Research Article

Determinants of Rice Yield in Central Khyber Pakhtunkhwa, Pakistan

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Abstract | Inputs' application in production process determine the level of output in agriculture. This study therefore attempted to investigate determinants of rice yield in central Khyber Pakhtunkhwa, Pakistan. A random sample of 275 rice growers was selected from district Swabi, using a multi-stage random sampling procedure. Pre-tested interview schedule was used for collection of data from rice growers. Through Cobb-Douglas type production function (CDPF) data was analyzed. Results indicated that 1 percent increase in labor hours and urea increased yield by 0.411% and 0.231%, respectively, at 0.01 level of α (p-value = 0.000). A percent increase in number of irrigation and tractor hours increased yield by 0.110% and 0.044%, respectively, at 0.05 level of α while chemicals increased yield by only 0.029% but was statistically insignificant. Summing up all the estimated coefficients of the regressed model resulted a value of 0.8266, implying that rice growers in the study area were operating with decreasing returns to scale. Findings of this endeavor revealed that a percent increase in labor hours, urea fertilizer and irrigation has enhanced rice productivity by 0.41%, 0.23% and 0.11%, respectively. Therefore, farmers need to increase labor hours, application of urea fertilizer and irrigation for accelerating rice output. Decreasing return to scale (DRS) was found in the use of all inputs, therefore re-allocation of these inputs is suggested and application of tractor hours and chemicals need to be rationalized.

Received | February 20, 2021; **Accepted** | July 19, 2021; **Published** | November 30, 2021
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Citation | Ali S., Murtaza, W. Ahmad, M. Israr, A. Khan, Hamdullah and S.A. Shah. 2022. Determinants of rice yield in central Khyber Pakhtunkhwa, Pakistan. *Sarhad Journal of Agriculture,* 38(1): 117-127.
DOI | https://dx.doi.org/10.17582/journal.sja/2022/38.1.117.127
Keywords | Rice, Determinants, Cobb-Douglas type production Function, Returns to scale, Khyber Pakhtunkhwa

Introduction

Sustainable agriculture promises sustainable economy, food security and sufficient income for farming community. Particularly in the developing world most of the countries rely on farming economically (Spash, 2007). Conferring to Food and Agriculture Organization (FAO) report nearly, 2.57 billion people rely on agriculture, hunting fishing forestry for their livelihood (FAO, 2018). Agriculture provides basic necessities to human beings and most of the industrial production is dependent on agriculture as source of raw materials for industries (Khan and Xiangyu, 2020).

Pakistan's agriculture sector still stands at 2nd important position in contribution to economy. In the year 2019-2020, this sector contributed 19.3% to gross domestic production (GDP) which has increased in comparison to previous year (18.5%) in year 2018-19. It also has engrossed 38.5% labor of the country's workforce. Despite of the pandemic (Covid-19) where all sectors' growth declined, the agriculture sector experienced remarkable growth of 2.67% which was relatively higher than the previous year. Among the major crops after sugarcane, rice was 2nd major crop which experienced tremendous growth of 2.9% (GoP, 2020).

Rice botanically known as Oryza Sativa L. is main staple food and cash crop of Pakistan. It has an awesome nutritional value and enriched with proteins, carbohydrates and also few essential vitamins like thiamin, niacin, riboflavin etc. (FAO, 2018). More than 120,000 rice varieties are grown worldwide, cultivated in various growing conditions like irrigated rain-fed low-lands and up-lands (Khush, 2020). According to FAO, 90% of world rice is produced and consumed in Asia with the major annual rice consumer countries of China, India, Indonesia, and Bangladesh having consumption of 143, 102, 37 and 35 million tonnes respectively. China is the major rice producing country followed by India, Indonesia Bangladesh and so on with the production of 212.13, 172.58, 83.04 and 56.42 million tonnes respectively. Similarly, the area allocated for rice was largest in India (44.50 million hectares) followed by China (30.19 million Hectares), Indonesia (16 million hectares) in the year 2018 (Statista, 2020). On the other side rice yield per hectare was highest in Australia followed by Egypt, USA, and Uruguay with the yield 10386, 8826.5, 8621.1, 8500 kg/hectare respectively. In this ranking, Pakistan falls at 57th position yielding 3844.4 kg/ hectare whereas in the production it was ranked as 10th in the major rice producer countries (FAOSTAT, 2018).

