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RESEARCH ARTICLE

An Assessment of Adoption Rates and Limiting Factors in the Uptake of Improved Vegetable Cultivation Practices among Small Farmers in Punjab, Pakistan

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ABSTRACT

The adoption of improved vegetable cultivation practices plays a critical role in enhancing agricultural productivity, food security, and farmer livelihoods, particularly in developing regions. This study investigates the extent of adoption and the constraints influencing the uptake of improved vegetable cultivation practices among small farmers in Punjab, Pakistan. Data were collected from 200 farmers through a structured questionnaire and analyzed using descriptive statistics, chi-square tests, and multiple regression models. The findings indicate that use of improved/hybrid seeds (71%) and balanced fertilization (63%) have high adoption levels among farmers, others such as integrated pest management (49%), post-harvest handling (44%), and protected cultivation (32%) were less widely adopted. Economic factors, particularly high input costs (mean score = 4.35) and limited access to affordable credit (mean score = 4.12), emerged as the most significant constraints. Institutional and infrastructural challenges, including weak extension services, limited availability of quality inputs, and inadequate storage and cold chain facilities, also hindered adoption. Regression analysis indicated that education level, farm size, extension contact, access to credit, and market access significantly influenced adoption, whereas farming experience did not. The study concludes that addressing economic and institutional barriers, strengthening extension services, improving access to affordable inputs and credit, and enhancing post-harvest infrastructure are critical for accelerating adoption.

Key words: Improved vegetable practices, Adoption, Small farmers, Constraints, Punjab, Pakistan.

INTRODUCTION

Agriculture serves as the backbone of Pakistan's economy, contributing approximately 22.7% to its GDP and employing 37.4% of the national labor force (GoP, 2025). Though most of the land is occupied by major crops such as wheat, rice, cotton, the vegetable production has become a crucial for food security, providing rural employment, and increasing as well as diversifying the farm income of farmers due to high economic returns per unit area (Ali et al., 2020).

Small farmers who are more than 80 percent in Pakistan mainly work in vegetable farming (Hussain & Thapa, 2021). Vegetable farming offers these farmers a prospect of high income and a better livelihood, as it is generally more profitable and more closely resembles cash crop farming than conventional crop farming (ADB, 2022). In response to this potential, national and provincial institutes of agricultural research as well as extension department have made considerable efforts towards the promotion of Improved Vegetable Cultivation Practices (IVCPs).

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IVCPs include high-yielding and disease-resistant hybrid seeds, nursery rearing in sheltered structures, drip irrigation, better fertigation systems, integrated pest management (IPM), plastic mulch technology, and the use of walk-in tunnels to produce off-season vegetables (Ullah et al., 2019).

The adoption of such technologies has been shown to have the potential to double or even triple yield while optimizing resource use (Qureshi et al., 2021). Despite the potential and government support, the adoption of IVCPs remains low. The adoption gap is concerning amid climate change, rising disease and pest outbreaks, and increasing production costs, which are affecting the ability to meet the targets of growing consumer demand for healthy vegetables (Qureshi et al., 2021). A growing body of literature highlights the constraints that suppress the adoption of recommended agricultural practices by farmers. -. Majority of constraints include structural, financial, and institutional i.e., weak extension system, increased cost of inputs, inadequate credit availability small (FAO, 2024; Pakistan Business Council, 2020; Ministry of Commerce, 2024). -At the farm level, technology adoption is further shaped by knowledge, risk perceptions, transaction costs and compatibility with the local environment. Studies from Punjab show that while vegetable growers often recognize the economic and environmental benefits of IPM the share of farmers implementing IPM to a high degree is markedly lower (Khan et al., 2021; Hussain et al., 2024). small. Given the importance of vegetables, it is necessary to understand the complex interactions among socio-economic, institutional, and environmental factors that influence the adoption of IVCPs and the constraints farmers face. This study is therefore focused on the objectives to assess the extent of adoption of improved vegetable cultivation practices among small land holders, to identify the key constraining factors that influence the uptake of improved vegetable production practices and to examine the relationship between farmers' demographic and farm characteristics and their level of adoption.

