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ACREAGE RESPONSE OF INDIAN FARMERS: A CASE STUDY
OF TAMIL NADU

M. C. Madhavan*

Whether and to what extent Indian farmers are influenced in their production decisions by economic stimuli is a question of central importance for agricultural planning in India.\(^1\) The government has been giving subsidies of various kinds for agricultural development but a critical review of these programmes has led the Planning Commission to conclude in 1962 that the general policy should be to reduce subsidies progressively and, where possible, to eliminate them, though there may be some justification for subsidies which are intended to benefit poorer sections of the community or to induce farmers to adopt improved agricultural practices (51, pp. 309-10).\(^\dagger\) A policy of support prices for selected foodgrains and commercial crops came to be adopted throughout the country in 1964\(^2\) but they remained mostly inoperative either on account of drought conditions particularly in 1966-67 or on account of inadequate purchase organization (52, pp. 108-109). The Fourth Five-Year Plan envisages schemes to remedy these situations and to increase agricultural production markedly. The government would continue to use both price support and input subsidy policies to achieve desired agricultural production objectives. It is not clear, however, how these policies would be mixed and whether one would be emphasized more than the other in respect of each crop. Moreover, in a vast country such as India, where regional variations to incentives could be considerable, knowledge of farmers' response in various regions would provide a better perspective in formulating a national policy. The objective of this paper is to make an acreage response analysis with respect to relative price, yield per acre and rainfall for four major cereal crops and four major commercial crops grown in Tamil Nadu.\(^3\)

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* San Diego State College, San Diego and National Institute of Bank Management, Bombay. An earlier draft was read in the Western Economic Association meetings held at the University of California, Davis in August, 1970. I am grateful to Professors R. Day, L. Bawden, T. Morgan and V. K. Chetty for comments on an earlier draft. However, I am responsible for all errors.
\(^\dagger\) Figures in parentheses refer to literature cited, given at the end of the paper.
1. For an excellent and penetrating review of main problems confronting Indian agriculture, see Bhagwathi and Chakravarthy (1).
2. An Agricultural Price Commission was set up in 1965 to advice the government from time to time on appropriate price policies for agricultural commodities.
3. The price elasticities of acreage are considered to be a good approximation of the elasticities of output on the assumption that when the acreage in a crop is varied other inputs can be varied pari passu, and over the relevant ranges of production functions returns to scale are not diminishing. See Nerlove (48) and Raj Krishna (28).

No estimate of acreage elasticity has so far been made for any crop grown in Tamil Nadu, though there have been attempts to relate price movements with changes in acreage. See Thomas and Sastry (60), Narain (43), Natarajan (44), Parthasarathy (50) and Kamala Devi and Rajgopalan (23). Though the results of these studies have not turned any conclusive evidence, food crops seem to be less price responsive than commercial crops such as groundnut, sugarcane and cotton.

Studies relating to Indian farmers' behaviour have produced evidences both for the price responsive hypothesis and against it. Those who support the hypothesis include Raj Krishna (28), Narain (43), Murti (40), Stern (59), and Venkataramanan (82) and those who do not agree with the hypothesis include Chand (7), Chauhan (8), Epstein (15), Lewis (29), Madan (30), Myrdal (41), Nair (42), Neale (45), Olsen (49), Poduval and Sen (53); and Gupta and Majid (20). See also articles in the Indian Journal of Agricultural Economics (23). (Contd.)
Section II outlines the model that will be used to estimate acreage response of farmers in Tamil Nadu. Section III presents the estimates of acreage response with particular reference to relative prices, yield and cross yield, discusses the results and compares them with earlier acreage response estimates for less developed countries and regions. Section IV summarizes the conclusions of the study.

II. THE MODEL

Since production relations in agriculture are very complex, and are known to differ from one crop to another in Tamil Nadu, let us assume for the purposes of deriving a demand function for an input such as land, a production function similar to the one suggested by Mukherjee (39). Let the function be

\[ Y_i = \gamma_i \left[ \delta_{i1} x_{i1} - \rho_{i1} + \delta_{i2} x_{i2} - \rho_{i2} + \ldots \right. \\
+ \left. (1-\delta_{i1} - \delta_{i2} \ldots \delta_{i, n-1}) x_{in} - \rho_{in} \right] \frac{-1}{\lambda_i} \]

---Equation 1

where output \( Y_i > 0 \), inputs \( x_i > 0 \), efficiency parameter \( \gamma_i > 0 \), distribution parameter \( \delta_i \) s lie between 0 and 1, substitution parameters \( \rho_i \) s between \(-1\) and \( \gamma_i > 0 \). This function is shown to have constant ratios of elasticity of substitution and is homogeneous only when \( \rho_{i1} = \rho_{i2} = \ldots = \rho_{in} = \lambda_i \).

