

## Integrated nutrient management of coconut-based farming system for sustained productivity

S. P. Singh, B. L. Manjunath, H. Hameed Khan\*, and Bhanu Shalini

ICAR Research Complex for Goa, Ela, Old Goa - 403 402

(Manuscript Received 1-9-2003; Revised : 16-1-2004; Accepted : 5-5-2004)

### Abstract

Among the horticultural crops, coconut stands second in area after cashew in the state of Goa. A field experiment on integrated nutrient management of coconut-based farming system was conducted between 1999-2002 at ICAR Research Complex for Goa in Old Goa. Three manurial treatments viz; T<sub>1</sub> (100% organics), T<sub>2</sub> (50% organics+50% inorganics) and T<sub>3</sub> (100% inorganics) were imposed in both coconut and hybrid napier forage grasses NB-21 and PBN-16 intercropped in coconut garden for three year. The results revealed that yield of forage grass NB-21 was same both in treatment T<sub>2</sub> (127 t/ha) and T<sub>3</sub> (126.97 t/ha), the difference being non-significant. However, the highest yield of PBN-16 (106 t/ha/year) was recorded in treatment T<sub>2</sub> followed by T<sub>3</sub> (104.9 t/ha/year), the differences being non-significant. Yield of coconut in NB-21 grass plot increased from 42 nuts/palm/year (1998-99) to 67 nuts/palm/year (2001-2002) whereas in PBN-16 grass plot it was from 80 nuts/palm/year to 78 nuts/palm/year for the period although the differences were non-significant.

Soil fertility status of plots receiving only organic manures depicted nearly the same pH over three years while plots receiving inorganic fertilizers showed a lower pH. There was slight increase in the organic carbon content in the manure applied plots especially in coconut basins. Nitrogen content at a depth of 30-60 cm in the coconut basins was found to be high in the plots receiving only inorganic fertilizers. However, the results obtained were non-significant.

*Key words:* Coconut-based farming system, integrated nutrient management, sustained productivity, organic recycling

### Introduction

Goa is a small state in the West Coast of India, with an area of 3,61,113 ha. The net sown area is 1,40,935 ha and the gross cropped area is 1,69,053 ha. It receives an annual rainfall of 280 cm with temperatures ranging from 19 to 35 °C. Among the horticultural crops, coconut ranks second in coverage after cashew. During the last five years, the area under coconut increased by 458 ha while production increased by five million nuts.

Monocropping of coconut with improper management has resulted in poor economic returns for the coconut growers in the state. However, vast scope exists for improving the economic viability of coconut gardens through multiple cropping with compatible intercrops like pineapple, banana, black pepper and forage grasses.

Further, one of the main reasons for the instability

in yield of coconut is the poor soil health. As vast majority of coconut area is under lateritic soil which is acidic and low in organic matter and water-holding capacity, an integrated nutrient management concept with addition of organics and recycling of farm wastes through integration of dairy enterprise and biogas unit, will lead to sustained productivity in coconut by stabilizing the soil health, in addition to improvement in income and creation of additional employment in the farm.

Studies conducted at CPCRI, Kasaragod earlier in this direction revealed that all the organic sources such as forest leaves, coconut sheddings, cattle manure and coir pith in conjunction with inorganics significantly improved the soil physical condition compared to treatment with inorganics alone in littoral sandy soil. Further, water retention at 0.2 and 1.0 bar, was higher in soil samples collected from the basins of coconut palms receiving organic matter regularly for seven years than in samples

\*Principal Investigator, NATP-INM (Hort), CPCRI, Kasaragod, Kerala

from the basins of palms not receiving any organic matter (Anon., 1978).

Further studies at CPCRI, Kasaragod also revealed that the organic 'C' status of the soil under mixed farming system was found to increase marginally (0.64-0.74%) over monocrop (0.38-0.4%). The bacteria and fungi counts were more in root region of both coconut + napier and coconut + guinea grass, when compared to monocrop. The nitrogen fixers and 'P' solubilizing bacteria were more in mixed farming system as compared to coconut monocropping. The soil enzyme activities (urease and dehydrogenase) and soil microbial biomass were higher in coconut based mixed farming compared to coconut monocropping (Maheshwarappa *et al.*, 1998).

Further, integration of dairy unit in the system with recycling of wastes / by products is known to bring in sustainability to the system (Manjunath *et al.*, 2002). Keeping this in view, the present investigation was carried out.

