*Research Article* *Journal of Plantation Crops, 2008, 36 (2): 112-116*

# Effect of integrated use of manures and fertilizers on coconut yield and changes in available nutrient content and N, P and K fractions of inceptisols of Konkan region

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(Manuscript Received: 06-09-07, Revised: 05-12-07, Accepted: 28-05-08)

## Abstract

A long-term field experiment was conducted at Regional Coconut Research Center, Bhatye, Dist. Ratnagiri to study the effect of integrated nutrient management on the changes in available nutrient status and fractions of nitrogen, phosphorus and potassium of the coastal lateritic soils and leaf nutrient content of coconut. The six treatments comprising $T_1$: control, $T_2$: recommended dose of fertilizers (RDF); $T_3$: 100% N through vermicompost; $T_4$: 50% N through vermicompost + 50% RDF; $T_5$ : neem cake + bone meal + ash and $T_6$: poultry manure were replicated four times in Randomized Block Design. The highest mean nut yield of four years, *viz.* 2001-02 to 2004-05 was recorded in the treatment receiving recommended dose of fertilizers (98 nuts/palm/year) followed by the treatment receiving 100% N through vermicompost (94 nuts/palm/year) and 50% N through vermincompost + 50% RDF (82 nuts/palm/year). Available nitrogen status of soil was found to be significantly improved due to application of vermicompost and 50% N through vermicompost + 50% RDF. The significant increase in available phosphorus and potassium status of soil recorded in 50% N through vermicompost + 50% RDF treatment was at par with vermicompost treatment. Maximum exchangeable $NH_4$-N, $NO_3$-N and hydrolysable N were maintained in the treatment receiving 50% N through vermicompost + 50% RDF followed by vermicompost treatment. The differences in Al-P content among the treatments receiving neem cake + bone meal + ash, 50% N through vermicompost + 50% RDF and vermicompost were non significant. As regards to Fe-P content, the treatment receiving neem cake + bone meal + ash and 50% N through vermicompost + 50% RDF were at par with each other and significantly superior over poultry manure, RDF and control. The treatment receiving neem cake + bone meal + ash maintained significantly higher water soluble and exchangeable K content over the treatments receiving poultry manure, RDF and control. Vermicompost is found to be promising source for improving leaf nutrient content. Thus, application of organic manures either alone or in combination with fertilizers is found to be beneficial for improving nutrient availability resulting into enhancement in nutrient uptake by coconut.

*Keywords:* Coconut, manures, N fractions, P fractions, K fractions, vermicompost

## Introduction

Organic manures are important sources in sustaining nutrient availability especially for a perennial crop like coconut, which requires continuous supply of nutrients. A number of organic manures can be prepared from the residues of plant and animal origin available in the country side, which include compost, neem cake, vermicompost, FYM, poultry manure, bone meal, ash etc. These manures are also useful in coconut nutrition. Although organic manures contain several nutrients in lesser concentration as compared to inorganic fertilizes, organic matter promotes microbial process in soil, minimizes the fixation of nutrients and stores the nutrients against leaching. Studies were, therefore, conducted for the characterization and quantification of various forms of major nutrients like N, P and K for understanding their contribution towards the available pool for the use of coconut palm and their influence on leaf nutrient content.

## Materials and Methods

A field experiment was conducted at Regional Coconut Research Center, Bhatye, Ratnagiri in inceptisols since June, 1998-99 in a coconut garden planted during June, 1957. The soils from experimental area are loamy sand in texture with a bulk density of 1.41 $mg^{m-3}$ and 22.5 per cent water holding capacity. Soils are slightly alkaline in reaction ($P^H$: 7.89) with low

