

Research Article



Identifying Key Factors for Maximizing Wheat Yield: A Case Study from Punjab (Pakistan)

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Abstract | Agriculture has a key role for the economy of Pakistan. This research is based on the input factors which has positive effect to increase the production of wheat. Variety, seed type, date of sowing, sowing mode, Urea fertilizer, DAP fertilizer, irrigation mode, numbers of irrigations and number of weedisides sprays are chosen as input factors. Descriptive statistics, multiple linear regression model and analysis of variance techniques are used which show that variety, sowing mode, nitrogen fertilizer and phosphorous fertilizer have significant effect on the wheat yield. Irrigation mode and weedisides spray also has much impact on the wheat yield.

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Keywords | Wheat yield, Input factors, Multiple linear regression model, ANOVA.

Introduction

Development of agriculture is very essential for any part of world for improvement of GDP. The association between escalating world population and food availability must be in the balance. Wheat is one of the main staple foods of the world and is the second highest production after maize with about 750 million tons produced throughout the world (FAO, 2017). It has been grown with the creation of mankind, 8000 years BC. In Holy Quran, example of wheat production is given in contest of charity as:

"مَثَلُ الَّذِينَ يُنْفِقُونَ أَمْوَالَهُمْ فِي سَبِيلِ اللَّهِ كَمَثَلِ حَبَّةٍ أَتَتْ سَنَابِلَ فِي كُلِّ سُنبُلَةٍ مِائَةٌ حَبَّةٌ وَاللَّهُ يُضْعِفُ لِمَنْ يَشَاءُ ۗ وَاللَّهُ وَاسِعٌ عَلِيمٌ"

Translation: Surah Baqarah Ayat 261.

"The likeness of those who spend their wealth in Allah's way is as the likeness of a wheat grain which groweth seven tillers, in each tiller a hundred grains. Allah giveth increase manifold to whom He will. Allah is All-Embracing, All-Knowing".

From the above example of wheat production given by Holy Quran wheat can be produced seven hundred times more than the wheat grain sown in land. If we sow one maund (40 kg) wheat grain in land we can produce seven hundred maund wheat grains. It is the target given by Allah to all of the mankind like other targets some of them are achieved and some are remaining till now. It is our faith target about wheat production will be achieved in near future.

Production of wheat has grown approximately three times more, since middle of the twentieth century and

expected to reach maximum point in the 21st century through the use of latest technologies. Historical developments have shown for the developed industrial economies are based on the progress in agriculture. From the Guinness world record the highest wheat yield is 16.791 tonnes per hectare (169.77 maund / acre) by Eric Watson in the New Zealand 17, February 2017. In Pakistan wheat yield competition by [Government of Punjab \(2014\)](#), Allah Buksh son of Muhammad Yar in Khushab district got first position by obtaining 98.78 maunds per acre wheat production.

Agriculture has a significant role in the economy of Pakistan. Agriculture and rural population is considered as the asset of national prosperity. Single largest sector of economy is agriculture, can help to achieve the ultimate objective of economic development. Pakistan is the eighth largest in the world and 3rd largest wheat producing country in the Asia ([FAO, 2017](#)). According to agriculture statistics, in 2016-17 the wheat production in Pakistan was approximately 26 million tons ([PES, 2016-17](#)), about 75% of wheat is produced by the Punjab province. The consumption requirement of Pakistan is around 23 million tons, so the remaining can possibly be exported. The contribution of Wheat in value addition to overall agriculture of Pakistan is about 23.55 percent and 4.67 percent of GDP ([PES, 2016-17](#)).

Developed countries have entered the new millennium on the wing of technology. But the third world countries are facing the problem of scarcity. Majority of the people in the third world countries depends on the agriculture. Unfortunately, these have been under stress for last decade due to lowest achievement in agricultural production as they use traditional methods of crop cultivation.

Purpose of this study is to make a renewed effort how production of wheat can be increased and may be a direction of the seven hundred maund wheat yield target assigned to the Agronomists of the world by Holy Quran. The main objective of the research is to identify the important key factors and their optimum levels for maximization of the of wheat yield. And also suggest the policy recommendations to the farmers and government and administrators for policy development.

