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Soil characteristics and plant nutrient status in the root (wilt) affected areas of humid tropics

Jeena Mathew[1], V. Krishnakumar[2], Merin Babu A.[3], Joseph Rajkumar[4], Anitha Kumari, P.[5] and C.G. Narayanan Namboothiri[6]

Central Plantation Crops Research Institute (Regional Station, Kayamkulam), India

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ABSTRACT

Field survey was conducted in the emerging areas of root (wilt) disease of coconut in Kerala and Tamulnadu during the period 2012-2014. The areas selected in Kerala were Kozhinjampara and Edava whereas in Tamil Nadu the areas were Cumbum and Colachel. In each sites, two gardens were selected, one with apparently healthy palms and the other with different intensities of root (wilt) disease. Soil and leaf samples were collected from the selected palms for the estimation of soil properties as well as on the leaf nutrient status. Site specific variation was prevalent in each site with respect to soil properties. With respect to Cumbum and Colachel, imbalance in base saturation and heavy texture of the soil was observed as the soil constraint. Deficiency of potassium (45.78 ppm) and magnesium (24.28 ppm) was observed in the region with diseased palms in Edava. Adoption of suitable management practices considering the inherent soil constraints may enhance the productivity of palms in the emerging areas of root (wilt) disease of coconut.

Key words : *Soil characteristics, root (wilt), humid tropics*

Introduction

Root (wilt) is a non lethal debilitating disease of coconut with symptoms such as flaccidity, yellowing and necrosis. Several decades of research have ruled out organisms like fungi, bacteria, virus as the possible causative agents. Later electron microscopic studies have confirmed Phytoplasma as the causative agent transmitted by insect vectors such as *Stephanitis typica* and *Proutista moesta*. With the reports of variation in symptoms from the typical root (wilt) disease symptoms and that of wide spread yellowing in newer areas of Kerala and Tamil Nadu, the present study was undertaken to understand the soil characters in the emerging areas of root (wilt) disease with varying symptom expression as well as the plant nutrient dynamics.

Methodology

Field survey was undertaken during 2012-2014 in the selected coconut growing areas of Kerala and Tamilnadu. In Kerala, the sites were Kozhinjampara in Palakkad district, and Edava in Thiruvananthapuram district. In Tamil Nadu, the sites selected were Cumbum in Theni district and Colachel in Kanyakumari district. In each site, two gardens were selected: one with disease symptom expression and the other which is rated as apparently healthy based on the visual expression of symptoms.

Twenty adult palms were selected from each garden and the root (wilt) indexing of the palms were done based on the at intensity of symptoms. Soil samples were collected at 1.5 meter from the base of

***Corresponding author's email:** jeenu15@gmail.com
[1,3] Scientist (Soil Science), [2] Head, [4,5]Principal Scientist [6]Technical Officer

the palm on opposite sides at a depth of 30-45 cm. They were analysed for the physical properties such as bulk density, particle density, porosity, water holding capacity, soil texture and specific volume and for the chemical properties such as soil reaction, electrical conductivity, organic carbon, available P, K, Ca, Mg, S, Fe, Mn, Cu and Zn as per the standard procedures outlined in Jackson (1973).

Canopy observations were recorded for understanding the intensity of symptoms and based on the total number of leaves, index leaf samples were collected for the analysis of N, P, K, Ca, Mg, S, Fe, Mn, Cu and Zn. The data on the various parameters were statistically analyzed using paired't' test.

Results and Discussion

Soil Properties at the Experiment Site

Cumbum

Cumbum is located in Theni district spanning between 10°11' N latitude and 77°30' E longitude. The garden with disease incidence showed symptoms such as severe orangish yellowing, occasional flaccidity and necrosis in the outer whorls. Leaf rot incidence was recorded in 15 per cent of the palms showing symptoms. Soil characters are depicted in Table 1.

Statistical analysis of the data revealed that there was significant difference between the two gardens having healthy palms and that with symptom expression with respect to pH, EC, organic carbon, available P, exchangeable Mg, available S, DTPA extractable Fe, Mn, Zn and Na.

In the garden with palms exhibiting different symptoms of root (wilt) disease, soil pH was 8.29 and the electrical conductivity was recorded as 0.226 dSm^{-1}. The average content of organic carbon at 30 cm depth in soils of the diseased palm area was 0.52 per cent. As indicated by the higher pH, the soil contains extensively higher amounts of Ca (1801 ppm) and Mg (6808 ppm). The average potassium content in the surface soil collected from the garden with symptoms was found to be 394.2 ppm and the content of sodium was found to be 320.6 ppm. The sulphur content in the soil was 1.72 ppm whereas the content of DTPA extractable Fe was 1.75 ppm. The average content of Zn and Mn in soil was found to be 1.65 and 4.97 ppm respectively. Among the nutrient parameters studied, available S and Fe was found to be below the critical level in the garden with disease symptoms.

