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Integrated nutrient management for root (wilt) diseased coconut (*Cocos nucifera*) palms

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ABSTRACT

An experiment was conducted during 2004–08 at the Regional Station of Central Plantation Crops Research Institute, Kayamkulam, Kerala on root (wilt) disease affected palms of West Coast Tall variety. The entire field was divided into 2 parts and applied with full dose of fertilizers (500:300:1000 g NPK/palm/year) and with 50 % fertilizers + organic manures as vermicompost and incorporation of local variety of green manure cowpea (*Vigna unguiculata* L. Walp.) raised in the palm basin. All the coconut palms were indexed for the disease during December–May (2005 to 2008). There was not much variation in the nutrient content in leaves of palms under various treatments except P and K which are slightly high in palms supplied with both fertilizers and organic manures. Presence of higher population of function-specific micro-organisms was found in the rhizosphere soils of disease early palms than in the other categories. Comparison of treatment after accounting for variations in disease index separately for various years was found non-significant. Though the post-treatment yield in both the treatments was non-significant, there was an increase of 17 % in yield in palms receiving both fertilizers and organic manures compared to 7 % increase in palms receiving only fertilizers. Negative correlation existed between yield and disease index in 2005, 2006 and 2007 and was respectively –0.223, –0.268 and –0.284 ($P<0.05$). In general, copra content was higher in palms applied with both fertilizers and organic manures and the overall increase was 4.57 % over the other treatment. The results indicated that through an integrated nutritional management, soil health as well as health of palms could be improved over the years or maintained without further deterioration.

Key words: Coconut, Integrated nutrient management, Productivity, Root (wilt) disease

Among the many factors contributing to the lower productivity of coconut in Kerala, root (wilt), a debilitative disease is a major constraint. The magnitude of this disease is high in the southern parts of Kerala, the highest being in Alappuzha (48.03 %), followed by Pathanamthitta (37.8 %), Kottayam (36.5%), and Ernakulam (33.0 %) districts (GoK 1996). The disease is also spreading to adjoining coconut gardens in Tamil Nadu and Karnataka. As this disease is caused by *Phytoplasma*, there is no effective and economic therapeutic control measure available. Often the farmers neglect the crop and end up in considerable reduction in yield of palms. Adoption of integrated nutrient management practices offer scope for maintaining health of soil as well as of disease-affected palms. The present study aims at evaluating the impact of integrated nutrient management practice on productivity of root (wilt) disease affected coconut palms.

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MATERIALS AND METHODS

The experiment was undertaken at the Regional Station of Central Plantation Crops Research Institute, Kayamkulam, Kerala, which is situated at 9° 8' N latitude and 76° 3' E longitude at an elevation of 3.05 m above mean sea level. The experimental area received an average annual rainfall of 2 350 mm, with the mean maximum temperature ranging between 30.0 and 33.5°C and the mean minimum temperature of 20.3 and 24.4° C. The soil was sandy loam with total N 340 ppm, available P 40 ppm, available K 90 ppm, organic carbon 0.25% and acidic in nature (*p*H 5.5). The study was conducted with West Coast Tall variety of coconut palms planted during 1965. High density multi-species cropping model with different crops was initiated in an area of 1 ha of coconut garden affected by root (wilt) disease during 1993–94. The present study was initiated from 2004 and continued till 2008.

The entire area was divided into 2 parts and palms in one half of the plot were applied with 100 % recommended dose of fertilizers (500:300:1000 g NPK/palm/year) and the remaining with 50 % fertilizers + organic manures in the

form of vermicompost and incorporation of *in situ* raised green manure cowpea (*Vigna unguiculata* L. Walp.). *In situ* vermicomposting of entire biomass was done using *Eudrilus* sp.of earthworm and applied to palms @ 25 kg/palm/year. The nutrient content of compost produced during each year was analyzed and the average content was found to be 1.413 % N, 0.112 % P and 0.304 % K. Green manure cowpea was raised in palm basins and incorporated. Fertilizers like urea, mussoriephos and muriate of potash were used to meet the requirement of N, P and K and they were applied in 2 split doses, 1/3 during May–June and 2/3 during August - September. Perfo irrigation was provided and water to a depth of 20 mm was applied during summer months @IW/CPE of 1.0.

