CHAPTER IV

DETERMINANTS OF YIELD, YIELD GAP AND YIELD CONSTRAINTS

This chapter presents the earlier studies related to yield gap. It is, also devoted to identify and compare the variables, which influence the yield of sugarcane for small and large farmers cultivating planted and ratoon crops in the study area. In addition to this, it examines the yield gap arising out of the difference between the maximum and the average yield at farm level under each group of farmers. It further investigates the yield constraints, which prevent the sugarcane farmers from achieving the potential yield at farm level in the study area.

4.1 REVIEW OF LITERATURE ON YIELD GAP:

This review of previous studies is of much use to the researcher to form the analysis in such a manner that the person who carries out research may not repeat what has been done already. It gives a clear picture of what is to be done. The forms and methods used by different authors guide the researcher to form a way for the analysis. It helps the researcher to minimise the difficulties while conducting a study. Thus review of related literature is essential to make this study more effective in analysing yield gap.
Davidson and Martin\textsuperscript{1} surveyed the variations in yield on farms and at experimental stations for different crops, including rice, in Australia. The yield gap between farms and experimental stations was observed to vary according to the cultivation season. During good years, the yield at experimental station was found to increase more rapidly than the yield of farmers within the same district. This was mainly because the farmers were more interested in maximising their profits by limiting their input investment, while the experimenters only aimed at maximising yield and had no cost restraints.

Herdit and Wickham\textsuperscript{2} referred to the total yield gap and partitioned the gap into year-to-year yield variation, seasonal effects (dry and wet) water control, economic constraints, lack of availability of inputs and non-adoption of technology. They attributed the yield gap in the negative direction to technical and allocative inefficiencies. Technical inefficiency was the difference between the highest possible yield for a given level of input and yield attained by the farmer whereas allocative inefficiency occurred when the farmer did not use the quantity of fertilizer or other inputs that would maximise the output.


\textsuperscript{2}R.W. Herdit and T. Wickham, "Exposing the Gap between Potential and Actual Rice Yields in the Philippines", \textit{Food Research Institute Studies}, Vol.16(2), 1975, pp. 163-181.
Adulavidhaya\textsuperscript{3} examined the relationship between yield and factors such as fertilizers, weed control cost, land tenure and rice variety in Thailand. The study indicated a weak relationship between yield and fertilizer and variety during the wet season. Weed control or tenure has no impact on yield. In the dry season, only fertilizer had a significant impact on rice yield. Other independent variables were not significantly related to yield.

Gomez\textsuperscript{4} in his study defined the factors responsible for yield gap as yield constraints. Yield gap I was hypothesized to be caused by either environmental differences between experimental station and farmer’s field or by non-transfer of technology. Yield gap II was caused by biological and socio-economic constraints. Biological constraints referred to the uncontrollable natural factors and socio-economic constraints to the social and economic factors that prevented the farmers from using the recommended technology. Gomez developed the conceptional model of yield gap.


Tripathy\textsuperscript{5} in his study had concluded that, about 17 per cent of the gap in the yield was caused by technology gap. The different packages of practices individually account for the technological gaps. Of the gaps water management, disease and pest control, and nitrogen application caused 20.34 per cent, 17.92 per cent and 12.37 per cent respectively. Another 19.83 per cent of the gap was due to the ecological factors like temperature, soil, rainfall and sunshine intensity.

Kuo, Wu and Li\textsuperscript{6} in their study, "Rice Production in Taiwan’s Agriculture", attempted to identify the factors associated with variations in yield, using a regression model. Data were collected from a sample of 60 farmers of Tah-yia, Taiwan in 1975. Fertilizers, labour, net returns, technician’s value and number of practices constituted the main explanatory variables. The analysis showed that the independent variables explained 51 per cent of the observed variability in rice yield. The result suggested that more extension services were needed in rice production. They also indicated that organic manure; complementary irrigation and hand-weeding produced positive effect on rice yields.

\textsuperscript{5}A. Tripathy, \textit{A Study of Technological Gap in Adoption of New Rice Technology in Coastal Orissa and Constraints Responsible for the Same}, Unpublished Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi, 1977.

\textsuperscript{6}Yi-chung Kuo, Carson Wu and Cheng Chang Li, "Rice Production in Taiwan’s Agriculture, Constraints of High Yields on Asian Rice Farms", \textit{An Interim Report}, IRRI, Philippines, October 1977, pp177-201.
Barker\textsuperscript{7} has highlighted two common ways of defining the concept of yield gap – first, by directly comparing the experimental station yield to the yield at farm; second, by comparing the yield of the best farm with that of the average or the poorest farm. Thus, yield gap may be classified into two kinds – Yield Gap I and Yield Gap II. The Yield Gap I represents the difference between experimental station yield and potential farm yield. The Yield Gap II corresponds to the potential farm yield and actual farm yield. The maximum yield obtainable from a variety under a particular situation is called ‘potential yield’, while the average yield attained under farm conditions is known as the ‘actual yield’. The factors that prevent farmers from achieving the potential yield under farmers’ conditions are known as ‘yield constraints’.

Saini\textsuperscript{8} in his study, “Allocation Efficiency in Agriculture-Crop Level Analysis”, covered 200 farms of 100 each, in the districts of Meerut and Muzaffarnagar in Uttar Pradesh. The analysis was based on the Farm Management data for 1955-56. Cobb-Douglas production function was fitted with output as the dependent variable and area, labour, bullock labour, farm manures and fertilizers and


irrigation as five independent variables. The analysis indicated that output was highly responsive and significantly related to land, followed by human labour.

Carson Wuu et al.,⁹ studied the variability in rice yield. Of the seven independent variables, damages by natural forces were reported to be the most significant factor affecting yield. Fertilizer and herbicide also had a significant impact on the yield of rice.

Fujimoto,¹⁰ in his study, analysed the determinants of rice yield with respect to cultivation techniques, using a regression model. The functional relationship between yield and four independent variables - labours, fertilizers, pesticides and farmers' educational levels was estimated using the data for 1977-78, the main season of Wellesley Province in Malaysia. The analysis revealed that 41 per cent and 63 per cent of the variations in yield among the Malay and Chinese farmers respectively, were jointly explained by the independent variables. Education was the most important determinant of yield in both groups.


