



## Technical efficiency of Sugarcane crop on different size of farms in western region of Uttar Pradesh

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### Abstract

Uttar Pradesh is the 2<sup>nd</sup> largest state in India. The economics of Uttar Pradesh is mainly based on agriculture and about 65 % of the total population is dependent on agriculture the main crop of Uttar Pradesh is Wheat. Wheat is the state's principal food crop and sugarcane is the main commercial crop. It is produced in the largest part of the state in about 24% of agricultural Land. Taking into account the significance of the aforementioned facts to measures the technical efficiency of sugarcane crop on different size of farms in western region of Uttar Pradesh year 2014-15. The results of investigating technical efficiency of the sample farm households under sugarcane crops indicated that output produced was less than the potential output to the extent of about 13 per cent, in sugarcane, respectively. On overall basis, however, much variation observed across farm size groups.

**Keywords:** Agriculture, Technical efficiency, Cobb- Douglas Production Function

### Introduction

Agriculture plays a vital role in India's economy, as 54.6 per cent of the population is engaged in agriculture and allied activities ([census 2011](#)) and it contributed 17.4 per cent to the country gross value added for the year 2016-17 (at current prices). As per the land use statistics (2014-15), the total geographical area of the country is 328.7 million hectares of which reported net sown area is 140.1 million hectares and gross cropped area is 198.4 million hectares with a cropping intensity of 142 per cent. The net area sown shared 43 per cent of the total geographical area. There has been a continuous decline in the share of agriculture and allied sector in the gross value added from 18.6 per cent in 2013-14, 18.0 per cent in 2014-15, 17.5 per cent in 2015-16 and 17.4 per cent in 2016-17 at current prices ([Agriculture Annual Report, 2017-18](#)). The 2017 global hunger index had rated India under 'serious' category with respect to under nutrition child stunting and child birth weight India was ranked 100 among 119 countries for which global hunger index was constructed. The population of India is projected to be 1.65 billion by 2050. Various studies indicate that the demand for food grains will

grow by about 50 percent in 2050. ([IFPRI, 2018](#)). Climate change is also posing serious threat to food security in India. The intensity and extent of extreme climate events, such as drought, high rise and fall in temperature, floods, untimely and unevenly rainfall are adversely affecting agricultural production, farm incomes and food security. The available estimates reveal a loss of 10-40 per cent in food production due to rise in temperature ([Joshi, 2016](#)). Various estimates suggest that India will experience an increase of 2.2 to 2.9 degree Celsius in average temperature by 2050 affecting overall production of crops. In addition, increasing demand for industrialization, urbanization, housing and infrastructure is forcing conversion of agricultural land to non- agricultural use; therefore, the scope for expansion of the area available for cultivation is limited ([Saxena, 2017](#)). The state of Uttar Pradesh has seen regular fluctuation in the growth rate in area, production and yield. The fluctuation shows the vulnerability of the sector to seasonal conditions. ([Koshal, 2012](#)). Category wise variation in resources across the farm size groups lead to varying efficiency in production of crops. Majority of the land holdings are very small in the region. The adoption of well

proven technology is constrained due to small size of holdings and poor farm resources.