MATERIALS AND METHODS

This study employed a quantitative survey research design to investigate the extent of adoption of improved vegetable cultivation practices and the constraining factors influencing their uptake among small farmers in Punjab, Pakistan. The research was conducted in Punjab province, Pakistan's leading agricultural region, which accounts for the largest share of vegetable production. Districts well known for vegetable cultivation—such as Faisalabad, Okara, Multan, and Sheikhupura—were selected purposively. The target population consisted of small vegetable farmers (cultivating less than 12.5 acres). A multistage sampling technique was used: first selecting districts, then tehsils, and finally villages. One tehsil was selected from each district (so four tehsils). Following this, five villages were selected from each tehsil, and finally, ten farmers were randomly selected from each village for data collection. Hence, a sample of 200 farmers was contacted to obtain data. Primary data were collected through a structured questionnaire, which was pre-tested on a small group of farmers to ensure clarity and reliability.

The collected data were coded and analyzed using Statistical Package for the Social Sciences (SPSS). Both descriptive and inferential statistics were employed. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to describe adoption levels and constraints. Adoption Index was constructed to quantify the extent of adoption at the farm level. Chi-square tests were applied to examine associations between demographic characteristics and adoption of improved practices. Multiple regression analysis was conducted to determine the influence of independent variables (age, education, farm size, farming experience, access to credit, extension contact, and market access) on the dependent variable (extent of ado The study ensured voluntary participation by respondents and maintained the confidentiality and anonymity of responses. Farmers were informed about the objectives of the research, and consent was obtained prior to data collection

RESULTS AND DISCUSSION

The results and discussion section presents the empirical findings organized according to the study's objectives. First, it starts with the socio-economic characteristics of sampled farmers, including age, education, farm size, tenancy status, farming experience, and economic status. These variables provide the foundation for understanding other results and interpreting them in light of the respondents' backgrounds. Following this, results on the adoption levels of Improved vegetable cultivation practices and the constraints farmers face are presented, offering a comprehensive understanding of the barriers the farming community faces. Last but not least, inferential statistics to measure the correlation between farmers' demographic characteristics and improved vegetable cultivation practices, using the chi-square test and multivariate analysis.

Demographic Characteristics

Table 1 presents the demographic profile of small vegetable farmers in Punjab, Pakistan. The results indicate that the majority of respondents were in the 31–40 age group (32.0%), followed by those aged 41–50 years (29.0%). Younger farmers (21–30 years) comprised 19.0%, while older farmers (above 50 years of age) accounted for 20.0%. This distribution reflects that a substantial proportion of vegetable growers are in their economically active years, aligning with earlier findings that middle-aged farmers are more engaged in commercial vegetable production due to their higher

risk-taking ability and energy levels (Obisesan, 2014; Rahman et al., 2018).

In terms of education, 15% of farmers were illiterate, whereas a majority had at least some level of schooling. The largest group had middle-level education (23.0%), followed by primary (21.0%) and matric/secondary (19.0%). Only 8.0% had graduate-level education or above. These results suggest that while most respondents had basic literacy, higher education levels remain limited among small farmers. Prior studies have shown that education significantly influences the adoption of modern farming practices by enhancing farmers' ability to process information and interact with extension services (Asfaw & Admassie, 2004; Doss, 2006). With respect to farm size, nearly half of the respondents (46.0%) cultivated 5–10 acres, followed by 31.0% with less than 5 acres, and 23.0% with farms ranging between 10–12.5 acres. This reflects the dominance of small to medium landholdings, a common feature of Punjab's agrarian structure (Pakistan Economic Survey, 2022).