Singh\textsuperscript{11} had found through his study, that the uncertain production trends, inadequate credit facilities for ratoons, continuance of old varieties and lack of technology transfer were the major constraints in increasing the production and productivity of sugarcane.

Swaminathan,\textsuperscript{12} a reputed agricultural scientist has evolved high-yielding varieties through increase in productivity rather than through expansion of the area cultivated. It involves the transfer of research from experimental laboratories to the farm. Agricultural research centres strive to maximise yield through optimum use of resources. These centres seek to develop technologies suitable to the socio-economic conditions of a region, through integrated socio-economic and biological research. Undertaking on-farm testing, demonstrations, operational research projects and the like examine the validity and viability of experimental findings. However, the farmers’ yields are often reported to be lower than those obtained at the experimental stations. The difference between the experimental station yield and the actual farm yield is referred to as “yield gap”.


Suryawanshi and Gaikwad,\textsuperscript{13} in their study “An Analysis of yield gap in Rabi and Jowar in Ahamednagar district”, found that, there was a wide gap in yield when the new technology was adopted. The yield was just 2.12 quintals/ha, under traditional method of cultivation, 3.42 quintals/ha, when there was partial adoption of technology and 7.02 quintals/ha., when it was fully adopted as in demonstration plots. Multiple regression analysis showed that early sowing not only increased yield of jowar but also resulted in the increase of productivity of the resource. Recommended varieties, fertilizers and timely sowing were found to be important factors to reduce the yield gap.

The Yield gap was conceptualised by Chandrasekaran.\textsuperscript{14} He has analysed yield gap I and II in his study. The yield gap I was the difference in yield between the research station yield and the potential yield in farmer’s field as estimated from the demonstration and the yield gap II was the difference in yield between the potential yield realised in the demonstration plots and the averaged farm yield from the sugarcane crop. His study revealed the fact that yield gap I was due to the non-transferable technology and environmental demonstration plots. The gap II was due to biological, socio-economic and technical constraints which were responsible for


the deviation in the adoption of recommended levels of technology. This gap would be narrowed down by reviewing the socio-economic and technical barriers constraining the adoption of technology in the farms.

Fale et al.,\textsuperscript{15} in their study, "An Economic Analysis of Yield Gap in Rice in Ratnagiri District", argued that yield obtained at the experimental station couldn't be achieved on farms because of differences in environment, input use and management. Therefore, they defined yield gap as the difference between the potential yield, that is, yield obtained in the demonstration plots and the actual farm yields. They defined potential yield as the yield that could be obtained in farmers' field by adopting the improved technology. They observed that, the gap between yields on experimental stations and those obtained on national demonstration plots (Gap I) was quite narrower (2 qtls/ha. or 3.83 per cent). However, the gap between potential yield and the actual yield on farmers' fields was very wide (i.e., 27 qtls/ha or 52 per cent). There existed difference in utilisation of improved inputs such as fertilizers and labour. Higher level of input was used on national demonstration plots as compared to farmers' level.

Flinn and Ali\textsuperscript{16} presented yield gap analysis instrumental in measuring the magnitude of gap in the yields and in the identification of constraints responsible for it. It is not proper to consider Yield Gap I in a study, as experimental stations rarely encounter the constraints experienced by the farmers. Such estimates would be biased and larger than what it is actually under the farmers’ conditions. Hence, Yield Gap II has been examined in this study. It is defined as the difference between the highest yield obtained by the most efficient farmer in the sample and the average level of yield achieved under farmer’s conditions.

Yadava and Gangwar\textsuperscript{17} stated that, per hectare yield gaps were eight and 10 quintals for early and late maturing rice in Bihar State. In this State, yield of high yielding variety rice was 35.56 quintals per hectare, which was about 160 per cent higher than that of local varieties. Yield gap between potential farm yield and the actual realised yield was quite high indicating future potential for increase in production of rice in the State. The reason for this yield gap was only the partial adoption of new rice technologies. The author remarked that there was a need to strengthen the extension and input supply services in Bihar immediately.


\textsuperscript{17}R.N. Yadava and A.C. Gangwar, “Rice Production and Constraints in Bihar State”, \textit{Agricultural Situation in India}, Vol.12, No.1, 1986, pp.9-13.
Subramaniyan and Nirmala\textsuperscript{18} in their study, "Yield Gap Analysis in Rice Cultivation", analysed yield gap among IR20 and Co.37 rice cultivators in Gokilapuram village of Madurai district for kharif 1986. Yield gap under the former variety (3.54 qtls. per acre) worked out to be higher than that of the latter (2.81 qtls. per acre). Further, Garrett's ranking technique was used to identify the important constraints to potential yield in the study area. The main constraints observed were water shortage, insects, credit, traditions, weeds and non-availability of seeds.

Mani and Pandey\textsuperscript{19} conceptualised yield gap as 'theoretical yield gap', 'field level yield gap' and 'farm level yield gap'.

Umamaheswari\textsuperscript{20} in her study, "Yield Gap Analysis of Principal Crops in Palani Taluk, Dindigul-Quaid-E-Milleth District", identified the technical and socio-economic constraints by using Garrett's ranking technique. She proved that technical and socio-economic constraints prevented the farmers from achieving the maximum possible yield. Non-availability of required chemicals was the major cause and lack


\textsuperscript{19}Gyanendra Mani and V.K. Pandey, "Cropping Pattern and Yield Gaps under Dry Land Farming Conditions in U.P.", \textit{Agricultural Situation in India}, Vol. 45(2), 1990, p. 1007-1010.

of finance and knowledge were some of the constraints for the use of recommended levels of plant protection measures in both irrigated and rain-fed crops.

