# YIELD VARIABILITY PATTERN IN COCOA

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## Introduction

Cocoa is mainly grown as a mixed crop in coconut and arecanut plantations. At present, cocoa is cultivated in an area of 40,519 hectares in India with a production of 11,820 tonnes. The average productivity of cocoa in India is 550 kg dry beans/ha (2008-09) which is very low. There is immense scope to enhance the productivity by using superior planting material and adopting proper management practices. Cocoa, whose natural environment is the lower storey of the forest, requires shade when young and also to a lesser extent when grown up. Young cocoa plants grow best with 50 per cent full sunlight. It grows very well in the partially shaded conditions prevailing in the arecanut and coconut gardens in our country.

The mixed plantation of arecanut and cocoa can be raised by adopting normal spacing of 2.7 x 2.7m for arecanut and 2.7 x 5.4 m for cocoa. When cocoa is to be raised as a mixed crop with coconut, either single hedge or double hedge system of planting may be adopted. In single hedge system, cocoa can be planted 2.7 m apart in a single row in between two rows of coconut, while in double hedge system it can be planted 2.5 m apart in double rows in between two rows of coconut palms. When cocoa is grown under arecanut with a spacing of 2.7 x 5.4 m, one hectare area accommodates about 650 trees.

An annual application of 100 g N, 40 g $P_2O_5$ and 140 g $K_2O$ per tree per year in two equal split doses is recommended. The first dose should be applied in February-March and the second in September-October. Cocoa plants require continuous supply of moisture for optimum growth and yield. During summer, the plants will have to be irrigated at weekly intervals. As the cocoa plants grow under the shade of arecanut and coconut plantations, it is necessary to regulate the canopy size and shape of plants so that the main crop is not affected. Proper and systematic pruning is essential in cocoa cultivation.

Cocoa flowers from the second year of planting and the pods take about 140-160 days to mature and ripen. Generally cocoa gives two main crops in a year, April-June and September-January, though off-season crops may be seen almost throughout the year, especially under irrigated condition. Under normal cultivation practices, cocoa tree gives an average yield of about 1 kg dry beans annually.

## Yield variation

Cocoa is characterized by a high degree of tree-to-tree variability in yield. A relatively high proportion of the trees is low yielding, and called 'passenger trees' by the farmers. Keeping these low yielding trees in a garden may not be economically feasible in most of the cases. If we can identify the low yielders in the early stages, the net return from the garden can be improved either by replacing the low yielding trees with good quality planting material or by removing/thinning down the low yielders, which will provide a better return from the remaining trees.

To study the tree-to-tree variation and the yield distribution of cocoa, 17 years yield data of cocoa planted under arecanut (2.7 x 2.7m spacing) with two different spacing of cocoa (2.7 x 2.7m and 2.7 x 5.4m) from the Arecanut + Cocoa mixed cropping experiments conducted at CPCRI Regional Station, Vittal were used. The distribution of 17 years average yield data of cocoa in two spacing are given in Table 1. There were a total of 112 trees in 2.7 x 2.7m spacing and 64 trees in 2.7 x 5.4m spacing. Total

number of trees is divided into four equal groups based on the 17 years cumulative yield data in the increasing order with Group I as low yielders and Group IV as high yielders. The 25 percentage of the low yielding trees (Group I) of 2.7 x 2.7m spacing provide only 12% of the total production with an average yield of 13 pods/tree/year. On the other hand, 25% of the high yielding trees (Group IV) of 2.7 x 2.7m spacing provide 40.5% of the total production with an average yield of 66 pods/tree/year (Fig 1a). Similarly in the case of 2.7 x 5.4 m spacing the 25 percentage of the low yielding trees (Group I) provide only 9.21% of the total production with an average yield of 25 pods/tree/year and the 25% of the high yielding trees (Group IV) provide 46.9% of the total production with an average yield of 86 pods/tree/year (Fig 1b). Note that it may not be economically feasible to maintain the low yielding trees (25%) which provide only about 10% of the total production. Hence, it is necessary to identify the low yielding trees in the early stages of growth so that it can be removed or replaced with good seedlings/grafts.

**Table 1. Average yield (no.of pods/tree/year) under different groups -17 years data**

| Group | 2.7 x 2.7m | | | | 2.7 x 5.4m | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | Yield (%) | Range | N | Mean | Yield (%) | Range |
| I | 28 | 13.01 | 11.95 | 3.7 - 18.1 | 16 | 24.9 | 9.21 | 11.0 - 34.2 |
| II | 28 | 23.51 | 20.64 | 18.4 - 27.7 | 28 | 43.0 | 16.65 | 37.3 - 50.2 |
| III | 28 | 38.47 | 26.91 | 27.6 - 49.8 | 28 | 56.1 | 27.23 | 51.0 - 63.7 |
| IV | 28 | 66.27 | 40.50 | 50.9 - 101.8 | 28 | 84.5 | 46.91 | 65.0 - 130.5 |
| Total | 112 | 35.32 | 100.00 | 3.7 - 101.8 | 112 | 52.1 | 100.00 | 11.0 - 130.5 |