[Larson \(1964\)](#) compared five varieties of wheat and observed the number of tillers per plant more in C-518 and Dirk than C-278, C-591, C-271. [John](#)

(1969) investigated the various factors affecting the annual aggregate wheat production in New Zealand over the fifty-year period. He concluded that shifts in proportion of different types of soil, irrigation, wheat varieties and significant technological changes directly influenced the wheat yield. He also determined that the specification of weather factor have not significantly affected the yield of wheat. [Ahmad \(1989\)](#) and [Aziz \(1989\)](#) both concluded that the irrigation has significant role in reducing the yield gap. According to Aziz fertilizer had also significant effect on the yield and narrowed yield gap among various forms of different farm size. [Torbica and Jasna \(2008\)](#) were discussing the influence of different factors on wheat proteins quality. [Carew et al. \(2009\)](#), study the relationship of different factors those are helpful to get the more production of wheat yields. They estimate mean production function and test the heteroscedasticity with a Breusch pegan Godfrey test. They found that heteroscedasticity and also confirm with goldfield quandt test and conclude that higher quality soils have found less yield variability while pesticide increase variability of yield. [Ashfaq et al. \(2009\)](#) discussed the climate situation of Pakistan where rains are not enough to irrigate wheat production requirements. They were studying to irrigate of ground surface of wheat product. One district of Punjab chooses as a sample. They were discussing some factors land holding, use of fertilizer and farming experience affecting the wheat production. They were concluded that adjusted R Square 0.59 indicate that data fit is good and F test showed that all result is significant. [Hassan et al. \(2010\)](#), conduct a study in 2006-7 at adoptive research farm of Punjab. They find out the most important factors those are affecting the production of wheat during the mixed season of cropping the various region of Punjab in Pakistan. They are conducting the study choosing the four villages of five district of Punjab those are growing wheat. For this study they were select a sample of 200 farms at randomly. Cobb Douglas production function use to assess the effect of various factors on the production of wheat yield. They were found that some factors producing higher yield such as sowing time, rotavator, education, seed rate, weedicide cost and the use of nitrogenous fertilizer of respondent farm. They were asses the production obtaining different values of the coefficients. They were study through multiple regression analysis of cob Douglas function by using ordinary least square method. They were estimate 0.55 value of multiple coefficient of determination that was indi-

cating good fit. They were suggesting that the higher education level leads towards the higher production of yield. Rao and Ketema (2016), study the effect of the yield production of wheat by using linear relationship of wheat production as dependent variable and others are independent variables. The secondary data obtained from the different offices of Ethiopia. In this study both descriptive and inferential techniques were applied. The result indicates that some factor like rain and land size effect are negative by using multiple regression analysis but other showed positive relationship. The results of these factors are significant. Abate et al. (2017) estimate impact of the use of new technologies on farmer wheat production. A sample of 490 wheat growers was chosen randomly and assign one group out of three group that are divided into full packages intervention group, marketing assistance only group and a control group. They conclude that 61% more production with use of technologies. The primary data at two stages were used, firstly when crop cutting season and secondly then crop growing season. They estimate the results by using regression analysis of different models and test the hypothesis.

Materials and Methods

Data is taken from the district Bahawalnagar as this district is producing more wheat as compared to the other district of the Pakistan for last twelve years. In 2016-17 Bahawanagar distict has first position with wheat production 1218.43tons, Rahim yar khan 953.73 tons second and Faisalabad 947.13 tons has third position in wheat production (Realised figures CRS 1990-2016). Data for the yield estimation survey 2017 was taken from the office of Assistant director (stat) Crop Reporting Service, Agricultural Department, Bahawalnagar. Almost every village of the district Bahawalnagar grow wheat crop, forty villages were selected randomly from each tehsil of district Bahawalnagar. Three fields of wheat were selected randomly from each randomly selected village, by Crop Reporting Service, Agricultural Department Punjab Lahore. Information about output factor “yield production of wheat” and input factors like variety “seed type, date of sowing, kind of sowing (spread or line sowing), Urea fertilizer, DAP fertilize, type of irrigation (canal, tubewell or rain), numbers of irrigations and numbers of widisides sprays were collected through sample survey conducted on the basis girdawri for the total cultivated area of wheat by a crop reporter in each randomly selected village.

Description of variables

Yield of the wheat from each field is observed in Kg. It is denoted by Y_i and explanatory variables expressed by X_i .