### Material and Methods

Field experiments were conducted at ICAR Research Complex, Old Goa, during 1999-2002 in a 12 years old coconut (variety Benaulim) situated in plain land with a spacing of 7.5 m x 7.5 m. Keeping each palm in the center and leaving a radius of 1.8 m, a plot size of 46.25 m<sup>2</sup> was available for planting of forage grasses, Hybrid napier NB-21 and PBN-16 which were planted with a spacing of 90 x 60 cm with a row of forage legume *Centrosema pubescens* in 1:1 ratio. The treatments included T<sub>1</sub> (100% organics, through FYM and Pressmud), T<sub>2</sub> (50% organics + 50% inorganics) and T<sub>3</sub> (100% inorganics) both for coconut and forage grasses in a Randomized Block Design with 4 replications. For coconut, an early *kharif* dose of 170 : 120:400 g of NPK/palm and late *kharif* dose of 330:200:800 g NPK/palm was given as per treatments through inorganic (Urea, SSP, MOP) and organic sources. For hybrid napiers, a fertilizer dose of 180:120:80 kg NPK/ha/year was given. Phosphorus and potassium were applied as basal dose and N was applied in four splits. All the growth and yield parameters of coconut as well as grass were recorded. The soil samples were taken at 0-15 and 0-30 cm depth both in coconut basin and the grass plots. The soils were dried, sieved and analyzed as per standard procedures (Jackson, 1973). The different growth parameters in forage grasses namely plant height, number of tillers, number of nodes, number of leaves, leaf length, leaf width, inter-nodal length, etc. were recorded in forage grasses in each cutting before harvest. A unit of five yielding crossbred milch cows (Jersy x Sindhi and Jersy x Gir) were integrated with the system.

## Results and Discussion

### 1. Effect of manurial treatments on growth and yield of forage, grass-hybrid napier and *Centrosema* as intercrop in coconut

In hybrid napier NB-21, maximum plant height obtained was 2.01 m in treatment T<sub>3</sub> followed by T<sub>1</sub> (1.94m). Maximum number of tillers were found in treatment T<sub>3</sub> (18.9/clump) followed by T<sub>1</sub> (17.21/clump). Yield of grass was found to be nearly the same both in treatment T<sub>2</sub> (127t/ha) and T<sub>3</sub> (126.97 t/ha) (Table 1).

Maximum plant height of 131.4 cm was recorded in hybrid Napier PBN-16 in treatment T<sub>3</sub> followed by T<sub>2</sub> (130.45 cm). Number of tillers was found to be maximum in T<sub>2</sub> (23.82/clump) followed by T<sub>3</sub> (22.61). Further, T<sub>2</sub> recorded a marginal increase in forage yield (106.3t /ha) over others (Table 2). The higher yield in T<sub>2</sub> may be attributed to the balanced fertilization of the grass both with organic and inorganics leading to a favorable situation for the crop growth.

Two harvests of perennial legume *Centrosema pubescens* were taken during the year. Maximum plant height of the legume (23.94 cm) recorded in T<sub>3</sub>. Biomass yield per plant was also found to be maximum in T<sub>3</sub> (0.95 kg) followed by T<sub>2</sub> (0.79 kg). Similarly, maximum yield was observed in T<sub>3</sub> (0.2 t/ha).

### 2. Soil fertility status in the coconut garden at different depths

Soils were analyzed for their nutrient content before fertilization and after the fourth harvest of grass for different depths. The EC of the soil ranged between 0.052 to 0.101 dS/m, pH between 5.9 to 6.1 and OC between 1.17 to 1.28 per cent in the grass plots. Nitrogen content of the soil was found to be low while P and K contents were high before grass cultivation (Table 2). Soil fertility status with regard to EC, pH, per cent organic carbon, nitrogen, phosphorus and potassium contents after four harvests of forage grasses showed that there was no significant difference among the treatments. The pH of the soil varied significantly among the treatments in the grass plots. Plots receiving only organic manures depicted nearly the same pH (5.87 and 5.83) over the period while plots receiving inorganic fertilizers depicted lowered pH of the soils (5.52) which may be due to the acidic nature of inorganic fertilizers applied. There was slight increase in the organic carbon content in the manure applied plots, owing to continuous application of organic manures, however, the result obtained was non-significant.

