Soil Suitability Assessment for Intercropping Cocoa in Coconut Gardens of Tamil Nadu

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ABSTRACT

Geo-referenced soil samples were collected from forty cocoa-growing locations across six districts (Coimbatore, Dindigul, Erode, Namakkal, Salem and Tirunelveli) of Tamil Nadu. Analysis of data revealed that a vast majority of the samples were alkaline (83 %), non-saline, low in organic carbon (51.3 %), low in KMnO$_4$-N (75 %), medium in available phosphorus (60 %) and medium in available potassium (51.25 %). The soils were predominantly deficient in DTPA Zn (71.25 %) and DTPA Cu (32.5 %) in the sampling locations. About 20 % of the cocoa-growing locations were calcareous. The correlation between free CaCO$_3$ content of soil and pod yield revealed that cocoa productivity is drastically affected if the free CaCO$_3$ content of soil is more than 8.0%. Soil suitability assessment is highly imperative before undertaking cocoa intercropping in coconut gardens of Tamil Nadu.

Key words: Calcareousness; Cocoa; Coconut; Intercropping; Pod yield; Soil Fertility

INTRODUCTION

Coconut is an important horticultural crop that exerts a profound influence on the rural economy of the state of Tamil Nadu. It spreads over an area of 4.36 lakh ha with a total production of 5370 million nuts and productivity of 12291 nuts per ha (CDB, 2019). Despite its importance and expanding acreage, the crop turned out to succumb to an array of biotic and abiotic stresses, including rampant pest and disease attack and fluctuating price chart of copra (Maheswarappa et al., 2003). Monocropping of coconut is no longer viable and hence crop intensification is the way forward to transform coconut farming into a viable enterprise to tide over the challenges. Cocoa, nutmeg and banana are widely intercropped with coconut in Tamil Nadu owing to the favorable microclimate. Although cocoa was introduced in India during the early 20$^{th}$ century (Jaganathan et al., 2015), large-scale cultivation started in the late 1980s in Tamil Nadu. The acreage under this crop extends over 29,205 ha in the state (DCCD, 2018), which has been dwindling in the recent past because of an array of cultural and socio-economic factors thus widening the gap between demand and supply of cocoa. The global cocoa demand is on the rise and considering the diminishing income of cocoa farmers, increasing cocoa productivity is highly imperative. Potential cocoa yields are determined based on location and crop-specific characteristics such as climate and crop’s natural life cycle (Van Vliet et al., 2015). Soil suitability and soil fertility are highly imperative for improving the productivity of cocoa in the coconut intercropping system.

MATERIAL AND METHODS

A survey was conducted during 2017 in forty major cocoa growing locations distributed across six districts (Coimbatore, Dindigul, Erode, Namakkal, Salem and Tirunelveli) in Tamil Nadu (Table 1) based on multi-stage stratified sampling method. Details pertinent to the variety of cocoa, age of the plant/coconut palm, irrigation, nutrient management, plant protection, harvesting, processing, marketing etc., were collected for both coconut and cocoa employing a survey questionnaire. Eighty geo-referenced soil samples were collected from cocoa gardens at 0 – 30 cm depth. Air-dried samples passed through 2 mm sieve were utilized for the determination of pH in 1:2.5 soil water suspension (Jackson, 1973). Available nitrogen (N) was estimated by alkaline permanganometry (Subbiah and Asija, 1956), available phosphorus (P) (Olsen et al., 1954; Bray and Kurtz, 1945), available potassium (K) by Flame Photometry (Stanford and English, 1976), organic carbon (OC) by wet digestion method (Walkley and Black, 1934), free CaCO$_3$ (Dewis and Freita, 1970), DTPA extractable micronutrients by Atomic Absorption Spectrophotometry (Lindsay and Norvell, 1978) and hot water-soluble boron by Azomethin – H reagent method (Berger and Truog, 1939).
The nutrients were classified as low, medium and high categories for macronutrients and deficient, sufficient for micronutrients based on their soil fertility classification. Nutrient Index Values (NIV) were calculated by employing the procedure of Ramamoorthy and Bajaj, 1969. The index values were rated into various categories viz., low (<1.67), medium (1.67-2.33) and high (>2.33) for OC and available NPK.