Table 1: Variable description.

Variables	Codes	Variables	Codes
X_1 = Name of Wheat variety	Bhahhar =0, Sehar= 1, Lani=2, Shafaq=3, Watan=4, Faisalabad=5, Glaxy =6, others=7	X_3 = Urea fertilizer	50 Kg =1, 100 Kg =2, 150 Kg=3
X_2 = Seed type	Home=0, certified seed=1	X_6 =DAP/Phosphorous fertilizer	50 Kg=1, 100 Kg=2
X_3 = date of sowing	Sowing from16 Dec-30dec =0, Ist Dec-15 =1, 16 Novmber-30 =2, Before November =3	X_7 = type of irrigation	Canal=0, tubwell=1, irrigated by both=2
X_4 = Sowing mode	Broad sowing =0, line sowing=1	X_8 = number of water given to the crop, X_9 = number of widisides sprays.	no spray=0 and for spray=1

To analyze the data we provide, descriptive statistics and run regression model.

In descriptive statistics we calculate mean, mode and standard deviation for each of the explanatory variables and also for the dependant variable.

Multiple linear regression analysis techniques are used to analyze the data. Linear Regression line can be written as:

$$Y_i = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9 + \epsilon_i$$

Where; Y_i is dependant variable yield of wheat, X_i 's are input factors as independent variables.

Results and Discussion

In Table 2, summary statistics for all variables are reported, which is obtained by using SPSS version 16.0. Average yield of each farmer is found to be 1608.0 kg with standard deviation 330.26kg. Most of the farmer used Faisalabad and Glaxy wheat variety and

the majority of farmers used home seed. Average date of sowing is 2 which mean 16 November to 30 November sowing date. Most of the farmer sow's wheat in Broadcast Method. Average of 2 bags of the urea fertilizer is used by the farmers 1 bag of DAP is used on average. Average of the irrigation mode is 2 which mean most of farmer used tub well as a source of water. Average number of the water given to wheat fields is four and one weed sides spray is applied to crop.

Table 2: Descriptive Statistics.

Source	Mean	Mode	Standard deviation	Minimum	Maximum
Yield	1599.0	722.10	330.260	722.10	2397.30
Wheatvariety	4.4833	6	1.96175	0	7
SEEDTYPE	0.2000	0	0.40168	0	1
Sowdate	2.3083	2	0.67108	0	5
Sowmode	0.2583	0	0.43955	0	1
Urea	1.6542	2	0.49279	0	2.50
DAP	0.9875	1	0.16478	0	1.50
Irrimode	0.9750	0	0.82465	0	2
Nowater	4.0083	4	0.98301	2	7
Noweedspray	0.8917	1	0.31210	0	1

Calculated value of Kolmogorov-Smirnov test of normality is less than p-value. We accept the hypothesis that the residual term ϵ which is calculated from observed and expected wheat yield is normally distributed.

Table 3: Testing the assumptions of Multiple Linear Regression, Tests of normality.

Kolmogorov-Smirnov		
Statistic	Df	Sig
0.062	120	0.200

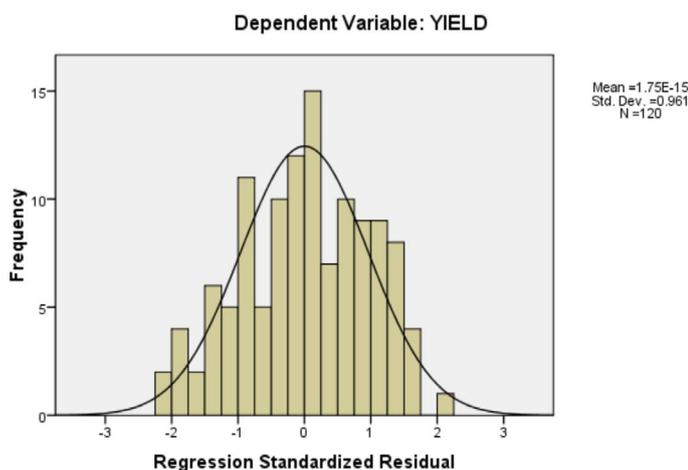


Figure 1: Histogram for regression standardized residual

The shape of the histogram approximately follows the normal curve. It accepted that histogram is close to normal curve with zero mean and constant variance.

