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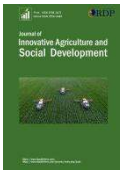

Article

Determination of Linkages among Citrus Growers and Agricultural Extension Workers: Evidence in Punjab, Pakistan

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ABSTRACT

This current study aimed to determine and improve the adaptation level of citrus farmers by finding the extent of linkage between farmers and extension workers. The main objectives were the identification of specific knowledge deficiency areas of farmers regarding citrus crop; constraints faced by citrus growers and differentiate the adaptation level of adopters and non-adopters. Primary data were collected from 400 citrus growers through well-structured and pre-tested questionnaire from four districts of Punjab province of Pakistan i.e. Sahiwal, Toba Tek Singh, Bhakkar and Layyah. Out of the total 400 targeted citrus growers, 60 were adopters while 360 were non-adopters (randomly selected farmers). The stratified random sampling technique was used for data collection. Twenty-five extension agents were interviewed from each district thus making a total of 100 extension workers from four districts in the study area. The knowledge deficient areas of farmers and lack of adaptation of recommendations as inquired from citrus growers and extension agents were divided into nine categories ranging from land preparation to post-harvest operations. The factor analysis was used to identify the constraints faced by the citrus growers. The extension agents were of the view that the farmer's adaptation found to be high. The detailed analysis revealed that adopters were aware of pest, nursery and plant/cultural management while they had poor knowledge of processing/ packaging, land preparation and soil and irrigation management. The non-adopters were lacking in processing/packaging, land preparation and soil management, irrigation and harvesting management. However, they had good knowledge of pest, nursery and plant/cultural management. It is recommended that government should fill the vacant posts to increase the extension workers to farmers' ratio. The In-Service training of the extension workers must be conducted regularly to refresh their knowledge and capacity building so that the latest techniques may be disseminated to the farmers to increase the profitability of citrus. Study recommended that farmers must be provided latest information regarding post-harvest operations other than only production practices.

Keywords: *Citrus Growers; Extension Workers; Adaptation; Recommendations; Adopters; Pakistan*

1. Introduction

Citrus is the most widely cultivated fruit crop and ranks first in world fruit production. Total production of the world citrus industry stands at 124.5 million tons and is being cultivated on area of 8.7 million hectares (FAO, 2021). The major citrus producing countries are Brazil, China, the United States, Mexico, India and Spain which contribute about 2/3 of the world's citrus production (FAO, 2016). Globally, total orange and kinnow production stand at 66.9 million tons and 32.9 million tons, respectively. During 2016, the total world citrus trade was 30.9 million tons. Citrus includes large varietal collection of orange, kinnow, grapefruit, lemon, tangerine, shaddock, sour orange, citron, dried orange peel, frozen orange pulp and lime (Ashebre, 2015). Citrus

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contains a good quantity of vitamin C, mineral, nutrients, phytochemicals and starches, which are essential for a healthy life. (FAO, 2017).

Citrus ranks at first position among fruits in area and production in Pakistan and Kinnow is cultivated in Punjab province. In Pakistan citrus was cultivated on an area of 206 thousand hectares with a total production of 2.3 million tons in 2020 (FAO, 2021). Globally, Pakistan ranked at 36th in terms of production and 56th in exports of citrus commodities Pakistan exported fruit of worth 641$ million in the fiscal year 2015-16 (FAO, 2016). In Pakistan, citrus is grown in Punjab; district Bhakkar, Layyah, Sargodha, Jhang, Mianwali, Multan, TT Singh and Sahiwal. KPK; district Swabi, Swat, Peshawar, Hazara, Mardan and Nowshera. Sindh; district Nawabshah, Khairpur and Sukkur. Balochistan; district Kech, Makran and Sibbi (Shaukat, 2013).

Pakistan is 5th largest kinnow exporter with a yield of 9.2 tons per hectare (Riaz, 2014). The country is exporting 10 percent of its total citrus production that can be increased thrice than existing export volume by providing modern technologies to farmers from plantation to post-harvest stages.

The quality and production of citrus fruit can be enhanced through suitable practices and management of proper nutrition in the plants (Lahey *et al*., 2004). Citrus plant requires three to four years to grow when it starts producing fruit. It requires seven to eight years to grow fully. Productive life of tree is 35 to 40 years (Sarfraz, 2015). Kinnow is very delicate in nature because 20-30 percent postharvest losses happen during storage due to fungal and bacterial adulteration on the fruit, low quality fruit, unsuitable weather conditions, delay in harvesting, lack of proper roads and improper cold storage facilities (Singh *et al*., 2004).

The citrus industry in Pakistan is facing pre-harvest and post-harvest issues, lead to low quality and quantity of fruits which finally results in lesser export and high economic loss to the country. These problems comprise; diverse diseases and pest attacks, low yield in the alternate year, underdeveloped citrus industry, lack of information to growers about the progressive industry, middle man exploitation, scarcity of skilled labor, poor management during harvesting, transportation, packing and storage, inadequate research and development facilities. (Ibrahim *et al*., 2007). Aging of citrus trees, poor management and inadequate market infrastructure. All these problems lead to declining and failure of citrus industry (Aatif *et al.,* 2015).

Best management practices can play an important role in improving quality and yield of citrus. Balanced use of nutrients can enhance the flowering, fruit size, fruit set and fruit's biochemical quality (Papadakis *et al.,* 2005). Citrus growers cannot ignore the effects of macro and micronutrients on plant's health. They must give due importance to balanced use of nutrients (Razi *et al*., 2011). Macronutrients are required in larger amount as compared to micronutrients. With balanced use of fertilizer, farmers can get better crop with more yields (Abd-Allah, 2006). Citrus growing districts in Punjab are Sargodha, Sahiwal, Toba Tek Singh, Layyah, Bhakkar, Jhang and M.B Din. (AMIS, 2021).

