ACADEMIA International Journal for Social Sciences
Volume 4, Issue 2, 2025 ISSN-L (Online): 3006-6638

Socioeconomic Determinants of Wheat Production in Southern Punjab, Pakistan: An Analysis

Muhammad Sammar Abbas
samargardezi14@gmail.com
PhD Scholar, School of Economics, Bahauddin Zakariya University Multan, Pakistan

Syeda Azra Batool
azrabatool@bzu.edu.pk
Professor, School of Economics, Bahauddin Zakariya University Multan, Pakistan
Corresponding Author: * Muhammad Sammar Abbas samargardezi14@gmail.com
Received: 02-05-2025 **Revised:** 27-05-2025 **Accepted:** 12-06-2025 **Published:** 30-06-2025

ABSTRACT

This study analyzes the socioeconomic determinants of wheat production in Southern Punjab, Pakistan. The structured questionnaire was designed to collect data from 400 farmers who were purposely selected in four districts of Multan Division including Multan, Khanewal, Lodhran and Vehari. For data analysis, different econometric techniques like Ordinary Least Squares (OLS) regression, correlation, independent sample t-test and one-way ANOVA analysis is used. These rigorous methodologies ensured that the study was able to capture the general trends and also the differences in productivity of wheat. The study found that education of the farmer, availability of credit, land ownership, wheat seed quality, fertilizer and pesticides quality are the encouraging factors of wheat production in Southern Punjab. On the other hand, incidence of disease is found to be the negative determinant of wheat production in Southern Punjab. These findings carry important implications for agricultural policy. Enhancing the quality and availability of inputs especially seeds and fertilizers should be a top priority. Expanding rural education and credit access can further support farmers' ability to make informed decisions and invest in productive technologies. Meanwhile, addressing plant disease through preventive and curative measures can substantially protect and improve yields. Ultimately, a multifaceted approach that addresses both the socioeconomic constraints and technical needs of farmers is essential to drive sustainable growth in wheat production.

Keywords: *Agriculture Production, Wheat, Southern Punjab, Pakistan*

INTRODUCTION

Agriculture is one of the most critical sectors of the global economy, serving as the backbone for food security, poverty reduction, and sustainable development (Alston & Pardey, 2014). It ensures food and nutrition availability for the world's population, which is projected to reach nearly 10 billion by 2050. Without a strong and resilient agricultural base, achieving global food security will be extremely difficult (Pawlak & Kołodziejczak, 2020). Economically, agriculture is a key driver of growth, particularly in developing countries where it contributes significantly to GDP and employment. It provides direct employment through farming, livestock, and fisheries and generates indirect opportunities in processing, trade, and transportation (Dogar, 2023). From an environmental perspective, agriculture has dual implications. While unsustainable practices contribute to soil degradation, biodiversity loss, and greenhouse gas emissions, the adoption of climate-smart and sustainable practices can mitigate these challenges. Innovations such as sustainable intensification and investment in agricultural technology can enhance productivity while reducing environmental harm (Pawlak & Kołodziejczak, 2020; Nsabiyeze et al., 2024).

In Pakistan, agriculture served as the backbone for food security, rural livelihoods, and economic growth. It contributes around 23.5 percent to the country's Gross Domestic Product (GDP) and employs more than one-third of the national labor force (Ghani, 2022; Pakistan Economic Survey, 2024-25). The sector provides sustenance to a growing population and supplies raw materials for major industries, particularly textiles and food processing, which account for a significant share of Pakistan's exports (Dogar, 2023). Agriculture is also vital for poverty reduction and rural development. In provinces such as Punjab and Khyber Pakhtunkhwa, it provides livelihoods for millions of households through crop cultivation, livestock, and related activities (Hamid & Akram, 2025). The sector supports a large proportion of Pakistan's population directly or indirectly, making it central to socioeconomic stability.

Wheat is the most important crop in Pakistan in terms of agriculture production and economic contribution. Wheat is the country's staple food crop, cultivated on the largest area of arable land and serving as the primary source of caloric intake for most of the population. It contributes significantly to food security and rural livelihoods, with Punjab being the largest wheat-producing province (Nazir et al., 2021). Ensuring self-sufficiency in wheat production is a national priority, as fluctuations in yield directly affect food availability, import bills, and inflation (Shahbaz et al., 2020). The global wheat consumption, especially in Pakistan, has surged significantly due to population growth, rising incomes, and advancements in wheat processing technology (Shahzad et al., 2022). The wheat production can be increased by expanding the cultivated land area or improving the yield. The potential for expanding the land area for wheat cultivation is constrained by limited land availability and competition from other crops such as sugarcane, pulses, oilseeds, and fodder. The primary focus is to enhance yield per hectare, achievable solely by implementing appropriate production technologies, including improved high-yielding varieties, optimal sowing times, effective weed management, precise application of inputs, and sufficient irrigation water supply. Studies have shown that wheat yield variation is significantly influenced by socioeconomic factors age, tractor ownership, land status (owner vs tenant), education, off-farm income, and agro-ecological region (Shahzad et al., 2022; Iqbal et al., 2017; Finger & El Benni, 2013; Hashmi et al., 2015; Falola et al., 2017). For example, smallholder wheat farmers' yield categories in Punjab are significantly associated with variables such as chemical fertilizer use, tractor ownership, and income diversification (Saeed et al., 2021; Raza et al., 2019).

Over the last two years in Pakistan, farmers have faced a major crisis as they could not receive the government-declared support price for their wheat harvest. The failure of procurement mechanisms, combined with excessive imports and market distortions, has caused domestic prices to collapse below the announced support level.[1] Table 1.2 highlights wheat production in Punjab and Pakistan from 2010-11 to 2024-25, measured in million tons. Production trends reveal fluctuations across the years, with noticeable increases in certain periods followed by declines. For instance, Punjab's output rose steadily from 17.7 million tons in 2010-11 to a peak of 24.2 million tons in 2022-23, before declining to 17.7 million tons in 2024-25. Wheat production also showed variation at the national level, reaching its highest level of 31.4 million tons in 2023-24. These shifts can be attributed to climatic conditions, rainfall patterns, seed quality, input availability and lack of wheat support price. As a result, farmers have experienced significant financial losses over the last two seasons despite high input costs for seeds, fertilizers, fuel, and irrigation. This mismatch between rising production costs and suppressed market returns has severely affected profitability, pushing many smallholders into debt and eroding their capacity to reinvest in farming. The absence of a reliable support price has discouraged wheat cultivation and undermined farmer confidence in government policies.

---

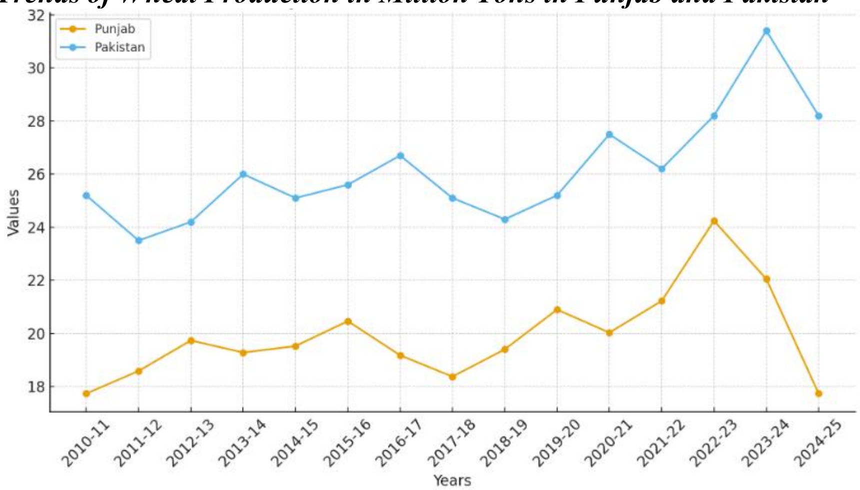
[1]Wattoo, K. S., & Ahmad, W. (2025, April 14). *Agriculture: Wheat woes and policy failure*. *Dawn*. https://www.dawn.com/news/1903989/agriculture-wheat-woes-and-policy-failure

Table 1:
Wheat Production in Million Tons in Pakistan

Years	Punjab	Pakistan
2010-11	17.739	25.2
2011-12	18.587	23.5
2012-13	19.739	24.2
2013-14	19.282	26.0
2014-15	19.527	25.1
2015-16	20.466	25.6
2016-17	19.179	26.7
2017-18	18.377	25.1
2018-19	19.402	24.3
2019-20	20.900	25.2
2020-21	20.032	27.5
2021-22	21.225	26.2
2022-23	24.243	28.2
2023-24	22.053	31.4
2024-25	17.739	28.2

Source: Crop Reporting Service, Punjab, Pakistan

Figure 1:
Trends of Wheat Production in Million Tons in Punjab and Pakistan



The ongoing situation in the wheat production is the matter of deep concern in Pakistan, not only for the farmers but for the economy as a whole. It calls for the attention of academicians and researchers. So, a great deal of research is needed to find out the underlying factors that have created disappointment among the stakeholders. Therefore, this study is designed to analyze the socioeconomic factors of wheat production in Southern Punjab, Pakistan. The study's outcomes will provide important implications for the policymakers to design policies to improve wheat production, particularly in Southern Punjab and Pakistan.