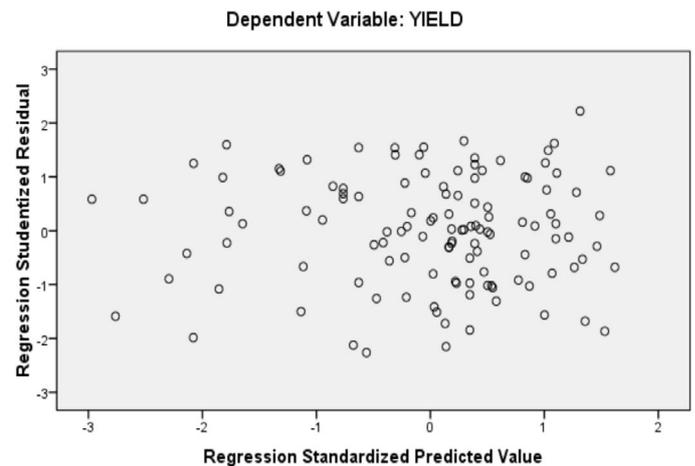


Figure 2: Scatterplot for predicted and residual values.

As it is seen from the graph of the residuals versus the predicted value (the wheat yeild) **Figure 2**, there is no systematic relationship between the residuals and fitted value. This indicates that there is no hetroscedasticity in the data. That means the error term ϵ 's are independently and identically distributed random variables having normal distribution with mean zero and constant variance δ^2 **Rao and Ketema (2016)**.

Table 4: ANOVA.

Model	Sum of Squares	Df	Mean Square	F Statistic	Sig.
Regression	4067461.940	9	451940.216	5.578	0.000
Residual	8912056.643	110	81018.697		
Total	12980000.00	119			
	R ² =0.313				

From **Table 4** we test H:

$$H_0: \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = 0$$

And $H_1: \beta_i \neq 0$ or to check the linear relationship between yield and the independent variables through analysis of variance F-calculated = 5.578 and p value =0.000 and α -value =0.05 so we accept $H_1: \beta_i \neq 0$ mean there is linear relationship between yield and independent variables. Yield of wheat is significantly increased by independent variables.

From the **Table 5** we estimate the regression coefficient of the independent variables standard error of regression coefficient and individual testing t-values

for each of the regressors X_1, X_2, \dots, X_9 . Also measures VIF a test of multicollinearity, which is less than 10 for each of the regressors. It means there is no problem of multicollinearity in the set of explanatory variables.

A parsimonious fitted model for the yield is.

$$Y_i = 315.001 + 34.161X_1 + 59.430X_2 + 32.293X_3 + 149.594X_4 + 170.840X_5 + 366.037X_6 + 35.875X_7 + 11.576X_8 + 313.787X_9$$

Table 5: Results of the Regression analysis.

Variables	B_i	S.E(B_i)	t-statistic	Sig. Value	VIF
Constant	315.001	257.055	1.225	0.223	-----
Wheat Variety	34.161	14.49	2.357	0.020	1.187
Seed Type	59.430	68.986	0.86	0.391	1.128
Sowing Date	32.293	40.657	0.794	0.429	1.093
Sowing Mode	149.594	65.044	2.300	0.023	1.201
Urea	170.840	55.384	3.085	0.003	1.094
DAP	366.037	166.946	2.193	0.030	1.112
Irrigation Mode	35.875	36.267	0.989	0.325	1.314
No. of Water	11.576	31.335	0.369	0.713	1.394
No. of Weed Spray	313.787	89.891	3.491	0.001	1.156

Wheat variety

Regression coefficient for the wheat variety is 34.161 which have positive relationship between yield and type of variety. T-ratio for wheat variety is 2.357, which has positive significant effect on the wheat yield. Sowing better variety provides one maund approximately increase in yield. Galaxy and Faisalabad wheat varieties provide more yield than the other wheat varieties.

Seed type

Coefficient for the seed type is 59.430, which has positive impact on the wheat yield. T-ratio 0.861 is also greater than p-value. This indicates that certified seed give more significant yield than the farmer used their own stored home seeds. Average wheat yield remain minimum because most of the farmers used their own stored home seeds.

