RESEARCH PAPER

Deciphering the role of socio-economic factors and agronomic practices on wheat production in Shujaabad, Multan, Pakistan

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Abstract

Wheat productivity in Shujaabad remains suboptimal, largely due to a complex interplay of socio-economic constraints, inconsistent agronomic practices, and limited access to agricultural information and resources. To address this issue, the present study investigates the influence of farmers' socio-economic characteristics, agronomic practices, and information sources on wheat production in Shujaabad, Multan, Pakistan. The data were collected from 250 wheat farmers using a multistage sampling technique. The results indicated that 72.8 % of the farmers were landowners, 44.8 % had landholdings of 6–10 acres, and 67.6 % lacked access to personal tube wells. Education level, income, farming experience, credit access, and tractor ownership were significantly associated with wheat yield ($p < 0.05$). For example, 50.6 % of farmers with primary education and 51 % with middle-level education achieved high wheat yields (>1600 kg/acre), while only 25.7 % of illiterate farmers reached this level. Similarly, 66.7 % of tractor owners achieved high yields compared to 38.9 % of non-owners. The most adopted agronomic practices were the use of recommended seed rate (mean score = 4.66), proper soil preparation (mean = 3.77), and irrigation scheduling (mean = 3.70). The most cited sources of agricultural information were electronic media (56.8 %), fellow farmers and early adopters (47.2 %), and private agro-based companies (41.2 %). Key constraints to wheat production included low income (ranked 1st), lack of technical knowledge (2nd), and unavailability of quality seed (5th). The study concludes that improving farmers' access to information, extension services, credit facilities, and mechanization alongside promotion of best agronomic practices can significantly enhance wheat productivity and socio-economic conditions in the region. The findings would be helpful for researchers and policy makers to understand influence of socio-economic features and agronomic practices on the major staple crop (wheat) of Southern Punjab (Multan), Pakistan.

Keywords: Agronomic practices, Information sources, Multan district, Productivity constraints, Socio-economic characteristics, Wheat production

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Introduction

Wheat (*Triticum aestivum* L.) is a staple food crop and a vital component of Pakistan's agricultural economy. It contributes significantly to the country's food security, rural livelihoods, and gross domestic product (GDP) (Iqbal et al., 2018; Abbas & Shafique, 2019; Mehmood et al., 2020). It occupies a significant share of the Rabi cropping season and is cultivated extensively across various agro-climatic regions of the country (Government of Pakistan, 2017). The crop contributes approximately 8.2 % to the total value added in agriculture and 1.9 % to the national GDP, highlighting its vital role in Pakistan's agricultural output and socio-economic development (Government of Pakistan, 2023). Among Pakistan's major wheat-producing regions, the province of Punjab holds a dominant position, accounting for nearly 76% of the total national wheat production (Mazhar, 2025). Within Punjab, the Multan district and more specifically, the tehsil of Shujaabad possesses considerable agronomic potential due to its fertile alluvial soils, canal irrigation infrastructure, and a traditionally agrarian population. Multan is the fifth largest district of Punjab province by population (4745109) and third largest city by area (3721 km^2). The city is located on the banks of the Chenab River. Multan has four tehsils i.e., Multan city, Multan Saddar, Shujaabad, Jalalpur Pirwala (Government of Punjab, 2014). The main source of income in Shujaabad area is agriculture and more than 60% of population is employed with agriculture. The district is famous for producing wheat, cotton, corn, sugarcane and many other crops (Ahsen et al., 2020). In regions like Shujaabad in Multan district, over 60% of the population relies on agriculture for livelihood, and wheat is a primary source of income and food (Alamgeer et al., 2022). Recent studies have highlighted the significance of both socio-economic characteristics and agronomic practices in improving wheat productivity (Dinsa & Balcha, 2024). Factors such as farmer education, landholding size, credit access, and mechanization have been found to strongly influence wheat yields (Larik et al., 2024). Alongside these socio-economic drivers, agronomic practices such as appropriate sowing dates, seed rates, irrigation management, and fertilizer application are crucial to maximizing yields (Mohammed et al., 2024).

Despite these advantages, wheat productivity in many parts of Shujaabad remains suboptimal. This is due to a complex interplay of socio-economic limitations, inefficient farming practices, and restricted access to agricultural innovations. Farmers in the region vary significantly in terms of education, income, landholding size, and access to credit and mechanization, all of which can influence the adoption of modern agronomic practices and, in turn, wheat yields (Ali et al., 2022a). Moreover, the dissemination and use of agricultural information whether through formal extension services or informal channels also plays a crucial role in shaping farmer behavior and productivity outcomes (Ali et al., 2020; Shitaye et al., 2025).