The soil in the disease free area recorded pH of 7.17 and EC of 0.432 mS^{-1}. The area recorded medium level of organic carbon content of 0.807 per cent. The average content of available P was 43.07 ppm whereas the content of K, Na, Ca and Mg was found to be 356.3 ppm, 166.8 ppm, 2026 ppm and 3455.2 ppm respectively. The available sulphur content in the soil was found to be 24.6 ppm. The content of micronutrients such as Fe, Mn and Zn were recorded as 4.52, 13.9 and 25.81 ppm respectively.

The cation exchange capacity of the soil was 38.7 and 11.6 milli equivalents per 100 g in the diseased and healthy gardens respectively. High base saturation in both the sites implies the predominance of calcium carbonate in the soil.

Nutrient composition in the index leaf samples

The nutrient composition in the index leaf of coconut palm (14^{th} leaf) and the youngest fully opened leaf were estimated by collecting leaflets from the middle of the respective fronds (Table 2). Nitrogen concentration in the leaf samples collected from healthy palms was 1.56 per cent whereas it was 1.48 per cent in the diseased palms. There was significant difference in nutrient composition between the leaf samples collected from the healthy and the diseased palms with respect to K, S, Ca, Cu, Zn, Fe and Mn.

The K content in the index leaf of the palm showing symptoms was 1.69 per cent where as in the healthy palms the content was 1.39 per cent. The total sulphur concentration was 0.141 per cent for healthy palms and 0.113 per cent for the palms

Table 1. Comparison of nutrient profile in the soil samples collected from diseased and healthy areas of the emerging tracts

	pH	EC dSm^{-1}	OC(%)	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	Na
								(ppm)					
Theni Healthy	7.17	0.432	0.807	43.07	356.3	2026	3455.2	24.5	4.52	13.9	0.85	25.8	166.7
Cumbum Diseased	8.29	0.226	0.52	27.91	394.2	1801	6808	1.72	1.75	4.97	0.63	1.65	320.6
't' stat	6.62	3.56	4.75	3.35	NS	NS	5.75	1.71	5.93	4.84	NS	6.72	8.59

showing symptoms. The Fe and Mn content in the healthy and diseased palms were found to be 196 mg per kg and 142.1 mg per kg for Fe and 37.43 mg per kg and 27.91 mg per kg for Mn respectively.

The data suggests an altered metabolism with the deficient content of S, Mn and Fe in the index leaf samples for the palms showing symptoms. In the case of calcium content in the leaf samples the content was 0.427 per cent in the healthy palms whereas it was 0.24 per cent in the diseased palms and the difference was significant statistically.

The concentration of Zn and Cu was significantly different between the leaf samples from the healthy and the diseased palm with the values such as 46.2 and 26.28 mg per kg in the case of Zn and 9.8 and 6.22 mg per kg in the case of Cu for the healthy and the diseased palms respectively.

The cationic ratio (Table 5) was found to have significant variation between the two categories. The Ca: Mg ratio in the healthy palms was double that of the diseased palms with the values 1.22 and 0.66 respectively. In the case of the ratio between K and Ca the values in the diseased and healthy palms were 11.2 and 5.69 respectively. The K:Mg ratio in the healthy palms were 6.92 whereas in the diseased palms it was 7.41 indicating the lower content of Mg in the index leaf samples.

This implies that even though the base nutrient ion concentration in terms of Ca, Mg and K were higher in the soil owing to its innate nature of the soil, the absorption of nutrients is hindered or even if absorbed from the soil, the translocation from the source to the sink might have been blocked due to altered metabolism in the system. Owing to below critical level of S in the index leaf samples the P/S ratio was higher for the diseased palm with the values 1.33 and whereas it was 1.09 from the healthy palms.

From these results it can be inferred that the imbalance in base saturation of the exchange complex and deficiency of iron and sulphur coupled with the heavy texture might have contributed to the reduced uptake of nutrients. Owing to the altered metabolism resulting from the pathogen attack, the plant may not get sufficient amounts of nutrients which also played a role in the expression of yellowing symptoms. Provision of the deficit nutrients along with improvement in physical condition of the soil can be opted as a strategy for the management of disease in these tracts.