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\text{Nutrient Index Value} = \frac{(\text{No. of samples in low category} \times 1) + (\text{No. of samples in medium category} \times 2) + (\text{No. of samples in high category})}{\text{Total number of samples}}
\]

RESULTS AND DISCUSSION

Soil Reaction, Electrical Conductivity and Organic Carbon

The pH of the soil samples ranged from 6.09 to 8.54, with a mean value of 7.28 across different sampling locations. About 6.25% of the samples were acidic in reaction whilst 78.75% of the samples remained alkaline and only 15% fell in the neutral range. All the samples were non saline in nature. About 83% of soils in Pollachi taluk, Coimbatore district are alkaline and pencil point syndrome is one of the alarming disorders as pointed out by Sudhalakshmi et al (2020). Selvamani and Duraisami (2014) reported that the pH ranged from 6.6 to 8.8 at 0 - 30 cm depth in coconut growing soils of Coimbatore and Tiruppur districts. In the present survey, only localized spots of acidity was witnessed and almost all the horizons were alkaline with kankar nodules.

Organic carbon content was low in 51.3% of samples and high only in 15% of samples analyzed. Due to the tropical climate prevailing in Tamil Nadu, there is rapid depletion of soil organic pool, falling in low to medium category. The nutrient index value for organic carbon was in the medium category as per the classification (Tables 1 and 4).

### Table 1. Soil Reaction, Electrical Conductivity and Organic Carbon Status of the cocoa-growing soils of Tamil Nadu.

| Location No. | Geographic Co-ordinates | pH | Electrical Conductivity (dSm⁻¹) | Organic Carbon (%) |
|--------------|-------------------------|----|-------------------------------|-------------------|
|              | Location 1 (L₁) | Location 2 (L₂) | L₁ | L₂ | L₁ | L₂ | L₁ | L₂ |
| Coimbatore District |
| 1. | 10° 31.483 N | 10° 31.507 N | 7.48 | 7.46 | 0.10 | 0.10 | 0.54 | 0.34 |
| 2. | 76° 58.160 E | 76° 58.147 E | 7.43 | 7.72 | 0.21 | 0.16 | 0.45 | 0.54 |
| 3. | 10° 29.654 N | 10° 29.825 N | 6.10 | 6.58 | 0.22 | 0.17 | 0.99 | 0.57 |
| 4. | 76° 54.222 E | 76° 54.228 E | 6.29 | 6.09 | 0.50 | 0.65 | 1.28 | 0.87 |
| 5. | 10° 29.251 N | 10° 29.598 N | 7.03 | 7.24 | 0.10 | 0.05 | 0.54 | 0.33 |
| 6. | 76° 54.194 E | 76° 54.400 E | 6.55 | 7.20 | 0.09 | 0.06 | 0.18 | 0.29 |
| 7. | 10° 29.796 N | 10° 29.798 N | 7.23 | 7.21 | 0.22 | 0.22 | 1.52 | 1.08 |
| 8. | 76° 53.378 E | 76° 53.372 E | 8.06 | 7.78 | 0.09 | 0.16 | 0.57 | 0.36 |
| 9. | 10° 37.298 N | 10° 37.298 N | 7.35 | 7.75 | 0.31 | 0.19 | 0.79 | 1.08 |
| 10. | 76° 52.913 E | 76° 52.913 E | 6.97 | 7.04 | 0.13 | 0.11 | 0.99 | 0.87 |
| 11. | 10° 36.903 N | 10° 36.903 N | 7.85 | 7.75 | 0.23 | 0.22 | 1.08 | 0.70 |
| 12. | 76° 53.079 E | 76° 53.065 E | 7.71 | 7.68 | 0.19 | 0.23 | 0.90 | 1.55 |
| 13. | 76° 56.192 E | 76° 56.192 E | 7.71 | 7.88 | 0.15 | 0.15 | 0.24 | 0.36 |
| 14. | 10° 38.424 N | 10° 38.634 N | 6.71 | 6.72 | 0.11 | 0.11 | 0.54 | 0.27 |
| 15. | 76° 52.910 E | 76° 52.910 E | 6.84 | 7.00 | 0.72 | 0.27 | 0.36 | 0.36 |
|   | 10°36.495 N 76°56.216 E | 10°36.495 N 76°56.216 E |   |   |   |   |
|---|----------------|----------------|---|---|---|---|
| 16 | 7.23 | 7.31 | 0.13 | 0.11 | 0.51 | 0.30 |

