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Determinants of sugarcane output variation among Farm units: Case of Finchaa Sugar Factory, Ethiopia

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ABSTRACT: Sugarcane production in Finchaa sugar factory is going on in large scale farm with different level of laborers of which farm units are the low level managers who do have decision power on their command area/farm land/ and on laborers they administer. The researcher used primary and secondary data. The data are analyzed using descriptive statistics and econometric model. The F-value is 184.57 and is highly significant at 1% level of significance, indicating that the regression model is well fitted. According to the MLRM estimation, the value of R^2 is 0.94, which mean 94% Variation in the output of sugarcane is explained by the explanatory variables. The study reveals that land size, irrigation application, weed control, cane age at harvest, amount of fertilizer and herbicide applied are significant variables to determine sugarcane output Variation among farm units. In order to narrow the gap between the highest and the lowest output of sugarcane among farm units in the farm estate, farm units should give due attention to the proper irrigation application, weed control at critical period, recommended cane age at harvest, amount of fertilizer and herbicide applied as per agronomical science.
KEYWORDS: *Sugarcane output, farm units, fertilizers, multiple linear regression model.*

1. INTRODUCTION

Sugar production is one of the major economic sectors in Ethiopia of which activities provide significant full time and temporary employment in sugar factories and technology transformation. Currently the country's three existing sugar factories (Wonji, Finchaa, Metehra) have an aggregate annual production capacity of 360,968 tones. This annual production is not sufficient to the local sugar demand forcing the government to annually import 1.5 million quintals from abroad. According to Sugar corporation report on Augest 2014, the total area developed by these factories is 82,340 hectares . Sugar production in Ethiopia started in 1954/55 when the Wonji Sugar Factory was commissioned and produced 15,843 tons of white sugar in the first campaign. When sugarcane development began in 1951, the company was owned by Dutch Company, HVA (Handlers - Vereeniging Amsterdam). The development of the sugarcane plantation was started on 5000 hectares in the upper reaches of the Awash basin, 100km, southeast of Addis Ababa which is capital city of Ethiopia.

Finchaa sugar production shows a pattern of progressive growth in both sugarcane cropping area and sugar mills production; but the output per hectare is decreasing. Hence the paper analyzed those factors that cause sugarcane output Variation among “cappos” on commercial sugarcane plantation in the irrigated area of the Finchaa valley. No best analysis is made on the most factors contributing for the Variations of sugarcane output among farm units not only in the research area but also in Ethiopia; hence, this study attempts to be a springboard of this problem.

The general objective of this study is to analyze factors that cause Variation of sugarcane output among farm units of Finchaa sugar factory.

The study result will show an entry point for further policy intervention to improve resource use efficiency of sugarcane production in Finchaa sugar Factory. Moreover, it helps investors engaged in such industry to come with some important idea of efficient utilization of available production input and best agronomical practices for field yield increases. They can play an important role informing farm managers to derive lessons about better production practices.

The study would focus only in Finchaa sugar Factory. Since the study is mainly related to the limited coverage of the study area, the finding of the research to be conducted is may not be generalized for all sugar industries of the country.

II. METHODOLOGY

Research Design

Types and sources of data

Both primary and secondary data were used for the research purpose. Secondary data, which was cross sectional data for cropping season 2015/2016, was obtained from sugarcane planting and development office where as primary data was collected through developed questioner.

Sampling technique and sample size

There were 170 farm units producing sugarcane in the study area during the study year (Table3.1). Since the number of farm units whose fields were harvested in the operation year 2015/2016 is 120, the researcher used purposive sampling procedures and took 120 sugarcane producing farm units out of the study population.

Data collection

Primary data was collected by local language speaking enumerators with degree and diploma who were working in the industry and trained on the method of data collection. The respondents were all farm units whose sugarcane fields harvested in the crop season 2015/16.

Method of data analysis

The data was analyzed using descriptive statistics and econometric model.

- ***Descriptive analysis***

The descriptive statistics used include: means, standard deviation, and frequency distribution to analyze and interpret the data and.

