



Macronutrient status and yield stability of arecanut (*Kahikuchi*) under integrated nutrient management practice in Assam

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(Manuscript Received:01-02-2015, Revised:01-05-2015, Accepted:13-08-2015)

Abstract

A long term field experiment was carried out in clay-loam soil at ICAR-CPCRI, Kahikuchi campus, Guwahati, Assam during 2000-2012 with arecanut variety Kahikuchi with seven nutrient combinations. The treatments included control (T1), 100 per cent vermicompost (T2), 200 per cent vermicompost (T3), 100 per cent chemical fertilizer (T4), 50 per cent vermicompost + 50 per cent chemical fertilizer (T5), 1/3rd vermicompost + 2/3rd chemical fertilizer (T6) and 2/3rd vermicompost + 1/3rd chemical fertilizer (T7). The treatment T7 produced highest fresh ripened arecanut yield of 16.7 kg *i.e.*, about 3.6 kg dry chali per palm. Positive correlations were obtained between yield of arecanut and soil available N, P and K content. Significant and positive correlation was found between leaf N, P, K and available N, P and K content in surface and sub-surface soil. Available N, P and K content increased over the years under nutrient applied plot that reflected in yield of arecanut. The average yield in various treatments followed in the order of T7 > T5 = T6 > T2 = T3 > T4 > T1. The application of targeted, sufficient and balanced quantities of organic and inorganic fertilizer will be the need of the hour to make nutrients available for higher yield, soil fertility maintenance and agricultural sustainability without polluting environment.

Keywords: Arecanut yield, nutrient combination, soil fertility status, vermicompost

Introduction

Arecanut is grown in an area of 90,000 hectares in North East (NE) India, comprising seven states with an average productivity of 1.2 tonnes per hectare. Nearly 82 per cent arecanut cultivation in the NE lies in Assam with an estimated area of 74,000 hectare producing 62,700 tonnes (NHB Database, 2010). It is grown in almost all households, which is literally called 'Bari' system of planting. General practices of non-application of manures, lack of awareness on technological development and absence of large scale plantation lead to poor production of arecanut in Assam. In a state where arecanut is part of economy and used in religious and social functions, application of manure is of utmost important for the crop which

provides economic return for 60 to 70 years. For good yield and maintenance of soil fertility, it is therefore, pertinent to adopt integrated nutrient management (INM) practices depending upon the local availability of nutrient resources. INM refers to the maintenance of soil fertility and plant nutrients supply at an optimum level for sustaining the desired productivity through optimisation of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner. Effect of INM practices in enhancing native soil nutrients, providing balance nutrient lost and increasing yield have been enumerated by many research workers in different agricultural crops (Reddy and Upadhyay, 2002; Mohandas, 2012; Singh *et al.*, 2004). However,

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hardly any literature is available on nutrient management in arecanut cultivation in North Eastern India, particularly in Assam. So, a field study was conducted to develop a farmer-friendly INM practices in arecanut for achieving sustainable crop production for long term period.