**Table 2. Transition probability matrix**

| Classification based on 17 years data | Classification based on initial 4 years data | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2.7 x 2.7m | | | | 2.7 x 5.4m | | | |
| | I | II | III | IV | I | II | III | IV |
| I | 0.61 | 0.21 | 0.18 | 0.00 | 0.50 | 0.25 | 0.19 | 0.06 |
| II | 0.32 | 0.36 | 0.25 | 0.07 | 0.38 | 0.38 | 0.06 | 0.19 |
| III | 0.04 | 0.36 | 0.43 | 0.18 | 0.13 | 0.25 | 0.44 | 0.19 |
| IV | 0.04 | 0.07 | 0.14 | 0.75 | 0.00 | 0.13 | 0.31 | 0.56 |

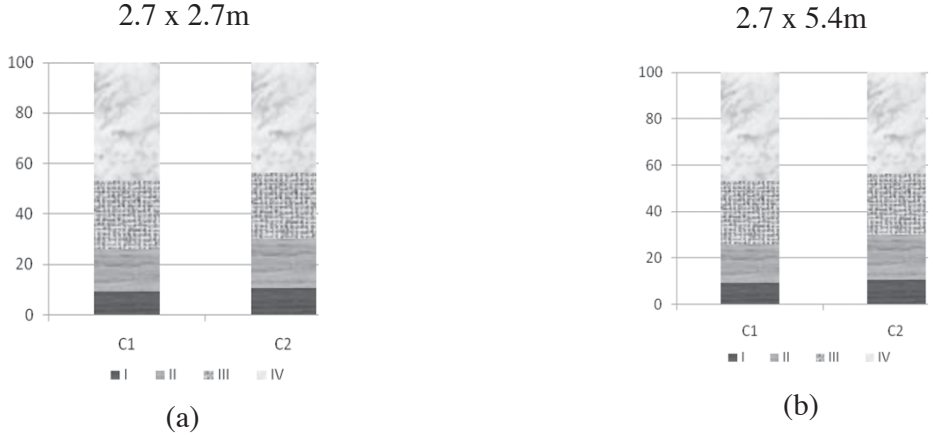


**Fig. 1. Percentage yield data of different yield groups classified based on initial 4 years data (C1) and 17 years data (C2)**

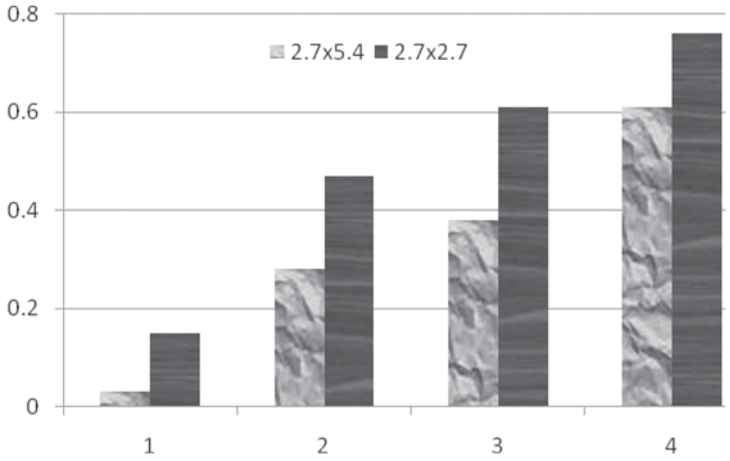


**Fig. 2. Correlation coefficient between initial years yield with 17 years cumulative yield**

The linear correlation coefficient between initial years yield and 17 years cumulative yield indicate that the initial 4 years yield will have high correlation (>0.60) with the yielding capacity (17 years cumulative yield) of a tree (Fig.2). The initial 4 years yield has been used to classify the trees into four equal groups and the accuracy of classification with respect to the 17 years cumulative yield is presented in the form of transition probability matrix in Table 2. It is noted that among the trees which are classified based on initial 4 years yield into the 4 groups, more than 80% of the trees will be in the same group or the nearest groups classified based on the 17 years yield data. The comparison of yield obtained from different yield groups classified based on 4 years and 17 years yield data are almost same (Fig.2). This shows that initial 4 years yield data can be used to identify the low yielding trees in a garden.

The average yield of cocoa in 2.7 x 2.7 m spacing is 35 pods/tree/year and the average yield of cocoa in 2.7 x 5.4 m spacing is 52 pods/tree/year which is 1.5 times more than the yield of cocoa in 2.7 x 2.7m spacing. The number of trees in 2.7 x 2.7m spacing is double than that of 2.7 x 5.4m spacing and if we remove 50% of the low yielding trees from the 2.7 x 2.7m garden we can expect 1.5 times increase in yield from the remaining trees. Note that the 50% of the low yielding trees in 2.7 x 2.7m spacing provide only 32.5% of the total yield and the remaining 50% of the high yielding trees provide 67.5% of the total yield. If we remove the 50% of the low yielding trees from the 2.7 x 2.7m spacing garden, the yield of the remaining trees which provides 67.5% of the total production is expected to increase 1.5 times and the total production will be 101% or in other words, if we remove 50% of the low yielding trees from the garden with 2.7 x 2.7m spacing, we can expect 1.5 times increase in the yield from the remaining trees and the total production from garden will be almost same. The results showed that it is better to remove or replant the low yielding trees in a garden instead of maintaining these trees which do not give any additional return.

## Conclusion

A high degree of tree to tree variation in yield is observed in cocoa. The low yielding 25% of trees in a cocoa garden provide only about 10% of the total production. It is better to remove or replant the low yielding trees in a garden instead of maintaining these trees which do not give any additional return. The initial 4 years yield is a good indicator for identifying the low yielding trees in a garden.