- ***Econometric Model***

In practice, economic models generally contain one dependent variable and two or more independent variables. Such models are called multiple regression models (Gujarati, 2003).

Before presenting the data analysis methods adopted, the study tried to specify the variables and models used under the study. Accordingly, Multiple linear regression models for analyzing determinants of sugarcane production Variation among the farm units was used for the purpose of this study and the study identified a total of eleven (11) variables including one dependent and ten independent variables. The data were processed through Stata 10.

Variable Selection and Definitional Hypotheses

Explained variable

Sugarcane Output (Y): This is a continuous variable in the model and it was measured in sugarcane output (total quintal).

Explanatory variables

Land Size (LS): This is a continuous variable expressed in hectare (Ha) of harvested area of the farm units.
Land Preparation (LP): a dummy variable explained whether the land preparation is good or not before the cane was harvested. It takes a value of 1 if yes or 0 if not.
Irrigation Water Application: A dummy variable responded whether the required amount of water and set-time is as per standard operation, which takes a value of 1 if yes or 0 if not.

Fig. 2.3a. Sugarcane Production with Sprinkler Irrigation in Finchaa Estate Farm

Fertilizer Application (*FA*): a continuous variable expressed in total quintals (qt) of fertilizers (DAP and/or urea) that had been applied on the harvested fields of the farm units.


Fig. 2.3b. Mechanical and Mannual Fertilizer Application on sugarcane
(Source: Own -camera shoots during field visit)

Herbicide spray (HS): a continuous variable expressed in total liter (lt) herbicide chemical (Atramet Co. or other) that had been applied on the harvested fields to control weeds.
Weed control (*WC*): This is a dummy variable explained whether or not weeds in cane fields had been controlled at proper time before the cane were harvested. It takes a value of 1 if yes or 0 if not.
Age of Sugarcane at harvest (*CAGE*): This is a continuous variable expressed in number of months at the time of harvest.
Dry off days (*DOD*): a continuous variable expressed in days of irrigation resumption on harvested fields before they are harvested.
Farming experience (*FEXP*): This is a continuous variable expressed in the number of years a farm unit has been involved in sugarcane farming. It is a proxy of the duration of the relationship between the field coordinator and the sugarcane command area to which the farmer is attached.
Extension Services and Supervision: A dummy variable responded whether the farm units received advices and properly trained in sugarcane operation standards or not. It attains a value of 1 if yes and 0 if no.

Model Specification

The general purpose of multiple regressions (the term was first used by Pearson, 1908) is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable.

The general linerized equation for the model is:

$Yi = \beta_0 + \sum_{i=1}^{10} \beta_i X_i + \varepsilon$……(equation no. 1)

Source: Raheman and Nasr, (2007).

Where:

Y i = Cane output of a farm unit *i ; i* = 1, 2, 3…, 120 farm units.

β_0 = intercept

β_i = Coefficient of X i variables

X i = The different independent variables for sugarcane production of farm unit i and ε = Error term. Finally, the above general least square model is converted in to specified variables as follows; $\hat{Y}_i = \hat{\beta}_o + \hat{\beta}_1 LS_i + \hat{\beta}_2 LP_i + \hat{\beta}_3 HS_i + \hat{\beta}_4 WC_i + \hat{\beta}_5 FA_i + \hat{\beta}_6 IRR_i + \hat{\beta}_7 CAGE_i + \hat{\beta}_8 DOD_i + \hat{\beta}_9 FEX_i + \hat{\beta}_{10} ESS_i + \varepsilon$

2.3.1. Hypothesis testing of coefficients

If we invoke the assumption that $u_i \sim N(0, \sigma^2)$, then we can use the *t* test to test a hypothesis about any *individual* partial regression coefficient. To illustrate the mechanics, consider the output. Let us postulate that

H_0: $\hat{\beta}_1 = \hat{\beta}_2 = \hat{\beta}_3 = \ldots \hat{\beta}_k = 0$ and H_1: $\hat{\beta}_1 \neq \hat{\beta}_2 \neq \hat{\beta}_3 \neq \ldots \hat{\beta}_k \neq 0$.

