CHAPTER V

SUMMARY AND CONCLUSIONS
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With the limitation of land and increasing population, the most suitable strategy to increase food production in our country seems to be to increase yield potential of crops per unit area per unit time. In other words, multiple cropping programme designed to raise more crops per year per hectare appears to be the only solution.

The present cropping patterns that are being followed by farmers have arisen out of necessity based on farmers' urge to become self-sufficient. Scientific information on high intensity of cropping is of vital importance. It is necessary that experimental data on various aspects of high intensity of cropping are determined and their economics worked out so that intensive multiple cropping involving specific cropping patterns can be recommended to farmers. Detailed investigations were, therefore, undertaken both in the field and in the laboratory to determine the effect of five cropping patterns, viz., Potato-rice-rice, Maize-rice-rice, Groundnut-jute-rice, Rice-jute-rice and Rice-rice, on the various soil physical and chemical properties and yield of crops, and finally to find out the most suitable and efficient cropping pattern from the point of view of maximization of yield and dry-matter
production per unit area per unit time and with maximum economic returns under recommended package of practices for individual crops, in a project entitled 'Effect of various cropping patterns on soil fertility and crop yields' at the Central Rice Research Institute, Cuttack during the years 1967-69. Salient findings of the investigations have been summarized in this chapter.

A. FIELD EXPERIMENT

The object of the field experiment was to compare the growth and yield performance of the crops in the cropping patterns.

1. Dalua rice

In respect of the number of effective tillers per square meter, during the first year (1967-68), the dalua rice in treatment Potato-rice-rice, Rice-jute-rice and Rice-rice produced higher number of effective tillers than the dalua rice in Maize-rice-rice treatment. During the second year (1968-69) the maximum number of effective tillers was obtained in treatment Potato-rice-rice closely followed by Rice-jute-rice. During both the years the lowest number of effective tillers was observed in the dalua rice crop following maize.

The rice plants in treatment Potato-rice-rice gave taller plants during dalua 1968 season, whereas during dalua 1969, the maximum height was attained by the rice plants in Rice-rice treatment. During the first year
all the treatments were planted with the variety IR.8 whereas during second year, Rice-rice treatment was planted with IR.8 and the rest of the treatments with Padma. Among those treatments planted with variety Padma, the maximum plant height was attained by the dalua rice crop in Potato-rice-rice treatment.

During the kharif season 1968, the maximum number of effective tillers was noticed in the kharif rice in treatment Groundnut-jute-rice, but in 1969 the maximum number of effective tillers was noticed in treatment Maize-rice-rice.

The maximum height of rice plant during kharif season 1968 was attained by the plants in treatment Rice-jute-rice where the tall indica variety T.141 was used. During the kharif season 1969, maximum height was attained by rice crops in treatment Groundnut-jute-rice where the same tall indica variety T.141 was used.

2. Maize

The maize plants in treatment Maize-rice-rice had taller plants during 1967-68 than during 1968-69. This was due to the higher initial fertility status of the soil as well as due to planting at optimum time. The number of green leaves put forth by the maize plant at different stages of growth during both the years was almost the same.
3. Potato

The potato plants in Potato-rice-rice cropping patterns were slightly taller during the first year than in the second year. The short plants during the second year were due to the late planting of the crop when the temperature was lowest. The number of shoots per hill was almost the same during both the years.

4. Groundnut

The number of branches as well as the height of the plants of groundnut in Groundnut-jute-rice cropping pattern was higher during the second crop cycle than during the first crop cycle because the plants during the first year were affected by Tikka disease.

5. Jute

The jute plants in the cropping pattern Groundnut-jute-rice were taller than the jute plants in cropping pattern Rice-jute-rice during both the crop cycles. Similarly the basal diameter of the jute plants following groundnut was much higher than the jute plants following rice during both the years. This was due to the better growth and performance of the jute crop following groundnut as compared to the jute crop following rice.

6. Rice Yield

Regarding the yield of dalua rice, the highest grain yields were obtained from the rice crop following potatoes in cropping pattern Potato-rice-rice during
both the cycles. This was due to the higher fertility status of the soil after potatoes. The lowest yields during both the years were obtained from the dalua rice crop following maize in cropping pattern Maize-rice-rice.

As far as the yield per hectare per day was concerned the highest yield during both the years were obtained from the dalua rice crop following potatoes and the lowest from the rice crop following maize.

The highest straw yield was obtained from the dalua rice crop following potatoes and the lowest from the rice crop following maize. The maximum dry-matter production per hectare as well as per day was also from the dalua rice crop following potatoes. The least dry-matter production per hectare and per day was by the rice crop following maize.