LITERATURE REVIEW

Different studies examined the factors of wheat production such as Wahidia et al., (2025) examined the economic factors affecting wheat production in Afghanistan's Bati Kot area. The study used the data of 120 respondents throughout the 2023 agricultural season. Descriptive statistics and Cobb-Douglas production functions were employed for data analysis. The study showed that Half of the respondents were under 40, 65 percent were literate past elementary, 43 percent had a 5-10-person family and 60% of respondents got 1–2 extension visits for the crop season. Wheat yielded 1400–1460 kg/acre. The cost of wheat production was 38,266.56 Afghani, the total income was 52,978.44, and net returns were 14,711.88. The study also showed that DAP, weedicides, and farmyard manure positively and significantly affect wheat output. However, wheat production in the research area was positively but insignificantly linked with seed, urea, and work days. Shirko (2021) analyzed the farm level determinants of wheat production by using the data of 101 families that were picked by random sampling technique. The study analyzed cross-section data using descriptive statistics and linear multiple regression to investigate wheat production and demographic, socioeconomic, and marketing variables. The regression model predicted that male-headed peasant households, educational level, farmland size, fertilization and use of HYV seeds, access to credit, possession of HH assets, and post-harvest selling were significantly and positively related to wheat production. Age of HH head, family size, and harvesting price negatively affected wheat production income.

Khan et al., (2021) examined wheat crop determinants in Charsadda, Khyber Pakhtunkhwa, Pakistan. Three villages were chosen for data collection: Aspandehri, Kamran Kalay, and Sarfaraz Kalay. From all wheat growers in these villages, 41 farmhouses were selected for data collection. Face-to-face interviews with semi-structured questionnaires were used to obtain primary data from randomly selected respondents. Data was analyzed using profit margin, gross margin, and the Cobb-Douglas production function. The study found profit per acre from the wheat crop was Rs. 12714. The study also found that Tractor, fertilizer, seed, and pest/weed inputs were the positive and significant factors of wheat production. The report advocated for reducing fertilizer prices and mandated the government to produce and distribute high-yielding certified seeds to farmers to enhance the agricultural sector. Faraj et al., (2020) assessed the impact of wheat cultivation, precipitation, and temperature on wheat productivity. The ARDL bound test of cointegration was employed to assess the time-series data. The calculated coefficients in long-term relationships indicate that wheat farming enhances wheat output and is highly significant at the 1 percent level. Rainfall contributed to wheat production, albeit not significantly. Temperature adversely impacts wheat, yet the effect were not statistically significant.

Bahşi & Çetin (2020) examined the influence of agricultural bank loans on the value of agricultural production in Turkey. The research analyzed the correlation between agricultural credit and agricultural production value in Turkey utilizing annual data on real agricultural loans and real GDP from 1998 to 2016. Ordinary Least Squares (OLS) was employed for statistical analysis. The OLS regression indicates that the proposed model accounts for 83.94% of the variation. Regression coefficients indicate that terms exert a greater influence than agricultural credits. This disparity may result from reliance on macroeconomic data and political frameworks. This paper advocates for establishing an agricultural credit framework to finance investments in technology and modernization for farmers. Wana & Sori (2020) examined the factors of wheat productivity in the Horo area of the Horoguduru Wollega Zone, Oromia Region, Ethiopia. The findings indicated considerable inefficiency in wheat production within the examined region. The outcomes showed that land, seed, DAP, and chemicals enhanced wheat productivity. The factor model indicated that family size, expertise in wheat production, and interaction with extension services positively and significantly influenced technical efficiency. The total area of farmed land markedly diminished technological efficiency. The findings indicate that wheat production in the study area can be enhanced. Consequently, government authorities and relevant stakeholders should consider the above socioeconomic and institutional factors to enhance wheat yield in the research region.

Mehri et al. (2020) examined the risk associated with wheat production in Gorgan County, Iran, employing the methodology established by the J-P (Just and Pope) approach. The data and information necessary for this research were acquired using stratified random sampling from 80 surveys completed throughout the 2015-2016 crop year. The estimation results indicated that production risk decreased when labor and farmers' age increased, whereas production risk increased with more chemical fertilizers. Consequently, it is advisable to alter the consumption pattern of this input to establish conditions conducive to mitigating the production risk of this crop in the region. Chandio et al., (2018) evaluated the impacts of short-term loans (STL) and long-term loans (LTL) on the productivity of small farms (wheat) in Sindh, Pakistan. The data collected were analyzed with different econometric tools such as the Cobb-Douglas production function and instrumental variables (two-stage least squares). This research confirmed that agricultural credit positively and significantly impacts wheat productivity, and short-term loans have a higher effect than long-term loans. The phenomenon can be explained by the significantly higher use of agricultural inputs, including improved variety seeds and fertilizers that can be transformed into wheat output during the same year. However, LTL users are characterized by significant investments in land preparation, irrigation, and plant care, which might lead to more wheat production in the years to come.

Kebede et al., (2017) used the Tobit econometric model to study wheat technology package uptake. The study included data from 136 wheat-growing farm households in Gurawa, Meta, and Habro districts of East and West Hararghe zones. The econometric models showed that gender, age, education status, farm size, distance to market, distance to FTC, membership to cooperative, dependency ratio, and annual income of the household significantly affected wheat technology package adoption. Older individuals adopted the wheat technology package more effectively than younger ones, possibly due to its reduced labor demands. The size of the farm positively influenced the adoption of wheat technology, perhaps due to the competitive advantage gained from intensified production and increased productivity relative to farm size. The distance to the market adversely and substantially affected the acceptance of the wheat technology package in the study area. Nonetheless, FTC significantly and robustly clarified adoption. Hussain et al., (2014) investigated the wheat yield gap and its determinants in Punjab. It utilizes cross-sectional data from 210 farmers for the 2009-10 crop year. In the mixed-cropping, cotton-wheat, and rice-wheat regions of the province, actual wheat yields at the farm level are 33.0%, 43.0%, and 50.6% below their potential. An ordinary least squares regression analysis of wheat production utilizing the Cobb-Douglas specification indicates that irrigation, farmyard waste, and fertilizers positively and significantly influence wheat crop yield. The coefficients of the dummy variables indicate that farmers in the mixed cropping zone produce a higher yield of wheat than those in other zones. The data indicated that farmers can enhance wheat production by utilizing more factor inputs; however, poverty may hinder this potential. Providing effective assistance to resource-constrained farmers can enhance wheat production nationally. Bashir et al., (2010) investigated the impact of loans on wheat crop yield in Lahore, Punjab, Pakistan. Primary data were collected from three strata of the district utilizing a meticulously designed questionnaire. Two villages were randomly chosen from each stratum, and ten UBL borrowers were randomly interviewed from each community. An equivalent number of non-loanees were selected for comparison. Multiple regressions were employed for analysis. The findings indicate that agricultural finance transforms agriculture and enhances farmer engagement in production.

DATA AND METHODOLOGY

Data Sources

The collection of data is crucial to the research process. Data serve as the foundation for all academic and scientific investigations. The core of each research project is the data gathering, analysis, and result interpretation. There are three ways to acquire data. These three sources serve as primary, secondary, and tertiary data sources. As a result, in the current investigation, we have used the primary data. The data of 400 farmers is collected using the questionnaire from the Multan Division. The questionnaire consists of socioeconomic profile of farmers, indicators about wheat production.

Sampling Design

In the first stage, Multan Division was selected purposively as the study area; it comprises four districts Multan, Khanewal, Lodharan and Vehari which constituted the secondary sampling units. An equal allocation approach was adopted to collect a data of 400 farmers with 100 farmers drawn from each district using convenient sampling technique (data collected in years 2023-24). Data were collected via face-to-face interviews following ethical procedures including informed consent and confidentiality assurances.

Model Specification

The study aimed to analyze the socioeconomic determinants of wheat production in Southern Punjab, Pakistan. To analyze the socioeconomic determinants of wheat production the model incorporates both farm-level and household-level variables, including landholding size, input use, access to credit and education which are hypothesized to influence wheat productivity. The functional form of the model is given as follows:

$$WPPA = f\left(AGE, EDU, HHS, WTFA, WPA, LOWS, CA, WSQ, FQ, PQ, DI\right) \quad (1)$$

Econometric Form of the Model

$$WPPA_i = \beta_o + \beta_1 AGE + \beta_2 \; EDU_i + \beta_3 HHS_i + \beta_4 WTFA_i + \beta_5 WPA_i + \beta_6 LOWS_i + \beta_7 CA_i + \beta_8 WSQ$$

$$+\beta_9 FQ_i + \beta_{10} PQ_i + \beta_{11} DI_i + u_i \quad (2)$$

Where WPPA is the wheat production per acre, AGE indicates age of the farmer, EDU represents Education of the farmer, HHS is the Household size, WTFA indicates the amount of fertilizers applied on wheat, WPA represents pesticides applied, LOWS specifies land ownership, CA is the credit availability, WSQ means wheat seed quality, WPA indicates pesticides applied, FQ represents fertilizer quality, PQ indicates pesticide quality, DI indicates the severe wheat disease incidence and u_i is the error term.