When the resources are limited, and they usually are in Tamil Nadu in the short run, any decision to expand the output of a crop can come about only by decreasing resource use in one or more alternatives. Thus, given cultivable land area, farm household labour and the cash amount that could be used to purchase inputs that are not available in the farm households, the farmers could attempt to utilize the available inputs, say \( n \), to produce various combinations of outputs, say \( s \). The production function for the farm as a whole in its implicit form could then be stated as

\[ G(Y_1, Y_2, \ldots Y_s, X_1, X_2, \ldots X_m) = 0 \]

---Equation 2

where Equation 2 is assumed to possess continuous first-and second-order partial derivatives which are different from zero for all its solutions. The Equation 2 can be rewritten as

\[ H(Y_1, \ldots, Y_m) = 0 \]

---Equation 3

where \( m = (n+s) \) and input and output levels are distinguished by signs.

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For others supporting the hypothesis see Brown (6), Bauer and Yamey (2), Behrman (3,4), Dean (14), Falcon (16), Fletcher and Mubayato (18), Ghulam Rabbni (19), Mangahas (37), Mellor (38) and Schultz (67), and for against it see Boeke (5), Dabasi-Schweng (11), and Dalton (12).

For discussions on economic rationality of Indian farmers, see Bhagwati and Chakravarthy (1), Rao (54), Chennareddy (9) and Sahota (56).
The farmers' net income maximizing function subject to the constraint may be stated as

\[ J = \sum_{i=1}^{m} P_i Y_i - \mu H(Y_1, \ldots, Y_m) \]

---Equation 4

where \( \mu \) = undetermined Lagrangean multiplier. Setting each of its \((m+1)\) partial derivatives equal to zero and considering two uses for a given amount of input such that its marginal value products in different uses are equal, we have

\[ \frac{\partial Y_i}{\partial x_{ii}} \cdot \frac{\partial Y_j}{\partial x_{jj}} = \frac{P_i}{P_j} \]

---Equation 5

where \( Y_i \) = output of crop \( i \); \( Y_j \) = output of crop \( j \); \( P_i \) = price of \( i \); \( P_j \) = price of \( j \); \( x_{ii} \) = land used in the output of \( i \); \( x_{jj} \) = land used in the output of \( j \).

Expanding \( \frac{\partial Y_i}{\partial x_{ii}} \), we will have

\[ \frac{\partial Y_i}{\partial x_{ii}} = \frac{\delta_{ii} \rho_i}{1 + \lambda_i} \cdot \frac{Y_i^{1+\lambda_i} \cdot x_{ii}^{1-\rho_i}}{\lambda_i \gamma_i} \]

---Equation 6

Similarly

\[ \frac{\partial Y_j}{\partial x_{jj}} = \frac{\delta_{jj} \rho_j}{1 + \lambda_j} \cdot \frac{Y_j^{1+\lambda_j} \cdot x_{jj}^{1-\rho_j}}{\lambda_j \gamma_j} \]

---Equation 7

Now Equation 5 can be written as

\[ \frac{P_j}{P_i} = \frac{\delta_{jj} \rho_j}{1 + \lambda_j} \cdot Y_j^{1+\lambda_j} \cdot x_{jj}^{1-\rho_j} = \frac{\delta_{ii} \rho_i}{1 + \lambda_i} \cdot Y_i^{1+\lambda_i} \cdot x_{ii}^{1-\rho_i} \]

---Equation 8

Multiplying Equation 8 by \( \frac{P_i}{P_j} \), we have

---Equation 8

4. Generally Tamilian farmers don't attempt to maximize expected profits mainly because neither they possess the knowledge of the relevant probability distribution for random input such as weather nor do they have an unlimited amount of money that would be needed to realize the expected earnings in a "game" of chance. Moreover, in Tamil Nadu where there seems to be widespread under-employment and unemployment among many of the farm families (63), and there is no possibility of productively employing them in alternative uses, it may not be incorrect to argue that family labour is "costless" or free good in the sense that no additional costs are involved in using, within limits, a relatively large quantity of it. If we further assume that all product and factor markets are competitive for it comes closer to approximating market conditions in agricultural production than any other type of market, then the farmers in the State would attempt to maximize net farm income (difference between the total revenue from the sale of all outputs and expenditure on purchased inputs) rather than profit.
\[ 1 = \frac{\delta_{ui} \lambda_i \gamma_i}{\delta_{ui} \lambda_i \gamma_i} \cdot \frac{1 + \lambda_i}{1 + \lambda_i} \cdot Y_i \cdot \frac{1 - \rho_{ui}}{1 - \rho_{ui}} \cdot Y_i \cdot \frac{1 - \lambda_j}{1 + \rho_{ui}} \cdot \frac{P_i}{P_j} \]

\[ -\text{Equation 9} \]