The Cobb-Douglas production function was used to compute the technical efficiency. It was found that the Cobb- Douglas approximation gave a fair fit with the range of observations. The study also computed the technical efficiencies of different states. The researcher found that for each state there was a different estimate of efficiency, according to the factors of production included in the analysis [Farrell \(1957\)](#). Examined the technical efficiency, Allocative efficiency and economic efficiency for a sample of sixty farmers in the Dajabon region by using maximum likelihood techniques were used to estimate a Cobb-Douglas production frontier, which was then used to derive its corresponding dual cost frontier. These two frontiers were the basis for deriving farm-level efficiency measures [Boris \(1997\)](#). Technical inefficiency in the production of rice was negatively related with farm size, education of the farmer, experience, extension contacts and percentage of good land and positively related with age and fragmentation of the land [Reddy and Sen \(2004\)](#). Examined the technical efficiency and environmental impact of Bt cotton & Non Bt cotton in North India for the period from 2007-08, using stochastic frontier production function and the environmental impact quotient (EIQ). The results revealed that average technical efficiency was higher in Bt cotton farming. Roughly 80 per cent of Bt cotton farms fall in the efficiency range of 80 to 95 per cent; this figure reduced to 60 per cent on Non Bt cotton farms [Manjunatha et al. \(2011\)](#). Examined the technical efficiency of cocoa production in south west Nigeria for the period 2012. The result showed that cocoa enterprise was profitable, and in terms of technical efficiency, cocoa farmers in the region were relatively production efficient Ekiti state had the highest mean efficiency relative to Ondo state and Osun state. They also reported that the years of schooling had a positive influence on the technical efficiency of farmers while area of land cultivated and age of cocoa trees had a negative influence [Graceoet al. \(2015\)](#). Examined the efficiency in foodgrains production in India for the period from 1960-61 to 2013-14, using DEA and SFA frontier approach. High average efficiency in farming operations for both the frontier methods was observed. The period after 1990 had witnessed improved agricultural performance as inferred from the frequency distribution of the efficiency scores which indicated that during this period the overall efficiency scores had been higher and there was not a single year in which the efficiency levels had been less than 90 per cent [Mathur \(2018\)](#). Taking into account the significance of the aforementioned facts a study of technical efficiency in major crops was planned for western region of Uttar Pradesh. So, in this case “Examine the technical efficiency of sugarcane crops on different size of farms in western region of Uttar Pradesh”.

## **Methodology**

The study is based on primary study and it is conducted in the western region of Uttar Pradesh. The technical efficiency of Sugarcane crops of region is examined using primary data.

Stratified random sampling and Cluster sampling technique has been adopted for the selection of respondent households of the western region for the agriculture year 2014-15. At the first stage out of total six divisions in the western region of Uttar Pradesh two divisions viz., Meerut Division and Aligarh Division were selected randomly. From each selected division two districts had been selected purposively, each one with highest and lowest productivity of Sugarcane crops. In Meerut Division, Meerut District was selected on the basis of high productivity and Ghaziabad District was selected on the basis of low productivity District, purposively. In Aligarh Division, Aligarh district was selected on the basis of high productivity, whereas, Kashganj District was selected on the basis of low productivity district, purposively. At next stage one development block was selected randomly from each selected district. From Meerut District, Mawana development block and from Ghaziabad district, Muradnagar Development block was selected randomly. Similarly, from Aligarh district, Koil development block and from Kashganj district, Kashganj development block were selected randomly. Thereafter, one village was selected randomly from each selected development block and three adjoint villages were also included to form a cluster to select respondent farmers. At last stage sixty farmers (15 each from marginal, small, medium and large farm size groups) were selected randomly from each cluster. Hence, total sample size comprised of 240 farm households to collect primary data for the study. Under Mawana development block Tigri village was selected randomly and Khalidpur, Niloha and Kareempur adjacent villages were included to form cluster. In case of Muradnagar development block Didholi village was selected randomly and Sultanpur, MohammadPur and Jalalabad adjacent villages included to form cluster. Similarly, under Koil development block Joraver Nagar village was selected randomly and Gadiyawali, Boner, Balrampur and Girdharpur adjacent villages were included to form cluster. In case of Kashganj development block Janhageerpur village was selected randomly to form a cluster with adjacent Mahawar, MohammadPur and dolna villages.

## **Selection of major crops**

Different crops are grown in various seasons in the region; however, major crops of the region are those crops which together accounted for nearest 75 per cent of the gross cropped area arranged in descending order. Major crops were selected on the basis of cropping pattern of western region of the Uttar Pradesh state in 2014-15 shown in Table No. 1.

So, according to cumulative total of the per cent area in term of major crops wheat, sugarcane paddy and bajra are found as major crops of the western region of Uttar Pradesh on the basis of cropping pattern 2014-15, which is shown in the above table out of which choose sugarcane crop purposively for measuring technical efficiency, because it is a commercial crop in western region.