**Dindigul District**

| 17 | 10°24.698 N 77°32.141 E | 10°24.698 N 77°32.141 E | 7.91 | 7.43 | 0.14 | 0.24 | 0.48 | 0.33 |
| 18 | 10°24.634 N 77°32.168 E | 10°24.634 N 77°32.168 E | 7.73 | 7.59 | 0.14 | 0.24 | 0.33 | 0.24 |
| 19 | 10°22.609 N 77°31.252 E | 10°22.609 N 77°31.252 E | 7.65 | 7.70 | 0.18 | 0.19 | 0.36 | 0.27 |
| 20 | 10°23.575 N 77°32.373 E | 10°23.575 N 77°32.373 E | 7.74 | 7.62 | 0.19 | 0.26 | 0.66 | 0.31 |
| 21 | 10°24.698 N 77°32.373 E | 10°24.698 N 77°32.373 E | 7.59 | 7.63 | 0.17 | 0.19 | 0.91 | 0.15 |
| 22 | 10°23.466 N 77°29.177 E | 10°23.466 N 77°29.177 E | 7.45 | 7.90 | 0.13 | 0.17 | 0.13 | 0.11 |
| 23 | 10°24.249 N 77°32.505 E | 10°24.249 N 77°32.505 E | 7.95 | 7.83 | 0.12 | 0.14 | 0.33 | 0.29 |

**Tirunelveli District**

| 24 | 9°074.930 N 77°37 E | 9°074.930 N 77°37 E | 7.80 | 7.80 | 0.43 | 0.47 | 0.31 | 0.24 |
| 25 | 9°005.280 N 77°26528 E | 9°005.280 N 77°26528 E | 8.45 | 8.40 | 0.58 | 0.50 | 0.46 | 0.40 |

**Erode District**

| 26 | 11°80.675 N 77°37.524 E | 11°80.675 N 77°37.524 E | 8.24 | 8.21 | 0.47 | 0.48 | 1.08 | 1.55 |
| 27 | 11°18.427 N 77°37.308 E | 11°18.427 N 77°37.308 E | 8.35 | 8.16 | 0.50 | 0.40 | 0.49 | 1.41 |
| 28 | 11°15.180 N 77°43.596 E | 11°15.180 N 77°43.596 E | 8.05 | 8.39 | 0.71 | 0.35 | 1.24 | 0.23 |
| 29 | 11°15.325 N 77°43.728 E | 11°15.325 N 77°43.728 E | 8.19 | 8.04 | 0.25 | 0.45 | 1.13 | 1.10 |
| 30 | 11°15.000 N 77°44.302 E | 11°15.000 N 77°44.302 E | 7.80 | 8.15 | 0.54 | 0.40 | 1.48 | 1.41 |

**Namakkal District**

| 31 | 10°29.291 N 76°58.254 E | 10°29.291 N 76°58.254 E | 8.12 | 8.16 | 0.31 | 0.45 | 0.33 | 0.49 |
| 32 | 11°18.640 N 78°17.778 E | 11°18.640 N 78°17.778 E | 8.34 | 8.42 | 0.28 | 0.36 | 0.29 | 0.33 |
| 33 | 11°18.627 N 78°17.927 E | 11°18.627 N 78°17.927 E | 8.14 | 8.32 | 0.14 | 0.28 | 0.36 | 0.54 |
| 34 | 11°18.733 N 78°17.540 E | 11°18.733 N 78°17.540 E | 8.22 | 7.86 | 0.26 | 0.51 | 0.26 | 0.48 |
| 35 | 11°18.680 N 78°17.609 E | 11°18.680 N 78°17.609 E | 7.98 | 7.64 | 0.54 | 0.47 | 0.49 | 0.40 |