Table 1: Demographic Characteristics of Small Vegetable Farmers in Punjab (n = 200)

Characteristic	Category	Frequency (n)	Percentage (%)
Age (years)	21–30	38	19.0
	31–40	64	32.0
	41–50	58	29.0
	Above 50	40	20.0
Education Level	Illiterate	30	15.0
	Primary	42	21.0
	Middle	46	23.0
	Matric (Secondary)	38	19.0
	Intermediate	28	14.0
	Graduate & above	16	8.0
Farm Size (acres)	Less than 5	62	31.0
	5 – 10	92	46.0
	10 – 12.5	46	23.0
Farming Experience	Less than 5 years	24	12.0
	6 – 10 years	52	26.0
	11 – 20 years	78	39.0
	Above 20 years	46	23.0
Tenancy Status	Owner	118	59.0
	Tenant	52	26.0
	Owner-cum-Tenant	30	15.0
Access to Credit	Yes	84	42.0
	No	116	58.0
Extension Contact	Regular	72	36.0
	Occasional	58	29.0
	None	70	35.0

Farming experience was another key variable. 39.0% of farmers had 11–20 years of experience, while 26.0% had 6–10 years, 23.0% had more than 20 years, and only 12.0% had less than 5 years. This indicates that most vegetable growers possess considerable farming experience, which could positively influence their confidence in adopting improved practices, as supported by studies in similar South Asian contexts (Khan et al., 2021; Mwangi & Kariuki, 2015). Regarding tenancy status, a majority (59.0%) were landowners, while 26.0% were tenants and 15.0% practiced owner-cum-tenant farming. Landownership has been recognized as a major determinant of investment in improved farming practices, as secure tenure provides greater incentives for long-term productivity improvements (Feder et al., 1985).

Access to institutional and informational support appeared limited. Only 42.0% of farmers reported having access to credit, compared to 58% without such access. Similarly, extension contacts were not widespread: 36.0% had regular contact, 29.0% had occasional contact, while 35.0% reported no contact with extension agents at all. The findings are parallel those of previous works in Pakistan that indicate low institutional support as main limitation to adoption of better agricultural technologies (Ashraf et al., 2015; Ali et al., 2019). The demographic picture indicates that vegetable growers in Punjab are small largely composed of middle-aged, moderately educated and moderately experienced growers; however, due to a lack of access to credit and extension, the potential of Punjab to adopt improved vegetable growing techniques might be restricted.

Adoption of Improved Vegetable Cultivation Practices

Table 2 shows the adoption levels of some improved vegetable cultivation practices followed by smallholder farmers in the Punjab province of Pakistan.

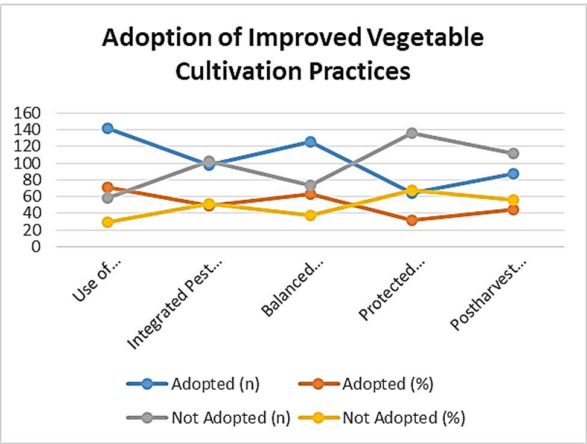

Fig. 1: Farmers' Adoption Level of Improved Vegetable Cultivation Practices.

The findings (Figure 1) show that there are disparities in uptake across practices, which align with varying levels of awareness, affordability, and accessibility of technologies. Improved or hybrid seeds were the most commonly adopted practice with 71%of the farmer reporting adoption. This implies that farmers are increasingly becoming aware of the benefits related to high yields and quality of hybrid varieties. The results of past research in Pakistan and South Asia support the idea that hybrid seeds are among the first technologies to be adopted because of the immediate benefit in productivity and profitability (Ali et al., 2019; Rahman et

al., 2018). The next most adopted practice was the use of balanced fertilization adopted by 63.0%. This indicates that there is greater knowledge of soil health and nutrient management. Nevertheless, the 37.0% non-adoption indicates limitations, such as high fertilizer costs and limited technical support. As noted earlier, the uptake of balanced fertilizer use is hampered by a lack of funds (Khan et al., 2021; FAO, 2020).