Colachel

Colachel is located in Kanyakumari district falling in the Agro climatic Zone 7 of Tamilnadu spanning between 8.1700° N latitude, 77.2400° East Longitude. Palms showing disease symptoms were selected from the Kodumatti Tract and the apparently healthy palms were selected from West Neyyoor region. Symptoms include flaccidity, yellowing and marginal necrosis.

Soils were slightly acidic with average pH in the tract with disease symptoms as 6.02 and that of the apparently healthy area as 6.14 and there was no significant difference in this parameter. But the difference in electrical conductivity was significant over the two sites with the average values in the diseased and healthy areas as 0.045 $dSm^{-1}$and 0.073 dSm^{-1} respectively. The organic carbon content in the diseased area was in the lower range (0.471 per cent) whereas it was 0.60 per cent falling in the medium

Table 2. Nutrient profile of the palms identified in the diseased and healthy spots in Cumbum

Site	N (%)	P mg/kg	K	Ca	Mg	S	Fe	Mn	Cu	Zn
Healthy	1.56	0.154	1.39	0.427	0.345	0.141	196.0	37.43	9.80	46.2
Diseased	1.48	0.151	1.69	0.24	0.363	0.113	142.1	27.90	6.21	26.28
't' stat	NS	NS	3.23	4.06	NS	2.35	2.76	3.79	4.22	2.82

Table 3. Comparison of nutrient profile in the soil samples collected from diseased and healthy areas of Colachel

	pH	EC (dSm^{-1})	OC (%)	P	K	Ca	Na	Mg	S	Fe	Mn	Zn	Cu
				ppm									
Healthy	6.14	0.045	0.6	31.5	92.86	1266.8	11.68	1867.1	7.33	19.12	22.28	18.07	2.12
Diseased	6.02	0.073	0.47	2.99	57.04	990.09	32.18	1200.3	1.34	17.28	21.04	12.6	2.05
't'stat	NS	2.31	NS	8.05	3.65	2.6	3.36	2.89	3.21	NS	NS	2.4	NS

range for the apparently healthy area. A marked variation was observed with regard to the content of exchangeable sodium in the surface as well as in the sub surface soil samples with values 11.68 ppm and 32.18 ppm in the healthy and the diseased areas respectively.

Sodium can cause disruption of soil structure resulting in soil dispersion. Soil dispersion causes clay particles to plug soil pores, resulting in reduced soil permeability. When soil is repeatedly wetted and dried and clay dispersion occurs, it then reforms and solidifies into almost cement-like soil with little or no structure. The three main problems caused by sodium-induced dispersion are reduced infiltration, reduced hydraulic conductivity, and surface crusting. Indeed these soil constraints may limit the uptake of water and nutrients by coconut roots.

Potassium is the key nutrient for coconut production as this is the nutrient which is removed in the highest proportion from coconut. The average K content in the soil with diseased palm was 57.04 ppm whereas in the palms which are apparently healthy, the content was 92.86 ppm. Replenishing the soil potassium removed through crop removal is an adequate pre requisite for sound crop management strategy in coconut. Potassium bearing minerals are not there in sufficient quantities in Colachel area. Quartz, Kyanite, Ilminite and Rutile are predominant minerals available in the area (Kumar and Asaithampi, 2013).

Sulphur has direct and indirect effects on disease through plant growth and resistance, reduced pathogen virulence or survival, changing the abiotic environment and changes in the biological environment. Sulphur in soil is required to balance other nutrients and make the environment less favourable for the pathogen infestation. The available S content in the healthy and diseased garden plots were 7.33 and 1.34 ppm respectively. The anionic ratio with regard to P and S was taken and it was significantly different between the two sites. The P/S ratio was 4.3 for the soil collected from the garden with symptoms and 2.33 for the sample from the healthy garden.

Nutrient ratio with respect to cations were compared between the samples collected from both the sites. In the case of K/Mg and K/Ca the values were 0.0497 and 0.0733 in the healthy garden and 0.048 and 0.0576 in the garden with symptoms respectively. The Ca: Mg ratio was 0.678 for the healthy garden and in the garden with diseased palms the ratio was 0.825.