In Pakistan, agriculture is structured around two main cropping seasons: Rabi and Kharif. Rabi crops are cultivated between November and April, while Kharif crops are grown from May to October, both playing a vital role in the country's agricultural economy (Qayyum & Pervaiz, 2013). Climate change poses serious risks to agriculture globally, especially in arid and semi-arid regions, by causing temperature increases, irregular rainfall patterns, and more frequent extreme weather events (Noroz et al., 2021; Omokhafe et al., 2024). In Pakistan's semi-arid and dry regions, low soil fertility is further exacerbated by climate change, as limited rainfall intensifies evapotranspiration and contributes to drought conditions (Baocheng et al., 2024; Sheikh et al., 2025). A temperature rise of just 1°C could potentially reduce wheat yields by 5 to 7 % (Aggarwal & Sivakumar, 2011). Moreover, expanding the area for wheat cultivation is constrained due to limited land availability and competition from other crops like oilseeds, sugar beet, sugarcane, and fodder (Khan et al., 2008).

In Pakistan, wheat production has experienced significant fluctuations, alternating between periods of near self-sufficiency and times of inadequate performance. These variations are largely attributed to climate change, which continues to affect agricultural productivity despite the presence of an extensive irrigation network in the Indus Basin (Ahmad et al., 2014). Climatic stressors such as rising temperatures, erratic rainfall, and prolonged droughts pose serious challenges to consistent wheat yields (Saleem et al., 2024; Mohammed et al., 2025). However, the adoption of modern agricultural technologies such as improved seed varieties, enhanced fertilizer use, and reliable water supply through canals and tube wells has contributed to increased wheat production by expanding cultivated areas and improving per-acre yields (Mehmood et al., 2018). In response, the Government of Pakistan has undertaken efforts to improve irrigation infrastructure, prevent salinity and waterlogging, and implement flood and soil erosion control measures to sustain and boost agricultural output (Government of Pakistan, 2004). While numerous studies in Pakistan have examined the role of socio-economic factors and agronomic practices on wheat productivity at the provincial or national level, limited research exists at the sub-district (tehsil) level, particularly in Shujaabad, Multan, a region with significant agricultural potential but persistently low wheat yields. Moreover, the specific constraints faced by farmers in Southern Punjab, including limited credit access, low literacy, and reliance on informal information sources, have not been systematically quantified in the context of wheat production. Keeping in view the above facts, the present study was conducted to assess the influence of farmers' socio-economic characteristics, agronomic practices, and sources of agricultural information on wheat production in Shujaabad tehsil of Multan district, Pakistan. The study aims to identify key determinants of wheat yield and provide recommendations for enhancing productivity through improved practices, resource access, and information dissemination.

Materials and Methods

Study sites

The study was conducted in Shujaabad tehsil, located in the Multan district of Punjab, Pakistan. This region was selected due to its agricultural significance, particularly in wheat production, and the high dependence of rural communities on farming for their livelihood. Data was collected to assess how wheat production is influenced by socio-economic conditions and agronomic practices in the area.

Research method

This study used a quantitative research method to collect and analyze numerical data related to farmers' socio-economic characteristics, agronomic practices, and wheat production in Shujaabad. The approach allowed for statistical analysis to identify patterns, relationships, and key influencing factors affecting wheat yield.

Research design

A cross-sectional survey design was used to conduct this study. This approach allowed the researcher to collect data at a single point in time from a sample of wheat farmers in Shujaabad. The design was suitable for identifying and analyzing the relationships between farmers' socio-economic characteristics, agronomic practices, and wheat production. The key variables were selected based on a thorough review of relevant literature and field observations.

Sampling procedure and sample size

A multistage cluster sampling technique was employed to ensure a representative sample of wheat farmers in Shujaabad tehsil. In the first stage, five Union Councils (UCs) including

Maahra, Dhundoon, Agar Khwani, Naseer Pur and Bumb were purposively selected based on their high engagement in wheat cultivation. In the second stage, within each selected UC, 2–3 villages were randomly chosen. In the third stage, from each village, a list of wheat farmers was obtained with the help of local agricultural extension officers, and a random sample of farmers was selected proportionally from each village. This approach ensured geographical diversity and minimized sampling bias. A total of 250 farmers were surveyed. The previous agricultural studies in Pakistan with comparable objectives and regional focus (e.g., Ali et al., 2022b; Larik et al., 2024) have used sample sizes in the range of 200–300 respondents, supporting the appropriateness of our sampling frame.

Tool for data collection

The instrument used for data collection in this study was a structured interview schedule. This instrument was carefully designed to capture both quantitative and qualitative information from wheat farmers in Shujaabad. Although the interview schedule was originally prepared in English, it was administered to respondents in their native languages (Punjabi and Saraiki) to ensure better understanding and accuracy of responses. The schedule included both open-ended and close-ended questions, enabling the collection of detailed and statistically analyzable data.