Rice crop is 2nd major essential and exporting commodity of Pakistan. It adds 3.1% value to agriculture and contributes about 0.6% to the GDP of the country. Pakistan allocated 3034 million hectares of area to rice and produced 7.410 million tonnes in the year 2019-20. Among the provinces, Punjab is the largest producer of rice followed by Sindh and Khyber Pakhtunkhwa. While in terms of yield Sindh is top most yielding province with 3.441 tonnes/ha followed by Balochistan with the yield of 3.262 tonnes/ha. Khyber Pakhtunkhwa is at 4th in the ranking of yield with yield of 2.394 tonnes/ha (GoP, 2019). Despite of having productive resources like water resources and fertile soil Khyber Pakhtunkhwa is not performing well. This reason motivate researchers to determine the different factors responsible for truncated production and low productivity.

The existing literature reveals several factors that determine the production and selection of various crops. The possible factors found in light of literature are; crops choices, seed quality and variety selection, soil fertility, water availability, marketing information, quality chemicals and fertilizers, tenure status, risk management, labor, institutional and environmental aspects, crop management techniques and practices etc. (Smile *et al*., 1994; Osanyinlusi and Kemisola, 2016). Socioeconomics characteristics like; age, gender, education, experience, income level, household size, wealth etc. are also key component that can influence productivity of crops (Okoronuwa *et al*., 2006). Nonvide (2008) argue that sufficient irrigation provides the chance of improving production and yield specially in developing world. A change in aforesaid factors can influence the productivity of crops (Mbam and Edeh, 2011). Few research works that shed light on this very issue are; (Okoronuwa *et al*., 2006; Joshi and Bauer, 2006; Akinbile, 2007; Ayoola *et al*., 2011; Mbam and Edeh, 2011; Basoru and Fasakin, 2012; Osanyinlusi and Kemisola, 2016, Tanko *et al*., 2016; Ayedun and Adeniyi, 2019) while in particular on rice crop few authors in Pakistan like (Abedullah *et al*., 2007; Javed *et al*., 2008; Bhatti, 2015; Shaikh *et al*., 2016; Jan and Khan 2019; Shah *et al*., 2019) had identified determinants responsible for productivity of rice.

In the light of above literature, the importance of rice crop is quite considerable. Because of the fact that rice is concerned with food, economy and particularly as a primary income of a segment of farming community, the yield of Khyber Pakhtunkhwa is relatively devastating and certainly the farmers' productivity in Swabi is low in comparison to other districts. There is an immense need to investigate empirically the factors responsible for the low productivity of rice.

Outcomes of the study are expected to be significant for the rice growers of district Swabi as the findings will help them improve the rice output. These results will also be helpful for policy makers in designing policies regarding rice crop in Swabi district and Khyber Pakhtunkhwa as well. This study therefore estimated costs and returns of rice crop and examined the determinants of rice yield in Central Khyber Pakhtunkhwa.

Materials and Methods

This section briefly focuses on location of the conducted study, the methods and tools used in the collection