Furthermore, in this study, the wheat farmers are categorized into small, medium and large farmers with respect to their land holdings. Farmers with less than 5 acres, between 6 to 12 acres and above 13 acres are considered as small, medium and large farmers, respectively. Primarily, this analysis allows the study to analyze variations in wheat production across different landholding groups. Farm size is a crucial determinant of access to resources, technology adoption, credit availability, and risk-bearing capacity. Small farmers often struggle with subsistence-level production, limited market integration, and financial constraints, whereas medium and large farmers are more likely to benefit from economies of scale and improved bargaining power. By distinguishing farmers according to landholding size, the study ensures a comparative assessment, enabling the identification of targeted policy measures for each group. For this purpose, the following model is developed:

$$WPPA_i = \beta_o + \beta_1 AGE + \beta_2 \ EDU_i + \beta_3 HHS_i + \beta_4 WTFA_i + \beta_5 WPA_i + \beta_6 CA_i + \beta_7 WSQ \\ + \beta_8 FQ_i + \beta_9 PQ_i + \beta_{10} DI_i + u_i \quad (3)$$

Where WPPA is the wheat production per acre, AGE indicates age of the farmer, EDU represents Education of the farmer, HHS is the Household size, WTFA indicates the amount of fertilizers applied on wheat, WPA represents pesticides applied, CA is the credit availability, WSQ means wheat seed quality, WPA indicates pesticides applied, FQ represents fertilizer quality, PQ indicates pesticide quality, DI indicates the severe wheat disease incidence and u_i is the error term.

Table 1:
Description of Variables

Variables	Description of Variables	
WPPA	Wheat production per acre	Munds
AGE	Age of the farmer	Years
EDU	Education of the farmer	Number of schooling years
HHS	Household size	Number of members in a household
WTFA	Fertilizers applied on wheat	Kilograms
WPA	Pesticides applied on wheat	Number of pesticides applied
LOWS	Land ownership	Number of acres
CA	Credit availability	= 1 if Yes = 0 if No
WSQ	Wheat seed quality	= 1 if High, = 0 if Low
FQ	Fertilizer quality	= 1 if High, = 0 if Low
PQ	Pesticide quality	= 1 if High, = 0 if Low
DI	Disease incidence	= 1 if High, = 0 if Low

Data Estimation Techniques

To analyze the socioeconomic determinants of wheat production, different econometric techniques are applied for data analysis. The description of these techniques is given as follows:

i. **Descriptive Analysis**

A descriptive analysis of data comprises the mean, standard deviation, minimum and maximum values, skewness and kurtosis values. The SPSS software is used to calculate the mean and the standard deviation of each variable. The mean value of the variable can be calculated using the following formula:

$$Mean = \frac{\sum X_i}{n} \quad (3)$$

Where;

$\sum X_i$ = Sum of values

n = Number of values

The standard deviation is a measure of the variation between a value and the mean, or the degree of deviation between a value and the mean. The standard deviation can be obtained by the following formula:

$$SD = \sqrt{\frac{\sum\left(X-\overline{X}\right)^2}{n}} \qquad (4)$$

ii. Correlation Analysis

Correlation analysis is used to test the degree of relationship between two variables. The sign and value of the correlation coefficient shows the direction and the magnitude of the correlation between two variables. The correlation analysis is done using the statistical software SPSS. The formula of the calculation of the correlation coefficient is as follows:

$$r=\frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n_1}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n_2}\right]}} \qquad (5)$$

iii. Ordinary Least Square Method

Linear regression model is applied in order to study the effects of two or more independent variables on a dependent variable. Multiple regression model is used to investigate the impact of two or more independent variables on a dependent variable. In the event that the dependent variable is randomly selected, the regression model is solved under ordinary least squares method. The following is the multiple linear regression model equation:

$$Y_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots\ldots\ldots + \beta_i X_i + u_i \qquad (6)$$

Where;

Y_i = Dependent Variable

X_i = Independent Variable

β_o = Intercept

β_i = Parameter of the variable measures the unit change in independent variable lead to how much change in dependent variable

An ordinary least square approach is applied to analyze the parameters of the regression model. Ordinary least square method is applied when data is randomly sampled.

iv. Independent Sample T-Test Analysis

To test the significant mean difference in wheat production concerning different socioeconomic factors, an independent sample t-test is used. The null hypothesis of the independent sample t-test is as follows:

$H_o = u_1 - u_2$ "two population means are equal"
$H_1 \neq u_1 - u_2$ "two population means are not equal"

Or

$H_o = u_1 - u_2$ "The difference between the two population means is equal to zero"
$H_1 \neq u_1 - u_2$ "The difference between the two population means is equal to zero"

There are two methods for calculating the t-value. Statistic's when the population is presuming equal variances; the t-statistic is calculated as follows.

$$t = \frac{\overline{x_1} - \overline{x_2}}{s_p \sqrt{\frac{1}{n_1} - \frac{1}{n_2}}} \quad (7)$$

Where;

$$s_p = \sqrt{\frac{(n_1 - 1)s_1^2 - (n_1 - 1)s_2^2}{n_1 + n_2 - 2}} \quad (8)$$

The t-result statistic's determines whether or not the null hypothesis is accepted. The null hypothesis is disproved if the value of the t-statistic exceeds the value that was tabulated.

v. One-Way ANOVA Analysis

One-way ANOVA (Analysis of Variance) is a statistical technique used to test whether there are significant differences between the means of three or more independent groups. Unlike a t-test, which compares only two groups, one-way ANOVA evaluates variations across multiple groups simultaneously. It works by partitioning the total variation in the data into two components: variation between groups (due to treatment or factor differences) and variation within groups (due to random error). The F-statistic, calculated as the ratio of between-group variance to within-group variance, determines whether the observed differences in means are statistically significant. A higher F-value with a corresponding low p-value indicates that at least one group mean differs significantly from others.

Hypotheses:

Null hypothesis (H_0): $\mu_1 = \mu_2 = \mu_3 \ldots \mu k$ (all group means are equal).
Alternative hypothesis (H_1): At least one group mean differs.

DATA ANALYSIS

Descriptive Statistics

This section illustrates the descriptive statistics of variables. Table 2 presents the descriptive statistics of variables (overall sample) in the form of mean, maximum, minimum value of data, standard deviation, skewness and kurtosis. It is found that the mean value of wheat production per acre is 39.288 Munds, maximum value is 65 Munds, minimum value is 15 Munds, standard deviation is 10.864, skewness value is 0.105 suggesting the positively skewed distribution and kurtosis value 2.282 indicates the platykurtic distribution. In addition, the mean, values of AGE, EDU and HHS are 44.805, 8.415 and 7.00, respectively. The maximum, values of AGE, EDU and HHS are 73, 16 and 18, respectively. The minimum, values of AGE, EDU and HHS are 18, 0 and 2, respectively. The mean value of land ownership in the form of acres is 7.608, maximum value is 40, minimum value is 1, standard deviation is 7.694, skewness value is 1.698 suggesting the positively skewed distribution and kurtosis value 5.814 indicates the platykurtic distribution. In a similar way, the descriptive statistics of other variables can be observed from the Table 2.

Table 2:
Descriptive Statistics (Overall)

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WPPA	39.288	65	15	10.864	0.105	2.282
AGE	44.805	73	18	12.673	0.054	1.919
EDU	8.415	16	0	3.633	-0.057	2.786
HHS	7.00	18	2	2.906	1.120	4.227
WTFA	1.419	2.75	0	0.479	-0.148	3.536
WPA	1.630	3	0	0.692	-0.450	3.078
LOWS	7.608	40	1	7.694	1.698	5.814
CA	0.645	1	0	0.479	-0.606	1.367
WSQ	0.510	1	0	0.501	-0.040	1.002
FQ	0.490	1	0	0.501	0.040	1.002
PQ	0.455	1	0	0.499	0.181	1.033
DI	0.330	1	0	0.471	0.723	1.523

Source: Author's Calculations using Survey Data

Table 3 presents the descriptive statistics of variables (small farmers) in the form of mean, maximum, minimum value of data, standard deviation, skewness and kurtosis. It is found that the mean value of wheat production per acre is 34.355 Munds, maximum value is 62 Munds, minimum value is 15 Munds, standard deviation is 9.506, skewness value is 0.330 suggesting the positively skewed distribution and kurtosis value 2.537 indicates the platykurtic distribution. In addition, the mean, values of AGE, EDU and HHS are 41.828, 7.588 and 6.050, respectively. The maximum, values of AGE, EDU and HHS are 73, 16 and 18, respectively. The minimum, values of AGE, EDU and HHS are 18, 0 and 2, respectively. In a similar way, the descriptive statistics of other variables can be observed from the Table 3.