The transferring of agricultural knowledge is the main responsibility of the Agricultural Extension Department, Government of Punjab. The provision of innovative technologies and their acceptance by farmers can be accomplished through skillful and effective agricultural extension advisory services. (Khan, 2010).

Agricultural extension has the mandate to deliver modern recommended technologies/ practices and assist farmers to attain a preferred level of crop production by transmitting innovations or practices from a research organization to farmers at their doorstep. The main objective of agricultural extension lies in conveying, transforming and providing a valuable bundle of agricultural and advisory services to farmers and supporting them in the application of this information (Ajieh, 2006).

Agricultural extension services serve as a bridge between research organizations and farming community. It transfers an exchange of information between farmers and extension agents in the form of applied information which is very useful to figure out ways to increase income in agriculture sector (Malik, 2003). Small holder's farmers remain more exposed to risk and ambiguity when they lack information about inputs, meteorological conditions, management practices and market. The farmers who collect and use up-to-date information may be able to reduce production and market risks (Anderson, 2007).

The recommended farmer to extension officer ratio ranges from 10 to 50 farmers to one extension

officer and this largely depends upon farm size and mainly distance the agricultural extension officer have to travel to farmer's farm (Banson *et al*., 2014). Agricultural extension services in Pakistan are under the authority of provincial agricultural departments. Several extension models and approaches have been executed up till now which include multiple programs directly related to agricultural and rural development (Afzal, 2008). There is a difference in the technical capabilities of agricultural officers due to their presence in training programs, there is a need for training of agricultural officers to improve their knowledge about the horticultural sector (Khan *et al.,* 2012)

Department of Agriculture and Livestock Products Marketing and Grading (DALPMG) should provide the latest marketing information to all stakeholders involved in the value chain of citrus especially the producers (Sharif *et al*., 2005). The production constraints faced by citrus growers as (i) lack of capital (ii) pest problem (iii) premature fruit drop (iv) low yielding trees (Oyedele and Yahaya, 2010). The government can use social media tools for speedy circulation of authentic, reliable and useful information to citrus growers which will lead to an overall improvement of citrus industry of Pakistan (Nawaz *et al.,* 2018).

Farmer should adopt proper recommendations/practices offered by agricultural extension staff e.g. proper plant to plant distance and suitable layout to reduce emerging environmental hazards (Easterling *et al*., 2003). By adopting technological developments with better farming practices and good quality of pesticides and fertilizers, citrus growers will be able to enhance their per hectare yield (Pellokila *et al.*, 2004). To enhance the adoption of extension recommendations by farmers, the government should equip agricultural extension workers with sufficient infrastructure for their easy mobility to contact farmers and provision of suitable monetary assistance to the farmers to adopt improved farm technologies (Emmanuel *et al*., 2016).

Keeping in view the significance of extension services in uplifting the citrus productivity by ensuring their strong linkages with farmers. The present study aimed to determine and improve the adaptation level of citrus farmers and find the shortcoming among farmers and extension workers linkages. In particular, the study focused on the following objectives.

1. Study the socio-economic characteristics of citrus growers and extension agents.
2. Identify the specific knowledge deficiency areas of farmers regarding citrus crop
3. Evaluate the extent of adaptation in view of extension agents by the farmers
4. Find out the constraints being faced by citrus growers.

2. Materials and Methods

This study aimed to investigate the farmers and extension worker's linkages, find out factors/ constraints that halting the farmers to get better citrus productivity and also identified the extent of adaptation of given recommendations by extension workers. For this purpose, the data have been collected from farmers as well as extension workers.

2.1. Study area

The four districts (Sahiwal, T.T. Singh, Bhakkar and Layyah) were chosen to collect primary data through a well-structured questionnaire. This study attempts to measure the citrus economy in the said districts. These districts are favorable for citrus cultivation due to their favorable soil and climate. The pre-testing of the questionaries also took place before the actual data collection. The data were collected in year 2022.

2.2. Extension workers data

The data from 100 extension agents were collected from four districts mentioned above, consisting of 25 extension agents from each district. The officers/officials were interviewed through a well-structured and designed questionnaire. The extension agents were inquired about their services in general and specifically for the citrus crop. They were asked either their services/recommendations were adopted by the farmers and rate the adaptation level on a scale of high, medium and low.

2.3. Citrus farmers data

Districts were divided into different stratum based on the division of villages where demonstration plots had been exhibited under the project by the

Department of Agricultural Extension. From each district, 100 farmers were randomly selected, out of which 90 were non-adopters and 10 farmers were adopters. The term "adopters" was used for the farmers whose citrus orchards were selected as demonstration plots by the agricultural extension department, while "non-adopters" were considered as the random farmers selected from the same villages. The stratified random sampling technique was used to identify the farmers taken for the survey. In the first stage, 04 districts were selected, at the second stage, 05 villages from each district were selected and at third stage 02 adopters and 18 non-adopters were selected from each village randomly. Thus, a sample of 40 farmers was taken from selected villages where demonstration plots have been established by the extension workers.