As far as the kharif rice yield was concerned the highest yield during 1968 was obtained from the cropping pattern Rice-jute-rice. Due to adverse weather conditions and to the attack of pest and diseases, the yield from other treatments planted with IR.8 was lower. During kharif season 1969, the highest rice yield was obtained from the crop in cropping pattern Potato-rice-rice. The lowest yields were obtained from the treatments Groundnut-jute-rice and Rice-jute-rice.

Among the kharif rice, the highest straw yield was obtained from the treatment Rice-jute-rice in 1968.
and Potato-rice-rice in 1969.

The maximum dry-matter production per hectare per day of kharif rice was from the cropping pattern Rice-jute-rice during the first year and Potato-rice-rice during the second year.

A comparison of the yield performance of dalua and kharif rice showed that in general the dalua rice in 1967-68 as well as in 1968-69 gave much higher yields than the kharif rice. The dalua rice showed better growth and was not affected by pest or disease. The highest yields were obtained from the dalua rice following potatoes during both years. The variety IR.8 during dalua season was of longer duration, had more number of bright sunshine hours, with a few number of cloudy days and had a higher accumulated temperature. These factors were responsible for the higher production during the dalua season when compared to the kharif season.

7. Maize Yield

The yield of maize grain in treatment Maize-rice-rice was higher during the first year than that of the second year. This was due to the higher initial fertility status of soil as well as due to the planting of the crop at the optimum time.
8. **Potato Yield**

The yield of potatoes in treatment Potato-rice-rice was higher during the first cycle than that of second cycle. The potatoes during second year was planted late due to adverse weather conditions and hence the low yield.

9. **Groundnut Yield**

The yield of groundnut pods in treatment Groundnut-jute-rice was higher during the second year. During the first year, the crop was affected by Tikka disease and hence the low yield.

10. **Jute Yield**

The jute crop following groundnut in treatment Groundnut-jute-rice gave significantly higher yield of fibre than the jute crop following rice in Rice-jute-rice treatment during both the years. Similarly the dry weight of leaves and dry-weight of jute sticks were much higher in the jute crop following groundnut than from the crop following rice. The dry-matter production from the jute crop following groundnut was much higher than the jute crop following rice.

Comparing the yield performance of crops in various cropping patterns, it was found that the maximum yield per hectare as well as per day was from the potato crop during both the years. The second highest yield per hectare as well as per day was from the dalua rice crop following potatoes. The lowest yield was from
the jute crop in treatment Rice-jute-rice.

Regarding the production potential of various cropping patterns, the maximum production in a year was obtained from the cropping pattern Potato-rice-rice in both the years. The maximum yield per day was also obtained from this cropping pattern.

The lowest total production per hectare was obtained from the cropping pattern Groundnut-jute-rice.

Comparing the dry-matter production it was found that among the crops, the maximum dry-matter per day per hectare was by the dalua rice crop following potatoes; the next being the dalua rice in Rice-jute-rice.

Among cropping patterns the highest dry-matter production per hectare was by the Rice-jute-rice treatment during the first year and by the Potato-rice-rice treatment during the second year. Thus the cropping patterns Potato-rice-rice and Rice-jute-rice had the maximum dry-matter production potential among the different cropping patterns investigated.

B. SOIL FERTILITY CHANGES

The soil fertility changes in respect of bulk density, water stable aggregates, soil pH, cation exchange capacity, organic carbon, total soil nitrogen, carbon:nitrogen ratio, total and extractable phosphorus, total and exchangeable potassium, exchangeable calcium, exchangeable magnesium and exchangeable hydrogen were
studied before and after individual crops in a given cropping pattern. The results obtained are summarised in this section.

No appreciable change in bulk density of the soil was noticed due to various cropping patterns. A slight decrease in bulk density was noticed after potato, maize and groundnut crops which had received large quantities of farmyard manure. An increase in bulk density was noticed after dalua and kharif rice.

Continuous cultivation of rice (Rice-rice rotation) and Rice-jute-rice treatment had deteriorating effect on soil structure. However, inclusion of groundnut in rotation with jute and rice, structure of the soil was found to improve slightly. It was found that soils where farmyard manure had been applied developed a good soil structure as indicated by the higher percentage of water stable aggregates after potato, maize and groundnut.

There was a decrease in soil pH in all cropping patterns after each cycle. The maximum decrease in soil pH was noticed in treatments receiving inorganic fertilizers alone.