Table 3:
Descriptive Statistics (Small Farmers)

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WPPA	34.335	62	15	9.506	0.330	2.537
AGE	41.828	73	18	13.050	0.348	1.994
EDU	7.588	16	0	3.304	0.304	3.002
HHS	6.050	18	2	2.326	1.536	7.763
WTFA	1.317	2.75	0	0.511	-0.149	3.424
WPA	1.376	3	0	0.719	-0.183	2.571
CA	0.448	1	0	0.498	0.209	1.044
WSQ	0.362	1	0	0.482	0.574	1.330
FQ	0.344	1	0	0.476	0.657	1.432
PQ	0.371	1	0	0.484	0.534	1.285
DI	0.389	1	0	0.489	0.455	1.207

Source: Author's Calculations using Survey Data

Table 4 presents the descriptive statistics of variables (medium farmers) in the form of mean, maximum, minimum value of data, standard deviation, skewness and kurtosis. It is found that the mean value of wheat production per acre is 43.0 Munds, maximum value is 65 Munds, minimum value is 29 Munds, standard deviation is 8.265, skewness value is 0.290 suggesting the positively skewed distribution and kurtosis value 2.401 indicates the platykurtic distribution. In addition, the mean, values of AGE, EDU and HHS are 48.385, 8.578 & 8.339, respectively. The maximum, values of AGE, EDU and HHS are 72, 16 and 16, respectively. The minimum, values of AGE, EDU and HHS are 27, 0 and 4, respectively. In a similar way, the descriptive statistics of other variables can be observed from the Table 4.

Table 4:
Descriptive Statistics (Medium Farmers)

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WPPA	43.000	65	29	8.265	0.290	2.401
AGE	48.385	72	27	11.219	-0.042	2.023
EDU	8.578	16	0	3.698	-0.557	3.181
HHS	8.339	16	4	3.113	0.688	2.565
WTFA	1.466	2.5	1	0.348	0.310	2.538
WPA	1.908	3	1	0.519	-0.127	3.586
CA	0.872	1	0	0.336	-2.221	5.933
WSQ	0.651	1	0	0.479	-0.635	1.404
FQ	0.679	1	0	0.469	-0.766	1.587
PQ	0.486	1	0	0.502	0.055	1.003
DI	0.284	1	0	0.453	0.956	1.914

Source: Author's Calculations using Survey Data

Table 5 presents the descriptive statistics of variables (large farmers) in the form of mean, maximum, minimum value of data, standard deviation, skewness and kurtosis. It is found that the mean value of wheat production per acre is 49.143 Munds, maximum value is 64 Munds, minimum value is 25 Munds, standard deviation is 9.414, skewness value is -0.685 suggesting the negatively skewed distribution and kurtosis value 2.841 indicates the platykurtic distribution. In addition, the mean, values of AGE, EDU and HHS are 48.629, 10.00 and 8.00, respectively. The maximum, values of AGE, EDU and HHS are 68, 16 and 16, respectively. The minimum, values of AGE, EDU and HHS are 22, 0 and 3, respectively. In a similar way, the descriptive statistics of other variables can be observed from the Table 5.

Table 5:
Descriptive Statistics (Large Farmers)

Variables	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
WPPA	49.143	64	25	9.414	-0.685	2.841
AGE	48.629	68	22	11.192	-0.349	2.234
EDU	10.00	16	0	3.502	-0.681	3.861
HHS	8.00	16	3	2.999	0.919	3.282
WTFA	1.668	2.5	1	0.450	0.155	2.303
WPA	2.000	3	1	0.482	0.000	4.375
LOWS	21.386	40	13	7.024	0.777	2.811
CA	0.914	1	0	0.282	-2.960	9.760
WSQ	0.757	1	0	0.432	-1.199	2.438
FQ	0.657	1	0	0.478	-0.662	1.438
PQ	0.671	1	0	0.473	-0.730	1.533
DI	0.214	1	0	0.413	1.393	2.939

Source: Author's Calculations using Survey Data

Correlation Analysis

The correlation coefficient is used to assess the degree of association between two variables. Table 6 illustrates the outcomes of correlation coefficient for a whole sample. The results shows that wheat production per acre is positively correlated with the age of the farmer, education of the farmer, household size, fertilizer applied, pesticides applied, land ownership, credit availability, wheat seed quality, fertilizer quality, and pesticide quality while WPPA is negatively correlated with the disease incidence.

Table 6:
Correlation Overall Sample

	WPPA	AGE	EDU	HHS	WTFA	WPA	LOWS	CA	WSQ	FQ	PQ	DI
WPPA	1.000											
AGE	0.343	1.000										
EDU	0.413	0.059	1.000									
HHS	0.431	0.500	0.141	1.000								
WTFA	0.446	0.264	0.284	0.329	1.000							
WPA	0.575	0.414	0.254	0.435	0.342	1.000						
LOWS	0.504	0.213	0.338	0.387	0.343	0.368	1.000					
CA	0.550	0.251	0.292	0.280	0.273	0.404	0.352	1.000				
WSQ	0.678	0.241	0.239	0.307	0.241	0.372	0.266	0.464	1.000			
FQ	0.515	0.205	0.133	0.270	0.216	0.293	0.238	0.330	0.581	1.000		
PQ	0.385	0.113	0.208	0.181	0.176	0.155	0.181	0.342	0.414	0.289	1.000	
DI	-0.354	-0.115	-0.186	-0.106	0.123	0.278	-0.172	-0.146	0.291	0.220	0.139	1.000

Source: Author's Calculations using Survey Data

Table 7 illustrates the outcomes of correlation coefficient for a small farmer's data. The results shows that wheat production per acre is positive correlated with the age of the farmer, education of the farmer, household size, fertilizer applied, pesticides applied, credit availability, wheat seed quality, fertilizer quality, and pesticide quality while WPPA is negatively correlated with the disease incidence.

Table 7:
Correlation Analysis of Small Farmers

	WPPA	AGE	EDU	HHS	WTFA	WPA	CA	WSQ	FQ	PQ	DI
WPPA	1.000										
AGE	0.404	1.000									
EDU	0.278	0.043	1.000								
HHS	0.393	0.547	-0.064	1.000							
WTFA	0.453	0.320	0.162	0.310	1.000						
WPA	0.606	0.449	0.220	0.437	0.330	1.000					
CA	0.503	0.168	0.187	0.161	0.221	0.327	1.000				
WSQ	0.614	0.253	0.191	0.276	0.252	0.445	0.457	1.000			
FQ	0.400	0.191	0.018	0.153	0.218	0.272	0.248	0.545	1.000		
PQ	0.403	0.136	0.164	0.153	0.216	0.264	0.382	0.415	0.312	1.000	
DI	-0.323	-0.168	-0.159	-0.125	-0.086	-0.301	-0.178	-0.254	-0.246	-0.190	1.000

Source: Author's Calculations using Survey Data

Table 8 illustrates the outcomes of correlation coefficient for a medium farmer's data. The results shows that wheat production per acre is positive correlated with the education of the farmer, household size, fertilizer applied, pesticides applied, credit availability, wheat seed quality, fertilizer quality, and pesticide quality while WPPA is negatively correlated with the age of the farmer and disease incidence.

Table 8:
Correlation Analysis of Medium Farmers

	WPPA	AGE	EDU	HHS	WTFA	WPA	CA	WSQ	FQ	PQ	DI
WPPA	1.000										
AGE	-0.045	1.000									
EDU	0.326	-0.086	1.000								
HHS	0.042	0.374	0.030	1.000							
WTFA	0.170	-0.074	0.172	0.017	1.000						
WPA	0.190	0.192	0.028	0.260	0.188	1.000					
CA	0.193	0.212	0.284	0.060	0.219	0.038	1.000				
WSQ	0.611	-0.021	0.120	0.105	0.080	-0.093	0.122	1.000			
FQ	0.337	-0.022	0.071	0.151	0.045	0.030	0.147	0.486	1.000		
PQ	0.261	-0.096	0.141	0.101	-0.023	-0.325	0.044	0.365	0.158	1.000	
DI	-0.304	0.151	-0.088	0.187	-0.084	-0.124	0.242	-0.179	0.042	0.038	1.000

Source: Author's Calculations using Survey Data

Table 9 illustrates the outcomes of correlation coefficient for a large farmer's data. The results shows that wheat production per acre is positive correlated with the age of the farmer, education of the farmer, household size, fertilizer applied, pesticides applied, credit availability, wheat seed quality, fertilizer quality, and pesticide quality while WPPA is negatively correlated with the disease incidence.

