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Root development of coconut reciprocal crosses and their parental cultivars at early bearing stage

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ABSTRACT

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To understand the influence of parent coconut cultivars on the root development of their hybrid, this study was conducted in Inopacan, Leyte using eight dwarf and tall reciprocal crosses and their parent genotypes.

Coconut crosses with dwarf (D) and tall (T) parents were found to have lighter roots than the tall parents but had heavier roots than the dwarf parents. Significant differences in root weight of reciprocal crosses were observed in some sampling points in specific cross combinations. However, these were not general trends for D x T and T x D crosses.

Generally, crosses involving Baybay Tall had more roots which were distributed wider and deeper in the soil than crosses with Puringkitan as one of the parents.

Keywords: coconut. reciprocal hybrids. root development.

INTRODUCTION

Some studies showed that knowledge of root development may prove beneficial in understanding not only fertilization and intercropping but also lodging and drought tolerance of coconut (*Cocos nucifera* L.) (Avilan *et al.*, 1984; Anilkumar and Wahid, 1988).

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Genotype is one of the major factors known to influence root development of coconut. Others are plant age, soil physical properties as well as agricultural practices such as fertilizer application and irrigation (Avilan *et al.*, 1984). Different genotypes are known to vary in their root development. Talls (T) have generally more extensive distribution of roots than the dwarfs (D) (Ortega, 1968; Banzon and Velasco, 1982; Avilan *et al.*, 1984) and some hybrids including MAWA (Santos *et al.*, 1986). Such differences may partly be responsible for the susceptibility of the latter to cyclone damage (Martyr *et al.*, 1986) compared with talls.

Le Saint and de Nuce de Lamothe (1987) observed denser root system of the D x D hybrid Malayan Yellow Dwarf (MYD) x Equatorial Green Dwarf (EGD) compared with that of the female parent MYD indicating heterosis. Since heterosis is a manifestation of the combining abilities of parents, understanding the influence of the parents on root development of their hybrids is vital in breeding for typhoon and drought tolerance of coconut. For this purpose, root development of eight dwarf and tall reciprocal crosses of coconut and their parental genotypes were studied in an upland area of Inopacan, Leyte, Philippines.

MATERIALS AND METHODS

Eight coconut reciprocal crosses of three dwarf and two tall parents namely, Albuera Dwarf (ALD), Coconiño (CNO), Tacunan (TAC), Baybay Tall (BAY) and Puringkitan (PUR) were used in the study. The crosses were ALD x BAY, BAY x ALD, ALD x PUR, PUR x ALD, CÑO x BAY, BAY x CNO, TAC x PUR and PUR x TAC. Sixteen seedlings of each cross were planted per replication in an 8.5 x 8.5 m triangular scheme, one cross in a plot. There were 3 replications laid out in a slightly rolling to hilly area. The palms were applied with optimum fertilizer following the recommended rates for coconut by the Philippine Coconut Authority (Appendix Table 1). They were also provided with the recommended cultural management inputs.

Root sampling was done at early bearing stage following the procedure of Ouvrier (1984). Two representative sample palms per plot were selected for root sampling. With the use of long plastic twine, 6 equidistant lines were

projected from each sample to adjacent palms. Markers were stuck in the ground at 0.5 m interval from the sample palm. Soil samples were separately collected from 0-20 cm , 20-40 cm and 40-60 cm depths at each marked point using a post-hole digger with 8 cm diameter. They were placed separately in labeled plastic bags indicating the sample palm, distance from the sample palm and depth of soil sampling. Roots were then collected from each bagged soil sample.

In the laboratory, the roots were washed and sorted out according to their diameter. They were then classified into large (> 5.0 mm diameter), medium (2.5-5.0 mm diameter) and fine (< 2.5 mm diameter). Sorted roots were dried at 60-85^{0}C until their weight became constant. Counting was not done since breakage of individual root can not be avoided which might contribute to error.