Taking logs and solving it for \( x_{ui} \),

\[ \log x_{ui} = \text{const.} + \frac{1}{1 + \rho_{ui}} \log \frac{P_i}{P_j} + \frac{1 + \lambda_i}{1 + \rho_{ui}} \log Y_i + \frac{-(1 + \lambda_i)}{1 + \rho_{ui}} \log Y_j + \frac{1 + \rho_{ui}}{1 + \rho_{ui}} \log x_{ji} \]

\[ -\text{Equation 10} \]

Assuming that yield per acre would be a proxy for all inputs other than land and by substituting \( \log x_{ui} \) and \( \log E_i \) (yield per acre) for \( \log Y_i \) and \( \log x_{ji} \) and \( \log E_i \) for \( \log Y_j \) and solving for \( \log x_{ui} \), we can rewrite Equation 10 as

\[ \log x_{ui} = \text{const.} + \frac{1}{\rho_{ui} - \lambda_i} \log \frac{P_i}{P_j} + \frac{1 + \lambda_i}{\rho_{ui} - \lambda_i} \log E_i + \frac{-(1 + \lambda_i)}{\rho_{ui} - \lambda_i} \log E_j + \frac{\rho_{ui} - \lambda_i}{\rho_{ui} - \lambda_i} \log x_{ji} \]

\[ -\text{Equation 11} \]

Since Equation 11 relates to the desired demand for land for the cultivation of crop \( i \), it can be written as

\[ \log \hat{x}_i = a_o + a_1 \log \frac{\hat{P}_i}{\hat{P}_j} + a_2 \log \hat{E}_i + a_3 \log \hat{E}_j + a_4 \log \hat{x}_j \]

\[ -\text{Equation 12} \]

where

- \( \hat{x}_i \) = desired acreage of crop \( i \)
- \( \frac{\hat{P}_i}{\hat{P}_j} \) = ratio of expected price of crop \( i \) with respect to crop \( j \)
- \( \hat{E}_i \) = planned yield per acre of crop \( i \)
- \( \hat{E}_j \) = planned yield per acre of crop \( j \)
- \( \hat{x}_j \) = desired acreage of crop \( j \)

- \( a_o = \frac{\delta_{ui} \lambda_i \gamma_i}{\delta_{ui} \lambda_i \gamma_i} \cdot \frac{1 + \lambda_i}{1 + \lambda_i} \cdot \frac{\rho_{ui} - \lambda_i}{\rho_{ui} - \lambda_i} \cdot \frac{1 + \lambda_j}{1 + \rho_{ui}} \cdot \frac{1 + \rho_{ui}}{1 + \rho_{ui}} \)
- \( a_1 = 1/(\rho_{ui} - \lambda_i) \)
- \( a_2 = (1 + \lambda_i)/(\rho_{ui} - \lambda_i) \), \( a_3 = -(1 + \lambda_j)/(\rho_{ui} - \lambda_i) \), and \( a_4 = (\rho_{ui} - \lambda_1)/(\rho_{ui} - \lambda_i) \)
Since marginal productivity relationship would not normally be satisfied exactly, we add an error term to Equation 12 to arrive at a regression model:

\[
\log \hat{x}_t = a_o + a_1 \log \frac{\hat{P}_t}{P_j} + a_2 \log \hat{E}_i + a_3 \log \hat{E}_j + a_4 \log \hat{x}_{j-1} + U_t
\]

—Equation 13

Owing to technological consideration such as crop rotations and the lack of knowledge about the market conditions, the farmer may not be able to fully adjust his acreage under cultivation of a crop in response to changes in variables such as relative price. It may not be incorrect, therefore, to assume that Tamil Nadu farmer may be able to increase the acreage of a crop in any year only to the extent of a fraction of the difference between the acreage they would like to plant (\(\hat{x}_t\)) and the acreage actually planted in the preceding year \(x_{t-1}\) such that

\[
\frac{x_t}{x_{t-1}} = B \begin{bmatrix} \hat{x}_t \\ x_{t-1} \end{bmatrix}
\]

—Equation 14

where \(B\) is the coefficient of adjustment.

