Root distribution pattern of coconut and its influence on nutrient uptake in littoral sandy soil of coastal Orissa

D.K. Dash[1], S.K. Pattanayak* and P.P. Samal

AICRP on Palms, Department of Horticulture
**Department of Soil Science and Agricultural Chemistry*
Orissa University of Agriculture and Technology, Bhubaneswar, Orissa

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Abstract

The performance of two hybrids and their parents considering the good and poor bearing characters of coconut were evaluated at AICRP on Palms, Konark, Orissa to find out the effective root zone and its influence on nutrient uptake and yield. The effective feeder root zone was found within the radius of 0-200 cm and at depth of 0-60 cm from the trunk. The yielding behavior of palms had a direct relation to the number of roots, nutritional status of root and the leaf. The bearing palms showed higher level of leaf and root N, P, K and root CEC than the poor bearing palms. The N, P and K content of root and root CEC were higher at the surface soil and gradually decreased with increase in depth of the profile.

Keywords: Coconut, roots, root distribution

Introduction

In Orissa, coconut is cultivated in an area of 51,000 ha with an estimated production of 275.8 million nuts and with productivity of 5,408 nuts per ha (2007-08). The major area concentrated are Puri, Gunjam, Cuttack, Balasore, Bhadrak, Jajpur, Kendrapara, Kurda and Jagatsinghpur districts. Its cultivation is mainly scattered in the homestead land, field borders and the organized cultivation is found in some parts of Puri, Gunjam and Balasore districts. The littoral sandy soils of coastal Orissa are characterized by low nutrient content, poor capacity of soil to retain the applied nutrients and very low water holding capacity, resulting in extreme drought situation during summer months. This results in very low productivity. The growth and productivity could be improved by a judicious application of organic and burial of coconut husk or application of tank silt or red earth to improve the structure and water retention of the soil. In coconut garden defective irrigation and manuring causes problem of button shedding and low yield. Knowing the effective root zone of coconut will enable the farmers to adopt effective irrigation technique and nutrient application to palms. The present study was undertaken to find out the reasons for variation in bearing habit of palms of same age and genetic makeup grown under similar soil and climatic conditions with the information on the root distribution pattern and its influence on nutrient uptake and productivity.

Materials and Methods

The present study was carried out at All India Coordinated Research Project on Palms, Konark, Orissa during 2002-03. The soil of the experimental site was texturally classified as sandy soil with a pH of 6.5, organic carbon status of 0.30 %. The experimental site has coconut plantation spaced at 7.5 m in both ways. The general package of practices for coconut was followed for all the experimental palms. The investigation was carried out on bearing palms (B) yielding more than 40 nuts / palm / year and poor bearing palms (PB), yielding less than 25 nuts / palms / year of the hybrids (GBD x ECT and ECT x GBD) and their parents (GBD and ECT). The selected palms are of age 20 years. The root studies were made at three depths (D_1: 0-30 cm, D_2: 31-60 cm and D_3: 61-90 cm) and three lengths from the trunk (L_1: 0 -100 cm, L_2: 101 -200 cm and L_3: 201-300 cm). The

[1]*Corresponding author, E mail: dilip_palms@yahoo.co.in*

feeder roots were collected by soil excavation process as suggested by Maheswarappa *et al.* (2000). A trench was opened at 3m away from the bole and the roots were washed from a sector of one-sixteenth portion of the full circular basin and to a depth of 1 m with the help of a hose pipe. The washed sand that collected in the trench was removed as and when it got filled. Soils from three sides of the basin were excavated taking care to retain the exposed roots in position. The main root and fine roots were collected from different depths for nutrient analysis and root CEC. Soil samples were collected at different depths of 30, 60 and 90 cm for analysis. For leaf analysis, fourteenth leaf of palms was selected as suggested by Prevot and Allagnier (1962). The total number of feeder roots at different depths and distance from the trunk were counted and recorded for each treatment. The vegetative and reproductive characters were recorded for each treatment during the year 2002-03 and after the excavation of roots during the 2003-04. The data were pooled for two years for analysis. The data on various characters obtained from different treatments of the study were subjected to statistical analysis through factorial design with three replications having four palms per treatment.

Results and Discussion

The level of NPK in soil at different depth indicated that N at 0-30 cm was medium (292.2 kg/ha) and was low in other two depths. The P and K status were medium and low, respectively in all the three depths (Table 1). The bearing (B) palms of hybrids and parents attained more heights as compared to the poor bearing palms. Similarly the number of leaves on crown, number of leaves, spadices and female flowers produced per year and nut yield were more in bearing palms as compared to the poor bearing palms (PB). Comparing the characters among different hybrids and their parents, GBGD (B), GBGD x ECT (B) registered high values for different characters studied. Palms under GBGD (PB), ECT x GBGD (PB) and parent ECT (PB) produced 9-10 leaves per year and recorded low nut yield (Table 2).