**Salem District**

| 36 | 11°45.429 N 77°48.013 E | 11°45.429 N 77°48.013 E | 8.24 | 8.32 | 0.34 | 0.27 | 0.52 | 1.73 |
| 37 | 11°45.868 N 77°49.547 E | 11°45.868 N 77°49.547 E | 8.41 | 7.96 | 0.19 | 0.23 | 0.96 | 1.13 |
| 38 | 11°45.838 N 77°39.812 N | 11°45.838 N 77°39.812 N | 8.54 | 7.92 | 0.20 | 0.49 | 0.31 | 0.63 |
| 39 | 11°47.073 N 11°36.372 N | 11°47.073 N 11°36.372 N | 8.18 | 7.90 | 0.12 | 0.16 | 0.52 | 0.21 |
| 40 | 11°46.974 E 77°45.075 E | 11°46.974 E 77°45.075 E | 8.50 | 8.13 | 0.22 | 0.31 | 1.13 | 1.22 |
**Available macronutrients**

The KMnO$_4$ N content ranged from 137 to 1140 kg ha$^{-1}$ with a mean value of 258 kg ha$^{-1}$. Trend analysis revealed that the content was low (< 280 kg ha$^{-1}$) in 75% of the samples tested, medium in 23.75% of the samples and high (> 450 kg ha$^{-1}$) in only one sample. Olsen P was low (< 11 kg ha$^{-1}$) in 10% of the samples, medium in 60% of the samples and high (> 22 kg ha$^{-1}$) in 30% of the samples analyzed. 1NNH$_4$OAc – K was low (< 118 kg ha$^{-1}$) in 7.5% of samples, medium in 51.25% of samples and high (> 280 kg ha$^{-1}$) in 41.25% of samples. About 20% of the samples were calcareous and 80% were non-calcareous. Rao and Batra (1983) established a positive correlation between pH and ammonia volatilization. In the present study, alkalinity was observed in 78.75% of soil samples; hence the low status of available nitrogen (60%) was noticed. The available P content ranged from 7.0 to 90.0 kg ha$^{-1}$ with an average of 22.7 kg ha$^{-1}$. About 48% of the samples fell in the medium category, 30% in high status and only 10% of samples were low in available phosphorus. In an earlier survey of coconut growing soils of Coimbatore and Tiruppur districts, Selvamani and Duraisami (2014) reported low status of available phosphorus in 0.76 per cent in coconut growing soils of Coimbatore and Tiruppur districts.

Table 2. KMnO$_4$ – N, Olsen P, 1NNH$_4$OAc – K and free CaCO$_3$ of the cocoa-growing soils of Tamil Nadu.