Assuming price lagged by a year is a close approximation to the expected price, competing crop's acreage lagged by a year to competing crop's desired acreage and yield per acre lagged by a year to the planned yield, we substituting Equation 14 into Equation 13 and solving it for \(x_t\), we have

\[
\log x_t = b_o + b_1 \log \frac{P_{t-1}}{P_{j-1}} + b_2 \log E_{i, t-1} + b_3 \log E_{j, t-1} + b_4 \log x_{i, t-1} + b_5 \log x_{j, t-1} + V_t
\]

—Equation 15

where \(B_o = a_o B, b_2 = a_2 B, b_3 = a_3 B, b_4 = a_4 B, b_5 = (1-B)\) and \(V_t = BU_t\).

\[
\frac{P_{i, t-1}}{P_{j, t-1}} = \text{relative price of crop } i \text{ with respect to crop } j, \text{ lagged one year},
\]

\(E_{i, t-1} = \text{yield per acre of crop } i, \text{ lagged one year},
\]

\(E_{j, t-1} = \text{yield per acre of crop } j, \text{ lagged one year},
\]

\(x_{i, t-1} = \text{acreage of competing crop, lagged one year, and}
\]

\(x_{j, t-1} = \text{acreage of crop } i, \text{ lagged one year}.
\]

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5. Before deciding on one-year lag both for price and yield variables, four different types of price and yield expectation models were tested. These are one-year lag, two-year lag, two-year moving average, and three-year moving average. One-year lag model yielded the highest R² values. For a good discussion of price expectation models applied to Uttar Pradesh, see M. S. Rao and Jai Krishna (65).
One variable that is important in any agricultural supply analysis, but which is not explicitly brought in Equation 15 is weather. The effect of weather input we specified in the production function is now submerged in the yield variable. If we assume that the impact of weather on all agricultural operations is not uniform, there may be a need to have three weather variables: one perhaps relating to the weather effect on sowing period decisions, and second and third, the effects on growth of the plant and harvesting time. It may not be incorrect, despite the presence of a yield variable, to include a weather variable, particularly because it could correct any error in the yield expectation model that we have specified, and also because farmers always take it into consideration in deciding on their cultivation pattern.

While choosing a weather variable, the question we ask ourselves is which part of the farmer’s land allocation decision-making process should be related to a weather variable? If we assume that the farmer’s decision-making process consists of two stages and in the first stage, with the knowledge he has of the variables specified in Equation 15, he would make his tentative but important decision towards the end of May (subject to the technological and cropping pattern constraints) as to what crop or crops should he cultivate in the next season to get maximum net income, then the weather variable should be relevant to the second stage when weather will be an important factor influencing his final decision. With the knowledge of the future weather situation that he would get from the Indian Meteorological Service and the Regional Centre at Madras and the actual rainfall at the start of the season he would decide either to make his tentative decision final or to revise it. It is, therefore, appropriate to include in the model a weather variable relating to sowing period rainfall. Since sowing periods differ somewhat from one district to another, a weather index, based on rainfall in the sowing period in each of the main growing districts and its relative importance is used. In cluding the weather index for crop i ($w_i$) in the model, we have

$$\log x_i = b_0 + b_1 \log \frac{P_i}{P_{i-1}} + b_2 \log E_{i-1} + b_3 \log E_{i-1} + b_4 \log x_{i-1} + b_5 \log w_i + U_{it}$$

Equation 16

Besides the variables specified in Equation 16, one would wish to include variables to bring in the effects on the farmers’ decision-making process of the farmers’ preference to allocate land first to cereal crops to meet their food requirements and of government’s policies, particularly land reform policy. This has not been considered because of lack of data.

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6. In earlier studies, some used annual rainfall for selected crops, and some rainfall during certain months when major proportion of the area under that crop was sown. See for example Dharm Narain (43). Of the four crops in Madras he studied, he found a systematic relationship only in the case of rice between sowing period rainfall, and area.

7. We have not used either the Angstrom Weather Index or other indices, because they are mainly intended to explain weather-crop output relationship.
The estimating Equation 16 indicates that the actual planted area of a crop in a given period is a log-linear function of a constant term, six variables and an error term. The second term in the right hand side of the equation refers to the relative price of the crop. In the earlier studies also, a lagged price variable has been included; one difference, however, between others and our model is that, unlike others who have used in the denominator a weighted average of the prices of all pre-determined competing crops, the lagged relative price variable in our model refers to a competing crop only. This may have some advantage for dealing with the conditions prevailing in Tamil Nadu where the number of competing crops for major crops are few, and also when we would like to recommend a policy favouring an increase in the acreage of a crop at the expense of a particular crop. Since increases in the expected price, other things remaining the same, would provide an incentive to allocate more land to that crop, we would expect, and the model yields, the coefficient $b_4$ to be positive.

