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ROOT DISTRIBUTION PATTERN IN TEA *(CAMELLIA SINENSIS)* AND CLOVE *(EUGENIA CARYOPHYLLUS)* MIXED SYSTEM

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ABSTRACT

Rooting pattern in the mono crop stands of one hundred years old seedling tea and mixed planted with clove was observed. Under mono cropping, in the first 30 cm soil layer, tea had over 60% of total roots and 76% feeder roots, while clove had about 50% each of total and feeder roots. More or less a similar pattern of distribution was seen in the length of roots also. Concentration of root activity in the top 30 cm soil depth was thus apparent in both the crops. In the mixed crop, clove had an increase in weight of roots from 50% to 67%, in number of roots from 56% to 72% and an increase in length from 50% to 60% in the first 30 cm soil depth. A similar increase was also observed in the case of the feeder roots of clove. A clear shift in the rooting pattern of clove from lower layers to the top was observed under mixed cropping. Clove under mixed crop also showed an increase of 19% in total fresh weight, 57% in the number of branches and 7% in total length of feeder roots. Tea on the other hand, showed only 13% increase in total fresh weight.

INTRODUCTION

Clove is being mixcropped in tea in the mid-country zones of Sri Lanka with a view to generating additional income especially from the low yielding degraded tea lands. Considering the high cash value of clove, the marginal reduction in yield of tea is more than compensated by the return from clove as evident from the net return of Rs. 57,000/ha from the mixed crop of tea and clove as against Rs 5700/ha of mono crop of tea (Van Til Burg, 1981). To understand the agronomic desirability of such a crop combination, the information on rooting pattern of the different crops, both in monoculture and in their combinations is essential. Although some information on root distribution pattern in certain perennial mixed cropping systems such as arecanut and cocoa (Bhat and Bavappa, 1972), oil palm and cocoa (Kien and Keshi, 1978) and coconut, cocoa, cinnamon and pineapple (Anonymous, 1974) are available, no studies have been reported in tea and clove mixed crop system.

MATERIALS AND METHODS

The study was carried out at the State Plantation Estate, Hunnasgiriya,

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Elkaduwa, Sri Lanka, located at an elevation of about 800 m above mean sea level. Seedling tea *Camellia sinensis*(L.) O. Kuntze, planted in this estate is about 100 years old, and spaced at about a metre apart. Clove, *Eugenia caryophyllus* Bullock et Harrison, had been planted about 15 years ago in the standing crop of tea at a distance of about 6 m to form a mixed stand of both the crops. Mono crop of clove and tea of similar ages planted in the same estate, were also used in the study.

In each system, the entire roots from the soil mass of 1/8 sector root zone within the radius of 60–300 cm from the main crop were excavated for analysis (Figs. 1-2). Excavated roots at three soil depths (*viz.*, 0–30 cm, 30–60 cm, 60–90 cm) and at eight distances from the centre of the sector (*viz.*, 60–90cm, 90–120cm, 120-150cm, 150-180 cm, 180–210 cm, 210–240 cm, 240–270 cm and 270–300 cm) were collected separately. In clove mono crop and in the tea-clove mixed crop, the distance was taken from clove plant while in tea mono crop, it was from the tea clump.

Roots were grouped into 'feeder roots' of size less than 1 mm thickness and 'larger roots' of size more than 1mm thickness and were studied for their fresh weight, total length and total number of branches. In all cases the weights were recorded the next day of sampling.

Plants of more or less uniform growth and age were selected for the study at random. The clove plants selected had a canopy width of about 3 m and a height of about 5 m. The tea plants had a height and spread of about 1 m.

All the excavation operations were carried out on the upward side of the trees to avoid any differences due to the slope of the land. Observations were recorded in four sets of trees in each system.

In this technique, a trench roughly of 60 cm width and 90 cm depth was cut perpendicularly at 300 cm radius from the centre. At every time the soil mass of 30 cm width from the trench towards the crop was washed down into the trench by water, sprayed through knapsack sprayer, exposing the roots. Exposed roots were cut and collected separately for different distances and depths. Operations were repeated till the distance of 60 cm from the crop was reached.

