Journal of the Andaman Science Association Vol. 21(2):15-20 (2016)
ISSN 0970-4183, Printed in India

Soil fertility and yield attributes of arecanut (*Areca catechu* L.) as affected by the nutrient levels and irrigation in a tropical island

A. Velmurugan and T.P. Swarnam
ICAR-Central Island Agricultural Research Institute, Port Blair-744101
Email: vels_21@yahoo.com

Abstract

Arecanut is grown in the coastal humid areas of India. Andaman and Nicobar islands produces 6700 tones of arecanut under rainfed condition from 4,400 ha area. The productivity is low owing to low input use and high evapo-transpiration. Therefore a study was carried out from 2009-2013 to assess the effect of fertilizer levels (N_1, N_2, N_3 and N_4), irrigation (I_1, I_2 and I_3) and their interaction on arecanut yield and soil fertility. The results showed that at the end of the experimental period due to irrigation the incremental growth in girth of the tree significantly increased in I_3 (0.107 m) followed by I_2 (0.093 m) when compared to control. Irrigating the palm tree during the dry month had significant impact on the yield with the highest yield observed in I_2 (2.45 kg/tree) which is 13% higher than the control followed by I_1. Similarly nutrient application had significant impact with the highest yield recorded in I_2N_3 (2.93 kg/tree) which was 72% higher than the control. There was no significant change in available N and K content however there was a perceptible improvement in P content.

Key words: *irrigation scheduling, nutrient level, palm yield, Bay island*

Introduction

Arecanut (*Areca catechu* L.) is one of the most important plantation crops in humid tropics of India which belongs to family Palmae (Bhat and Sujatha, 2009). Arecanut palm is cultivated primarily for its kernel obtained from the fruit which is chewed in its tender, ripe or processed form. Arecanut grows well from almost sea level up to an altitude of 1000 m in areas receiving abundant and well distributed rainfall or under irrigated conditions on laterite, red loam and alluvial soils. The maximum numbers of inflorescences are produced during December–March therefore the post-monsoon period from December to May is highly critical for nutrient and water supply (Ananda, 2004). The utilization of soil nutrients and moisture is also depends on the rooting pattern of crops. Arecanut has shallow root system with more than 70% of the roots concentrated in top 60 cm of the soil in a radius of 60cm (Bhat and Leela, 1969). Due to this reason, nutrient application in proper form or combinations is necessitated in synchrony with crop demand. In the present-day context, agriculture is challenged to manage water and nutrients such that production benefits are maximized, while adverse environmental effects are minimized. The right combination of water and nutrients is a prerequisite for higher yields and good quality produce.

Andaman and Nicobar islands has 4,400 ha under arecanut cultivation and produces 6700 tons of arecanut (DES, 2015). Though these islands receives copious amount of rainfall, water is a limiting factor during dry period from December to May due to high evapo-transpiration and poor ground water storage. Because of these often nut falling and drying of leaves are experienced which significantly affects the production and income of farmers. Thus, irrigation during this period would contribute to higher yields and higher productivity. Further, the soils of arecanut growing areas are coarse textured, acidic with low nutrient supplying capacity, higher P fixation and potentially eroded (Velmurugan et al. 2014). The organic carbon and N content is medium and have poor K reserve. As a result the productivity of arecanut is less than 1250 kg ha^{-1}. Thus, adequate irrigation and appropriate fertilization becomes essential for achieving higher production and productivity of arecanut. Keeping this in view, a study was conducted to assess the effect of nutrient levels and their source, irrigation, and their interactions on soil fertility and arecanut yield in Andaman Islands. The study was aimed at improving the arecanut yield and soil fertility status under humid tropical conditions.

Materials and Methods

The study area

Andaman and Nicobar Islands are topographically undulating, characterized by hills and longitudinal valley areas. There are no great elevations and the slopes are moderate to steep and rugged. The island has typical hot and humid tropical climate. The average rainfall is 3074 mm of which maximum rainfall is received during south-west monsoon season (Fig. 1). The relative humidity (RH) varies from 68 to 86% and the maximum and minimum temperature is 32 and 22 °C, respectively. Though these islands receive more than 300cm total annual rainfall, water deficit is the major problem during dry season.