Table 9:
Correlation Analysis of Large Farmers

	WPPA	AGE	EDU	HHS	WTFA	WPA	CA	WSQ	FQ	PQ	DI
WPPA	1.000										
AGE	0.129	1.000									
EDU	0.398	-0.064	1.000								
HHS	0.474	0.338	0.352	1.000							
WTFA	0.289	0.139	0.482	0.521	1.000						
WPA	0.256	0.073	0.189	0.151	0.084	1.000					
CA	0.365	-0.042	0.185	0.151	-0.056	0.213	1.000				
WSQ	0.718	0.164	0.126	0.214	-0.030	0.070	0.422	1.000			
FQ	0.729	0.149	0.169	0.224	0.069	0.063	0.209	0.574	1.000		
PQ	0.173	0.078	0.111	0.081	-0.027	-0.064	0.329	0.242	0.200	1.000	
DI	-0.395	-0.102	-0.236	-0.298	-0.099	-0.146	-0.213	-0.435	-0.356	-0.079	1.000

Source: Author's Calculations using Survey Data

Socioeconomic Determinants of Wheat Production: Overall Analysis

This section illustrates the OLS estimates of the socioeconomic determinants of wheat production in Southern Punjab. The Ordinary Least Squares (OLS) regression analysis provides an in-depth understanding of the socioeconomic factors influencing wheat production. The dependent variable used in a model is wheat production per acre (WPPA) whereas the independent variables are age of the farmer (AGE), education of the farmer (EDU), household size (HHS), fertilizer applied (WTFA), pesticides applied (WPA), land ownership (LOWS), credit availability (CA), wheat seed quality (WSQ), fertilizer quality (FQ), and pesticide quality (PQ) and disease incidence (DI). The regression model exhibits strong explanatory power, with an R-squared value of 0.706, indicating that approximately 70.6% of the variation in wheat production is explained by the included independent variables. The adjusted R-squared value of 0.689 further confirms the robustness of the model. The F-statistic (84.656) is highly significant ($p = 0.0000$), suggesting that the overall model is statistically valid.

First, analyzing the relationship between age of the farmer and wheat production, the results show that the coefficient for age of the farmer is 0.025 while it's associated p-value reaches 0.374 thus showing statistical insignificant relationship. Age by itself produces no significant effect on wheat production levels. These findings suggests that the factors of farming efficiency depend more on education and technology adoption along with access to credit than on farmer experience. Young farmers face better access to contemporary agricultural technology yet older farmers mainly use traditional techniques thus aging itself does not significantly influence production figures. The positive relationship between age of the farmer and wheat production is also found by Hashmi et al., (2015) and Mustafa et al., (2025). The findings also show that education of the farmer is positively and significantly related to the wheat production per acre in Southern Punjab. The coefficient value indicates that as it upsurges by a unit the wheat production also increases by 0.350 units. These results indicates that farms operated by better-educated farmers demonstrate higher probability to implement enhanced agricultural practices while using first-rate inputs as well as making knowledgeable decisions about farm operations and therefore helpful in improving the wheat production per acre. The positive relationship between education of the farmer and wheat production was also found by Hashmi et al., (2015); Falola et al., (2017). The study found that the impact of household size on wheat production is positive but statistically insignificant (coefficient = 0.145, $p = 0.270$). These findings indicate that larger households offer extra workers yet their basic limitations including land shortage and input and tool availability together with poor mechanization practice limit the actual effect of household size expansion. Becoming proficient in mechanized agriculture methods will decrease the effects of labor deficits in homes with limited members. Positive relationship between household size and wheat production is also found by Bekele et al., (2009) and Alemu et al., (2014).

Table 10:
OLS Estimates of Socioeconomic Factors of Wheat Production

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	17.589	1.473		11.937	0.000
Age of the Farmer	0.025	0.028	0.030	0.890	0.374
Education of the Farmer	0.350	0.092	0.117	3.793	0.000
Household Size	0.145	0.131	0.039	1.105	0.270
Fertilizer Applied	2.755	0.711	0.121	3.872	0.000
Pesticides Applied	2.897	0.552	0.185	5.251	0.000
Land Ownership	0.220	0.046	0.156	4.729	0.000
Credit Availability	2.648	0.771	0.117	3.433	0.001
Seed Quality	7.181	0.834	0.331	8.610	0.000
Fertilizer Quality	2.164	0.747	0.100	2.898	0.004
Pesticide Quality	1.183	0.678	0.054	1.746	0.082
Disease Incidence	-2.051	0.684	-0.089	-3.000	0.003
R^2			0.706		
Adj-R^2			0.689		
F-Stat.			84.656		
Prob. F-Stat			0.0000		

Source: Author's Calculations using Survey Data

The application of fertilizer significantly enhances wheat production, with a coefficient of 2.755 and a p-value of 0.000. These findings suggest that soil fertility increases and yield grows higher because of fertilizer usage thus demonstrating its vital function. Wheat production is mainly depends on timely use and accurate amounts of quality fertilizers. Knowing how to use fertilizers properly can help in preventing both land degradation and environmental contamination that occurs when using too much fertilizer. These results are also found by the studies of Iqbal et al., (2017); Finger & El Benni (2013); Iqbal et al., (2011) and Falola et al., (2017). Similarly, pesticide application has a strong positive effect on wheat production, with a coefficient of 2.897 and a p-value of 0.000. It suggests that pest and disease management stands as the essential factor to achieve good plant development and elevated harvest levels. The strategic employment of pesticides by farmers allows them to avoid losses from infestations which results in enhanced production levels. These results are also found by Finger & El Benni (2013); Iqbal et al., (2011). On the other hand, the land ownerships also determine significant influence on the production of wheat. The land ownership coefficient is 0.220 and p-value is 0.000 which indicates that land ownership has a significant positive effect on wheat production. Giving farmers more land to cultivate will make them invest in keeping their soil healthy and acquire irrigation systems and utilize modern farming technology. Ownership of land allows farmers to implement productive decisions that increase their rate of harvests amid the existence of tenant farmers who experience constraints due to rent payments and uncertainty in land ownership. These results are correlated with the results of Hashmi et al., (2015); Falola et al., (2017). The other important variable affecting the production of wheat is the availability of credit. The findings show that credit availability is positively and significant linked to the wheat production in Southern Punjab with a coefficient of 2.648 and p-value of 0.001. Access to credit enables the farmers to have the financial ability to purchase better inputs and also to acquire mechanization equipment and adopt better farming methods. Banks should come up with farming credit schemes to supply essential resources to the farmers such as the smallholders. The positive relationship between credit availability and wheat production is found by Falola et al., (2017); Ahmad et al., (2015) and Bashir et al., (2010).

Furthermore, seed quality is found to be positively related to the wheat production in Southern Punjab, with a coefficient of 7.181 and a p-value of 0.000. High-quality seeds enhance yield potential at a substantially higher level. High-resistance seeds which are certified improve both existing productivity levels and germination success rates when planting begins. Improving both seed varieties and seed distribution methods needs to become the top agricultural policy focus of government officials. Positive relationship between seed quality and wheat production is also found by Husenov et al., (2021) and Hussain et al., (2018). Similarly, the quality of fertilizers used by farmers has a significant positive impact on wheat production, with a coefficient of 2.164 and a p-value of 0.004. The effectiveness of the fertilizer plays an equal role with quantity when enhancing soil fertility and crop production. The productivity of agricultural land can receive additional improvement through promoting farmers to use soil-optimized high-quality fertilizers which maintain balanced nutrient ratios. These results are also found by Falola et al., (2017); Hussain et al., (2014). Pesticide quality has a positive effect on wheat production, it is statistically insignificant (coefficient = 1.183, p = 0.082). These results suggest that due to the significance of effective pesticide quality the application methods along with integrated pest management approaches lead to better pest regulation. Farmer pest management techniques become more effective when they receive training about proper pesticide application methods. These results are also found by Hossard et al., (2014); Tudor et al., (2023). Lastly, disease incidence has a significant negative impact on wheat production in Southern Punjab, with a coefficient of -2.051 and a p-value of 0.003. These outcomes demonstrate that crop diseases result in major harvest reductions in agricultural production. Farmland owners need to implement successful disease control methods which combine crop rotations with disease-resistant seeds and proper pesticide treatment to reduce yield reduction. Timely disease identification and control practices offered by strong agricultural extension services would lead to substantial farmer benefits. These results are also found by Jevtic et al., (2017) and Matzen et al., (2019).

Socioeconomic Determinants of Wheat Production: Farmer's Landholdings-Wise Analysis

This section presents the socioeconomic determinants of wheat production with respect to the farmer's land holdings. The farmers are divided into small, medium and large farmers with respect to their land holdings. Farmers with less than 5 acres, between 6 to 12 acres and above 13 acres are considered as small, medium and large farmers, respectively. The R^2 values indicate how well the models explain variations in farm productivity. Small farms have an R^2 of 0.624, medium farms have 0.546, and large farms have the highest at 0.815. This suggests that the model explains farm productivity best in large farms. The F-statistics are highly significant for all farm sizes, confirming that the models provide strong explanatory power.

