
Poor attendance of farmers	33 (9.3)	275 (77.7)	46 (13.0)	0 (0.0)	0 (0.0)	9.9	0.007
Lack of professional knowledge	29 (8.2)	288 (81.4)	37 (10.5)	0 (0.0)	0 (0.0)	1.5	0.476
Small holders not preferred	48 (13.6)	272 (76.8)	34 (9.6)	0 (0.0)	0 (0.0)	6.8	0.034
Involvement of other stakeholders	47 (13.3)	274 (77.4)	33 (9.3)	0 (0.0)	0 (0.0)	8.7	0.130
Scheduling for conduction	20 (5.6)	290 (81.9)	44 (12.4)	0 (0.0)	0 (0.0)	6.2	0.045
Accessibility issues	85 (24.0)	225 (63.6)	44 (12.4)	0 (0.0)	0 (0.0)	4.5	0.106
Institutional policies	16 (4.5)	282 (79.7)	56 (15.8)	0 (0.0)	0 (0.0)	4.4	0.109

Scale: S. Agree=5, Agree =4, Neutral= 3, Disagree=2, S. Disagree=1 (Values in parenthesis are the percentages)

The table highlights scale wise percentage response of the cotton farmers. The response indicates that overall, most of the farmers agreed that there exist challenges which are major concerning factors for getting successful benefits from PHCs. Farmers agreed that lack of interest from many of the farmers was the highly concerning challenge for PHCs (85.6%). Other major factors include "Limited resources for PHCs" (84.5%), "time schedule for PHCs" (81.9%) and "lack of professional knowledge among experts" (81.4%). Farmers showed agreement that all the listed challenges exist though they are not to very high level but they do exist and are barrier to proper functioning of PHCs. The findings are correlated with the CABI plant-wise report 2016 who reported that low coverage and accessibility issues are among the major changes to Plant Health Clinics.

3.10 Regression analysis

Table 14

Model-I (Change in Plant Production & Protection Practices)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.884[a]	.781	.779	1.803

a. Predictors: (Constant), frequency of visit to Plant Health Clinics, how do you hear about Plant Health Clinics? location of nearest Plant Health Clinics, have you visited Plant health clinic or not?

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4049.420	4	1012.355	311.539	.000[b]
	Residual	1134.086	349	3.250		
	Total	5183.506	353			

a. Dependent Variable: Difference in plant production & protection practices due to plant health clinics
b. Predictors: (Constant), frequency of visit to Plant Health Clinics, How do you hear about Plant Health clinics?, location of nearest Plant Health Clinics, have you visited Plant health clinic or not?

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-1.971	.950		-2.076	.039
	Location of nearest Plant Health Clinics	-.152	.277	-.019	-.550	.583
	How do you hear about Plant Health clinics?	.046	.087	.014	.530	.597
	have you visited Plant health clinic or not?	6.744	.433	.881	15.573	.000

a. Dependent Variable: Change in plant production & protection practices due to plant health clinics

The R value of 0.884 indicates a strong correlation between the predictors (frequency of visits, awareness of PHCs, location, and past visits) and the dependent variable. The R Square value of 0.781 shows that about 78% of the variance in plant production and protection practices can be explained by the predictors. The F-statistic (311.539) is highly significant ($p < 0.001$), indicating that the model is a good fit. The constant term is negative, but only the variable "Have you visited Plant Health Clinic or not?" shows a significant positive effect on the outcome ($B = 6.744$, $p < 0.001$). Other predictors (location, how people hear about PHCs & frequency of visits) have minimal or no significant impact on changes in plant production and protection practices. The analysis confirms that visit to plant clinics have significant role in producing significant difference in plant production and protection practices before PHCs and at present (due to PHCs).

Table 15

Regression Model-II (Change in Farm Expenses)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.531[a]	.282	.274	2.989

a. Predictors: (Constant), frequency of visit to Plant Health Clinics, How do you hear about Plant Health clinics?, location of nearest Plant Health Clinics, have you visited Plant health clinic or not?

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1224.264	4	306.066	34.254	.000[b]
	Residual	3118.360	349	8.935		
	Total	4342.624	353			

a. Dependent Variable: Change in farm expenses due to plant health clinics
b. Predictors: (Constant), frequency of visit to Plant Health Clinics, How do you hear about Plant Health clinics?, location of nearest Plant Health Clinics, have you visited Plant health clinic or not?

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	24.940	1.575		15.838	.000
	Location of nearest Plant Health Clinics	-.237	.459	-.032	-.517	.606
	How do you hear about Plant Health clinics?	-.016	.144	-.005	-.112	.911
	have you visited Plant health clinic or not?	-4.312	.718	-.616	-6.006	.000
	frequency of visit to Plant Health Clinics	-.476	.361	-.127	-1.319	.188

a. Dependent Variable: Difference in *in farm expenses due to plant health clinics*

The R value of 0.531 suggests a moderate correlation, with R Square at 0.282 indicating that around 28% of the variance in farm expenses is explained by the predictors. The F-statistic (34.254) is significant, confirming the model's relevance (p < 0.001). The constant term is positive (24.940), indicating a base increase in farm expenses. The significant negative coefficient for "Have you visited Plant Health Clinic or not?" (B = -4.312, p < 0.001) suggests that visiting a PHC reduces farm expenses. Other predictors (location, frequency, awareness) do not show significant effects.