electrical conductivity (0.08 dS $m^{-1}$), organic carbon (4.05 g $kg^{-1}$) and available nitrogen (205.4 kg $ha^{-1}$). Available phosphorus (30.7 kg $ha^{-1}$) and available potassium (481.4 kg $ha^{-1}$) were in the medium and high range, respectively. The climate of the area is characterized as humid, subtropical and monsoonic. The precipitation during June to September ranges from 2500 to 3000 mm. In well-nourished coconut gardens, the average yield is 90 nuts per palm. The field experiment was laid out in randomized block design with six treatments : $T_1$- control, $T_2$ – Recommended dose of fertilizers @ 1.0 kg N, 0.5 kg $P_2O_5$, 1.0 kg $K_2O$; $T_3$ – Vermicompost @ 1.0 kg N; $T_4$ – 50% N through vermicompost + 50% RDF; $T_5$ – neem cake @ 1 kg N + bone meal @ 1 kg + ash @ 20 kg, $T_6$ – poultry manure @ 1 kg N per palm per annum. Different organic manures were applied as per treatments by opening coconut basin of 1.8 m radius around the palm at 20 cm depth and were covered with soil. The nutrient content of manures was vermicompost : 1.6 % N, 1.0 % $P_2O_5$, 1.2 % $K_2O$; neem cake : 5.1 % N, 1.0 % $P_2O_5$, 1.2 % $K_2O$; bone meal : 2.0 % N and 25% $P_2O_5$; ash : 2.5 % $K_2O$; and poultry manure : 2.5 % N, 1.5 % $P_2O_5$, 1.2 % $K_2O$. Chemical fertilizers such as urea, single super phosphate and muriate of potash were applied as 1/3$^{rd}$ (0.333 kg N, 0.166 kg $P_2O_5$ and 0.333 kg $K_2O$) in June and remaining 2/3$^{rd}$ (0.667 kg N, 0.320 kg $P_2O_5$ and 0.667 kg $K_2O$) during September. The yield data of four years (2001-02 to 2004-05) were collected and analyzed. Soil samples were collected in May, 2006 from three depths i.e. 0-25 cm, 25-50 cm and 50-100 cm at a distance of 1.2 meter away from the trunk of the palm.

Available soil nitrogen was determined by alkaline $KMnO_4$ method given by Subbaiah and Asija (1965). Brays – I extractant was used for the estimation of available phosphorus by spectrophotometry (Black, 1965), while available potassium was determined flame photometrically using neutral normal ammonium acetate extractant (Jackson, 1973). The various N fractions were determined by a procedure outlined by Hesse (1971). The phosphorus fractions were estimated by the method outlined by Hesse (1971). Total and water soluble K were determined by digestion with HF and $HCO_3$ and 6NHCl and water, respectively by the method given by Jackson (1973). As regards to plant analysis, total nitrogen, phosphorus and potassium were determined by microkjeldhal, vanadomolybdate yellow colour and flame photometry using diacid digestion with $HNO_3$ and $HClO_3$ methods, respectively (Jackson, 1973). Calcium and magnesium were estimated by Versenate titration method (Cheng and Bray, 1951).

## Results and Discussion

### Coconut yield

The data on influence of continuous application of manures and fertilizers on the nut yield of coconut palm recorded from June, 2001-02 to May, 2004-05 are presented in Table 1. Among the various treatments, application of recommended dose of fertilizers (RDF) ($T_2$) registered maximum nut yield followed by the treatment receiving vermicompost ($T_3$) during all the years except 2003-04. Although the treatment receiving vermicompost recorded maximum nut yield/palm/year during 2003-04, it was statistically at par with the treatment receiving RDF.

**Table 1. Effect of integrated use of manures and fertilizers on yield of coconut.**

| Treatments | Average pre treatment yield nuts/ palm/year | Yield (nuts/palm/year) 2001-02 | 2002-03 | 2003-04 | 2004-05 | Mean yield (2001-05) |
|---|---|---|---|---|---|---|
| $T_1$ | 65 | 58.4 | 58.2 | 57.0 | 54.0 | 56.5 |
| $T_2$ | 86 | 97.1 | 100.6 | 96.0 | 96.0 | 97.5 |
| $T_3$ | 72 | 93.8 | 89.5 | 97.0 | 92.0 | 93.1 |
| $T_4$ | 75 | 90.8 | 76.6 | 70.0 | 92.0 | 82.3 |
| $T_5$ | 64 | 68.4 | 68.3 | 74.0 | 79.0 | 72.4 |
| $T_6$ | 65 | 75.6 | 80.1 | 73.4 | 78.7 | 76.9 |
| CD(P=0.05) | NS | 23.51 | 24.5 | 20.06 | 25.57 | 18.77 |