2.4. Empirical analysis

2.4.1. Extent of adaptation in view of extension workers

The extension workers were asked to rate the farmer's adaptation level of the recommendations given by the extension workers on a scale of High, Medium and Low, respectively. Thus, the farmer's adaptation level was measured as they are adopting recommendations made by extension workers and their adaption level also. The extension workers were asked to rank their services and adaptations made by them at the scale of high, medium and low.

2.4.2. Ranking of provision of services and problems faced by extension workers

The non-parametric test Kendall's W test was used to identify the raking of the services provided by the extension workers to the farmers. Similarly, the constraints were ranked using the same test. The detailed description of the test has been given below.

2.4.3. Kendall's W test

A nonparametric test commonly used to determine the overall agreement among the set of rankings is Kendall's coefficient of concordance (Zhao *et al.* 2015). This method does not need any specific distribution of the data (Siegel, 1957). The study used Kendall's W test to check whether different respondents within a certain group agreed on the ranking of the constraints. Kendall's W assesses the degree of consensus among multiple ratings and making it ideal for analysis for results of study. The null hypothesis of Kendall's W test is that "there is no agreement among the ranking given by the respondents." Kendall's W value ranges from 0 to 1, and a value of 0 indicated "no agreement" and 1 indicated "complete agreement." If the value of Kendall's W generated from the test has low significance at the given level, then the null hypothesis was rejected, and it was concluded that some degree of agreement exists among the respondents (Zhao *et al.* 2015).

2.4.4. Constraints analysis of farmers

The farmers were asked about different constraints faced by them in citrus production. These constraints were measured on a Likert scale ranging from 1 to 5 i.e. 1= strongly agree to 5= strongly disagree. These constraints were identified through Focus Group Discussions (FGDs) with farmers while doing Pilot testing of the questionnaire and with the help of literature review.

2.4.5. Reliability test

The reliability of these items was assessed through a non-parametric test known as Cronbach Alpha. The Cronbach Alpha coefficient (α) has a value ranging from 0 to 1. The higher value of α shows that the scale used is more reliable and vice versa (Santos, 1999). However, generally, the value of α must be greater than 0.70 (Tavakol and Dennick, 2011).

2.4.6. Ranking of the constraints

The Kendall's W test was used to rank the constraints faced by the farmers, which has been described in the previous sections. It will tell us the most crucial constraints faced by the farmers in citrus production.

3. Results

3.1. Socioeconomic characteristics of the consumers

This section discusses descriptive statistics of the sampled population i.e extension agents and farmers, the extent of adaptation of recommendations by the farmers being given during various activities in citrus cultivation and also explain the constraints which citrus growers are facing in citrus production and marketing as well as by the extension workers while performing their duty (see table 1).

Table 1 shows that 52 percent of farmers (adopters) were visiting the extension workers as per their need, while 42 percent were visiting them on monthly basis and 2.5 percent on a weekly and fortnightly basis each. Similarly, 55 percent extension workers visit the farmers on call, 27.5 percent on monthly basis, 15 percent on

fortnightly and 2.5 percent were visiting the farmers on a weekly basis. It is maybe concluded that the frequency of visits does not improve the extension services it depends on the capabilities and awareness of the extension workers.

The extension methods are as follows: 42.5 percent farmers said that extension workers made individual contacts with them, 2.5 percent attended farmer's training programs, 10 percent claimed that they attended farmer field schools, 12.5 percent told that they attended field days and 32.5 percent claimed that they got information through other methods. Similarly, different tools were used for knowledge dissemination by extension staff and it was observed that 42.5 percent got information through handouts/brochures, 5 percent through demonstration sites, 7.5 percent through visual aids and 45 percent got information through all these methods or mixture of all the knowledge dissemination tools.

3.2. Agricultural extension staff view regarding adaptation level of recommendations

The extension workers were asked different questions about the advisory services they are providing to farmers. These questions were divided into nine categories/ groups from land preparation and sowing to harvesting, processing and packaging of the citrus crop (see table 2). The adaptation level of agricultural extension recommendations regarding citrus cultivation, production and marketing by farmers was measured on a high, medium and low scale.

The overall adaptation rate was calculated by dividing all the detailed questions. The results revealed that the overall adaptation rate of the extension worker's services/recommendations was found to be 21, 61 and 18 percent as high medium and low, respectively. The detailed results reveal that processing/ packaging has the lowest percentage adaptation rate of 38 percent, harvesting is at second number with a 25 percent low adaptation rate, and fertilizer management is ranked at third with the 20 percent low adaptation rate. Thus, it is concluded that processing/packaging, harvesting methods and timing and fertilizer management are the top three crucial areas where recommendations/ suggestions provided by the extension workers experienced a low adaptation rate. The top three areas with the high adaptation rate were found to be nursery management, land preparation and soil management, pest management with figures 29, 26 and 24 percent, respectively.

Table 1. Interaction between Adopters and Extension Workers

Variable	Item/ Description	Freq.	% age
Farmers Visits to the Agricultural Extension Offices	Weekly	1	2.5
	Fortnightly	1	2.5
	Monthly	17	42.5
	When needed	21	52.5
	Overall	40	100
Agricultural Extension Officer visits to Farmers	Weekly	1	2.5
	Fortnightly	6	15
	Monthly	11	27.5
	On-Call	22	55
	Overall	40	100
Extension Method used by Agricultural Extension Staff	Individual Contact	17	42.5
	Farmer Training Program	1	2.5
	Farmer Field School	4	10
	Field Days	5	12.5
	Others	13	32.5
	Overall	40	100
Knowledge Dissemination Method used by Agricultural Extension Staff	Brochures/ Handouts	17	42.5
	Demonstration Sites	2	5
	Agricultural Exhibition/ Fairs	0	-
	Videos Movies	3	7.5
	Others	18	45
	Overall	360	100

Source: Data collected by authors

3.3. Non-Adopters Knowledge/Level of Agricultural Extension Recommendations

The different questions were asked from farmers either they know about the land preparation and soil management, nursery, fertilizer, pest, and irrigation management. Further, they were asked about plant/cultural practices, knowledge about citrus diseases and their identification, the standard harvesting and post-harvesting techniques. Table 3 shows the overall knowledge deficiency areas of the non-adopter's farmers interviewed.