Uma\textsuperscript{21} studied yield gap in Thanjavur district, applied yield gap function, discriminant function and constraint analysis and also applied percentage analysis to identify the factors causing yield gap. She concluded that out of several technical constraints, water problem ranked first. Out of 90 farmers interviewed, 79 attributed inadequate and untimely water supply as the major technical constraint leading to yield gap. In socio-economic constraints, 50 per cent of the farmers expressed non-availability of labour as the main factor followed by lack of credit facilities (44.44 per cent), lack of own funds (28.87 per cent) and lack of awareness (22.22 per cent).

Thiruvenkatachari et al.,\textsuperscript{22} defined yield gap as the difference in the yield between the one obtained by the demonstration plots using recommended dosage of inputs and yield registered by the individual sample farmers.

Rajeswaran and Varadarajan\textsuperscript{23} defined yield gap II as the difference between maximum yield realised in farms in a region and actual yield of other farmers. They


\textsuperscript{22}Thiruvenkatachari, B.N. Viswanathan and K.S. Seetharaman, “An Economic Analysis of Groundnut Production in Rainfed Area – A Study in Tamil Nadu”, \textit{Agricultural Situation in India}, Vol. 46(6), 1991, p. 433.

indicated yield gap analysis as the measure of resource-use efficiency of farms for the conventional resources.

Shanmugam and Thirupathi\textsuperscript{24} used Cobb-Douglas type of production function for identifying the influence of technical and socio-economic constraints on yield gap in hybrid cotton and seed enterprise. The availability of agricultural chemicals and nutrients in proper time and labour supply during peak seasons were found to be the important technical constraints. Lack of education and poor access to credit were the major socio-economic factors influencing yield gap.

Ramasamy et al.,\textsuperscript{25} in their study decomposed yield gap into two parts namely yield gap I indicating the difference between experiment station’s maximum yield and an on-farm experiment’s maximum yield and yield gap II accounting for the difference between actual farm yield and yield attained in on-farm experiments.

Nagaraj et al.,\textsuperscript{26} examined the resource-use pattern and yield obtained in different cropping systems in Tungabhadra project command area in Karnataka


\textsuperscript{25}C. Ramasamy, T.R. Shanmugam and D. Suresh Kumar, \textit{Constraints to Higher Yields in Different Rice Production Environments and Prioritization of Rice Research in Southern India}, Tamil Nadu Agricultural University, Coimbatore, 1994, p. 3.

\textsuperscript{26}Nagaraj, H.S.S. Khan, H.G. Shankara Murthy and H.S. Vijayakumar, “Resource-Use Pattern and Yield Obtained in Different Cropping System in TBP Command area (Karnataka State)”, \textit{Agricultural Situation in India}, Vol. 42(3), 1995, pp. 121-125.
State. They identified that in the case of cotton and maize – sunflower system, the yield gap observed on small farms was wider than that on large farms due to inadequacy of water supply and lower quantities of fertilizer use. The study indicated a positive and significant relation for the interaction between fertilizer and irrigation.

Jagadish Lal\(^{27}\) in his study on “Raising Sugar Productivity through Improvement in Sugarcane Development, Marketing and Supply” found that the wide gap between commercial and competition plots was due to the non-adoption of the recommended levels of technologies. He suggested that consolidation of holdings should be done and effort should be made to develop suitable association of cultivators so as to improve productivity up to 240-280 tonnes of sugarcane.

In the present study, yield gap analysis has been carried out on the basis of yield gap II concepts adopted by most of the authors.

4.2 THE ANALYTICAL FRAMEWORK:

In order to identify the determinants of yield per acre for small and large farmers producing sugarcane of planted and ratoon crops, the multiple linear regression models of Cobb-Douglas type is used in the study. The per acre yield is

taken as the dependent variable and the four factor inputs are included as independent variables. The regression model in the case of planted sugarcane fitted is of the following form:

\[
\log Y = \alpha_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \beta_3 \log X_3 + \beta_4 \log X_4 + U \quad \text{----- (4.1)}
\]

where

\( Y \) = Per acre yield (in tonnes),

\( X_1 \) = Human labour per acre (in Rs.)

\( X_2 \) = Bullock labour per acre (in Rs.)

\( X_3 \) = Fertilizer per acre (in Rs.)

\( X_4 \) = Capital flow per acre (in Rs.) and

\( U \) = Disturbance term

The variable bullock labour (\( X_2 \)) was excluded from the model (4.1) and the following form was estimated in the case of ratoon sugarcane.

\[
\log Y = \alpha_0 + \beta_1 \log X_1 + \beta_3 \log X_3 + \beta_4 \log X_4 + U \quad \text{----- (4.2)}
\]

In order to examine the structural difference, between small and large farmers producing planted and ratoon sugarcane crops, Chow's test is applied.

\[
F = \frac{\sum e^2 - (\sum e^2_1 + \sum e^2_2)}{k} \frac{(\sum e^2_1 + \sum e^2_2) / (n_1 + n_2 - 2k)}{k} \quad \text{----- (4.3)}
\]
where,

\[ k = \text{The number of parameters including the intercept term in the regression model,} \]

\[ \sum e^2 = \text{Unexplained or residual sum of squares of the sample corresponding to both small and large farmers.} \]

\[ \sum e_1^2 = \text{Unexplained or residual sum of squares of the sample corresponding to small farmers.} \]

\[ \sum e_2^2 = \text{Unexplained or residual sum of squares of the sample corresponding to large farmers.} \]

\[ n_1 = \text{Sample size of small farmers and} \]

\[ n_2 = \text{Sample size of large farmers.} \]

The 'F' test is carried out and if the computed value of 'F' is less than the table value of F at 5 per cent level of significance with \((k, n_1+n_2-2k)\) degrees of freedom, the null hypothesis that there is no structural difference between the two groups of farmers could be accepted. If there is a structural difference between the two groups, to test whether the difference occurs at the intercept or at the slope level or at both levels has to be conducted by incorporating the dummy variables at the intercept and slope levels in the regression model (4.1).
The structural differences between the two groups of farmers are tested by using the regression model of the following form:

\[
\log Y = \alpha_0 + \alpha_1 D + \sum_{i=1}^{4} \beta_i \log X + \sum_{i=1}^{4} r_j D \log X_i + u \quad \text{-------- (4.4)}
\]

In the model (4.3) D is the dummy variable. The dummy variable D is 0 for the small farmers and 1 for the large farmers.