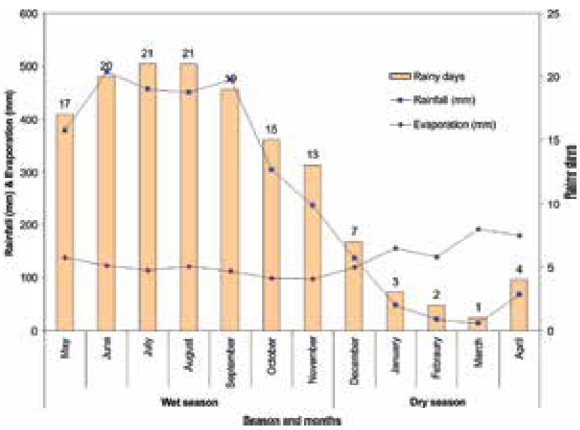


Fig. 1. Average rainfall, rainy days and evaporation of Bay Islands

Experimental details

Arecanut is mainly grown under rainfed condition with low or no external nutrient supply. In recent times decreasing rainy days during summer months have resulted in nut falling which necessitates irrigation to sustain the yield. On the other hand, availability of water during this period is limited. Hence, a field experiment was conducted from 2009 to 2013 with three levels of irrigation based on IW/CPE ratio and five levels of nutrient treatments in a split plot design with three replications to standardize the water and nutrient use. Irrigation treatments were assigned to the main plots and nutrient treatment were given to the subplots.

The experimental site selected for the study was the arecanut plantation of 10-12 year-old seedlings (cv. Mangla) at a spacing of 3.0m x 3.0m. The soil of the experimental site was sandy loam to loam in texture, acidic in pH (4.8) and non saline (EC 0.8). It contained high organic carbon (0.85 %), low in phosphorus (7 kg/ ha) and potash (75 kg/hg). Each treatment consisted of nine palms and each replication was imposed in three palms. The value for replication was the mean of three palms. The treatments details are given below;

A. Three irrigation levels:

- No irrigation (I0)
- IW/CPE of 0.5 (I1)
- IW/CPE of 0.5 (I2)

B. Five levels of nutrients;

- Control (N_0),
- 100 % of N, P,K through inorganic (N_1),
- 50 % of N, P,K through inorganic (N_2),
- 100 % of N through V.C : Inorganic @50:50 (N_3) and
- 50 % of N through V.C : Inorganic @50:50 (N_4)

The recommended dose of fertilizers was 100g N, 40g P_2O_5 and 140g K_2O per tree/ year.

Water requirement

The water requirement and scheduling of irrigation of arecanut were calculated as given below:

- IW/CPE = 0.75 & 0.5; IW for Arecanut = 60 mm
- Therefore, 60/0.75 = 80 mm and 60/0.5 = 120 mm
- The scheduling was done beginning from 20/02/2010

A. IW/CPE = 0.75 = 0.75 x 0.0796 = 0.0597 m

Area : 5.0625 m^2 x 0.0597 = 0.302 m^3

Total water requirement = 0.302 x 1000 = 302 litre

Water requirement = 302/ 18 = 16.8 litres/day/palm

B. IW/CPE = 0.5 = 0.5 x 0.1171 = 0.0586 m

Area : 5.0625 m2 x 0.0586 = 0.296 m3 = 296 litres

Water requirement = 296/26 = 11.4 litres/day/palm

The irrigation treatment was applied only during dry season (February to May) and nutrients in three split doses (Fig. 2). Effect of nutrient levels and irrigation influences plant growth parameters. Hence, time of flowering, No. bunch/plant, No. of nuts/bunch, Nut weight and total yield were recorded.

