A Comparative Study of the Growth and Nitrogen Accumulation Capacity of Hybrid Coconut (Cocos Nucifera L.) Seedlings

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Seedlings of three hybrid crosses were compared for growth characteristics and their potential for nitrate reduction. MYD × WCT seedlings exhibited higher net assimilation rate (NAR), relative growth rate (RGR), crop growth rate (CGR), leaf area index (LAI), and leaf area ratio (LAR), in comparison with MOD × WCT and COD × WCT. The total quantity of nitrate reduced through nitrate reductase (NR) activity by the leaves of MYD × WCT was 2.6 and 8.2 times higher than in MOD × WCT and COD × WCT, respectively. The percentage of nitrogen contributed by the leaves to the total shoot nitrogen varied from 6.7 to 19.9. Nitrogen uptake efficiency (NupE) of MYD × WCT was 0.41 as against 0.25 and 0.014 in MOD × WCT and COD × WCT, respectively. Differences were also obtained in leaf sugar and starch levels of hybrids. The data show that MYD ÷ WCT is superior to both MOD × WCT and COD × WCT in all its growth attributes.

Key Words: *Cocos nucifera* L., nitrogen uptake efficiency, nitrate reductase activity, leaf area, dry matter accumulation

INTRODUCTION

In recent years, several hybrid crosses between indigenous and exotic cultivars of coconut have been developed in India. Evaluation of these hybrids using biochemical and physiological criteria at the seedling stage is important in view of the long period required for flowering and yield. Seedling selection criteria in coconut have been developed by Liyanage (1955) on the basis of correlations obtained between seedling characteristics and their yield as adult palms. However, more detailed investigations on coconut seedling physiology have not been carried out. Work done in oil palm has shown that the rate of growth in the main nursery is correlated with early development in the field and adult palm yield over at least the first 2 years of bearing (Tan and Hardon 1976). Based on these results, it has been suggested that by using nursery selection procedures it might be possible to select the more vigorous hybrids to effectively increase yield.

This study was, therefore, taken up with a view to comparing three hybrid crosses for some components which have been shown to be determinants of crop growth and yield (Whittington 1981).

MATERIALS AND METHODS

One hundred seedlings each of three hybrids: Chowghat Orange Dwarf × West Coast Tall (COD × WCT), Malayan Orange Dwarf × West Coast Tall (MOD × WCT), and Malayan Yellow Dwarf × West Coast Tall (MYD × WCT) were raised in the sand bed nursery with five replications at a spacing of 0.3 m × 0.3 m. Irrigation was provided at weekly intervals to the seedlings during summer months. Observations of seedling growth were taken at 6, 8, 10 and 12 month stages as reckoned from the date of germination. In all four stages, 10 seedlings of each hybrid were selected at random, with the exclusion of the border plants, and were used for destructive sampling in the estimation of leaf area and shoot dry mass. The individual values presented in this paper are the means of 10 replicates.

After detaching the thick rachis from the laminar portion, leaf area was measured with an electronic leaf area meter (Licor 3000). Total shoot dry mass was determined after drying the plant parts in an electric oven at 80°C for 48 hr. Seedling growth characters like relative growth rate (RGR), crop growth rate (CGR), leaf area ratio (LAR), leaf area index (LAI), and net assimilation rate (NAR) were estimated following the method of Kvet et al. (1971).

Nitrate reductase (NR) activity was estimated *in vivo* by Jaworski's procedure (1971) with some

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modifications (Shivashankar and Ramadasan 1983). For the study of the rate of nitrate accumulation by plants, 10 seedlings of each hybrid were given uniform dressing of nitrogenous fertilizer. The total amount of nitrate reduced by the leaves in 1 month was computed by multiplying the cumulative NR activity by a factor of 15, computed as the ratio of the total area under the curve showing the diurnal changes in the enzyme activity to its peak activity at 2 P.M. (Shivashankar and Rajagopal 1983). Total reduced nitrogen (N) was determined following the microkjeldahl procedure (AOAC 1975). Reducing sugars and total sugars were extracted from dry tissue powders in 80% alcohol following Highkin and Frankel (1962) and estimated using the method of Somogyi (1952) and Dubois et al. (1956) respectively. Starch was extracted following McCready et al., and estimated following Somogyi (1952). Nitrogen uptake efficiency (NupE) was computed following Sanford and MacKown (1986).