Table 1. N, P, K status in soil at different depths

Depth (cm)	N (kg / ha)	P (kg / ha)	K (kg / ha)
0-30	292.2	31.1	71.8
31-60	233.8	18.1	55.8
61-90	193.3	14.0	50.2
S.E (m)±	13.8	2.9	7.2
CD (P=0.05)	39.3	8.3	20.5

Table 2. Vegetative and reproductive characters of different hybrids and their parents

Hybrids / Parents	Average number of				
	Leaves on crown	Leaves produced per year	Spadices produced per year	Female flowers	Mean yield (no. of nuts)
GBGD (B)	28.3	14.3	10.3	338.0	61.6
ECT (B)	29.0	13.3	8.3	135.3	42.3
GBGD (PB)	24.3	12.3	3.3	94.3	23.0
ECT (PB)	18.6	10.0	1.3	7.3	1.3
GBGD x ECT (B)	30.0	12.3	8.3	135.6	50.0
ECT x GBGD (B)	29.3	13.0	8.6	186.0	45.6
GBGD x ECT(PB)	22.0	9.0	20.6	27.0	3.6
ECT x GBGD (PB)	23.6	10.3	1.6	13.6	2.3
S.E (m)±	1.3	0.783	0.598	14.4	3.8
CD (P=0.05)	3.9	2.4	1.8	43.6	11.6

B = Bearing palms (>40 nuts/palm/year)
PB = Poor Bearing Palms (<25 nuts/palm/year)

Root distribution

Feeder root distribution irrespective of hybrids and parents was recorded at higher side (40.7) in the zone of 31- 60 cm followed by 0-30 cm of soil depth (Table 3). With respect to lateral spread, maximum numbers of feeder roots were found within the radius 0-200 cm. In both bearing and poor bearing palms, the effective depth and lateral spread with respect to the concentration of feeder roots (92%) were confined to 31- 60 cm and 101-200 cm respectively. The findings are in accordance with the findings of Anil Kumar and Wahid (1988), Louis (1989) and Maheswarappa *et al.* (2000). The finding also indicated that the higher feeder root accumulation in hybrids and parents might have resulted in higher nut yield.

Table 3. Number of feeder roots at different depths and lateral distances from the trunk

Depth (cm)	Number of roots		
	Lateral distances (cm)		
	0 - 100	101 - 200	201 - 300
0 - 30	28.4	27.6	3.3
31 - 60	40.7	42.1	5.0
61 - 90	18.1	13.5	4.9
	S.E.(m)	0.945	
	C.D(P=0.05)	2.637	

Maximum number of feeder roots was found at D_2L_1 and D_2L_2 zone (Table 4). The bearing palms recorded maximum number of roots in comparison to poor bearing palms. Maximum number (56.6) of feeder roots per palm was recorded in GBGD x ECT (B) at a depth of 31-60 cm and lateral spread of 101-200 cm from the trunk. The GBGD x ECT (B), ECT x GBGD (B), GBGD (B) and ECT (B) recorded higher number of feeder roots per palm as compared to their respective poor bearing counter parts. The total feeder roots ranged from 2446 to 3530 in poor bearing and bearing palms, respectively. The present finding showed lower number of feeder roots. Louis (1989) observed 5000 to 7000 number of feeder roots in eight year old palms. The low yield of coconut may be due to the lower number of feeder roots produced in sandy soils with poor nutrient status.

ensuring high and consistent yields. Phosphorous is not that important in nutrition of palm, particularly after a satisfactory build up in soil is obtained (Khan *et al.*, 1983). Maximum content of N (0.288 %) and K (0.951 %) was estimated in the roots of GBGD x ECT (B) at 0-30 cm depth.

Root CEC

Root cation exchange capacity was higher (6.84) at surface layer i.e. 0 -30 cm depth for all the palms and

Table 4. Feeder root distribution of different hybrids and their parents at different depth (D) and Lateral distance (L) from trunk

	Number of roots (in 1/16th of basin)								
Hybrids / Parents	D1L1	D1L2	D1L3	D2L1	D2L2	D2L3	D3L1	D3L2	D3L3
GBGD (B)	31.3	25.3	2.3	56.0	40.0	5.3	25.0	18.6	4.3
ECT (B)	29.6	29.3	3.0	42.3	35.3	4.6	22.3	17.0	5.0
GBGD (PB)	28.0	24.0	3.6	19.6	34.0	5.0	19.6	10.6	5.6
ECT (PB)	21.6	27.3	3.0	34.3	30.0	3.6	20.6	8.3	8.0
GBGD x ECT (B)	36.0	31.0	3.6	51.0	56.6	6.6	15.3	14.0	4.0
ECT x GBGD (B)	32.3	33.0	4.0	48.6	53.0	7.0	18.3	16.0	4.6
GBGD x ECT(PB)	23.0	24.6	3.0	38.0	42.6	3.6	11.6	9.3	3.6
ECT x GBGD (PB)	25.0	26.3	3.0	35.6	45.0	4.0	12.0	13.6	3.6

