CANOPY STRUCTURE ON GROWTH AND DEVELOPMENT OF CASSAVA (*Manihot esculenta* CRANTZ)[1] /

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Resumen

Se estudió el crecimiento y desarrollo de 10 genotipos de yuca clasificados en cuatro grupos con base en sus características morfológicas. Los resultados indican que para obtener los rendimientos de 2.5 por periodos largos la altura de la planta, el número de nudos y el grosor del tallo no se relacionan con el rendimiento de tubérculos, aunque aumentan el peso seco total. La longevidad de las hojas de yuca bajo las condiciones de kerala, varió entre 36 y 54 dias, ocurriendo la caída de hojas en forma acelerada después del sexto mes debido a la sequia. Si se desean tipos con alta ramificación es preferible contar con hojas angostas lobuladas.

Introduction

The productivity of cassava in terms of calories per unit area appears to be significantly higher than that of other food crops (2). However, great variations are noticed among cultivars with respect to tuber yield. It is being suggested that the differences in yields are largely associated with leaf area index, orientation of leaves, photosynthetic efficiency and partitioning of dry matter (1, 3, 4, 6, 7). Investigations were made in the present study to evaluate the association of canopy structure in relation to productivity of cassava genotypes under rainfed conditions in Kerala.

Materials and methods

Field experiments were conducted at the Central Tuber Crops Research Institute, Trivandrum during 1977 and 1978 cropping seasons, with the following ten varieties of cassava in a randomized block design, with four replications. Based on the morphological characters, the ten genotypes were classified into four groups:

1. Non-branching with broad lobed leaves: M. 4, H.2304, H. 165 (tall) and C.I. 590 (short).

2. Semi-branching with broad lobed leaves: H.97 (tall)

3. Late branching with broad lobed leaves: C I.288 and C E.161

4. Early and profusely branching types with different leaf shape:

   a. Broad lobed leaves C.E.22.
   b. Medium lobed leaves H.1423
   c. Narrow lobed leaves C I.167

Stem cuttings containing 6 to 8 buds were planted at 90 x 90 cm apart, following the recommended dosages of manures (FYM 12.5 t/ha) and fertilizers (NPK: 100:100:100 kg/ha). Two shoots per plant were allowed to grow and the crop was harvested by the 10th month. Monthly observations on dry matter distribution, plant height, number of nodes, leaves, and tubers were recorded from the 1st month till harvest. For non-destructive growth analysis four plants in each replication were marked at random and periodical observations on plant growth, leaf area, number of leaves retained, fallen leaves and new leaves produced per plant were recorded. The leaf area was calculated using the linear measurement method (5). Since similar results were obtained for both seasons, the results of 1978 crop alone are presented and discussed.

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Results

The canopy growth among the genotypes indicated that the cultivars H.2304, C.E.22 and C.E.161 established early canopy coverage when compared to others. Among the non-branching types, the hybrid H.2304 retained more leaves during the growth period (average of 60 leaves per plant) while the short statured non-branching type C.I.590 retained an average of 45 leaves per plant which was on par with the local M.4 and the hybrids H.165 and H.97 (Table 1). The rate of new leaves produced per shoot per week was significantly higher in branching types when compared to non-branching types. Great variations were noticed regarding this factor among branching varieties (10 to 22 leaves), while the values for non-branching varieties remained almost the same (4 to 5 leaves). It was observed that the leaf production was controlled by soil moisture availability and intensity of branching.

Significant differences were noticed among the genotypes with regard to plant height, canopy growth, number of nodes, stem thickness, leaf life and rate of leaf shedding (Table 2). The number of nodes per plant depended on plant height, internodal length and intensity of branching, while the number of leaves retained depended on the rate of leaf production, leaf life and node number, in addition to branching characters. Though the collection C.I.590 is short statured and non-branching its node number was on par with H.165, indicating that C.I.590 possesses shorter internodes. Stem thickness among varieties showed little differences and had no relationship with tuber yield.

The leaf life of H.2304 and C.E.22 was 52 and 54 days respectively, which was significantly higher than that of the other varieties (36 to 41 days). The varieties also differ significantly with respect to leaf area and leaf area index (LAI). The mean LAI of the profusely branching variety C.E.22 during the growth period was 4.2 (Table 3) which was significantly greater than that of the other varieties. The mean LAI of H.2304 (high yielding) was 2.51 which was on par with other high yielding hybrids H.165 and H.97; the late branching types C.I.288 and C.E.161 and the profusely branching variety C.I.167 (narrow lobed leaves). The rate of leaf shedding in semi and non-branching varieties did not differ from each other (10 to 13), while in branching types the values differed significantly (16 to 24). Hence it is clear that the leaf area duration depends on the specific leaf area, leaf life and rate of leaf production.