4.2.1 Estimated Results of Regression Model for Planted Sugarcane:

The regression model (4.1) is estimated by the method of least squares for small, large and overall sample farmers cultivating planted sugarcane separately. The estimated results are presented in Table 4.1
TABLE 4.1  
ESTIMATED REGRESSION RESULTS FOR SMALL AND LARGE FARMERS CULTIVATING PLANTED SUGARCANE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Small Farmers</th>
<th>Large Farmers</th>
<th>Overall Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.7343</td>
<td>3.1068</td>
<td>2.9817</td>
</tr>
<tr>
<td>Log X₁</td>
<td>0.3241*</td>
<td>0.2979*</td>
<td>0.3083*</td>
</tr>
<tr>
<td></td>
<td>(2.9241)</td>
<td>(3.1052)</td>
<td>(2.9869)</td>
</tr>
<tr>
<td>Log X₂</td>
<td>0.0969</td>
<td>0.0481</td>
<td>0.0803</td>
</tr>
<tr>
<td></td>
<td>(1.0212)</td>
<td>(0.6093)</td>
<td>(0.0942)</td>
</tr>
<tr>
<td>Log X₃</td>
<td>0.3088*</td>
<td>0.2768*</td>
<td>0.2851*</td>
</tr>
<tr>
<td></td>
<td>(2.9531)</td>
<td>(2.6763)</td>
<td>(3.2244)</td>
</tr>
<tr>
<td>Log X₄</td>
<td>0.2953*</td>
<td>0.3986*</td>
<td>0.3292*</td>
</tr>
<tr>
<td></td>
<td>(4.0701)</td>
<td>(3.9183)</td>
<td>(4.1763)</td>
</tr>
<tr>
<td>R²</td>
<td>0.7694</td>
<td>0.8101</td>
<td>0.7983</td>
</tr>
<tr>
<td>F- Value</td>
<td>48.7448</td>
<td>37.49618</td>
<td>46.1464</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>0.098</td>
<td>0.094</td>
<td>0.376</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>97</td>
<td>53</td>
<td>150</td>
</tr>
</tbody>
</table>

Figures in bracket represent t-value.
* Indicates that the co-efficients are statistically significant at 5 per cent level.

It is found from Table 4.1, in the case of small farmers, R² value indicates that about 77 per cent of variations in yield are jointly explained by the four explanatory variables included in the model. Human labour, fertilizer and capital flows are found to be statistically significant at 5 per cent level. It indicates that one per cent increase in these variables can increase yield by 0.3241 per cent, 0.3088 per cent and 0.2953 per cent respectively. It is also found that the human labour has a greater influence
on the determination of yield, followed by fertilizer. As per F-value, the fitted regression model is statistically significant at 5 per cent level.

As far as the large farmers are concerned, all the four explanatory variables together accounted for 81 per cent variation in yield. All the four variables are positively related to yield. Human labour, fertilizer and capital flows are emerged statistically significant at 5 per cent level, indicating that one per cent increase in these variables can increase the yield per acre by 0.2979 per cent, 0.2768 per cent and 0.3986 per cent respectively. The impact of capital flow on yield of sugarcane is found to be higher in the case of large farmers. The F-value shows that the estimated regression model is statistically significant at 5 per cent level.

In the case of overall sample farmers, the four independent variables are jointly accounted for about 80 per cent of the variations in the yield of sugarcane. All the four variables have a positive effect on the determination of yield. The input variables such as human labour, fertilizers and capital flow are found to be significantly related to the yield of sugarcane. It means that an additional percentage of use of these variables is capable of increasing the yield by 0.3083 per cent, 0.2851 per cent and 0.3292 per cent per acre respectively. The capital flows are found to be the most influential input on yield determination of sugarcane, followed by human labour and fertilizer. The F-value shows that the overall regression model emerged statistically significant at 5 per cent level.
Thus, it may be concluded from the analysis that the explanatory variables included in the model together explain for 77 to 81 per cent of the observed variability in the yield of sugarcane in the case of small, large and overall farmers. Human labour is found to be the most significant input influencing the yield of sugarcane in the case of small farmers, whereas, in the case of large farmers and overall farmers, capital flow has a greater influence on yield of sugarcane.

4.2.2 Test for Structural Difference:

In order to examine the structural differences between small and large farmers producing planted sugarcane, Chow’s test (4.3) is carried out. The results are given in Table 4.2.

| TABLE 4.2 |
| TEST FOR EQUALITY OF PARAMETERS BETWEEN SMALL AND LARGE FARMERS PRODUCING PLANTED SUGARCANE |

<table>
<thead>
<tr>
<th>$\sum e^2$</th>
<th>$\sum e_1^2$</th>
<th>$\sum e_2^2$</th>
<th>$(n_1+n_2-2k)$</th>
<th>F</th>
<th>$(6,138)$ at 1 per cent level</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.376</td>
<td>0.098</td>
<td>0.094</td>
<td>138</td>
<td>21.93</td>
<td>2.80</td>
<td>Structural difference exists between small and large farmers</td>
</tr>
</tbody>
</table>

From Table 4.2, the result of Chow’s test shows that the computed F-value is higher than the table F-value ($F_{0.01}$) at one per cent level and it is statistically
significant at 1 per cent level. It means that structural difference existed between small and large farmers producing planted sugarcane.

