Proceedings of the Pakistan Academy of Sciences: A: Physical and Computational Sciences 57 (4): 99-112 (2020)

ISSN: 2518-4245 (print), 2518-4253 (online)

Pakistan Academy of Sciences

Research Article

Analysis of Factors Affecting Yield of Agricultural Crops in Bahawalpur District

Muhammad Akbar Ali Shah[1], Muhammad Mohsin[2*], Christophe Chesneau[3], Asma Zulfiqar[4], Farrukh Jamal[5], Kashif Nadeem[6], and Rehan Ahmed Khan Sherwani[7]

[1,5,6]Department of Statistics, The Islamia University of Bahawalpur, Bahawalpur, Pakistan
[2]Department of Geography, Govt. Sadiq Egerton Graduate College, Bahawalpur, Pakistan
[3]LMNO, University of Caen-Normandie, 14032 Caen, France
[4]Department of Botany, University of the Punjab, Lahore, Pakistan
[7]College of Statistical and Actuarial Sciences, University of the Punjab, Lahore, Pakistan

Abstract: The main objective of this paper is to analyze and investigate the factors/variables which are affecting the yield/acre of the major crops in the district of Bahawalpur. Secondary data of crops is obtained from the Crop Reporting Service (CRS), Agriculture Department, Government of the Punjab for the period 2008-2016. Multiple Linear Regression (MLRM) models are utilized to check the effects of 12 independent variables (regressors) on the production of major crops. The findings revealed that factors such as the plough and rotavator number, planking, irrigation, seed type, seed treatment, DAP and urea fertilizer, farmyard manure, latest varieties, certified seed, weed spray, diseases and pests' sprays are found to be contributing factors to a higher yield of all crops, whereas soil type (kalrathi), excessive seed rate, home seed, weeds, diseases, and pests' attack are found to be foes. Except for the factors (fresh and ratoon, seed type) sugarcane, (seed treatment, seed quantity; diseases attack), rice, and (other fertilizer and amount of watering) cotton, all the factors were found to be statistically significant. Descriptive analysis revealed that 60-70% of farmers used less and unbalanced quantities of inputs, which are the main cause of lower yield/acre of all crops in the study area.

Keywords: Major Crops, Factors, Multiple Regression Model, Yield, Bahawalpur.

1. INTRODUCTION

Agriculture is the lifeline and an essential element of the economy of Pakistan. It supplies raw materials to many industries, which help reduce poverty. The agriculture sector, though, is a backward sector of the country's economy, yet it engages 38.5% of the total country's workforce and contributes 18.5% of GDP. In Pakistani agriculture, the major crops have a definite share of over 21.90% after livestock [1]. Both food and cash crops are included in Pakistani agriculture. I.e., the leading food crops are wheat and rice, while cotton, sugarcane, and maize are the important cash crops. These are the source of provision of raw materials to many agro-based and allied industries. There is a positive and significant impact of the agriculture sector on the economic development of Pakistan [2, 3]. Worldwide, many studies have been undertaken to find out the significant factors affecting the yield of various agricultural crops. Among these, seed, fertilizer, farm size and age are the influential variables that increase the production of crops [4]. It is found that the sowing time affected the wheat yield and yield parameters significantly. Moreover, high temperatures are not suitable for the growth of the wheat crop [5]. A study was conducted in South Tongu District of Volta Region, Ghana to explore the factors of low sugarcane production. The factors which caused the decline in output and earning of the farmers in the study area were high cost of production, inadequate land preparation,

Received: July 2020; Accepted: December 2020
*Corresponding Author: Muhammad Mohsin < mohsinshahzad10@yahoo.com >

customary/premature methods of farming, and inadequate information about getting good production [6]. To explore the factors which affect the production of agricultural crops, the regression model has been used for statistical analysis to check the effect of the influencing factors on farm and crop output. The variables such as fertilizers, improved seed, irrigation, crop rotation and size of land holding were empirically determinant variables that influenced the production of crops and income of farms positively [7]. A study was conducted in south western Kenya to analyze the effect of fertilizers like phosphate and manure on maize yield. The results revealed that the application of phosphate fertilizers and manure is vital to boosting the production of maize [8]. A simple linear regression was used to examine the impact of time on rice production in Jammu and Kashmir. The result was significant and the null hypothesis was rejected at a high level of significance (5%) which showed that the production of rice depends on time [9]. There is quite an association between crop production and climatic factors. It is found in a statistical analysis that fertilizers, irrigation, seed quality and pesticides, etc., significantly affect crop production [10]. The productivity of crops is highly determined by essential factors like education, research, canal irrigation and extension, rainfall and proper fertilizer use [11]. In a study to find the growth rates of paddy crops in different districts of Chhattisgarh in India, linear and logarithmic regression models were found best fitted for estimating the yield of paddy crops. The results showed an overall increasing trend in the yield of paddy crops [12]. A study was carried out to predict the area of major crops, output, yield and food availability per person through the ARIMA model using the time series data of 67 years (1947-48 to 2013-14). The findings revealed the raising trends of the area of major crops, output, and yield except for the sugarcane crop. Sugarcane yield fell during the predicted period due to less use of available resources in the crop. The per capita predicted availability of food would be wheat from 138.2 kg to 185 kg, rice from 36.2 kg to 50.8 kg and maize from 26.8 kg to 43.5 kg for an increasing population [13]. Similarly, using time series data of 25 years, a study was conducted to forecast the yields of cash crops in Pakistan. Results show that crop production will grow if farm mechanization, efficient use of irrigation, agriculture credits, better harvesting services may be provided to farmers and this ultimately increases the yield per acre as well [14]. A study was conducted in Baluchistan province (Pakistan) to investigate the factors influencing the wheat yield. The findings revealed that less rain and water shortage, high price of chemical fertilizers and less quantity use of phosphor fertilizer/acre and non-availability of high yielding wheat varieties were the main responsible factors for the reduction in the production of wheat [15]. A study was conducted in Tehsil Melsi and Tehsil Daska in order to examine the factors that affect the sunflower crop. According to the statistical analysis, fertilizers, seed rate, land preparation, irrigation, and drilling sowing have a positive effect on sunflower yield, whereas higher seed rate and pest attack have a negative impact [16]. The huge gap between the obtained and real production in Pakistan, due to many factors like a lack of new technologies, inappropriate use of crop inputs, absence or shortage of water and insufficient awareness about diseases, pests and insect control [17]. In an investigation of the impact of weighted rainfall on the production of wheat in the Province of Punjab, Pakistan, it was found that as the rainfall increased in the important months of Rabi season, the average wheat yields also increased while excess rainfall caused a decline in yield. The study supported the use of weighted rainfall instead of total rainfall in the Rabi season [18]. In light of the study results, the main factors affecting the production of wheat are affected by time of cropping, labor, rainfall amount and cropping period [19].