Pre-testing

Before the actual data collection, the interview schedule was pre-tested with a small group of farmers from the study area. This helped identify unclear or confusing questions. Based on the feedback, minor changes were made to improve the clarity and flow of the questions. This process ensured that both the researcher and respondents clearly understood the questions during the full-scale survey.

Data analysis

The data collected were analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize farmers' socio-economic characteristics and agronomic practices. The Chi-square test was applied to examine associations between categorical variables. Gamma statistics were used to measure the strength and direction of relationships between ordinal variables related to wheat production and socio-economic factors.

Results

Selected demographic and socio-economic characteristics of the respondents

The data on various demographic characteristics of the farmers were collected from Shujaabad, Multan (Table 1). The data indicated that 24.4 % of farmers come under the category of young age, which is 35 years, while 42.4 % come in the range of 35 to 50 years of age and only 33.2 % are above 50 years. The literacy survey data of sampling area and size showed that 28 % farmers are illiterate in Shujaabad, Multan, 34.8 % have only primary education, 19.6 % have Middle & Matric, and 17.6 % farmers have higher education. Similarly, the birth rate among farming community ranges 21.6 % having less than 5 family members, 43.6 % have 5 to 10 family members and only 34.8 % have above 10 family members. Similarly, 39.2 % of farmers have a nuclear family system, 48.4 % joint family system and only 12.4 % have an extended family system. The land holding of the farmers varies from the farm size 34 % have 6 acres, 44.8 % have 6 to 10 acres and only 21.2 % have above 10 acres. The tenancy status of the farmers depicted that 72.8 % are owner, 15.2 % are owner-cum-tenants and only 12 % are tenants. Similarly, the professional skill of farmers showed that 32.4 % have 10 years farming experience, 35.6 % have 11-to-12-year farming experience and only 32 % have over 20-year farming experience. The earning capacity of the farming community depicted that 33.2 % farmers have monthly income up to 30,000 rupees, 39.2 % 30,000 to 40,000 rupees and 27.6 % have above 40,000 rupees. The classification and percentage distribution based on debt showed that 21.2 % farmers who are in debt took loans for wheat cultivation and 78.8 % of farmers cultivating wheat without taking loans.

Ownership of agricultural equipments

The data presented in Table 2 showed that only 16.8 % farmers had their own tractor, and the remaining 83.2 % farmers were using rented tractor for wheat cultivation. Similarly, 32.4 % of farmers had their own tube well and the remaining 67.6 % farmers were deprived of their own tube well. The survey data regarding field implements (Table 3) showed that 16.8 % farmers had their own tools, 12.4 % farmers had their seed drill, 8 % farmers had their own disk/plate furrows, 15.6 % own threshers, 11.2 % own rotavator and 1.6 % had their own combine harvester.

Sowing and harvesting operations

The survey data (Table 4) showed that 34.8 % of farmers never used the drilling method for sowing wheat, 24.8 % used it occasionally, 22 % used it often, and 18.4 % always used the drilling method. Similarly, 18.4 % farmers never used broadcast method for sowing wheat, 22.8 % used some time broadcast method, 24 % often used broadcast method and remaining 34.8 % farmers always used broadcast sowing method. The data also shows that 39.2 % farmers never used combine harvester for wheat harvesting, 32.0 % sometimes used combine harvester, 16.8 % often used combine harvester and 12 % always used combine harvester for wheat crop. The manual harvesting operation through labor, only 12 % of the farmers reported never hiring labor for manual harvesting of wheat, 18 % farmers occasionally hired manual labor, 30.8% often hired labor for harvesting, 39.2% farmers always hired labor for wheat crop, respectively. The survey data also showed that 94.0 % farmers always used threshing machines for threshing operations and only 6 % of farmers often used threshing machines, 3.2 % farmers sometimes used threshing machines and 2.8 % often used harvesters for threshing operation of wheat crop.

Adaptation of ranking wise wheat sowing recommendations

The survey data (Table 5) showed the rank order of wheat sowing recommendation such as use of recommended dose of seed, ranked 1st, Well preparation of soil ranked 2nd, Application of water with reasonable intervals ranked 3rd, Timely sowing of wheat ranked 4th, Sowing of new seed variety ranked 5th, Use of weedicide ranked 6th, best way of harvesting ranked 7th better method of storage ranked 8th, application of fertilizer on recommended dose ranked 9th, Fumigation of seed ranked 10th, Manual weed removing ranked 11th and analysis of soil ranked 12th respectively.