The third and fourth terms are lagged yield per acre of dependent crop and of competing crop. The inclusion of an expected yield variable is desirable because not only the expected value per acre seems relevant to the planting decisions, but also the number of units one might expect to produce. Both Behrman (3) and Raj Krishna (26) included an expected yield variable or a yield ratio in the equation. *Ceteris paribus* an expected increase in yield per acre of a dependent crop (or an expected decrease in the yield per acre of a competing crop) would make the production of the dependent crop desirable. We would, therefore, expect, and our model suggests, the coefficient of yield elasticity $b_2$ to have a positive sign, and the coefficient of cross yield elasticity $b_3$ to have a negative sign. Our model could be reduced to have a yield ratio if we assume the substitution parameters of crops i and j to be equal.

The inclusion of a lagged dependent variable would perhaps pose estimation problems since the Durbin-Watson test for existence of serial correlation need not necessarily be conclusive (21, 48). Despite this it is desirable to have a lagged dependent variable, especially when we are interested in the speed of adjustment.

III. EMPIRICAL RESULTS

For each of the crops, the parameter space for the acreage response model was explored, using Equation 16 in the previous section. If, in such an exploration, the estimate of the structural coefficient either of the lagged acreage of the competing crop or of weather was not significantly different from zero at the 20 per cent level, that variable has subsequently been dropped. All these regressions together with their standard errors are given in Table I, and their implied elasticities are summarized in Table II.  

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8. State level aggregative data for the period 1947-1965 are used to determine the acreage response of farmers in Tamil Nadu.

9. For a review of competing crops, see Madhavan (31).

10. Another set of computations were also carried out assuming three-year moving average of yield, but the results were not generally better than those reported here, except in the case of groundnut equations where the use of three-year moving average yield variable resulted in higher elasticity values. Acreage elasticity estimates were also made using Nerlove-Raj Krishna type linear equations. The results are not in general better than those reported here. See Madhavan (31).
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<tr>
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**Commercial Group**

<p>| Sugarcane  | Rice           | 0.62      | 0.44      | 1.32      | 1.48      | -0.35 | -         | 0.88  | 0.82        |
|            | (0.18)         | (0.88)    | (0.73)    | (1.23)    | (0.20)    |       |           |       |             |
| Ragi       | ...            | 0.52      | 1.70      | 0.58      | 1.14      | -0.20 | 0.57      | 0.58  | 0.43        |
|            | (0.34)         | (1.30)    | (1.04)    | (2.25)    | (0.40)    |       |           |       |             |
| Groundnut  | ...            | 0.63      | 1.27      | 1.86      | 0.57      | -0.35 | 0.17      | 0.85  | 0.75        |
|            | (0.25)         | (0.86)    | (0.60)    | (0.53)    | (0.23)    |       |           |       |             |
| Groundnut  | Cumbu          | 0.22      | 1.01      | 0.33      | -0.27     | -     | 0.28      | 0.80  | 0.74        |
|            | (0.11)         | (0.28)    | (0.14)    | (0.20)    |           |       |           |       |             |
| Ragi       | ...            | 0.35      | 0.91      | 0.33      | -0.62     | -     | 0.48      | 0.87  | 0.83        |
|            | (0.07)         | (0.17)    | (0.23)    | (0.51)    |           |       |           |       |             |
| Sorghum    | ...            | 0.19      | 1.07      | 0.25      | -0.64     | -     | 0.38      | 0.79  | 0.68        |
|            | (0.17)         | (0.37)    | (0.24)    | (0.34)    |           |       |           |       |             |</p>
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Standard errors are given in parentheses.
**TABLE II—Estimated Short Run and Long Run Acreage Elasticities of Tamil Nadu Crops**

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<tr>
<th>Crop</th>
<th>Competing crop</th>
<th>Short run elasticities of acreage with respect to</th>
<th>Coefficient of adjustment</th>
<th>Long run elasticities of acreage with respect to</th>
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<td>( E_{t-1} )</td>
<td>( E_{t-1} )</td>
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(Contd.)
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<td>0.43</td>
<td>-0.55</td>
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The overall success of the model in explaining the changes in the area devoted to the crops may be judged from the last column of Table I. F tests indicate that all the adjusted multiple correlation coefficients but three are significant at the one per cent level and all at the 5 per cent level. The numerical values of the adjusted $R^2$ of all those significant at the one per cent level range from 0.43 to 0.88. Nearly three-fourths of them are greater than 0.6 and 90 per cent greater than 0.50. For all crops excepting sorghum, the model seems to explain substantial part of the variance in acreage devoted to their cultivation.