The outcomes reveals that age of the farmer manifests substantial influence only in small and large farms yet fails to affect medium farm wheat production. The impact of farmer age on productivity of small farms reveals a positive effect through the coefficient value of 0.268. The age of large farmers significantly impacts production of wheat through positive outcomes (0.337) because prolonged experience enables them to better manage resources and take informed decisions for farm improvement. The -0.017 coefficients in medium farms demonstrates that older farmers do not influence outputs since its effect is statistically non-significant. Medium-scale farming demands a combination of experienced practices and contemporary farming skills but age of the farmer might not determine either one. The relationship between farmer education and wheat production found to be significant for medium and large farm operations yet it does not affect small wheat farmers in Southern Punjab. The outcomes suggest that education lacks any substantial role in improving productivity in cases of small wheat farmers. Education plays a greater part in the farming enterprise as farm scale expands. Positive educational effects on wheat yield stem from farmers' abilities to handle technical information and financial skills along with contemporary farming methods. Higher education produces substantial benefits for large-scale farmers because they must handle intricate choices and extensive resource management tasks. Household size has a significant positive effect on small wheat farmers (3.345), indicating that larger households provide additional labor, which is crucial in small-scale farming where mechanization is limited. However, for medium farms, the effect is negative but insignificant (-0.193), suggesting that household size does not play a meaningful role in productivity. For large farms, the coefficient (2.371) is positive but not statistically significant. This could imply that while household labor is essential for small farms, larger farms rely more on hired labor and mechanization, reducing the impact of household size. The application of fertilizers has a significant positive effect on small and large wheat farms but not on medium wheat farms in Southern Punjab. For small wheat farmers, the coefficient is 3.130, indicating that increased fertilizer use leads to higher productivity. Similarly, for large farmers, the coefficient (2.742) suggests a significant boost in yield from fertilizer application. However, in medium farmers, the coefficient (0.210) is not statistically significant, suggesting that large scale farmers may already using appropriate amount of fertilizers. The strong effect in small and large wheat farms highlights the importance of proper nutrient management to enhance crop yield. These results are also found by the studies of Finger & El Benni (2013); Iqbal et al., (2011) and Falola et al., (2017).

Table 11:
OLS Estimates of Socioeconomic Factors of Wheat Production

Variables	Small		Medium		Large	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
(Constant)	0.051	0.039	24.636***	4.113	-0.070	0.052
Age of the Farmer	0.268**	0.132	-0.017	0.058	0.337*	0.186
Education	0.311	0.221	0.421**	0.165	0.644***	0.232
Household Size	3.345***	0.882	-0.193	0.212	2.371	1.541
Fertilizer Applied	3.130***	0.729	0.210	1.729	2.742**	1.162
Pesticides Applied	3.404***	0.949	4.297***	1.262	5.126***	2.263
Credit Availability	4.963***	1.167	4.603**	1.954	9.708***	1.699
Seed Quality	0.993	1.040	8.592***	1.497	8.410***	1.380
Fertilizer Quality	1.224	0.956	0.938	1.410	3.745**	1.218
Pesticide Quality	-1.560*	0.888	2.293*	1.304	3.563**	1.490
Disease Incidence	-0.061*	0.039	-3.286**	1.411	-0.070	0.052
R^2	0.624		0.546		0.815	
Adj-R^2	0.606		0.499		0.784	
F-Stat.	34.816***		11.771***		25.973***	
Prob. F-Stat	0.000		0.0000			
N	121		109		70	

Source: Author's Calculations using Survey Data

The use of pesticides has a significant and positive influence on all wheat farm sizes in Southern Punjab. The coefficient is 3.404 in case of small farms, 4.297 on medium farms, and 5.126 in case of large wheat farms. The findings show that pest control is a key factor to enhancing productivity in wheat farms. The effect is greatest in large wheat farms, which may owe to their increased exposure to pest infestation and capability of investing in quality pesticides. The results indicate the significance of the integrated pest management approaches in order to improve the wheat yields. These findings also appear in Hossard et al., (2014); Tudor et al., (2023) and Keler et al., (2020). Access to credit is a crucial factor influencing productivity across all wheat farm sizes. In small wheat farms, the coefficient is 4.963, highlighting the importance of credit in enabling farmers to purchase inputs such as seeds, fertilizers, and equipment. In medium wheat farms, the effect is also significant (4.603), and in large wheat farms, the impact is even greater (9.708). This suggests that as farm size increases, access to credit becomes even more critical for scaling operations. Credit availability enables wheat farmers to invest in modern farming techniques and infrastructure, ultimately leading to higher productivity. The positive relationship between credit availability and wheat production is found by Falola et al., (2017); Ahmad et al., (2015) and Bashir et al., (2010). Seed quality has a significant impact on medium and large wheat farms but not on small wheat farms in Southern Punjab. In small wheat farms, the coefficient (0.993) is not statistically significant, implying that small scale farmers not using quality seeds that are why the relationship between seed quality and wheat production is statistically insignificant. However, for medium wheat farms (8.592) and large wheat farms (8.410), the effect is highly significant, suggesting that high-quality seeds are essential for achieving better yields. The strong impact on larger wheat farms could be due to their ability to invest in improved seed varieties that offer higher resistance to diseases and adverse weather conditions. Positive relationship between seed quality and wheat production is also found by Husenov et al., (2021) and Hussain et al., (2018).

The quality of fertilizers is not a major determinant of small and medium wheat farms with the coefficient of 1.224 and 0.938, respectively. The quality of fertilizer, however, has a positive influence in large wheat farms (3.745). This means that small and medium wheat farms can use standard fertilizers whereas large wheat farms would fare better with high quality fertilizers, perhaps because of their size of operation and investment in new soil management techniques. Falola et al., (2017); Hussain et al., (2014) also find positive relationship between the quality of fertilizer and wheat production. The quality of pesticides has different effects depending on the size of the wheat farms in Southern Punjab. The coefficient in the small wheat farms is negative (-1.560) and this means that inadequate pesticide quality can be harmful as far as productivity is concerned. On the contrary, the coefficient of the medium wheat farms is positive and significant (2.293), which implies that productivity increases with the quality of pesticides. Nonetheless, it is significant (1.563) in large farms, which means that other aspects might have a stronger influence on managing pests. The findings imply that quality control measures should be enforced in the distribution of pesticides to achieve positive results. Hossard et al., (2014); Tudor et al., (2023) and Keler et al., (2020) also find positive relationship between quality of pesticide and yield of wheat. The negative impact of the disease incidence on medium and small wheat farms (-3.286, -0.061) indicates that the productivity is greatly diminished by disease outbreaks. The coefficients are however not significant in small and large wheat farms which means that the incidence of diseases may not be a key determinant of productivity in these cases. The adverse impact on medium farms is very strong implying that the disease should be controlled in specific ways in order to reduce losses. Jevtic et al., (2017) and Matzen et al., (2019) also obtain such results.

Independent Sample T-Test Analysis

This section presents the independent sample t-test to test the significant mean difference of wheat production with respect to the credit availability, seed quality, fertilizer quality, pesticide quality, and disease incidence in Southern Punjab. The outcomes are given in Table 12. The independent sample t-test results indicate significant differences in wheat production based on key factors such as credit availability, seed quality, fertilizer quality, pesticide quality, and disease incidence. Farmers with access to credit had a significantly higher mean production (43.71) compared to those without credit (31.25), suggesting that financial support positively influences productivity. Similarly, high-quality seeds resulted in a much higher mean yield (46.50) compared to low-quality seeds (31.79), emphasizing the importance of seed selection. Fertilizer quality also played a crucial role, with high-quality fertilizers yielding a mean production of 44.99 compared to 33.81 for low-quality fertilizers. The use of high-quality pesticides improved production (43.86) compared to low-quality pesticides (35.47), showing their effectiveness in protecting crops. Conversely, high disease incidence significantly reduced wheat production (33.82) compared to low disease incidence (41.98). The statistical significance (p-value = 0.000) for all factors confirms their strong influence on wheat production.

Table 12:
Independent Sample T-Test Estimates to Test the Significant Mean Difference of Wheat Production With Respect to Different Factors

Variables		N	Mean	SD	T-Stat.	Prob.
Credit Availability	Yes	258	43.71	9.617	13.830	0.000
	No	142	31.25	8.030		
Seed Quality	High	204	46.50	8.117	18.396	0.000
	Low	196	31.79	7.875		
Fertilizer Quality	High	196	44.99	9.805	11.989	0.000
	Low	204	33.81	8.837		
Pesticide Quality	High	182	43.86	9.659	8.380	0.000
	Low	218	35.47	10.344		
Disease incidence	High	132	33.82	9.557	-7.545	0.000
	Low	268	41.98	10.464		

Source: Author's Calculations using Survey Data

One-Way ANOVA Analysis

This section presents the one-way ANOVA analysis to test the significant mean difference of wheat production with respect to the age, education of the farmer, household size, and land holdings in Southern Punjab. Table 13 shows the outcomes of one-way ANOVA analysis with respect to the farmer's age. The results reveal a significant difference in wheat production based on the age of farmers (F = 21.810, p = 0.000). Younger farmers, particularly those aged 20 or less, had the lowest mean production (22.33), followed by those aged 21 to 30 (28.40). As age increases, productivity improves, with farmers aged 31 to 40 (40.53) and 41 to 50 (40.68) achieving significantly higher yields. The highest production levels were observed among farmers aged 51 to 60 (43.13), suggesting that experience plays a crucial role in maximizing output. Interestingly, production slightly declines for farmers aged 61 and above (41.21), though it remains relatively high. The findings indicate that younger farmers may lack the necessary experience, skills, or resources to optimize wheat production. These results highlight the importance of agricultural training and support for younger farmers to enhance their productivity and sustain wheat production efficiency across different age groups.

