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Impact of temperature and rainfall on production and productivity of coconut

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ABSTRACT

An experiment was conducted to assess the impact of Integrated Nutrient Management technology on the productivity of coconut based cropping system. The coefficient of rainfall of 0.758 indicates a strong positive relationship between the annual mean rainfall and the nut yield of coconut. The regression analysis revealed that the rainfall pattern over the experimental years accounts 57.5 per cent of variability in coconut yield. The study indicated that rainfall shares the larger portion of the coconut yield variation than temperature. Economic assessment of the coconut based cropping system revealed that the highest net returns of Rs. 334064/ha was recorded in T_1 (75% of recommended NPK + 25% of N through organic recycling with vermicompost) followed by application of 50% of recommended NPK + 50% through organic (T_2) and fully organic treatment (T_3). The monocrop of coconut recorded the lowest net returns (Rs.107120/ha). The system productivity with respect to nut equivalent yield in coconut based cropping system was 28422 nuts/ha, whereas lower productivity of 14005 nuts/ha was recorded in monocrop.

Key words: *Cocos nucifera*, Cropping system, nut yield, Climate and Economics

INTRODUCTION

Coconut (*Cocos nucifera* L.) is an important multipurpose perennial crop of the tropics which has a significant bearing on the livelihood security of small and marginal farmers of the country. In India, coconut is cultivated in 18 states and 3 Union Territories. Almost 90% of total area under coconut cultivation and 93% of total production falls within four southern states *viz*., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. During2018-19, India produced 21384 million nuts from an area of 2.17 million ha, with a productivity of 9815 nuts per hectare (CDB, 2). Coconut is usually planted with a spacing of 7.5 m x 7.5 m offering ample scope for intercropping with suitable perennial, biennial and seasonal crops. A well designed high density multistoreyed crop model suited to a given agro-climatic situation generates greater biomass output, yields more economic produce, generates steady and higher total income, additional employment opportunities for family labours and meets diversified needs of the farmers (Maheswarappa *et al*., 7). Chowdappa and Singh (3) recorded that multi species cropping of coconut with pepper, banana, nutmeg, pineapple, ginger, turmeric and elephant foot yam generated a net income of Rs 3.7 lakhs per ha, which is 150% higher than that of coconut monocrop (Rs 1.4 lakhs). Use of both organic and inorganic nutrient sources together confirms the significance of conjunctive use of chemical and organic fertilizers than the individual one which might be due to the solubilization effect of plant nutrients by the addition of FYM and vermicompost leading to increased uptake of NPK (Naveen Kumar *et al*., 8). Coconut palms have high nutrient requirements that have to be met throughout their long growing periods. Non-adoption of regular nutrient management practices to compensate nutrient uptake by the coconut tree has resulted in deterioration of soil fertility. Coconut is a crop which removes large quantity of nutrients from the soil compared to other perennial crops. Enrichment of nutrient pool occurs from additions from the trees, crops, livestock and farm waste. Trees like cocoa raised as mixed crop in coconut contribute to the nutrient pool by way of litter fall. The residue from inter-crop components (banana pseudo stem, non edible vegetative portion of tuber and other herbaceous crops can be recycled as mulches (Jnanadevan, 4). About 6-8 tonnes of leaf wastes is produced annually from per hectare coconut garden. Use of organic manures, apart from improving physical and biological properties of soil, helps in improving the use of efficiency of chemical fertilisers. The nut yield and nutrient content under coconut based cropping systems increased over the initial status indicating that addition and recycling of organic matter added considerable amount of nutrients into the system (Maheswarappa *et al*., 7). The amount and temporal distribution of rainfall is

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generally the single most important determinant of interannual fluctuations in national crop production levels (Bewket, 1). According to VonBraun, (14) for instance, a 10% decrease in seasonal rainfall from the long-term average generally translates into a 4.4% decrease in the country's food production. Hence, the present investigation was conducted to assess the impact of climate variability on productivity of coconut based cropping system under Integrated Nutrient Management system.