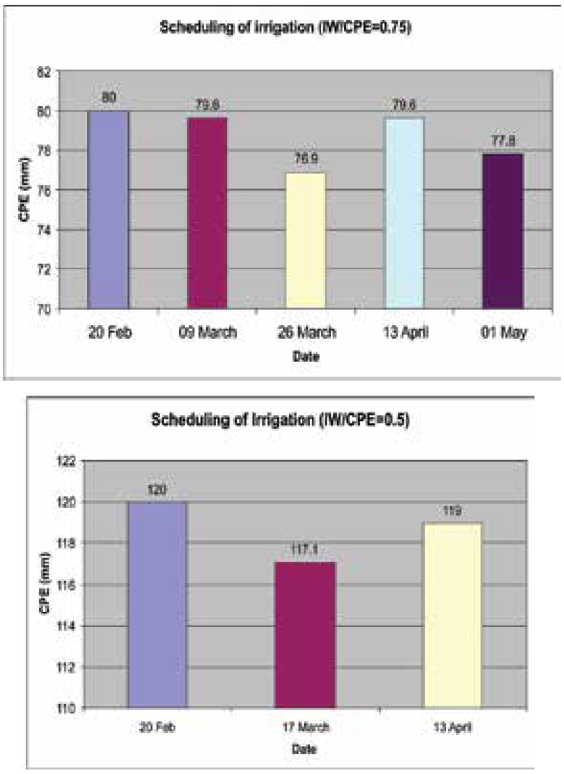


Fig 2. Scheduling of irrigation based on cumulative pan-evaporation

Soil sampling and analysis

Surface soil samples (0-30cm) were collected from each treatment 60 cm away from the base of the trunk before the monsoon season in each year. The collected samples were shade dried and determined for soil pH, EC, nitrogen (N), phosphorus (P), potassium (K^+) and calcium (Ca^{2+}) following standard procedures (Jackson, 1973).

Statistical analysis

The experiment was a factorial randomized block design. Significant difference for the factors and nutrients were determined by analysis of variance (ANOVA) and based on the least significance difference at 5% probability level.

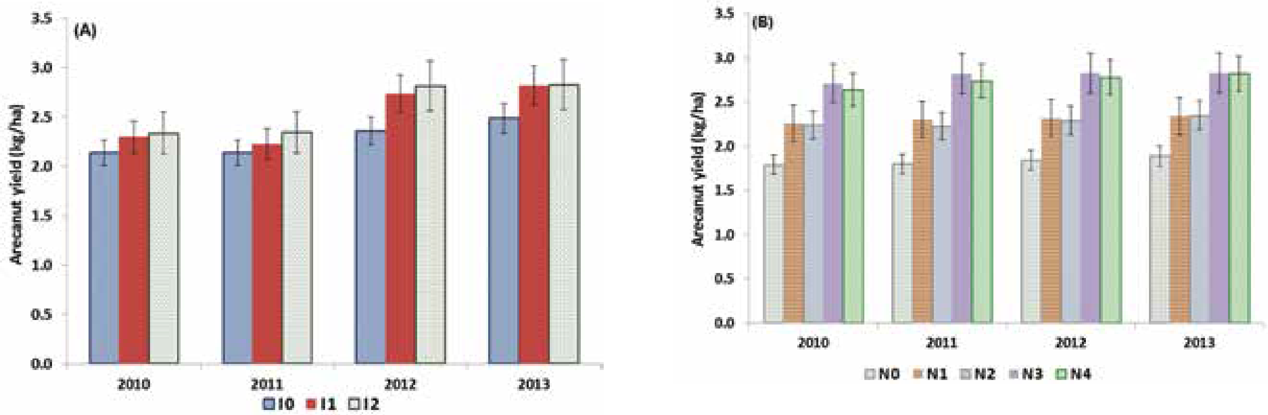
Results and Discussion

Growth

Different nutrient and irrigation levels certainly influences plant growth parameters but any significant difference is expected only after a period of time as the arecanut palm is a tall growing tree with a solid trunk. As a result the effect of irrigation, nutrient level and their interaction had no effect on the growth and yield attributes of arecanut in the initial two years of initiation of the experiment. But the effect was felt on some of the yield attributes with the progress of time. The results of the present study showed no significant difference either in height or number of scars in the trunk of arecanut one year after the initiation of experiment (Nov 2009 - Nov 2010). Similar was the case at the end of the experimental period in November 2013. But, the results indicated that after four years in November 2013 due to irrigation the incremental growth in girth of the tree has significantly increased in I_3 (0.107 m) followed by I_2 (0.093 m) when compared to control.