Nutrient concentration in leaf samples

Considering the leaf nutrient concentration of the sample collected from colachel the healthy leaf tissues recorded a value of 1.45 per cent whereas the diseased palms have N concentration of 1.52 per cent. There was significant difference between palms in the two categories with regard to the P concentration from the palms collected from both the areas with the values such as 0.118 per cent in the healthy palm and 0.142 per cent in the palm with symptoms. In the case of K, there was significant difference between the two sets, and the content (0.662 per cent) in the palms with symptoms was below the critical level where as in the healthy palm it was 1.38 per cent.

Ca concentration was 0.22 per cent in the healthy palms and was 0.305 per cent for the diseased palms. There were no significant difference between the palms in the two sites with respect to the concentration of Mg, Mn and Cu. The sodium concentration in the healthy palms was 0.321 per cent whereas it was 0.318 per cent in the palms with symptoms and they were significantly different.

Even though not significant, the concentration of sulphur in the index leaf samples collected from the diseased palms were less than the critical level. The sulphur concentration in the healthy palm was 0.103 per cent whereas in the palms with symptoms the content was 0.085 per cent.

Iron concentration was significantly different between the two categories and the value of 222.43 mg/kg was recorded in the healthy palms whereas it was 90.57 mg/kg in the palms with symptoms. Zn concentration was 22.29 mg/kg in the healthy palms whereas it was 14.44 mg per kg in the diseased palms and they were significantly different.

Nutrient ratios in index leaf samples

The ratio between the macro and secondary nutrients and between the primary nutrients and secondary nutrients in the leaf samples were assessed (Table 6). Leaf analysis studies in fruit trees indicated that the N/K ratio less than 0.5 and K/Ca ratio less than 0.2 are considered as critical. Wahid *et al.* (1974) reported the antagonistic effect of Na, Ca and Mg on K in the palms detected through foliar analysis. In our study it was observed that in the symptom free palms, the ratio between N and K was 1.05 whereas it was 2.3 in the diseased palms which

implies the imbalance in nutrient ratios between the two categories. The difference in this aspect was also obvious with regard to K/Ca (6.27 in healthy site and 2.21 in the garden with disease symptoms), K/Mg (7.08 in healthy garden and 3.31 in the diseased garden) and P/K ratio which were 0.086 in the healthy garden and 0.215 in the diseased garden.

Soil properties at the sites identified in Kerala

Kozhinjampara and Edava are the sites which were identified in Kerala for studying the pre disposing factors of root (wilt) disease.

Kozhinjampara, located in Palakkad district of Kerala falls in the AEZ 5 (Palakkad Plains) and the AEU-23 (Eastern Plains of Palakkad). It is geographically located at 10°40.350′ N latitude and 76°49.10′E longitude at an elevation of 10 metre above msl with the average depth of water table as 5 metre. The average pH in diseased area and in the apparently healthy gardens are 7.33 and 7.11 respectively and their corresponding electrical conductivity values as 0.1707 and 0.114 dSm^{-1}. The organic carbon content of the soil was respectively 1.12 per cent and 0.86 per cent in the apparently healthy and the garden with disease symptoms. The available P content in the diseased sites were 12.83 ppm where as in the garden with apparently healthy palms the content of available P was 39.43 which were significantly different. With respect to potassium the content was 153.2 ppm for the disease free site and 221.1 ppm for the site with healthy palms.

The content of exchangeable calcium was as high as 2536 ppm in the disease free site and 2763 ppm in the garden with diseased palms. In the case of exchangeable Mg, in both the areas the content was below the sufficiency level and was 114.19 and 96.35 ppm in the area with apparently healthy palms and the area with diseased palms respectively. Except that of Zn, the micronutrient content in the soil were in the sufficiency range for both the areas. In the case of Zn, the content was recorded as 1.12 ppm in the area with symptomatic palms and 1.53 ppm in the area with apparently healthy palms.

Considering the soil conditions in Edava, there is deficiency of K, Mg in the soil with the average values 45.78 ppm and 24.28 ppm respectively. The organic carbon content is in the medium range (0.421 per cent) whereas in the healthy area it was 0.634 per cent. Calcium was on the deficient range the values 134.06 ppm and 188.01 ppm, respectively.

Nutrient concentration in the leaf samples

Nitrogen concentration was significantly different in the index leaf samples of healthy (1.78 per cent) and diseased palms (1.49 per cent). In the case of phosphorus concentration, though there was no significant difference between the samples the healthy palms had higher P concentration (0.208 per cent) in their tissues compared to the diseased palms (0.147 per cent).

Another significant parameter was with regard to

Table 4. Soil nutrient ratio in the identified sites

	Ca/Mg	K/Ca	K/Mg	P/S
ColachelHealthy	0.678	0.0733	0.0497	4.30
ColachelDiseased	0.825	0.0576	0.048	2.23

Table 5. Nutrient ratio in leaf samples collected from healthy and diseased palms.