RESULTS AND DISCUSSION

Root distribution patterns

Root sampling was done at 42 months after planting when most of the sample palms were at initial bearing stage. This is particularly important since this stage was reported to be the time when D x T hybrid coconuts are susceptible to lodging due to the imbalance in above ground and underground growth of the young palms (Ouvrier, 1984).

Data showed varying root distribution patterns of the different plant types although general trends were also noted (Tables 1-3). Generally, roots were concentrated within the 0.5 m distance from the palm and 0-20 cm depth of soil as shown by the fact that more than 70% of the total root weight was obtained from this soil zone. This agrees with previous reports that coconut roots were concentrated in the surface soil horizon (Pomier and Bonneau, 1987; Avilan *et al.*, 1984; Ortega, 1968) and that there was much more root activity in the surface than in the lower zones (Anilkumar and Wahid, 1988). Furthermore, based on dry weight, there were more large and fine roots than medium roots in each sample palm. Large variations in the weight of large and fine roots among the different hybrids and cultivars were also observed at

Table 1. Dry weight (g) of large roots (>5mm) at different sampling distances and soil depths

Distance (m)	Depth (cm)	CROSS								PARENT CULTIVARS				
		ALD x BAY	BAY x ALD	ALD x PUR	PUR x ALD	CÑO x BAY	BAY x CÑO	TAC x PUR	PUR x TAC	ALD	CÑO	TAC	BAY	PUR
0.5	0-20	3.13	3.10	2.29	1.97	4.43	2.41	1.65	4.40	3.72	2.36	1.79	9.75	3.27
	20-40	1.57	0.82	1.00	0.97	2.21	0.96	0.51	1.88	0.99	0.74	0.75	0.99	1.13
	40-60	0.38	0.29	0.20	0.21	0.54	0.54	0.08	0.69	0.18	0.14	0.32	0.94	0.02
1.0	0-20	0.77	0.66	1.33	0.60	0.95	1.22	0.31 *	1.86 *	1.03	1.16	0.84	2.29	2.01
	20-40	0.31	0.09	0.05	0.16	055	0.12	0.08	0.20	0.26	0.05	0.33	0.04	0.04
	40-60	0.06	0.03	0	0	0.12	0	0	0.07	0.03	0	0	0	0
1.5	0-20	0.49	1.06	0.36	0.99	1.26	0.94	0.36	3.86	0.39	0.80	0.24	0.97	0.62
	20-40	0	0.05	0.11	0	0.10	0	0.05	0.10	0.02	0.03	0.29	0.03	0
	40-60	0	0.02	0	0	0.80	0	0	0.02	0.03	0	0	0	0
2.0	0-20	0.64	0.46	0.62	0.05	0.29	0.58	0.12	0.27	0.17	0.14	0.17	0.43	0.41
	20-40	0.05	0.05	0	0	0	0	0	0.09	0	0	0	0	0.31
	40-60	0	0.04	0	0	0.31	0	0	0	0	0	0	0	0
2.5	0-20	1.05	0.36	0.11	0.08	0.31	0.40	0.08	0.06	0	0.04	0	1.69	0.01
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0.21	0	0	0	0	0	0	0	0
3.0	0-20	0.15	0.20	0	0.03	0.29	0.06	0	0.30	0	0.04	0	0.03	0.06
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0-20	0	0.39	0	0	0	0	0	0	0	0	0	0	0
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0

* Reciprocal crosses with significantly different means

Table 2. Dry weight (g) of medium roots (2.5-5.0mm) at different sampling distances and soil depths