Though the varieties M.4 and H.2304 were grouped as non-branching types, 25 percent of the population were found to be branched after the fourth month. The intensity of branching in H.97 was 60 per cent, which was limited to secondary branching, in contrast to multiple branching observed in profusely branching types.

The net assimilation rate (NAR) and crop growth rate (CGR) permit interesting observations (Table 4). All the profusely branching types (C.E.22, H.1423 and C.I.167) recorded a very low NAR (15.3 to 25.6 mg/dm^2/day) when compared to other groups, indicating that the photosynthesis at canopy level was reduced due to mutual shading. Both H.2304 and the local M.4 recorded a maximum NAR of

Table 1. Rate of leaf production and number of leaves retained during the maximum growth period in cassava genotypes.

Variety	Months after planting											
	2		3		4		5		6		Average	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
M–4	34	4	43	6	47	6	35	2	31	2	38	4
H–2304	50	5	61	7	57	5	69	5	62	4	60	5
H–1423	43	10	81	15	93	15	106	27	83	27	81	19
H–165	32	6	46	6	52	5	50	5	39	4	44	5
H–97	38	8	48	6	61	12	50	12	41	12	48	10
C.E.22	57	10	113	18	141	27	214	30	203	12	146	19
C.E. 161	48	7	60	6	60	15	72	18	61	12	60	12
C.I.167	41	8	66	18	100	36	129	36	132	12	94	22
C.I.288	40	5	58	7	64	9	76	18	68	12	61	10
C.I.590	35	5	46	5	55	4	46	2	42	2	45	4

a Number of leaves retained per plant.

b Rate of leaf production per shoot per week.

Table 2. Variations in growth parameters among the genotypes.

Variety	Plant ht (cm)	Nodes/plant	Stem thickness (cm)	Leaf life (days)	Rate of leaf shedding No./plant/week	Canopy growth rate (cm/week)	Branching (%)
M–4	201.0	377	6.0	37	11	5.3	25
H–2304	196 0	350	7 0	52	10	5.4	25
H–1423	136 2	647	7.0	41	21	4.0	100
H–165	145.0	254	6.0	41	13	6.0	nil
H–97	197.5	331	7 0	41	11	5 6	60
C.E.22	122.5	917	7.5	54	24	3.4	100
C E.161	197.0	437	8.0	36	16	5.6	100
C.I.167	141 2	606	7.0	37	23	5.0	100
C.I 288	153 3	456	7.5	40	16	4 6	80
C.I.590	120.0	255	6 0	37	12	4 3	nil
C.D. (5%)	15.34	22.4	0.85	6.99	4.35	0 83	–

Table 3. Leaf area (dm^2) per plant and leaf area index in cassava genotypes during maximum growth period.

Variety	Months after planting 2		3		4		5		6		Average	
	LA	LAI	LA	LAI	LA	LAI	LA	LAI	LA	LAI	LA	LAI
M–4	80 4	0.99	129 5	1 59	129.5	1 59	171.6	2.11	110.2	1.36	124.2	1 53
H–2304	124 7	1.54	227 4	2.80	254.0	3.14	235 2	2.90	175 9	2.17	203.4	2.51
H–1423	112 2	1 38	300 9	3 71	366.3	4 50	364 7	4 52	145 0	1 78	257 8	3.18
H–165	83.5	1 02	163 5	2.01	219 3	2.70	193.7	2 39	156.0	1 93	163 2	2 01
H–97	100 4	1 23	151.6	1 87	238 7	2 95	205.0	2 53	167.1	2 06	172 6	2 13
C.E 22	154 4	1 90	295 0	3 63	467.1	5.76	434.0	5 35	337 6	4 16	337.6	4 16
C.E.161	116 2	1 42	209 8	2 59	204.3	2 52	241.0	2 98	176 4	2 18	189 5	2.34
C.I.167	77 1	0 95	139 8	1 73	231.0	2 85	313 5	3 87	240 6	2 97	200 4	2 47
C I 288	159 3	1 95	238 7	2 94	222 7	2 74	224 5	2 77	127 5	1 57	194 5	2 40
C.I.590	86 7	1 07	123 3	1 56	177 2	2 18	122 8	1 51	122.7	1 51	126.5	1 56

Table 4. Net assimilation rate, crop growth rate and total dry matter production of cassava genotypes.