	Ca/Mg	K/Ca	K/Mg	P/S
TheniHealthy	1.22	5.69	6.92	1.09
CumbumDiseased	0.661	11.20	7.41	1.33

Table 5. Nutrient profile of the palms identified in the diseased and healthy spots of Colachel

Site	N	P	K	Ca	Mg	S	Na	Fe	Mn	Cu	Zn
	(%)	(mg/kg)									
ColachelHealthy	1.45	0.118	1.38	0.220	0.195	0.103	0.321	222.43	45.23	1.36	22.29
ColachelDiseased	1.52	0.142	0.662	0.305	0.200	0.085	0.318	90.57	36.39	0.93	14.44
't stat'	NS	2.86	12.94	4.03	NS	NS	3.69	4.50	NS	NS	3.38

Table 6. Nutrient ratios in the leaf samples collected from Colachel

Site	Ca/Mg	K/Ca	K/Mg	K/Na	N/P	N/K	P/K
Colachel Healthy	1.13	6.27	7.08	5.52	12.2	1.05	0.086
Colachel Diseased	1.5	2.21	3.31	5.52	10.7	2.3	0.215

the sulphur concentration which was 0.31 per cent in the healthy palms compared to 0.235 per cent in the diseased palms. Significant difference in the calcium content of leaves of healthy and diseased palms was observed. It was 0.5% in the diseased palms and 0.30% in the healthy palms. Mg concentration was not significantly different between the two categories and the values were 0.29 per cent in the healthy palms and 0.296 per cent in the diseased palms. Similarly copper concentration in the tissues were also not significantly different between the palms (6.34 mg per kg in the healthy palms and 6.02 mg per kg in the diseased palms). Zn was significantly different in both the categories and the contents were 25.22 mg per kg in the healthy palms and 20.31 mg per kg diseased palms. Iron content was 137.3 mg per kg in the healthy palms and 184.77 mg per kg in the diseased palms and there was significant difference between the two categories.

In Edava, with severe orangish yellowing on the lower the N content in the healthy palms was 1.55 per cent whereas in the diseased palms the content was 1.44 per cent. The striking difference was observed with regard to the potassium concentration in the index leaf samples where the content in the healthy palms recorded a content of 1.43 per cent whereas the palms with severe orangish yellowing showed a content of 0.61 per cent

According to Fremond (1965) the capacity of resistance to disease causing organism is lost when the plant is malnutritioned. These factors coupled with low pH and stress may result in the easy susceptibility of palm to the attack of pathogen.

In Edava, the Ca/Mg ratio was 1.38 in the garden with healthy palms whereas it was 1.42 in the garden with disease symptoms. Owing to the deficient levels of potassium in the area with symptomatic palms, the K/Ca ratio was 2.21 in the healthy area and 1.3 in the diseased palm garden. Similarly the K/Mg ratio in the healthy garden was 3.05 and in the diseased garden it was 1.84. The imbalance was noticed in the N/P and N/K ratio which were 4.95 and 1.08 in the healthy garden and 5.83 and 2.36 in the garden with diseased palms respectively. P/K ratio was 0.219 in the healthy garden and 0.405 in the diseased garden.

Pillai (1975), based on the ratings of Muhr *et al*. (1963), has reported that all the soil groups of Kerala under coconut are generally deficient in available K. Bastin and Venugopal (1986) indicated that the

Table 7. Comparison of nutrient profile in the soil samples collected from diseased and healthy areas of the emerging tracts

	pH	EC (dSm^{-1})	OC (%)	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn
				ppm								
KozhinjamparaHealthy	7.11	0.171	1.12	39.43	153.2	2536	114.19	23.8	59.23	28.99	0.232	1.53
KozhinjamparaDiseased	7.33	0.114	0.86	12.83	221.1	2763.3	96.35	23.04	53.39	36.18	0.218	1.12
't stat'	NS	3.27	3.55	7.03	3.18	NS	NS	NS	NS	3.42	NS	2.12
EdavaHealthy	6.34	0.054	0.634	8.46	149.12	188.01	47.24	23.73	22.5	2.3	0.256	0.524
EdavaDiseased	6.02	0.069	0.421	18.94	45.78	134.06	24.28	14.74	32.4	1.58	0.601	0.761
't stat'	19.358**	NS	11.212**	8.125**	15.32**	4.07**	6.20**	NS	NS	NS	NS	NS