We can also test the regression equation as a whole rather than just the individual parts. We can use information in the ANOVA table to test the hypothesis:

$H_0 : \beta_1 = \beta_2 = \beta_3 = \dots = \beta_k = 0$

H_A : Not all of the β 's $= 0$

As mentioned above, for this research OLS (ordinary least square) was used. Therefore, before the regressions were run tests for fulfillment of basic CLRM assumptions are tested. Consequently, the basic CLRM assumptions tested in this study are normality of the error distribution, linearity and multicollinearity (variance inflation factor (VIF)).

III. RESULTS AND DISCUSSIONS

3.1 Descriptive Statistics

- **Sugarcane output of farm units in the study area:** Though there were 18 sugarcane plantation sections in the study area, two sections', namely Neshe 3 and Neshe 4, sugarcane fields were not harvested due to late planting time and immature age of sugarcane.

The largest area harvested was from section Hora, which was 1,077.01ha with a output of 1,314,974 quintals where as the smallest area harvested was 263.08 ha from section Dembi with output of 294,006 qt. Accordingly, from total output Hora accounts for 10% while Dembi 2.2%.

Besides these, there was a farm unit with largest sugarcane output of 257,427 qt and the smallest output of 24,791 qt.

- **Land size**: out of 120 farm units, there was a farm unit with the largest land size of 212.37 while the smallest plot size was 32.21 ha. This indicates there was Variation of land size from which sugarcane harvested in the study year resulting output Variation.
- **Fertilizer application**: The table above indicates the amount of fertilizer applied varies among farm units. The highest amount was 854 qt while the lowest was 85qt.
- **Herbicide application**: some farm units did not apply herbicide and the largest volume of herbicide applied was 1146 lit. 37.5% of the farm units did not use herbicide.
- **Land Preparation:** Out of 120 farm units' sugarcane fields, 54% of the farm units' fields were not properly prepared (before harvesting) where as 46 % of the farm units' land preparation were as per the standard. i.e. the subsequent tillage practices which are land clearing/uprooting/, ripping, plowing(1^{st} and 2^{nd}), harrowing and furrowing shall be operated to get proper land preparation for sugarcane cultivation.
- **Weed Control:** the result showed 37 % of the farm units' cane fields weed were not controlled at the standard time. Sugarcane plant should be weed free up to three months of cane age (Sugar corporation, 2014). Whereas 63 % of the farm units' cane fields weed were controlled at the standard time.
- **Irrigation water application:** out of 120 farm units 75 % of them responded the required amount of water is applied to their sugarcane plantation as per standard operation where as 25 % of them responded their cane fields plantation didn't get irrigation as the standard.
- **Extension Services and Supervision**: Farm units should obtain extension services and supervised by agricultural office managers/supervisors/. 62 % the farm units received advices and properly trained in sugarcane operation standards where as the rest were not properly supervised and did not get proper extension services.

Econometric Analysis

Test results for CLRM assumption

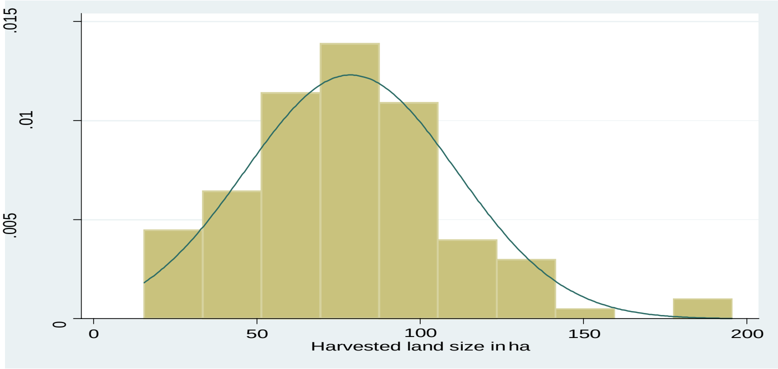
Under this subsection, the study presented three different results for the test of CLRM. Firstly the test results for normality assumption are presented using both graphic method followed by tests for linearity and multicollinearity (variance inflation factor (VIF)) are presented.