As per the census 2017, the population of Pakistan was 207.7 million with an average 2.4% growth rate per annum over the period of 1998-2017 (19 years) while the agriculture growth rate is 3.46% [20]. In Pakistan, the population is increasing over the years and production of major crops is also increasing, but the increase in yield/acre of all crops like sugarcane, rice, wheat and cotton is comparatively low to meet the requirements of the rapidly increasing population. The yield/acre is also low as compared to other sugarcane, rice, wheat and cotton growing countries. So there is a need to investigate the reasons for low yield/acre and the government must take necessary/essential steps to increase the production in the country. Therefore, the major objective of the current study was to explore the factors which are affecting the yield per acre of major crops in the district of Bahawalpur.

2. MATERIALS AND METHODS

2.1 Study Area

The district of Bahawalpur is surrounded by Lodhran district in the north, Bahawalnagar district and India in the east, India in the south and Rahim Yar Khan and Muzzafargarh districts in the west. The total geographical area of the district is 24,830 km2. The total cultivated area of Bahawalpur district is 920,000 acres. The major crops of the district are cotton, wheat, rice and sugarcane. The cotton crop was cultivated on 598,000 acres; sugarcane was cultivated on 63,000 acres, rice on 36,000 acres and wheat was cultivated on 742,000 acres in 2016-17 [21, 22]. The weather in the summer and winter is extreme and the average temperature in summer is 40°C and 22°C in winter. Rainfall is very scarce and the average is 20-25mm annually. The main source of irrigation for crops is canal water.

2.2 Data Collection

Secondary data of sugarcane, rice, wheat and cotton is obtained from the Crop Reporting Service (CRS), Agriculture Department, Government of the Punjab, Pakistan for the period 2008-2016 (9 years). About 839 data values of sugarcane, 551 data values of rice, 1,023 data values of wheat and 788 data values of cotton have been used for each variable for this research work. The Crop Reporting service is the largest statistical organization and collects the data of all miners and major crops regarding acreage, yield, harvest price and cost of production. In Bahawalpur, the work was done in 38 sample villages and the data was collected from all major crops for yield estimation.

2.3 Data Analysis

The data are analyzed through a statistical package for social sciences (SPSS) 16 software. Multiple regression analysis, f-test, t-test were used to recognize the factors that influence the yield/acre of the said crops.

2.4 Model Selection

2.4.1 Multiple Regression Model

As the response variables are continuous, i.e., quantity of crops yield, multiple regression models were used to observe the effects of all factors that are affecting the yield/acre of all crops. The variables for this study are:

Regress and (response) variables:
Yield of sugarcane, rice, wheat and cotton crops (Yi) in Mds/acre.
Exogenous variables:
No. of plough and rotavator (land preparation)
Seed type, Dummy variables, 0= Home seed, 1= certified seed.
Soil Type, Dummy variable, 0= *Kalrathi*, 1= *Chikni mera.*
DAP and Urea fertilizers are used in kg/acre
Other fertilizer Farmyard manure, Dummy variables, 0= no use of farmyard manure (FYM/Ghbor), 1= use of farmyard manure (FYM/Ghbor).
No. of watering (irrigation)
Pesticides, Dummy variables, 0= no use of pesticides, 1= use of pesticide.
Seed quantity
Weeds spray (only for wheat), Dummy variables, 0= no use of weeds spray, 1= use of weeds spray
Fresh and Ratoon crop (only for sugarcane), Dummy variables, 0= Ratoon crop, 1= Fresh crop.
Seed treatment (seed poisoning before sowing), Dummy variables, 0= no seed treatment, 1= seed treatment.
Cotton varieties (only for cotton crop), Dummy variables, 0= BT-Cotton, 1= Non-BT cotton.
Diseases attack, Dummy variables, 0= no diseases attack, 1= diseases attack.
The following multiple regression models are suggested for statistical analysis of crops:
Multiple regression model for sugarcane crop is as follows:

$$Yi = \beta_o + \beta_1 PAR + \beta_2 ST + \beta_3 SOT + \beta_4 DAPF + \beta_5 UF + \beta_6 OMF + \beta_7 NW + \beta_8 PS + \beta_9 SQ + \beta_{10} SDT + \beta_{11} DAT + \beta_{12} RF + U_i$$

Multiple regression model for rice crop is as follows:

$$Yi = \beta_o + \beta_1 PAR + \beta_2 ST + \beta_3 SOT + \beta_4 DAPF + \beta_5 UF + \beta_6 OMF + \beta_7 NW + \beta_8 WS + \beta_9 SQ + \beta_{10} SDT + \beta_{11} NOP + U_i$$

Multiple regression model for wheat crop is as follows:

$$Yi = \beta_o + \beta_1 PAR + \beta_2 ST + \beta_3 SOT + \beta_4 DAPF + \beta_5 UF + \beta_6 OMF + \beta_7 NW + \beta_8 WS + \beta_9 SQ + \beta_{10} SDT + \beta_{11} NOP + U_i$$

Multiple regression model for cotton crop is following:

$$Yi = \beta_o + \beta_1 PAR + \beta_2 ST + \beta_3 SOT + \beta_4 DAPF + \beta_5 UF + \beta_6 OMF + \beta_7 NW + \beta_8 PS + \beta_9 SQ + \beta_{10} SDT + \beta_{11}\, DAT + \beta_{12}\, CTV + U_i$$

Where βo is the intercept and β_1, β_2, $\beta_3 \ldots \beta_{12}$ are the coefficients of the explanatory variables in all the above mentioned multiple regression models.
Where:
Yi= Mean yield/acre in Mds of sugarcane, rice, wheat and cotton.
PAR= Plough and Rotavator
ST= Seed type
SOT= Soil type
DAPF= DAP fertilizer used in kg/acre.
UF = Urea fertilizer used in kg/acre.
OFM= Other fertilizer Farmyard manure used.
NW= No. of water used/acre.
PS= Pesticides spray used/acre.
WS= Weeds spray (only for wheat crop).
SQ= Seed quantity used/acre.
RF= Ratoon and fresh crop (only for sugarcane).
SDT= Seed treatment.
DAT= Diseases attack (only for sugarcane, rice and cotton).
NOP= Planking (only for wheat).
CTV= Cotton varieties (BT and Non-BT).