Fresh weight of roots, root length and number of roots were recorded in each section separately. The clove and tea roots were identified on the basis of their colour.

RESULTS

Fresh weight

The data on fresh weight of total roots showed that in the 30 cm depth of soil, the mono crop of clove had 51.7% of the total roots while tea had 63.6% (Fig. 3). In the subsequent depths of 30–60 cm and 60-90 cm clove had 33.5% and 14.8% of roots respectively and tea had 30.0% and 6.4% respectively. It was also observed that when tea and clove were grown in mixed stand, there was a shift in the total weight of roots

FIG. 1. DIAGRAM SHOWING TRENCH AND EXCAVATED ONE EIGHTH SECTOR ROOT ZONE

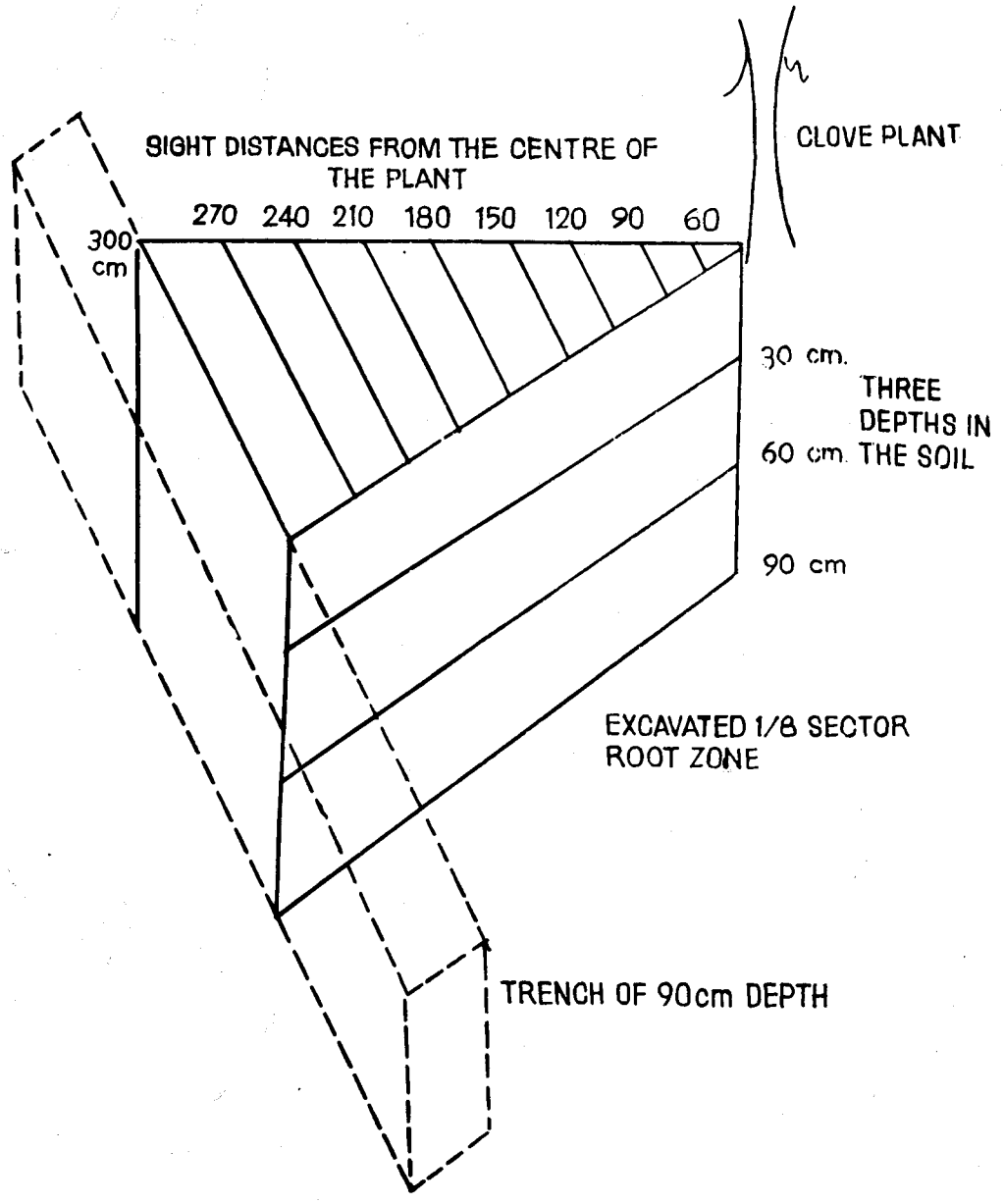
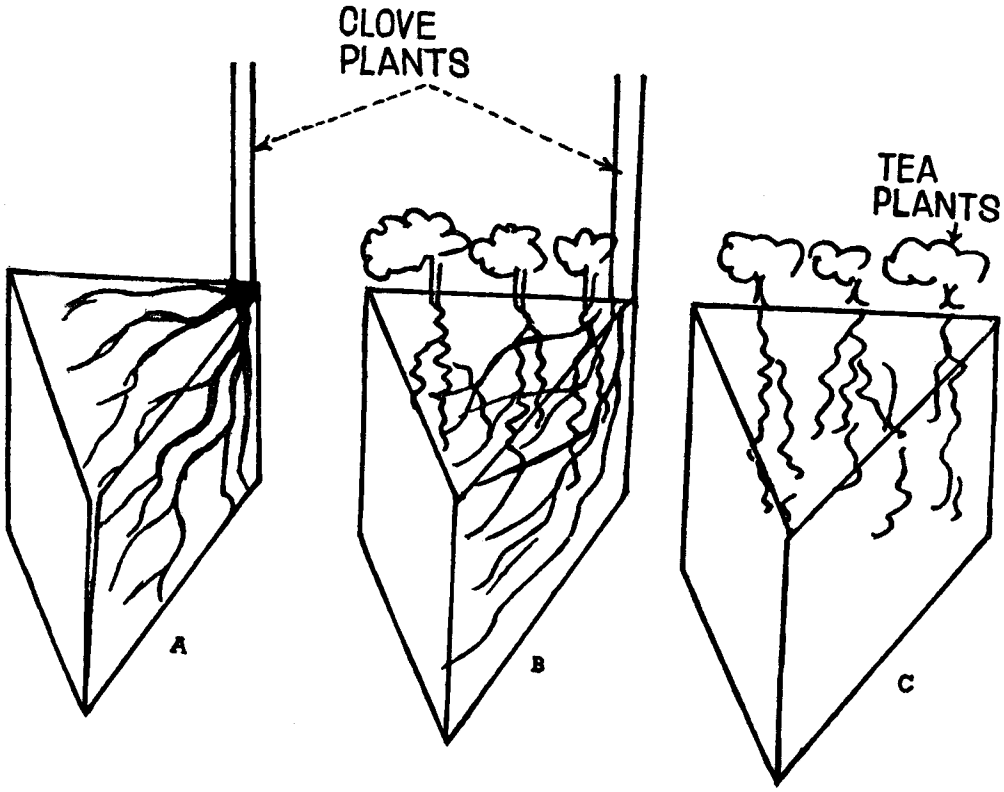