Table 2. Adaptation level by Citrus Growers (Agricultural Extension View)

No.			Bhakkar	Layyah	Sahiwal	TT Singh	Total
1.	Land Preparation and Soil Management	High	7	8	3	8	26
		Medium	12	14	19	14	58
		Low	6	3	3	3	16
2.	Nursery Management	High	8	7	4	9	29
		Medium	12	15	21	14	63
		Low	4	2	0	2	9
3.	Fertilizer Management	High	9	5	2	4	19
		Medium	11	18	21	11	61
		Low	6	3	2	10	20
4.	Pest Management	High	10	7	2	7	25
		Medium	11	17	21	15	65
		Low	4	1	1	3	10
5.	Disease Management	High	9	7	3	6	24
		Medium	11	16	22	17	66
		Low	5	2	0	2	10
6.	Irrigation Management	High	4	8	5	8	24
		Medium	13	14	19	12	59
		Low	8	3	2	5	17
7.	Plant/Cultural Management	High	9	8	2	3	22
		Medium	12	15	17	18	62
		Low	4	3	6	4	16
8.	Harvesting	High	4	6	1	3	13
		Medium	13	13	19	16	62
		Low	8	6	5	6	25
9.	Processing/Packaging	High	2	4	0	2	8
		Medium	13	12	13	17	54
		Low	10	10	12	6	38
Overall Adaptation Level.		High	7	6	2	6	21
		Medium	12	15	19	15	61
		Low	6	4	3	4	18

Source: Data collected by authors

The results show the same pattern as indicated in the previous section when the same questions were asked by the extension agents. Thus, these results are fruitful in identifying the weak areas of non-adopters and they can be equipped with need-based knowledge. The overall result reveals that 52 percent of farmers are well versed with recommendations made by extension workers and 48 percent of farmers are not aware of the different recommended practices. It means that about half of the citrus growers are not adapting recommendations being provided by the extension workers. However, the detailed results reveal that the non-adopters (farmers) are weak in the following categories.

1. Processing/ packaging: (15 percent YES, 85 percent NO)
2. Land preparation and soil management (34 percent YES, 66 percent NO)
3. Irrigation Management (39 percent YES, 61 percent NO)
4. Harvesting Management (52 percent YES, 48 percent NO)

Table 3: Overall, Knowledge Deficiency Areas (Non-Adopters).

		Bhakkar	Layyah	Sahiwal	TT Singh	Total
Land Preparation and Soil Management	Yes	34	37	36	29	34
	No	66	63	64	71	**66**
Nursery Management	Yes	74	55	74	70	70
	No	26	45	26	30	30
Fertilizer Management	Yes	60	58	64	69	63
	No	40	42	36	31	37
Pest Management	Yes	80	65	72	71	72
	No	20	35	28	29	28
Disease Management	Yes	59	48	71	62	60
	No	41	52	29	38	40
Irrigation Management	Yes	38	32	43	43	39
	No	62	68	57	57	61
Plant/Cultural Management	Yes	59	56	74	67	62
	No	41	45	26	33	38
Harvesting	Yes	52	46	52	57	52
	No	48	54	49	43	48
Processing/Packaging	Yes	13	23	10	13	15
	No	87	77	90	87	85
Overall Knowledge	Yes	52	47	55	53	52
	No	48	53	45	47	48

Source: Data collected by authors

The processing/ packaging is an important post-harvest activity, which helps the farmers to obtain the due price of their agricultural produce and 85 percent of farmers do not know or either they are not adopting the recommended practices. Secondly, land preparation and soil management are not maintained properly as it plays an important role in obtaining better yield. Thirdly, farmers are not water efficient which means that water productivity is very low compared to the recommended practices suggested by the extension workers. The reasons for these weaknesses have been explained in constraint analysis faced by the farmers. However, some encouraging findings have been indicated below;

1. Pest management (72 percent YES, 28 percent NO)
2. Nursery management (70 percent YES, 30 percent NO)
3. Plant/ cultural management (62 percent YES. 38 percent NO)

The above information shows that citrus growers are aware of pest management, nursery management and cultural management. Most of the farmers are doing in these activities according to the guidelines being recommended by the extension agents. This analysis highlighted the knowledge deficiency areas in various activities of citrus cultivation. That proposes intensive training of extension agents in those aspects for the more effective message to communicate. The comparison of non-adopters, adopters and extension agents according to these categories has been portrayed in this preceding section.

3.4. Adopters Knowledge/Level of Agricultural Extension Recommendations

There were 40 adopters (farmers) out of a total sample of 400 farmers from four districts, selected from the study area. The same questions were asked to the adopters as were asked from the extension agents and non-adopters. This detailed analysis made us clear in identifying the specific gray areas, where the citrus growers can be equipped with more knowledge through various interventions and by taking possible measures. The results of the same 9 categories are explained in table 4. Result shows the overall knowledge deficiency areas for sampled adopters. The adopters are those citrus growers who had demonstration plots at their citrus orchards and their yield is higher than the other non- adopters (farmers). It was observed that overall 57 percent

had good knowledge of recommendations made by extension agents in the following nine categories ranging from sowing to post-harvest losses. There was 43 percent of farmers who had not complete knowledge of these recommendations provided by the extension workers.