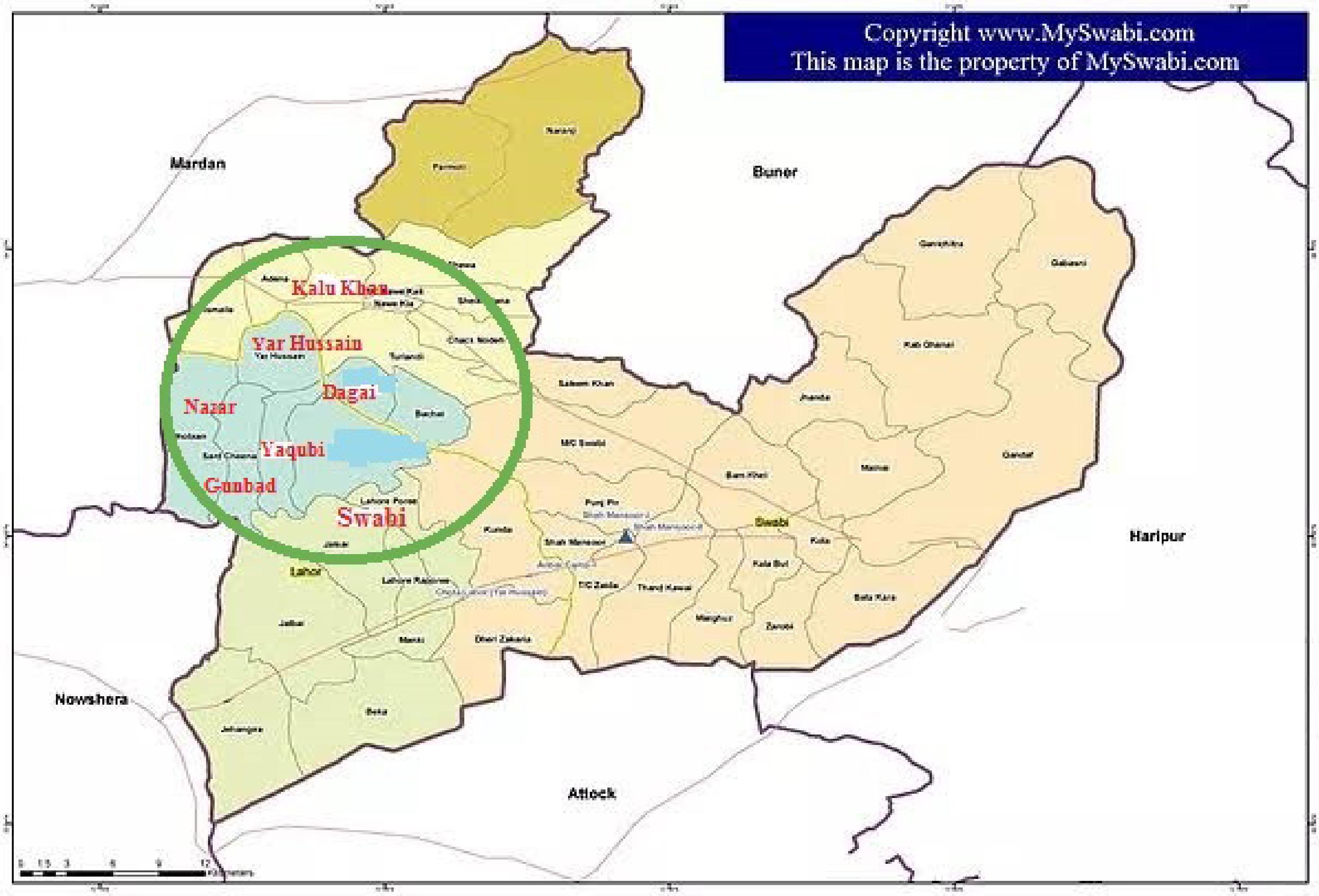

Figure 1: *Map of the study area (District Swabi).*
Source: *www.myswabi.com*

of both the primary and secondary data, size of the sample taken, conceptual framework, general and specified form of the model and multiple tests to diagnose the data for problems like heteroscedasticity, multicollinearity and normality.

Study location

District Swabi was chosen for this specific study that covers an area of 1,543 square kilometers [Government of Khyber Pakhtunkhwa (GoKP, 2017) with the coordinates of 34° 7′ 0″ N, 72° 28′ 0″ E and its total population was recorded as 1,826,804 (GoKP, 2017; Ali *et al*., 2019). In 2017, the total area in district Swabi was reported as 1, 48,689 hectares where 87, 046 area was cultivated, 89, 171 was cropped, 61, 643 was un-cultivated, 26, 630 was cultivable waste, 26, 505 hectares comprised of forests and 8, 505 hectares were even not applicable cultivating crops (GoKP, 2017).

District Swabi is a well-known district of Khyber Pakhtunkhwa; quite rich in fertile lands, enhanced irrigation system, conducive agro-climatic environment and diligent farming community. Being capable of producing multiple crops, vegetables and fruits, the district is mainly engaged in growing major cash crops like sugarcane, tobacco, and grains like maize, wheat and rice. Map of the study area is provided as follows (Figure 1).

