DEGRADATION OF AGRO-ECOSYSTEM—AN EXPLORATORY STUDY ON COTTON FARMING

D. V. Subba Rao, K. R. Chowdry and G. G. Venkata Reddy*

Indian agriculture is in transition due to the recent technological advances in crop production as well as changes in the developmental strategies for improving agricultural productivity. These technologies and strategies have both positive and negative impact on the society as well on the ecosystem. The negative effects of these technologies and strategies have created serious imbalances in crop ecosystem resulting in several deleterious effects, besides disrupting the traditional ecological balance.

The change in crop ecosystem in Guntur and Prakasam districts in Andhra Pradesh has been taking place on account of cotton farming. With the evolution of potentially high-yielding hybrids and varieties of cotton, there is a dramatic change in the cropping pattern and management practices. These high-yielding varieties (HYVs) require phenomenally high doses of fertilisers and continuous use of pesticides resulting in minor pests being transformed into major pests, posing a threat to cotton cultivation itself. Added to this, mono-cropping itself leads to multiplication of some pests. Further, with the advent of irrigation facilities provided by the Nagarjuna Sagar dam, cotton cultivation has increased. Earlier, ideal crop rotations were practised and now the same cotton is cultivated year after year in the same land for about 15-20 years.

Mono-cropping has disturbed the natural ecosystem and the special inputs like pesticides that go along with high doses of fertilisers have further aggravated the situation. The cropping pattern involving several different crops practised in the past created conditions for the existence of natural predators and parasites. Lack of diversified host plants induced the minor pests developing into major pests on a single crop. The above problems emphasise the need to analyse the present trends in cotton farming. The present study seeks to (a) analyse the changes in the cropping pattern adopted, and growth trends in area and productivity of cotton, (b) examine the extent of use of fertilisers and pesticides in cotton farming, (c) examine the effects of cotton mono-cropping on ecosystem in the region and (d) suggest alternative measures for promoting better ecosystem.

METHODOLOGY

Primary and secondary data of the cotton belt of Guntur and Prakasam districts of Andhra Pradesh were used. Time-series data of 21 years in res-

* Assistant Research Officer, Agricultural Economist and Research Officer, respectively, Agro-Economic Research Unit, Andhra Pradesh Agricultural University, Hyderabad-30.
pect of area and productivity were taken from Season and Crop Reports of Andhra Pradesh for the period 1965-86 to study the changes in growth rates of area and productivity. The period has been divided into two sub-periods, viz., period I (1965-75) and period II (1975-86). The exponential function of the form \( Y = AB^t \) was fitted to work out the compound growth rates, where \( Y = \text{area/productivity} \), \( A = \text{constant} \), \( B = 1+r \); \( r = \text{compound growth rate} \) and \( t = \text{time variable} \).

The primary data were collected from 82 sample cultivators belonging to two districts through stratified proportionate random sampling method. The data related to 1983-84 and this was made use of to study the cropping pattern, crop rotation, level of fertiliser and pesticide use, etc. The quadratic form of the function \( Y = a + bx + cx^2 \) was used to study the fertiliser response. The specific function used was

\[
Y = a + a_1N + a_2P + a_3K + a_4NP + a_5NK + a_6PK + a_7NPK + a_8N^2 + a_9P^2 + a_{10}K^2
\]

where \( N = \text{nitrogen} \); \( P = \text{phosphorus} \) and \( K = \text{potash in kg./ha} \).

Multiple regression equation of the type \( Y = b_1X_1 + b_2X_2 + b_3X_3 \) was employed to find out the intensity of insecticide use where \( Y = \text{yield of cotton} \), \( X_1 = \text{area} \); \( X_2 = \text{value of conventional pesticides} \) and \( X_3 = \text{value of synthetic pyrethroids} \).

RESULTS AND DISCUSSION

The factors causing the ecological degradation of the region are identified to be changes in the cropping pattern and excessive and indiscriminate use of fertilisers and pesticides.

Changes in Cropping Pattern

The variability of area and productivity of cotton was studied for the two periods, i.e., 1965-75 and 1975-86. It was found that during the second period, i.e., 1975-86, the proportion of area under cotton to the total cropped area was high. Farmers were influenced more by the price factor than the ideal crop rotations required for the restoration of soil health. The compound growth rates for area and productivity for both the periods were observed to be positive and indicated increasing trend. The compound growth rates of area and productivity were 17 and 9.8 per cent and 18.2 and 16.4 per cent for Guntur and Prakasam districts respectively for the overall period 1965-86.