To check the overall significance of the models, the significance of the multiple regression coefficients and drawing inferences, statistical testing techniques are used.
F-test: It is used for testing the general significance of the model and defines as:

F=(SSReg/k-1)/(SSRes/n-k)

Where "n" is the number of observations and "k" is the number of independent variables.
t-test: It is used for testing the individual parameters and is defines as:

$$t = \frac{\hat{\beta} - \beta}{S.E(\hat{\beta})}$$

Coefficient of determination (R^2):- It is used to check the amount of variation explained by the model under study:

$$R^2 = \frac{\sum(\hat{y} - \bar{y})^2}{\sum(y - \bar{y})^2}$$

And

$$R^2_{adj} = 1 - (1 - R^2)\left(\frac{n-1}{n-k}\right)$$

"$\boldsymbol{R^2}$" is the amount of variation in the regression model while "1-($\boldsymbol{R^2}$)" is the amount of unexplained variation in the model usually called error or residuals variation.

The role of coefficient of determination $\boldsymbol{R^2}$ is key for model-building because of two contending models. These models have the equal mean square error (MSE) and the model that has bigger R^2 value is chosen over others because it allows more variation in the dependent variable because of the regressors under observation [23].

3. RESULTS AND DISCUSSION

3.1 Overall Significance of Multiple Linear Regression Models for Sugarcane, Rice, Wheat and Cotton Crop

Table 1 shows the fitted models of sugarcane, rice, wheat and cotton. The values of ***R*** =0.911, 0.677, 0.583 and 0.706 respectively show that there is a strong association between an independent variable and explanatory variables for all crops. The value of $\boldsymbol{R^2}$=0.831, 0.458, 0.340 and 0.498 which indicate that 83.3% variations in sugarcane production, 45.5% variations in rice production, 58.3% variation in wheat production and 49.8% variation in cotton production are explained by the explanatory variables of the respective model. The mean square error (MSE) of the sugarcane, rice, wheat and cotton models are 5861.96, 74.309, 61.826 and 33.468, respectively, are statistically significant. The value of the Durbin-Watson test is less than 2 in the multiple regression fitted models for all crops, indicating that there is no autocorrelation in the model because the value of the Durbin-Watson test is around 2, indicating that there is no autocorrelation in the data. Thus, the model summary indicates the strength of the relationship between the model and the independent variables.

3.2 Analysis and Interpretation for the Multiple Regression Coefficients of Sugarcane, Rice, Wheat and Cotton Crop Models

3.2.1 No. of Plough and Rotavator (Land Preparation) β_1

Table 2 shows that in the fitted model of sugarcane, the value of no. of plough and rotavator β1=43.011 is statistically significant, indicating that increasing the number of ploughs and rotavator results in an increase in sugarcane yield of up to 43.011 Mds/acre and the factor plough and rotavator affecting sugarcane production positively. Table 3 shows that in the fitted rice model, the value of no. of plough and rotavator β1=3.242 is statistically significant, indicating that increasing the number of ploughs and rotavator results in an increase in rice yield of up to 3.242 Mds/acre and the factor number of plough and rotavator affecting rice production positively. Table 4 shows in the fitted model of wheat the value of no. of plough and rotavator β1=1.060 which is statistically significant. This means that increasing the number of ploughs and rotavators results in a yield increase of up to 1.060 Mds/acre, with the number of ploughs and rotavator positively affecting wheat production. Table 5 shows in the fitted model of cotton the value of no. of plough and rotavator β1= 0.787 which is significant. That indicates increasing the number of ploughs and rotavator results in the yield increasing up to 0.787 Mds/acre and the number of ploughs and rotavator affecting the production of cotton positively. Hassan et al. [24] conducted a study on various factors affecting wheat crop yield in the mixed cropping zone of the province of Punjab from five villages of Toba Tek Sing, Faisalabad, Jhang, and Sargodha, including seed rate, time of sowing, fertilizers, watering, and education. The effects of factors were investigated through multiple regression analysis. Many factors are found to positively contribute towards higher wheat production. The effects of education, seed

Table 1. Model summary for crops

Model	Sum of squares	d.f	MSE	F	Sig.	R	R Square	Adj. R square	Durbin - Watson
Sugarcane Crop									
Regression	23739134	12	1978261	337.474	.000	.911	.831	.828	1.713
Residual	4841980	826	5861.961						
Total	28581114	838							
Rice Crop									
Regression	35750.598	11	3250.054	43.737	.000	.677	.458	.448	1.439
Residual	42281.602	569	74.309						
Total	78032.200	580							
Wheat Crop									
Regression	32133.587	11	2921.235	47.249	.000	.583	.340	.332	1.791
Residual	62506.170	1011	61.826						
Total	94639.756	1022							
Cotton Crop									
Regression	25779.582	12	2148.298	64.189	.000	.706	.498	.491	1.637
Residual	25937.838	775	33.468						
Total	51717.420	787							

rate, rotavator use, weedicide cost and use of nitrogenous fertilizer were highly significant.

3.2.2 Seed Type (Home Based or Certified Seed) β_2

There are two types; the first is home based and the second is the certified seed. Dummy variable 0 is used for home seed and 1 for certified seed.

Table 2 shows the coefficient value of seed type β_2=20.912 which is statistically insignificant. It means that the changes in yield of sugarcane (response variable) are not associated with seed type factor (explanatory variable) and the sample is silent regarding seed factor variable.

Table 3 shows the coefficient value of seed type β_2=4.420 which is statistically significant and indicates that the use of certified seed results in an increase in rice yield of up to 4.420 Mds/acre and the factor certified seed positively affecting rice yield/acre.

Table 4 shows the coefficient value of seed type β_2=5.372, which is statistically significant and indicates that increasing the use of certified seed results in an increase in wheat yield of up to 5.372 Mds/acre and that certified seed has a positive effect on wheat yield/acre. Iqbal et al. [25] identified the factors affecting the production of wheat in the study area of Peshawar, Pakistan. Farmers who utilized certified seed grew 127.41 kg surplus yield as compared to the farmers who did not use certified seed. Table 5 shows the coefficient value of seed type β_2=3.712, which is statistically significant and indicates that the use of certified seed results in an increase in cotton yield of up to 3.712 Mds/acre and the factor certified seed positively affecting cotton yield/acre.