To evaluate the effect of integrated nutrient management on root (wilt) disease, all the palms were indexed during December–May (2005 to 2008). The procedure involves assigning weighted average grade points for the different symptoms for coconut leaves. The disease index (DI) was calculated using the formula given by George and Radha (1973) as

$$DI = \frac{\text{sum (F+Y=N)} \times 10}{L}$$

where F, Y and N are the grade points assigned to flaccidity (0–5), necrosis (0–3) and yellowing(0–2) and L is the number of leaves observed. Palms with disease index 0–20 are classified as disease early, 21–50 are disease middle and >51 are disease advanced. The index of palms in the disease middle (DM) category (DI: 21–50) was further divided into DM1 (21–35) and DM2 (36–50) to analyze the impact of nutritional management in improving the health of coconut palms. No coconut palm was found to be in the disease advanced category.

Soil samples (at 1.0 m away from the bole of palm at 2 depths: 0–25 and 25–50 cm) and leaf samples (from 14th leaf) were analyzed for nutrient contents using standard procedures. Soil samples were also collected at a depth of 0–25 cm and analyzed for general (bacteria, fungi and Actinomycetes) and function-specific microbial community (free-living N_2-fixers and phosphate solubilizers) through serial dilution and pour plate method by employing standard procedures.

Individual palm-wise yield data was collected from January 2004 to December 2007 from each harvest (total of six harvests/year at an interval of 60 days) and the average worked out. Copra content of all palms from different disease index categories was recorded from harvests made during Dec.2005; Sept. and Nov.2006; Jan., Feb., April, July and Sept.2007 by taking representative samples of nuts. Number of nuts obtained for 2003 and 2004 was taken as the pre-treatment yield and that of 2005 to 2007 as the post-treatment yield. Copra content/nut recorded during different seasons in 2006 and 2007 was averaged and multiplied with number of nuts to arrive at the copra yield. To test the treatment difference, ANOVA as well as ANOCOVA (with pre-treatment yield as covariate) were employed and prior to which assumptions were tested by following data exploring techniques. Yield data (number of nuts/palm) was subjected to square root transformation (Jacob Mathew 2001). The difference in yield between pre-treatment and post-treatment was tested by means of paired t-test. The changes in copra content over seasons were analyzed using the ANOVA procedure for repeated measurements. The 'disease-middle' category (20<DI<50) was further grouped into 2 as DM 1(20<DI<35) and DM2 (35<DI<50) and yield comparisons were performed among all the disease categories. Correlation analysis was attempted to study the relationship between yield and disease index at different years of the experiment. SPSS v.15.0 was used for the aforesaid statistical analyses.

RESULTS AND DISCUSSION

Soil nutrient status

In general, an increase was noticed in available P, Mg and Ca under the fertilizer +organic manures applied plots in different disease categories than in plots applied with fertilizers alone. The reverse was the trend in most of the cases for total N and available K. Increase in available P with integrated nutrient management might have contributed to the P-solubilizing capacity of organic manure. *In situ* green manuring in basins also resulted in an increase in the level of major nutrients in soil of coconut basin. Sahoo *et al.* (2004) found that application of farmyard manure and fertilizers improved the nutrient status of coconut soils. Similar results are also available from the studies of Talashilkar *et al*. (2008) who reported an increase in the contents of available P and K in soil with the application of 50% N through vermicompost and 50% recommended dose of fertilizers in Maharashtra. They also found vermicompost to be a promising source for improving leaf nutrient content.

Leaf nutrient status

Leaf nutrient status did not vary much except that P and K contents are slightly high in palms supplied with both fertilizers and organic manures. However, there is gradual increase in the nutrient content in leaves of coconut palms as the disease index increases from disease early to disease middle 1 and 2. Nagwekar *et al.* (2008) noticed that application of vermicompost recorded the highest N and P in the leaves of palms, whereas the highest K content was observed in leaves of palms applied with both fertilizers and vermicompost.