FIG. 2. DIAGRAM SHOWING EXCAVATED ONE EIGHTH SECTOR ROOT ZONE IN (A) MONO CROP OF CLOVE, (B) MIXED CROP OF TEA AND CLOVE AND (C) MONO CROP OF TEA



to the first 30 cm depth from the lower layers; clove having 66.9% in this layer as against 51.7% in the monocrop. Tea did not show such difference.

It was observed that in the top layer of soil, clove mono crop had 49.5% and tea mono crop had 75.7% of their roots of size less than 1 mm (Fig. 4). In the next two layers of 30-60 cm and 60-90 cm, clove had 35.5% and 15.5% respectively and tea had 16.04% and 7.9% respectively. On a fresh weight basis, clove in the mixed crop had larger quantity of feeder roots than the mono crop, while in tea there was no such difference.

Number o. branches

The data gathered on total number of root branches showed that clove as a mono crop had 55.6% of total number of root branches in the first 30 cm depth of the soil, while tea had 83.3% (Fig.5). In the second and third layers clove had 30.8% and 13.6% of the roots respectively and tea had 13.6% and 3.1% respectively. In the mixed crop, clove showed 71.7% of total number of branches in the first depth, as against 55.6% in the mono crop. But in the subsequent layers it could be seen that there was a lower proportion of root branches in the mixed crop than in the

FIG. 3. RELATIONSHIP BETWEEN FRESH WEIGHT OF ROOTS AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE

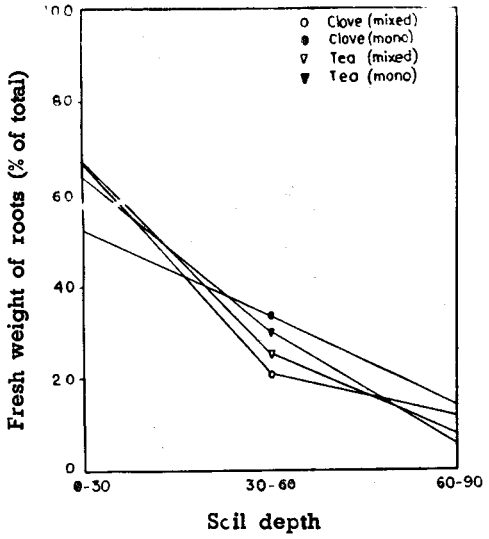


FIG. 4. RELATIONSHIP BETWEEN FRESH WEIGHT OF ROOTS (SIZE LESS THAN 1 MM) AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE

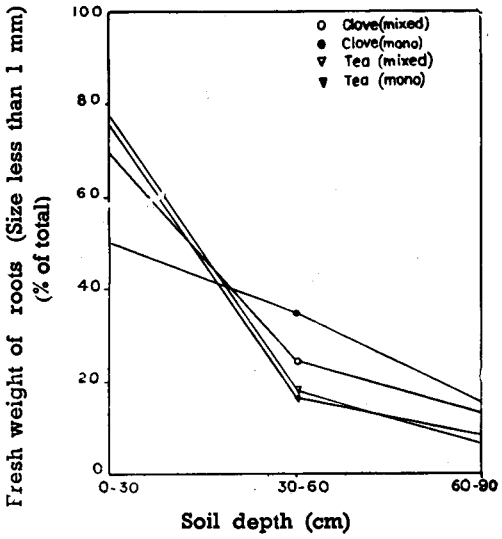


FIG. 5. RELATIONSHIP BETWEEN NUMBER OF ROOT BRANCHES AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE

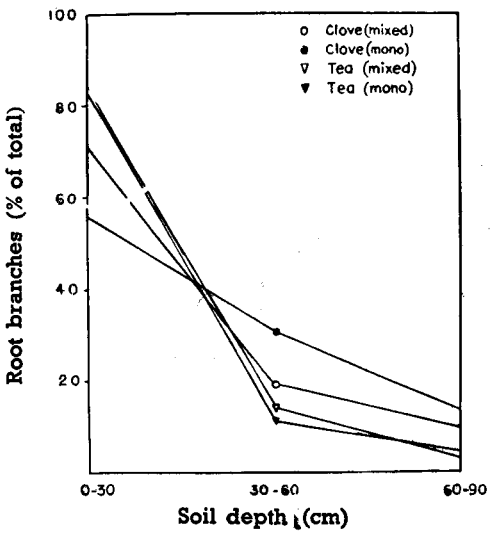
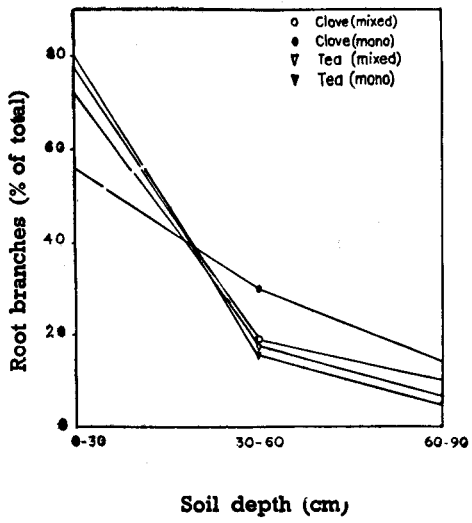


FIG. 6. RELATIONSHIP BETWEEN NUMBER OF ROOT BRANCHES (SIZE LESS THAN 1 MM) AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE



mono crop. But this difference in tea was small in all the three layers.