**Table 1. Major Crops grown in western region of Uttar Pradesh (2014-15)**

Crop	Per cent of gross cropped Area	Cumulative Total
Wheat	39.00	39.00
Paddy	18.33	57.33
Sugarcane	14.33	71.33
Bajra	8.56	79.89
Potato	4.25	84.14
Maize	3.56	87.7
Urd	0.86	88.56

**Analytical framework**

The estimation of technical efficiency in the production of different crops are indicated as difference in the rates of adoption of technical change. It also helps to determine the effectiveness of growth promoting institutions such as education, extension services, and credit institution of production practices available to the farmers. Technical efficiency is examined to identifying the possibilities for further increase in output of any crop while conserving the resource use. The technical efficiency refers to the proper choice of production function among all those activities in use by various farmers in the agriculture. Estimation of technical efficiency involved two stage procedures. Initially, estimates are obtained of frontier function a model which is neutrally upwardly scaled version of the ordinary least squares or average model. In the second stage, individual farms deviation from the frontier is used to estimate the technical efficiency. This also indicate that how much extra output could be obtained if a particularly farm was to reach on the frontier. For the measurement of technical efficiency, the uniform weighted average prices of input and output are used for all the sampled farmers. Quantities of output and input on per hectare basis are used as the weights.

The index of technical efficiency is constructed using the following formula:

$$T.E.j = Y_j / Y^*j$$

OR

$$\ln T.E.j = \ln Y_j - \ln Y^*j \dots\dots\dots(1)$$

Where,

- T.E.j = Technical Efficiency of jth farmer
- Yj = Actual gross return in Rs./ha of jth farmer
- Yj \* = Potential (maximum possible) gross return of jth farmer at present input use

Ln = Natural logarithm

Three methods are generally used for developing frontier production function as well as for calculating potential (maximum possible) gross return i.e. Y\*j. These are Linear Programming, Corrected Ordinary Least Square (COLS) Technique and Maximum Likelihood Method.

Out of these, Corrected Ordinary Least Square technique is used in the present study to develop frontier function for each farmer, because COLS technique is simple and very widely used method for developing frontier production function (Russell and Young, 1983). Due to presence of multicollinearity, per farm crop cultivation data were transformed in per hectare input use and output of for different farm size groups, calculate zero order correlation matrices.

**Corrected ordinary least squares (COLS) method:**

The Cobb- Douglas production function, as hypothesized in equation (1) stated as followed in log form:

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} + V_i$$

or

$$\log Y_j = a_0 + b_i X_i + V_i \dots\dots\dots(2)$$

- Where,
- Yj = Gross income from jth crop of the ith farm (Rs. per ha.)
- Xi = Level of t<sup>th</sup> variables used in jth crop (quantity /value per hectare)
- a = Constant term
- bi = Regression Coefficients of the respective resource
- Vi = Error term

After the estimation of above production function, the estimated value of lnYj \* has been estimated for each farmer, using the original data set. Then residual, μj is calculated as follows:

$$\mu_j = \ln Y_j - \ln Y_j^{\wedge} \dots\dots\dots(3)$$

- where,
- lnYj = Actual gross return in Rs./ha of jth farmer
- lnYj<sup>^</sup> = gross return of jth farmer, calculated by using original input data set in above estimated production function (2).

By the equation (3) a series is found. Among all the μj, the larger positive (+) is selected and denoted as μj max. Then, the correction is made in production function (2) by sifting the constant term upwardly by an amount equal to the value of μj max.

Thus, the new form of production function has become as follows:

$$\ln Y = (\ln a + \mu_j \max) + b_i \ln X_i \dots\dots\dots(4)$$

By combining the term  $(\ln a)$  and  $(\mu_j \max)$ , a new term is found and called as “ $\ln a_0$ ”. this  $(\ln a_0)$  has been assumed as the constant term for the frontier production function of estimated production function.

The form of frontier production function is as follows:

$$\ln Y = \ln a_0 + b_i \ln X_i \dots\dots\dots(5)$$

By the use of frontier production function and the farmer’s original input data set,  $Y_j^*$  estimated for each farmer. Therefore, technical efficiency of the farm households, across farm size group, has been worked out.