Area under cultivation and wheat yield

The survey data (Table 6) on socio-economic impact of wheat production revealed that 46.8 % farmers have allocated an area of 5 acres for wheat cultivation, while 37.6 % farmers allocated 5 to 10 acres for wheat cultivation, and 15.6 % farmers have allocated above 10 acres for wheat cultivation. Similarly, the survey data (Table 7) reported that 24.4 % farmers getting wheat yield up to 1400 kg per acre, similarly 32 % farmers getting wheat yield up to 1440 to 1600 kg per acre and 43.6 % farmers getting wheat yield above 1600 kg per acre.

Table 1 Selected demographic and socio-economic characteristics of the respondents

Selected characteristics	Frequency	Percentage
Age		
Young (Up to 35 years)	61	24.4
Middle (35 – 50 years)	106	42.4
Older (Above 50 years)	83	33.2
Educational level		
Illiterate	70	28.0
Primary (5 years of schooling)	87	34.8
Middle (8 years of schooling)	49	19.6
Matriculation and above (10 years of schooling and above)	44	17.6
Family size		
Less than 5 members	54	21.6
5 – 10 members	109	43.6
Above 10 members	87	34.8
Family structure		
Nuclear	98	39.2
Joint	121	48.4
Extended	31	12.4
Farm size		
Up to 6 acres	85	34.0
6 – 10 acres	112	44.8
Above 12	53	21.2
Tenancy status		
Owner	182	72.8
Owner-cum-tenants	38	15.2
Tenants	30	12.0
Experience in farming		
Up to 10 years	81	32.4
11 – 12 years	89	35.6
Above 20 years	80	32.0
Income from all sources (in Pakistani Rupees)		
Up to 30,000	83	33.2

30001 – 40,000	98	39.2
Above 40,000	69	27.6
Credit for wheat cultivation		
Response in "Yes"	53	21.2
Response in "No"	197	78.8

Table 2 Classification of the farmers according to their ownership of tractor and tube well

Response	Tractor		Tube well	
	Frequency	Percentage	Frequency	Percentage
Yes	42	16.8	81	32.4
No	208	83.2	169	67.6
Total	250	100.0	250	100.0

Table 3 Classification of the farmers concerning ownership of equipments of sowing, planting and harvesting

Machinery	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Cultivator	42	16.8	208	83.2
Seed drill	31	12.4	219	87.6
Disk/plate furrows	20	8.0	230	92.0
Threshers	39	15.6	211	84.4
Rotavator	28	11.2	222	88.8
Harvester	4	1.6	246	98.4

Table 4 Classification of the farmers concerning sowing and harvesting operations for wheat

Farm operations	Never		Sometimes		Often		Always	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Drilling	87	34.8	62	24.8	55	22.0	46	18.4
Broadcasting	46	18.4	57	22.8	60	24.0	87	34.8
Harvesting through machine	98	39.2	80	32.0	42	16.8	30	12.0
Harvesting through Labor	30	12.0	45	18.0	77	30.8	98	39.2
Thresher machine	0	0.0	0	0.0	15	6.0	235	94.0
Harvester	235	94.0	8	3.2	7	2.8	0	0.0

% denotes percentage. Freq. denotes frequency

Table 5 Weighted score, mean, standard deviation and rank order of adaptation of recommendation practices for wheat sowing

Wheat sowing recommendations	Weighted score	Mean	S.D.	Rank
Use of recommended seed rate	1166	4.66	0.83	1
Seedbed preparation	943	3.77	1.33	2
Irrigation scheduling	925	3.70	1.33	3
Timely sowing of wheat	904	3.62	1.42	4
Sowing of new seed variety	896	3.58	1.48	5
Use of weedicide	870	3.48	1.48	6
Best way of harvesting	861	3.44	1.44	7
Better method of storage	841	3.36	1.55	8
Application of recommended dose of fertilizer	833	3.33	1.62	9
Fumigation of grains	622	2.49	1.39	10
Manual weed control	577	2.31	1.66	11
Soil analysis	276	1.10	1.41	12

Table 6 Classification of the farmers concerning their area under wheat crop

Area under wheat crop (acres)	Frequency	Percentage
Up to 5	117	46.8
>5-10	94	37.6
Above 10	39	15.6
Total	250	100

Table 7 Classification of the farmers concerning their average yield of wheat

Production of wheat (kg per acre)	Frequency	Percentage
Up to 1400	61	24.4
1440 to 1600	80	32.0
Above 1600	109	43.6
Total	250	100

Constraints for low production and non-adoption of wheat production technology

The survey data reported (Table 8) the constraints of low yield of wheat and non-adoption of modern wheat production technologies, the farmers having low yield and non-adoption of modern technology due to low income was ranked 1st. similarly, 2nd ranked farmers with Lack of technical knowledge, 3rd rank farmers due to Fear & suspicion, 4th rank farmers due to Tractor ownership, 5th rank farmers due to non-availability of quality seed, 6th rank farmers due to Insufficient fertilizer use, 7th rank farmers due to Lack of extension services, 8th rank farmers due to inadequate medium of information source, 9th rank farmers due to delayed planting, 10th rank farmers due to Weeds infestation, 11th rank farmers due to Lack of access to credit facilities, 12th rank farmers due to distance from market, 13th rank farmers due to water shortage.

