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COMPARATIVE STUDY OF CROP ESTIMATION TECHNIQUES: A CASE STUDY OF DISTRICT BHAKKAR

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ABSTRACT

This research study is planned to obtain better and well timed estimates of crop production. In this study the small plot size for crop cutting experiments has been compared with the existing plot size of crop reporting service, agriculture department, Punjab. Some sampling estimators like Ratio, Regression, Product and Generalized modified product estimators have been applied to compare yield of four crops wheat, gram, ground nut and mung of district Bhakkar. The small plot size data of these crops provide better and well time estimates as compared to large plot size. These two methods of crop cutting experiments have also been compared with actual yield and method of small plot size yielded the results which are near to actual results. The main objective of this study is to minimize cost, time and wastage of crop which is not ensured in the present practice of the crop estimation techniques.

Key Words: Ratio estimator, Regression estimator, Product estimator, Modified product estimator, Crop Reporting Service, Mean Square Error and Correction Factor.

INTRODUCTION

Agriculture sector is the backbone of our economy. When Pakistan was established it was an agriculture based country. At that time agriculture was the largest contributor towards the GDP of Pakistan., Now other service sectors are larger contributors of GDP and agriculture is third contributor GDP in Pakistan. Agriculture plays an important role in the employment of Pakistan. More than 50% people belong to rural areas. According to the report of UNDP in 2015-2016 65% people of total population lived in rural areas. More than 45 percent of our labour force is engaged in this sector. Agriculture is the best way to increase tax revenue. Pakistan is a country in which the increasing rate of population almost 2% per year. To sustain such a higher population, agriculture plays a key role. The success of economic policies and plans in this sector depends on the timely and reliable estimation of agriculture crops. All countries in the world do make an estimate of the production of different crops, so that they may plan to import as much as their production runs short of the requirement or they may able to export the surplus amount of their production. Different countries use their own ways and means to make these estimates. In Pakistan, the Crop Reporting Service, Agriculture Department, is responsible to issue crops acreage and production estimates, which are worked out for each district and then accumulate for total provincial and national acreage and production (CRS, 2016). Primary data regarding wheat, gram, mung and ground nut crops from district Bhakkar, Punjab is collected under the guidance and help of Crop Reporting Service, Government of Punjab, Bhakkar. This data is included small plot size (6x8) feet of all crops and this is compared with the data which is collected through CRS using existing plot size (12x16) feet for gram, mung and ground nut and (15x20) feet for wheat crop. The main objective of this research is to recommend an improved technique for crop production estimate which minimizes cost, time and wastage of crop during estimation process as compared to current procedure of crop estimation technique.

Mahalanobis (1946) calculated that when experienced staff harvested sample plots under the supervision of trained statisticians, a previous upward bias of 14.9% (when compared to a circular area of 100 sq. ft.) decreased to almost zero. It is calculated that if, under proper supervision, random points in the field were chosen objectively and if plants just outside the plot borders were excluded, accurate estimates could be obtained using small plots. Panse (1954) reported the results on cotton which showed that even with best supervision and training, it is not unlikely that plots up to 200 sq. ft. may give Biased estimator. An experiment conducted in Orissa on jute, the plot of size 10 links X 10 links were found to give significant overestimation as compared to plot of 25 links x 25 links size. Fielding and Riley (1997) suggested using two large quadrants in the order of 50–75 m^2 each. They concluded that use of two subplots of any crops build in a check on the reliability of harvest data and also allow highlighting of peculiar values. Foeken and Owuor (2000) found that in crop cutting experiments of wheat, the estimates of total yield were much higher for sample units of small sizes as compared to actual yield obtained from harvesters and combiners. Therefore, it is not safe to work with plot sizes less than 42 square meters. It is noticed that estimated yield variance increases with the decrease of plot size cuts that coincides with the previous findings. El-Sergani and El-Geddawy (1992) concluded that the yield estimation attains a stable value when the plot size is significantly large. But when plot size is small the results are not stable. In this process high accuracy and reliability of data is achieved through personal efforts and interest. In this study primary data is selected in two cropping season (2013 to 2014) Rabi and Kharif. Two crops wheat and gram of rabi season, ground nut and mung of kharif season.