**Result & Discussion on technical efficiency**

As explained in the above section, the technical efficiency had been measured through an index of actual output of a farmer and the maximum possible output at his given level of resource use. At the first step, Cobb-Douglas production function had been estimated at the average resource use level of the sample farmers. Then the frontier production function has been obtained by finding the largest

error amount (i.e.,  $\mu_j = \ln Y_j - \ln y_j^*$ ) and shifting the intercept of estimated Cobb-Douglas production function to find out the largest possible output level at the average resource use of the sample farmers.

**Cropping pattern followed by sample farm households in the western region of Uttar Pradesh**

In the western region the technical efficiency index had been constructed for each farm in different size group as well as for overall farm size group by estimated COLS frontier. Based on cropping pattern followed by farm household’s area under sugarcane appeared as (28 per cent) to gross cropped area in the western region of the state, during 2014-15. On the basis of cumulative total of the selected crops, total three crops; viz., wheat, sugarcane and bajra emerged as the major crops of the western region of Uttar Pradesh based on primary survey out of these crop sugarcane crop selected for estimating the technical efficiency on different size of farms which is shown in table 2&3.

**Table 2. Cropping pattern followed on sample farm household in western region of Uttar Pradesh during 2014-15 (Hectare per farm)**

Crop	Farm Size Group				
	Marginal	Small	Medium	Large	Overall
Maize	0.03(3.17)	0.12(5.23)	0.32(7.35)	0.58(8.45)	0.2(5.62)
Jowar	0.28(27.91)	0.36(15.65)	0.46(10.66)	0.59(8.48)	0.65(18.26)
Urd	0(0.00)	0.03(1.3)	0.04(0.99)	0.1(1.4)	0.03(0.84)
Bajra	0.04(4.37)	0.34(14.78)	0.71(16.45)	1.15(16.62)	0.41 (11.52)
Wheat	0.32(31.88)	0.75(32.61)	1.35(31.20)	2.11(30.45)	1.15(32.3)
R&M	0(0.00)	0.01(0.44)	0.01(0.35)	0.06(0.88)	0.01(0.28)
Potato	0.003(0.33)	0.05(2.17)	0.09(2.14)	0.14(2.08)	0.04(1.12)
Pea	0.03(3.24)	0.05(2.17)	0.08(1.76)	0.11(1.57)	0.08(2.25)
Sugarcane	0.29(29.10)	0.59(25.65)	1.26(29.10)	2.08(30.07)	0.99(27.81)
Gross Cropped Area	1.008	2.3	4.32	6.93	3.56
Net Cultivated Area	0.65	1.45	2.79	4.15	2.29
Cropping intensity in per cent	155.08	158.44	154.79	166.97	155.46

**Table 3. Major Crops Grown in Western Region**

Major crops in Western Region		
Crop	Area (per cent to GCA)	Cumulative Total
Wheat	32.30	32.30
Sugarcane	27.81	60.11
Bajra	11.52	71.63
Maize	5.62	77.25
Potato	1.12	78.37
Pea	2.25	80.62
Urd	0.84	81.46
R & M	0.28	81.74

**Figures in parentheses indicate per cent to gross cropped area**

**Technical Efficiency in Sugarcane Crops**

On the basis of primary survey three major crops; i.e., sugarcane, wheat and bajra were selected for measuring the technical efficiency of the selected farm household in the western region of Uttar Pradesh. Here Only Discuss about the Technical Efficiency in Sugarcane crops along with category wise as well as overall farm size. These efficiency indices for each farm household category wise as well as for overall farm size were presented in appendix. The descriptive statistics as well as the distributions of farmers (category wise) according to their technical efficiency status (in per cent term) are given in tables 4, 5,6 for sugarcane crop.

**Status of technical efficiency in sugarcane cultivation**

The technical efficiency indices of individual farm households (category wise) were presented in appendix. The descriptive

statistics as well as the distributions of farmers category wise according to their technical efficiency class (in per cent term) are given in tables 4, 5 and 6.