Table 8 Rank order of ~~reasons/~~constraints for low production and non-adoption of wheat production technology

Constraints	Weighted score	Mean	S.D.	Rank
Low level of income	1117	4.47	0.49	1
Lack of technical knowledge	1096	4.38	0.63	2
Fear and suspicion	1084	4.34	0.65	3
Tractor ownership	1076	4.30	0.94	4
Non availability of quality seed	1070	4.28	0.80	5
Insufficient fertilizer use	1045	4.18	0.86	6
Lack of extension services	1028	4.11	0.97	7
Inadequate medium of information source	1025	4.10	0.79	8
Delayed planting	1014	4.06	0.88	9
Weeds infestation	999	4.00	1.14	10
Lack of access to credit facilities	992	3.97	0.99	11
Distance from market	960	3.84	1.12	12
Water shortage	677	2.71	1.21	13

Sources of information for wheat production

The results presented in Table 9 indicate that wheat farmers in Shujaabad rely on a variety of sources for agricultural information. The most frequently used source was electronic media, with 56.8 % of farmers reporting regular use of television, radio, or internet platforms to obtain wheat production guidance. This suggests growing reliance on mass media as a tool for agricultural extension. Fellow farmers and early adopters were also a major influence, cited by 47.2 % of respondents, highlighting the importance of peer learning and informal knowledge transfer in rural farming communities. Private agro-based companies, such as seed and fertilizer suppliers, were consulted by 41.2 % of the farmers, indicating their emerging role in agricultural advisory services. Government extension services, traditionally a major channel of information, were reported by 35.6 % of farmers, suggesting possible gaps in accessibility or outreach. Additionally, 30.8 % of farmers received information from input suppliers and local dealers, and 22 % utilized printed material such as pamphlets and agricultural magazines. Participation in agricultural exhibitions or field days was relatively low at 15.2 %, while only 10.4 % of farmers accessed digital platforms such as mobile apps or SMS services.

Table 9 Distribution of the farmers by sources of agricultural information for wheat production

Information source	Frequency (n = 250)	Percentage (%)
Electronic media (TV/Radio/Internet)	142	56.8
Fellow farmers / Early adopters	118	47.2
Private agro-based companies	103	41.2
Government extension officers	89	35.6
Input suppliers / Local dealers	77	30.8
Printed material (pamphlets, magazines)	55	22.0
Agricultural exhibitions/fairs	38	15.2
Mobile apps/ SMS services	26	10.4

Association of age of the farmers with wheat production

The data given in Table 10 represents the association between the age of farmers and wheat production. The Chi-square value (χ^2 = 25.66, p = .000) is highly significant, indicating that there is a statistically significant association between age groups and wheat production levels. However, the Gamma statistics (0.000, p = .998) show no directional or consistent relationship between these variables. This suggests that while age groups differ in their wheat production, the pattern is not linear or predictable. Middle-aged farmers appear to have higher production levels compared to both younger and older farmers, but this trend is not strong or consistent enough to suggest a meaningful direction. Therefore, although an association exists, the hypothesis that "age of the farmers is associated with wheat production" is only weakly supported, and the results should be interpreted with caution.

Association of education of the farmers with wheat production

Similarly, data given in Table 11 represents the association among education of the farmers and their potential wheat yield. Chi-square value (χ^2 = 25.90) a highly significant (p = .000) which describes association among farmers education level and their wheat production. Gamma statistics showed significant and strong positive correlation among the variables. So, the illiterate farmers have less wheat production as compared to literate farmers. The illiterate farmers (45.7 %) have low level of wheat production and literate farmers have middle standard education (51 %) while matric and above (50 %) farmers have high level of wheat production. So, the hypothesis "Education of the farmers is associated with wheat production" is accepted.