Total villages are 573 in district Bhakkar in which wheat is cultivated. Directorate of Agriculture, Crop Reporting Service Punjab has selected 39 villages of district Bhakkar in (2015-2016). For collecting the data of (8x6) feet plot size personal efforts are used with the help of the staff of Crop reporting service Bhakkar which is called primary data for this study. In this study, the primary data results will be compared with secondary data which is collected by the department. The results of small plot size (8x6) feet and large plot size (15x20) feet are known as primary data and secondary data respectively. The data will be collected only from 39 villages of district selected by the department.

In district Bhakkar total 407 villages are cultivated for Gram crop and 33 villages are selected by the Directorate of Agriculture, Crop Reporting Service Punjab in (2015-2016). Similarly for this crop small plot size (8x6) feet and large plot size (15x20) feet data has been collected and then compared the results. Similarly the total 179 villages of Ground Nut crop are cultivated in district Bhakkar and sample size of 9 villages has been taken. The data of these selected villages has been taken with personal efforts and corresponding department. For this crop also (8x6) feet has been as small plot size plot and (12x16) feet as large which is the existing plot size of department.

Finally another minor crop for Kharif season is mung which is cultivated in 514 villages and 26 villages are selected as a sample from these 514 by the crop reporting service Punjab. Similarly the previous method is used for getting small plot size (8x6) feet and large plot size (12x16) feet data. Besides this data of actual yield from selected villages of all crops have been collected through interviewed by the farmers. The following variables are used to find expected results:

v = yield of selected villages (study variable)
u = cropped area of selected fields (auxiliary variable)
U= cropped area of selected villages

For the analysis of the data following four sampling estimators are applied:

1. Ratio estimator
2. Regression estimators
3. Product estimators
4. Generalized Modified product estimators

Ratio estimator and its mean square error:

If the correlation between study variable and auxiliary variable is positive then Ratio estimator is more efficient. In this estimator the use of auxiliary information helps to achieve higher efficiency and more precise results. This estimator is used to estimate Ratio like per capita income or expenditure. Similarly the use of this estimator is to estimate yield per unit area. It is very important in case of agriculture surveys like use of fertilizer per acre for any crop. It is also applied in industry and commerce to estimate input or output Ratios.

$MSE(\bar{v}_r) = (\frac{1-f}{n}) \bar{V}^2 (C_v^2 + C_u^2 - 2 \rho C_u C_v)$

u = study variable (yield of the crop from selected villages)
v = auxilury variable (Cropped area of the selected villages)
Where ρ = correlation coefficient between U and V
If the U is not known then we use

MSE $(\bar{v}_r) = (\frac{1-f}{n}) (s_v^2 + \hat{R}^2 s_u^2 - 2 \hat{R} S_{uv})$

Regression estimator and its Mean square error:

Regression estimator is also used when the correlation between study variable (v) and auxiliary variable (u) is positive and if the regression of v of v on u is linear, the regression line does not passes through origin like Ratio estimator then this estimator is more efficient. In this estimator auxiliary information is also used to increase efficiency.

The regression model is

$V_i = \alpha + \beta\mu_i + \epsilon_i$ i = 1, 2 …N

where $\sum_{i=1}^{N} \epsilon_i = 0$

We assume random sample where v_i and u_i are each calculated for every unit in the sample and that the population mean $\overline{U}$ of u_i is known, the linear regression estimator of $\overline{U}$ (the population mean of v_i) is $\hat{\hat{V_r}} = \bar{v} + b(\overline{U} - \bar{u})$ is called regression estimator of $\overline{V}$ where $\bar{v}$ and $\bar{u}$ are sample mean of the variable V and U. The subscript $\hat{\hat{V_r}}$ denote the linear regression and b is change in V when U is increased by unity , estimated through least square. Regression estimator uses little more calculations as compared to ratio estimator and it is at least as efficient ratio estimator for obtaining population mean or population total. For instance Watson (1937) found regression of leaf area on leaf weight to compute the mean life area for a plant. The regression estimator has the following properties:

(i) This estimator is consistent.

(ii) It may be biased estimator when the ratio between bias and standard error is negligible when the sample size is large.