Materials and methods

The field experiment was laid out at ICAR-Central Plantation Crops Research Institute, Research Centre, Kahikuchi, Guwahati, Assam, following randomized block design during 2000. The experimental site, Kahikuchi is located in sub-humid area at 20°18' N latitude and 91°78' E longitude. It receives an average annual precipitation of 2500 to 3000 mm. The mean maximum temperature varies between 15 °C and 34 °C and mean minimum temperature varies from 8 °C to 22 °C and is located at 50 m above MSL. The soil of experimental site was clay loam in texture and was acidic in nature with initial pH range between 4.4 and 5.4 at surface soil and 4.5 and 6.7 at subsurface soil. Initial organic carbon as well as available N, P and K content varied from 0.98 to 1.37 per cent and 194.0 to 249.5, 21.9 to 43.8, 173.6 to 268.8 kg ha⁻¹, respectively at surface soil and subsurface soil contains 0.67 to 0.99 per cent organic carbon, 166.3 to 212.5 kg N ha⁻¹, 14.0 to 30.9 kg P ha⁻¹ and 159.6 to 205.8 kg K ha⁻¹. The arecanut crop variety considered was Kahikuchi. The arecanut palms were planted following a spacing of 2.7 m in both the ways. The different integrated nutrient management treatments include: control (T1), 100 per cent vermicompost (T2), 200 per cent vermicompost (T3), 100 per cent chemical fertilizer (T4), 50 per cent vermicompost + 50 per cent chemical fertilizer (T5), 1/3rd vermicompost + 2/3rd chemical fertilizer (T6) and 2/3rd vermicompost + 1/3rd chemical fertilizer (T7). Absolute control was maintained for comparison. Fifty g borax per plant per was applied every year in two splits at the base of each treated palm to maintain the homogeneity due to less or limiting content of boron in soil.

The response of different treatments was observed since 2007, at nut bearing stage and carried on upto 2012. The treatments were imposed in two splits and each treatment was replicated thrice with six palms per replication. Vermicompost was prepared from arecanut leaf with *Eudrilus eugeniae*

earthworm and it contained 1.8 per cent N, 0.46 per cent P and 0.61 per cent K with a pH of 7.2 and organic carbon of 19.6 per cent. Fresh nut yield and number of fresh nuts per palm at ripening stage was observed. The nuts were dried in two split and chali yield was recorded. The soil and leaf samples were collected from two palms in each replicated plot during April. Soil samples were taken from two opposite sides of the base of the palm, from the circular basins 75 cm away from the bole at two different depths *i.e.*, 0-30 cm and 30-60 cm. The soil samples were dried in shade, sieved (2 mm sieve) and analysed for pH, organic carbon, available nitrogen, available phosphorus and available potassium content. pH (soil:water 1:2.5) was measured with the help of pH meter (Jackson, 1973); organic carbon by Walkley and Black (1934) chromic acid digestion method. Available nitrogen in soil was determined by using Kel-plus nitrogen distillation unit (Subbiah and Asija, 1956). The available phosphorus was determined following the procedure described by Bray and Kurtz (1945) and potassium was determined flame photometrically by neutral normal ammonium acetate extraction method (Hanway and Heidel, 1952). The leaf samples were collected from 4th leaf from the top by cutting 4-5 leaflets from the middle of the leaf on both sides. Leaf samples were washed with distilled water, oven dried at 65-72 °C and then powdered. The nitrogen content in leaf sample was estimated by using Kel-plus digestion and distillation method described by Jackson (1973). The powdered fraction (0.5 mm) of leaf sample was digested in HNO₃:HClO₄ (3:1) di-acid mixture and analysed for phosphorus and potassium content (Jackson, 1973).

Results and discussion

Yield parameters

Different INM treatments had a significant influence on fresh ripened nut weight, number of nuts per palm and chali yield per palm (Table 1 & 2) for six consecutive years (2007 to 2012). The average mean data of single fresh ripened nut weight (42.2 g) was recorded maximum in the palms under treatment T7 which was 19 per cent increase over the control. During 2012, fresh ripened nut weight increased over control by 20.6 per cent under T7 treatment. Fresh ripened nut weight increased upto 2008 (8th year of age) and then remained almost

Table 1. Fresh arecanut yield under different treatments from 2007 to 2012

Treatments	Dry chali yield (kg palm ⁻¹)						Pooled Mean
	2007	2008	2009	2010	2011	2012	
T1	1.4	2.0	2.1	2.1	2.1	2.1	2.0
T2	1.9	2.7	2.7	2.8	2.9	2.9	2.7
T3	2.3	2.8	2.9	3.0	3.0	3.0	2.8
T4	1.9	2.3	2.7	2.7	2.6	2.6	2.5
T5	2.4	2.9	3.4	3.5	3.7	3.5	3.2
T6	2.1	2.9	3.8	3.8	3.7	3.8	3.3
T7	2.6	3.6	3.9	4.0	4.0	4.0	3.7
P=0.05	0.11	0.13	0.12	0.12	0.13	0.12	0.22