Sampling procedure and size of the sample

District Swabi was chosen purposively to be the study area because of constrained budget and time. A random sample of rice growers was taken using a multi-stage random sampling procedure. In the very early stage of the sampling, the district was divided into four tehsils and tehsil Razarr was chosen randomly among them. Among the leading rice producing villages, six villages namely Kalu-Khan, Yarhussain, Nazar, Gumbad, Dagai and Yaqubi were randomly chosen in stage 2nd. In the last stage, a total of 275 respondents from four union councils were picked randomly. Yamane's formula was used to decide the size of the sample for this study as it is used generally (Yamane, 1967; Ahmad *et al*., 2019; Murtaza *et al*., 2020), given as;

$$n = \frac{N}{(1 + N(e)^2)} \dots\dots\dots (1)$$

Where;

n: Number of rice growers to be chosen; *N*: Total number of rice producers in the particular villages; *e*: Precision's level.

To determine the exact number of rice growers from each and every chosen village, Proportional Allocative Sampling technique was then used, given as;

$$n_i = \frac{N_i}{N} \times n \dots\dots\dots (2)$$

Where;

n_i: number of respondents to be picked up from i[th] village; *N*: number of all the rice growers in the chosen villages; N_i: number of rice farmers in the i[th] chosen village; *n*: total number of rice growers decided by Yamane's formula.

Table 1 depicts details of union councils, total rice growers, sampled respondents and their percentage shares.

Table 1: *Size of the sample and sampling procedure.*

District	Tehsil	Union councils	Total rice growers	Sampled respondents	%age
Swabi	Razarr	Yarhussain	195	61	22.1
		Kalu-Khan	184	57	20.7
		Dagai	151	47	17.0
		Yaqubi	133	41	14.9
		Nazar	117	36	13.0
		Gumbad	105	33	12.0
		Total	885	275	100

Source: *Department of agriculture extension, Swabi (2019).*

Data

Both the primary and secondary data were used in the study whereas primary data were collected from the rice growers personally at their homes and farms using a well-designed survey questionnaire, being pre-tested in the field while secondary data were taken and punched into this study from the local extension department, Pakistan Bureau of Statistics and FAO Statistics.

Theoretical concept

Profitability and net return: Net revenue is referred as the gross margin less the fixed inputs' cost while gross margin is calculated by subtracting total variable cost from total revenue (Omotayo and Adefemi, 2016; David and Stanley, 2000). According to Varian (1992), Fagoyinbo (1999) and Debertin (2012) net return is termed as the difference between the total revenue and the total input's cost in a production process, whereas the total revenue of a firm is the market value of the quantity he/she produced and the total cost of a producer includes the fixed and variable costs. Following Siliphouthone *et al.* (2012), Arayaphong (2012), Bajracharya and Sapkota (2017) and Naeem *et al.* (2017), the net revenue of the rice growers was calculated by the formula given as:

$$\pi(NR) = TR - TC \dots\dots\dots (3)$$

$$TR = PQ_i \times Q_i \dots\dots\dots (4)$$

$$TC = Px_i \times X_i \dots\dots (5)$$

Profitability refers to the ratio of profit (net revenue) and total factor cost of a production process. Higher the profitability value of a firm, the more profitable in revenue and more efficient in resources' allocation he/she is (Dillon and Hardaker, 2019). Following Chanda *et al.* (2019); Khan *et al.* (2020) and Murtaza *et al.* (2020), profitability of the rice growers in the study area was measured by the formula given as:

$$Profitability = \frac{NR}{TC} \dots\dots\dots (6)$$

Whereas;

π(NR): Net return of the rice growers; TR: Total revenue of the rice growers; TC: Total production cost; PQ_i: Market price of i[th] unit of output; Q_i: Amount of output; PX_i: Market price of each and every input used; X_i: Total amount of inputs utilized.

General and Specified form of the model

The study aimed to scrutinize and analyze the major determinants that affect the productivity of farming community involved in rice farming in the study area. Generally, production models/functions are used to determine the relationship between endogenous (productivity) and exogenous (farm inputs) variables. Tintner (1944) and Heady (1946) are considered as the pioneers of such production models but following Khuda *et al.* (2005), Shaikh *et al.* (2016), Osanyinlusi and Kemisola (2016), Jan and Naushad (2019) and Omoare and Wasiu (2020), this study used Cobb-Douglas type production function to analyze the response of productivity with respect to change in farm inputs because of its accuracy and simplicity. The general form of the model is given as:

$$Y_i = f(K_i, L_i, X_i) \ldots\ldots\ldots\ldots\ldots (7)$$

Whereas;
Y_i: Output; K_i: Invested physical capital; L_i: Labor involved in production; X_i: Other major factors affecting the output such as age, farm size, education and farming experience etc.