Table 1. Growth and yield parameters of Hybrid Napier NB-21

Treatment	Harvest	Plant height (cm)	No. of tillers/clump	No. of nodes/tiller	No. of leaves/tiller	Leaf length (m)	Leaf width (cm)	Internodal length (cm)	Yield (kg/plot)	Yield (t/ha)
T <sub>1</sub> (100% organics)	1st harvest	3.01	15.13	15.21	18.68	0.96	5.20	9.86	130.6	28.24
	2nd harvest	2.65	17.3	14.77	15.34	0.92	3.05	20.90	116.2	25.13
	3rd harvest	1.78	19.00	13.27	15.49	0.92	2.83	18.36	67.3	14.56
	4th harvest	1.19	23.39	9.57	14.60	0.91	2.58	12.01	69.0	14.92
	5th harvest	1.23	13.50	9.00	14.57	1.04	3.97	13.23	83.0	17.95
	6th harvest	1.70	14.92	11.62	15.47	1.04	2.69	13.24	102.2	22.09
	<b>Mean/Total</b>	<b>1.94</b>	<b>17.21</b>	<b>12.24</b>	<b>15.69</b>	<b>0.97</b>	<b>3.38</b>	<b>14.60</b>	<b>568.3</b>	<b>122.8</b>
T <sub>2</sub> (50% organics + 50% inorganics)	1st harvest	2.86	16.47	15.73	19.39	1.02	5.39	12.66	135.0	29.19
	2nd harvest	2.69	15.43	14.37	15.09	0.93	3.15	19.96	122.6	26.51
	3rd harvest	1.49	20.00	11.32	12.78	0.91	2.57	19.38	74.3	16.07
	4th harvest	0.94	21.17	8.02	12.78	0.90	2.45	11.33	69.4	15.00
	5th harvest	1.16	13.34	8.46	14.66	0.98	2.62	12.72	82.0	17.23
	6th harvest	1.74	15.16	12.42	15.88	1.06	3.11	13.83	106.4	23.01
	<b>Mean/Total</b>	<b>1.79</b>	<b>16.93</b>	<b>11.71</b>	<b>15.09</b>	<b>0.96</b>	<b>3.21</b>	<b>14.98</b>	<b>590.0</b>	<b>127.0</b>
T <sub>3</sub> (100% inorganics)	1st harvest	3.03	16.20	16.10	20.00	1.04	5.50	13.28	137.0	29.62
	2nd harvest	2.77	18.44	14.87	15.56	0.89	3.25	20.87	122.9	26.59
	3rd harvest	2.32	20.56	11.50	12.91	0.86	2.41	21.01	68.7	14.85
	4th harvest	1.00	26.93	7.81	12.91	0.91	2.52	10.32	73.6	15.91
	5th harvest	1.16	13.17	8.55	14.23	0.99	2.74	13.60	79.0	17.08
	6th harvest	1.85	15.07	13.22	15.83	1.07	2.98	13.57	106.0	22.92
	<b>Mean/Total</b>	<b>2.02</b>	<b>18.39</b>	<b>12.01</b>	<b>15.23</b>	<b>0.96</b>	<b>3.22</b>	<b>16.38</b>	<b>587.2</b>	<b>126.9</b>
C.D. @ 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Growth and yield parameters of Hybrid Napier PBN-16