It was observed that the number of root branches of less than 1 mm size was the highest in the first 30 cm layer in both clove and tea mono crops. (Fig.6). Clove mono crop had 56.0% and tea mono crop had 79.8% of roots of size less than 1 mm at the first depth. In the subsequent depths of 30–60 cm and 60–90 cm, clove had 30.4% and 13.6% respectively and tea had 16.4% and 3.8% respectively. Tea had a higher percentage of root branches than clove in the first soil layer. Clove in the first soil depth showed a higher number of root branches in the mixed crop than in the mono crop. But there was a reduction of roots in the subsequent layers. In tea there was no difference between mixed and mono crops at all three depths.

Length

The data on total length of roots are presented in Fig. 7. It could be seen that total length of roots of clove mono crop was 50.2% in the first 30 cm depth of the soil while that of the tea was 76.0%. In the next two layers, clove had 31.4% and 18.4% respectively and tea had 19.1% and 4.9% respectively. In the mixed crop, clove produced 61.1% of total length of roots in the first soil layer as against to 50.2% in the mono crop. There was a slight reduction in the total length of roots of tea and clove in the mixed crop compared to their mono crops.

The data on the length of roots less than 1 mm in size showed that in the first 30 cm soil layer, clove produced 50.40% of its total roots while tea

FIG. 7. RELATIONSHIP BETWEEN LENGTH OF ROOTS AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE

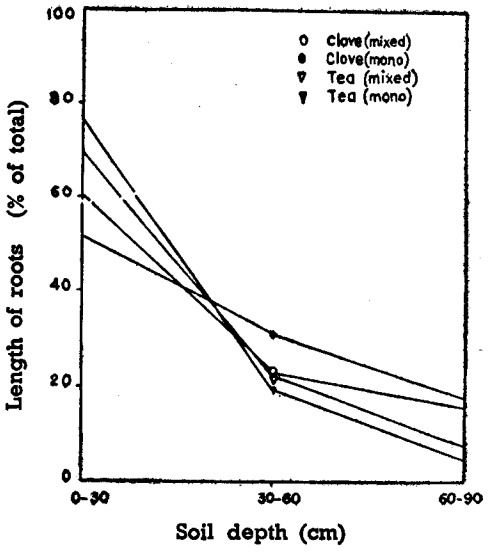
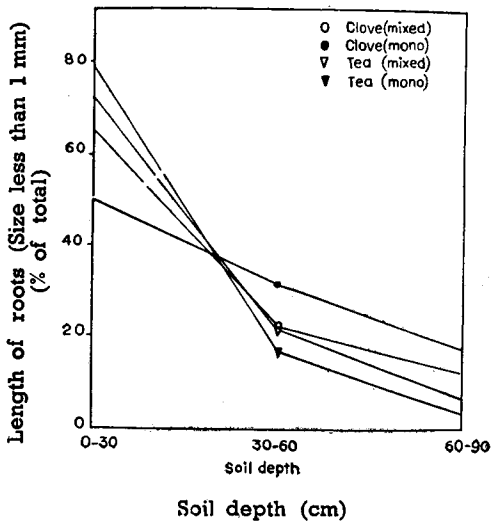


FIG. 8. RELATIONSHIP BETWEEN LENGTH OF ROOTS (SIZE LESS THAN 1 MM) AND SOIL DEPTH IN MONO AND MIXED STANDS OF TEA AND CLOVE



produced 78.5% (Fig.8). In the next two layers, there were clove roots 31.7% and 17.9% and tea roots 17.3% and 4.2% respectively. In both clove and tea mono crops maximum length of roots was seen in the top 30 cm soil layer. This was higher in tea than in clove. The total length of clove roots in the top soil layer was greater in the mixed crop than in the monocrop. But the difference between the respective lengths became smaller in the subsequent depths. Difference between the lengths observed between mixed and mono crops of tea was very small in all three soil depths.