**Sugarcane production function estimates**

The estimates of Cobb Douglas production function obtained using Ordinary Least Square technique, which are used to examine the technical efficiency of sugarcane growers in the region, are shown in table 4. In case of marginal farmers, the number of human labours, quantity of fertilizer, quantity of plant protection chemical and use of machine power had significantly contributed to the value of gross returns. The coefficients of human labour and fertilizer had been found to be negative and significant. In case of small farmers, sugarcane production responded significantly and positively to the number of human labour and machine cost. It indicates that there was room for improving gross return from sugarcane production by increasing the level of these inputs.

**Table 4. OLS estimates of the production function in sugarcane crop in western region during 2014-15**

particular	Farm size group			
	Marginal farmers	Small farmers	Medium farmers	Large farmers
Intercept	17.909*** (2.481)	2.267 (1.383)	8.503* (2.895)	6.122* (1.814)
Seed	0.019 (0.045)	0.547** (0.003)	-0.14* (0.217)	-0.541* (0.139)
Human labour	-0.282* (0.070)	0.027 (0.031)	-0.106**** (0.055)	0.067 (0.078)
Irrigation	0.058 (0.182)	0.454 (0.299)	-0.141 (0.301)	0.423*** (0.181)
Fertilizer	-2.502* (0.389)	0.120 (0.179)	0.075 (0.28)	0.128 (0.326)
Insecticide	3.631* (0.494)	-0.685 (0.432)	1.512*** (0.722)	0.714 (0.454)
Machine power	0.216*** (0.104)	0.264** (0.106)	-0.154 (0.094)	0.281* (0.078)
R square	0.98	0.82	0.90	0.97

**Note: \*, \*\*, \*\*\*, \*\*\*\* indicate significance at 1,2,5 and 10per cent probability levels, respectively. (Figures in parameters indicate standard errors)**

In case of medium farmers value of seed, human labour and value of insecticide had significantly contributed to the value of gross returns. The coefficient of seed and human labour was negative and significant. In case of large farmers, value of seed, numbers of irrigation and machine

power had significantly contributed to the value of gross return. The coefficient of seed had been found to be negative and significant. In case of overall farmers, value of seed,

quantity of fertilizer, and quantity of insecticide and machine power significantly contributed to the value of gross returns. The coefficient of fertilizer has been found to be negative and significant.

Results shown in tables 4,5 and 6 reveal that in sugarcane production lowest efficiency levels had been recorded as 81.4, 73.8, 75.2 and 84.5 per cent, respectively in marginal, small,

medium and large farm size groups. Highest efficiency level had found more than 99 per cent across the farm size groups.

**Table 5. Descriptive statistics of Technical Efficiency of sugarcane crop in Western region of Uttar Pradesh based on COLS frontier model**

Technical efficiency	Farm size group			
	Marginal	Small	Medium	Large
Minimum efficiency level	0.8145	0.7384	0.7522	0.8448
Maximum efficiency level	0.9929	0.9961	0.9922	0.9916
Mean efficiency level	0.8801	0.8803	0.8730	0.9118
Variance	0.0014	0.0036	0.0032	0.0012
Standard deviation	0.0378	0.0605	0.0566	0.0344
Coefficient of variation	4.30	6.87	6.48	3.77

Among marginal farm households, about 20 per cent of the farmers had been found efficient between 81 – 85 per cent levels. Most of the farmers; about 70 per cent, had been found to be 86-90 per cent efficient. Only 3.33 per cent of the farmers were in the 91-95 per cent efficiency range. The mean

efficiency level of the marginal farmers in the sugarcane production observed 88 per cent indicating that, on an average, about 12 per cent less output is being produced as compared to the frontier (potential) level of output.