MATERIALS AND METHODS

Field experiment was conducted for five years from 2013 to 2018 under All India Co-ordinated Research Project on Palms at Coconut Research Station, TNAU, Aliyarnagar to find out the impact of Integrated Nutrient Management technology on the productivity of coconut. The research station is situated at 10.49° N latitude and 77° E longitude with an altitude of 20 m above the mean sea level. The soil is sandy loam in texture, non-calcareous, non-saline and neutral in pH. The station received an average annual rainfall of 818.52 mm during 2013-2018 and 50 percent of rainfall was received from North East Monsoon. The mean maximum air temperature was higher in the month of April (32.88 °C) and mean minimum temperature (21.48°C) was in January month. Banana (Nendran), suckers of pineapple (Kew) and cocoa (CCRP) were planted in the coconut based cropping system. In one hectare area of 26 years old coconut garden (175 numbers), intercrops *viz*., 350 numbers of cocoa, 700 numbers of banana and 5000 numbers of pineapple were planted. The experiment consisted of four treatments *viz*.,: T_1: 75 % of RDF + organic recycling with vermicompost, T_2: 50 % of RDF + organic recycling with vermicompost, vermiwash application, Biofertilizer application, green manuring and composted coir pith, T_3: Fully organic (organic recycling with vermicompost, vermiwash application, Biofertilizer application, Green manuring, green leaf manuring (Glyricidia loppings) and composted coir pith and T_4: Coconut - monocrop (control). Total nutrient composition of vermicompost assessed employing standard procedures revealed that it contained 1 % nitrogen, 0.25 % phosphorus, 0.48 % potassium, 18.2 % organic carbon and C:N ratio of 18:1. As the experiment was laid out in a block of 0.45 ha area for each treatment, the weather parameters during the year influenced the productivity of the system. Hence, in the analysis, year effect was taken as fixed effect in the ANOVA table, and treatment effect as error. The statistical analysis was performed using statistical analysis system 9.3 computer software. DMRT procedure was used at P=0.05 level to determine the significance among the treatments. Five years data of maximum, minimum temperature and rainfall for the period 2013-2014 to 2017-18 have been collected form the Meteorological Observatory of Coconut Research Station, Aliyarnagar. Statistical analysis like mean, Standard Deviation, trendline analysis, coefficient of variation and regression were performed for measuring the relationship between climate variability and nut yield. The gross returns from the economic produce of coconut and intercrops were worked out by considering the market price prevailed during 2013-2018. The cost of production was calculated considering labour charges, cost of manures, fertilizers, seeds and other inputs used for raising the crops. The net returns was computed as the difference between the gross returns and the cost of production. The coconut equivalent yield (CEY) of intercrops, system productivity and economics were worked out for different crops based on prevailing market price of input and output (Thiruvarassan *et al*., 13). Irrigation was provided by sprinkler system at IW/CPE ratio of 1.0.

$$\text{Nut equivalent yield (NEY)} = \frac{\text{Yield of intercrop (kg ha}^{-1}) \times \text{Market price (Rs. kg}^{-1})}{\text{Market price of a nut (Rs.)}}$$

$$\text{Total System Productivity (Nuts ha}^{-1}) = \text{Yield of coconut (nuts ha}^{-1}) + \frac{\text{Yield of intercrop (kg ha}^{-1}) \times \text{Market price (Rs. kg}^{-1})}{\text{Market price of a nut (Rs.)}}$$

RESULTS AND DISCUSSION

Temperature and rainfall are important weather factors that bears great influence on the growth and productivity of the palm. The optimum climatic conditions for growth and yield of coconut production are, a well-distributed annual rainfall of 1000 mm and mean annual temperature of 27 °C with diurnal variation of 5 °C (less than 20°C and more than 34°C is not suitable). Among different abiotic stresses affecting coconut, drought and high temperature are considered as major stress factors with high negative impact on nut yield (Samarasinghe *et al*., 10).

Figure 1 reveals an ascending trend line for temperature for 2013-14 to 2017-18. For five years, the highest mean maximum temperature of 33.44°C occurred in 2016-17 and the lowest maximum temperature of 32.06 recorded in 2014-15 with the mean maximum temperature of 26.3°C and the standard deviation of 0.57 °C.

Figure 2 reveals a descending trend line for minimum temperature for the period 2013-14 to 2017-18. During 2015-16, the lowest mean minimum temperature (19.63°C) was observed, whereas the highest mean minimum temperature (23.00°C) was observed in 2013-14 with the mean minimum temperature of 21.48°C and standard deviation of 1.09 °C.