Total roots

The data on fresh weight, branch number and length of roots of all three depths showed that clove in the mixed stand had 19.4% increase in the total root fresh weight, 57% increase in the total root branch number and 2.0% increase in the total root length of taking the mono stand as the basis. In tea in the mixed crop, although there was an increase of 12.7% in the total root fresh weight, there was a reduction in the total root branch number and total length of roots. In clove, in the mixed crop, out of roots less than 1 mm size, there was 5% increase in total fresh weight, 58% increase in total root branch number and 2% reduction in total root length. Tea in this mixed crop showed 26% reduction in fresh weight, 21% reduction in branch number and 12% reduction in length that of mono crop.

DISCUSSION

Data available on the distribution pattern of roots in the old seedling tea are meagre. In this study the seedling tea of about 100 years age under mono-cropping had 63.6% of the total roots and 75% of the roots less than 1 mm size, normally referred to as feeder roots in tea in the first 30 cm soil layer. The root activity in an old seedling tea was thus found to be by and large concentrated in the first 30 cm soil depth.

Clove under mono cropping had 51.7% of its total roots by fresh weight, 55.6% by number of branches and 50.2% by length of roots in the first 30 cm soil layer. As against this in the mixed crop, clove had 66.9% of the total fresh weight, 71.7% of the total number of branches and 61.1% of the total length of roots in the first 30 cm layer. Thus a clear shift in the rooting pattern of clove under mixed cropping is observed from the lower layers to the first 30 cm soil depth.

In a study, the top soils under the mono crop of tea and the mixed crop of tea and clove had shown over 600 ppm of available soil phosphorus, while it was less than 160 ppm in the mono crop of clove and bare land (Mathavan, 1982). This higher levels of available phosphorus in the top soil seems to be one of the reasons for higher root activity in this layer. Investigations indicate that there could be a significant formation of soil organic matter during active root growth, most of it directly from the root tissues without intervention of soil microflora (Martin, 1977). Sauerbeck and Johnen (1977) found that the total production of microbially decomposable organic matter by the plants can be 3–4 times

greater than the amounts of root residues at harvest. Martin (1977) suggested that the release of carbohydrate-rich organic material from actively growing roots would represent an energy input into the soil ecosystem which can support a substantial microbial population. Organic carbon in the root zone as in the case of palms (Nair, 1979) would have been higher in the active root growing top soil profile. The root system of tea during its growth period of nearly a century would have thus added substantial quantities of organic matter to the soil.

The tendency of sending their roots for lower depths observed in closely planted arecanut (Bhat and Leela, 1969) and coffee (Leon and Umana, 1959) can be the adaptation of the plants to overcome the physical situation due to the intra-species crop competition. The observation of a shift in the roots of clove from the lower layers to the surface is possible if there is no physical competition when adequate nutrients are available. Though data on the nutrient level is not available from the present study, the information of higher phosphate level and organic matter addition, (Mathavan, 1982) in the top 30 cm layer in tea plantations indicates that it can support another crop like clove.

The increase in the total fresh weight and the number of branches of clove in the mixed cropping situation than in the mono crop seems to represent physiological adaptation of clove plant to the mixed cropping situation where it has to compete with tea for nutrients. The increase of 58% in the number of feeder roots appears to enable the clove plants to absorb the required nutrients from the same soil depth in which tea also had its major proportion of feeder roots. The 19.4% increase in the total fresh weight of roots under mixed cropping situation, also seems to be the effect of competitive need of clove. A similar behaviour had been shown by tea also under mixed cropping situation in which the total fresh weight of tea roots increased by 12.7%.

In spite of the favourable soil moisture, phosphate and organic matter situation prevalent in the first 30 cm soil of tea and clove mixed stand (Mathavan, 1982) a reduction in the number of feeder roots in tea has been observed in this layer of soil.

No evidence is available from the present study to explain this reduction in the number of feeder roots of tea, which might have a bearing on the yield of this crop. However, considering the high cash value of clove, the reduction in tea yield even if it is to occur will be more than compensated by the return from clove as evident from the net return of Rs. 57,000/ha from the mixed crop of tea and clove as against Rs 5,900/ha of monocrop of tea (Van Til Burg, 1981). Since mixed cropping aims at maximizing production/return per unit area of land, tea and clove as a mixed crop combination holds out considerable promise.

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