Table 13:

One-Way ANOVA Analysis to Test the Significant Mean Difference of Wheat Production With Respect to the Age of the Farmer

Age	N	Mean	S.D.	F-Stat.	Prob.
20 or Less	3	22.33	2.517	21.810	0.000
21 to 30	62	28.40	7.476		
31 to 40	107	40.53	11.687		
41 to 50	82	40.68	10.026		
51 to 60	103	43.13	8.034		
61 or Above	43	41.21	10.072		
Total	400	39.29	10.864		

Source: Author's Calculations using Survey Data

Table 14 presents the outcomes of one-way ANOVA analysis to test the significant mean difference of wheat production concerning household size in Southern Punjab. The results indicate a significant difference in wheat production based on household size (F = 30.290, p = 0.000). Farmers with smaller households (three or fewer members) had the lowest mean production (24.50), while those with slightly larger households (4 to 6 members) produced an average of 35.35. The larger the household size the higher the productivity and those households with 7 to 9 members had a productivity of 43.58 whereas the households with 10 to 12 members had a productivity of 44.96. The largest mean production (45.17) was recorded in the household size of 13 or more. The results indicate that bigger families result in increased wheat production, probably because the number of people to work on the farm is increased. The findings substantiate the role of household labor in agricultural productivity, and it is possible to assume that small households might need more labor assistance or mechanization to increase their wheat production and make their farming activities more effective.

Table 14:
One-Way ANOVA Analysis to Test the Significant Mean Difference of Wheat Production With Respect to the Household Size

HHS	N	Mean	S.D.	F-Stat.	Prob.
3 or Less	16	24.50	5.465	30.290	0.000
4 to 6	184	35.35	9.650		
7 to 9	130	43.58	10.274		
10 to 12	47	44.96	7.129		
13 or Above	23	45.17	10.866		
Total	400	39.29	10.864		

Source: Author's Calculations using Survey Data

Table 15 presents the outcomes of one-way ANOVA analysis to test the significant mean difference of wheat production concerning land ownership. The one-way ANOVA results indicate a significant difference in wheat production based on land ownership (F = 81.616, p = 0.000). Farmers with less than 5 acres of land had the lowest mean production (34.33), while those owning 6 to 12 acres achieved a higher yield (43.00). The highest production levels were observed among farmers with more than 13 acres (49.14). The research indicates that enlarged agricultural land properties lead to better wheat production outcomes because they enable increased cultivation capabilities with enhanced farming strategies and economies of scale benefits. Farmers who possess smaller landholdings overcome challenges from resource scarcity alongside insufficient farming equipment and limited availability of advanced farming materials hence limiting their productivity. Small-scale farmers require finance together with technical help for improving their efficiency and wheat production output.

Table 15:
One-Way ANOVA Analysis to Test the Significant Mean Difference of Wheat Production With Respect to the Land Ownership

Land (Acres)	N	Mean	S.D.	F-Stat.	Prob.
Less than 5	221	34.33	9.506	81.616	0.000
6 to 12	109	43.00	8.265		
More than 13	70	49.14	9.414		
Total	400	39.29	10.864		

Source: Author's Calculations using Survey Data

Table 16 presents the outcomes of one-way ANOVA analysis to test the significant mean difference of wheat production concerning education of the farmer in Southern Punjab. The one-way ANOVA results show a significant difference in wheat production based on the education level of farmers (F = 19.640, p = 0.000). Farmers with only primary education had the lowest mean production (32.78), while those with middle school education produced slightly more (38.82). Production levels increased with higher education, with matric-educated farmers achieving 41.20, and intermediate-educated farmers reaching 43.11. The highest productivity was recorded among those with bachelor's (50.20) and master's or higher education (50.00). These findings suggest that education plays a crucial role in improving farming efficiency, likely due to better knowledge of modern agricultural practices, resource management, and technology adoption. The illiterate farmers (38.83) did better than the primary educated ones, which may be as a result of more experience in farming. The findings indicate that agricultural education programs and training initiatives are essential to provide the farmers with the skills required to increase productivity of wheat and the overall efficiency of the farming process.

Table 16:
One-Way ANOVA Analysis to Test the Significant Mean Difference of Wheat Production With Respect to the Education of the Farmer

Education	N	Mean	S.D.	F-Stat.	Prob.
Illiterate	18	38.83	8.169	19.640	0.000
Primary	116	32.78	9.055		
Middle	92	38.82	8.588		
Matric	76	41.20	11.949		
Intermediate	57	43.11	10.239		
Bachelors	25	50.20	7.654		
Masters of Above	16	50.00	8.050		
Total	400	39.29	10.864		

Source: Author's Calculations using Survey Data

CONCLUSIONS

The study analyzes the socioeconomic determinants of wheat production in Southern Punjab. The analysis found that the interaction between socio-economic, demographic, and farm-level factors had a noteworthy impact on the agricultural production in southern Punjab. The results show that education of the farmers, fertilizer application, pesticide application, land ownership, availability of credit, quality of seed and quality of fertilizers have significant and positive effect on wheat production while disease occurrence has adverse effect on wheat production in Southern Punjab. The effect of household size and farmer age was found to be varied across different models. Education proved to be a vital factor of wheat production at the aggregate level. Educated farmers were more able to embrace modern practices, apply high quality inputs and practice improved management of farms. These findings indicated that the amount of wheat yield is directly correlated with literacy and years of schooling. Application of fertilizers and pesticides also boosted production, which indicated the further dependence of wheat cultivation to externalities. Such dependence, however, creates the problem of sustainability and the necessity of balanced utilization of input so that soil erosion and environmental damage may be prevented. The study also found that land ownership affect the farmers to invest in soil fertility, irrigation, and mechanization. Tenant farmers were restricted in such a way that they could not capitalize on production to the extent possible to them. Furthermore, farmers accessed the necessary inputs at the right time through the provision of credit, which demonstrated that institutional finance is important in enhancing wheat productivity. The quality of the seeds and fertilizers also increased these effects, therefore the importance of ensuring farmers gain access to certified and quality inputs. On the other hand, the prevalence of the disease led to reduction of wheat production, which highlights why wheat was vulnerable to attacks by pests and pathogens.

The study also conducted disaggregated analysis based on the land holdings. The study show that wheat production also varies based on the different farm size. The outcomes reveals that age of the farmer manifests substantial influence only in small and large farms yet fails to affect medium farm wheat production. The relationship between farmer education and wheat production found to be significant for medium and large farm operations yet it does not significantly affect the small wheat farmers in Southern Punjab. Household size has a significant positive effect on small wheat farmers, indicating that larger households provide additional labor, which is crucial in small-scale farming where mechanization is limited. However, for medium farms, the effect is negative but insignificant, suggesting that household size does not play a meaningful role in productivity. The application of fertilizers has a significant positive effect on small and large wheat farms but not on medium wheat farms in Southern Punjab. The use of pesticides has a significant and positive influence on all wheat farm sizes in Southern Punjab. Seed quality has a significant impact on medium and large wheat farms but not on small wheat farms in Southern Punjab. The quality of fertilizers is not a major determinant of small and medium wheat farms, however, has a positive influence in large wheat farms. This means that small and medium wheat farms can use standard fertilizers whereas large wheat farms would fare better with high quality fertilizers, perhaps because of their size of operation and investment in new soil management techniques. Lastly, the study found a negative impact of the disease incidence on medium and small wheat farms indicating that the wheat productivity is greatly diminished by disease outbreaks.

In conclusion, the wheat production in Southern Punjab is related to socioeconomic status of the farmers, resource endowments, and institutional support. Policy actions that have been noticed to help in strengthening the extension services, fostering education among the farmers, improving credit delivery mechanisms and access to certified inputs are imperative. Moreover, the adverse effect of crop diseases would be reduced by investing in the research of disease-resistant types of wheat and improved disease surveillance systems. Food security is achievable by implementing policies that combine these measures to make farms profitable and to make wheat production sustainable in the long run.

POLICY IMPLICATIONS

The research has far reaching consequences on agricultural policy, rural development and reduction of poverty in Southern Punjab.

1. The role of education in enhancing productivity and profitability remains constant, thus the necessity of providing educational and training programs to the farmers. Enhancement of agricultural extension services and vocational training programs will empower the farmers to embrace modern practices and use inputs effectively.

2. The outcomes emphasize on the need to increase access to affordable credit. The credit systems of institutions should be empowered in order to minimize dependence on exploitative informal lenders. The gaps on inputs can be bridged by individualized financial plans by the smallholders, which would involve microcredit, interest-free lending, etc and this can enable them to adopt modern practices at the right time.
3. The positive contribution of the quality of seed, fertilizer, and pesticides means that the input markets need to be tightened by regulation. The policies must emphasize the distribution of certified seeds and stimulating the use of soil-specific fertilizer mixtures and the quality of the pesticide market. These interventions will insure farmers against non-focus inputs and ensure that there are increased outputs.
4. The findings confirm that there is an immediate necessity to work out more effective disease management practices. Agricultural research that will develop a variety of crops that are resistant to diseases, early warning systems and pest management will guarantee yields and profitability is maintained.
5. Inequality in terms of land ownership means that there are structural inequalities in the agrarian sector. Large scale farmers have always remained vulnerable to smallholders due to their economies of scale. These inequalities can be addressed by specific land reform, protection of tenancy rights and resource sharing plans such as cooperative farming.
6. The government should facilitate the infrastructure (especially road) to improve the market network of wheat producer which encourages the farmers to produce effectively and supply their products to the market with low transportation cost that increase farmers experience in the long run.