The specified form of the model is given as:

$$logYield = \beta_0 + \beta_1 lnUrea + \beta_2 lnChemicals + \beta_3 lnTractor + \beta_4 lnLabor + \beta_5 lnIrrigation + e_i \ldots\ldots\ldots (8)$$

Whereas;
ln: Natural logarithm; β'_s: Model's parameters; *Urea*: Urea (fertilizer) used in kilograms; *Chemicals*: Amount of pesticides used in terms of liters; *Traactor*: Tractor hours in the preparation of seed bed; *Labor*: Working hours of labor till harvest; *Irrigation*: Number of times the crop is irrigated; e_i: Error term.

Post-estimation tests
Generally cross-sectional data result in several econometric problems like heteroscedasticity (when the variance of the error term across the observations is not constant), normality (the assumption about the error term's distribution in the model whether it is symmetric or skewed) and multicollinearity (arises when the independent variables of the model have a strong relationship among each other). All these problems lead to unfair results, incongruous estimates, high R^2-value and inaccuracy of the model (Gujarati, 2009). Therefore, to check the problems of multicollinearity, heteroscedasticity and normality multiple tests like correlation matrix, Breusch-Pagan and residuals' histogram were conducted respectively.

Results and Discussion

Cost incurred on per acre rice production
Table 2 displays the total cost incurred on per acre rice production in the study area. Average total cost of the rice farmers was calculated by summing up the production and marketing costs. Production cost includes both the fixed and variable costs. Land usually is considered as a fixed variable in short run production process and hence its rent was measured as a fixed cost while the cost incurred on all the other variables such as seed, labor, tractor, chemicals, urea and irrigation were measured as variable cost. The total production cost of rice farmers was recorded as Rs.35809.11 per acre contributing 98.237 percent to the total cost.

Table 2: *Cost incurred on rice production per acre.*

Particulars	Unit	Cost/unit (PRs)	Quantity	TC	Percentage
Tractor	Hrs.	1200	2.1	2520	6.9132
Labor	Hrs.	68.30	208	14207.89	38.977
Seed sown	Kgs.	100	5.263	526.3	1.4438
Urea	Kgs.	39	96.398	3759.52	10.313
Chemicals	Litres	803.76	2.73	2194.26	6.0197
Irrigation	No.	43.29	17	736	2.0191
Land rent	PRs.	11865.14	1	11865.14	32.550
Production cost	-	-	-	35809.11	98.237
Marketing cost	-	-	-	642.435	1.7624
Total Cost	-	-	-	36451.54	100

Source: *Author's calculation (Rice data, 2020).*

The production cost includes
Seed cost: Local seed named as "Garma" was used by all the sampled respondents in the study area. On average 5.26 kgs of rice seed was sown with the unit cost of Rs.100 and an average cost of Rs.526.3 per acre contributing 1.4438 percent to the total cost.

Tractor cost: Tractor on average was used for 2.1 hours for pre sowing land preparation. The unit cost of tractor in the study area was recorded as Rs.1200 and the average per acre tractor cost was calculated as Rs.2520 contributing 6.913 percent to the total cost.

Labor cost: Labor in the production process performed multiple tasks like seed bed preparation for raising seedlings, seed sowing, making furrows, seedling transplantation, fertilizers and chemicals' application, irrigating the farm, harvesting the crop and threshing. The unit for labor used was taken in working hours and the average hourly wage rate was recorded as Rs.68.30. The average cost incurred on labor was Rs.14207.89 sharing 38.977 percent to total cost.

Urea cost: Among the various fertilizers only urea was applied by the rice farmers to influence their rice yield, measured in kgs and the cost per unit of it was Rs.39. On average it was used as 96.398 kgs per acre and its total cost was calculated as Rs.3759.52 which is about 10.31 percent of the total cost.

Chemicals cost: Pesticides and weedicides both were introduced to the rice farm to avoid weeds and pests' attack. The sampled farmers applied 2.73 litres of chemicals on average with the unit cost of Rs.803.39. The total cost of chemicals used was Rs.2194.26 sharing 6.019 percent to the total cost.