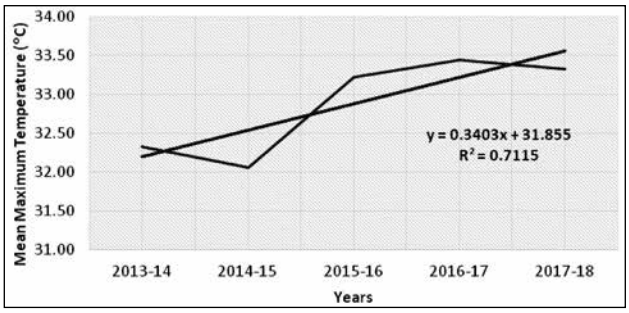

Fig. 1. Maximum Temperature trendline graph (2013-14 to 2017-18)

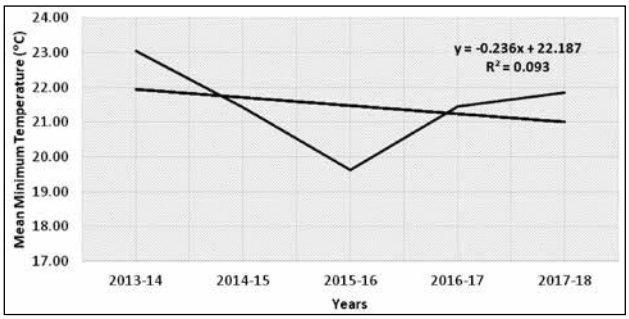

Fig. 2. Minimum Temperature trendline graph (2013-14 to 2017-18)

Figure 3 portrays trend of annual rainfall from 2013-14 to 2017-18. Total annual rainfall also varied from 1139.50 mm (2014-15) to 504.70 mm (2016-17) during the experimental period, with the mean rainfall of 818.52 mm and standard deviation of 224.12 mm.

Correlation and regression was established among rainfall, temperature and crop yield. Maximum temperature and coconut nut yield linkages provide correlation coefficient of -0.75 representing strong negative relationship. Minimum temperature and coconut nut yield correlation gives coefficient of 0.641 denoting strong positive relationship. The regression

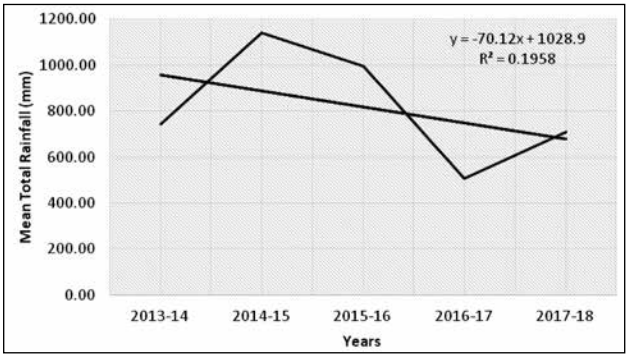

Fig. 3. Total annual rainfall trendline graph (2013-14 to 2017-18)

results show R value of 0.641 and R square of 0.411 meaning temperature contributes 41.1% of yield variation in coconut [Y = 259.99x + 11394 * Temperature]. Rainfall and coconut yield show correlation coefficient of 0.758 indicating as strong positive relationship between the two variables. The regression analysis indicates R value of 0.682 and R square of 0.575 implying that rainfall accounts for 57.5% of the variability in coconut yield while the rest 42.5% variation is explained by other factors [Y = 1.3866x + 16223]

Maximum temperature and low rainfall during 2014-15 reduced nut yield (16706 nuts/ha) in coconut. Incremental units of maximum temperature followed by moisture stress showed gradual decrease in nut yield production (Ramsinghe *et al.* 9). The rainfall pattern over the experimental period accounted for 57.5% of variability in coconut yield. The study concludes that rainfall explains the larger portion of the coconut yield variation than temperature.

Pooled mean over five years showed significant variation in nut yield (Table 1). The treatment comprising of 75% of recommended dose of NPK + 25% of N through organic recycling with vermicompost (T_1) recorded significantly higher nut yield (18082 nuts/ha),

Table 1. Effect of Integrated Nutrient Management Practices on yield and economics (Pooled data 2013 - 2018)

Treatment	Coconut (Nuts/ ha)	Yield of Intercrops			Cost of Cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)
		Cocoa beans (kg/ha)	Banana (kg/ha)	Pineapple (kg/ha)			
T_1: (75 % of RDF + 25 % organic) (CS)	18082	282	18460	2520	211994	546058	334064
T_2: (50 % of RDF + 50 % organic) (CS)	16775	277	18278	2320	196739	506264	311015
T_3: (100 % organic) (CS)	16078	270	18070	2276	189814	499138	309323
T_4 : (Monocrop) (RDF)	14005	-	-	-	123340	230460	107120
SEd	856.50	5.64	167.35	67.27	4975.86	15548.91	11745.96
CD 0.05	1825.59	11.70	350.07	149.92	10841.58	33878.47	25592.49

followed by application of 50% of recommended NPK + 50% through organics (T_2) and it was on par with fully organic treatment (T_3) treatments. Coconut based cropping system recorded the highest mean nut yield of 16978 nuts/ha/year and it was 17.5 per cent higher compared to monocrop of coconut. Similar results of higher nut yield with integrated use of manures and fertilizers was earlier reported by Temgire (12) and Talashilkar *et al*. (11).