| Location No. | Coimbatore District | Dindigul District | Tirunelveli District |
|-------------|---------------------|-------------------|---------------------|
|             | KMnO$_4$ – N (kg ha$^{-1}$) | Olsen P (kg ha$^{-1}$) | 1NNH$_4$OAc – K (kg ha$^{-1}$) | Free CaCO$_3$ (%) |
| L1          | L2                  | L1              | L2              | L1          | L2              | L1          | L2          |
| Coimbatore District |
| 1.          | 244 244             | 35 57           | 108 109         | 3.00 2.88   |                |              |
| 2.          | 230 213             | 25 61           | 186 197         | 2.38 0.88   |                |              |
| 3.          | 291 314             | 54 21           | 408 148         | 0.75 0.81   |                |              |
| 4.          | 269 1140            | 82 90           | 750 1092        | 1.38 1.31   |                |              |
| 5.          | 196 190             | 29 24           | 227 132         | 1.75 0.31   |                |              |
| 6.          | 224 193             | 63 25           | 369 113         | 0.25 0.44   |                |              |
| 7.          | 294 258             | 31 20           | 276 328         | 1.19 1.56   |                |              |
| 8.          | 185 244             | 61 31           | 118 160         | 2.31 1.63   |                |              |
| 9.          | 347 280             | 28 20           | 555 299         | 1.56 2.38   |                |              |
| 10.         | 428 406             | 24 17           | 253 290         | 2.69 3.19   |                |              |
| 11.         | 286 339             | 20 28           | 368 360         | 5.38 5.88   |                |              |
| 12.         | 263 333             | 16 28           | 229 364         | 5.63 1.31   |                |              |
| 13.         | 224 238             | 12 18           | 274 188         | 2.00 2.69   |                |              |
| 14.         | 294 188             | 14 15           | 178 180         | 0.25 1.88   |                |              |
| 15.         | 188 137             | 15 13.2         | 180 196         | 1.88 0.25   |                |              |
| 16.         | 260 199             | 18.2 15         | 100 114         | 2.19 1.73   |                |              |
| Dindigul District |
| 17.         | 252 255             | 20 26           | 853 266         | 2.88 2.25   |                |              |
| 18.         | 249 207             | 15 15           | 316 336         | 3.19 2.00   |                |              |
| 19.         | 173 272             | 20 14           | 138 151         | 2.56 1.31   |                |              |
| 20.         | 137 258             | 17 38           | 151 170         | 2.69 2.44   |                |              |
| 21.         | 258 244             | 15 21           | 291 298         | 1.88 1.88   |                |              |
| 22.         | 241 283             | 14 15           | 224 255         | 0.25 1.00   |                |              |
| 23.         | 218 224             | 16 15.2         | 474 168         | 0.88 1.19   |                |              |
| Tirunelveli District |
| 24.         | 330 302             | 20 14           | 617 241         | 1.81 0.44   |                |              |
| 25.         | 288 353             | 17 42           | 225 637         | 8.20 8.75   |                |              |
The available potassium content ranged from 100 to 1092 kg ha\(^{-1}\) with an average of 313.9 kg ha\(^{-1}\). About 51.25 % of samples fell in the medium-fertility category (118 – 280 kg ha\(^{-1}\)) and 41.25 % of the samples were under high fertility status. Motsara (2002) reported that 36 % of the soils of Tamil Nadu fall under the medium category and 52 % under the high status of available potassium. About 20 % of the cocoa soils were calcareous in nature with free Ca\(_{3}O\) content > 5 % and 80 % ranged from 1 – 5 %. Nutrient index values were 1.23 (low) for nitrogen, 2.2 (medium) for phosphorus and 2.33 (medium) for potassium (Tables 2 and 4). Index values of nitrogen, phosphorus and potassium were reported as low, medium and medium for the soils of Salem district of Tamil Nadu (Maragatham et al., 2014).

![Fig. 1. Correlation between free Ca\(_{3}O\) and pod yield of cocoa](image)

**Available micronutrients**

The content of DTPA Fe ranged from 2.40 to 44.6 mg kg\(^{-1}\) with a mean value of 7.28 mg kg\(^{-1}\). DTPA Fe was sufficient in 83 % of the soil samples and the rest of the samples were deficient. The DTPA Mn content ranged from 1.40 to 17.2 mg kg\(^{-1}\) with a mean value of 7.30 mg kg\(^{-1}\). The nutrient was sufficient (> 2.0 mg kg\(^{-1}\)) in 92.5 % of soil samples and the deficiency (< 2.0 mg kg\(^{-1}\)) was witnessed only in 7.5 % of samples. The content of DTPA Zn ranged from 0.13 to 9.45 mg kg\(^{-1}\) with a mean value of 1.50 mg kg\(^{-1}\). DTPA Zn was deficient (< 1.2 mg kg\(^{-1}\)) in 71.25 % of samples and sufficiency (> 1.2 mg kg\(^{-1}\)) was noticed across 28.75 % of the samples. The content of DTPA Cu in cocoa-growing soils ranged from 0.33 to 4.72 mg kg\(^{-1}\) with a mean value of 1.50 mg kg\(^{-1}\). DTPA Cu deficiency (< 1.2 mg kg\(^{-1}\)) was noticed in 32.5% of the samples and sufficient (> 1.2 mg kg\(^{-1}\)) across 67.5% of the sampling locations. Hot water soluble boron content ranged from 0.75 to 8.52 mg kg\(^{-1}\) with a mean value of 2.24 mg kg\(^{-1}\) and was sufficient (> 0.46 mg kg\(^{-1}\)) in all the sampling locations (Tables 3 and 4).