It is recommended that the seed crop be pest and disease free, erect and healthy for good germination and crop growth [26]. Use of certified seed is not more than 30% in most agricultural countries [18]. The factors influencing cotton output are being investigated. Results revealed that fertilizer, seed and watering (irrigation) were scant commodities for all categories of farmers [27]. There is a deep need to manage and trust the availability of basic inputs by both private and public quarters as the inputs are the main requirements for the cotton crop.

3.3.3 Soil Type (β_3)

There are two types of soil, chikni mera (clay soil) and kalrathi (saline patches) in which sugarcane is sown in the study area. Dummy variable 0 is used for chikni mera soil and 1 for kalrathi soil.

Table 2 shows in the fitted model of sugarcane the coefficient value of soil type β_3= -39.004 which is statistically significant and indicates that kalrathi soil is expected to decrease the sugarcane production up to 39.004 Mds/acre and the factor kalrathi soil affecting the sugarcane yield in the study area negatively.

Table 3 shows in the fitted model of rice the coefficient value of soil type β_3= -7.930 which is statistically significant and indicates that kalrathi soil decreases the rice production up to 7.930 Mds/acre and the factor kalrathi soil affects the rice yield negatively.

Table 4 shows in the fitted model of wheat the coefficient value of soil type β3= -10.835 which is statistically significant, indicating kalrathi soil decreases wheat production up to 10.835 Mds/acre in the study area.

Table 5 shows in the fitted model of cotton the coefficient value of soil type β_3= -4.341 which is statistically significant and indicates that kalrathi soil decreases cotton production up to 4.341 Mds/acre and the factor kalrathi soil affecting the cotton yield negatively.

Cofas et al. [10] studied that the production potential of major crops, i.e., wheat, corn, sunflower, sugar beet etc could be increased by improving floodplain soils affected by excess moisture, erosion, salinization or compensation.

3.3.4 DAP Fertilizer (β4)

Table 2 shows that in the fitted model of sugarcane, the coefficient value of DAP fertilizer β_4=1.124 is statistically significant and indicates that increasing 1 kg of DAP fertilizer results in an increase in sugarcane yield of up to 1.124 Mds/acre and the factor DAP fertilizer affecting the yield positively.

Table 3 shows that in the fitted rice model, the coefficient value of DAP fertilizer β4=0.083 is statistically significant and indicates that increasing 1 kg use of DAP fertilizer results in an increase in rice yield of up to 0.083 Mds/acre and the factor DAP fertilizer affecting rice crop yield positively.

Table 4 illustrates in the fitted model of wheat the coefficient value of DAP fertilizer β_4= 0.116, which is statistically significant. It means that increasing the use of DAP fertilizer by 1 kg results in an increase in wheat yield of up to 0.116 Mds/acre, and the factor DAP fertilizer has a positive effect on wheat yield.

Table 5 shows that in the fitted cotton model, the coefficient value of DAP fertilizer β_4=0.137 is statistically significant and indicates that 1 kg increase in the use of DAP fertilizer results in an increase in cotton yield of up to 0.137 Mds/acre and the factor DAP fertilizer affects cotton yield positively.

3.3.5 Urea Fertilizer (β_5)

Table 2 shows in the fitted model of sugarcane the coefficient value of Urea fertilizer β5=0.226 which is statistically significant. This means that increasing 1 kg of urea fertilizer use results in an increase in sugarcane yield of up to 0.226 Mds/acre, and the factor urea fertilizer has a positive effect on sugarcane crop yield.

Nazir et al. [28] investigated the factors that influenced the sugarcane yield. The results revealed that the cost of inputs of sugarcane such as DAP, Urea, FYM, seed, land preparation, weed spray and watering cost were the important factors that affected the output return of sugarcane cultivators.

Table 3 shows that the coefficient value of Urea fertilizer β_5=0.052 in the fitted rice model is statistically significant, implying that increasing 1 kg use of urea fertilizer results in an increase in rice yield of up to 0.052 Mds/acre and the factor urea fertilizer affecting rice yield positively.

Table 4 shows in the fitted model of wheat the coefficient value of Urea fertilizer β_5=0.024 which is statistically significant. It implies that increasing 1 kg of urea fertilizer use results in an increase in wheat yield of up to 0.024 Mds/acre, with the urea fertilizer factor positively affects wheat yield.

Table 5 shows that in the fitted model of rice, the coefficient value of Urea fertilizer β_5=0.016 is statistically significant, implying that increasing 1 kg use of urea fertilizer results in an increase in cotton yield of up to 0.016 Mds/acre and the factor urea fertilizer affects cotton yield positively.

Shah et al. [29] investigated the factors affecting rice production in the district of Lodhran, Punjab, by applying multiple linear regression (MLR), Durbin-Watson test. They found the three most important factors affecting yield/acre were DAP fertilizer, Urea fertilizer and disease attack. Mohsin et al. [30] conducted a study in district Bahawalpur on kitchen gardening and also certified that by the use of fertilizers (Urea, DAP, Potash, Manure), over 85% of cultivators gained enhanced production of different vegetables with p-value (.000) of chi-square which was highly significant.

3.3.6 Other Fertilizer (Farm Yard Manure/ Ghober)β_6

There are two types of farmers. The first use farmyard manure and the second is not used. Dummy variable 0 is used for those farmers who do not use farmyard manure (FYM) and 1 for those who use FYM.

Table 2 shows in the fitted model of sugarcane the coefficient value of FYM β_6=25.401 which is statistically significant and indicates that use of farmyard manure in sugarcane crops increases the production up to 25.40 Mds/acre and the FYM factor affects the yield of sugarcane positively.

It is found that input cost of sugarcane like as Urea, DAP, FYM, land preparation significantly influences the production of sugarcane and determinant factors of sugarcane productivity [6, 31].

Table 3 shows in the fitted model of rice the coefficient value of FYM β_6=4.364, which is statistically significant and indicates that use of farmyard manure in rice crops increases the production up to 4.364 Mds/acre and the factor of farmyard manure affects the yield of rice positively.

Table 4 shows in the fitted model of wheat the coefficient value of FYM β_6= 2.571, which is statistically significant. It is indicated that the use of farmyard manure in wheat crop increases the production up to 2.571Mds/acre and the farmyard manure affects the yield of wheat positively.