static in the subsequent years in all the treatments barring control (Table 2) where it remained almost stagnant over the study period. Number of nuts per palm differed significantly among various INM treatments during study period except T2 and T3 which were at par. Nut yield per palm differed among the treatments but it increased upto 2008 *i.e.*, 8th year of age under the treatments of T1, T2, T3 and T4 and remained at par in the subsequent years. Remaining treatments T5, T6 and T7 showed highest nut number in 2009 *i.e.* and remained at par in the subsequent years. Production capacity of arecanut (Var. *Kahikuchi*) reached the highest in 8th years of age (in 2008) under single form (organic/inorganic) of nutrient application and in 9th year of age under integrated nutrient supply (in 2009). However, significantly more number of nuts (420 per palm) was produced under the treatment T₇ at the end of sixth year of study compared to control treatment *i.e.*, 58.6 per cent over the control in 2012.

It was on par during 2009 to 2011 and 58.5 to 63.5 per cent over control. The mean pooled data described the superiority of the treatment T7, T6 and T5 over other treatments. Statistically T5 and T6 were at par, but T7 significantly differed from other treatments. Maximum per cent increase in ripened nut number was observed under T6 in 2012 (75.1%) which was at par in 2009 (72.3%) over the initial yield.

Almost similar trend was observed in chali yield per palm where it was highest under T7 treatment and it significantly differed from the other treatments. Among the other treatments, T6 and T5 were at par but significantly higher than T1, T2, T3 and T4. It clearly showed that blending of inorganics and organics had more positive effect on the yield and yield characters of arecanut. Kalpana *et al.* (2006) reported that the highest coconut yield palm⁻¹ year⁻¹ was recorded in the treatment receiving 50

Table 2. Nut yield of arecanut under different treatments from 2007 to 2012

Treatments	Single fresh nut weight (g)							No. of nuts palm ⁻¹						
	2007	2008	2009	2010	2011	2012	Pooled mean	2007	2008	2009	2010	2011	2012	Pooled mean
T1	35.6	35.1	35.3	35.5	35.7	35.4	35.4	180.7	254.7	261.1	265.2	260.3	265.1	244.4
T2	38.2	39.3	39.4	39.5	39.3	39.5	39.1	219.1	303.1	309.4	319.2	332.4	330.6	296.6
T3	39.4	39.5	39.3	39.5	39.7	39.8	39.5	254.2	315.5	328.8	333.7	330.5	335.4	312.5
T4	36.1	36.4	37.9	37.8	37.9	37.8	37.2	235.5	283.3	312.8	310.4	305.2	300.5	289.4
T5	39.5	41.2	41.6	41.8	41.9	41.8	41.2	267.3	315	363.5	375.1	385.8	370.4	341.3
T6	38.8	40.5	41.2	41.4	41.2	41.3	40.6	231.4	315.4	398.8	400.2	395.2	405.2	348.2
T7	39.7	42.6	42.8	42.9	42.8	42.7	42.2	301.2	386.7	413.9	420.3	425.6	420.5	389.5
P = 0.05	0.46	0.49	0.48	0.48	0.49	0.49	0.62	25.03	26.12	26.16	26.22	26.12	26.13	19.61

per cent organics + 50 per cent inorganics compared to 100 per cent organic treatment.