Irrigation: Rice usually consumes more water than any other crop. Almost all the farmers used canal system to irrigate their crops and was measured in terms of times each time they irrigated the farm. On average rice field was irrigated 17 times with an average cost of Rs.43.29 per unit. The mean cost for irrigation was calculated as Rs.736 which is about 2.0 percent of the total cost.

Land rent: Depending upon the soil fertility and water availability land rent varied across the selected villages. The average land rent for rice crop was recorded as 11865.14 per acre which contributes 32.55 percent to the total cost.

Marketing cost: Marketing cost includes the cost on purchasing bags, loading and unloading, transportation and commission charges etc. The marketing cost contributed only 1.762 percent to total cost because in the study area all the farmers on average faced only the cost of Rs.642.435 on purchasing bags, as all of them sold out their product directly at their farms.

Total revenue, net revenue and profitability of rice farmers

Table 3 portrays the revenue gained from both the main and by-product, the net revenue, total cost incurred and profitability of rice growers in the study area. The average revenue gained from rice grains and by-product per acre was recorded as Rs.59580.7 and Rs.12399.32 respectively. The average gross revenue per acre was Rs. 71980.02 and the cost incurred per acre on average was recorded as Rs.36451.54. On average the rice farmers achieved the net revenue of Rs.35528.48 per acre. The calculated profitability ratio of rice growers was 0.974, enlightening that an investment of a single rupee in rice cultivation generated a profit of 0.974 rupee in the study area.

Summary statistics of variables used in production model

Table 4 presents the summary statistics of all the variables used in the estimated Cobb-Douglas type production model. The mean calculated value for yield was recorded as 1572.89 kgs with the minimum, maximum and standard deviation of 1050 kgs, 2066.667 kgs and 232.338 kgs respectively. On average tractor in the study area used for land preparation was recorded as 2.1 hours with the standard deviation of 0.267 hours, maximum of 4 and minimum of 2 hours. The average labor working hours were calculated as 142.257 with the standard deviation of 22.941 hours, ranged from 97.5 to 208 hours per acre. Urea being an important factor in rice production was used as 96.398 kgs on average with the minimum, maximum and standard deviation of 60 kgs, 166.67 kgs and 22.881 kgs respectively. The mean calculated value for chemicals used was 2.73 litres ranging from 2 to 4 litres with the standard deviation of 1.209 litres. On average rice crop in the study area was irrigated 17 times with the standard deviation of 1.86 times, ranged from 12 to 22 times.

Table 3: *Total revenue, net revenue and profitability of rice farmers (per acre).*

Particulars	Unit	Amount	Profitability
Revenue from grain	PRs.	59580.7	=*NR/TC* = 35528.48/36451.54 = 0.974
Revenue from by product	PRs.	12399.32	
Total Revenue	PRs.	71980.02	
Cost incurred	PRs.	36451.54	
Net Revenue	PRs.	35528.48	

Source: *Author's calculation (Rice data, 2020).*

Table 4: *Summary statistics of variables used in production model.*

Particulars	Unit	Maximum	Minimum	Mean	S.D
Yield	Kgs.	2066.667	1050	1572.989	232.338
Urea	Kgs.	166.667	60	96.398	22.881
Chemicals	Bottles	4	2	2.73	1.209
Tractor	Hrs.	4	2	2.1	0.267
Labor	Hrs.	208	97.5	142.257	22.941
Irrigation	No.	22	12	17	1.86

Source: *Author's calculation (Rice data, 2020).*

Diagnostic tests

After the estimation of Cobb Douglas type production model for rice growers, it was checked for several statistical problems like multicollinearity, distribution of the residuals and heteroscedasticity by performing multiple tests given below.

Multicollinearity

Variance inflation factor (VIF) and correlation matrix were used to check the problem of multicollinearity in the model. The results of both the tests revealed that the problem doesn't exist and all the regressors were independent of each other. Table 5 and 6 represent the tests' results.

Normality (Residuals' distribution)

The problem of normality was checked by histogram's construction and Jarque-Bera test. The JB p-value (0.90) revealed that the data is normal while histogram for residuals also showed the normal distribution (symmetric and bell shaped) of all the residuals about the mean as shown in the Figure 2.