Among individual crops, the maximum decrease in soil pH was noticed after jute and kharif rice. In the two year period, there was a decrease in pH by 0.6 units in Rice-jute-rice treatment and 0.7 units in Rice-rice treatment.
The cation exchange capacity of the soil was only slightly affected by various crops and cropping patterns. There was an increase in cation exchange capacity after potato and maize crops during both the years and after groundnut during the second year. There was no marked change in cation exchange capacity after the jute crop. A slight decrease was noticed after the dalua and kharif rice.

In all the cropping patterns except Potato-rice-rice there was a slight fall in cation exchange capacity after the completion of each cycle.

There was marked increase in organic carbon content of the soil after potato and maize during the first year and after potato, maize and groundnut during the second year. After dalua rice there was a small decrease but after the kharif rice the decrease was more evident.

After completion of two cycles, there was decrease in organic carbon content of the soil in all cropping patterns, the maximum decrease being noticed in continuous cultivation of rice (Rice-rice cropping pattern).

The total nitrogen content of the soil increased after potato, maize and groundnut during both the crop cycles, the maximum being noticed after the potato crop. After dalua and kharif rice there was marked decrease in total nitrogen in almost all treatments. After
completion of each cycle a decrease in total nitrogen was observed in all cropping patterns. The minimum loss after two cycles was noticed in cropping patterns Potato-rice-rice and Groundnut-jute-rice whereas the maximum loss was noticed in Rice-rice treatment.

There was a decrease in carbon:nitrogen ratio in all treatments during the first year. An increase in carbon:nitrogen ratio was noticed during the second year after potato, maize and groundnut. After completion of two cycles, the carbon:nitrogen ratio was less than the original status except in Rice-jute-rice treatment.

There was a slight increase in total phosphorus after each cycle in all cropping patterns except Rice-rice where there was an increase after the first year, but no change after the second year.

The extractable phosphorus of the soil increased after potato, maize and groundnut, the increase being greatest after the potato crop. There was a slight decrease after the succeeding dalua rice but increased again after the kharif rice. In cropping patterns including jute, a slight decrease was noticed after the jute crop. In continuous cropping of rice, there was slight decrease after dalua rice but an increase after kharif rice.

After completion of two crop cycles, there was an increase in extractable phosphorus of soil over the
original status in cropping patterns Potato-rice-rice and Maize-rice-rice, whereas there was no appreciable change in Groundnut-jute-rice rotation. But in Rice-jute-rice and Rice-rice cropping patterns, there was a decrease in extractable phosphorus over the original level.

The total potassium content of the soil showed slight increase after potato, maize and groundnut, a small decrease after dalua rice and a severe fall after kharif rice. A remarkable fall in total potassium was also noticed after the jute crop in both the cropping patterns where jute was included.

After each crop cycle, the total potassium content of the soil decreased, the maximum decrease being noticed in Rice-rice cropping pattern during both the years.

Exchangeable potassium status of soil increased after potato and maize crops whereas it decreased after dalua rice and jute. The decrease was small after dalua rice, but high after jute crop. After kharif rice there was decrease in Potato-rice-rice and Maize-rice-rice rotations, but in Groundnut-jute-rice and Rice-jute-rice rotations there was a slight increase. In continuous cropping of rice (Rice-rice treatment) there was a decrease in exchangeable potassium after every crop of rice. After completion of each cycle the exchangeable potassium in all cropping patterns was
was much lower than the original status.

The exchangeable calcium in the soil showed an increase after potato and maize but decreased after groundnut, *dalua* rice, jute and *kharif* rice. The decrease was small after *dalua* rice but very high after jute and *kharif* rice. Almost the same trend in change was noticed in case of exchangeable magnesium.

The exchangeable hydrogen in soil showed a decrease after potato but an increase after maize, *groundnut,* *dalua* rice, jute and *kharif* rice. The increase was remarkable after jute and *kharif* rice, but low after maize and groundnut. After completion of two cycles, the maximum increase was noticed in cropping pattern *Rice—jute—rice,* the next being *Groundnut—jute—rice.*

C. UPTAKE OF NITROGEN, PHOSPHORUS AND POTASSIUM BY VARIOUS CROPS

Groundnut kernels had the highest percentage of nitrogen, the next maximum being noticed in jute leaves. The potato tubers and haulms came third in the order. The lowest percentage of nitrogen was found in jute stick and maize pith.

The highest percentage of phosphorus was found in maize grain and the lowest percentage in groundnut shells and jute sticks.

Potato leaves and tubers contained the highest percentage of potassium. The next highest percentage was found in jute leaves, followed by rice straw.
So far as the total removal or uptake of nitrogen was concerned, groundnut crop removed the maximum nitrogen, the next being dalua rice crop following the potatoes. The uptake of nitrogen was much higher by the dalua rice than by the kharif rice.