Treatment	Harvest	Plant height (cm)	No. of tillers/clump	No. of nodes/tiller	No. of leaves/tiller	Leaf length (m)	Leaf width (cm)	Internodal length (cm)	Yield (kg/plot)	Yield (t/ha)
T <sub>1</sub> (100% organics)	1st harvest	154.0	14.89	11.31	11.84	72.84	2.80	13.24	75.0	16.08
	2nd harvest	136.5	12.21	12.23	10.22	85.26	2.56	8.21	71.26	15.40
	3rd harvest	100.5	23.11	15.14	10.44	98.95	3.58	7.79	115.0	24.86
	4th harvest	120.8	17.89	16.08	12.02	68.96	2.50	10.82	75.67	16.36
	5th harvest	131.7	31.00	14.39	12.06	66.70	1.93	12.29	76.58	16.55
	6th harvest	73.21	34.15	11.54	7.68	45.92	1.79	8.34	66.63	14.41
	<b>Mean/Total</b>	<b>119.6</b>	<b>22.21</b>	<b>13.45</b>	<b>10.71</b>	<b>84.70</b>	<b>2.53</b>	<b>10.11</b>	<b>480.14</b>	<b>103.7</b>
T <sub>2</sub> (50% organics + 50% inorganics)	1st harvest	163.0	16.11	12.42	10.60	70.78	3.08	12.39	75.67	16.36
	2nd harvest	141.1	14.11	12.56	10.31	84.79	3.01	7.69	71.78	15.52
	3rd harvest	107.2	22.34	15.25	9.67	97.39	3.75	8.02	115.3	24.93
	4th harvest	124.6	17.33	17.36	13.05	73.98	2.78	10.22	78.33	16.94
	5th harvest	144.9	38.30	14.89	12.92	68.71	2.14	11.66	81.17	17.55
	6th harvest	102.0	33.75	12.84	9.42	67.07	2.02	8.92	69.27	14.98
	<b>Mean/Total</b>	<b>130.45</b>	<b>23.21</b>	<b>14.22</b>	<b>10.99</b>	<b>77.12</b>	<b>2.79</b>	<b>9.82</b>	<b>491.52</b>	<b>106.3</b>
T <sub>3</sub> (100% inorganics)	1st harvest	158.0	16.45	9.48	10.23	72.06	3.04	14.89	75.00	16.22
	2nd harvest	138.2	14.25	12.23	10.10	85.44	3.02	8.39	71.36	15.43
	3rd harvest	115.9	23.0	14.44	9.50	96.84	3.64	8.43	114.3	24.71
	4th harvest	131.7	19.4	17.44	13.44	73.51	2.71	10.76	75.00	16.23
	5th harvest	149.5	28.07	14.61	12.86	67.09	2.24	12.33	84.27	18.22
	6th harvest	73.21	34.45	12.96	8.50	73.84	1.95	8.86	65.59	14.18
	<b>Mean/Total</b>	<b>130.45</b>	<b>22.61</b>	<b>13.53</b>	<b>10.77</b>	<b>78.13</b>	<b>2.77</b>	<b>10.61</b>	<b>485.52</b>	<b>104.9</b>
C.D. @ 5%		NS	NS	NS	NS	NS	NS	NS	NS	NS

**Table 3.** Soil fertility status in the grass plots at 0-15 cm depth (before fertilization)

Treatment	EC(ds/m)	pH	%OC	N(kg/ha)	P (kg/ha)	K (kg/ha)
T <sub>1</sub>	0.101	6.10	1.22	162.0	274.8	410.7
T <sub>2</sub>	0.052	6.03	1.17	150.0	200.9	328.5
T <sub>3</sub>	0.056	5.93	1.28	156.0	183.2	462.9
CD at 5%	NS	NS	NS	NS	NS	NS

Similarly EC, pH and organic carbon at the root zone depth in the coconut basin ranged between 0.01 to 0.086 dS/m, 5.5 to 5.95 and 0.81 to 1.16 per cent, respectively (Table 4). Nitrogen was low (avg. 147 kg/ha) while P and K contents were high (avg. 191 and 640 kg/ha). Though non-significant, nitrogen content at a depth of 0-30 cm in the coconut basins was found to be high in the plots receiving only inorganic fertilizers (Table 6). Phosphorus and potassium contents of soil were high in treatments receiving 50 per cent organic manure and 50 per cent inorganic manures. The results obtained were however, non-significant.

**Table 4.** Soil fertility status in the grass plots at 0-15 cm depth (before fertilization)

Treatment	EC(ds/m)	pH	%OC	N(kg/ha)	P (kg/ha)	K (kg/ha)
T <sub>1</sub>	0.066	5.75	1.05	142	119.9	481.6
T <sub>2</sub>	0.062	5.73	1.05	151	237.2	821.3
T <sub>3</sub>	0.068	5.95	1.16	148	219.0	619.5
CD at 5%	NS	NS	NS	NS	NS	NS

**Table 7.** Yield of coconut (average nuts/palm/year) in NB-21 grass plot

Treatment	1998-1999			1999-2000			2000-2001			2001-2002			Av. nut yield over the period (1998-2002)
	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	
T <sub>1</sub>	2	95	39.58	2	77	51.33	3	149	49.67	4	293	73.25	53.45
T <sub>2</sub>	2	86	39.09	3	95	34.55	3	156	52.00	5	262	52.40	44.51
T <sub>3</sub>	5	211	45.87	3	106	32.62	5	347	74.30	5	371	74.20	56.47
Average			41.51			39.50			58.66			66.62	
C.D.@5%			NS			NS			NS			NS	