Microbial population

In general, the population level of general and function-specific microbial community was higher in the rhizosphere

Table 1 Population of general and function-specific microbial communities

Treatment	Disease category	Microbial community				
		Bacteria ($\times10^6$)	Fungi ($\times10^4$)	Actinomycetes ($\times10^5$)	N_2-fixers ($\times10^6$)	P-solubilizers ($\times10^6$)
50% fertilizers+ organic manure	Disease early	40.0	4.0	1.00	52.7	36.7
	Disease middle	46.0	8.7	0.33	33.3	33.3
Fertilizers alone	Disease early	26.0	2.0	1.67	45.7	35.3
	Disease middle	37.0	5.0	0.84	34.0	30.7

of palms applied with both fertilizers and organic manures except in the case of Actinomycetes (Table 1). The population level of bacteria and fungi was higher in the rhizosphere of palms in the disease middle category, whereas that of Actinomycetes and function-specific microbes was high in the disease early category. Presence of high bacterial count in the rhizosphere of root (wilt) disease, affected palm and high count of Actinomycetes and N_2- fixers in rhizosphere of palms showing field resistance to the disease has been reported by Muraligopal *et al.* (2005). Presence of higher number of function-specific microbes in the rhizosphere of disease early palms could be maintaining soil health and providing better nutrient availability to palms, thereby helping them to give better yield.

Yield of coconut

The results of ANOVA indicated that there was no significant difference between the treatments with regard to the pre-treatment yield and post-treatment yield. The effect of treatments was also compared after accounting for the pre-treatment yield differences (ANOCOVA), but it was also found to be non- significant. Treatment comparison after accounting for variations in disease index separately for 2005, 2006 and 2007 was also observed to be non-significant. The result of data exploring technique suggested that the data complies with the assumptions of ANOVA. The mean yield of palms under different disease index categories during the pre and post-treatment are given in Fig 1. Though there was a slight improvement in yield in the post-treatment period in both the treatments, it was found to be non-significant according to the paired t-test. However, there was an increase of 17 % in yield in palms receiving both fertilizers and organic manures compared to 7 % increase in palms receiving only fertilizers. Further, the correlation analysis indicated that negative correlation existed between yield (2006–2007) and disease index in 2005, 2006 and 2007 and was respectively, –0.223, –0.268 and –0.284 ($P < 0.05$). The general tendency in palms affected by the root (wilt) disease is that yield gradually goes down either due to pre-mature button shedding or due to decrease in production of female flowers or due to less bunch and reduction in percentage of nut set. Thus, though there was a slight reduction in yield during the post-treatment period, it could be inferred that in spite of the disease in varying intensities, the yield of coconut palms could be maintained at satisfactory level by appropriate nutrient management practices. Even though the yield has a negative correlation with the intensity of disease, it may be possible to increase the yield, since the percentage of variation in yield due to the intensity of disease was evidently less. Significant negative correlation observed may be due to the fact that some of the palms in the advanced stage (DM 2) of the disease have very low yield; probably these palms might have contracted the disease much earlier. When the palms get the disease at a later stage either after the commencement of flowering or after yield stabilization, they may produce satisfactory yield under proper management, in spite of the disease. Maheswarappa and Anithakumari (2005) reported the mean nut yield (1997-2002) of root (wilt) disease affected palms in different index categories as 61, 53 and 30 for disease early, disease middle and disease advanced, respectively. The increase in nut yield of palms supplied with both fertilizers and organic manures might be due to the better nutrition the palms could receive under that treatment.