Yield attributes

The results showed that the response to applied nutrients and irrigation was not significant at initial years but increased over the years (Fig. 3). This is due to the fact that nutrients in the harvested yield of perennial crops are a fraction of the nutrients in the above and below ground biomass (Hartemink, 2005). This implies that nutrients immobilized in perennial crops are higher than nutrient removal and hence the response to applied nutrients will be visible only after few years as in the case of the present study. However, at the end of the experimental period (4 years after the treatment) the results indicated that irrigating the arecanut during the dry season had significant impact on chali weight and yield. While number of nuts per plant was significantly increased by nutrient application (Table 1) however, the interaction effect was non-significant. Among the nutrient treatments chali weight was more (13.93 g) in inorganic fertilizer treatment (N_1) followed by VC + inorganic fertilizer (N_3) at 100% RDF. Increasing nutrient level from 50% RDF to 100% had significant impact due to more availability of nutrients.



(Note: Yield at the beginning of the experiment in 2009 was 1.69 (±0.31) kg/tree)

Fig. 3 Changes in arecanut yield as affected by irrigation (A) and nutrient (B) treatment

Table 1. Effect of irrigation and nutrient treatments on arecanut yield parameters (2013)

Treatments	N_0	N_1	N_2	N_3	N_4	Mean
	Chali weight (g)					
I_0	10.83	11.62	11.15	11.53	10.59	11.15
I_1	11.17	13.93	11.44	13.87	12.02	12.49
I_2	11.05	13.24	11.94	13.14	11.95	12.26
Mean	11.02	12.93	11.51	12.85	11.52	11.97
SED	0.06	0.08	0.14	0.13		
CD (0.05)	I 0.18	N 0.16	I at N 0.30	N at I 0.27		
	No of nuts/tree					
I_0	154.27	203.00	191.67	217.10	203.87	193.98
I_1	161.03	197.33	195.43	203.33	192.20	189.87
I_2	172.10	215.90	196.80	214.77	196.00	199.11
Mean	162.47	205.41	194.63	211.73	197.36	194.32
SED	2.62	4.35	7.24	7.54		
CD (0.05)	NS	8.99	NS	NS		
	Yield (kg/tree)					
I_0	1.68	2.36	2.14	2.49	2.14	2.16
I_1	1.80	2.74	2.23	2.82	2.30	2.38
I_2	1.89	2.83	2.35	2.82	2.34	2.45
Mean	1.79	2.64	2.24	2.71	2.26	2.33
SED	0.02	0.05	0.08	0.08		
CD (0.05)	I 0.06	N 0.09	NS	NS		

Irrigating the palm tree during the dry month had significant impact on the yield with the highest yield observed in I_2 (2.45 kg/tree) which is 13% higher than the control followed by I_1. Irrigation has significant impact in increasing the yield mostly by reducing the fruit drop due to intensive heat during dry season. Similarly nutrient application had also shown significant impact with the highest yield recorded in inorganic + VC at 100% of RDF (N_3). The highest yield was observed in I_2N_3 (2.93 kg/tree) which was 72% higher than the control. The significant response was due to application of nutrient and water during December–March during which maximum numbers of inflorescences are produced (Ananda, 2004).

Unlike annual crops which require nutrient in available form within a short period of its growth cycle perennial crops like palm tree can meet their nutrient requirement from organic sources. This was reflected in the results of nutrient treatments which indicated no significant difference between inorganic and VC + inorganic treatments both at 100 % and 50 % RDF probably due to irrigation and quick release of nutrient from vermicompost. Another important aspect of nutrient management is without yield reduction, 50% of inorganic fertilizer demand can be met through organic manures. However, the interaction of irrigation and nutrient is non-significant.

Effect on soil properties

In Andaman islands (experimental condition), arecanut is predominantly cultivated in acidic soils which have inherent constraints like P fixation, rapid hydraulic conductivity, leaching of basic cations and low cation exchange capacity. The results indicated that there is a mixed response in soil fertility status due to nutrient treatment. The changes were not clear at the beginning which started showing some trend at the end of the four year experimental period. Any significant change in soil physical properties is expected only after the stabilization of added nutrients either through inorganic or organic manures. For these reasons the response to added manures and fertilizer at the beginning of the experiment was minimal.