Table 4. Overall Adopters' Knowledge Deficiency Areas

		Percentage
Land Preparation and Soil Management	Yes	38
	No	62
Nursery Management	Yes	77
	No	23
Fertilizer Management	Yes	66
	No	34
Pest Management	Yes	77
	No	23
Disease Management	Yes	64
	No	36
Irrigation Management	Yes	48
	No	52
Plant/Cultural Management	Yes	69
	No	31
Harvesting	Yes	53
	No	47
Processing/Packaging	Yes	21
	No	79
Overall Knowledge	Yes	57
	No	43

Adopters are weak in the following described categories and the almost same pattern was observed as in the case of non-adopters. The adopter's knowledge is better as compared to the non-adopters and the percentage of farmers with "YES" is larger than the adopters.

1. Processing/ packaging: (21 percent YES, 79 percent NO)
2. Land preparation and soil management (38 percent YES, 62 percent NO)
3. Irrigation Management (48 percent YES, 52 percent NO)
4. Harvesting Management (53 percent YES, 47 percent NO)

Processing/ Packaging is the main cause of farmers getting low prices in the markers and it the area where farmers are equipped with less knowledge like non-adopters. The activities where adopters are performing well or they have a better understanding regarding recommended practices are as follows.

1. Pest management (77 percent YES, 23 percent NO)
2. Nursery management (77 percent YES, 23 percent NO)
3. Plant/ cultural management (69 percent YES. 31 percent NO)

The ranking in the above-mentioned areas is explained in the preceding section and cross-examined with the view of extension agents. It has been found that adopters are well aware while managing their citrus orchard against pests. Most of the farmers i.e. 77 percent also have good knowledge about citrus nursery management and also performing cultural practices according to the recommended way.

3.5. Comparison of Extension Workers Vs Farmer's View (Adopters and Non-Adopters): Knowledge Deficiency Areas

Table 5 presents the view of extension workers regarding the extent of adaptation level made by farmers and the same questions were asked by farmers to check their knowledge regarding different practices recommended by extension workers as mentioned earlier. There were many questions asked and they were grouped into nine different categories. The overall knowledge of the farmers was average among all the nine categories.

The left-hand side of the Table 5 presents the extension worker's view and the extent of adaptation made by the farmers ranging from Low to High. It was concluded that Processing/ packaging, harvesting and fertilizer management were the areas with the lowest adaptation rates i.e. first, second and third, respectively. The same pattern was observed when we see the top three knowledge deficient areas of the farmers (adopters and non-adopters). The processing/packaging is at first as told by extension agents. The second most knowledge deficient area was land preparation and soil management. The third one knowledge deficient area was irrigation management which was followed by harvesting management at rank four. Similarly, according to the extension workers, the top three areas with a high adaptation rate were nursery management, disease management and pest management.

Table 5. Overall Knowledge Deficiency Areas Vs Extent of Adaptation (Cross-Check the Response of Farmers and Extension Agents)

Ranking of Extent of Adaptation in view of Extension Agents by the Farmers		Ranking of Knowledge Deficiency Areas of Adopters and Non-Adopters				
Adaptation Level		Extension Workers (n=100)	Non-Adopters (n=360)	Adopters (n=40)	Adaptation Level	
LOW TO HIGH	1	Processing/ Packaging	Processing/ Packaging	Processing/ Packaging	9	HIGH TO LOW
	2	Harvesting	Land Preparation and Soil Management	Land Preparation and Soil Management	8	
	3	Fertilizer Management	Irrigation Management	Irrigation Management	7	
	4	Irrigation Management	Harvesting Management	Harvesting Management	6	
	5	Plant/Cultural Management	Disease Management	Disease Management	5	
	6	Land Preparation and Soil Management	Plant/Cultural Management	Fertilizer Management	4	
	7	Pest Management	Fertilizer Management	Plant/Cultural Management	3	
	8	Disease Management	Nursery Management	Nursery Management	2	
	9	Nursery Management	Pest Management	Pest Management	1	

However, the farmer's top three areas were pest, nursery and fertilizer management by adopters. While non-adopters were aware in pest, nursery and plant/ cultural management. Thus, it is concluded that the processing/ packaging, harvesting and fertilizer management are the top three areas with the lowest rates of adaptation. On the other hand, the same was identified by the adopters and non-adopters with the highest knowledge deficiency areas. Secondly, the farmers wanted to get more training in land preparation and soil management. Thirdly, it was irrigation management where farmers have poor knowledge about irrigation scheduling, approved irrigation methods and groundwater testing, etc.

3.6. Constraints Analysis of Farmers in Citrus Production

The weaknesses and strengths of farmers have been described so far by the adopters and non-adopters as well as the adaptation level in view of extension workers. The Kendall's W test was used to rank the constraints faced by the farmers.

Table 6 shows the ranking of the constraints and tested statistically through Kandall's W test. It has been found that climatic variables i.e. flood, high rainfall, drought and fog/smog are the crucial constraints faced by the farmers. Then underground water quality pumped through tube wells is a major constraint faced by the citrus growers. Similarly, adulteration in pesticides/weedicides and high labor wages are also major production constraints. The results or Kandal's W ranking tests are observed as significant i.e. Kandall's W coefficient is highly significant, 0.085 which shows that there is a consensus among the respondents regarding the ranking of these constraints.