Tests for Normality

- **Graphic test results for normality**

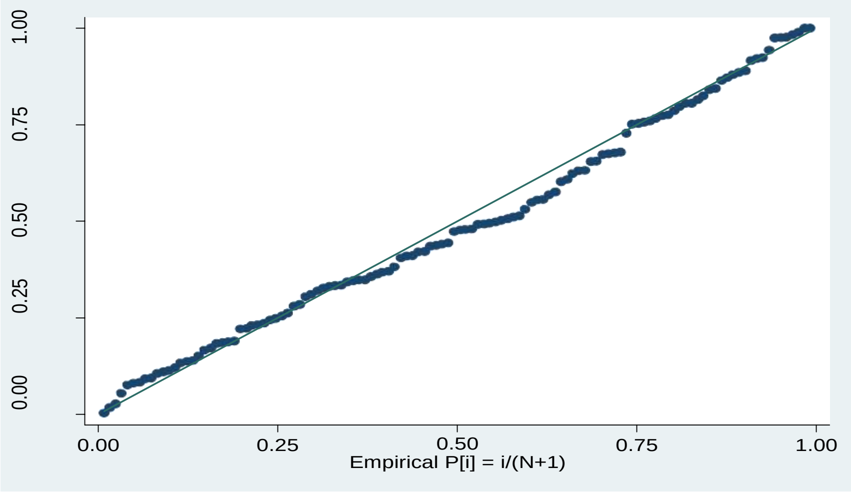
Figure 4.1 revealed that the data is normally distributed and residuals are normally distributed, the histogram is bell-shaped.

Figure 3.1 Histogram of normality test

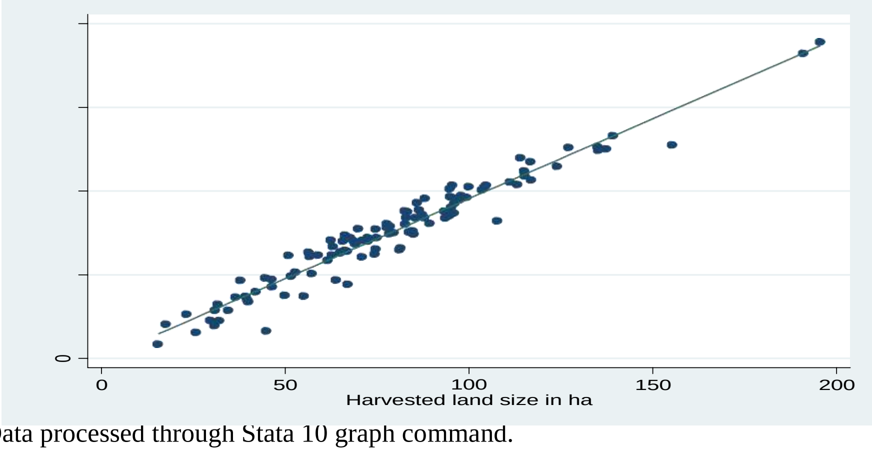


The graph shown above is bell –shaped that shows normality.

Fig.4.2 Normal probability plot of standardized residuals



(The graphical tests for normality of other continuous variables were on appendix 3).
Fig. 3.3. Graph Test for Linearity



Source: Data processed through Stata 10 graph command.

Test result for Heteroscedasticity

The test hypotheses:

Ho: u_i's are homoscedastic H1: u_i's are heteroscedastic

If in an application the computed critical $(\chi^2 = \frac{Ess}{2})$ exceeds the critical $\chi 2$ value at the chosen level of significance, one can reject the hypothesis of homoscedasticity; otherwise one does not reject it(Gujarati D., 2004 pp 522).