4 CONCLUSIONS

It was concluded that majority (49.2%) of the cotton growers are aged between 41 to 50 years, indicating that middle-aged individuals dominate the cotton farming sector. The largest segment, 39.8%, has completed primary education. Most of the farmers (58.2%) possessed own 11–15 acres of land of agricultural land. Majority (59.9%) of respondents reported having a clinic near their residence. Fellow farmers are the most common source, accounting for 38.7. Majority of respondents used to visit PHC on weekly basis. It was concluded that PHCs are mainly effective in improving agricultural productivity of cotton growers by significantly improving their knowledge level regarding best cotton production practices, providing in time access to agricultural knowledge and information, offering cost effective and efficient plant protection services, and diagnosing pests and diseases. Role of PHCs in enhancing farmers' technical knowledge and skills, development of stakeholder's linkages, and serving as an inclusive approach appears less effective, as these factors showed lower agreement levels and no significant statistical association. Overall, PHCs played a significant and valuable role in information dissemination and problem diagnosis. Results regarding change in plant production & protection practices of cotton growers due to PHCs showed limited and non-significant impact on most of the cotton production and protection practices as indicated by high p-value. The overall trend of the respondents remains neutral. It was also concluded that PHCs contributed significantly in reducing farm expenses particularly application of fertilizer and harvesting cost which are statistically significant. Overall, PHCs have moderate impact in reducing farm inputs of cotton growers. Results regarding change in competencies of staff due to PHCs show that PHCs didn't significantly improve staff competencies in terms of education, training and skills enhancement. It was concluded that PHCs had a moderate positive impact on farmer-extension linkages by making agricultural extension & outreach advisory services more demand-driven. Cotton growers identified several challenges being faced in efficient functioning of PHCs. Out of these operational and systematic limitations are the leading ones. Findings of Regression Analysis show that visit to PHC is the most critical and important factor in brining change in plant production and protection practices by cotton growers. Therefore, extension field staff must encourage farmers to visit PHCs. Additionally, findings of second regression model reveals that PHCs have significant impact on improving plant production and protection practices of cotton growers but their impact of reducing farm input expenses is limited. This has been concluded that visit to PHCs by the cotton growers significantly associated with reduction of farm expenses ($\beta = -0.616$, $p < 0.001$).

4.1 Recommendations

The study recommended following few measures keeping in view the field based collected data:

- PHCs focus should be extended from few crops to all the major crops grown all over Pakistan.
- Farmers must be motivated to visit PHCs through Extension field staff. This will increase their confidence over government and on PHCs.
- Challenges faced by PHCs especially those factors causing hurdle in the service delivery should be addressed on priority so that PHCs should provide them independently without any external pressure.

4.2 Extended summary

Cotton is one of the leading cash crops of Pakistan and is the backbone of national economy development. General purpose of present doctoral research study was to measure the effectiveness and impact of Plant Health Clinics (PHCs) on farm productivity of cotton growers of the Punjab Province of Pakistan. The study was conducted in the two major cotton growing districts of the Punjab i.e., Multan and Khanewal districts. The study was limited to 354 study respondents randomly selected through multistage sampling technique. Structured reliable and validated interview schedule was used as the data collection for this study. Personal face-to-face interviews were conducted for the collection of data. The collected data were coded into excel and analyzed using Statistical Package for Social Sciences (SPSS). Descriptive as well as correlational analytical techniques were used for the interpretation of data.

The data corresponding to the demographic profile of respondents showed that around half of the respondents were middle-aged cotton growers with low educational level that indicate a major challenge in adopting agricultural innovations. Most of the farmers possessed 11-15 acres of agricultural land for farming that indicate medium-sized farm households. Farmers got agricultural related information from multiple sources. M of respondents got information from their fellow farmers. This indicates that wide prevalence of farmer-to-farmer extension in the research area. This also reflects the reliance of majority of farmers on informal networks for seeking agricultural related information. Around half of the respondents used to visit PHCs on fortnight basis. Findings of the study indicate that respondents generally agreed that PHCs improve knowledge and awareness level, improve accessibility of agricultural related information, and assist farmers in diagnosis of crop pests and diseases. Among perceived benefits, cost-efficiency and diagnostic support showed highly statistical significance and associations, whereas aspects such as linking stakeholders and ensuring inclusive service delivery were less strongly associated. Findings also indicate that the adoption of recommended plantation practices were significantly associated with visit to PHCs by the cotton growers. While other agronomic practices like laser land leveling, cotton seed treatment, fertilizer application, pest management, and post-harvest showed no statistically significant association. This shows the existence of knowledge–practice gap among cotton growers.

Cost-benefit analysis showed that most of the respondents agreed that PHCs contributed to reduce cost of inputs, particularly in terms of fertilizer application expenses. Harvesting cost reductions were moderately significant, while other cost components exhibited no significant changes. These findings suggested that although PHCs, influence input-related decisions, especially fertilizers, but have limited impact on broader cost-benefit structure. With regard to capacity building of staff of PHCs, most of the respondents disagreed that staff were highly trained. However, factors such as experience, problem-solving ability, and communication/time management skills showed significant associations with effectiveness, whereas formal training and education levels were not statistically significant. This highlights the need for capacity building to improve the technical capacity of staff of PHCs. The study identified several constraints that limit the effectiveness of PHCs. These constraints include insufficient staff technical training, lack of stakeholder engagement, and weak integration with agricultural extension and outreach advisory services.

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CONFLICTS OF INTERESTS

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