S.E (m) ± 2.66
CD (P = 0.05) 7.46

Nutrient content in the root

The N, P and K content of roots decreased with increased in depth and was the highest (0.37 %, 0.15 % and 0.91 %, respectively at 0-30 cm depths (Table 5). Similar results were obtained by Avilan *et al.* (1984) who reported that root distribution was markedly influenced by soil physical properties as well as fertilizer application practices, which tend to concentrate the roots in the soil layer of 30 cm from the surface under the outer half of the crown radius (1.5 m). As regards to the nutrient content of roots in different hybrids and parents, the results (Table 6) indicated that the bearing palms contained comparatively higher percentage of N, P, and K than the poor bearing counterparts. This shows that the root N, P and K content has influence over bearing behavior of palms. A review of the experiments of NPK nutrition of coconut palms revealed that K and N content are needed to be at optimum and are highly essential for

Table 5. Root NPK and root CEC at different depths

Depth (cm)	N (%)	P (%)	K (%)	Root CEC (cmole (p+) kg^{-1})
0-30	0.37	0.15	0.91	6.84
31-60	0.26	0.12	0.59	4.89
61-90	0.17	0.10	0.32	3.84
S.E (m)±	0.028	0.004	0.05	0.237
CD (P=0.05)	0.079	0.011	0.145	0.675

it decreased as depth increased (Table 5). The result is supported by the findings of Wahid *et al.* (1974). The highest root CEC (9.9) was observed in GBGD x ECT (B), followed by ECT (B) and minimum (3.1) was found in ECT (PB) roots (Table 6). The hybrid showing higher CEC also recorded more number of feeder roots and nut yield. In general, the bearing palms had higher root CEC as compared to poor bearing palms. The palms having higher root CEC had higher N, P and K contents. The findings revealed that yield component may be directly related to the root CEC of the palm and palms having higher value have more yield than the palms having low values.

Nutrient content in leaf

The NPK content of leaf (Table 6) was higher in bearing palms compared to poor bearing ones. The estimates were just at par with the critical level except P worked out by IRHO (Thampan, 1982). This may be the reason for production of less number of nuts in bearing palms. The maximum N content (2.21 %) was estimated in ECT (B) followed by GBGD (B). Similar observation was made by Jose *et al.* (1988), who reported that the yield of the palm was correlated with N content of the leaf lamina.

Comparison of the estimated leaf NPK content with optimum leaf nutrient values quoted by IRHO indicated that the N and K level of bearing palms were very near to the critical values of N and K (i.e. 1.8- 2.0

Table 6. N, P, K and CEC content of feeder roots and leaf of hybrids / parents

Hybrids / Parents	N (%)		P (%)		K (%)		Root CEC (cmole (p+) kg -1)
	Root	Leaf	Root	Leaf	Root	Leaf	
GBGD (B)	0.304	2.13	0.140	0.180	0.789	1.28	4.2
ECT (B)	0.302	2.21	0.147	0.183	0.431	1.17	6.6
GBGD (PB)	0.233	1.07	0.090	0.143	0.496	0.94	3.3
ECT (PB)	0.236	1.08	0.101	0.167	0.379	0.89	3.1
GBGD x ECT (B)	0.288	1.73	0.132	0.167	0.951	1.03	9.9
ECT x GBGD (B)	0.254	2.10	0.114	0.183	0.577	1.13	5.8
GBGD x ECT(PB)	0.287	1.55	0.123	0.160	0.871	1.03	4.6
ECT x GBGD (PB)	0.198	1.29	0.199	0.183	0.369	1.14	3.8
S.E (m)±	0.046	0.245	0.006	0.008	0.083	0.102	0.387
CD (P=0.05)	0.013	0.525	0.017	0.017	0.236	0.218	1.102

% N and 0.80-1.0 % K). The N level of poor bearing palms was found below the critical level, whereas in both bearing and poor bearing palms, P percentage in leaf was found to be at higher side of optimum level compared to the critical level of P (0.12 %).

Conclusion

Maximum feeder roots were found at a depth of 0-61 cm and confined to 0-200 cm laterally. Irrespective of hybrids and parents, the active feeder root zone was confined to this zone and the root nutrient percentage was also found more. Feeder root distribution varied significantly in different hybrids and parents at different depths and distances from the bole. In general, the bearing palms had more number of feeder roots as compared to poor bearing palms. Number of roots may have positive influence on the yielding behavior of palms. The maximum yielder in the bearing palms category had more number of feeder roots than other hybrids and parents. The yielding behavior of palms had direct relation to the number of roots and nutritional status of root and leaf. The sandy soil of Konark required nutritional management with regard to N and K. The yield of palms was influenced by the root cation exchange capacity and the bearing palms had higher values than the poor bearing palms.

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