**Table 8.** Yield of coconut (average nuts/palm/year) in PBN-16 grass plot

Treatment	1998-1999			1999-2000			2000-2001			2001-2002			Av. nut yield over the period (1998-2002)
	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	Av. no of yielding palms	Total nuts	Av. yield	
T <sub>1</sub>	3	216	83.08	3	203	73.82	3	159	53.00	3	293	97.67	77.07
T <sub>2</sub>	2	148	82.22	2	113	56.50	3	166	55.33	3	190	63.33	64.34
T <sub>3</sub>	3	209	74.64	3	127	46.18	3	348	49.33	3	221	73.67	60.95
Average			79.98			58.83			52.55			78.22	
C.D.@5%			NS			NS			NS			NS	

**Table 5.** Soil fertility status in the grass plots at 0-15 cm depth (after fertilization)

Treatment	EC(ds/m)	pH	%OC	N(kg/ha)	P (kg/ha)	K (kg/ha)
T <sub>1</sub>	0.073	5.87	1.22	174.59	85.03	238.9
T <sub>2</sub>	0.088	5.83	1.22	126.66	127.4	365.9
T <sub>3</sub>	0.105	5.52	1.06	117.52	103.0	216.5
CD at 5%	NS	0.21	NS	NS	NS	98.39

**Table 6.** Soil fertility status in the coconut basin of the treated plots at 0-30 cm (after fertilization)

Treatment	EC(ds/m)	pH	%OC	N(kg/ha)	P (kg/ha)	K (kg/ha)
T <sub>1</sub>	0.079	6.03	1.59	126.21	204.4	612.3
T <sub>2</sub>	0.085	5.90	1.22	122.23	163.5	559.0
T <sub>3</sub>	0.117	5.73	1.32	120.48	174.9	470.4
CD at 5%	NS	NS	NS	NS	NS	NS

### 3. Yield of coconut in the system

Nut yield in coconut in NB-21 grass plot increased over the period from 42 nuts/palm/year to 67 nuts/palm/year. However, the average nut yield/palm/year over the period in different treatments remained non-significant.

In PBN-16 grass plot, the yield remained the same from 80 nuts/palm/year in the year 1998-99 to 78 nuts/palm/year in the year 2001-2002. There was a slight increase in the total production over the period which increased from 191 nuts/0.6 ha in the year 1998-99 to 235 nuts in the year 2001-2002 in the treated blocks.

Overall average production per palm per year was found to be 67 nuts (Table 5B). However, production of nuts treatments - wise was found to be statistically non-significant over the period. Increased yield of coconut may be due to the better nutrient status over the period which has also been reported earlier by Maheshwarappa *et al.* (1998).

#### 4. Quantification of wastes and recycling in the system

Total cow dung obtained in the system was 21178 kg for a period of ten months from five cows. Total fodder waste recorded from all the five cows was 10754 kg for a period of eight months. Coconut leaflet wastes recorded in the system was 945 kg/experimental plot (5625 m<sup>2</sup>). Leaf petioles were found to be 415 kg from the plot. All wastes were used for composting during the year and about 750 kg of FYM was obtained after decomposition, which was recycled to the forage grass and coconut as per treatment, Similar studies at CPCRI, Kasaragod revealed that coconut leaf waste, inflorescence etc. recycled in the system helped in substantial saving of fertilizer input through efficient recycling of the wastes available in the field (Subramanian *et al.*, 2000)

#### Acknowledgement

Authors are thankful to the World Bank for providing financial assistance to the National Agricultural Technology Project entitled, 'Integrated Nutrient Management of palm-based cropping system for sustained productivity under coastal agro ecosystem', and are also thankful to the Director of ICAR Research Complex for Goa, Ela, Old Goa for the valuable contribution in pursuing the above said project successfully.

#### References

- Anonymous, 1978. All India Co-ordinated Coconut and Arecanut Improvement Project, Progress Report for 1976-77, Central Plantation Crops Research Institute, Kasaragod.
- Maheshwarappa, H. P., Hegde, M. R., Dhanapal, R. and Biddappa, C.C. 1998. Mixed farming in Coconut : Its impact on soil physical and chemical properties, coconut nutrition and yield. *J. Plantn. Crops* **26** : 139-143.
- Manjunath. B. L., Singh, S. P. and Sundaram, R.N.S. 2002. Farming system approach in enhancing the profitability and employment potential and coconut gardens in Goa. *Indian Coconut J.* **32** (12): 6-9.
- Subramanian, P., Upadhyay A. K., Srinivasa Reddy, D. V. and Gopalsundaram, P. 2000 *National Seminar on Recent Advances in Plant Biology - An inter-disciplinary approach to unravel plant functions*, (Abstr.), Indian Society for Plant Physiology and Biochemistry, New Delhi, pp. 38-39.