(iii) If b = 0 then $\hat{\hat{V_r}} = \bar{v}$

There are two cases arise in regression estimator

(i) When b is known

In simple random sampling if b = b_0 than this estimator is unbiased with variance

E ($\hat{\hat{V_r}}$) = 0 and

V ($\hat{\hat{V_r}}$) $= \frac{1-f}{n}(S_v^2 - 2\, b_0 S_{uv} + b_0^2 S_u^2)$ Where $b_0 = \frac{s_{yx}}{s_x^2}$

(ii) when b is unknown

When b is unknown we compute it by least square method

$b = \frac{\sum_{i=1}^{n}(v_i - \bar{v})(u_i - \bar{u})}{\sum_{i=1}^{n}(u_i - \bar{u})^2}$

MSE ($\hat{\hat{V_r}}$) $= (\frac{1}{n} - \frac{1}{N})\, s_v^2\, (1 - r^2)$

Where $r = \frac{S_{uv}}{S_u S_v}$ is the sample correlation coefficient.

Product estimator and its mean square error:

If the correlation between auxiliary and study is positive then the Ratio and regression type of estimators have been preferred. But there are many situations where these variables are negatively correlated to each other then the product estimator is more efficient.

The Ratio estimator is more efficient then product estimator

If $\rho > \frac{1}{2}\frac{C_v}{C_u}$ if R > 0

But in the following case Product estimator is preferred then other estimators

$\rho < -\frac{1}{2}\frac{C_v}{C_u}$

The Product estimator of the population mean $\overline{V}$ is defined as

$\hat{\hat{V_p}} = \frac{\bar{v}\bar{u}}{\overline{U}}$

It is assumed that population mean $\overline{U}$ to be know so the bias and variance of $\hat{\hat{V_p}}$ is as follows

Bias ($\hat{\hat{V_p}}$) $= \frac{N-n}{Nn}\left(\frac{S_{uv}}{\overline{U}}\right)$ Bias ($\hat{\hat{V_p}}$) $= \frac{N-n}{Nn}\overline{V}\rho C_u C_v$

Mse ($\hat{\hat{V_p}}$) = E $\left(\hat{\hat{V_p}} - \overline{V}\right)^2$

Mse ($\hat{\hat{V}}_p$) = $\frac{N-n}{Nn}$[s_v^2+ $\hat{R}^2 s_u^2$+ 2 $\hat{R} s_{uv}$]

Where $\hat{R} = \frac{\bar{v}}{\bar{u}}$ or $\hat{R} = \frac{\sum_{i=1}^{n} v_i}{\sum_{i=1}^{n} u_i}$

Generalized modified product estimators:

Like Product estimator when study variable (v) and auxiliary variable (u) are negatively correlated then Generalized Modified Product estimator is more efficient. Also in this estimator use of auxiliary information increase the precision and efficiency. It is denoted by$\hat{\hat{V}}_{Gp}$.

$\hat{\hat{V}}_{Gp}$= $\frac{\bar{v}}{\bar{U}}\left[\alpha\bar{u} + (1-\alpha)\bar{U}\right]$

Therefore E ($\hat{\hat{V}}_{Gp}$) = $\bar{V} + \frac{1-f}{n}\bar{V}$ [($\alpha\rho C_v C_u$)]

MSE ($\hat{\hat{V}}_{Gp}$) = $\frac{1-f}{n}\bar{V}^2$ (C_v^2 + $\alpha^2 C_u^2$ + 2 $\rho C_v C_u$)

For finding αdifferentiate equation with respect to $\alpha$and putting equal to zero

α_{min} = - $\rho\frac{C_v}{C_u}$ = - $\frac{\beta}{R}$

$\hat{\hat{V}}_{Gp_{min}}$ = $\bar{v}$ [1 - $\frac{\beta}{R}$ ($\frac{\bar{u}-\bar{U}}{\bar{U}}$)]

So the Bias and Mean square error of above equation

Bias ($\hat{\hat{V}}_{Gp})_{min}$= - $\frac{1-f}{n}$ ($\frac{r^2}{\bar{v}}$)

and MSE ($\hat{\hat{V}}_{Gp})_{min}$= $\frac{1-f}{n} S_v^2$ (1 - r^2)

Where r = sample correlation between u and v.