Variety	NAR ($mg/dm^2/day$)	CGR (kg/ha/day)	Total dry matter at harvest (g/plant)
M–4	59 9	50 6	1 230 7
H–2304	61 8	64 0	1 554 7
H–1423	25 6	48 1	1 169 4
H–165	48 6	50 5	1 226 2
H–97	48 0	64 9	1 578 1
C E 22	15 3	35 3	859 0
C.E 161	47 8	51 7	1 256 7
C.I 167	23 3	50 0	1 211 6
C.I.288	45 5	47 3	1 147 2
C.I.590	43 0	34 4	835 1
C.D.(5%)	5 43	3 96	381 01

61.8 and 59.9 mg/dm^2/day respectively which were significantly superior to other hybrids and collections.

The crop growth rate of the genotypes did not show any relationship with NAR. The CGR of H.2304 and H.97 were on par with each other (64.0 and 64.9 kg/ha/day respectively) but significantly greater than those of other varieties. The short profusely branching type C.E.22 registered lower CGR (35.3 kg/ha/day) which was on par with the short non-branching type C.I.590, even though the collection C.E.22 recorded a maximum LAI of 4.2 in contrast to C.I.590.

The yield parameters (Table 5) revealed that both tuber number and mean tuber weight are important factors for tuber yield. The tuber number in H.2304 was 14 while in H.97 it was only 7. However, both recorded higher yield, indicating that this can be achieved either through a higher tuber number or through greater individual tuber weight which would explain the sink capacity.

The total dry matter production depends on tuber weight and stem growth. The collection C.E.22 accumulated more dry matter in the shoot while the other varieties accumulated more dry matter in the economically useful part (tuber). However, there exist significant differences among the cultivars with respect to tuber yield and total dry matter production and distribution (Table 5 and Figure 1). All the three released hybrids H.97, H.165 and H.2304 were found superior to other genotypes with respect to tuber yield. The harvest indices of branching types were also lower when compared to non-branching types which clearly indicated that the former plant type accumulated more biomass in the shoots.

Discussion

For higher levels of productivity it is obviously necessary to have sufficient leaf area to intercept most of the incoming radiation but it has been reported that many varieties of cassava do not have sufficient leaf area to achieve their potential yield (1, 6). In the present study it was noticed that the tuber yield is influenced by canopy structure, since greater variations were noticed among the genotypes with respect to LAI, NAR, CGR and harvest index.

Contrasting statements were made between the association of leaf area and tuber yield. Williams and Ghazali (7) reported that the lowest yielding varieties had the highest leaf area, while Enyi (3) stated that high yielding varieties had the highest leaf area per plant. However, the results of the present experiment clearly show that the leaf area has a definite relationship with tuber yield. The varieties M.4 and C.I.590 maintained a low LAI when compared to other non-branching varieties, H.2304 and H.165, and the tuber yield of the above hybrids was on par with each other but significantly superior to M.4 and C.I.590. This indicates a positive relationship between LAI and tuber yield as far as non-branching varieties is concerned. The present study also suggestes that a LAI beyond a certain optimum may favour more accumulation of dry matter in vegetative parts as evidenced from the low yield of the profusely branching type C.E.22.

The advantage of narrow lobed leaves over broad lobed leaves was also demonstrated in the present experiment, supporting the findings of Williams and Ghazali (7). The narrow lobed variety C.I.167, though branched profusely, recorded higher yields when compared to C.E.22, which possesses broad lobed leaves. Hence it is suggested that under dense

Table 5. Variations in yield parameters in cassava genotypes.

Variety	Tuber No. plant	Mean tuber weight (g)	Dry matter of tuber (%)	Tuber yield (g/plant)
M–4	10	234.0	41.9	2 280
H–2304	14	237.4	39.3	3 280
H–1423	13	174.4	37.9	2 208
H–165	10	343.3	30.2	3 350
H–97	7	464.4	39.3	3 206
C.E.22	9	193.5	28.0	1 722
C.E.161	10	269.8	32.0	2 650
C.I.167	10	245.4	37.2	2 360
C.I.288	9	241.1	36.2	2 060
C.I.590	11	216.9	31.0	2 310
C.D. (5%)	2.02	78.47		385.8