Table 5 shows in the fitted model of cotton the coefficient value of FYM β_6= 0.84 in the fitted model of cotton, which is statistically insignificant and indicates that the change in cotton yield (response variable) is not associated with the change in farmyard manure (FYM) factor (explanatory variable).

3.3.7 No. of Watering (Irrigation) β_7

Table 2 shows that the coefficient value of no. of watering β_7=24.407 in the fitted sugarcane model is statistically significant and indicates that increasing one amount of watering results in the expected sugarcane yield increasing up to 24.407 Mds/acre and the factor amount of water affecting the sugarcane yield positively.

Table 3 shows that in the fitted rice model, the coefficient value of no. of watering β_7=0.843 is statistically significant and indicates that increasing one amount of water results in an increase in rice yield of up to 0.843Mds/acre and that the factor amount of water affects rice yield positively.

Table 4 shows in the fitted model of wheat the coefficient value of no. of watering β_7=1.733 in the fitted wheat model is statistically significant and indicates that increasing one irrigation at the right time results in an increase in wheat yield of up to 1.733 Mds/acre and the factor number of watering affecting wheat yield positively. Ashfaq et al. [32] examined the effect of groundwater on the production of wheat in Jhang district. It is evident that the use of sub-standard ground water could reduce wheat production if used without proper precautions.

Table 5 shows in the fitted model of cotton the coefficient value of no. of watering β_7=0.257 which is statistically insignificant and indicates that the change in cotton yield is not associated with the change in the number of water factors (explanatory variable).

Shah et al. [33] studied the variability of different crops in Bahawalpur district by using Two Stage Systematic sampling. The results revealed that the lowest mustered production was due to unsuitable climatic factors and irregularity in irrigation, and the main cause of low sunflower crop productivity was the use of low quality seeds. The results also showed that the main cause of variation in rice yield were government policies.

3.3.8 Spray (Pesticides) β_8

In the model, dummy variable 0 is used for the use of spray and 1 for the use of spray.

Table 2 shows that in the fitted sugarcane model, the coefficient value of Spray (pesticides) β_8=53.733 is statistically significant and indicates that spraying pesticides on sugarcane crops increases production up to 53.733 Mds/acre and that the factor pesticide spray affects sugarcane yield positively.

Table 3 shows that the coefficient value of Spray (pesticides) β8=4.762 in the fitted rice model is statistically significant and indicates that the use of pesticide spray on rice crops increases production up to 4.762 Mds/acre and that the factor pesticides spray against pests and diseases affects rice yield positively.

Table 5 shows in the fitted model of cotton the coefficient value of Spray (pesticides) β_8=2.443 which is statistically significant and indicates that the use of pesticide spray on cotton crops increases cotton production up to 2.639 Mds/acre and the factor spray affects the yield of cotton positively.

Othman et al. [34] examined the important factors affecting the wheat output in the new land in Egypt. The decline in production was caused by some problems that farmers faced, such as irrigation problems and a lack of access to water for their land for 21.4% of the sample farmers, fertilizer and seed purity problems for 15.52% of the farmers, crop disease problems for 12.07% of the farmers, and high labor costs for 6.9% of the farmers.

3.3.9 Spray (weeds) β_8

In the wheat model, dummy variables 0 and 1 represent no use of weed spray and use of weed

Table 2. Results of regression model for sugarcane crop

Model (MLR) Variables	Coefficient(β)	Std. error	T	Sig.	Tolerance	VIF
Constant	-14.783	4.27	-4.995	.000	----	----
β1 No. of plough & rotavator	43.011	4.715	9.123	.000	0.489	2.047
β2 Seed type (Home or certified)	20.912	13.328	1.569	.117	0.887	1.127
β3 Soil type	-39.004	11.159	-3.535	.000	0.785	1.274
β4 DAP fertilizer	1.124	.101	11.104	.000	0.629	1.591
β5 Urea fertilizer	0.226	.070	3.213	.001	0.903	1.107
β6 Other fertilizer (Manure)	25.401	10.946	2.321	.002	0.968	1.033
β7 No. of watering	24.407	1.853	13.174	.000	0.364	2.748
β8 Spray (pesticides)	53.733	8.816	6.095	.000	0.470	2.126
β9 Seed quantity	0.286	0.031	9.140	.000	0.378	2.647
β10 Seed treatment	56.051	16.083	3.485	.001	0.934	1.070
β11 Diseases attack	-32.198	8.119	-3.966	.000	0.890	1.124
β12 Fresh or Ratoon	8.004	5.422	1.476	.140	0.951	1.052

Table 3. Results of regression model for rice crop

Model (MLR) Variables	Coefficient(β)	Std. Error	T	Sig.	Tolerance	VIF
Constant	-2.227	3.144	-.708	.479	----	-----
β1 No. of plough & rotavator	3.242	.436	7.436	.000	.771	1.296
β2 Seed type (Home or certified)	4.420	1.072	4.125	.000	.919	1.089
β3 Soil type	-7.930	1.507	-5.263	.000	.900	1.111
β4 DAP fertilizer	.083	.017	4.741	.000	.857	1.167
β5 Urea fertilizer	0.052	.013	3.849	.001	.910	1.099
β6 Other fertilizer (Manure)	4.364	1.055	4.136	.000	.911	1.098
β7 No. of watering	0.843	.137	7.436	.000	.771	1.296
β8 Spray (pesticides)	4.762	.861	5.532	.000	.697	1.434
β9 Seed quantity	-0.110	0.244	-.450	.653	.843	1.186
β10 Seed treatment	1.164	1.356	.859	.391	.869	1.150
β11 Diseases attack	-0.788	0.840	-0.937	.349	.724	1.381

Table 4. Results of regression model for wheat crop

Model (MLR) Variables	Coefficient(β)	Std. Error	T	Sig.	Tolerance	VIF
Constant	13.820	2.856	4.839	.000	-----	-----
β1 No. of plough & rotavator	1.060	.304	3.481	.001	.771	1.296
β2 Seed type(Home or certified)	5.372	.794	6.767	.000	.947	1.056
β3 Soil type	-10.835	1.085	-9.984	.000	.960	1.042
β4 DAP fertilizer	.116	.014	8.317	.000	.923	1.083
β5 Urea fertilizer	0.024	.008	2.841	.005	.884	1.131
β6 Other fertilizer (Manure)	2.571	.775	3.317	.001	.971	1.030
β7 No. of watering	1.733	.319	5.437	.000	.891	1.122
β8 Spray (weeds)	2.486	.520	4.780	.000	.914	1.094
β9 Seed quantity	-0.078	0.039	-1.998	.046	.898	1.113
β10 Seed treatment	2.453	1.113	2.205	.028	.960	1.042
β11 Planking	3.638	0.848	4.290	.000	.920	1.086