The soil pH slightly improved in all the treatments particularly in organic+inorganic treatment however there was no noticeable change in EC. Among the nutrient treatment inorganic+organic at 100% RDF found to contain more available NPK. On an average, the soil available P content increased from 6.5 kg ha^{-1} to 11.4 kg ha^{-1} and highest amount was observed in 100% NPK as inorganic. There was no significant change in available N and K content however there was a perceptible improvement in P content. This was attributed to the nutrient uptake by arecanut which was estimated as 79 kg N, 28 kg P_2O_5 and 79 kg K_2O per hectare (Rethinam, 1990). Further, it was noticed that leaching of K^+ and Ca^{2+} due to heavy rainfall is a major production constraint in arecanut. The nutrient losses were more particularly from inorganic sources during monsoon period due to heavy and intensive rainfall, poor nutrient retention capacity due to low CEC. Consequently the nutrient use efficiency of arecanut is reported as very low: 10–15% for nitrogen, 25–30% for phosphorus and 20–25% for potassium. Thus, application of adequate amount of nutrients consistently through organic+inorganic source will support its growth and yield. Considering the soil and crop constraints, fertilizers and manures should be applied in synchrony with crop demand in smaller quantities during post-monsoon season (Bhat and Sujatha, 2009).

Conclusions

Arecanut production in India has now almost reached a level of self-sufficiency. Therefore, the present policy is not to adopt intensive cultivation and take up replanting of the aged and unproductive gardens. The results of the present investigation indicated that the adoption of summer irrigation and application of 100% RDF through organic+inorganic means increased the yield and was a good management technique to satisfy the nutrient demand of arecanut and replenish part of the nutrients leached due to heavy rain. Nutrient treatment had a positive impact on soil pH, N, P and available K content. Inter and mixed cropping in arecanut gardens is also advocated to augment the income from the existing arecanut garden in the islands with irrigation and nutrient application. The outcome of the study showed the effect of standardizing the irrigation and nutrient management strategies for enhancing the yield performance of arecanut plantations under island conditions.

Acknowledgements

The authors are thankful to the ICAR-Central Island Agricultural Research Institute, Port Blair for funding the research. We place on record our sincere gratitude to the Director, ICAR-CIARI for his support and encouragement. Our thanks also goes to project staff, technical and supporting staff of the Division of Natural Resource Management, ICAR- CIARI, Port Blair for their assistance rendered during the implementation of the project.

References

Ananda, K.S., (2004). Botany. In: Balasimha, D., Rajagopal, V. (Eds.), Arecanut. CPCRI, Kasaragod, pp. 7–46.

Bhat, K.S., & Leela, M., (1969). The effect of density of planting on the distribution of arecanut roots. Tropical Agric. 46, 55–61.

DES, (2015). Basic Statistics, 2015. Statistical Handbook on Andaman and Nicobar districts, Directorate of Economics and Statistics, Andaman and Nicobar Administration, Port Blair.

Hartemink, A.E., (2005). Nutrient stocks, nutrient cycling, and soil changes in cocoa ecosystems: a review. Adv. Agron. 86, 227–253.

Jackson, M.L., 1973. Soil chemical analysis, Prentice Hall Publication, New Delhi, p.184.

Ravi Bhat, R. & Sujatha, S. (2009). Soil fertility and nutrient uptake by arecanut (Areca catechu L.) as affected by level and frequency of fertigation in a laterite soil. Agricultural water management, 96: 445 – 456.

Rethinam, P., (1990). Potassium in plantation crops. In: Singh, M., Mishra, M.K. (Eds.), Potassium for Plantation Crops. Proceedings of Seminar, Bangalore, 6–8 November. Potash Research Institute of India, pp. 7–15.

Velmurugan, A., Swarnam, T.P., Ambast, S.K., Ravisankar, N. & Subrmani, T. (2014). Land degradation and its spatio-temporal changes induced by natural events in Andaman islands, Journal of the Andaman Science Association. 19(1):65-74.