Table 10 Relationship between age of the farmers and wheat production

Age	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
Young	15	26	20
(Up to 35)	24.6 %	42.6 %	32.8 %
Middle	29	16	61
(36-50)	27.4 %	15.1 %	57.5 %
Older	17	38	28
(Above 50)	20.5 %	45.8 %	33.7 %
Total	61	80	109
	24.4 %	32.0%	43.6 %

Chi-square = 25.66; d.f. = 4; P-value = .000**; Gamma = 0.000; P-value = 0.998^{NS}

Table 11 Relationship between education of the farmers and wheat production

Education	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
Illiterate	32	20	18
	45.7 %	28.6 %	25.7 %
Primary (5 years of schooling)	13	30	44
	14.9 %	34.5 %	50.6 %
Middle (8 years of schooling)	9	15	25
	18.4 %	30.6 %	51 %
Matric and above (10 years of schooling and above)	7	15	22
	15.9 %	34.1 %	50 %
Total	61	80	109
	24.4 %	32 %	43.6 %

Chi-square = 25.90; d.f. = 6; P-value = .000**; Gamma = 0.291; P-value = .000**; ** = Highly significant

Association of farming experience with wheat production:

The data represented in Table 12 showed the association regarding farming experience and wheat production. Chi-square value (χ^2 = 12.25) is significant (p = .016) which depicts association among farmers working experience and their wheat production. Gamma statistics showed significant and strong positive correlation among the variables. So the farmers having more experience have more wheat yield as compared to less experienced farmers. So, the hypothesis "Farming experience will be associated with their wheat production" is accepted.

Association of income of the farmers with wheat production

The survey data on socio-economic conditions of the farmers given in Table 13 is describing the association among the farmers income and wheat production. Chi-square value (χ^2 = 27.39) is highly significant (p = .000) which describes association among farmers income and potential wheat production. Gamma statistics also showed significant and strong positive correlation among the variables. So, the low-income farmers produce low level of wheat quantity as compared to others. Among wheat-producing farmers, 37.3 % had a low-income level, 38.6 % achieved medium production, and 42 % attained a high level of production. The hypothesis "Income of the farmers will be associated with their wheat production" is accepted.

Table 12 Relationship between farming experience of the farmers and wheat production

Farming experience	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
Up to 10 years	27	31	23
	33.3 %	38.3 %	28.4 %
11-20 years	19	27	43
	21.3 %	30.3 %	48.3 %
Above 20 years	15	22	43
	18.8 %	27.5 %	53.8 %
Total	61	80	109
	24.4 %	32 %	43.6 %

Chi-square = 12.25; d.f. = 4; P-value = .016*; Gamma = 0.274; P-value = .001**; * = Significant; ** = Highly significant

Table 13 Relationship between income from all sources of the farmers and wheat production

Income (PKR)	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
Up to 30000	31	32	20
	37.3 %	38.6 %	24.1 %
30001-40000	13	25	60
	13.3 %	25.5 %	61.2 %
Above 40000	17	23	29
	24.6 %	33.3 %	42.0 %
Total	61	80	109
	24.4 %	32 %	43.6 %

Chi-square = 27.39; d.f. = 4; P-value = .000**; Gamma = 0.228; P-value = .007**; ** = Highly significant

Association of agriculture loans with wheat production

The data on wheat yield given in Table 14 is revealing the association among availing loan facility by the farmers and their wheat production. Chi-square value ($\chi 2$ = 6.28) a significant (p = .051) which depicts association among availing loan facility by the farmers and their wheat production. Gamma statistics showed a significant and positive correlation among the variables. It tells us, loan facilities had a positive impact on wheat production. So, the hypothesis "Agriculture loan will be associated with wheat production" is accepted.

Table 14 Relationship between credit facility of the farmers and wheat production

Taking loan	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
No	53	65	79
	26.9 %	33 %	40.1 %
Yes	8	15	30
	15.1 %	28.3 %	56.6 %
Total	61	80	109
	24.4 %	32 %	43.6 %

Chi-square = 6.28; d.f. = 2; P-value = .051*; Gamma = 0.299; P-value = .018*; ** = Highly significant

Association of tractor ownership with wheat production

Association among tractor ownership and wheat production of the farmers is represented in Table 15. Chi-square value (χ^2 = 11.15) is highly significant (p = .004) which describes association among tractor ownership and wheat production of the farmers. Gamma statistics showed a significant and strong positive correlation among the variables. So, the ownership of tractor having positive impact on wheat production, the hypothesis "Tractor ownership will be associated with wheat production" is accepted.