Date of sowing

Slope coefficient for the date of sowing variable is 32.293 it has positive effect on the yield. T-statistics for date of sowing has also explains significant impact for increasing wheat yield. Wheat crop is sown in the month of October, November and December. Sowing

of wheat crop in the month of November produce more yield than the sowing in the month of December and other sowing dates.

Sowing mode

Sowing mode with 149.594 has large and positive marginal effect on the yield. Sowing mode has positive relationship with yield and the value of t-statistics for sowing mode has significant effect for increasing the wheat yield. This shows that line sowing give more yield than broad sowing. Most of the farmers used broad sowing method, but per acre yield of the farmers who use line sowing method was significantly high than other farmers.

Urea

Regression estimate for the fertilizer nitrogen (urea) is 170.840 and t-value for urea is 3.085 it shows highly significant effect for increasing the wheat yield. Nitrogen is a key factor for increasing the yield but some farmers use only 50 kg, most of them use 100 kg and some farmers use 150 kg. Wheat yield is extensively increased by using 50 kg more level of urea fertilizer.

DAP

Fertilizer Phosphorous (DAP) has regression coefficient 366.037, its value of t-statistics is 2.193 which shows much positive and significant effect on the yield, it mean wheat yield increased by using 50 kg additional amount of DAP for the wheat crop. DAP fertilizer is also important key factor wheat yield is significantly increased by using one more level of DAP fertilizer, most of the farmers used 50 kg and some use 100 kg as level of DAP.

Irrigation mode

Regression coefficient for the irrigation mode is 35.875, which shows positive relationship between yield and irrigation mode. T-statistics for the irrigation mode is also positive and significant effect for increasing the yield of wheat. Farmers use canal, tube well and both canal and tube well three type of irrigation mode. Wheat produce the more yield with crop irrigated by both sources canal and tube well.

Number of water

Marginal effect of the number of the water is 11.576. This has positive relationship between yield and number of water. Water is main key factor for maximizing the yield of wheat. Wheat yield increase by a suitable number of water, three or four numbers of irrigation

are suitable for wheat crop. Most of the farmers in this study use four number of water to irrigate their crop, for this reason marginal effect for the number water is not high.

Number of weediside spray

Regression coefficient for weediside spray is 313.787; it shows that weediside spray has much positive impact on yield. Value of t-ratio is 3.491 also explain that weediside spray has much positive and significant effect for increasing wheat yield. Wheat yield increased by eradicating weeds growing in the wheat crop, so it is necessary to control weeds growing in the crop by applying weedisides spray.

Conclusions and Recommendations

In this study all the independent variables chosen have positive impact on the yield of wheat. Most of the farmer used variety Faisalabad and Glaxy which increase the more wheat yield than the other varieties. Certified seed also increased the yield than the home stored seed grown by the farmers. Sowing of wheat crop in the month of November give more yield than the sowing in the month of December and October. Line sowing method increase yields more than broadcast method of sowing. Fertilizer nitrogen (urea) phosphorus (DAP) both increase yield much significantly. These two fertilizers are main the factors for maximizing wheat yield. Crop irrigated by both canal and tube well give more yield than other irrigation methods, three or four irrigations were applied. One weediside spray applied to crop give maximum yield than no weediside spray applied to the wheat crop. From this study farmers are proposed to use best type certified seed and complete sowing their crop in the month of November. They adopt line sowing method and use 100 kg amount of both phosphorus and nitrogen fertilizer. One weediside spray and four numbers of irrigations are suggested to get maximum yield. Governments are suggested to pay special intention to provide best kind of varieties, fertilizers, sprays, canal water and loan to the farmers, and also make awareness to the farmers about the input factors and their suitable level to maximize the wheat yield. Agricultural scientists are requested to make team work to tackle unfavorable and favorable nutrients for the crop present in land and make favorable environment like rain and suitable temperature. Also, scientists work to decide suitable level of input factors to achieve the maximum yield of wheat targeted by

Holy Quran.

Author's Contribution

Qaisar Mehmood: Idea, data collection, methodology, SPSS analysis, abstract, conclusion and overall management of the article.

Muhammad Riaz: Helped in writing introduction and literature review

Dr. Maqbol, H. Sail: Helped in discussion of the Results and guidance.

Dr. Muhammad Moeen: Helped in discussion of the Results and guidance

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