The highest mean yield was recorded in treatment receiving recommended dose of fertilizers (97.5 nuts/ palm/year) followed by the treatment receiving vermicompost (93.1 nuts/palm/year) and 50% N through vermicompost + 50 % RDF ($T_4$) (82.3 nuts/palm/year). These treatments were significantly superior over control treatment. The treatments receiving 50 % N through vermicompost + 50 % RDF (82.3 nuts/palm/year), neem cake + bone meal + ash (72.4 nuts/palm/year) and poultry manure (76.9 nuts/palm/year) were at par with each other. Kalpana *et al.* (2006) reported that the highest nut/palm/ year (113) were recorded in the treatment receiving 50 % organics + 50 % inorganic compared to only 89 nuts/ palm/year in 100% organic treatment.

The data on available nitrogen, phosphorus and potassium content of soil collected from three depths are presented in Table 2. Available nitrogen status of soils was found to be significantly improved due to application of vermicompost ($T_3$) and 50 % N through vermicompost + 50 % RDF ($T_4$) in all the three depths. Significant increase in available phosphorus status of soil was recorded in the treatment receiving 50 % N through vermicompost + 50 % RDF ($T_4$) over the treatment

**Table 2. Effect of integrated use of manures and fertilizers on available nutrient content (kg ha$^{-1}$) of soil at different depths**

| Treatments | N | | | $P_2O_5$ | | | $K_2O$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0-25 cm | 25-50 cm | 50-100 cm | 0-25 cm | 25-50 cm | 50-100 cm | 0-25 cm | 25-50 cm | 50-100 cm |
| $T_1$ | 162.6 | 97.5 | 84.2 | 20.0 | 9.6 | 7.7 | 308.4 | 216.4 | 174.7 |
| $T_2$ | 183.0 | 125.1 | 94.7 | 27.5 | 13.6 | 9.1 | 391.4 | 268.8 | 205.2 |
| $T_3$ | 205.4 | 169.2 | 106.6 | 29.1 | 14.7 | 10.4 | 481.4 | 325.9 | 294.3 |
| $T_4$ | 200.1 | 156.7 | 106.0 | 30.7 | 15.4 | 12.0 | 519.1 | 375.9 | 302.3 |
| $T_5$ | 194.2 | 137.6 | 100.0 | 25.6 | 14.8 | 9.2 | 502.0 | 349.0 | 294.6 |
| $T_6$ | 178.0 | 114.0 | 105.8 | 23.4 | 12.4 | 9.0 | 448.1 | 341.2 | 283.7 |
| **CD(P=0.05)** | **13.92** | **13.10** | **5.76** | **2.73** | **1.67** | **0.62** | **36.21** | **26.20** | **20.80** |

receiving recommended dose of fertilizers ($T_2$) poultry manure ($T_6$) and control ($T_1$). The treatment receiving 50 % N through vermicompost + 50 % RDF ($T_4$) was at par with vermicompost ($T_3$) in respect to available P (Bray –I P) content of soil in 0-25 and 50-100 cm depths. Application of 50 % N through vermicompost + 50 % RDF ($T_4$) recorded significantly higher available potassium status of the soil as compared to recommended dose of fertilizers ($T_2$) and control ($T_1$). This treatment was at par with the treatments receiving neem cake + bone meal + ash, vermicompost and poultry manure at 50-100 cm depth. Sahoo *et al.* (2004) reported that the application of 25 kg FYM/palm/year + chemical fertilizer (NPK) has recorded significantly higher N (2.53 %), P (0.25 %) and K (1.38%) as compared to the recommended dose of fertilizers which recorded N, P and K content to the tune of 1.45 %, 0.17 % and 0.85 %, respectively. A gradual reduction in available nutrients from the surface down the profile in the coconut basin was noted in almost all the treatments.