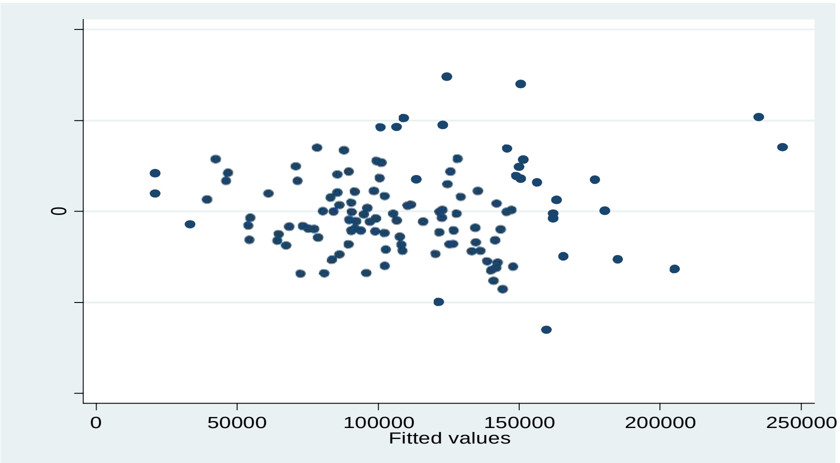
Table 3.4. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance	Variables: fitted values of Y
chi2(1) = 11.26	
Prob > chi2 = 0.0008	

Source: Stata 10 specification test command

The result of Breusch-Pagan / Cook-Weisberg test for heteroskedasticity in table 4.4 shows critical $\chi 2$ value is 11.26 and computed critical , $\chi^2 = \frac{Ess}{2} = 667059.91$. Accordingly, the null hypothesis should be rejected and the presence of unequal variance accepted.

The other diagnosis for presence of heterskedasticity is through Plot residual-versus-fitted plot, rvfplot. Non constant spread means heteroscedasticity. Accordingly, the plot is:



Graph 3.2 Plot residual-versus-fitted plot

According to the above graph, the scattered and outlier points show there is a problem of non constant spread means.

Correcting for heteroskedasticity: There are two cases in correcting a Heteroscedasticity problem

The source of heteroscedasticity in this study could be skewness in the distribution of one or more repressors like the Variations of amount of herbicide and fertilizer applications, extension services and supervisions among farm units.

Test results for multicollinearity

Stata 10 computation result depicts none of the variance inflation factors (VIF) is greater than 10 and and *t* ratios of most variables are significant. These results show there is no multicollinearity problem.

Table 3.5 Variance Inflation Factor (VIF) of the variables

Variable	**VIF**	**1/VIF= Tolerance**	**t-ratios,** P>t
Land size	5.39	0.185	0.000
Fertilizer application	5.05	0.198	0.001
Herbicide application	1.36	0.737	0.000
Cane age	1.46	0.686	0.031
Dry off days	1.68	0.595	0.198

Farm unit experience	1.56	0.642	0.042
Land preparation	1.02	0.979	0.075
Weed control	2.12	0.471	0.024
Extension service	1.06	0.943	0.294
Irrigation application	1.99	0.501	0.000
Mean VIF	2.27		

Source: Inferential result, 2015/16

The partial pair wise correlations between variables are lays between ±1. Therefore, majority of correlation are on between - 0.45 and 0.403 as presented on Appendix 4. Likewise, the minimum correlation of -0.0029 is observed between output and land preparation (LP) while the maximum correlation of 0.91 is between cane production/output/ (Y) and average land size.

Results for multiple regression

The table below shows the result of linear regression model after running OLS estimation through Stata 10.