RESULTS

Leaf Area Development and Dry Matter Accumulation

The rate of leaf area development and dry matter accumulation in MYD × WCT seedlings was significantly higher than in MOD × WCT and COD × WCT at all stages of growth (Table 1). At the 12th month stage, the leaf area of MYD × WCT was 1.011 m^2, as against 0.82 m^2 and 0.62 m^2 for MOD × WCT and COD × WCT, respectively. The increment in shoot dry mass also showed a similar trend. The leaf area and shoot dry mass of MYD × WCT seedlings at the 6th month stage were comparable to those at the 8th month in the case of MOD × WCT, and at the 10th month in the case of COD × WCT. The rate of production of new leaves and increment in height were also generally higher in MYD × WCT than in the other two hybrids.

NAR (Rate of increase of dry matter/dm^2 leaf area/$month^1$) which is an index of assimilation efficiency, was not significantly different among the hybrids (Table 2). CGR (Increase in dry matter/dm^2 ground area/$month^1$) and LAI among the hybrids were significantly different at all stages (Tables 2 and 3). MYD × WCT recorded higher LAI than COD × WCT and MOD × WCT. CGR decreased in both MOD × WCT and MYD × WCT while COD × WCT showed a gradual increase up to the 12th month. RGR was significantly higher at the 8th month in MYD × WCT, while COD × WCT showed the lowest values of RGR. LAR also differed significantly among the hybrids up to the 10th month.

Nitrate Reductase Activity, Nitrogen Uptake Efficiency, and Nitrogen Accumulation

The substrate-inducible NR activity in leaves of MYD × WCT was significantly higher throughout the experiment period (Fig. 1). The endogenous activity measured before application of nitrogenous fertilizer was also higher in MYD × WCT. The total amount of nitrate reduced by the leaves of MYD × WCT was about three times higher than in MOD × WCT. Also MYD × WCT accumulated more N in the shoot (1.90 g) as compared to 1.24 g in MOD × WCT and 0.69 g in COD × WCT (Table 4). The percent increase in shoot dry weight in 1 month was similar in the hybrids. The contribution of reduced N by way of shoot nitrate reduction was 6.7%, 10%, and 19.9% of the total shoot N in COD × WCT, MOD × WCT, and MYD × WCT, respectively. The rate of N accumulation in all the hybrids was significantly correlated with dry matter production ($r = 0.5782^{**}$).

Starch and Sugar Contents

MYD × WCT showed higher levels of reducing sugars and very low starch in leaves, while COD × WCT exhibited an exactly opposite trend (Table 5).

DISCUSSION

Net assimilation rate is a measure of the photosynthetic efficiency which is dependent on the incident solar radiation. The hybrids did not show significant differences in values of NAR. However, NAR was maximal between 6 and 8 months and tended to decrease subsequently. This may be attributed to the large increase in leaf area beyond 8 months, leading to mutual shading by the leaves. The results show that assimilation efficiency may not be a major factor contributing to growth differences among the hybrids.

CGR is the product of NAR and LAI and so it gives the rate of increase of dry matter per unit land area. The hybrids showed significant differences in CGR up to the 10th month; although the values were gradually decreasing. At all stages, MYD × WCT recorded higher values of CGR. The observation shows that the MYD × WCT is highly efficient in dry matter production (Table 2). Obviously, the large increases in leaf area of MYD × WCT is an important factor contributing to its higher rates of dry matter production. Significantly higher values of LAR in MYD × WCT also shows that it is able to maintain a high proportion of photosynthetic area in relation to non-photosynthetic area. But the decrease in

CGR beyond the 8th month confirms that the optimum LAI is reached at 8th month.

RGR, a measure of dry matter accumulation, (Kvet et al 1971) was higher in MYD × WCT than in MOD × WCT and COD × WCT, suggesting that differences do exist in the growth rates of the hybrids.

The high rates of endogenous and inducible NR activity in MYD × WCT are indicative of high nitrate reducing potential, under both sub-optimal and optimal conditions of substrate availability, which is largely beneficial to its growth and development. Palis and Bustrillos (1976) concluded from their experiments on winter wheat that a high ratio of induced-to-endogenous NR activity is a desirable trait in the selection of plants for better N utilization status. Hence, MYD × WCT, which exhibits a relatively high ratio of induced-to-endogenous activity, must be superior to other hybrids.