Analysis of data:

There are four estimators have been applied on four different crops like Ratio estimator, Regression estimator, Product estimator and Generalized modified product estimators. These four crops are wheat, gram, mung and Ground nut.

1. Wheat:

If the correlation between study variable and auxiliary variable is negative then the product and generalized modified product estimator are more efficient. Table 1 show the comparison of small (6x8) feet and large (15x20) feet plot size of wheat crop using product and Generalized modified product estimator.

Table 1. Comparison of small and large plot size of wheat crop.

Estimator	Plot size	Mean square error
Product estimator	(15x20) Feet	25.0856
Product estimator	(6x8) Feet	0.6353
Generalized modified product estimator	(15x20) Feet	3.1945
Generalized modified product estimator	(6x8) Feet	0.0558

So small plot size has the minimum value of mean square error than large plot size using product and generalized modified product estimator. The technique of small plot size is more efficient as compared to large plot size.

2. Gram:

Similarly if the correlation between study variable and auxiliary variable is negative then the product and generalized modified product estimator are more efficient. Table 2 shows the comparison of small (6x8) feet and large (15x20) feet plot size of gram crop using product and Generalized modified product estimator.

Table 2. Comparison of small and large plot size of gram crop.

Estimator	Plot size	Mean square error
Product estimator	(15x20) Feet	0.8510
Product estimator	(6x8) Feet	0.0228
Generalized modified product estimator	(15x20) Feet	0.1544
Generalized modified product estimator	(6x8) Feet	0.0042

Therefore small plot size has the minimum value of mean square error than large plot size using product and generalized modified product estimator. The technique of small plot size is more efficient as compared to large plot size.

3. Mung:

When the correlation between study variable and auxiliary variable is positive then the Ratio and Regression estimator are more efficient. So if correlation between study and auxiliary variable of mung crop is positive then Ratio and Regression estimator are preferred. Table 3 shows the comparison of small (6x8) feet and large (12x16)) feet plot size of mung crop using Ratio and Regression estimator.

Table 3. Comparison of small and large plot size of Mung crop.

Estimator	Plot size	Mean square error
Product estimator	(15x20) Feet	0.2205
Product estimator	(6x8) Feet	0.0017
Generalized modified product estimator	(15x20) Feet	0.1270
Generalized modified product estimator	(6x8) Feet	0.0076

So small plot size has the minimum value of mean square error than large plot size using Ratio and Regression estimator. The technique of small plot size is more efficient as compared to large plot size.

Table 4. Comparison of small and large plot size of ground nut crop.

Estimator	Plot size	Mean square error
Product estimator	(15x20) Feet	1.3583
Product estimator	(6x8) Feet	0.0051
Generalized modified product estimator	(15x20) Feet	0.3315
Generalized modified product estimator	(6x8) Feet	0.0327

Therefore small plot size has the minimum value of mean square error than large plot size using Ratio and Regression estimator. The technique of small plot size is more efficient as compared to large plot size.

Comparison of actual yield with small and large size plot of Wheat crop:

The following table explains which method is more suitable to find better yield:

Table 5. Comparison of total production of wheat.

Methods	Actual production	Estimate of wheat production by	
		15x20 feet plot size	6x8 feet plot size
Total Production (Million Kilograms)	461.95	481.438	466.7928

The actual production of district Bhakkar is 461.95 million kgs using farmer's interviews, 481.438 million kgs for 15 x 20 feet plot size and 466.7928 million kgs for 6 x 8 feet plot size. The difference between actual production and large plot size is 19.480 million kgs. And the difference between actual production and small plot size is 4.8428 kgs. The difference between small plot size production and actual production is less as compared to the difference between large plot size and actual production. So the Method of small plot size (8x6) feet is better than large plot size (15 x 20) feet.

Comparison of actual yield with small and large size plot of Gram crop:

The following Table explains which method is best to find better yield:

Table 6. Comparison of total production of gram.