Table 15 Relationship between tractor ownership and wheat production

Tractor ownership	Wheat production (maunds/acre) (1 maund = 40 kg)		
	Low production (Up to 35)	**Medium production (36-40)**	**High production (Above 40)**
No	56	71	81
	26.9 %	34.1 %	38.9 %
Yes	5	9	28
	11.9 %	21.4 %	66.7 %
Total	61	80	109
	24.4 %	32.0 %	43.6 %

Chi-square = 11.15; d.f. = 2; P-value = 0.004**; Gamma = 0.463; P-value = .001**; ** = Highly significant

Discussion

In Pakistan, wheat is a staple food and exerts significant importance on the economy of country. Major part of wheat yield comes from the little land holders of nation. Utilizing the technique of multiple regressions to obtained data, the impact of various logical factors on production of wheat was evaluated. The consequences of the examination vividly distinguished some real factors, for example, seed rate, sowing time, N.P.K. fertilizers having a direct effect on the noteworthy increase in wheat yield (Ahmad et al., 2003). Ahmed et al. (2011) reported that the major social and economic features such as education and average farm size were small and most of the scheme tenants were rented in River Nile. The farming system of this scheme was dominantly occupied by the production of wheat and water prices were found to be high. The factors affecting the productivity of wheat were average age, home to field distance, family labor, and distance from source of water, hired labor and term of irrigation. The real production requirements confined the manageability of this vital crop.

Our findings align with Farooq et al. (2007), who studied wheat yield performance and varietal differences in irrigated areas of Kohat, Charsadda, and Swat (Khyber Pakhtunkhwa) during July 2005 to inform policy recommendations. The farmers of the zone allotted two thirds of the crop area to wheat crop. Prohibited (rust powerless) variety Inqilab 91 was extremely well known, and the dominant part of farmers use it. Fakhrisarhad was the best yielding variety in the examination territory with a normal yield of 30.4 maunds for each section of land. The normal yield of various varieties increased from 19.43 to 30.40 mounds from each acre of land. Generally, the normal yield of wheat in the study zone was 22.52 mounds from each acre of land. Lobell et al. (2012) investigated how temperature influences senescence in wheat. When wheat plants were subjected to temperature exceeding 34 °C, an accelerated rate of senescence was recorded. Their study demonstrated that elevated temperatures during the growing season significantly impact the senescence process in wheat. In as similar research Auffhammer et al. (2011) highlighted that high temperature affected the production of rice crop quite severely in India than reported earlier. In India during a period from 1996 to 2002 only 5 to10 % reductions in crop yield were observed that might be due to climate change.

Our findings are supported by the earlier research report by Mahmood et al. (2013) who evaluated the adoption of most recent technology in the farms of Faisalabad. The cross-sectional survey results indicated that majority of the farmers were middle-aged. Dominant part of the farmers embraced wheat sowing recommendations for example well readiness of soil, utilization of prescribed measurements of seed, use of fertilizers, most ideal method for harvesting and better strategy for storage while manually removing weed and fumigation of seed found respectively 33 % and 37.8 %. Moreover, regarding the degree of adoption the recommended wheat sowing, well arrangement of soil and best storage strategy were embraced respectively by 84.4 % and 63.7 % whereas respondents received the wheat sowing proposals for example utilization of prescribed seed (56.3 %) and utilization of weedicide (55.6 %) to a normal degree. Similarity of agriculturalists' inclinations with the proposals and genuine practices give valuable indicators of adoption. Siddiqui et al. (2015) conducted a study to find out the impact of climate change on four cash crops of Punjab province in Pakistan. The impact of two variable temperatures and precipitation was determined. It was found that high temperature is affecting badly the wheat crop initially, but an increase was also found in wheat production with higher average temperature. Similarly, high rainfall affects badly the production of wheat crop. But on the other hand, high precipitation is not affecting the rice crop. Rise in temperature and precipitation badly affected the cotton crop.

Similarly rise in temperature significantly affected the sugarcane crop and decreased production. It's also confirmed that the intensity of impact is changing with the time duration of temperature and precipitation.

Our findings were also in parallel with the previous research studies by Chandio et al. (2018) who assessed the effect of credit on wheat productivity in Pakistan. It has confirmed that agriculture credit has a positive and significant impact on wheat production, while the transient advance strongly affected wheat efficiency than the long-haul advance. The use of agrarian information sources like seeds of improved assortment and composts which can change into wheat around the same time. The long-haul credit clients have higher interests in land readiness, water system and plant security which may prompt higher wheat production in the coming years. Mahmood and Ahmad (2005) analyzed the wheat farmer's technical efficiency in the mixed cultivating systems of Punjab evaluated by utilizing stochastic frontier production function fusing technically inefficient effect model. The Cobb Douglas generation work has observed for satisfactory portrayal of the information given detail of the comparing Trans log frontier model. Technically inefficiency effects were found from variables to be a linear function. The consequences of frontier models described that wheat production can be expanded by expanding wheat zone, weedicides, utilization of pesticides and cultivation. The consequences of the inefficiency effect, model demonstrated that technical inefficiency could be decreased by sowing the crops in time, expanding training of farmers, by giving credit to producers and sowing the yield by bore strategy. The deficiency of irrigation water then again expanded inefficiency of the wheat production in the mixed cultivating system of the province. Inefficiency effect model demonstrated non-significant however the joined impact of all the ten factors was noteworthy in diminishing the inefficiency of the wheat agriculturists in the mixed cultivating system of Punjab, Pakistan.