**Table 6. Descriptive statistics of technical efficiency of sugarcane crop based on COLS frontier model in Western region of Uttar Pradesh (Number)**

T.E.Rating (%)intervals	Farm size group			
	Marginal	Small	Medium	Large
71-75	0 (0.00)	1 (3.33)	0 (0.00)	0 (0.00)
76-80	0 (0.00)	3 (10.00)	2 (6.67)	0 (0.00)
81-85	6 (20.00)	6 (20.00)	9 (30.00)	2 (6.67)
86-90	21 (70.00)	12 (40.00)	11 (36.66)	8 (26.66)
91-95	1 (3.33)	3 (10.00)	6 (20.00)	18 (60.00)
96-100	2 (6.67)	5 (16.67)	2 (6.67)	2 (6.67)

**Note: Figure in parentheses show per cent to total number of sample farm household**

Among small farm households only 3.33 per cent of the farmers had been found efficient between 71-75 per cent. Twenty per cent of the farmers found efficient in the range of 81-85 per cent. Most of the farmers, about 40.00 per cent, found 86-90 per cent efficient. The per cent of the small farmers in the range of 96-100 per cent had been about 17. The mean efficiency level of the small farmers in the sugarcane production had been about 88 per cent indicating that, on an average, about 12 per cent less output is being produced as compared to the frontier (potential) level of output by this category of farmers also.

Among medium farm households only 6.67 per cent of the farmers had been found efficient between 76-80 per cent. Most of the farmers, about 36.66 per cent, were found to be 86-90 per cent efficient. Only 20 per cent of the farmers were in the 91-95 per cent efficiency level; whereas, the per cent of the small farms in the range of 96-100 per cent had been about 6.67. The mean efficiency level of the medium farmers in the sugarcane production had been found to be 87 per cent indicating that, on an average, about 13 per cent less output is being produced as compared to the frontier (potential) level of output by medium farmers.

In large farm households about 6.67 per cent of the farmers had been found efficient up to 81-85 per cent level; i.e., minimum efficient level. Only 26.65 per cent of the farmers are found in the 86-90 per cent efficiency level. Most of the

farmers, 60.00 per cent, are found between 91-95 per cent efficient level. The mean efficiency level of the large farmers in the sugarcane production observed 91 per cent indicating that, on an average, about 9 per cent less output is being produced as compared to the frontier (potential) level of output.

The result of investigation on technical efficiency of the sample farm households under sugarcane crop cultivation indicates that existing output is less than the potential output to the extent of about 13 per cent on the medium farm households. So potential output can be obtained by the better resource use and management practices. The coefficients of human labour, value of seed, number of irrigation and machine power (medium farmers) have been found to be less contributed to the value of gross return. There is scope for use of more tractor power, human labour, seed and irrigation in sugarcane which may help to produce potential level of output. The coefficients of seed and human labour have been

found to be negative and significant by using production function estimates of sugarcane crop, indicating that the presence of excess use of seeds and disguised unemployment acted as constraints to produced potential level of output.

**Policy Implication**

On the basis of above findings, it is concluded that there is a need to introduce suitable innovation in the region to increase the productivity of Sugarcane. The result of investigation of technical efficiency of the sample farms under sugarcane crop indicates that 12 per cent less than the potential output is being obtained on the medium farm households. There is scope for use of more tractor power, human labour, seed and irrigation in sugarcane which may help to produce potential level of output. Hence, further emphasis is required on sugarcane crop. So, it is a matter of concern for the policy makers.

**Appendix I: Technical efficiency indices of sugarcane producer obtained byCOLS method in Western region of Uttar Pradesh during 2014-15**

Farm size group					
S.No.	Marginal	Small	Medium	Large	Overall
1	0.8861	0.8563	0.8516	0.9242	0.9216
2	0.8498	0.9734	0.9620	0.8821	0.7512
3	0.9040	0.8840	0.8763	0.9168	0.9468
4	0.8892	0.8835	0.8200	0.9404	0.8623
5	0.8781	0.8916	0.8791	0.9136	0.8884
6	0.8720	0.8710	0.8791	0.8645	0.8747
7	0.8694	0.8280	0.9525	0.8885	0.8092
8	0.9040	0.8720	0.8763	0.9261	0.9468
9	0.8669	0.8476	0.8288	0.9257	0.7936
10	0.8781	0.8945	0.9178	0.9240	0.8884
11	0.8882	0.7932	0.8316	0.9136	0.8714
12	0.8963	0.9326	0.8696	0.9619	0.8623
13	0.9928	0.9672	0.8763	0.9916	0.9928
14	0.8144	0.9960	0.9418	0.8615	0.8232
15	0.8675	0.9741	0.8708	0.8641	0.8518
16	0.8598	0.9167	0.9056	0.9261	0.9321
17	0.8708	0.8582	0.8365	0.9468	0.8092
18	0.8708	0.9762	0.8217	0.8448	0.8092
19	0.8383	0.7384	0.8708	0.8910	0.8362