Methods	Actual production	Estimate of gram production by	
		15x20 feet plot size	6x8 feet plot size
Total Production (Million Kilograms)	149.842	157.633	155.880

The actual production of district Bhakkar for gram crop 149.842 million kgs is estimated by using farmer's interviews 157.63345 million kgs for 15 x 20 feet plot size and 155.8896 million kgs for 6 x 8 feet plot size. The difference between actual production and large plot size is 7.7914 million kgs and the difference between actual production and small plot size is 6.0476 million kgs. The difference between small plot size production and actual production is less as compared to the difference between large plot size and actual production. So the Method of small plot size (6x8) feet is better than large plot size (15 x 20) feet.

Comparison of actual yield with small and large size plot of Ground Nut crop:

The following table explains which method is best to find better yield:

Table 7. Comparison of total production of ground nut.

Methods	Actual production	Estimate of ground nut production by	
		15x20 feet plot size	6x8 feet plot size
Total Production (Million Kilograms)	1.0350	1.0259	1.0338

The actual production of district Bhakkar of Ground Nut crop is 1.035 million kgs using farmer's interviews, 1.0259 million kgs for 12 x 16 feet plot size and 1.0338 million kgs for 6 x 8 feet plot size. The difference between actual production and large plot size is 0.0091 million kgs and the difference between actual production and small plot size is 0.00116 million kgs. The difference between small plot size production and actual production is less as compared to the difference between large plot size and actual production. So the Method of small plot size (6x8) feet is better than large plot size (12x16) feet

Comparison of actual yield with small and large size plot of Mung crop:

The following table explains which method is best to find better yield

Table 8. Comparison of total production of mung.

Methods	Actual production	Estimate of mung production by	
		15x20 feet plot size	6x8 feet plot size
Total Production (Million Kilograms)	40.7960	41.8498	40.5766

The actual production of district Bhakkar is 40.7960 million kg using farmer's interviews, 41.8498 million kg for 12 x 16 feet plot size and 40.5766 million kg for 6 x 8 feet plot size. The difference between actual production and large plot size is 1.0538 million kg and the difference between actual production and small plot size is 0.2194 kg. The difference between small plot size production and actual production is less as compared to the difference between large plot size and actual production. So the Method of small plot size (8x6) feet is better than large plot size (12 x 16) feet.

CONCLUSION

In this research work primary data has been taken to estimates the production of wheat, gram, ground nut and mung by using crop cutting experiments of plot size 15x20 and 6x8 square feet from district Bhakkar. Plot cutting experiments have been conducted under the guidance of the staff of Crop Reporting Service, agriculture department Bhakkar, Punjab. Here it is concluded that the data of small plot size give minimum mean square error as compared to large plot size. This is also concluded that the difference between actual yield which is obtained from farmer's interviews and small plot size yield is the minimum as compared to difference between actual yield and existing plot size yield. So is concluded that the small plot size, that is, 6x8 square feet for crop cutting experiment provides better estimates of the crop production.

REFERENCES

Foeken, D. W. and S.O. Owuor (2000). *Urban farmers in Nakuru, Kenya*. ASC working papers 45 / 2000. African studies center, Leiden, Netherlands

Fielding, W. J. and J. Riley (1997). How Big Should On-Farm Trials Be and How Many Plots Should Be Measured? PLA Notes 29:19–22. International Institute of Economic Development, London

Panse, V. G. (1954). *Manual on the Estimation of Crop Yields*. Food and Agricultural Organization of the United Nations, Rome, Italy (Reprinted in 1964).

Mahalanobis, D. C. (1946). *Report on the Bihar crop survey: rabi season 1943 - 1944*. Sankyhaz., 1: 29-106 Crop Reporting Service, Agriculture Department, Government of Punjab, Lahore, Punjab Agriculture Statistics.

CRS (2016). Crop Reporting Service, Agriculture Department, Government of Punjab, Lahore, Punjab Agriculture Statistics.

El-Sergani, D. Z. and I. H. El-Geddawy (1992). Estimation of soil variability, optimum plot size, slope and number of replications for sweet sorghum in calcareous soils. *Egypt. Agric.*, 70 (5): 845-859.

Watson, D. J. (1937). The estimation of leaf areas. *Jour.Agri. Sci*., 27: 474.

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