The cotton crop has replaced the traditional crops such as jowar, bajra, coriander, tobacco, chillies, bengal gram, etc., to a great extent. The cropping pattern at the farm level indicated that 84 per cent of the cropped area was occupied by cotton and the remaining 16 per cent was used for growing other crops in the cotton belt. It was further revealed that the proportion of area under cotton to the total operational area increased with the farm size. This indicated that commercialisation of farming increased with an increase in the farm size. A dramatic change is observed from the food and
fodder based cropping system to fibre based cropping system. Further, cotton is being cultivated as a pure crop in the same lands without any crop rotations since more than a decade. Thus, it has become monoculture in the region violating the principle of ideal cropping sequence. This has tremendous ill-effects on the ecology and environment of the region.

**Nutritional Imbalances**

Crop nutrition plays a very significant role in productivity. The imbalances in nutrition would lead to declining yields due to deficiencies of nutrients and physiological disorders. Continuous mono-cropping, low levels of organic manures and high levels of chemical fertilisers are some of the factors responsible for depletion of nutrients, leading to disorders in other crops and also in cotton crop too. The imbalances in fertilisation is evident from Table I.

<table>
<thead>
<tr>
<th>Size-group</th>
<th>Organic manures (tonnes)</th>
<th>Nitrogen (kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>2.69</td>
<td>183.5</td>
</tr>
<tr>
<td>Medium</td>
<td>2.83</td>
<td>187.1</td>
</tr>
<tr>
<td>Large</td>
<td>4.73</td>
<td>172.9</td>
</tr>
<tr>
<td>Overall</td>
<td>4.00</td>
<td>178.0</td>
</tr>
</tbody>
</table>

It is revealed from the table that the farmyard manure was applied to the extent of four tonnes per hectare on an average against the recommended level of 15 tonnes. Only 57 per cent of the selected cotton growers applied farmyard manure. It is also evident that the amount of nitrogen fertiliser application was 178 kg. per hectare while the recommended dose is 90 to 120 kg. per hectare in the region. Further, the fertiliser response function also indicated that application of high nitrogen level alone or in combination with other nutrients did not show any response in increasing yields of cotton, which is evident from the following functions and this should prompt the growers to reduce the level of application of nitrogen:

1. High-yielding varieties:
   \[
   Y = 6.82 + 0.063N + 0.067P + 0.429K - 0.0001NP \\
   - 0.002NK - 0.003PK + 0.00001NPK + 0.00004N^2 \\
   - 0.00003P^2 + 0.00002K^2
   \]

2. Hybrid varieties:
   \[
   Y = 28.71 + 0.012N - 0.035P - 0.008K + 0.0001NP \\
   + 0.0001NK + 0.0006PK - 0.00003NPK - 0.00006N^2 \\
   + 0.00007P^2 + 0.0001K^2
   \]
Thus, the imbalances in nutrients due to low levels of organic manures and higher levels of nitrogen coupled with mono-cropping of high yielding and hybrid varieties of cotton for more than a decade led to nutritional disorders of cotton and made this crop susceptible to pests like white-fly, aphids, mealy-bugs, etc. Also increased application of nitrogen fertiliser was one of the factors responsible for severe white-fly outbreak from the year 1984-85 onwards which was earlier a minor pest. Thus, the cumulative imbalances in plant nutrients led to a decline in yields and heavy crop damage and a decline in income due to a decline in the quality of produce.

*Indiscriminate Insecticide Use*

The plant protection in cotton farming crossed the subsistence phase of cultural and mechanical measures and exploitation phase of classical control with limited use of insecticides. The crisis phase of excessive injudicious use of newer potent broad spectrum insecticides resulted in unavoidable side-effects such as accelerated pest resistance, pest resurgence and newer pest situations. As it stands now, it has entered finally the disaster phase, *i.e.*, increased cost of plant protection making cotton cultivation uneconomical.

An evidence is provided in Table II, indicating high incidence of cost and nature of insecticide used.

<table>
<thead>
<tr>
<th>Size-group</th>
<th>Expenditure on</th>
<th>Total operational</th>
<th>Percentage of pesticide expenditure to total operational expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conventional insecticides</td>
<td>Synthetic pyrethroids</td>
<td>expenditure</td>
</tr>
<tr>
<td>Small</td>
<td>1,053.44</td>
<td>970.64</td>
<td>2,024.08</td>
</tr>
<tr>
<td>Medium</td>
<td>1,070.58</td>
<td>1,017.48</td>
<td>2,088.06</td>
</tr>
<tr>
<td>Large</td>
<td>1,034.52</td>
<td>808.91</td>
<td>1,843.43</td>
</tr>
<tr>
<td>Overall</td>
<td>1,046.39</td>
<td>883.57</td>
<td>1,929.96</td>
</tr>
</tbody>
</table>

It is apparent that the expenditure on mere insecticides was around Rs. 2,000 per hectare constituting 20 to 25 per cent of the total operational expenditure which is very high. Further, the multiple regression analysis was done to study the influence of insecticides on yield ($Y$), with land ($X_1$) in hectares, conventional pesticides ($X_2$) and synthetic pyrethroids ($X_3$). The regression equation fitted to the data was:

$$Y = -1.8 + 32.73** X_1 - 0.002 X_2** - 0.002$$

(1.29) (0.007) (0.001)

** Significant at one per cent level.
The negative signs of the coefficients for both conventional and synthetic pyrethroids from the above regression equation indicated indiscriminate use of both the types of insecticides which implied irrational behaviour of cotton growers.