## NPK fractions

The data on nitrogen, phosphorus and potassium fractions of soil from the surface layer of 0-25 cm are presented in Tables 3, 4 and 5, respectively.

Maximum exchangeable $NH_4$-N and $NO_3$-N contents of soil were noted in the treatment receiving 50 % N through vermicompost + 50 % RDF followed by the treatment receiving vermicompost. These treatments were significantly superior over recommended dose of fertilizers and control. Application of 50 % N through vermicompost + 50 % RDF, neem cake + bone meal + ash and vermicompost maintained higher status of fixed $NH_4$-N as compared to the treatments receiving poultry manure, recommended dose of fertilizers and control. These treatments were at par with each other. Application of 50 % N through vermicompost + 50 % RDF maintained significantly higher level of total hydrolysable N over other treatments. The treatment receiving 50 % N through vermicompost + 50 % RDF and vermicompost

**Table 3. Effect of integrated use of manures and fertilizers on nitrogen fractions (ppm)**

| Treatments | Exch. $NH_4$-N | Nitrate-N | Fixed-$NH_4$-N | Total hydro.-N | Hydro. $NH_4$-N | Hexo-samine-N | Amino acid-N | Unidenti. hydro.N | Unide.non hydro.N | Total -N |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 13.9 | 5.9 | 15.8 | 558.7 | 130.6 | 51.7 | 230.3 | 146.0 | 245.5 | 840.2 |
| $T_2$ | 17.1 | 7.6 | 23.8 | 626.4 | 149.0 | 57.4 | 251.5 | 168.3 | 353.8 | 1029.3 |
| $T_3$ | 23.5 | 11.0 | 44.6 | 764.9 | 179.3 | 61.8 | 340.8 | 182.8 | 317.7 | 1162.5 |
| $T_4$ | 25.7 | 13.0 | 47.5 | 848.0 | 218.3 | 71.2 | 376.9 | 181.4 | 276.5 | 1211.0 |
| $T_5$ | 21.3 | 10.5 | 46.1 | 708.8 | 170.0 | 57.2 | 329.8 | 151.7 | 291.0 | 1078.3 |
| $T_6$ | 20.2 | 9.1 | 30.7 | 696.1 | 154.9 | 64.6 | 284.5 | 184.7 | 308.4 | 1103.1 |
| **CD(P=0.05)** | **3.68** | **1.87** | **3.94** | **40.92** | **17.21** | **8.84** | **41.09** | **N.S.** | **N.S.** | **68.78** |

**Table 4. Effect of integrated use of manures and fertilizers on phosphorus fractions (ppm)**

| Treatments | Saloidbound-P | Al-P | Fe-P | Ca-P | Occluded-P | Reductant soluble-P | Organic-P | Total-P |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 7.2 | 35.4 | 127.5 | 15.4 | 45.4 | 110.1 | 232.3 | 573.7 |
| $T_2$ | 11.1 | 44.3 | 153.3 | 20.4 | 51.4 | 123.3 | 250.1 | 654.2 |
| $T_3$ | 14.3 | 57.0 | 161.5 | 29.8 | 69.2 | 134.4 | 469.5 | 936.0 |
| $T_4$ | 15.6 | 58.2 | 172.1 | 24.8 | 70.4 | 139.8 | 478.4 | 959.5 |
| $T_5$ | 20.1 | 61.2 | 172.6 | 28.6 | 73.3 | 145.5 | 518.3 | 1019.9 |
| $T_6$ | 13.3 | 48.3 | 153.0 | 22.5 | 61.4 | 128.7 | 412.3 | 871.6 |
| **CD(P=0.05)** | **1.89** | **4.49** | **8.88** | **2.75** | **5.12** | **8.98** | **60.94** | **57.10** |