Table 3.6 Results of Model Regression

Variables	**Coefficient**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
Land size	902^{***}	66	13.69	0.000	771.65	1032.88
Land preparation	3310^{*}	1843	1.80	0.075	-343.62	6964.02
Irrigation application	12017^{***}	2968	4.05	0.000	6134.34	17899.72
Fertilizer application	39^{***}	12	3.26	0.001	15.39	63.06
Weed control	6278^{**}	2752	2.28	0.024	823.45	11732.63
Herbicide application	16^{***}	4	4.16	0.000	8.37	23.61
Dry off days	-104	81	-1.30	0.198	-263.93	55.30
Cane age	-17^{**}	8	-2.19	0.031	-33.15	-1.65
Farm unit experience	1104^{**}	536	2.06	0.042	41.83	2165.41
Extension service	2000	1896	1.06	0.294	-1757.46	5758.12

(Source: Own computation using Stata 10 output, 2015/16).

*The result is rounded to two decimal place. *** is significant at 1% level, ** is significant at the 5% level & * is significant at the 10% level.*

The estimated regression was presented as:

Y= -860+902LS +39FA +16HS -17CAGE - 104DOD +1104FEXP+3310LP + 6278WC +2000ESS+12017IRR

According to the result in table 4.6 above, land size, fertilizer application, herbicide application and irrigation application are highly significant at 1% level of significance in affecting sugarcane output and thereby vary the output among farm units. In the same table, cane age, farm unit experience and weed control affect the output at 5% level of significance.

Test result for significance of the model

The hypothesis test:

$H_0 : \square_1 \ \square \ \square_2 \ \square \ \square_3 \ \square \quad \dots \quad \square \ \square_k \ \square \ 0$

H_A : Not all of the □ 's □ 0

Table 4.7 ANOVA linear regression for significant of the model

ANOVA[b]						
Model	Sum of square	Df	Mean square	F	Sig.	R^2
Regression	3083643.3	10	308364.33	184.57	0.000^a	0.94
Residual	1334119.82	109	12239.6314			
Total	4417763.13	119	37124.0599			

(Source: Own computation using STATA 10 Output for the data 2015/16)

a. Predictors: (constant), LS, FA, HS, PS, CAGE, DOD, FEXP, LP, WC, ESS, IRR

b. Predicted: Y

As table 4.6 revealed, at a significance level of (0.000) the regression model predicts the outcome variables

Comparing computed F-value with tabulated values at 1% and 5 % , For $\alpha = 0.01$, $F_\alpha(10, 109) = 2.47$ and for $\alpha = 0.05$, $F_\alpha(10, 109) = 1.91$

Since the test statistics (computed F-value) is greater than the tabulated F-value at 1 and 5%, the null hypothesis is rejected and concluded that the model is adequate .

The R-squared is 0.94, meaning that approximately 94% of the variability of sugarcane output among farm units is accounted for the variables in the model.

Interpretations of Estimated Coefficients of the Explanatory Variables

The following explanatory variables were interpreted based on MLRM results and referred with agricultural operation standards for Finchaa sugar factory in table 4.8 below.

Land Size (LS): As the MLRM analysis result showed, land has positive coefficient (902) which was strongly significant at one percent level of significance. This implies, one ha greater in land size will tend to vary output of sugarcane by about 902 qt among the farm units, other things being held constant.

Land Preparation: As regression analysis showed, land preparation as per work standard has positive relation with output and significant at 10%. This factor varied sugarcane output by 3310 qt among farm units whose land preparation was as per the operation standard and at substandard, ceteris paribus.

Irrigation application: Water application as operation standard (table 4.8) has positive relation with output and significant at 1%. According to the regression result, it varied sugarcane output among farm units by 12017 i.e. Other things being constant, a farm unit who applied irrigation as the work standard had 12017 qt of sugarcane greater than the farm unit who did not apply irrigation as per the standard. **Fertilizer (DAP and Urea in qt) /FERT/:** It is a variable with positive coefficient (39) and strongly significant at 1% level of significance. Fertilizer input (DAP, urea) application at the recommended rate positively affect and varies the output among farm units by 39 qt, other things being held constant. According to Dejene's finding (2013:68) fertilizer, as per the SPF result, is a variable with positive coefficient and strongly significant at one percent level of significance as per the working standard level of T-Ratio level.