Table 8. Soil nutrient ratio in the identified sites

	Ca/Mg	K/Ca	K/Mg	P/S
KozhinjamparaHealthy	0.678	0.060	1.34	1.66
KozhinjamparaDiseased	28.68	0.0800	2.29	0.557
EdavaHealthy	3.98	0.793	3.16	0.357
EdavaDiseased	5.52	0.341	1.89	1.28

Table 9. Soil Physical properties at the identified sites

Site	Colachel	Cumbum	Kozhinjampara	Colachel	Cumbum	Kozhinjampra	Colachel	Cumbum	Kozhinjampara
	Porosity(%)			Water Holding Capacity(%)			Specific Volume		
Diseased	40.05	61.04	45.29	29.15	32.23	11.6	0.739	1.03	0.792
Healthy	52.48	62.34	49.87	29.95	35.32	19.27	0.834	1.053	0.861

Table 10. Nutrient profile of the palms identified in the diseased and healthy spots

Site	N	P	K	Ca	Mg	S	Na	Fe (mg/kg)	Mn (mg/kg)	Cu (mg/kg)	Zn (mg/kg)
					(%)						
Kozhinjampara Healthy	1.78	0.208	1.34	0.3	0.290	0.310	0.371	137.38	35.16	6.34	25.22
Kozhinjampara Diseased	1.49	0.147	1.43	0.50	0.296	0.235	0.500	184.77	41.81	6.02	20.31
't stat'	2.79	NS	NS	4.06	NS	2.28		2.24	NS	NS	2.91
Edava Healthy	1.55	0.313	1.43	0.65	0.469	0.358	0.345	312.47	105.92	9.88	24.97
Edava Diseased	1.44	0.247	0.610	0.47	0.332	0.332	0.247	78.048	14.42	24.25	1.44
't stat'	1.73^{NS}	1.26^{NS}	25.02**	0.14^{NS}	0.061^{NS}	NS	NS	NS	NS	NS	NS

Table 11. Nutrient ratios in the index leaf samples collected from the different areas in Kerala

Site	Ca/Mg	K/Ca	K/Mg	K/Na	N/P	N/K	P/K
Kozhinjampara Healthy	1.19	3.88	4.62	3.61	8.55	1.32	0.154
Kozhinjampara Diseased	1.69	2.86	4.83	2.86	8.71	1.04	0.12
Edava Healthy	1.38	2.21	3.05	4.14	4.95	1.08	0.219
Edava Diseased	1.42	1.30	1.84	2.47	5.83	2.36	0.405

alfisols, which are intensively cultivated for coconut, are generally low to medium in potash status.

The reserves of potassium in the plantation growing soils are lower due to low CEC and higher amounts of 1:1 clay type, mainly Kaolinite, which have very low K fixation capacity. Since, K is required in many physiological functions but does not form part of plant structure, huge investments are required in terms of K currency to meet the crop requirement.

Accomplishing efficient recycling requires a thorough understanding and management of K dynamics (Vilela and Ritchey, 1985). This requires efforts to enhance the CEC of the soil and reduce soil solution level K^+ to match the required rate of uptake at any given time and increase the amount of time during which K is held in above ground plant materials.

Soil physical properties at the disease affected areas

Soil physical properties holds a direct relation with the water transmission characters, the retention of water and nutrients, the root penetration and thereby the absorption of water and nutrients from the soil.

Porosity indicates the percentage of soil occupied by soil air and water which include both micro and macropores. In all the three sites the diseased sites have less porosity compared to the healthy area. Water holding capacity is directly linked to the pore spaces and the percentage composition of primary particles in soil and in all these sites the site with diseased palms have less water holding capacity compared to the healthy area. Soil texture holds a relationship with the water holding capacity of the soil.

It can be seen that specific volume indicates the extent of soil compaction and which implies the resistance to root penetration. Higher value of specific volume indicates the lower degree of compaction. In the healthy area the specific volume is higher compared to the area with diseased palms.

Conclusion

Site specific variation in soil properties and consequently on the nutrient absorption pattern was observed on the identified sites which recorded root (wilt) disease of coconut. Accordingly management strategies in these areas are to be focused on the identified constraints. Even if sufficient amounts of nutrients are present in the soil, because of the unsuitable physical condition and poor root proliferation and development, efficient translocation of ions may not take place. In that case suitable management of the physico chemical properties of the soil can ensure better returns from the palms through the enhanced nut production from the palms.

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