4.2.3 Tests of the Stability of Intercept and Slope:

In order to find out the variables causing structural difference between two groups of farmers producing planted sugarcane, slope and intercept dummy variables are introduced in the regression model (4.1). The model (4.4) is estimated by the method of least squares and the results are given in Table 4.3 below:
**TABLE 4.3**

**TESTS FOR STABILITY OF INTERCEPT AND SLOPE BETWEEN SMALL AND LARGE FARMERS PRODUCING PLANTED CROP OF SUGARCANE**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.9324</td>
<td></td>
</tr>
<tr>
<td>Intercept dummy -d</td>
<td>0.0968</td>
<td>1.0218</td>
</tr>
<tr>
<td>log X₁</td>
<td>0.3282*</td>
<td>4.1927</td>
</tr>
<tr>
<td>log X₂</td>
<td>0.1063</td>
<td>0.0927</td>
</tr>
<tr>
<td>log X₃</td>
<td>0.2972*</td>
<td>3.1483</td>
</tr>
<tr>
<td>log X₄</td>
<td>0.3726*</td>
<td>2.7963</td>
</tr>
<tr>
<td>D log X₁</td>
<td>-0.0383</td>
<td>-0.0443</td>
</tr>
<tr>
<td>D log X₂</td>
<td>0.0046</td>
<td>0.0921</td>
</tr>
<tr>
<td>D log X₃</td>
<td>-0.0278*</td>
<td>-2.4261</td>
</tr>
<tr>
<td>D log X₄</td>
<td>0.0361</td>
<td>0.0394</td>
</tr>
<tr>
<td>R²</td>
<td>0.8129</td>
<td></td>
</tr>
<tr>
<td>F-Value</td>
<td>36.7267</td>
<td></td>
</tr>
<tr>
<td>No.of Observations</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

* Indicates that the co-efficient is statistically significant at 5 per cent level.

It is revealed from Table 4.3 that the dummy coefficient corresponding to the intercept is not statistically significant. It reveals that there is no difference between two groups of farmers with regard to technological change. It implies that the nature of technological change is neutral for both group of farmers. It indicates that the
yield curve of small farmers has shifted neutrally in relation to that of large farmers. In the slope dummy, the co-efficient corresponding to fertilizer emerged statistically significant. This implies that the structural difference between the two groups of farmers is caused with respect to the fertilizer.

In the case of small farmers, all the explanatory variables have positive impact on yield per acre. Out of the four, three variables namely human labour, fertilizers and capital flows emerge statistically significant at 5 per cent level. A percentage increase in these variables is capable of increasing yield by 0.3282, 0.2972 and 0.3726 per cent respectively. It is found that the human labour is the most influential variable in relation to yield, followed by fertilizer.

In the case of large farmers it is revealed that a structural difference is found due to the variable fertilizer. It indicates that an additional percentage of fertilizer is capable of increasing the yield of small farmers by 0.2972 per cent and large farmers by 0.2694 \[0.2972 + (-0.0278)\] per cent. It is observed from the analysis that fertilizer has a greater effect on the yield of small farmers than the large farmers producing planted sugarcane. The F-value shows that the fitted regression model is statistically significant at one per cent level.
4.2.4 Estimated Results of Regression Model for Ratoon Crop:

The regression model (4.2) is fitted by the method of least squares for small, large and overall farmers producing ratoon crop of sugarcane. The results are presented in Table 4.4.

**TABLE 4.4**

**ESTIMATED REGRESSION RESULTS FOR SMALL AND LARGE FARMERS CULTIVATING RATOON SUGARCANE**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small Farmers</td>
</tr>
<tr>
<td>Intercept</td>
<td>2.7224</td>
</tr>
<tr>
<td>Log $X_1$</td>
<td>0.3214*</td>
</tr>
<tr>
<td></td>
<td>(2.9148)</td>
</tr>
<tr>
<td>Log $X_3$</td>
<td>0.3022*</td>
</tr>
<tr>
<td></td>
<td>(2.9480)</td>
</tr>
<tr>
<td>Log $X_4$</td>
<td>0.2952*</td>
</tr>
<tr>
<td></td>
<td>(4.0698)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.7032</td>
</tr>
<tr>
<td>F- Value</td>
<td>48.7421</td>
</tr>
<tr>
<td>Residual Sum of Squares</td>
<td>0.0390</td>
</tr>
<tr>
<td>No. of Observations</td>
<td>86</td>
</tr>
</tbody>
</table>

Figures in bracket represent t-value.
* Indicates that the co-efficient is statistically significant at 5 per cent level.
It is seen from Table 4.4 that in the case of small farmers, \( R^2 \) value indicated that about 70 per cent of variation in yield are jointly caused by the three explanatory variables included in the model. All the three variables namely, human labour, fertilizer and capital flows are found to be statistically significant at 5 per cent level. It means that one per cent increase in these variables can increase the yield by 0.3214 per cent, 0.3022 per cent and 0.2952 per cent per acre respectively. It is also found that human labour has a greater influence on the determination of yield, followed by fertilizer and capital flow. As per F-value, the fitted regression model is statistically significant at 1 per cent level.

As far as the large farmers are concerned, all the three explanatory variables together accounted for 67 per cent variation in the yield. All the three variables included in the regression model, namely human labour, fertilizers and capital flow are found to be statistically significant at 5 per cent level. It indicates that a one per cent increase in these variables can increase the yield per acre by 0.2963 per cent, 0.2841 per cent and 0.3927 per cent respectively. The impact of capital flow on yield of sugarcane is found to be higher in the case of large farmers. The F-value shows that the estimated regression model is statistically significant at 1 per cent level.

In the case of overall sample farmers, the three independent variables are jointly accounted for 69 per cent of the variations in the yield of sugarcane. All the three variables have a positive effect on the determination of yield. The input
variables, human labour, fertilizer and capital flow are found to be significantly related to the yield of ratoon sugarcane. It indicates that an additional percentage of use of these variables is capable of increasing the yield by 0.3112 per cent and 0.2818 per cent and 0.3273 per cent per acre respectively. Capital flow is found to be the most influential input on yield determination of ratoon sugarcane crop, followed by human labour and fertilizer. The F-value shows that the overall regression model emerge statistically significant at 1 per cent level.

Thus, it may be concluded from the analysis that human labour is found to be a significant variable in the case of small farmers producing ratoon sugarcane whereas in the case of large farmers, capital flow is the most important variable influencing the yield of sugarcane.