REFERENCES

Ahmad, A., Jan, I., Ullah, S., & Pervez, S. (2015). Impact of agricultural credit on wheat productivity in District Jhang, Pakistan. *Sarhad Journal of Agriculture*, *31*(1), 65-69.

Alemu, T., Emana, B., Haji, J., & Legesse, B. (2014). Smallholder wheat production efficiency in selected agroecological zones of Ethiopia: a parametric approach. *J. Econ. Sustain. Dev*, *5*, 155-163.

Alston, J. M., & Pardey, P. G. (2014). Agriculture in the global economy. *Journal of Economic Perspectives*, *28*(1), 121-146.

Bahşi, N., & Çetin, E. (2020). Determining of agricultural credit impact on agricultural production value in Turkey. *Ciência Rural*, *50*, e20200003.

Bashir, M. K., Yasir Mehmood, Y. M., & Sarfraz Hassan, S. H. (2010). Impact of agricultural credit on productivity of wheat crop: evidence from Lahore, Punjab, Pakistan. *Pak. J. Agri. Sci.,* Vol. 47(4), 405-409.

Bekele, A., Viljoen, M. F., Ayele, G., & Ali, S. (2009). Effect of farm size on efficiency of wheat production in Moretna-Jirru district in Central Ethiopia. *Indian Journal of Agricultural Economics*, *64*(1).

Chandio, A. A., Jiang, Y., Wei, F., & Guangshun, X. (2018). Effects of agricultural credit on wheat productivity of small farms in Sindh, Pakistan: are short-term loans better?. *Agricultural Finance Review*, *78*(5), 592-610.

Dogar, A. H. (2023). The role of agriculture in Pakistan's economic development: Challenges and opportunities in a globalized market. *Annals of Human and Social Sciences, 4*(1), 494–505.

Falola, A., Achem, B. A., Oloyede, W. O., & Olawuyi, G. O. (2017). Determinants of commercial production of wheat in Nigeria: a case study of Bakura Local Government Area, Zamfara State. *Trakia Journal of Sciences*, *15*(4).

Faraj, F. S., Ismail, F., & Ab-Rahim, R. (2020). Determinants of Wheat Production in Libya. *International Journal of Academic Research in Business and Social Sciences*, *10*(12), 178-191.

Finger, R., & El Benni, N. (2013). Farmers' adoption of extensive wheat production–Determinants and implications. *Land Use Policy*, *30*(1), 206-213.

Ghani, U. (2022). Sector wise contribution of agriculture to the economic growth of Pakistan. *Global Journal of Humanities and Social Sciences Research, 2*(1), 1–6.

Government of Pakistan, Ministry of Finance. (2024-25). *Agriculture* (Chapter 25). In *Economic Survey of Pakistan*. Retrieved from https://www.finance.gov.pk/survey/chapter_25/2_Agriculture.pdf

Hamid, A., & Akram, N. (2025). Significance and role of agriculture sector in the socio-economic development of Khyber Pakhtunkhwa. *Dialogue Social Science Review, 3*(1), 1383–1391.

Hashmi, M. S., Kamran, M. A., Bakhsh, K., & Bashir, M. A. (2015). Technical efficiency and its determinants in wheat production: Evidence from the Southern Punjab, Pakistan. *Journal of Environmental and Agricultural Sciences*, *3*, 48-55.

Hossard, L., Philibert, A., Bertrand, M., Colnenne-David, C., Debaeke, P., Munier-Jolain, N., ... & Makowski, D. (2014). Effects of halving pesticide use on wheat production. *Scientific reports*, *4*(1), 4405.

Husenov, B., Asaad, S., Muminjanov, H., Garkava-Gustavsson, L., & Johansson, E. (2021). Sustainable wheat production and food security of domestic wheat in Tajikistan: Implications of seed health and protein quality. *International journal of environmental research and public health*, *18*(11), 5751.

Hussain, A., Aujla, K. M., & Badar, N. (2014). Yield gap determinants for wheat production in major irrigated cropping zones of Punjab, Pakistan. *Pakistan Journal of Agricultural Research*, *27*(3).

Hussain, M., Farooq, M., Sattar, A., Ijaz, M., Sher, A., & Ul-Allah, S. (2018). Mitigating the adverse effects of drought stress through seed priming and seed quality on wheat (Triticum aestivum L.) productivity. *Pakistan Journal of Agricultural Sciences*, *55*(2).

Iqbal, M., Ahmad, M., Abbas, K., & Mustafa, K. (2003). The impact of institutional credit on agricultural production in Pakistan [with comments]. *The Pakistan Development Review*, 469-485.

Iqbal, M., Khan, M. F., Suhail, M., & Zaman, Q. (2017). Determinants of various factors for wheat production. *J. Agric. Res*, *55*(2), 379-385.

Jevtic, R., Župunski, V., Lalošević, M., & Župunski, L. (2017). Predicting potential winter wheat yield losses caused by multiple disease systems and climatic conditions. *Crop Protection*, *99*, 17-25.

Kebede, D., Ketema, M., Dechassa, N., & Hundessa, F. (2017). Determinants of adoption of wheat production technology package by smallholder farmers: Evidences from eastern Ethiopia. *Turkish Journal of Agriculture-Food Science and Technology*, *5*(3), 267-274.

Keler, V. V., Martynova, O. V., & Ovchinnikova, T. G. (2020, August). Pesticides effect on the quantity and quality of gluten in spring wheat. In *IOP Conference Series: Earth and Environmental Science* (Vol. 548, No. 5, p. 052036). IOP Publishing.

Khan, S., Khan, M., Alam, A., Shah, I., Khan, M., & Khan, F. M. (2021). Factors Affecting Wheat Productivity of Small Farm Households in the Rural District Charsadda. *Sarhad Journal of Agriculture*, *37*.

Matzen, N., Jørgensen, J. R., Holst, N., & Jørgensen, L. N. (2019). Grain quality in wheat—Impact of disease management. *European Journal of Agronomy*, *103*, 152-164.

Mehri, M., Eshraghi, F., & Keramatzadeh, A. (2020). An analysis of the determinants of wheat production risk in Gorgan County. *Journal of Agricultural Science and Technology*, *22*(5), 1153-1164.

Mustafa, F., Tabasam, N., Sadaf, T., Rouf, A., & Azhar, U. (2025). Impact of Increased Fertilizer Prices on its Use in Wheat Crop and Wheat Productivity in Selected Districts of Punjab Province. *Research Journal for Social Affairs*, *3*(1), 103-109.

Nazir, A., Hussain, A., & Raza, M. A. (2021). Wheat production in Pakistan: Constraints, opportunities and future prospects. *Cereal Research Communications, 49*(4), 585–596.

Nsabiyeze, A., Ma, R., Li, J., Luo, H., Zhao, Q., Tomka, J., & Zhang, M. (2024). Tackling climate change in agriculture: A global evaluation of the effectiveness of carbon emission reduction policies. *Journal of Cleaner Production*, *468*, 142973.

Pawlak, K., & Kołodziejczak, M. (2020). The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. *Sustainability*, *12*(13), 5488.

Raza, M. H., Bakhsh, A., & Kamran, M. (2019). Managing climate change for wheat production: An evidence from southern Punjab, Pakistan. *Journal of Economic Impact*, *1*(2), 48-58.

Saeed, R., Qasim, M., Mahmood, I., & Akhtar, W. (2021). Factors affecting wheat yield variation of smallholder farmers in Punjab province: Application of ordered logistic model. *Advances in Agriculture and Animal Science*, *37*(2), 126-131.

Shahbaz, P., Ahmad, M., & Rehman, A. (2020). Food security and wheat production in Pakistan: Implications for sustainable development. *Journal of Economic Impact, 2*(1), 23–31.

Shahzad, A., Hamid, A., Hussain, A., Rashid, M., Khan, M., & Hussain, Z. (2022). Current situation and future prospects of wheat production in Pakistan. *Journal of Life and Social Sciences*, *2022*(1), 5-5.

Shirko, T. B. (2021). Determinants of Wheat Production in Sodo Zuriya District, Wolaita Zone, Snnprs of Ethiopia. *International Journal of Research and Analytical Reviews (IJRAR)*, *8*(3).

Tudor, V. C., Stoicea, P., Chiurciu, I. A., Soare, E., Iorga, A. M., Dinu, T. A., ... & Dumitru, E. A. (2023). The use of fertilizers and pesticides in wheat production in the main European Countries. *Sustainability*, *15*(4), 3038.

Wahidia, E., Alia, A., Younasa, H., Shaha, S. A., Jana, A., & Ullahb, R. (2025). Economic analysis and determinants of wheat production in bati kot district of nangarhar province, Afghanistan. *Journal of Economic Impact,* 7(1), 41-47.

Wana, H., & Sori, O. (2020). Factors affecting productivity of wheat production in Horo district of Oromia region, Ethiopia. *Journal of Poverty, Investment and Development*, *52*(2020), 1-13.