Model (MLR) Variables	Coefficient(β)	Std. Error	T	Sig.	Tolerance	VIF
Constant	4.517	2.226	2.030	0.043	------	-----
β1 No. of plough & rotavator	0.787	.239	3.287	0.001	0.813	1.230
β2 Seed type (Home or certified)	3.712	.723	5.136	0.000	0.933	1.072
β3 Soil type	-4.341	1.027	-4.302	0.000	0.949	1.054
β4 DAP fertilizer	0.137	0.008	17.123	0.000	0.794	1.260
β5 Urea fertilizer	0.016	0.007	2.369	0.018	0.894	1.119
β6 Other fertilizer (Manure)	0.841	0.515	1.632	0.103	0.898	1.113
β7 No. of watering	0.257	0.149	1.727	0.085	0.850	1.176
β8 Spray (pesticides)	2.443	0.875	2.793	0.005	0.801	1.248
β9 Seed quantity	0.664	0.169	3.925	0.000	0.788	1.270
β10 Seed treatment	2.058	0.698	2.947	0.003	0.976	1.024
β11 Cotton variety	-2.384	0.514	-4.635	0.000	0.959	1.163
β12 Diseases attack	-5.696	1.245	-4.574	0.000	0.967	1.034

which is statistically significant and indicates that 1 kg

spray, respectively. Table 4 shows in the fitted model of wheat the coefficient value Spray (weeds) β8=2.486 which is statistically significant and indicates that use of weed spray on wheat crop increases the production up to 2.486 Mds/acre and the factor weed spray affects the yield of wheat positively. Dangwal et al. [35] investigated the effect of weeds on wheat production in Tehsil Nowshehra, district Rajouri (Jammu Kashmir), and discovered that weeds are a serious competitor of the wheat crop, reducing wheat production by up to 25% in the study area.

3.3.10 Seed Quantity (β_9)

Table 2 shows that the coefficient value of seed quantity in the fitted model of sugarcane is β9=0.286, which is statistically significant and indicates that 1 kg increase in the use of sugarcane seed quantity results in sugarcane yield increasing up to 0.286 Mds/acre and the factor seed quantity affects sugarcane yield positively.

Table 3 shows the coefficient value of seed quantity in the fitted model of rice is β_9= -0.110 which is statistically insignificant and indicates that rice yield is not affected by increasing/decreasing the rice seed quantity.

Table 4 shows the coefficient value of seed quantity in the fitted model of wheat is β9=-0.078 which is statistically significant and indicates that 1 kg increase in the use of seed quantity from the recommended seed quantity results in the yield of wheat is expected to decrease up to 0.078 Mds/acre because more than the recommended seed quantity/acre affecting the wheat yield negatively.

Table 5 shows the coefficient value of seed quantity in the fitted model of cotton is β9=0.664 which is statistically significant and indicates that 1 kg increase Cotton yield is expected to increase up to 0.664 Mds/acre due to plants per acre being less than the recommended plants and the factor seed quantity positively affecting cotton yield.

Seed of any crop play a vital role to get good production. Pure and high quality certified seed with proper quantity have more resistance against weeds and pest as compare to the uncertified seed [36]. Seed has the key place in bridging the gap between the available crops average output and the potential crop output of various crops varieties [37].

3.3.11 Seed Treatment (β_{10})

Seed treatment means seed poisoning and certain chemicals application with suitable fungicide before sowing in order to save plants from disease and for good germination. Dummy variables are used, 0 for no seed treatment and 1 for yes seed treatment.

Table 2 shows the coefficient value of seed treatment in fitted model of sugarcane is β_{10}=56.051 which is statistically significant and indicates that treated seed use increases the production up to 56.051 Mds/acre and the seed treatment affects the yield of sugarcane positively.

Table 3 shows the coefficient value of seed treatment in the fitted model of rice is β_{10}=1.164 which is statistically insignificant and indicates that rice yield (response variable) is not affected by seed treatment.

Table 4 shows the coefficient value of seed treatment in the fitted model of wheat is β_9= -0.078 which is statistically significant and indicates that 1 kg increase in the use of seed quantity from the recommended seed quantity results in the yield of wheat is expected to decrease up to 0.078 Mds/acre because use of seed quantity/acre more than the recommended quantity affecting the wheat yield negatively.

Table 5 shows that the coefficient value in the cotton fitted model is β_9=0.664, which is statistically significant and indicates that a 1 kg increase in seed quantity results in an increase in cotton yield of up to 0.664 Mds/acre the factor seed quantity affecting cotton yield positively.

It is noted that modern seed treatment technologies such as chemical and biological treatments are inevitable for better and surplus output of various crops as they are helpful for plant germination [38].

3.3.12 Diseases Attack (β_{11})

In the model, dummy variables are used, 0 for no disease attack and 1 for disease attack.

Table 2 shows that in the fitted model of sugarcane, the coefficient value is β_{11}=-32.198 which is statistically significant and it implies that disease attack decreases sugarcane production up to 32.192 Mds/acre

Table 3 shows that in the fitted model of rice the coefficient value is β_{11}=-0.788 which is statistically insignificant and shows that rice yield is not affected by disease attack.

Table 5 shows that the coefficient value in the cotton fitted model is β_{12}=-5.696, which is statistically significant and indicates that diseases that attack cotton crops reduce cotton yield by up to 5.696 Mds/acre in the study area.

It has been discovered that disease attack, pests, and insects are significant factors influencing crop yield per acre [29, 39].

3.3.13 Planking (β_{11})

Table 4 shows that the coefficient value of planking in the fitted wheat model is β_{11}=3.638, which is statistically significant and indicates that increasing one number of planking results in an increase in wheat yield of up to 3.638 Mds/acre and that the factor use of planking affects wheat yield positively.

3.3.14 Cotton Variety (Bt and Non-Bt) β_{11}

In the model, dummy variable 0 is used for BT cotton and 1 for non-BT cotton.