**Correlation between free Ca\(_{3}O\) and pod yield**

A correlation was established between free Ca\(_{3}O\) content of soil and cocoa pod yield (Fig. 1). The pod yield ranged from 8 to 68 pods per plant per year across the cocoa growing locations surveyed. It is highly conspicuous that, of diverse soil fertility parameters, a prominent negative correlation exists between free Ca\(_{3}O\) content of soil and pod yield of cocoa (Fig. 1). As free Ca\(_{3}O\) content of soil increased above 7 %, there was a drastic decline in productivity and as it crossed 8.0 %, even the very establishment of cocoa plants was difficult.
Table 3. DTPA Fe, DTPA Mn, DTPA Zn, DTPA Cu and HWS -B of the cocoa-growing soils of Tamil Nadu.

| Location No. | DTPA Fe | DTPA Mn | DTPA Zn | DTPA Cu | HWS B |
|--------------|---------|---------|---------|---------|-------|
| Coimbatore District |         |         |         |         |       |
| 1.           | 6.2     | 7.1     | 6.5     | 9.7     | 0.45  |
| 2.           | 9.1     | 7.4     | 10.4    | 9.0     | 0.44  |
| 3.           | 28.0    | 22.0    | 13.8    | 12.0    | 0.76  |
| 4.           | 27.4    | 44.6    | 7.2     | 7.3     | 3.63  |
| 5.           | 13.7    | 5.4     | 17.2    | 6.4     | 2.13  |
| 6.           | 15.2    | 13.1    | 10.9    | 9.2     | 1.05  |
| 7.           | 9.1     | 11.1    | 11.3    | 12.8    | 3.43  |
| 8.           | 5.8     | 4.6     | 8.8     | 4.6     | 0.61  |
| 9.           | 7.1     | 5.5     | 2.7     | 2.7     | 1.24  |
| 10.          | 8.9     | 5.6     | 4.9     | 7.7     | 1.00  |
| 11.          | 10.1    | 6.6     | 7.7     | 11.8    | 2.49  |
| 12.          | 6.9     | 5.4     | 9.9     | 13.2    | 1.40  |
| 13.          | 4.7     | 11.3    | 11.2    | 8.7     | 1.59  |
| 14.          | 2.4     | 4.9     | 2.6     | 10.3    | 0.18  |
| 15.          | 4.9     | 6.7     | 10.3    | 9.5     | 0.59  |
| 16.          | 7.2     | 5.3     | 6.3     | 8.4     | 1.10  |
| Dindigul District |         |         |         |         |       |
| 17.          | 4.8     | 5.9     | 10.5    | 9.3     | 1.53  |
| 18.          | 4.8     | 6.4     | 7.9     | 6.2     | 0.56  |
| 19.          | 5.9     | 5.5     | 10.3    | 9.4     | 1.49  |
| 20.          | 7.2     | 6.8     | 7.8     | 6.8     | 0.85  |
| 21.          | 6.9     | 8.0     | 9.2     | 6.7     | 0.50  |
| 22.          | 5.3     | 3.8     | 8.8     | 8.2     | 0.42  |
| 23.          | 3.4     | 3.8     | 5.5     | 7.8     | 0.31  |
| Tirunelveli District |         |         |         |         |       |
| 24.          | 3.9     | 4.6     | 14.5    | 10.6    | 1.57  |
| 25.          | 6.0     | 7.0     | 7.7     | 4.2     | 0.26  |
| Erode District |         |         |         |         |       |
| 26.          | 4.7     | 4.5     | 9.3     | 6.8     | 1.31  |
| 27.          | 3.9     | 4.4     | 6.4     | 9.1     | 1.21  |
| 28.          | 4.2     | 4.5     | 6.7     | 6.7     | 1.00  |
| 29.          | 3.6     | 7.5     | 6.4     | 6.3     | 0.79  |
| 30.          | 6.1     | 4.5     | 11.6    | 7.6     | 9.45  |
| Namakkal District |         |         |         |         |       |
| 31.          | 6.0     | 5.8     | 6.7     | 5.5     | 0.74  |