4.2.5 Test for Structural Differences:

Table 4.5 highlights the results of Chow’s test (4.3) used to examine whether any structural differences existed between small and large farmers producing ratoon sugarcane crop in the study area.
TABLE 4.5
TEST FOR EQUALITY OF PARAMETERS BETWEEN SMALL AND LARGE FARMERS PRODUCING RATOON SUGARCANE CROP

<table>
<thead>
<tr>
<th>$\Sigma e^2$</th>
<th>$\Sigma e_1^2$</th>
<th>$\Sigma e_2^2$</th>
<th>$(n_1+n_2-2k)$</th>
<th>$F^*$</th>
<th>$F_{0.05}$ (6, 138)</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2967</td>
<td>0.0390</td>
<td>0.0481</td>
<td>138</td>
<td>58.17</td>
<td>2.80</td>
<td>Structural difference exists between small and large farmers</td>
</tr>
</tbody>
</table>

From the Table 4.5, the result of Chow’s test shows that the computed $F$-value ($F^*$) is higher than the table $F$-value ($F_{0.01}$) at one per cent level and it is statistically significant at 1 per cent level. It shows that structural differences existed between small and large farmers producing ratoon sugarcane.

4.2.6 Tests of the Stability of Intercept and Slope:

In order to find out the variables causing structural difference between small and large farmers producing ratoon sugarcane, slope and intercept dummy variables are incorporated in the regression model (4.1). The model (4.3) is estimated by the method of least squares and the results are shown in Table 4.6 given below:
### TABLE 4.6
TEST FOR STABILITY OF INTERCEPT AND SLOPE BETWEEN SMALL AND LARGE FARMERS PRODUCING RATOON CROP OF SUGARCANE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>t-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>2.0187</td>
<td></td>
</tr>
<tr>
<td>Intercept dummy (d)</td>
<td>1.0132</td>
<td>0.7089</td>
</tr>
<tr>
<td>(\log X_1)</td>
<td>0.2687*</td>
<td>3.7961</td>
</tr>
<tr>
<td>(\log X_3)</td>
<td>0.3012*</td>
<td>4.0122</td>
</tr>
<tr>
<td>(\log X_4)</td>
<td>0.3187*</td>
<td>3.7294</td>
</tr>
<tr>
<td>(D \log X_1)</td>
<td>0.0298</td>
<td>0.0499</td>
</tr>
<tr>
<td>(D \log X_3)</td>
<td>0.0681</td>
<td>0.0914</td>
</tr>
<tr>
<td>(D \log X_4)</td>
<td>0.0180*</td>
<td>2.7076</td>
</tr>
<tr>
<td>(R^2)</td>
<td>0.8083</td>
<td>--</td>
</tr>
<tr>
<td>F-Value</td>
<td>43.5241</td>
<td>--</td>
</tr>
<tr>
<td>No. of observations</td>
<td>150</td>
<td>--</td>
</tr>
</tbody>
</table>

* Indicates that the co-efficient is statistically significant at 5 per cent level.

As in the case of planted crop, the dummy co-efficient corresponding to intercept is also not statistically significant for ratoon sugarcane. It reveals that there in no difference between two groups of farmers with regard to technological change. It indicates that the yield curve of small farmers has shifted neutrally in relation to that of large farmers. In the slope dummy, the co-efficient corresponding to capital flow is emerged statistically significant. This implies that the structural differences
between the two groups of farmers are caused with respect to the variable capital flow.

Further, it is revealed from Table 4.6 that in the case of small farmers, all the three explanatory variables have positive impact on yield per acre. The three variables, namely human labour, fertilizers and capital flow emerged statistically significant at 5 per cent level. A percentage increase in these variables is capable of increasing the yield by 0.2687 per cent, 0.3012 per cent and 0.3187 per cent respectively. It is observed that the capital flow is the most influential variable in relation to yield, followed by the fertilizer.

In the case of large farmers, it is revealed that the structural difference is found due to the variable capital flows. It indicates that an additional percentage of capital flows is capable of increasing the yield of small farmers by 0.3187 per cent and large farmers by 0.3367 per cent. It is observed from the analysis that capital flows have a greater effect on the yield of large farmers than that of small farmers. The F-value shows that the fitted regression model is statistically significant at 1 per cent level.

4.3 YIELD GAP AND YIELD CONSTRAINTS:

For most of the crop varieties released from the research stations, the actual yield at field level differs from its potential yield tested at research stations. This
may be due to the difference in the level of adoption of technology between different farms and several other external factors. This gap between the actual yield realised by the farmers at the field level and the potential yield at research stations is otherwise termed as “yield gap”.

The yield gap analysis helps to measure the magnitude of the gap and identify the causes. This will help in suggesting suitable measures that could be adopted to reduce the gap. The yield gap is divided into three parts, Yield Gap I, II and III.

(i) Yield Gap I:

The difference between experimental station yield and potential farm yield (yield technology) is referred to as Yield Gap I. Yield gap I is caused by either environmental difference between stations and farmers field or by non-transfer of technology.

(ii) Yield Gap II:

Yield Gap II represented the difference between potential farm yield and actual farm yield. It is caused by biological and socio-economic constraints. Biological constraints refer to natural factors like soil fertility, rainfall, pest and diseases. Socio-economic constraints refer to social and economic conditions that prevent farmers from using the recommended technology. The socio-economic constraints are the attitude and knowledge level of the farmers, cost and returns, credit institutions and input availability.
Figure 4.1

Yield Gap

Gap I:
* Controlled environment
* Better Inputs
* Better Management

Gap II:
a) Technical Constraints
   • Pests and diseases
   • Lack of suitable varieties
   • Climatic conditions of the area

   b) Socio-Economic Constraints
      • Credit availability
      • High cost of inputs
      • Lack of labour

Gap III:
* Non-optional use of resources
* Managerial inefficiencies in crop management practices
* Inadequate and inefficient extension activities
(iii) Yield Gap III:

Yield gap III is due to the differences in the adoption of the improved technology and input usage between the individual farmers of the area.