Table 5: *VIF test for multicollinearity.*

Variable	VIF	1/VIF
LnUrea	1.26	0.794780
LnChemicals	1.51	0.663552
LnTractor	1.08	0.926304
LnLabor	1.42	0.703968
LnIrrigation	1.06	0.940502
Mean VIF	1.27	

Source: *Author's estimation (Rice data, 2020).*

Table 6: *Correlation matrix.*

	LnUrea	Ln Chemicals	Ln Tractor	Ln Labor	Ln Irrigation
LnUrea	1.000				
LnChemicals	0.3929	1.000			
LnTractor	-0.0706	0.1430	1.000		
LnLabor	0.3429	0.5163	0.1242	1.000	
LnIrrigation	0.1557	0.1395	-0.1551	0.1079	1.000

Source: *Author's estimation (Rice data, 2020).*

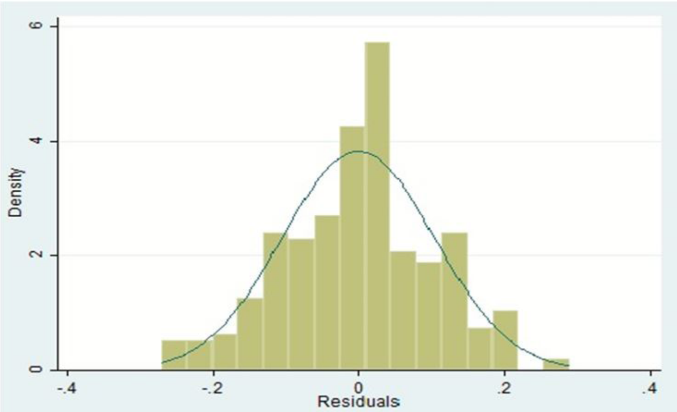

Figure 2: *Residuals' histogram.*
Source: *Author's estimation (Rice data, 2020).*

Heteroscedasticity

In order to check the problem of heteroscedasticity Breusch Pagan and white tests were performed. The Breusch Pagan test showed that data is homoscedastic but as it is less appropriate and accurate test as compared to the Halbert White's test. Therefore, white test was conducted and its chi-square value of 96.10 with the p-value of 0.000 revealed that data had a heteroscedasticity problem and hence robust estimation was used to overcome it.

Estimates of Cobb-Douglas type production function

Table 7 illustrates the results of estimated Cobb-Douglas type production model. The results showed that regressors such as labor, urea, tractor and no. of irrigation had positive and highly significant effect on the rice yield while chemicals' application had a positive but insignificant effect on the dependent variable. The coefficient of chemical fertilizer (Urea) exposed the positive and highly significant effect of 0.23% on rice productivity with a unit change in urea's application. It indicates that greater the use of chemical fertilizers like urea, the more fruitful the rice growers become and the results are supported by the findings of Osanyinlusi and Adenegan (2016) who estimated the positive and statistically significant effect of fertilizers while determining the major factors affecting rice productivity in Nigeria. The coefficient estimated for chemicals was highly insignificant and it might be due to the lowest rice weed infestation during the last year's rice cropping season. The reason for low weed and pest infestation was the lack of rainfall during the season, providing no suitable conditions to weeds and pests to attack the rice crop. Hence the rice growers didn't use the required and appropriate dose of the chemicals like pesticides and weedicides etc. and so its effect on rice productivity was insignificant. The results are in correspondence to Ayedun and Adeniyi (2019) who find out the positive and insignificant effect of chemicals on rice productivity. Rice is a deep-rooted crop and needs the land being well prepared and tilled deeply to save more moisture, so that the feeding and conical roots may infiltrate deeply into the nutritional zone and get more nutrients. That is the reason deeply tilled land is always preferred over conventional and conservative tillage in rice farming because the former situation results more yield as compared to the later one (Arora *et al*., 2018). In the current study the rice farmers did so and the estimated coefficient of tractor hours (0.04) was positive and highly significant at 5% level of significance, implying that rice yield significantly increased by 0.04% with respect to a unit change in the use of tractor and the results are in line to that of Shah *et al*. (2020) while estimating determinants of rice crop. The estimated coefficient for labor hours was highest among all the explanatory inputs and it revealed that a unit increase in labor working hours affected the rice yield positively and significantly by 0.41%. It implies that rice growers' productivity increases as the labor working hours increase because rice being a laborious crop, requires more labor's attention and time. The same positive and significant effect of labor on rice productivity was also estimated by Ogundele and Okoruwa, (2006) and Shaikh *et al.* (2016). The estimated 0.11 coefficient of irrigation showed that a unit increase in irrigating the rice farm significantly increased the rice yield by 0.11 percent. This indicates that more the rice farm is irrigated, the more productive it would be because rice is a highly water intensive crop and requires more water than any other crop. The results of the study for irrigation are supported by the findings of Jan and Naushad (2019) who observed the same positive and significant effect of irrigation on rice yield in Lower Dir, Pakistan. Summing up all the estimated coefficients of the regressed model resulted a value of 0.826, implying that rice growers in the study area were operating with decreasing or diminishing returns to scale which means that increase in the explanatory variables didn't lead even the equivalent increase in the rice yield and it might be due to the misuse of inputs or using them in an inappropriate and inadequate amount. The F-statistic with the probability value of 0.000 revealed that the overall model is highly significant while R^2 with the value of 0.61 (as quite as good in case of cross-sectional data) showed that 61 percent variation in the rice yield was explained by all the regressors included in the production model. Our estimated production function showed diminishing return to scale (DRS) of 0.826691 implies that when all inputs are doubled, output increases by less than double.