Distance (m)	Depth (cm)	CROSS								PARENT CULTIVARS				
		ALDx BAY	BAYx ALD	ALDx PUR	PURx ALD	CÑOx BAY	BAYx CÑO	TACx PUR	PURx TAC	ALD	CÑO	TAC	BAY	PUR
0.5	0-20	0.81	0.85	0.73	0.42	3.34	0.35	0.50	1.22	0.79	0.83	1.01	1.27	0.98
	20-40	0.40	0.31	0.22	1.67	1.92	0.12	0.17	0.38	0.14	0.22	0.31	0.30	0.26
	40-60	0.15	0.06	0.14	0.08	0.64	0.04	0.07	0.18	0	0	4.47	0	0
1.0	0-20	0.44	0.32	0.70	0.42	1.00	0.29	0.27*	0.78*	0.62	0.47	0.28	0.58	0.58
	20-40	0.30	0.09	0.03*	0.18*	0.49	0.02	0.14	0.46	0.17	0.16	0.12	0.08	0.10
	40-60	0.09ab	0.12ab	0.06b	0 b	0.28a*	0 b*	0 b	0.04b	0.04b	0 b	0.03b	0.03b	0 b
1.5	0-20	0.42	0.63	0.42	0.99	0.88	0.46	0.28	0.63	0.33	0.96	0.21	0.36	0.57
	20-40	0.09	0.01	0.06	0.08	0.14	0.02	0.02	0.12	0.02	0.05	0.01	0.07	0.06
	40-60	0.07b	0.07b	0.02b	0.03b	029a*	0 b*	0 b	0 b	0 b	0 b	0 b	0 b	0 b
2.0	0-20	0.52	0.45	0.10	0.15	0.42	0.39	0.26	0.26	0.23	0.18	0.10	0.32	0.16
	20-40	0.13b	0.12a	0 b	0.01b	0 b	0.01b	0.02b	0.01b	0 b	0 b	0 b	0 b	0.01b
	40-60	0	0.05	0.03	0	0.15	0	0.02	0	0	0	0	0	0
2.5	0-20	0.37	0.26	0.20	0.06	0.43	0.25	0.06	0.15	0.06	0.07	0.02	0.17	0.12
	20-40	0	0.03	0.01	0	0	0	0	0	0	0.06	0	0	0
	40-60	0	0.01	0	0	0.08	0	0	0	0	0	0	0	0
3.0	0-20	0.22	0.10	0	0	0.35	0.08	0	0.13	0.03	0.06	0	0.12	0.11
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0.01
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0-20	0.10	0.03	0	0	0.08	0.02	0	0.07	0	0.05	0	0.10	0
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0

Means with the same letter are not significantly different

* Reciprocal crosses with significantly different means

Table 3. Dry weight (g) of fine roots (<2.5 mm) at different sampling distances and soil depths

Distance (m)	Depth (cm)	CROSS								PARENT CULTIVARS				
		ALD x BAY	BAY x ALD	ALD x PUR	PUR x ALD	CÑO x BAY	BAY x CÑO	TAC x PUR	PUR x TAC	ALD	CÑO	TAC	BAY	PUR
0.5	0-20	5.98	3.01	4.53	2.62	3.02	3.83	3.30	3.36	3.16	3.43	3.69	6.09	2.76
	20-40	1.12	0.97	0.71	0.79	0.76	0.60	0.42	0.58	0.62	0.38	0.76	0.58	0.52
	40-60	0.44	0.41	0.41	0.11	0.17	0.14	0.24	0.20	0.20	0.06	0.22	0.34	0.20
1.0	0-20	0.76	1.89	1.31	1.31	1.72	1.15	0.74	1.78	1.89	0.82	0.87	1.63	1.20
	20-40	0.27	0.38	0.22	0.57	021	0.43	0.09	0.19	0.43	0.02	0.16	0.12	0.25
	40-60	0.71	0.12	0.23	0.03	021	0.14	0	0.04	0.10	0.01	0.04	0.04	0
1.5	0-20	1.24	2.33	1.70	1.15	1.20	1.01	0.50	1.35	1.40	0.49	0.63	1.46	1.25
	20-40	0.21	0.30	0.21	0.14	0.17	0.13	0.08	0.14	0.17	0.04	0.05	0.18	0.10
	40-60	0.50	0.11	0	0.01	0.02	0	0.01	0.18	0.01	0	0	0	0.11
2.0	0-20	0.96	1.18	0.55	0.34	1.20	0.63	0.61	0.62	0.97	0.78	0.33	0.89	0.30
	20-40	0.04	0.28	0.02	0.04	0.03	0.05	0.34	0.01	0	0	0	0.04	0.03
	40-60	0.15	0.08	0	0	0	0	0	0	0	0	0	0	0
2.5	0-20	0.57	0.74	0.11	0.18	0.78	0.62	0.11	0.34	0.43	0.22	0.02	0.46	0.17
	20-40	0.02	0.08	0.01	0	0.01	0	0	0	0	0.12	0	0.01	0
	40-60	0.08	0.01	0	0	0	0	0	0	0	0	0	0	0.07
3.0	0-20	0.32	0.37	0.01	0.02	0.38	0.25	0	0.17	0.16	0.09	0.02	0.29	0.02
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0-20	0.14	0.13	0	0	0.13	0.03	0	0	0	0	0	0	0
	20-40	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-60	0	0	0	0	0	0	0	0	0	0	0	0	0