The difference between the average farm yield and the yield obtained by progressive farmers or in the trials conducted on the farmers' fields was defined as the yield gap by Gangwar and Pandey.28

Meenakshisundaram and Sundaresan observed Gap I as the total yield gap that might be bridged with the present level of technology while Gap II as the difference between maximum possible yield and maximum yield recorded by sample farms.29

Rajeswaran and Varadarajan defined yield Gap II as the difference between maximum yield realised in farms in a region and actual yield of other farmers. They indicated yield gap analysis as the measure of resource-use efficiency of farms for the conventional resources.30


Haqub, in his study, reported the influence of various technological, infrastructural, institutional agro-climatic and socio-cultural factors resulting in low yields of the causing inter-district and inter-form variations. He identified the absence of adequate irrigation facilities and water management, lack of capital topography (upland and low land situations), non-availability of quality inputs and higher prices of inputs, irregularity of rainfall leading to drought and flood situations, tenancy and absence of land reclamation as important constraints to high yields of rice.31

Badrinarayanan, in his study, defined three gaps namely yield gap I as the difference between the best yield obtained in the research station in recent years and the maximum yield in the sample farms for the variety of a crop under question. Yield Gap II is treated as the difference between the maximum farm yield and the average yield realised by farmers for the variety of the crop under question and yield gap III as the difference in the average yield between the districts.32

The research study of International Rice Research Institute showed that three primary factors as detailed below are responsible for yield gap.

1. Physical, environmental constraints, most of which are either uncontrollable by man or require excessive cost for their removal.

2. Physical and biological constraints which were most severe in the tropics, but which are controllable if appropriate technology is available. These physical constraints are partially removable through improved technology and management practices, and

3. Socio-economic factors faced by the farmers in the tropics.33

This study analyses the yield gap with respect to small and large farmers producing planted and ratoon crop of sugarcane in Theni district. Further, it attempts to identify the main factors that act as constraints to the achievement of potential (maximum) yield at farm level in the study area. In the present study, Yield Gap II has been adopted. Yield Gap II is defined as the difference between maximum yield and average yield obtained under farmer’s conditions in the study area.

The observed yield gap at farm level between the potential and average yield in the study area with respect to small and large farmers producing planted and ratoon crops of sugarcane is projected diagrammatically in Figures 4.2 and 4.3 respectively.

Figure 4.2

Yield Gap of Small and Large Farmers Cultivating Planted Sugarcane Crop
Figure 4.3
Yield Gap of Small and Large Farmers Cultivating Ratoon Sugarcane Crop
In the case of small farmers, producing planted crop of sugarcane in the study area, the maximum yield reaped was 56.32 tonnes per acre while the average yield was 51.21 tonnes per acre. This resulted in a yield gap of 5.11 tonnes per acre. In the case of large farmers, the maximum yield obtained by them is 53.44 tonnes per acre and the average yield is 47.81 tonnes. This caused a yield gap of 5.63 tonnes per acre.

It is observed that the farmers producing ratoon crop of sugarcane, the resulted yield gap is found 5.43 tonnes for small farmers and 5.74 tonnes for large farmers. The maximum yield obtained by small and large farmers has been 52.14 tonnes and 49.58 tonnes respectively. The average yield is 46.71 tonnes and 43.84 tonnes for small and large farmers respectively.

Thus it is inferred from the analysis that the yield gap identified under large farmers in both planted and ratoon crop of sugarcane is larger compared to that of small farmers.

4.4 YIELD CONSTRAINTS:

There are three kinds of yield constraints namely (i) Environmental, (ii) Bio-Physical and (iii) Socio-economic constraints. Environmental constraints arise due to environmental difference between the experiment station and an average farm. Usually, experiment stations are located in areas most ideal for farming. But this is
not the case with majority of the farmers’ fields. The high cost inputs used in the experiment stations are out of reach of many farmers. Most of the farmers face the problem of water scarcity. Above all, some of the technologies adopted at the experiment station may not be transferable as such to the farmers’ field.

The bio-physical constraints include (i) non-use of high yielding varieties, (ii) water shortage, (iii) soil fertility, (iv) insects, (v) weeds, (vi) improper preparation of land and (vii) lack of facilities for training of farmers and staff. Eventhough these constraints could be effectively overcome by using high yielding variety seeds, fertilizers, insecticides, pesticides and proper water management, all the farmers cannot afford to adopt all such measures.

The socio-economic constraints refer to the traditional beliefs and attitudes which stand in the way to adopt the latest technology, non-availability of credit and inputs, consideration of cost and return and the knowledge level of the farmers. Some farmers may not like to give up their traditional practices of farming and to adopt new scientific methods. The farmers are not able to apply the recommended doses of inputs due to their cost or input constraints. This is also due to lack of institutional facilities like non-availability of inputs and credit. Since most of the farmers are uneducated, it may not be possible for them to understand and adopt all aspects of the new technologies.
4.5 GARRETT RANKING TECHNIQUE:

In order to analyse the constraints faced by the sugarcane growers in the sugarcane cultivation, they are asked to list and rank the constraints in their respective order. The reasons are then scored and ranked according to the score indicating the preference of the growers by using Garrett's ranking technique.34

Garrett's Ranking Technique is adopted to identify the main constraints to potential yield in the study area. The sample farmers are asked to rank the constraints faced by them as per priority. The order of merit assigned to each constraint by the respondents is converted into scores by using the formula:

\[
\text{Per cent position} = \frac{100 \ (R_{ij} - 0.5)}{N_j}
\]

where

\( R_{ij} \) = Rank given by the \( i^{th} \) farmer for the \( j^{th} \) factor

\( N_j \) = Number of farmers ranked for \( j^{th} \) factor.

The per cent position of each rank thus obtained is converted into scores by referring to Garrets ranking table. The scores of all respondents for each factor are then added together and divided by the number of respondents experiencing that particular constraint. The mean scores of each factor thus arrived at are arranged in descending order and the corresponding ranks are allotted.