alone maintained significantly higher hydrolysable $NH_4$-N status over the treatment receiving poultry manure, recommended dose of fertilizers and control. As regards to hydrolysable N fractions of organic nitrogen, the treatment receiving 50 % N through vermicompost + 50 % RDF maintained significantly higher level of hexosamine N and amino acid N over the treatments receiving RDF and control. The differences in unidentified hydrolysable N due to application of organic manures and fertilizers were non significant. Application of organic manures and fertilizer did not influence significantly the unidentified non hydrolysable N fraction in 0-25 cm depth. The treatments receiving 50 % N through vermicompost + 50 % RDF and vermicompost alone recorded significantly higher level of total N content of soil over the treatments receiving neem cake + bone meal + ash, RDF and control. Prasad and Rokima (1991a) observed that all fractions of N except $NO_3$-N and hexosamine N increased with increasing doses of NPK with and without manures.

The treatment receiving neem cake + bone meal + ash maintained significantly higher saloid bound P as compared to rest of the treatments. The differences in Al-P content among the treatments receiving neem cake + bone meal + ash, 50 % N through vermicompost + 50 % RDF and vermicompost were non significant. These treatments maintained significantly higher Al-P content, over other treatments. As regards to Fe-P content, the treatments receiving neem cake + bone meal + ash and 50 % N through vermicompost + 50 % RDF were statistically at par with each other and significantly superior over the treatments receiving poultry manure, recommended dose of fertilizers and control. The treatments receiving vermicompost and neem cake + bone meal + ash were statistically at par with each other and maintained significantly higher Ca-P content over the treatments receiving poultry manure, recommended dose of fertilizers and control. The differences in occluded-P among the treatments receiving neem cake + bone meal + ash, 50 % N through vermicompost + 50 % RDF and vermicompost were non significant. These treatments recorded significantly higher occluded P as compared to recommended dose of fertilizers and control. Maximum reductant soluble – P was maintained in the treatment receiving neem cake + bone meal + ash followed by the treatments receiving 50 % N through vermicompost + 50 % RDF which was significantly superior over poultry manure, recommended dose of fertilizers and control. The differences in organic P content among the treatments receiving neem cake + bone meal + ash ($T_5$), 50 % N through vermicompost + 50 % RDF ($T_4$) and vermicompost ($T_3$) were found to be non significant. Maximum total P content of soil recorded in the treatment receiving neem cake + bone meal + ash ($T_5$) which was significantly superior over rest of the other treatments. The significant differences in various forms of inorganic phosphorus in soil due to application of fertilizers with or without FYM were observed by Bhardwaj *et al.* (2000).

Maximum water soluble K was reported in the treatment receiving neem cake + bone meal + ash which was significantly superior over the treatments receiving poultry manure, vermicompost and control. The treatment receiving neem cake + bone meal + ash maintained significantly higher exchangeable K over the treatments receiving poultry manure, recommended dose of fertilizers and control and was statistically at par with treatment receiving 50 % N through vermicompost + 50 % RDF. The differences in non exchangeable K content among the treatments receiving recommended dose of fertilizers, 50 % N through vermicompost + 50 % RDF and poultry manure were non significant. Maximum lattice K was obtained in the treatment receiving recommended dose of fertilizers followed by the treatment receiving 50 % N through vermicompost + 50 % RDF which was significantly superior over rest of the treatments. As regards to total K content of soil, the treatments receiving recommended dose of fertilizers and 50 % N through vermicompost + 50 % RDF maintained significantly higher total K content as compared to other treatments. Prasad and Rokima (1991 b) observed an increase in water soluble K, exchangeable K and non