4. Results

The use of Kendall's W test indicates that the citrus farmers in Punjab are also in agreement on the issues affecting citrus farming. The major concern is unstable climatic conditions such as; floods, rain, dry spurs, and smog, affect citrus productivity. These are in concordance with other works hence Ahmed et al. (2019); Khan et al. (2021), that noted that citrus production is likely to be interrupted by changes in the temperature and any abnormal rainfall. These weather conditions wash fruits and also affect flowering, fruit development and ripening thus decreasing both quality and quantity at the time of harvesting.

Table 6: Kandall's W Ranking of the Constraints

Rank	Kandall's W Rank	Mean Rank	Mean	Std. Deviation
1	Flood	21.68	3.41	0.88
2	High Rainfall	19.64	3.10	0.96
3	Drought	19.08	3.05	0.96
4	Fog/Smog	18.19	2.88	0.76
5	Tube well Water Quality	16.96	2.81	1.08
6	Impure Pesticide/Weedicides	16.84	2.68	0.95
7	Poor Produce Quality	16.15	2.66	0.95
8	High Labor Wages	15.35	2.45	0.83
9	Deteriorating Soil Quality	15.04	2.45	0.83
10	High Electricity Prices	14.62	2.43	0.88
11	Extreme Temperature	13.82	2.37	0.88
12	High Ploughing Prices	13.73	2.28	0.73
13	High Fertilizer Prices	13.52	2.25	0.71
14	Packaging Material Shortage	13.43	2.21	0.79
15	Input Price Fluctuation	13.23	2.24	0.90
16	High Fuel Prices	13.06	2.18	0.76
17	High Marketing Charges	12.79	2.16	0.86
18	Improper Citrus Markets	12.75	2.13	0.72
19	Citrus Diseases	12.69	2.12	0.79
20	Poor marketing Knowledge	12.06	2.05	0.81
21	Weak Knowledge of Extension Workers	12.05	2.06	0.81
22	High Nursery Prices	11.42	1.99	0.67
23	Lack of Storage Facilities	11.04	1.93	0.75
24	Poor ISO Standards Knowledge	9.90	1.81	0.80
25	Cool Chain Facilities	9.77	1.79	0.77
26	Farmers and Extension Workers weak Linkages	9.74	1.79	0.75
27	Lack of Extension Workers	9.46	1.76	0.80

Kendall's W (Coefficient of Concordance) =0.085 | Chi-Square = 1970.32 |N=400 | df=26 | Asymp. Sig. = 0.00

It is identified that poor ground water quality, especially the ground water extracted from the tube well also a main issue confronting the farmers. The similar findings have also highlighted by other researchers like Ali et al. (2018), Hussain et al. (2020) investigated the issue in the citrus orchards. They said that the use of salty groundwater discourages the soil and makes farming costly due to frequent use of fertilizers and soil amendments. This is particularly so where canal is incomplete or unavailable in some parts or it may not be used frequently for one reason or the other. This is the main reason that force farmers to rely on the usage of groundwater even more than before. At times without the water testing or a need of irrigation water management departments support.

However, diluted pesticides and weedicides not only affects pest and disease control but also undermines faith of farmer toward input markets and extension services. Rehman, et al., (2017) and Nasir, et al., (2021) opine that poor quality or fake agrochemicals results into cycle of crop failure, pest resilient and demoralization of farmers over extension officers who advocate for fake inputs.

This erodes the existing farmer-extension worker interfaces, even though the latter may play the part of technology transfer and advisory services.

High cost of labour has also been ranked as a serious limitation by the respondents. It is especially a labor-intensive activity during the harvesting period of the crops and due to changes in population trends where people from the rural settings are migrating to work in other sectors that are not related to farming, they find it very hard to come by cheap labor. Even though mechanization could be applied towards solving some of these problems, it is however not applicable by most of the small-scale citrus farmers since they cannot afford it, they are not aware of it or extension agencies have not promoted it enough.

The results imply that there is a crucial challenge in the use of agricultural extension to overcome these practical challenges. Even though such guided extension systems have been established for the practice of recommended citrus practices, their uptake remains low. Similar findings were made by Latif et al. (2019) however they also pointed out that limited training of the extension service providers, lack of field visits and the top-down approach used in the dissemination of information by the extension services do not enable the extension services in Pakistan. Such a model of extension involves the farmer's feedback, active participation, and intervention through a need-forces model.

In addition, the problems that do affect the outlook of citrus farming include; poor institutional support, weak policy implementations, and lack of quality inputs and credit facilities to support best practices. These institutional deficiencies have been highlighted in different studies for instance, (Shah et al., 2020, Abbas et al., 2021) have why there is need for increased collaboration between public extension institutions, research organizations and private sector agencies. Increasing the offer for contract farming, subsidizing with genuine agrochemicals, and introducing replanting to high impact resistant citrus varieties may offer the medium to long-term solution.

Nevertheless, the Kendall's W value pointing more than 0,5 shows the essential level of agreement among farmers where all the constraints need to be met in a coherent and integral way. Creating trust, effective delivery and enhancing capacity between citrus growers and the extension services are crucial in improving adoption of better citrus practices and production in the region.