**Response to Relative Price**

The estimates of the coefficients of relative prices are of considerable interest from the policy point of view. Almost all the relative price coefficients excepting those relating to *cumbu* equations have the right signs. Only one of the coefficients with negative sign, however, is significant at the 5 per cent level. Of those with right signs, about half of them is significant at 5 per cent level and two-thirds at the 10 per cent level. Thus the Tamil Nadu farmers in general seem to respond to relative prices, but the degree of response differs from crop to crop.

In general sugarcane, gingelly, groundnut and cotton that are mainly grown for sale seem to respond more to relative prices than subsistence oriented crops such as rice, sorghum, *ragi* and *cumbu*. Short run acreage elasticity is the highest for sugarcane, followed by gingelly. Groundnut price elasticities are generally higher than those of cotton. Among cereal crops, sorghum and *ragi* seem to respond more to relative prices than rice, the main staple food of high and middle income groups, and *cumbu*, the main staple food of low income groups.

A broad pattern of acreage response with respect to price is discernible. Elasticity estimates are generally relatively high when both the dependent and competing crops are from the commercial crop group, and low when both are from the cereal crop group. Elasticities associated with the dependent commercial crop and competing cereal crop are, in most cases, higher than those associated with dependent cereal crop and competing commercial crop. This suggests a classification of four types of responses depending upon the nature of the crops: (1) between a commercial crop and another; (2) between a commercial crop and a cereal crop; (3) between a cereal crop and a commercial crop; and (4) between one cereal crop and another. As we move from category 1 to 4, elasticities generally decline. The above pattern is consistent with the dualistic nature of the agriculture in developing regions and the generally held notions such as (a) there is likely to be a positive acreage response to relative prices between crops grown for the market, and (b) there is

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11. Something similar to this classification was also suggested by Sethi (58).
likely to be a considerable range over which there is no foodgrains—commercial crop substitution, because of the desire on the part of the farmers to grow foodgrains to meet their family requirements.

Response to Yield

The estimates of the coefficients of yield per acre and cross yield per acre have the right signs in almost all the cereal crop equations. Yield per acre seems to be significant in the determination of the acreage under rice and sorghum and cross yield per acre in the case of ragi and cumbu. Among the cereal crops, yield elasticity estimates are consistently higher than price elasticities. Possibly yield exerts a greater influence on groundnut acreage than price. Yield elasticities are generally smaller than price elasticities in the case of sugarcane and gingelly. In the cotton equations an inverse relationship between yield per acre and acreage is suggested.

Response to Other Factors

The negative signs of the coefficients of lagged acreages of competing crops in the ragi and groundnut equations suggest a free movement of acreage between each of them and its substitute crops. The positive signs in the equations of sugarcane and cotton indicate that substantial growth in the acreage under these crops during the period may be due to the growth in the additional irrigated acreage brought under cultivation. Rainfall in the sowing season is a significant factor in influencing the acreages under rice and cotton, and has a negative relationship with sugarcane acreage, which generally enjoys an assured irrigation.

Speed of Adjustment

The rapidity with which the farmers adjust the acreage under a crop in response to the movements in factors discussed above may be seen from the numerical values of the adjustment coefficient (B) which can be derived from the regression coefficient of the lagged acreage of the ith crop. The values thus estimated indicate that in general commercial crop acreages get adjusted faster than cereal crops. Gingelly, whose acreage has declined absolutely, seems to over-adjust as evidenced by the negative sign of lagged acreage coefficient. B values for other commercial crops vary between 0.4 and 0.9. Most of these values for sugarcane and groundnut fall between 0.7 and 0.9 and for cotton 0.4 and 0.6. Among the cereal crops, acreages under both rice and sorghum get adjusted sooner than ragi and cumbu. B values for sorghum and rice are in the range of 0.7 — 0.8, for ragi 0.5 — 0.6 and cumbu 0.1 — 0.4.