Soil nutrient status

The soil available N, P, K, pH and organic carbon content at two different depths *i.e.*, 0-30 cm and 30-60 cm are shown in Table 3 for three alternate years (2008, 2010 and 2012). The soil available nitrogen in surface soils differed significantly by different INM treatments in every year of study. Build up of available nitrogen in soil was observed in all the treatment except the absolute control where there is a gradual decrease in available nitrogen content of soil. Available nitrogen content significantly increased gradually in surface soils over the initial content by 3.7 (2010) and 7.4 per cent (2012) in the 200 per cent vermicompost applied plots. Available phosphorus and potassium content in the soil showed significant variation among the treatments. Continuous application of 100 per cent inorganic fertilizer (T4) resulted in the build up of more available phosphorus and potassium in the soil, as the other integrated

treatments consisting of vermicompost contains less phosphorus (0.46%) and potassium (0.61%). Similar trend was also noticed in sub surface soils. In the 100 per cent chemical fertilizer applied plot, available P content increased significantly over the years by 4.3 in 2010 and 5.2 per cent in 2012 in surface soil. The treatments which received chemical fertilizers resulted in excess deposition of available K in both surface and subsurface zone. The significantly higher deposition was observed under 100 per cent chemical fertilizer applied plots. The sub-surface soils contained comparatively less available N, P and K content.

Data on soil pH in surface soil showed that under the treatment T4 and T6, the pH was less when compared to other treatments. Continuous application of inorganic fertilizer might be the reason for more acidic nature of soil in the above treatments. High rainfall and humid conditions in the experimental soil leads to the binding of cations and organic acids resulting in leaching of soluble solids, increasing acidity the soil. In the treatment T7, soil pH showed an equal or increasing trend

Table 3. Chemical properties of the soil during growth period of arecanut

Treatments	pH (1:2.5)			OC (%)			Available N (kg ha ⁻¹)			Available P (kg ha ⁻¹)			Available K (kg ha ⁻¹)		
	2008	2010	2012	2008	2010	2012	2008	2010	2012	2008	2010	2012	2008	2010	2012
0 – 30 cm depth															
T1	5.3	5.2	5.2	1.1	1.0	1.0	194.0	184.8	184.6	21.9	20.0	20.4	173.6	170.5	168.0
T2	5.1	5.0	5.0	1.2	1.2	1.2	240.2	249.5	249.5	27.9	27.1	27.2	218.4	216.8	212.8
T3	5.1	5.0	5.0	1.4	1.4	1.5	249.5	258.7	268.0	30.2	31.2	31.7	257.6	255.4	257.6
T4	4.8	4.8	4.8	1.0	1.0	1.0	212.5	221.8	221.8	43.8	45.6	46.0	268.8	272.3	274.4
T5	5.0	4.9	4.9	1.1	1.2	1.2	221.8	231.0	231.0	38.5	39.8	40.0	240.4	241.6	246.4
T6	4.4	4.4	4.4	1.0	1.0	1.1	231.0	240.2	240.2	40.0	40.3	41.5	252.0	258.8	257.6
T7	5.0	5.0	5.0	1.2	1.2	1.3	212.5	221.8	231.0	31.7	31.0	30.9	196.0	201.6	201.6
P = 0.05	0.12	0.14	0.13	0.06	0.07	0.07	11.41	13.24	13.56	2.50	3.34	3.17	36.90	33.45	34.56
30 – 60 cm depth															
T1	4.9	5.0	5.0	1.0	0.8	0.8	166.3	157.1	175.6	13.6	13.0	12.8	156.8	140.9	140.0
T2	5.0	5.1	5.1	0.9	1.0	1.0	212.5	212.5	212.5	19.6	18.6	18.1	179.2	164.7	168.0
T3	4.7	5.1	5.1	1.0	1.0	1.0	212.5	212.5	221.8	24.1	22.7	23.4	179.2	165.4	173.6
T4	6.7	6.7	4.8	0.8	0.6	0.6	194.0	203.3	203.3	31.7	32.2	32.4	196.0	201.2	207.2
T5	5.2	5.2	5.2	0.7	0.7	0.7	194.0	203.3	203.3	24.9	25.6	25.7	190.4	193.2	196.0
T6	4.5	4.6	4.6	0.7	0.8	0.8	203.3	212.5	203.3	25.7	26.3	27.2	207.2	199.6	207.2
T7	5.3	5.4	5.4	1.0	1.0	1.0	184.8	184.8	184.8	21.1	21.4	21.9	173.6	176.7	179.2
P = 0.05	0.33	0.34	0.33	0.05	0.05	0.06	13.07	14.37	14.78	0.87	1.08	1.12	1.78	2.26	2.88