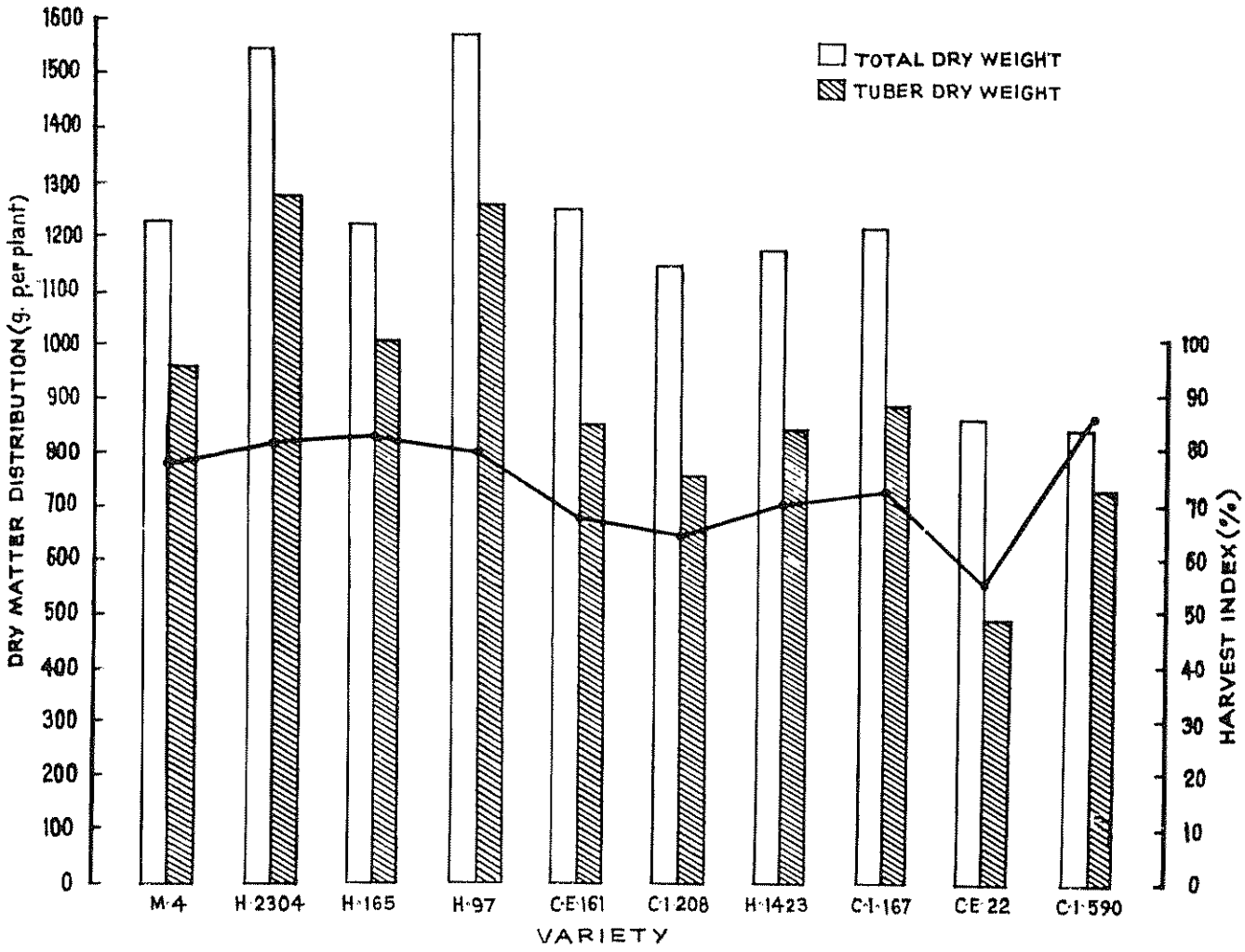

Fig. 1 Variation in drymatter production and harvest index among the genotypes

canopy, which developed due to profuse branching, small and narrow lobed leaves are desirable characters. Even though the leaf number and intensity of branching in C.I.167 were very high, it recorded a LAI of only 2.47. It is also expected that the leaves that are vertical at midday will allow better light penetration to the lower levels of the canopy. But Cock (1) observed only little differences in growth rates of varieties having more vertical leaves against those having horizontal leaves at similar leaf area indices. However, in the present study the advantage of vertically oriented leaves on crop growth rate was noticed with H 1423 under dense canopy structure

The photosynthetic efficiency, estimated as NAR, was negatively correlated with LAI (3). This is in agreement with profusely branching types only which registered a high LAI due to the dense foliage and a low NAR caused by mutual shading. However, in the case of non-branching types, the LAI has no relationship with NAR. The other morphological traits, like number of nodes, plant height and stem thickness showed no direct effect on tuber yield but may contribute more towards total dry matter production. Reports of Williams and Ghazali (7) and Cock (1) indicated that more total dry matter production does not necessarily lead to a higher tuber yield. The proportion of dry matter distribution between roots and vegetative parts varied greatly among the genotypes (Figure 1) which suggests that the partitioning of photosynthate is under genetic control.

Summary

Growth and development of ten cassava genotypes classified under four groups based on morphological

characters were studied. The results showed that an optimum LAI of 2.5 maintained for long period is most essential to achieve high yield. Plant height, node number and stem thickness have no relationship with tuber yield but increased the total dry weight. The leaf life of cassava under rainfed condition in Kerala, ranges from 36 to 54 days and the plants started shedding leaves faster after the 6th month due to dry spell. For profusely branching types the narrow lobed leaves are desirable characters.

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