* Reciprocal crosses with significantly different means

closer distance to each sample palm and at 0-20 cm depth of soil. Differences in weight of roots at deeper soil zones were not significant except for medium roots at 1.5 m distance. Fine roots were generally heavier than large and medium roots at sampling points beyond 1.5 m from the palm.

Differences among the parents and their hybrids were noted only on the weight of medium roots at 1-2 m distance from the sample plants. The hybrids ALD x BAY, BAY x ALD and CÑO x BAY gave significantly heavier roots than the parental cultivars and the other hybrids. The two tall parental cultivars BAY and PUR slightly differed in the weight of large and fine roots at 0.5 m distance and 0-20 cm soil depth although the differences were not significant. However, BAY roots extended up to 3.5 m from the sample tree but roots of PUR extended up to 3.0 m distance only. Both had roots that were almost confined to the upper 0-40 cm deep layer at sampling distances beyond 2 m from each palm. Both had large roots which were heavier at the top 0-20 cm soil layer than those in the lower soil zones. They also had fine roots which were heavier than medium sized ones in majority of the sampling points.

The dwarfs had narrower and shallower root system than BAY but had almost the same amount and length of roots as PUR. Generally, roots reached only up to 3 m horizontal distance from the sample plants. CÑO, a very fragile dwarf cultivar did not differ much from ALD and TAC in terms of root weight at the different sampling distances. It was noted, however, that although CÑO had roots up to 3.5 m from the palm, it had very much less roots in most sampling points at 40-60 cm depth compared with the two other dwarfs. Further, its medium and fine roots were the lightest among the cultivars. ALD, on the other hand, had large roots which were heavier closer to the base of palms than TAC and CÑO but these sharply declined beyond 0.5 m from the base. In addition, its medium roots were heavier than TAC beyond 0.5 m and at 0-20 cm soil depth. It also had heavier fine roots than all the cultivars beyond 0.5 m distance at 0-20 and 20-40 cm depth of soil. TAC had lighter large roots at the top 0-20 soil layer but its medium and fine roots were almost the same as those of the other two dwarfs.

The hybrids, on the other hand, had lighter roots than their tall parents but had heavier roots than their dwarf parental cultivars. Hybrids between CÑO and BAY had heavier roots than CÑO. Similarly, crosses between ALD and BAY produced heavier roots than ALD, specifically beyond 1 m

distance from the sample tree. Moreover, the roots of the hybrids extended up to 3.5 m distance from the palms whereas ALD had roots up to 3 m distance only. Crosses between ALD and PUR produced roots which were heavier than those of the dwarf parent but only at sampling distance beyond 1 m from the palms. Roots of ALD were heavier than that of its crosses with PUR closer to the sample plant.