Adoption of integrated pest management (IPM) was moderate, with 49.0% of farmers adopting it, while 51.0% had not. Research documented that despite the reduction in pesticide dependency and advance environmental sustainability, IPM is not widely used due to inadequate support for farmers through extension and trainings (Parsa et al., 2014; Baig et al., 2013). Conversely, use of protected cultivation practices (such as tunnels and nets) was low, addopted by 32% of farmers. The poor adoption could be explained by high initial cost of investment, prevailing lack of technical expertise and the lack of institutional support for small farmers. The same trends have been reported in South Asia, where farmers are resource-poor, and face challenges to adopt technologies that are capital-intensive (Naveed et al., 2017; Gul et al., 2020). Lastly, 44% of farmers adopted improved post-harvest practices (grading, packing and storage), with the rest (56%) rely on conventional practices. This indicates significant post-harvest waste in vegetable supply chains, largely due to poor infrastructure, extension systems, and market motivations (Kitinoja & Kader, 2015; Ali & Afzal, 2011).

Constraining Factors Influencing Adoption of Improved Vegetable Cultivation Practices

The findings of table 3 show that financial challenges were the most vital factors hindering adoption. Under this, high prices of seeds, fertilizers, and pesticides (Mean = 4.35) ranked first. High prices of covered cultivation including greenhouse structures (Mean = 4.20), and difficulty gaining access to cheap credit (Mean = 4.12) have also high mean scores. These results are consistent with past studies explaining that the high cost of production and the inaccessibility of financial capital significantly suppress innovation in agricultural activities (Khan et al., 2020; Ali et al., 2019).

Weak extension services and irregular visits recorded a high mean score of 4.05, ranking fourth overall and constituting the most crucial gap in the flow of knowledge and technical advice. Similar findings were reported by Sadaf et al. (2021), who documented that weak extension contacts suppressed the level of awareness and implementation of enhanced cultivation practices in Punjab. In addition, the low accessibility to quality inputs in local markets (Mean = 3.75) was another salient constraint, as found by Rehman et al. (2019). Technical aspects including insufficient knowledge of IPM practices (Mean = 3.85, Rank 5), inappropriate training of post-harvest crop handling (Mean = 3.60, Rank 7), reveal a lack of advanced technical ability to implement improved farming practice. The results are aligned by Mehmood et al. (2020) and Qayyum et al., (2024) that one of the major hindrances to adopting sustainable practices in vegetable farming was absence of training opportunities.

Regarding market and infrastructural constraints, price fluctuations and lack of access to markets (Mean = 4.08, Rank 5) were a primary concern, indicating vulnerability of farmers to market fluctuations. Likewise, inadequate cold chain and storage facilities (Mean = 3.50, Rank 8) were perceived as a serious hindrance to enhancing the value chain of vegetables. This aligns with the findings of Hameed et al. (2021) that post-harvest losses occurred due to poor infrastructure and a lack of market connectivity.

Bivariate Associations (Chi-square Test)

According to Table 4 results, age significantly correlated with adoption (χ^2= 6.82; p = 0.033), indicating that younger farmers are more likely to adopt IVCPs than older ones. This corresponds to the outcomes presented by Rehman et al. (2019), who stated that younger farmers tend to be more open to innovations because of their greater degree of risk taking and inclination towards novel technologies.