The amount of N assimilated by the leaves was observed to have a contribution to the total N pool ranging from 6.7 to 19.9% only. Aside from the leaves, the roots thus could have played a major role in N assimilation. It has been shown by Wallace (1986) that in certain legumes 30-60% of the total NR activity occurs in the roots. The roots also metabolize a major portion of the absorbed N, resulting in either less nitrate available for transport (Olday, Barker, and Maynard 1976), or restriction in the secretion of nitrate from the symplast of the root to the xylem (Radin 1978). Since the seedlings in the present study were given high N levels, it appears that the low contribution of reduced N by the leaves may be due to a low transport rate at the roots.

Sanford and MacKown (1986) measured the NupE in soft red winter wheat genotypes by determining the total plant N as a function of N supply, and showed it was associated with a significant portion of genotypic variation in yield and protein content. In our experiments on coconut, the NupE of MYD × WCT was comparatively higher than those of MOD × WCT and COD × WCT (Table 4). The NR activity was positively correlated with shoot dry weight (r = 0.60). Earlier, a similar relationship was reported (Shivashankar, Rajagopal, and Ramadasan 1985) in F_1 seedlings of COD × WCT hybrid. It is clear from the results presented that leaf NR activity could serve as a valuable index of the plant's ability to accumulate dry matter. This conforms with the suggestion of Hageman et al. (1967) that leaf NR can be used to select high yielders.

High starch content in leaves has been reported as an end-product inhibitor of photosynthesis (Huber 1981). Also, in COD × WCT hybrid, very high respiratory rates lead to low rates of dry matter accumulation (Shivashankar, Kasturi Bai, and Ramadasan 1984). Since the nitrate reducing capability is dependent on photosynthesis, NR activity is also affected. The net result is the reduced rate of leaf area development and dry matter accumulation in COD × WCT as compared to MOD × WCT.

CONCLUSION

From a physiological viewpoint, the MYD × WCT is superior to MOD × WCT and COD × WCT in all the growth characteristics. The comparatively high rates of nitrate assimilation, leaf area development, dry matter production, and other associated characteristics exhibited by the MYD × WCT seedlings in the nursery are indicative of potentials for high productivity. The planting of the seedlings has already been made to test the correlation between the seedling characteristics and their yields at their maturity.

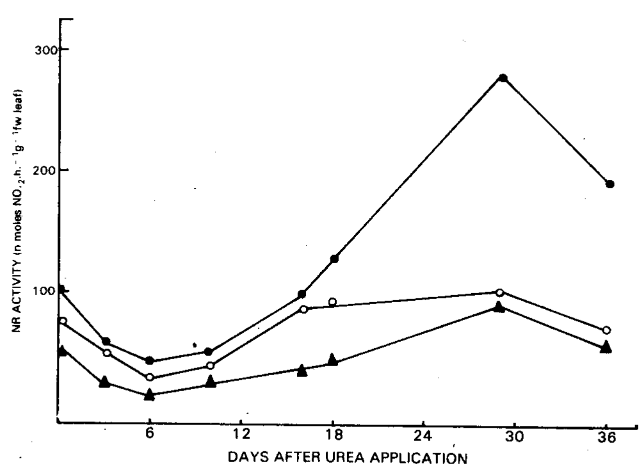

Figure 1: Changes in leaf nitrate reductase activity after application of N (○—○ MOD × WCT; MYD × WCT ●—● ▲—▲ COD × WCT)

TABLE 1. Growth parameters of hybrid seedlings

HYBRID	AT 12TH MONTH Height cm	Girth cm	No. of leaves	LEAF AREA (m^2) Months 6th	8th	10th	12th	SHOOT DRY MASS (g) Months 6th	8th	10th	12th
COD × WCT	145.40 (7.21)	13.4 (0.15)	7.0 (0.14)	0.205 (0.001)	0.318 (0.002)	0.441 (0.002)	0.619 (0.003)	49.16 (2.424)	68.65 (2.596)	103.22 (11.055)	130.67 (10.225)
MOD × WCT	156.70 (6.92)	16.0 (0.63)	7.6 (0.25)	0.279 (0.003)	0.426 (0.004)	0.609 (0.004)	0.822 (0.005)	57.12 (7.018)	91.45 (9.407)	117.06 (9.158)	154.08 (10.659)
MYD × WCT	164.40 (5.86)	17.8 (0.63)	9.0 (0.32)	0.410 (0.007)	0.550 (0.004)	0.782 (0.003)	1.011 (0.119)	87.36 (9.571)	128.72 (12.428)	164.60 (13.437)	197.90 (15.128)
C.D (P = 0.05)	—	1.6**	0.758**	0.14**	0.10**	0.10**	0.23**	21.4**	27. 9	34.7**	—

Values are mean of 10 replicates.
( ) SE of mean.
**Significant at 1% level.