5. Conclusion

The study yields at least three key findings based on empirical results which are new to literature in the case of citrus cultivation in the study area. The first was about the poor adaptation by farmers regarding processing/packaging, then in harvesting operations and irrigation management. The fact was also confirmed by the extension workers as the results revealed that farmers were less adaptive to post-harvest operations/activities. Secondly, the ranking of the constraints and tested statistically through Kandall's W test. It has been found that climatic variables i.e. flood, high rainfall, drought and fog/smog are the crucial constraints faced by the farmers The results or Kandal's W ranking tests are observed as significant i.e. Kandall's W coefficient is highly significant, 0.085 which shows that there is a consensus among the respondents regarding the ranking of these constraints.

Thirdly, the farmer- extension linkages were found to be satisfactory as more than half of the respondents were of the view that extension workers were available to them whenever they needed them. However, the details reveal that extension worker's recommendations were highly adapted for a nursery, land preparation and soil management, pest and disease management while adaption rate was very low for processing/packaging, harvesting methods and timing and fertilizer management. The results of this study may be generalized to citrus growers while formulating policy. The following policy implications are recommended based on the empirical results of this study.

- The government should make appointments against the vacant posts to narrow the extension workers to the farmer's ratio. Lower staff should be assigned a lesser area to maximize their frequency in outreach activities.
- The In-service training of the extension workers must be conducted regularly to enhance/refresh their knowledge and improve the capacity building. This will help to disseminate the modern and latest technology/techniques to the farmers. Results reveal that extension workers may

be given training on priority basis in fields i.e. of processing/packaging, harvesting management and fertilizer management where adaptation rate was lowest among the farmers.

- The farmers must be given information regarding post-harvest operations i.e. processing/packaging, harvesting management, irrigation management and more demonstration plots should be established at the village level so that the latest citrus recommendations could be presented to farmers.
- The major constraints faced by citrus growers must be taken care of by giving them subsidies on input use to lower the costs so that their profitability can be increased.
- There should be Good Agricultural Practices (GAP) certification at the farm level and cold chain facilities must be developed. The farmers must be given awareness regarding SPS measures and ISO standards so that exports may be boosted by citrus crops.
- The constraint analysis reveals that weather is one of the major constraints in citrus cultivation being faced by citrus growers so there should be more emphasis on research and development (R&D). The new climate-resistant varieties may be developed to cope with the harsh climatic conditions without affecting production.

Authorship contribution statement

Abdullah Hammad: Conceptualization, Methodology, Data Analysis, Writing - original draft, Review & Editing, Validation. Asghar Ali: Conceptualization, Methodology, Resources, Validation, Supervision. Ali Tahir: Methodology, Resources, Data Analysis, Writing - review & editing, Validation, Investigation.

Conflicts of interest

The authors of this manuscript declare no conflicts of interest.

Data availability

Data is available upon request.

Consent statement

Oral consent was taken from the respondents before data collection. We only considered those respondents who gave their consent to answer all questions of interview.

References

Aatif, M., Z. Hassan and S. Ahmed. 2015. Pakistan's citrus industry (An overview of key constraints). Journal of Agricultural and Biological Science. 5: 122-124.

Abbas, M., Ali, S., & Aslam, M. (2021). Institutional constraints in the citrus supply chain in Pakistan. *Sarhad Journal of Agriculture*, 37(3), 651–659.

Abd-Allah, A. S. E. 2006. Effect of spraying some macro and micro nutrients on fruit set, yield and fruit quality of Washington Navel orange trees. Journal of Applied Sciences Research, 2(11), 1059-1063.

Afzal, M. 2008. Overview of agricultural research and extension in Pakistan. Pakistan Agricultural Research Council, Islamabad

Ahmed, M., Hussain, T., & Raza, M. (2019). Impact of climate change on citrus production in Pakistan: A farmer's perspective. *Pakistan Journal of Agricultural Sciences*, 56(3), 789–795. https://doi.org/10.21162/PAKJAS/19.8490

Ajieh, P.C., 2006. Farmers' perception of extension services of the Delta Stat Agricultural Development Programme (DTADP). Journal of Agriculture and Social Research (JASR), 6(2).

Ali, S., Nawaz, M., & Aslam, M. (2018). Water quality issues and their impact on citrus productivity in Southern Punjab. *Soil and Environment*, 37(1), 50–57.

Anderson, J.R. and Feder, G., 2007. Agricultural extension. Handbook of agricultural economics, 3, pp.2343-2378.

Anwar, M., Shahbaz, B., & Ashfaq, M. (2020). Labor shortage in agriculture: Implications for productivity and rural livelihoods in Punjab, Pakistan. *Journal of Rural Development and Agriculture*, 5(2), 23–30.

Ashebre, K.M. 2015. Pre-Harvest and Post-Harvest Factors Affecting Citrus fruit and Post-Harvest treatments. Journal of Biology, Agriculture and Healthcare. 5(23): 19-20.

Banson, K. E., Nguyen, N. C., & Bosch, O. J. (2014, June). Systemic intervention to

tackle the constraints and challenges facing stakeholders and the performance of the agricultural sector in Ghana. In 2014 9th International Conference on System of Systems Engineering (SOSE) (pp. 31-36). IEEE.

Easterling, W.E., Chhetri, N. and Niu, X., 2003. Improving the realism of modeling agronomic adaptation to climate change: simulating technological substitution. In Issues in the Impacts of Climate Variability and Change on Agriculture (pp. 149-173). Springer, Dordrecht.

Emmanuel, D., Owusu-Sekyere, E., Owusu, V. and Jordaan, H., 2016. Impact of agricultural extension service on adoption of chemical fertilizer: implications for rice productivity and development in Ghana. NJAS-Wageningen Journal of Life Sciences, 79, pp.41-49.