Table 2: Adoption of Improved Vegetable Cultivation Practices among Smallholder Farmers in Punjab (n = 200)

Improved Practice	Adopted (n)	Adopted (%)	Not Adopted (n)	Not Adopted (%)
Use of Improved/Hybrid Seeds	142	71.0	58	29.0
Integrated Pest Management (IPM)	98	49.0	102	51.0
Balanced Fertilization	126	63.0	74	37.0
Protected Cultivation (e.g., tunnels, nets)	64	32.0	136	68.0
Postharvest Handling (grading, packing, storage)	88	44.0	112	56.0

Table 3: Mean Scores of Constraining Factors Influencing Adoption of Improved Vegetable Cultivation Practices (n = 200)

Constraint Category	Specific Constraint	Mean Score	Rank
Economic Constraints	High input costs (seeds, fertilizers, pesticides)	4.35	1
	Limited access to affordable credit	4.12	3
	High cost of protected cultivation structures	4.20	2
Technical Constraints	Lack of knowledge of IPM techniques	3.85	5
	Limited training in postharvest handling	3.60	7
Institutional Constraints	Weak extension services/irregular visits	4.05	4
	Limited availability of quality inputs in markets	3.75	6
Infrastructural Constraints	Poor storage and cold chain facilities	3.50	8
Market Constraints	Price fluctuation and lack of assured markets	4.08	5

Table 4: Chi-Square Test: Association between Demographic Characteristics and Adoption of Improved Vegetable Practices (n = 200)

Demographic Variable	χ^2 Value	df	p-value	Significance
Age (years)	6.82	2	0.033	Significant (p < 0.05)
Education Level	12.47	3	0.006	Significant (p < 0.01)
Farm Size (acres)	9.15	2	0.010	Significant (p < 0.05)
Farming Experience (years)	4.28	2	0.118	Not Significant
Access to Extension Services	15.62	1	0.000	Highly Significant (p < 0.001)
Access to Credit	8.94	1	0.003	Significant (p < 0.01)

There was also a significant correlation between the level of education and adoption (χ^2 = 12.47, p = 0.006), indicating that highly educated farmers were ready to adopt improved seeds, integrated pest management (IPM) and balanced fertilization. Corresponding findings are supported by Ali et al. (2020) and Khan et al. (2021), who stated that literacy equips farmers the skills to source, absorb and utilize modern agricultural information. Similarly, farm size also had a significant relationship (χ^2 = 9.15, p = 0.010), bigger landholders tended to engage in improved practices due to their financial ability and the capability to absorb risks. This coincides with the findings by Chandio et al. (2021), which indicated that size of land positively relates to the use of modern agricultural technologies in South Asia.

On the other hand, farming experience was not significantly related (χ^2 = 4.28, p = 0.118), meaning that experience in vegetable farming per se does not ensure adoption of innovations. This conclusion is echoed by Sadaf et al. (2021), who claimed that traditional farming experience can at times be a hindrance, as older farmers are more inclined to stick to their usual practices rather than embrace new ones.

Moreover, extension services exhibited a highly significant relationship (χ^2 = 15.62, p = 0.000) with adoption, highlighting the importance of extension contact in encouraging farmers to embrace new technologies. Mehmood et al. (2020) and Sulaiman and Davis (2019) demonstrated frequent extension visits had a considerable effect on enhancing the knowledge of farmers and their adoption rates.

Similarly, access to credit played a major role in stimulating adoption (χ^2 = 8.94, p = .003), implying that financial help can help small farmers mitigate the issue of liquidity and make investments in better practices. The result aligns with that of Abedullah et al. (2016) and Bashir et al. (2021), who identified credit as one of the principal variables in the use of modern farming technologies in Pakistan.

Multivariate Effects (Regression Analysis)

Table 5 shows the results of the multiple regression analysis investigating farmers socio-economic as well as instructional variables in relation to the level of adoption of the improved vegetable cultivation practices. The model was statistically significant (F = 39.84, p < 0.001) and explained enough variance (R 2 = 0.551), indicating that selected variables had a strong explanatory power. The findings show that education level had a strong significant positive impact on the adoption (beta = 0.298, p < 0.001). This indicates that educated farmers are in a better position to learn and adopt technologies such as new seeds, balanced fertilization, and integrated pest management. These findings align with those of Ali et al. (2020) and Khan et al. (2021), who found that education is one of the major determinants of technology acceptance among vegetable growers in Pakistan.