TABLE 2. Net assimilation rate, crop growth rate, and relative growth rate of the hybrid seedlings at three stages

HYBRID	NAR (g/dm^2/month) Months 6 – 8	8 – 10	10 – 12	CGR (g/dm^2/month) Months 6 – 8	8 – 10	10 – 12	RGR (g/dm^2/month) Months 6 – 8	8 – 10	10 – 12
COD × WCT	0.42 (0.03)	0.29 (0.02)	0.26 (0.01)	1.19 (0.08)	1.20 (0.08)	1.52 (0.05)	0.20 (0.0004)	0.12 (0.001)	0.12 (0.0001)
MOD × WCT	0.45 (0.09)	0.31 (0.06)	0.23 (0.08)	2.15 (0.40)	1.90 (0.23)	1.75 (0.20)	0.22 (0.0028)	0.16 (0.0013)	0.12 (0.0008)
MYD × WCT	0.46 (0.04)	0.35 (0.04)	0.22 (0.02)	2.30 (0.21)	1.98 (0.23)	1.97 (0.11)	0.26 (0.0009)	0.16 (0.0009)	0.11 (0.0005)
C.D (P = 0.05)	—	—	—	7.88*	5.75*	—	0.10**	—	—

* Significant at 5% level.
** Significant at 1% level.

TABLE 3. Leaf area index and leaf area ratio at various growth stages of hybrid seedlings

HYBRID	LAI Months 6	8	10	12	LAR (cm^2/g) Months 6	8	10	12
COD × WCT	2.27± 0.15	3.54± 0.18	4.94± 0.28**	6.94± 0.28	36.9± 2.42	47.0± 1.44	42.9± 0.56	45.2± 0.46
MOD × WCT	3.10± 0.35	4.73± 0.42	6.72± 0.48	9.14± 0.55	49.2± 1.66	46.2± 3.12	47.0± 2.13	49.7± 2.69
MYD × WCT	4.48± 0.65	6.48± 0.85	8.80± 1.12	11.51± 1.39	45.1± 2.27	47.2± 2.27	48.0± 2.18	52.4± 2.45
CD (P = 0.05)	1.60**	1.65**	2.13**	2.60%	13.7**	7.15*	5.35**	5.40**

Values are mean + SE of replicates
** Significant at 1% level.
* Significant at 5% level.

TABLE 4. Total amount of nitrate reduced and N accumulated by the seedling shoots in 1 month after N application (50g N/seedling)*

HYBRID	% INCREASE IN SHOOT DRY WEIGHT	TOTAL SHOOT N (g)	TOTAL NITRATE REDUCED BY SHOOT (milli moles)	N CONTRIBUTED BY SHOOT NITRATE REDUCTION (mg)	NupE	% N CONTRIBUTED BY SHOOT
COD × WCT	22.1	0.698 ± 0.036	3.29 ± 0.34	46.06 ± 4.76	0.0143	6.13
MOD × WCT	23.8	1.240 ± 0.075	8.81 ± 2.35	123.34 ± 32.90	0.25	10.00
MYD × WCT	24.9	1.901 ± 0.068	27.08 ± 4.32	379.11 ± 60.48	0.40	19.99
CD (P = 0.05)		0.190	—	—		

*N rate recommended at 6 months after field planting.

TABLE 5. Leaf starch and sugar content in the hybrid seedlings (mg/100mg dry wt. of leaf)

HYBRID	TOTAL SUGARS	REDUCING SUGARS	STARCH
COD × WCT	3.91 ± 0.28	1.74 ± 0.22	8.53 ± 0.81
MOD × WCT	5.29 ± 0.33	2.94 ± 0.82	7.82 ± 0.85
MYD × WCT	6.18 ± 0.03	2.99 ± 0.29	6.46 ± 0.76
CD (P = 0.05)	0.91**	0.82**	—

** Significant at P = 0.01.

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