Table 4. Nitrogen, phosphorus and potassium content (%) in arecanut leaf for six consecutive years

Treat- ments	Nitrogen						Phosphorus						Potassium					
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
T1	1.29	1.31	1.32	1.32	1.32	1.32	0.17	0.18	0.18	0.18	0.18	0.18	0.96	0.96	0.97	0.98	0.98	0.97
T2	1.66	1.66	1.68	1.68	1.69	1.69	0.20	0.21	0.21	0.21	0.21	0.21	1.10	1.12	1.13	1.13	1.13	1.12
T3	1.67	1.69	1.70	1.70	1.70	1.71	0.20	0.22	0.21	0.22	0.22	0.23	1.11	1.13	1.13	1.14	1.14	1.15
T4	1.43	1.48	1.48	1.49	1.48	1.49	0.25	0.26	0.26	0.26	0.25	0.25	1.19	1.21	1.22	1.22	1.21	1.22
T5	1.60	1.60	1.62	1.63	1.63	1.63	0.23	0.23	0.24	0.24	0.26	0.26	1.17	1.18	1.20	1.21	1.20	1.21
T6	1.52	1.55	1.56	1.56	1.56	1.56	0.20	0.21	0.22	0.23	0.22	0.23	1.13	1.14	1.16	1.17	1.17	1.18
T7	1.47	1.50	1.52	1.53	1.53	1.54	0.21	0.22	0.22	0.21	0.22	0.22	1.12	1.14	1.16	1.17	1.16	1.16
P = 0.05	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03	0.04	0.03	0.02	0.03

justifying the application of integrated nutrient management in true proportion. The sub-surface soils were comparatively less acidic irrespective of the treatments, except under the treatment 'absolute control'. Organic carbon content was high in surface soil as compared to sub-surface soils in all the treatments. The influence of different treatments in building up of organic matter was significant in different years. Maximum organic matter was recorded in T3 at the end of study period both in surface soil (1.45%) and sub-surface soil (1.02%). This effect may be ascribed to the direct addition of water-soluble carbon through vermicompost application (Singh *et al.*, 2009). Maheswarappa (2008) and Bopaiah and Shetty (1991) reported similar phenomenon that integrated approach not only has the advantage of improving nutrition, but recycling of organic substances play major role in organic matter build up which is the site of all chemical and biotic activity in the soil.

Leaf nutrient content

The leaf N, P and K content as influenced by different treatments is listed in Table 4. This indicated that foliar content of N, P and K varied from 1.32 to 1.54, 0.18 to 0.26 and 0.97 to 1.22 per cent respectively in 2012. Similar results were also reported by Bhat and Mahapatra (1989). The leaf nutrient content either increased or remained stable during the course of study in all the INM treatments. However, maximum leaf nitrogen content (1.71%) was recorded in the palms that received 200 per cent vermicompost (T3) followed by T2 (1.69%). Among all the treatments, highest yield was obtained in T7 where, comparatively less leaf N, P and K content was recorded. This shows the