Yield obtained from different intercrops (Table. 2) indicated that application of 75% of recommended dose of NPK + 25% of N through organic recycling with vermicompost (T_1) recorded higher yield in intercrops *viz.,* cocoa (282 Kg ha^{-1}), banana (18460 Kg ha^{-1}) and pineapple (2520 Kg ha^{-1}). In cocoa and pineapple, application of 50% of recommended NPK + 50% through organics (T_2) was on par with fully organic treatment (T_3) treatments. Significantly lowest banana yield was recorded in fully organic treatment (T_3) treatments. Naveen Kumar *et al.* (8) also reported that application of organic manures combined with recommended dose of inorganic fertilizers showed superior performance in coconut based vegetable intercropping system.

Pooled economic analysis indicated that, total cost of production was higher in INM (T_1 and T_2) treatments compared to fully organic treatment (T_3) treatment. On farm utilization of organic and green manures reduced the cost of cultivation in T_3 treatment. Application of 75% of recommended NPK through fertilizers coupled with 25% NPK through organic recycling with vermicompost recorded higher gross and net income (Rs.546058/ha and Rs.334064/ ha) followed by 50% of recommended NPK + 50% through organic (T_2) and fully organic treatment (T_3) treatments. Lowest gross and net income (Rs.230460/ha and Rs.107120/ha) was recorded in coconut monocrop (T_4) treatment. Additional income through intercropping system resulted in higher gross and net income compared to monocrop and the are in accordance with the Maheswarappa *et al*. (7) who opined that, significantly higher net returns of Rs. 16,673/- per ha was obtained under 25 % vermicompost (VC) + 75 % NPK followed by 50 % VC + 50 % NPK (Rs. 16,144/-per ha) compared to other substitution level of vermicompost with inorganic fertilizers.

Nut equivalent yield (29815 nuts/ha) was maximum in coconut based cropping system under T_1 treatment (75% of recommended NPK through fertilizer coupled with 25% NPK through organic recycling with vermicompost). The system productivity with respect to nut equivalent yield in coconut based cropping system was 28422 nuts/ha, whereas lower productivity of 14005 nuts/ha was recordedin monocrop. Enhanced system productivity in coconut based cropping system with INM has been attributed to better growth of the crops which reflected on the yield of crops in the system.

Integrated application of 75% of recommended NPK through fertilizers coupled with 25% NPK through organic recycling with vermicompost was found to be productive and profitable for coconut based cropping system than other INM practices. The coefficient of maximum temperature indicated a negative relationship between the annual maximum temperature and the nut yield of coconut. The coefficient of rainfall showed a strong positive relationship between the annual mean rainfall and the nut yield of coconut. The regression analysis revealed that the rainfall pattern over the experimental years accounted 57.5 per cent of variability in nut yield of coconut. The study concludes that rainfall explains the larger portion of the coconut yield variation than temperature. Intercropping system under coconut is more profitable than monocropping which promises to the farmers with additional productivity of crops, besides generating employment opportunities.

Table 2. Effect of Integrated nutrient management Practices on total system productivity of coconut based cropping system (Pooled data 2013 – 2018)

Treatments	Coconut	Coconut equivalent yield of intercrops (No. of nuts/ha)			Total CEY in CBCS (No. of nuts/ha/yr.)	Total System Productivity (Nuts ha^{-1})
	No. of nuts/ha	Cocoa beans (kg/ha)	Banana (kg/ha)	Pineapple (kg/ha)		
T_1: (75 % of RDF + 25 % organic) (CS)	18082	2808	7700	1225	11733	29815
T_2: (50 % of RDF + 50 % organic) (CS)	16775	2682	7595	1150	11427	28202
T_3: (100 % organic) (CS)	16078	2520	7500	1150	11170	27248
T_4 : (Monocrop) (RDF)	14005	-	-	-	-	14005
SEd	856.50	25.59	190.68	68.77	79.51	994.76
CD 0.05	1825.59	55.76	NS	NS	173.23	2034.77

AUTHORS' CONTRIBUTION

Conceptualization of research (S.R,H.P.M); Designing of the experiments (S.R,H.P.M); Contribution of experimental materials (S.R,H.P.M); Execution of field/lab experiments and data collection (S.R,C.S); Analysis of data and interpretation (S.R,C.S); Preparation of the manuscript (S.R,H.P.M,).

DECLARATION

The authors declare no conflict of interest

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