Food Crops : Rice

The above discussion suggests that the importance of the variables included in the regression analysis in influencing the acreage allocation decisions of the
farmers differs from crop to crop. In the determination of area under rice, yield per acre and rainfall are significant. This is what one would have expected, because the policies pursued by the Tamil Nadu government were in the nature of inducing farmers to adopt improved methods of cultivation and were aimed at achieving self-sufficiency in foodgrains in general and rice in particular (31, 34), the demand for which has increased both due to growth of population and shift in consumption in favour of rice. Rainfall is a significant factor because nearly 50 per cent of the area under rice is irrigated from the rain-fed tanks. An earlier study also found a close association between rice acreage and rainfall in the sowing season. Yield per acre and rainfall seem to account for almost the entire variation in rice acreage.\textsuperscript{12}

\textit{Sorghum}

If \textit{cumpu} is considered as the main substitutable crop for sorghum in the State as a whole, then yield per acre is significant. However, in Coimbatore district where sorghum is competing with cotton for land, proper specification seemed to have resulted in a higher, significant price coefficient than for the State as a whole. This is quite conceivable because a significant part of the sorghum production in the Coimbatore district is market oriented (63).

\textit{Cumpu}

Of the crops considered here, \textit{cumpu} is the only crop which is possibly negatively responsive to price movements. This is not surprising because (1) it is one of the best dry crops grown almost entirely for subsistence, and (2) it is the "rescuer of the last resort," particularly when the monsoon fails. Cross yield seems to be the significant determinant of \textit{cumpu} acreage. It takes much longer time than any crop to complete the adjustment process.

\textit{Ragi}

Another crop which also takes a sufficiently long time to adjust and whose acreage is very much influenced by cross yield is \textit{ragi}. Unlike \textit{cumpu}, however, the latter is somewhat price responsive. The short run acreage elasticity with respect to price is in the range of 0.10–0.15 and is smaller than that for sorghum.

\textit{Commercial Crops: Sugarcane}

Sugarcane seems to respond more to relative price than any other crop. The short run price elasticity of 0.6 is highly significant at the 0.5 per cent level and the speed with which the sugarcane acreage is adjusted to changes in factors is quite high. The high price response and quick adjustment could be attributed to the general behaviour of the large land owners who produce mainly for the market. (This group accounts for a substantial part of the sugarcane acreage.) Yield elasticity is higher in numerical value when \textit{ragi} and groundnut are competing crops, but are statistically significant only at a much lower level. The positive relationship between sugarcane

\textsuperscript{12} If we regress the relative price alone of the rice acreage, price seems to be significant with the short run elasticity of about 0.3, explaining about 30 per cent of the variation in acreage.
acreage and cross yield may be due to the cropping pattern associated with sugarcane cultivation. At the time of making a choice between sugarcane and, say, rice, they will be competing crops. But once the choice is made to cultivate sugarcane in the first year, rice becomes a complementary crop. This might perhaps explain the positive relation. The negative relationship between acreage and rainfall is consistent with such an association suggested by an earlier study (43).

Cotton

Price responsive nature of cotton is mixed. Against groundnut, cotton is price responsive and has a statistically significant short run price elasticity value of 0.3. None of the economic factors is significant in other equations. It is likely that some other factor like price stability might be important. In fact, coefficient of variations of cotton harvest prices and cotton price ratios are small. The relative price stability which would have given a greater assurance of a steady income might have caused the growth in the area under cotton. Rainfall is also a significant factor in the determination of cotton acreage. This is reasonable because it is grown mostly in hard black cotton soil areas without assured irrigation facilities.

Groundnut

Yield seems to be the most important factor influencing the groundnut acreage. It is generally more responsive to relative price than cotton. However, its price elasticity estimates vis-a-vis other commercial crops do not follow the broad classification of response outlined earlier. This may be because it is generally competing with cereal crops for land. In most parts of the Salem and Coimbatore districts, it is considered competitive with ragi and cumbu; in North and South Arcot districts with ragi and other inferior cereals and sugarcane, and in some other districts, with sorghum.

Gingelly

In the case of gingelly, relative price is more important in its influence on acreage than yield. The response of the farmers to changes in relative price and yield is very quick. As mentioned earlier, this is the only crop of those studied which seems to over-adjust.

Comparison with Other Estimates

Detailed comparison of our estimated acreage elasticities with those for less developed countries and regions would require an extensive analysis of institutions and procedures which are specific to each of these estimates. However desirable this might be, this is not done here. Despite the lack of adequate knowledge of situations relating to other estimates and the differences in methodologies, it may not be incorrect to compare our acreage elasticity estimates with respect to relative price with similar estimates to get an idea of the relative response of the farmers in Tamil Nadu.
ACREAGE RESPONSE OF INDIAN FARMERS

Of the eight crops considered here, only for two of them—rice and cotton—acreage elasticity estimates are available for some less developed countries. For three other crops—sugarcane, sorghum and *cumhu*—comparable estimates are available only for Punjab. Acreage elasticity estimates for gingelly, *ragi* and groundnut presented in this study seem to be the first of their kind.