Table 5 shows that in the fitted model of cotton, the coefficient value of cotton variety (BT and Non-BT) β_{11}= -2.384 which is statistically significant and indicates that use of non-BT cotton variety decreases the yield of cotton up to 2.384 Mds/acre and it means that farmers should always use Bt-cotton variety for good production.

A study was conducted in two major cotton growing districts of Punjab (Muzzafargarh and Rahim Yar Khan) to assess the technical efficacy of the farmers. The results clear that the farmers of Bt cotton in both districts are more efficient technically than the farmers of non-Bt. The important factors for better Bt cotton production were seed, labor, sown area, irrigation and fertilizer. Empirical findings specified a cropped area, seed, labor, fertilizer and irrigation while extension services, irrigation and pesticides were important for enhancing the production of the farmers of Non-Bt cotton [40].

3.3.15 Fresh and Ratoon Crop (β_{12})

The two types of sugarcane crops are the new (fresh) crop and the ratoon crop. The dummy variable 0 represents ratoon crop and the dummy variable 1 represents fresh crop.

Table 2 shows that the fitted model of sugarcane has a coefficient value of β_{12}=8.004, which is statistically insignificant and indicates that fresh and ratoon crop has no effect on yield.

In Pakistan, as per a survey conducted by the agricultural prices commission of Pakistan, the share of ratoon crop in total acreage of sugarcane crop is about 50%. However, the overall yield of the ratoon crop ranges from 65-90% [41]. A study on fresh and ratoon sugarcane crop returns was conducted in three districts of central Punjab (Jhang, Chiniot, and Faisalabad). The total cost of fresh and ratoon crop is PKR 95,660 and PKR 73,961/acre, respectively, with a net return of PKR 28,363 and PKR 27,429 per acre [42].

4. CONCLUSION

The current study examined the result of different factors on yield per acre of main crops using multiple regression model and other statistical techniques. The study revealed that the factors i.e. plough and rotavator, planking, irrigation, seed type, seed treatment, DAP and urea fertilizer, farmyard manure, latest varieties, certified seed, weed spray, diseases and pests' sprays are found as contributing factors towards higher yield of all crops while soil type (*kalrathi*), excessive seed rate, home seed, weeds, diseases and pests attack are found negatively influencing the yield of crops under study. All factors were found to be statistically significant for all crops except sugarcane (fresh and ratoon, seed type), rice (seed treatment, seed quantity, disease attack), and cotton (other fertilizer and amount of watering), which were found to be statistically insignificant. It is concluded that, in order to improve the productivity of the main crops in the study area, the number of ploughs used for land preparation, the quantity of DAP and farmyard manure (FYM), and the seed quantity of sugarcane and cotton per acre may be increased, and the use of certified and treated seed, weeds, and pesticides spray may be increased to ensure good and enhanced production.

5. ACKNOWLEDGEMENT

The authors would like to thank the anonymous reviewer for very constructive comments for great improvement in this manuscript.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

7. REFERENCES

1. GoP. Economic Survey of Pakistan 2018-19 (Ch.2 Agriculture). Ministry of Finance, Government of Pakistan. Islamabad, Pakistan (2018). Available from http://www.finance.gov.pk/survey/chapters_19/2-

Agriculture.pdf (13-5-2020).

2. S.A. Raza, Y. Ali, and F. Mehboob. Role of agriculture in economic growth of Pakistan. *International Research Journal of Finance and Economics* 83: 180–186 (2012).
3. M.A. Raza, L.Y. Fenga, A. Manaf, A. Wasaya, and M. Ansar. Sulphur application increases seed yield and oil content in sesame seeds under rainfed conditions. *Field Crops Research* 51–58 (2018) DOI: https://doi.org/10.1016/j.fcr.2017.12.024.
4. D. Jakperik, and S. Oduro. Statistical analysis of factors affecting crop production in Novrongo, Tono irrigation dam a case study. *Albanian j. Agric. Sci.* 12(1): 33–36 (2013).
5. M. Aslam, A.H. Sanghi, S. Javed, and L. Khalid. Effect of sowing time on yield and yield components of wheat sown in standing cotton. *Journal of Agricultural Research* 51(2): 133-140 (2013).
6. M. Francois, A. Kofi, A.W. Saviour, and P. Harvim. Time series and factor analysis of sugarcane production: Case study at Tosukpo, Volta Region Ghana. *International Journal of Innovative Research & Development* 4(4): 367–379 (2015).
7. B.K. Abrha. Factors affecting agricultural production in Tigray Region, Northern Ethiopia. PhD Thesis, University of Africa. (2015).
8. J.S. Ademba, J.K. Kwach, A.O. Esilaba, and S. M. Ngari. The effect of phosphate fertilizers and manure on maize yield in South Western Kenya. *East African Agricultural and Forestry Journal* 81(1): 1–11 (2015).
9. M.J. Kaloo, R. Patidar, and T. Choure. Production and productivity of rice in Jammu and Kashmir: An Economic Analysis. *International Journal of Research* 1(4): 464–473 (2014).
10. E. Cofas, M.D. Constantin, and I. Zaharia. Analysis of the main climatic factors and their impact on crop production. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development* 14(2): 71–76 (2014).
11. E. Kannan. Total factor Productivity growth and its determinants in Karnataka Agriculture. Working Paper 265. ISBN 978-81-7791-121-3. The Institute for Social and Economic Change, Bangalore, India (2011).
12. D.P. Singh, D. Kumar, M.S. Paikra, and P.S. Kusro. Developing statistical models to study the growth rates of Paddy crops in different Districts of Chhattisgarh. *American International Journal of Research in Formal, Applied & Natural Sciences*, 5(1): 102–104 (2014).
13. D. Ahmad, M.I. Chani, and A.A. Humayon. Major crops forecasting area, production and yield evidence from agriculture sector of Pakistan. *Sarhad Journal of Agriculture* 33(3): 385–396 (2017). DOI: http://dx.doi.org/10.17582/journal.sja/2017/33.3.385.396
14. A. Tunio, H. Magsi, M.A. Solangi. Analyses of growth trends and production forecast of cash crops in Pakistan. *International Journal of Agronomy and Agricultural Research* 9(1): 158–164 (2016).
15. J.K. Bajkani, K. Ahmed, M. Afzal, A.R. Jamali, I.B. Bhatti, and S. Iqbal. Factor affecting wheat production in Balochistan province of Pakistan. *IOSR Journal of Agriculture and Veterinary Science* 7(12): 73–80 (2014).
16. M.S. Javed, A. Ali, and H. Badar. Factors affecting the production of Sunflower in Punjab. *Pakistan Journal of Life and Social Sciences* 1(1): 42–44 (2003).
17. A. Rehman, L. Jingdong, B. Shahzad, A.A. Chandio, I. Hussain, G. Nabi, and M.S. Iqbal. Economic perspectives of major field crops of Pakistan: An empirical study. *Pacific Science Review B: Humanities and Social Sciences* 1: 145–158 (2015).
18. A. Qayyum, and M.K. Pervaiz. Impact of weighted rainfalls on the yield of wheat in the Punjab, Pakistan. *African Journal of Agricultural Research* 5(22): 3017–3025 (2010).
19. H.M. Hammad, A. Ahmad, K.Q. Laghari, F. Abbas, W. Nasim, W. Farhad, and A.H. Malik. Organic farming in wheat crop under arid condition of Pakistan. *Pakistan Journal of Agricultural Sciences* 48(2): 97–102 (2011).
20. GoP. Economic Survey of Pakistan 2016-17. Government of Pakistan, Ministry of Finance, Islamabad (2017). Available from http://www.finance.gov.pk/survey/chapters_19/2-Agriculture.pdf (1-5-2019).
21. Govt. of Punjab. Revenue Department Bahawalpur 2016-17. (2016). Available from http://www.agp.gov.pk/uerfiles1/file/DAGP-AR-2016-17.pdf (1-9-2019).
22. CRS. Punjab Agricultural Statistics, 2008 to 2016. Directorate of Agriculture, Crop Reporting Service (CRS), Punjab, Pakistan (2016).
23. D.C. Montgomery. Introduction to linear regression analysis (3rd Ed.). New York: Wiley Publishing (2003).
24. I. Hassan, M.B. Chattha, T.H. Chattha, and M.A. Ali. Factors affecting wheat yield: A case study of mixed cropping zone of Punjab. *Journal of Agricultural Research* 48(3): 403–408 (2010).