20	0.8426	0.8651	0.7570	0.9257	0.7512
21	0.8687	0.8651	0.8220	0.8725	0.7936
22	0.8176	0.8964	0.9416	0.8448	0.8384
23	0.9863	0.8682	0.8115	0.9350	0.9045
24	0.9259	0.8171	0.8283	0.9261	0.8741
25	0.8789	0.7979	0.9158	0.9350	0.7931
26	0.8802	0.8687	0.9158	0.9261	0.9216
27	0.8669	0.8499	0.8973	0.9468	0.8092
28	0.8850	0.9381	0.9921	0.9142	0.8714
29	0.8726	0.8779	0.8857	0.9055	0.7936
30	0.8813	0.8075	0.7522	0.9142	0.8884
31					0.9436
32					0.7486
33					0.8035
34					0.9792
35					0.8874
36					0.9327
37					0.7616
38					0.9019
39					0.8809
40					0.8827
41					0.9446
42					0.8882
43					0.8333
44					0.8077
Average T.E.	0.8801	0.8803	0.8730	0.9118	0.8863

**Appendix IV: Zero Order correlation matrix between independent variable and dependent variable for marginal farmers of Sugarcane crop in Western region**

	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	0.153144	1					
X3	-0.6892	-0.36853	1				
X4	0.181921	0.288537	-0.49185	1			
X5	0.136348	0.179081	-0.52684	0.249067	1		
X6	0.476454	0.186745	-0.54696	0.36073	0.496189	1	
Y	0.044312	-0.21997	0.096442	-0.21396	-0.42464	-0.3535	1



**Appendix V: Zero Order correlation matrix between independent variable and dependent variable for small farmers of Sugarcane crop in Western region**

	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	0.189423	1					
X3	0.258535	-0.06511	1				
X4	-0.18225	0.125876	0.177605	1			
X5	0.162025	0.155589	-0.01878	0.280127	1		
X6	-0.24096	0.127869	0.436457	0.367153	0.288954	1	
Y	0.177118	0.00647	-0.1566	-0.03683	0.034979	-0.0527	1

**Appendix VI: Zero Order correlation matrix between independent variable and dependent variable for medium farmers of Sugarcane crop in Western region**

	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	0.197246	1					
X3	-0.35772	-0.41206	1				
X4	0.107073	0.213887	-0.46507	1			
X5	0.132053	0.110417	-0.39529	0.211773	1		
X6	-0.14495	0.158528	-0.44061	0.169725	0.165228	1	
Y	0.200268	-0.19475	0.295724	0.073656	0.224738	0.13486	1

**Appendix VII: Zero Order correlation matrix between independent variable and dependent variable for large farmers of Sugarcane crop in Western region**

	X1	X2	X3	X4	X5	X6	Y
X1	1						
X2	0.174541	1					
X3	-0.07004	0.03338	1				
X4	-0.03446	0.144346	-0.75234	1			
X5	0.157834	-0.02575	0.128374	-0.16368	1		
X6	-0.10584	0.047564	-0.76812	0.178562	0.193192	1	
Y	0.536261	0.457164	0.667417	0.352485	0.416681	0.408141	1

Note: X1 = Expenditure on seed per ha.  
 X2 = Expenditure on human labour per ha.  
 X3 = Expenditure on irrigation charges per ha.  
 X4 = Expenditure on fertilizer per ha.  
 X5 = Expenditure on ppc per ha.  
 X6 = Expenditure on tractor power per ha.  
 Y = Gross return in Rs. Per ha.

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