Our findings are consistent with Yamin et al. (2010), who assessed farm mechanization trends across all regions of Punjab using GIS data on machinery use, sown area, and wheat production from 1995 to 2004. Their multivariate spatial analysis revealed that central, southern, and eastern Punjab had higher mechanization levels and wheat cultivation than northern regions, highlighting a need for improved machinery access in underdeveloped areas like Mianwali and Attock. Similarly, Hussain and Thapa (2012) analyzed wheat production efficiency in Punjab using a Cobb-Douglas production frontier model, based on data from 70 randomly selected households in 2009–2010. Their study showed that farmyard manure, irrigation frequency, and balanced fertilizer use significantly enhanced wheat yields in various cropping zones, while inefficiencies stemmed from technical and socioeconomic constraints. Hashmi et al. (2015) examined the socio-economic status of wheat growers, highlighting that factors such as farm size, machinery use, age, education, and farming background significantly influenced scale efficiency. They found that the size and type of producer were the most critical determinants. Abate et al. (2018) evaluated the impact of Ethiopia's Wheat Initiative technology package comprising improved seed, reduced seeding rate, row planting, fertilizer recommendations, and marketing support on wheat farmers in the highlands. Results showed that farmers adopting the full package achieved 14 % higher yields, though adoption varied, with only 61 % implementing row planting and some control farmers using parts of the package, which limited yield differences. Din and Khattak (2018) assessed the role of mechanization in wheat and maize productivity in Peshawar Valley, surveying 175 farmers across three districts. Most farmers lacked ownership of machinery, and although full mechanization was rare, mechanized farms showed slightly higher yields than non-mechanized ones.

Conclusion and Recommendations

The study revealed that the wheat farmers in Shujaabad utilize diverse sources of agricultural information, with 56.8% relying on electronic media, followed by 47.2% consulting fellow farmers and early adopters, and 41.2% using private agro-based companies. These channels significantly influence farmers' adoption of wheat production technologies. The adoption of recommended wheat sowing practices was positively associated with socio-economic factors such as age, education, farming experience, income, access to agricultural credit, and ownership of farm machinery. Farmers who adopted improved technologies generally achieved higher wheat yields, demonstrating the beneficial impact of modern agronomic practices on productivity. Despite this, only 35.6% of farmers reported receiving information from government extension officers, indicating potential gaps in public sector outreach. Participation in digital platforms and agricultural exhibitions was also limited, suggesting opportunities to diversify extension approaches. To enhance wheat production in Shujaabad, it is essential to strengthen government extension services by improving their accessibility and effectiveness, particularly for farmers with lower education levels and limited information access. Given the prominent role of electronic media and fellow farmers as information sources, extension efforts should integrate mass media campaigns with community-based peer learning to facilitate wider dissemination of modern technologies. Furthermore, fostering partnerships with private agro-based companies can utilize their advisory role and input supply networks. Policies aimed at improving farmers' access to agricultural credit and farm machinery will support the adoption of recommended practices and boost productivity. Lastly, expanding the use of digital platforms, such as mobile apps and SMS services, should be prioritized to reach more farmers and provide timely agricultural guidance, addressing the currently low uptake of these technologies. It is expected that these findings would be useful for agriculture advisors, researchers, academia, and policy makers to understand effect of socio-economic and agronomic practices on wheat production in Southern Punjab, Pakistan. Based on this understanding, policymakers can formulate targeted and evidence-based strategies to enhance wheat productivity and support sustainable farming practices in the region.

Declarations

i. Ethics approval and consent to participate

This study did not require formal ethical approval from an institutional review board, as per the policies of the researchers' affiliated institutions. However, all ethical considerations for social research involving human participants were carefully followed. Informed consent was obtained from all participating farmers prior to data collection. Participation was entirely voluntary, and confidentiality and anonymity of responses were ensured.

ii. Consent for publication

Consent for publication is not applicable, as the study does not include any identifying information or personal data of individual participants.

iii. Data availability

All data generated or analyzed during this study are included in this article.

iv. Competing interests

Authors have declared that no competing interests exist.

v. Authors' contributions

M.S. conceptualized the study, collected the data, developed the methodology, and led the data analysis and manuscript writing. M.A. contributed to data curation, literature review, and manuscript editing. M.U.H. assisted in data analysis and interpretation of results. All authors read and approved the final manuscript.

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viii. SDGs addressed

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