**Table 5. Effect of integrated use of manures and fertilizers on potassium fractions (ppm)**

| Treatments | Water soluble K | Exchangeable K | Non exchangeable K | Lattice K | Total K |
|---|---|---|---|---|---|
| $T_1$ | 28.3 | 148.7 | 383.7 | 1026.7 | 1587.5 |
| $T_2$ | 31.4 | 157.5 | 485.0 | 2351.6 | 3025.5 |
| $T_3$ | 28.7 | 188.7 | 463.7 | 1618.7 | 2300.0 |
| $T_4$ | 37.6 | 221.8 | 480.0 | 2135.5 | 2875.0 |
| $T_5$ | 40.0 | 246.8 | 422.5 | 1513.4 | 2222.7 |
| $T_6$ | 27.6 | 168.2 | 466.2 | 1492.5 | 2200.0 |
| **CD (P=0.05)** | **5.57** | **33.84** | **36.59** | **272.36** | **265.98** |

exchangeable K with the application of FYM, Biofertilizers and FYM + bio fertilizers over chemical fertilizers.

**Leaf nutrient content**

The data presented in Table 6 revealed that maximum leaf N content (1.98%) was registered in the treatment receiving vermicompost @ 50 kg/palm/year, followed by the treatment receiving 50 % N through vermicompost + 50 % RDF (1.95 %). The treatment receiving vermicompost was significantly superior over the treatments receiving neem cake + bone meal + ash, poultry manure, recommended dose of fertilizers and control. The maximum leaf P content of coconut palm was registered in the treatment receiving RDF (0.107%) followed by the treatments receiving neem cake + bone meal + ash (0.106%) and vermicompost (0.101%). These treatments were statistically at par with each other and significantly superior over rest of the treatments.

**Table 6. Effect of integrated use of manures and fertilizers on leaf nutrient content of coconut palm.**

| Treatments | Leaf nutrient (%) | | | | |
|---|---|---|---|---|---|
| | N | P | K | Ca | Mg |
| $T_1$ | 1.41 | 0.096 | 0.45 | 0.112 | 0.081 |
| $T_2$ | 1.62 | 0.107 | 0.65 | 0.124 | 0.098 |
| $T_3$ | 1.98 | 0.101 | 0.71 | 0.134 | 0.101 |
| $T_4$ | 1.95 | 0.098 | 0.99 | 0.139 | 0.111 |
| $T_5$ | 1.76 | 0.106 | 0.94 | 0.141 | 0.009 |
| $T_6$ | 1.71 | 0.100 | 0.63 | 0.116 | 0.089 |
| CD (P=0.05) | 0.091 | 0.006 | 0.090 | 0.007 | N. S. |

The treatments receiving 50 % N through vermicompost + 50 % RDF (0.99%) was at par with the treatment receiving neem cake + bone meal + ash (0.94%) in respect of leaf K content. These treatments were significantly superior over all the treatments. Application of neem cake + bone meal + ash (0.141 %) recorded significantly higher Ca content of coconut leaf than the treatments receiving recommended dose of fertilizers, poultry manure and control, however, it was statistically at par with the treatments receiving 50 % N through vermicompost + 50 % RDF and vermicompost alone. The differences in Mg content of leaf were non significant. The significant absorption of major nutrients such as N, K, Ca, and Mg was noted in treatments receiving manures alone like vermicompost and neem cake + bone meal + ash as compared to a treatment receiving chemical fertilizers, which may perhaps be due to their residual effect in building up soil fertility. Sahoo *et al.* (2004) noted significantly higher N, P and K content in leaf as compared to the treatment receiving the recommended dose of fertilizers alone.

It is, therefore, concluded that application of vermicompost either alone or in combination with inorganic fertilizers enhanced the available nutrient content in soil. Maximum content of easily available N fractions was noted in the treatment receiving vermicompost in combination with inorganic fertilizers followed by a treatment receiving vermicompost alone. The treatment receiving neem cake + bone meal + ash was found to be at par with the treatment receiving 50 % N through vermicompost + 50 % RDF in respect of available forms of phosphorus and potassium. Thus, application of organic manures either alone or in combination with fertilizers is found to be beneficial for available pool of nutrients in coastal lateritic soils of Konkan.

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