The farmers cultivating sugarcane, reported six factors among the various biological and socio-economic constraints as the major yield constraints which limited them from achieving the potential yield in the study area. It included (i) high cost of labour, (ii) non-availability of labour especially during harvest, (iii) high cost of fertilizer, (iv) shortage of irrigation water facilities, (v) inadequate credit facilities and (vi) non-availability of transport facilities in time.

Table 4.7 highlights the yield constraints of small farmers producing planted crop of sugarcane. It is presented below:

**TABLE 4.7**

**YIELD CONSTRAINTS OF SMALL FARMERS PRODUCING PLANTED CROP OF SUGARCANE**

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Constraints</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>High cost of labour</td>
<td>64.18</td>
<td>I</td>
</tr>
<tr>
<td>2.</td>
<td>Non-availability of labour especially during harvest</td>
<td>54.73</td>
<td>II</td>
</tr>
<tr>
<td>3.</td>
<td>High cost of fertilizer</td>
<td>45.63</td>
<td>III</td>
</tr>
<tr>
<td>4.</td>
<td>Shortage of irrigation water facilities</td>
<td>39.27</td>
<td>IV</td>
</tr>
<tr>
<td>5.</td>
<td>Inadequate credit facilities</td>
<td>28.18</td>
<td>V</td>
</tr>
<tr>
<td>6.</td>
<td>Non-availability of transport facilities in time</td>
<td>22.76</td>
<td>VI</td>
</tr>
</tbody>
</table>
It is seen in Table 4.7 that the high cost of labour is ranked the first followed by non-availability of labour especially during harvest. High cost of fertilizer is ranked third and shortage of irrigation water facilities fourth. Inadequate credit facilities and non-availability of transport facilities in time are ranked fifth and sixth respectively.

The ranks assigned to the six identified factors for large farmers producing planted crop of sugarcane are given in Table 4.8.

**TABLE 4.8**

**YIELD CONSTRAINTS OF LARGE FARMERS PRODUCING PLANTED CROP OF SUGARCANE**

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Constraints</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Non-availability of labour especially during harvest</td>
<td>60.27</td>
<td>I</td>
</tr>
<tr>
<td>2.</td>
<td>High cost of labour</td>
<td>47.18</td>
<td>II</td>
</tr>
<tr>
<td>3.</td>
<td>High cost of fertilizer</td>
<td>40.27</td>
<td>III</td>
</tr>
<tr>
<td>4.</td>
<td>Inadequate credit facilities</td>
<td>35.16</td>
<td>IV</td>
</tr>
<tr>
<td>5.</td>
<td>Shortage of irrigation water facilities</td>
<td>27.48</td>
<td>V</td>
</tr>
<tr>
<td>6.</td>
<td>Non-availability of transport facilities in time</td>
<td>27.69</td>
<td>VI</td>
</tr>
</tbody>
</table>
It is found from Table 4.8 that the non-availability of labour especially during harvest season is ranked first followed by high cost of labour. High cost of fertilizer is ranked third and inadequate credit facilities ranked fourth. Shortage of irrigation water facilities and non-availability of transport facilities in time are ranked fifth and sixth.

The mean score and ranks assigned to the six identified factors for small farmers producing ratoon crop of sugarcane are presented in Table 4.9.

**TABLE 4.9**

**YIELD CONSTRAINTS OF SMALL FARMERS PRODUCING RATOON CROP OF SUGARCANE**

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Constraints</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>High cost of fertilizer</td>
<td>64.27</td>
<td>I</td>
</tr>
<tr>
<td>2.</td>
<td>Shortage of inadequate water facilities</td>
<td>59.83</td>
<td>II</td>
</tr>
<tr>
<td>3.</td>
<td>Inadequate credit facilities</td>
<td>51.67</td>
<td>III</td>
</tr>
<tr>
<td>4.</td>
<td>Non-availability of labour especially during harvest</td>
<td>44.38</td>
<td>IV</td>
</tr>
<tr>
<td>5.</td>
<td>High cost of labour</td>
<td>38.61</td>
<td>V</td>
</tr>
<tr>
<td>6.</td>
<td>Non-availability of transport facilities in time</td>
<td>29.13</td>
<td>VI</td>
</tr>
</tbody>
</table>
It is inferred from Table 4.9 that the high cost of fertilizer is ranked first followed by shortage of irrigation water facilities. Inadequate credit facilities are ranked third and non-availability of labour especially during harvest ranked fourth. High cost of labour and non-availability of transport facilities in time are ranked fifth and sixth.

Table 4.10 highlights the yield constraints of large farmers producing ratoon crop of sugarcane.

**TABLE 4.10**

**YIELD CONSTRAINTS OF LARGE FARMERS PRODUCING RATOON CROP OF SUGARCANE**

<table>
<thead>
<tr>
<th>SI. No.</th>
<th>Constraints</th>
<th>Mean Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Inadequate credit facilities</td>
<td>59.18</td>
<td>I</td>
</tr>
<tr>
<td>2.</td>
<td>Non-availability of labour especially during harvest</td>
<td>52.27</td>
<td>II</td>
</tr>
<tr>
<td>3.</td>
<td>High cost of labour</td>
<td>45.18</td>
<td>III</td>
</tr>
<tr>
<td>4.</td>
<td>High cost of fertilizer</td>
<td>37.23</td>
<td>IV</td>
</tr>
<tr>
<td>5.</td>
<td>Non-availability of transport facilities in time</td>
<td>29.83</td>
<td>V</td>
</tr>
<tr>
<td>6.</td>
<td>Shortage of irrigation facilities</td>
<td>22.61</td>
<td>VI</td>
</tr>
</tbody>
</table>

It is found from Table 4.10 that the inadequate credit facilities is ranked first followed by non-availability of labour especially during harvest. High cost of labour
is ranked third and high cost of fertilizer ranked fourth. Non-availability of transport facilities in time and shortage of irrigation water facilities are ranked fifth and sixth.

4.6 SUMMARY

Thus, it may be concluded that the use of fertilizers and capital flows are found to be more influential in determination of yield for small and large farmers. The yield gap is found to be higher in the case of large farmers. The inadequate credit facilities and water shortage are identified as the major constraints of yield.