utilization of applied manures to maximum extent and a little luxury consumption of N, P and K by the palms under T7. The correlation between soil available N and leaf N ($r = 0.96^{**}$ and $r = 0.91^{**}$) soil available P and leaf P ($r = 0.91^{**}$ and $r = 0.95^{**}$) and soil available K and leaf K ($r = 0.78^*$ and $r = 0.89^{**}$) were positive and significant at both the depth of the soil, which suggests that plant can uptake P and K from the soil when soil bears good quantities of its available form. Arecanut yield might be attributed to this phenomenon as P and K content in plant plays major role determining the yield potential of the crop. Singh and Ram (1992) reported that the significant improvement in plant growth, yield attributes and yield of chickpea on account of vermicompost application along with inorganic sources of NPK resulted in translocation of nutrients from soil and enhanced supply of macro and micro-nutrients during entire growing seasons and microbial decomposition. Mishra *et al.* (2011) suggested that the addition of manures add sufficient amount of organic matter to the soil and solubilise plant nutrients and improve physical conditions of the soil by accelerating porosity, aeration and water holding capacity. It is also well documented fact that incorporation of organic manures with inorganic fertilizers in the soil not only acts as store house of macro- and micro-nutrients but also favourably affect physical and chemical characteristics of soil and plant (Bhriyuvanshi, 1988).

Acknowledgement

The authors are grateful to the Director, ICAR-CPCRI, Kasaragod for the guidance and facilities provided to carry out the work. Financial support

from Central Sector Scheme on Horticulture Mission for North East and Himalayan States is gratefully acknowledged.

References

- Bhat, N.T. and Mahapatra, A.R. 1989. Effect of supplying nutrients through organic manures, inorganic fertilizers and their combinations on areca nut crop. *Journal of Plantation Crops* **16** (Supplement): 443-447.
- Bhargavanshi, S.R. 1988. Long term effect of high doses of farm yard manure on soil properties and crop yield. *Journal of Indian Society of Soil Science* **36**: 787-790.
- Bopaiah, B.M. and Shetty, H.S. 1991. Soil microflora and biological activities in rhizospheres and root regions of coconut based multi-storeyed cropping and coconut monocropping system. *Soil Biology and Biochemistry* **23**: 89-94.
- Hanway, J.J. and Heidel, H. 1952. Soil analysis methods used in Iowa State College, Soil Testing Lab, Iowa Agronomy, **57**: 1-31
- Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice Hall, New Delhi.
- Kalpana, M., Rao, D.V.R. and Srinivaslu, B. 2006. Integrated nutrient management in coconut based cropping system under coastal ecosystem of Andhra Pradesh. *Journal of Plantation Crops* **34**(3): 258-262.
- Maheswarappa, H.P. 2008. *In-situ* waste management in integrated nutrient management system under coconut (*Cocos nucifera*) based high density multi-species cropping system in tropical soils of India *Indian Journal of Agricultural Sciences* **78**: 924-928.
- Mishra, S, Choudhary, M.R., Yadav, B.L. and Singh, S.P. 2011. Studies on the response of integrated nutrient management on growth and yield of ber. *Indian Journal of Horticulture* **68**(3): 318-321.
- Mohandas, S. 2012. Integrated nutrient management in East Coast Tall coconut. *Madras Agricultural Journal* **99**(1-3): 92-95.
- NHB Database 2010. Indian Horticulture Database 2010, Published by NHB, DAC.
- Reddy, D.V. and Upadhyay, A.K. 2002. Impact of integrated nutrient management on the mineral nutrition and yield of WCT coconut in littoral sandy soil at Kasaragod. *Proceedings of Placrosym XV* : 274-281.
- Singh, P.N. and Ram, H. 1992. Effect of phosphorous and sulphur on concentration and uptake of micronutrients in chickpea. *Journal of Indian Society of Soil Science*, **40**: 307-312.
- Singh, S.K., Singh, J.P. and Singh, M.D. 2009. Soil organic carbon pools after seven years of manures and mineral fertilizers application in a rice-wheat rotation. *Archives of Agronomy and Soil Science* **55**(2): 197-206.
- Singh, S.P., Manjunath, B.L., Hameed Khan, H. and Shalini, B. 2004. Integrated nutrient management of coconut-based farming system for sustained productivity. *Journal of Plantation Crops* **32**(2): 16-20.
- Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available nitrogen in soils. *Current Science* **25**(8): 259-260.