25. M. Iqbal, M. Fahime, Q. Zaman, M. Usman, Sundus, and A. Rahman. Effect of various factors on wheat production. *Sarhad Journal of Agriculture* 30(1): 135–143 (2014).
26. Govt. of Punjab. Guidelines for Quality Seed. Punjab Agriculture Research Board (PARB), Agriculture (Extension) Department, Region Bahawalpur (2007).
27. I.S. Chaudhry, M.B. Khan, and M. Anwar. Factors affecting cotton production in Pakistan: Empirical evidence from Multan District. *Journal of Quality and Technology Management* V(I1): 91–100 (2009).
28. A. Nazir, G.A. Jariko, and M.A. Junejo. Factor affecting sugarcane production in Pakistan. *Pakistan Journal of Commerce and Social Sciences* 7(1): 128–140 (2013).
29. M.A.A. Shah, G. Özel, C. Chesneau, M. Mohsin, F. Jamal, and M.F. Bhatti. A statistical study of the determinants of rice crop production in Pakistan. *Pakistan Journal of Agricultural Research* 33(1): 97-105 (2020) DOI: http://dx.doi.org/10.17582/journal.pjar/2020/33.1.97.105
30. M. Mohsin, M.M. Anwar, F. Jamal, F. Ajmal, and J. Breuste. Assessing the role and effectiveness of kitchen gardening toward food security in Punjab, Pakistan: A case of district Bahawalpur, *International Journal of Urban Sustainable Development* 9(1): 64–78 (2017) DOI: 10.1080/19463138.2017.1286349.
31. S. Erfio, P. Tesfaye, and B. Ayenew. The determinant factors of sugarcane productivity: The case of Wondo Genet, Ethopia. *Journal of Resources Development and Management* 25: 60–65 (2016).
32. M. Ashfaq, M. Akram, I.A. Baig, and A. Saghir. Impact of ground water on wheat production in district Jhang, Punjab, Pakistan. *Sarhad Journal of Agriculture* 25(1): 121–125 (2009).
33. M.A.A. Shah, A. Yasmeen, and H. Qasim. Statistical analysis of agriculture crops data by Two Stage Systematic Sampling. *American-Eurasian J. Agric. & Environ. Sci.* 14(10): 1026–1029 (2014).
34. A.Z. Othman, N.Y. Solieman, and A.A. Hassan. Study of the most important factors affecting the production of wheat crop in the New Lands in Egypt (Nubaria Area). *Middle East Journal of Agriculture Research* 3(1): 20–26 (2014).
35. l.R. Dangwal, A. Singh, A. Singh, and C. Sharma. Effect of weeds on the yield of wheat crop in Tehsil Nowshera. *Journal of American Sciences* 6(10): 405–407 (2010).
36. K. Nadeem. Factors analysis of major agricultural crops: A case study in Bahawalpur District. Unpublished M.Phil Thesis, Department of Statistics, *The Islamia University of Bahawalpur, Punjab, Pakistan (*2018).
37. M.A. Iqbal. An Investigation into crops improved seed availability, snags and future prospect for Pakistan. *American-Eurasian J. Agric. & Environ. Sci.* 15(3): 308–314 (2015) DOI: http://10.5829/idosi.aejaes.2015.15.3.12512.
38. K.K. Sharma, U.S. Singh, P. Sharma, A. Kumar, and L. Sharma. Seed treatments for sustainable agriculture-A review. *Journal of Applied and Natural Science,* 7(1): 521–539 (2015).
39. I. Mukhtar. Sunflower disease and insect pests in Pakistan: A review. *African Crop Science Journal* 17(2): 109–118 (2009).
40. D. Ahmad, and M. Afzal. Comparative analysis of Bt and non-Bt cotton farmers technical efficiency of core cotton zone in Punjab Pakistan. *Sarhad Journal of Agriculture* 35(2): 358–368 (2019). DOI: http://dx.doi.org/10.17582/journal.sja/2019/35.2.358.368
41. R.S Verma. Sugarcane Ratoon Management. Charbagh, Lucknow: International Book Distributing Co. (2002).
42. S. Hassan, A. Bashir, I. Mehmood, M.R. Yaseen, and M. Qasim. Comparative economics of fresh and ratoon sugarcane production across selected districts of Central Punjab. *Journal of Agricultural Research* 55(3): 557–564 (2017).