Weed control (WC): Leul(2005:78) explained that "weeds cause a yield loss of about 20-90% yield loss in industrial crop especially sugar cane production." According to regression model, the variable's coefficient was 6278 at 5% level of significance. This show sugarcane output varies by 6278qt among farm units who controlled and did not control weed at proper period, ceteris paribus.

Herbicide Application (Atramet Combi-chemical): This variable was measured in liter of chemical sprayed to control weed infestation. The analysis shows a positive relation with sugarcane production at 1 % level of significance indicating a unit increase of herbicide application will increase the output by 16 qt, ceteris paribus. It also implies sugarcane output varied by 16 qt among farm units who applied and did not apply herbicide.

Dry off Days (DOD): This variable is the number of days elapsed between irrigation water stoppage from matured sugarcane and its harvesting days. MLRM analysis predicted that this variable has negative coefficient, (-104), but less significantly affect the output of farm units.

Sugarcane Age at Harvest (CAGE): This variable was measured by number of days, which is significant at 5 % level of significance with a coefficient -17.

This shows as age of sugarcane exceeds by one day from the standard, sugarcane output of the farm unit decreased by 17 qt, ceteris paribus.

Sugarcane Producing Farm unit's Experience (FEXP): Having adequate experience in sugarcane production plays vital role in the output harvested because of agronomic knowledge is developed through experience and practices.

The result also indicates FEXP is significant at 5% with the coefficient of 1104. This shows, a farm unit with one-year greater experience than the other exceeds by 1104 qt, ceteris paribus.

IV. CONCLUSION AND RECOMMENDATION

a. Conclusions

The research finding presented the statistical and regression results that were computed using different methods adopted to investigate the determinants of sugarcane production on firms' output. The Variations of sugarcane output among farm units were assessed; hence land size, fertilizer application, herbicide application, irrigation water supply, weed control, cane age and farm unit experience are significantly affects cane output, where as land preparation, dry off days, and extension services and supervision also affect but less significant.

❖ According to the study, land size, amount of fertilizer applied, irrigation water application and herbicide applied are major factors to vary sugarcane output among the farm units where as land preparation, weed control, farm unit experience, dry off days and cane age at harvest are the minor factors.

b. Policy Implications and Recommendations

Based on the study findings the researcher recommended the following points:

- Fertilizer application has a positive relation with sugarcane output. Even though DAP and UREA has different effect, using separately for research study creates serious multicollinearity problems.
- Since these inputs (DAP and Urea) are crucial for sugarcane output Variation among farm units, it is recommended to apply them at proper time, rate and method as the standard.
- Herbicide is a chemical sprayed to control weed infestation. The analysis shows a positive relation with sugarcane production indicating a unit increase or decrease from the standard set (6-8 liter /ha Atramet-combi) of application will increase or decrease the output, ceteris paribus. It is recommended to spray herbicide as per the standard.
- Scientific study has to be intensively done to tackle the knock-on effect of chemical uses for fertilizer, weed and plant disease control.
- Dry off period and age of sugarcane have negative relationship with sugarcane output which implies as age of sugarcane and dry off days exceeds from the standard its output will decreases. Therefore, it is better for sugarcane producers to harvest their sugarcane after proper dry off days and at recommended cane age.
- The Variation of sugarcane output among farm units is not only the case of land size harvested and OSD implementation but also farm units' attributes such as the farm unit's experience and commitments on implementation of OSD, Therefore, it is better to hire experienced and devoted person in order to gain good output.
- The variation of sugarcane output among farm units is the promising for output reduction and uneven sugarcane output trend, which is not accepted by sugar producing firms. Therefore, it is better to give due attention to proper land preparation, plot size of farm units, sugarcane husbandry as per operation standards.
- It is better for a farm units and managers to list out the bottlenecks in cane production and strive to tackle the problems in order to narrow the Variation of sugarcane output among farm units.

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