Acreage elasticities of rice with respect to price in some of the less developed countries vary widely from 0.05 to 0.62 depending upon the extent of substitution possible and the proximity of the region to the main trading centre, but are generally skewed to lower values. If rice is mainly grown as a subsistence crop as it is in East Pakistan or in some parts of Thailand, Philippines and Indonesia, the short run price elasticity value is generally around 0.1 (3, 37, 18, 22). If it is partially market oriented as it seems to be in the case of Thai Changwads such as Chai-nut and Sukhothai, Ilocos and S. Tagalog regions of the Philippines, Punjab in India and Java and Madura regions of Indonesia, the short run price elasticity is around 0.20. If it is mainly market oriented, made possible by the proximity of a large marketing centre (as seems to be the case in certain Thai Changwads), the short run price elasticity can be as high as 0.6 or even exceed unity (3). In Tamil Nadu rice is mainly grown as a subsistence crop. Therefore, it is not surprising to have a very low short run acreage elasticity with respect to price, about the same as was reported for East Pakistan.

Being a market oriented crop, cotton acreage elasticities with respect to price are generally high, around 0.5. If we consider groundnut and gingelly as the most important competing crops for cotton in Tamil Nadu, cotton acreage elasticity in the State with respect to price is around 0.3. Though it is relatively high it is much below the reported estimate for post-war India (27).

Compared to the Punjab farmers’ response to price changes, Tamil Nadu farmers’ response seem to be higher in the case of sugarcane and sorghum and lower in *cumhu*. The short run acreage elasticity of sugarcane (0.60) in Tamil Nadu is almost twice as high as that reported for Punjab. While sorghum in Punjab seemed to have a negative response, *cumhu* in Tamil Nadu seems to respond negatively. However, it is not statistically significant except when *ragi* is the competing crop. This difference in response is possible in view of the differences in soil conditions and cultivation practices.

IV. SUMMARY AND CONCLUSIONS

Our model when applied to Tamil Nadu data yields better results than those obtained from a Nerlove-Raj Krishna type formulation both in terms of statistical significance of the coefficients and the explanatory power of the equation.13

13. See Madhavan (31).
The results indicate that the farmers' response to variations in product price and yield per acre is about equal to or greater than those acreage elasticities reported in earlier studies. However there is no one variable that is equally important in all the crops. Rice, sorghum and groundnut seem to respond more to variations in yield per acre, and sugarcane and gingelly to price movements, than do other crops. Acreage elasticity estimates with respect to price are high when both dependent and competing crops are from the commercial crop group, and low when both are from the cereal crop group. Elasticities associated with a dependent commercial crop and a competing cereal crop are generally higher than those associated with a dependent cereal crop and a competing commercial crop. Price policy could therefore be used to influence a commercial crop acreage more than a cereal crop acreage. If guaranteed prices are fixed at a level sufficient to provide incentive, then price elasticity coefficients may be even higher than those reported here. There is a need for further research to ascertain the effect of price certainty on supply response.

Though price can be manipulated more easily than can other policy-determined influences on production decisions, the equations suggest that transformation of agriculture in Tamil Nadu cannot be brought about by price movements alone. In almost all the cereal crop equations and even in some commercial crop equations, acreage elasticity with respect to yield exceeds acreage elasticity with respect to price. This result indicates that if the objective is to increase food production in the State, the preferable means is an input subsidy policy. Even so, it is possible that efforts in the direction of improving technology and organization can be retarded or accelerated by price relationships. There is need to take co-ordinated action. Incentive measures in one field may not be fully effective unless complemented by measures in one or more other fields. However, since administrative and financial resources are limited, one aspect of the policy may have to be emphasized more than others for a given crop. For example, our results suggest price policy should be emphasized more in the case of sugarcane, gingelly, and cotton than other crops such as rice, sorghum, and groundnuts.

In spite of some allocative rationality suggested by our equations, it could still be argued that Tamil Nadu farmers may not be able to increase the total output substantially in response to changes in terms of trade, particularly because the possibilities of expanding the supply of land are limited. There may be some truth in this view. Our results could be used to shed some light on this question. As a first approximation we may state that if the output (acreage) of one crop is price responsive to increases in its prices and at the same time the outputs of competing crops are at least maintained, then we may conclude that total output, and not only the output of one crop, is price responsive (28). Viewed against this, our results suggest that even total output in Tamil Nadu may be price responsive at the margin. This is, however, only a very tentative conclusion and further research in this area needs to be done to establish some firm propositions about the responsiveness of aggregate output to changes in price relations.
REFERENCES


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