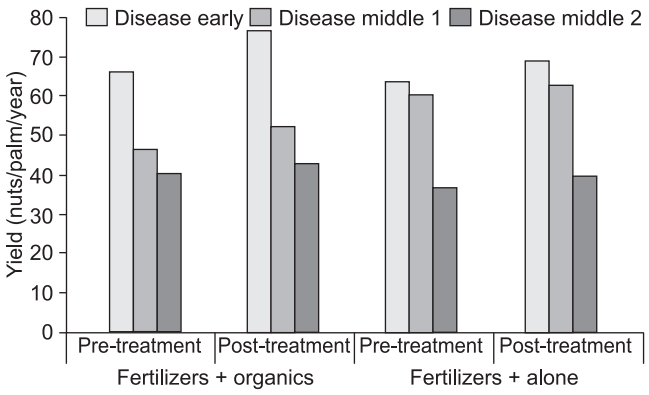

Fig 1 Yield of coconut palms under different disease index

Copra content

The data on copra content of palms under different disease categories are given in Table 2. In general, the copra content of coconut was higher in palms applied with both fertilizers and organic manures except in the case of disease middle 2 category. The overall percentage increase in copra content of palms applied with fertilizers and organic manures over

Table 2 Average copra content of coconut (g/nut) as influenced by integrated nutrient management practices (mean of 8 observations from December 2005 to September 2007)

Disease Index	50% fertilizers + organic manure	Fertilizers alone
Disease early	179	160
Disease middle 1	178	169
Disease middle 2	168	171
Mean	175	167
CD(*P*=0.05)	Not significant	

fertilizers alone applied palms was 4.57. Maheswarappa and Anithakumari (2005) noticed copra content of root (wilt) disease affected palms of different categories to be 182, 182 and 181 g /nut for disease early, disease middle and disease advanced , respectively. The statistical analysis indicated that the copra content was not significantly different between treatments, among the disease index categories as well as interaction between these factors. The copra content observed at 8 time intervals during the experimental period when subjected to ANOVA of repeated measurements indicated significant interaction of treatments with time. It was noticed that in the later half of 2007, the copra/nut was found to be more in the treatment receiving both fertilizers and organic manure (Fig 2), but the difference is significant only in September 2007. Further, it was observed that in the post-treatment period, the copra content in the fertilizers alone treatment was considerably reduced to 153 g during 2007 from the initial value of 175 g recorded during 2005, whereas, it was slightly increased to 175 g from initial value of 170 g/ nut in case of application of both fertilizers and organic manure.

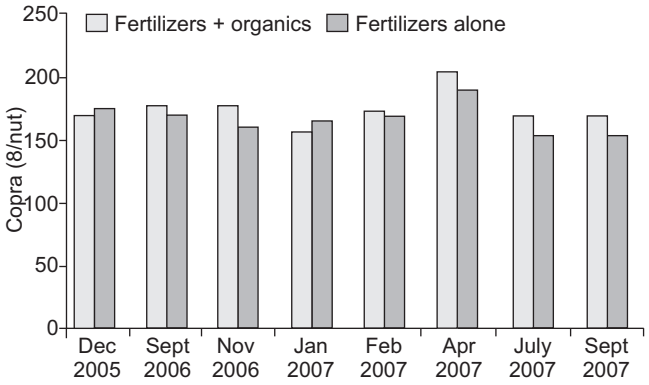

Fig 2 Copra content of root (wilt) disease affected palms during different harvests

Root (wilt) disease index

The changes in disease index during December 2005–May 2008 was compared between the treatments by employing the procedures for repeated measurements. While the values of index varied significantly over time, there was no significant interaction between treatment and time (Fig 3). As the

Table 3 Yield (nuts/palm/year) and number of palms under different disease index categories during 2005 and 2007

Disease categories and index during 2007	Disease categories and index during 2005			Average
	Disease early (DE) DI<20	Disease middle 1 (DM-1) 20<DI<35	Disease middle 2 (DM-2) 35<DI<50	
Disease early	65.4	64.8		65.0
	(13)	(18)	(0)	(31)
Disease middle 1		53.9	41.9	52.8
	(0)	(41)	(4)	(45)
Average	65.4	57.2	41.9	57.8
	(13)	(59)	(4)	(76)