FAO,2017. Food and Agricultural Organization of United Nations. Available online with updates at http:/www.faostat.fao.org/site/342/default.aspx.

FAO,2021. Food and Agricultural Organization of United Nations. Available online with updates at http:/www.faostat.fao.org/site/342/default.aspx

Hussain, S., Shahid, M., & Manzoor, A. (2020). Groundwater salinity and its implications on citrus farming in central Punjab. *Environment and Agriculture*, 10(1), 14–22.

Ibrahim, M., Ahmad, N., Anwar, S.A. and Majeed, T., 2007. Effect of micronutrients on citrus fruit yield growing on calcareous soils. Advances in plant and animal boron nutrition, pp.179-182.

Khan, G.A., 2010. Present and prospective role of electronic media in the dissemination of agricultural technologies among farmers of the Punjab, Pakistan (Doctoral dissertation, UNIVERSITY OF AGRICULTURE, FAISALABAD PAKISTAN).

Khan, M.Z., Nawab, K., Khatam, A., Qasim, M., Ayub, G. and Nawaz, N., 2012. Communication gap and training needs of Pakistan's agricultural extension agents in horticulture. Sarhad Journal of Agriculture, 28(1).

Khan, R. U., Rehman, A., & Khan, M. (2021). Effects of climatic variations on citrus fruit quality and yield in Punjab, Pakistan. *International Journal of Horticultural Science and Technology*, 8(1), 17–25.

Lahey, K.A., Yuan, R., Burns, J.K., Ueng, P.P., Timmer, L.W. and Chung, K.R., 2004. Induction of phytohormones and differential gene expression in citrus flowers infected by the fungus Colletotrichum acutatum. Molecular Plant-Microbe Interactions, 17(12), pp.1394-1401.

Latif, A., Zafar, M. I., & Bashir, A. (2019). Evaluation of agricultural extension services for fruit growers in Punjab. *Pakistan Journal of Agricultural Research*, 32(2), 284–291.

Malik, W., 2003, May. Operationalizing Agricultural Extension Reforms in South Asia: A Case of Pakistan. In Regional Workshop on 'Operationalizing Reforms in Agricultural Extension in South Asia'New Delhi, India.

Nasir, M., Yasin, M., & Khan, M. H. (2021). The menace of adulterated agro-chemicals: A threat to sustainable agriculture in Pakistan. *Journal of Agricultural Practices and Research*, 5(1), 12–19.

Nawaz, M.A., F. Shireen, Z. Hussain, W. Ahmed, M. Afzal, T. Ashraf, B. Saleem and M.N. Khan. 2018. Guidelines to improve the Production of citrus fruits in Pakistan. Journal of Agricultural Research. 26(5): 310-321.

Oyedele, O.O. and Yahaya, M.K., 2010. Citrus farmers production constraints and attitude to training on improved techniques of citrus production. Journal of Agriculture and Social Research (JASR), 10(2).

Papadakis, I. E., Protopapadakis, E., Dimassi, K. N., and Therios, I. N. 2005. Nutritional status, yield, and fruit quality of "Encore" Mandarin trees grown in two sites of an orchard with different soil properties. Journal of plant nutrition, 27(9), 1505-1515.

Pellokila, M.R., Wiendiyati and Raya, U.R., 2004. The Impact of Technology Improvement on the Profitability of Soe Keprok Citrus Farming in Timor Tengah Selatan. Kupang: Universitas Nusa Cendana.

Razi, M. F., Khan, I. A., and Jaskani, M. J. 2011. Citrus plant nutritional profile in relation to Huanglongbing prevalence in Pakistan. Pakistan Journal of Agricultural Sciences, 48(4), 299-304

Rehman, F. U., Iqbal, M., & Mehmood, K. (2017). Adulteration of agrochemicals and its impact on the productivity of major crops in Pakistan. *Asian Journal of Agriculture and Rural Development*, 7(2), 31–37.

Riaz, S. 2014. Citrus Quality to Meet Global Demand. IUP Journal of Agricultural Economics. 6(2): 36-39.

Santos, J. R. A. (1999). Cronbach's alpha: A tool for assessing the reliability of scales. Journal of extension, 37(2), 1-5.

Sarfraz, E. 2015. Land of the best citrus ever. Ecotoxicology and environmental safety. 4(6): 190-197.

Shah, M. A., Tariq, A., & Hassan, M. (2020). The role of institutions in promoting citrus value chains in Pakistan. *Pakistan Journal of Agricultural Economics*, 8(1), 59–68.

Sharif, M., Farooq, U. and Malik, W., 2005. Citrus marketing in Punjab: Constraints and potential for improvement. Pakistan Development Review, 44(4), pp.673-695.

Shaukat, S. 2013. Introduction to Citrus in Pakistan and List of Local Varieties. ARPN Journal of Agricultural and Biological Science. 7(9): 27-36.

Siegel, S. (1957). Nonparametric statistics. The American Statistician, 11(3): 13-19.

Singh, I.P., A.K. Srivastava, V.J. Shivankar and S. Singh. 2004. Storage of Citrus fruits. In: Ladaniya, M.S. Advance in Citriculture. Jagmander Book Agency, Delhi, pp:608-645

Tavakol, M. and Dennick, R. (2011). Making sense of Cronbach's alpha. International journal of medical education, 2, 53.

Zhao, X., Hwang, B. G., Pheng Low, S., & Wu, P. (2015). Reducing hindrances to enterprise risk management implementation in construction firms. Journal of Construction Engineering and Management, 141(3), 04014083.