Among the various cropping patterns, Potato-rice-rice removed the maximum quantity of nitrogen during both the years, closely followed by Rice-jute-rice during the first year and Groundnut-jute-rice during the second year. The lowest removal during both the years was by the Rice-rice treatment.

The dalua rice following potatoes removed the maximum quantity of phosphorus during both the years. The dalua rice removed much more phosphorus than kharif rice. The removal of phosphorus by potato, groundnut and jute was very low. Among the cropping patterns the maximum quantity of phosphorus was removed by Potato-rice-rice during both the years. The lowest uptake was by cropping patterns Groundnut-jute-rice and Rice-rice.

The dalua rice in treatment Rice-jute-rice removed the maximum quantity of potassium during the first year, whereas the dalua rice following potatoes removed the highest quantity during the second year.

The cropping pattern Potato-rice-rice removed the maximum quantity of potassium followed by Rice-jute-rice during both the years. The uptake of potassium
was lowest by the cropping pattern Groundnut-jute-rice during both the years.

For the production of one ton of dry-matter maximum quantity of nitrogen was removed by groundnut during both the years. The next maximum quantity was utilized by potatoes. The most efficient crop in utilizing nitrogen for dry-matter production was jute, the next most efficient being dalua rice.

The maximum quantity of phosphorus was utilized by maize for the production of one ton of dry-matter. The lowest quantity of phosphorus was used by jute.

Potato utilized maximum quantity of potassium for the production of one ton of dry-matter. During the first year, kharif rice used more potassium to produce one ton of dry-matter than dalua rice. But during the second year, the quantity used by dalua rice was slightly more than kharif rice. Groundnut utilized the least quantity of potassium for producing one ton of dry-matter.

The highest protein yield was obtained from the cropping pattern Potato-rice-rice during both the years. The highest protein yield per day was also obtained from the same cropping pattern. The second highest protein yield was obtained from Rice-jute-rice during the first year and Groundnut-jute-rice during the second year.
D. BALANCE SHEET OF PLANT NUTRIENTS

There was loss in nitrogen from all cropping patterns during the first crop cycle, whereas during the second crop cycle, there was loss in all cropping patterns except Groundnut-jute-rice, where there was a gain in nitrogen. The loss during both the years was maximum from the cropping pattern Maize-rice-rice and the least from Groundnut-jute-rice and Rice-jute-rice.

The balance sheet of extractable phosphorus of the soil showed a loss in all treatments. In general loss was very low and the minimum loss was from Groundnut-jute-rice during the first year and Potato-rice-rice during the second year.

The total potassium balance in the soil showed heavy loss during both the years. The maximum loss occurred in Groundnut-jute-rice treatment during the first year and Rice-rice treatment during the second year.

The balance sheet of exchangeable potassium showed a small loss in treatments Potato-rice-rice, Maize-rice-rice and Groundnut-jute-rice during the first year and Potato-rice-rice and Maize-rice-rice during the second year. In treatments Rice-jute-rice and Rice-rice there was a slight gain in exchangeable potassium during both the years, whereas in Groundnut-jute-rice there was a gain in the second year. The
maximum loss occurred in treatment Maize-rice-rice during the first year and Potato-rice-rice during the second year.

E. CULTURAL AND IRRIGATIONAL PRACTICES

The cultural and irrigational practices of various crops were affected by the cropping patterns. In treatment Potato-rice-rice, the rice following potatoes needed less preparatory tillage than other rice crops. The irrigation requirement was also less. The jute crop following groundnut also needed less preparatory tillage. On the other hand, the jute crop following rice required more preparatory tillage, took more time for sowing and was more expensive.

It was generally observed that irrigation requirements for the cropping pattern Groundnut-jute-rice were the lowest, whereas it was highest for Potato-rice-rice.

F. ECONOMICS

Among individual crops the maximum cost of cultivation was for potatoes, the next highest being for dalua rice. The lowest cost of cultivation was for jute.

As far as the cropping patterns were concerned, the maximum expenditure was incurred for the Potato-rice-rice cropping pattern. The lowest expenditure was for Rice-rice cropping pattern.
Potato crop gave the maximum profit, the next being the dalua rice in Potato-rice-rice treatment.

Comparing the various cropping patterns, the maximum net profit per hectare was obtained from Potato-rice-rice during both the years. The next most profitable cropping pattern was Rice-jute-rice during the first year and Maize-rice-rice during the second year. The cropping pattern Rice-rice gave the lowest profit during both the years.

The results obtained from two years' data are definitely indicative but insufficient to make very specific recommendations. However, this investigation has shown that the cropping pattern Potato-rice-rice can be successfully followed without deteriorating soil fertility for maximum production and profit.