Contact with extension agent was also a good predictor (β = 0.356, p < 0.001), indicating that regular communication with extension agents was a major determinant to adopt improved practices. This reinforces the previous results by Mehmood et al. (2020) and Sulaiman & Davis (2019), who pointed out that advisory services play a key role in enhancing agricultural decision-making and building capacities among farmers. Access to credit also contributed positively and significantly (β = 0.192, p < 0.01), as indicated by Abedullah et al. (2016) and Bashir et al. (2021). Farm size also had a positive correlation (β = 0.211, p < 0.01), highlighting that farmers with large landholdings tend to invest in innovations because of greater economic capabilities and economies of scale. Similar findings were reported by Chandio et al. (2021), who found that smaller landholders are not adopting technologies as quickly as larger ones.

Conversely, farming experience had no significant effect (p = 0.199), nullifying the argument that traditional experience was sufficient to adopt. The result is consistent with that of Sadaf et al. (2021), who stated that experienced farmers tend to be more traditional.

Table 5: Multiple Regression Analysis: Influence of Farmer Characteristics on Extent of Adoption of Improved Vegetable Practices (n = 200)

Independent Variable	Unstandardized Coefficient (B)	Standard Error	Standardized Beta (β)	t-value	p-value	Significance
Age (years)	-0.142	0.067	-0.112	-2.12	0.035	*Significant* (p < 0.05)
Education Level (years)	0.421	0.088	0.298	4.78	0.000	Highly Significant (p < 0.001)
Farm Size (acres)	0.316	0.105	0.211	3.01	0.003	Significant (p < 0.01)
Farming Experience (years)	0.083	0.064	0.071	1.29	0.199	Not Significant
Access to Credit (dummy: 1 = yes, 0 = no)	2.145	0.711	0.192	3.02	0.003	Significant (p < 0.01)
Extension Contact (frequency)	0.524	0.097	0.356	5.41	0.000	Highly Significant (p < 0.001)
Market Access (distance in km)	-0.186	0.082	-0.143	-2.27	0.024	*Significant* (p < 0.05)

Model Summary: R = 0.742; R^2 = 0.551; Adjusted R^2 = 0.537; F-statistic = 39.84 (p < 0.001)

Interestingly, age (β = –0.112, $p < 0.05$) and market access (β = –0.143, $p < 0.05$) had negative and significant effects on adoption. The negative age coefficient may reflect older farmers' reluctance to adopt improved practices; this may stem from risk aversion and a tendency among some farmers to prefer and stick to traditional ways of doing things (Rehman et al., 2019). Likewise, greater distances to markets reduce adoption because higher transportation costs and weaker market linkages decrease the incentive for small farmers. Similar conclusions were also reached by Oluwatayo & Adedeji (2019) in their focus on the influence of the proximity of markets on the adoption decisions.

Conclusion

The results showed that although some of the practices, namely the use of improved seeds and balanced fertilization, have attained relatively high levels of adoption, others, including the use of well-protected cultivation technology, post-harvest handling, and integrated pest management are still low. Multiple regression analysis established that education, farm size, access to credit, extension contact and market access were significant factors in predicting the level of adoption. However, farming experience was not a significant factor. A combination of economic (high input costs and limited access to cheap credit), institutional, and infrastructural factors (poor extension services and poor storage facilities) was identified as a significant impediment to the adoption of IVCPs. These findings highlight the need to improve outreach services, provide financial assistance, and develop rural infrastructure such as roads and markets.

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Ethics Statement: This work involved human data. The work was approved by the Institute of Agricultural Extension, Education, and Rural Development, University of Agriculture, Faisalabad, Pakistan.

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