TAC x PUR had lighter roots than TAC and had the most limited root growth reaching only 2.5 m distance from the palms. Reciprocal cross PUR x TAC had heavier roots which extended up to 3.5 m distance from the palm. This was greater than the roots of both parents which reached only 3 m distance from the palms. Both hybrids, however, had better vertical growth than their dwarf parents whose roots were limited to the 0-20 cm soil layer at sampling points beyond 1.5 m distance. Results also indicated that crosses involving BAY had heavier roots which were distributed wider and deeper than crosses with PUR as one of the parents.

Differences in root weight of reciprocal crosses were likewise observed but these differences were statistically significant in a few cases only. For instance, the large roots of TAC x PUR at 1 m distance, 0-20 cm deep soil layer, the medium roots of CÑO x BAY at 1 m distance, 40-60 cm layer and the medium roots of PUR x TAC at 1 m distance, 0-20 cm layer were significantly heavier than those of their reciprocal crosses.

Root composition

At early bearing stage, fine roots (<2.5 mm diameter) were heavier than large (≥5 mm diameter) and medium (≥2.5 mm to <5 mm diameter) roots in the hybrids ALD x BAY, ALD x PUR, BAY x ALD, BAY x CÑO, TAC x PUR and PUR x ALD as well as in the parental cultivars ALD and CÑO. The proportion of large roots was higher than medium and fine roots in CÑO x BAY, PUR x TAC, BAY and PUR. Medium roots comprised much smaller proportion of the total root weight except in TAC, ranging only from 11.2% in BAY x CÑO to 37.4% in TAC. Most often, medium roots were less than 20% of the total root weight as observed in ALD x BAY, BAY x ALD, ALD x PUR, BAY x CÑO, TAC x PUR, ALD and BAY.

Hybridization seems to have increased the growth of fine roots since the hybrids generally had heavier fine roots at sampling distance beyond 1 m from the palms compared with both their dwarf and tall parental cultivars. More fine roots or rootlets could have increased the surface area of the roots for water and nutrient absorption as well as the soil volume explored by the roots. Thus, the hybrids apparently have increased efficiency for water and nutrient absorption resulting in better growth relative to their dwarf parents. The hybrids were usually taller with bigger girth size than the dwarf parents (Table 4).

Table 4. Growth of eight (8) coconut reciprocal crosses and their parental cultivars at early bearing stage (48 months after planting)

Cultivar/Hybrid Cross	Height (cm)	Girth Size (cm)	Semi-annual Leaf Production
ALD	320.8	68.5	4
ALD x PUR	403.1	97.4	4
PUR x ALD	404.5	89.1	4
TAC x PUR	380.2	98.4	4
PUR x TAC	402.4	101.9	4
PUR	468.4	104.4	4
TAC	372.5	95.6	4
ALD x BAY	375.2	89.2	5
BAY x ALD	428.6	107.5	4
BAY	440.0	108.6	4
CÑO x BAY	393.0	86.8	4
BAY x CÑO	368.2	91.3	4
CÑO	323.0	66.5	3

CONCLUSION

Root development in hybrid coconuts was influenced by parental cultivars. Hybrids of tall and dwarf parents developed root systems that were less extensive and less dense than that of the talls but were more extensive and denser compared with that of the dwarf parents. Further, crosses involving a cultivar with heavier roots like BAY developed better root systems than crosses involving a cultivar with poor root development like PUR. Reciprocal hybrids, however, did not show a consistent trend as to the influence of maternal parent on root development.

Hybridization improved the growth of fine roots specifically beyond 1 m distance from the palm. Good development of fine roots had contributed much to the better growth of the hybrids relative to their dwarf parents.

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Appendix Table 1. Recommended fertilizer rates for coconut by the Philippine Coconut Authority

Age of Palm	Ammonium Sulfate/Muriate of Potash (g/palm)
At planting	150/100
6	200/150
12	500/500
24	750/750
36	1000/1000
48	1500/1250
Bearing onwards	2000/1500