Table 7: *Estimates of Cobb-Douglas type production function (Yield as a dependent variable).*

Variables	Coefficients	S.D	t-statistics	p-value
Constant	3.870844	0.249939	15.49	0.000
LnUrea	0.231221	0.031088	7.44	0.000
LnChemicals	0.029095	0.017769	1.64	0.103
LnTractor	0.044338	0.019426	2.28	0.023
LnLabor	0.411215	0.051693	7.95	0.000
LnIrrigation	0.110822	0.051874	2.14	0.034
No. of observations	275			
F-statistics	114.37 (α = 0.000)			
R-squared	0.6140			
Return to Scale (RTS)	0.826691			

Source: *Author's estimation (Rice data, 2020).*

Conclusions and Recommendations

The findings of the study revealed that rice growers in the study area were quite profitable as they got higher net revenues on average. The estimated Cobb-Douglas type production model revealed that that regressors such as labor, urea, tractor and no. of irrigation had positive and highly significant effect on the rice yield while chemicals' application had a positive but insignificant effect on the dependent variable. The model was overall highly significant and 61 percent variation in the rice yield was explained by all the regressors included in the production model. The summation of estimated coefficients of the regressed model implied that rice growers in the study area were operating with decreasing return to scale.

Based on the findings of this endeavor farmers need to increase labor hours, application of urea fertilizer and irrigation for accelerating rice output as with a percent increase in these inputs enhanced rice productivity significantly. Decreasing return to scale (RTS) was found in the use of all inputs, therefore reallocation of these inputs is suggested and application of tractor hours and chemicals need to be rationalized.

Limitations of the study

1. Due to financial and time constraints, this endeavor was limited to district Swabi of the province.
2. As this study was limited to one district, therefore findings and recommendations need to be carefully generalized to other areas of the province.
3. This study examined only the determinants of rice yield while other aspects such as technical, allocative or economic efficiencies were not estimated.

Novelty Statement

Resources' allocation in a production process governs the productivity of any crop. This specific article endeavored to scrutinize the key determinants hastening the rice production in central Khyber Pakhtunkhwa and is supposed to assist both the present and forthcoming farming communities to boost up the production by employing the resources optimally.

Authors' Contribution

Shahid Ali: Developed main theme of the study, wrote title of the study, objectives and constructed interview schedule.
Murtaza: Reviewed literature, wrote conceptual framework, specified the model and wrote results and discussion.

Waqas Ahmad: Collected data and punched in excel sheet and helped in review of literature.
Muhammad Israr: Helped in writing abstract, conclusions and recommendations.
Aftab Khan: Helped in developing interview schedule and writing results and discussion.
Hamdullah: Compared results with the findings of other studies and discussed comparison of results.
Syed Attaullah Shah: Estimated the model and interpreted the results. All authors read and approved the final manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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