| 32.          | 8.2     | 7.8     | 6.6     | 6.8     | 0.78  |
| 33.          | 6.4     | 6.2     | 3.2     | 2.3     | 0.80  |
| 34.          | 3.6     | 4.2     | 2.1     | 2.5     | 0.68  |
| 35.          | 4.2     | 4.8     | 7.7     | 5.4     | 1.14  |
| Salem District |         |         |         |         |       |
| 36.          | 3.6     | 4.4     | 2.1     | 2.5     | 1.87  |
| 37.          | 3.9     | 4.8     | 2.3     | 2.2     | 0.62  |
| 38.          | 3.9     | 5.0     | 2.1     | 1.9     | 0.24  |
| 39.          | 4.2     | 4.9     | 1.8     | 2.1     | 0.81  |
| 40.          | 3.8     | 5.1     | 1.4     | 1.5     | 0.72  |
A plethora of evidence states that carbonate activity in calcareous soils influences the rate of volatilization of ammonia (Ryan et al., 1981) and that carbonate affects the rhizospheric processes, especially in acidification factor. The presence of CaCO$_3$ directly or indirectly affects the chemistry of nitrogen, phosphorus, iron, zinc, magnesium, calcium, potassium and copper (Marschner, 1995) through ammonia volatilization and phosphorus precipitation. In addition, iron, zinc and magnesium deficiencies are common in soils with high CaCO$_3$ and alkaline pH values (Marschner, 1995). Hillel (1986) recorded that emergence of bean seedlings in fine sandy loam soil was reduced from 100 to 0% when crust strength increased from 108 to 273 mbar because of calcareousness. The growers of cocoa commonly noticed Lime-induced iron chlorosis in calcareous soils. On foliar spraying with micronutrients, the plants reverted back to normalcy only for a brief period of time and again they turned chlorotic. In intensely calcareous soils, there was problem even with the very establishment of cocoa seedlings and it was more conspicuous in Erode and Salem districts of Tamil Nadu. Thus it can be concluded that cocoa cultivation is not remunerative if free CaCO$_3$ content in the soil is > 8 %.

**CONCLUSION**

From the survey conducted across six prominent cocoa growing districts of Tamil Nadu, it was found that about 78.75% of the soils were alkaline in reaction and the electrical conductivity was non-saline across the sampling locations. The low status of KMnO$_4$ N, Olsen P and 1NNH$_4$OAc K was witnessed in 75%, 10% and 7.5% of the sampling locations respectively. About 20% of the cocoa-growing locations surveyed were calcareous in nature with free CaCO$_3$ content > 5%. DTPA Fe was deficient across 17%, DTPA Mn across 7.5%, DTPA Zn over 71.2% and DTPA Cu in 32.5% of the sampling locations. Hot water soluble boron was sufficient all through the sampling locations. The correlation between free CaCO$_3$ and pod yield was negative. Pod yield is drastically affected to the tune of <10 pods per plant per year in intensely calcareous soils. Thus the survey revealed that intercropping of cocoa is not remunerative if free CaCO$_3$ content in the soil is > 8.0%. Soil testing and crop suitability assessment are imperative for undertaking intercropping of cocoa in coconut gardens of Tamil Nadu to avoid huge economic losses by cultivating in unsuitable soils.

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