Figures in parentheses indicate number of palms

Mauchly's Test of sphericity (i e the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix) is significant, the inference from the conventional test of significance in which time is considered as a factor within the treatment was not taken into account though it was significant. It was noticed that some of the palms have shown reduction in disease index over the years. For instance there were 59 palms in the disease middle 1 category, of which 18 were shifted to disease early in the course of the experiment (Table 3). Similarly, all the 4 palms in disease middle-2 during 2005 have become disease middle 1 by 2007. None of the palms in the early and middle categories has shown any progression in the disease index. Average yield of palms (post-treatment) against the cross classification of disease categories (based on disease index in 2005 and 2007) is also shown in Table 3. It may be seen that there is gradual reduction in yield of palms as the disease index increases, which is also indicated by the correlation analysis. It is found that there is a significant difference in nut yield between disease early (65.0) and disease middle 1 (52.8) palms as revealed by the ANOCOVA with pre-treatment yield as the concomitant variable.

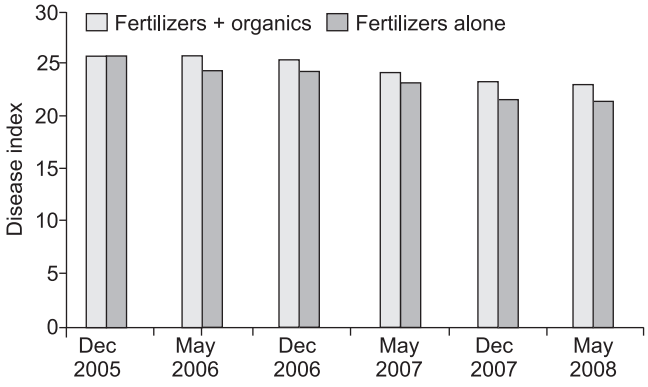

Fig 3 Root (wilt) disease index of coconut palms during different periods

Table 4 Percentage of coconut palms under different root (wilt) disease intensity categories

Treatment	Disease index category	Year			
		2005	2006	2007	2008
Fertilizers+ organic manure	Disease early	20.5	20.5	29.5	36.4
	Disease middle 1	56.8	53.8	61.4	54.5
	Disease middle 2	22.8	22.8	9.1	9.1
Fertilizers alone	Disease early	12.1	15.2	42.4	51.5
	Disease middle 1	78.8	75.8	54.5	48.5
	Disease middle 2	9.1	9.1	3.0	0

A further analysis of percentage of coconut palms falling under different root (wilt) disease intensity categories during each year (2005 and 2008) was done and the results are presented in Table 4. The data presented indicate that through an integrated nutritional management, the health of palms could be improved over the years or maintained without further deterioration, thereby bringing more palms from the disease middle category (2) to (1) or from category(1) to disease early category. This will in turn help palms to give higher yield in the subsequent years as coconut palms take 3 ½ to 4 years from initiation of inflorescence to harvest of nuts.

Reduction in disease index was observed mainly due to the improvement in general health of palms on account of reduction in scoring for yellowing and necrosis, together which contribute 50% of the grade for indexing. Maheswarappa *et al.* (2005) obtained reduction in root (wilt) disease index in coconut palms over the years due to management practices. Anithakumari (2007) also noticed reduction in disease intensity of root (wilt) disease-affected coconut palms in the disease middle and improvement in the disease early categories in farmers' fields through crop diversification and recycling of organic residues available in homestead farms.

The results of the study on the impact of integrated nutrient management practice on productivity of root (wilt) disease-affected coconut palm by applying fertilizers either alone or in combination with organic manures indicated that though there was a slight improvement in yield in the post-treatment period in both the treatments, it was found to be non-significant according to the paired t-test. However, there was an increase of 17 % in yield in palms receiving both fertilizers and organic manures compared to 7 % increase in palms receiving fertilizers alone. Copra content was also found to be not significantly different between treatments, among the disease index categories as well as interaction. It could be observed that through an integrated nutritional management, the health of palms could be improved over the years or maintained without further deterioration, thereby bringing more palms from the disease middle category (2) to (1) or from category (1) to disease early category and sustain the nut yield.

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