In cotton farming the pesticide use is also characterised by higher concentration of insecticides than the recommended and high frequency of pesticide application with insufficient coverage of foliage. On an average, the conventional insecticides with 1.0 to 1.25 litres of concentrate in 250-280 litres of water works out to 4 to 5 ml of concentrate for every one litre of water. The conventional insecticides are being applied in combination with other insecticides. The most commonly used combinations were Nuvacron with Sevin, Parathion and Ekalux, Parathion with Ekalux or Sevin, etc.

The study also revealed that on an average, the spray fluid was to the extent of 111, 175 and 265 litres per hectare during early, growing and peak growth stages of crop respectively with an average of 187 litres. It clearly indicates that the spray fluid is not sufficient to cover the foliage completely giving scope for pests to shelter. The insecticides were applied for about 14 times on an average during the crop season in 1983-84 even though the year was very favourable for cotton. However, about 20-25 applications were noticed on an average.

The use of ineffective and spurious conventional insecticides over the years has resulted in the development of insect resistance and emergence of new pest situation. Thereby, the farmers resorted to use synthetic pyrethroids. Unregulated use of synthetic pyrethroids has led to high incidence of sucking pests particularly the outbreak of white-fly due to elimination of natural predators.

It is evident that the farmers have realised an yield of 7.5 to 10 quintals as against normal yields of 20 to 25 quintals per hectare due to white-fly during 1985-86. It is estimated that the loss was about 24 lakh quintals worth Rs. 120 crores in Guntur district alone.

**Declining Productivity**

There is ample evidence to show as to how the yields of cotton decreased due to indiscriminate and excessive use of modern inputs. The details of the decline in productivity of cotton are presented in Table III.

<table>
<thead>
<tr>
<th>Year</th>
<th>Guntur district</th>
<th>Prakasam district</th>
<th>Andhra Pradesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983-84</td>
<td>635</td>
<td>756</td>
<td>362</td>
</tr>
<tr>
<td>1984-85</td>
<td>489</td>
<td>313</td>
<td>302</td>
</tr>
<tr>
<td>1985-86</td>
<td>267</td>
<td>182</td>
<td>204</td>
</tr>
</tbody>
</table>
It is estimated that the yields declined to the extent of about 60 per cent in Guntur district and 75 per cent in Prakasam district.

**ALTERNATE POLICY MEASURES**

On the basis of available evidence, there was a shift in the cropping pattern from diversified farming to specialised farming. Continuous monocropping of new seeds of cotton for more than one and half a decade and indiscriminate use of chemical fertilisers and insecticides resulted in disorders of macro- and micro-nutrients and pest outbreak and finally declining yields. Thus, it is apparent that the agro-ecosystem was changed. It is therefore essential to establish most efficient and sustainable and productive agro-ecological system with minimum interference keeping in mind the long run perspective.

The area under cotton should be restricted to at least half of the total area of the holding and the remaining area may be brought under oilseeds crops like sunflower and fodder crops facilitating crop rotations. Pulse crops rotating with cotton would help in fixation of biological nitrogen which will help in maintaining soil structure and fertility.

Crop rotations with alternate crops coupled with application of organic manures would help in rectifying the nutritional disorders of crops. Therefore, organic manures must be given due importance. Hence, the cropping system must be adjusted in such a way as to support the cattle whose services are essential in farming and provide supplementary income through sale of milk and milk products.

Increased nitrogen application disregarding balanced nutrition led to incidence of insect pests particularly white-fly; the use of the same must be limited to the extent desirable. Need-based plant protection measures must be adopted. Relevant and quality insecticides must be supplied based on the local needs of the farmers.

Crop improvement programmes must be adopted for all the crops so as to make alternative crops to be remunerative as the neglect by certain crops would lead to displacement in the farming system due to economic considerations. Therefore, every crop must be given due importance in improving yields. In view of the increased use of plant protection chemicals and emergence of new pest situations, breeding of resistance varieties having high yield potential is the need of the hour.

The extension agency must educate the farmers thoroughly on the negative limitations of the new technologies and the strategies and the farmers must be oriented to maintain the balance in crop ecosystem to provide room for every living organism without disturbing the normal system.