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Partitioning of dry matter in relation to yield performance in five cultivars of cowpea, *Vigna unguiculata* s.sp. *unguiculata.*

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Abstract

Dry matter accumulation (DMA) and its pattern of partitioning were studied in five cultivars of cowpea, *Vigna unguiculata* s.sp. *unguiculata* (L.) Walp.

Generally, TVx 1839-9G and TVx 1193-9F flowered and podded earliest while TVu 1190E and Tvu 1977 were the slowest to flower and pod; Ife Brown was intermediate. TVu 1977 and TVu 1190E accumulated more dry matter in their stems, leaves and pods than any of the other cultivars. The proportion of dry matter deployed into pods was highest in TVx 1836-9G (81 percent) and TVx 1193-9F (75 percent), and least in TVu 1190E and TVu 1977 (63 and 67 percent each). In Ife Brown, it was 67 percent. Grain yields were similar in TVu 1977, TVu 1190E and TVx 1836-9G (505, 528 and 516 kg/ha respectively), but only 359 kg/ha in Ife Brown. It was 472 kg/ha in TVx 1193-9F. Harvest index was low in TVu 1190E and TVu 1977 (18 and 20 percent, respectively), medium in Ife Brown (23 percent) and high in TVx 1836-9G and TVx 1193-9F (30 and 26 percent respectively).

Correlation between seed yield and DMA though positive, was not significant. No correlation was observed between seed yield and harvest index, but correlation between DMA and harvest index was negative and significant.

Introduction

Yield in cowpea *(Vigna unguiculata* s.sp. *unguiculata* (B.) Walp) depends upon the accumulation of dry matter in the seeds. As in other grain legumes, this is controlled by the length of the reproductive period which in turn, depends on the time from anthesis to maturity of individual pods (Wien and Ackah, 1978). Ezedinma (1973) reported that cowpea pods generally completed their development and matured between 12 and 15 days after fertilization. Wien and Ackah (1978) also reported on the extremely rapid development rate of Prima cowpea pods (18 days from anthesis to maturity of individual pods). Their study showed that cowpea seed yields were not limited because of low rates of dry matter production, but rather through

both an insufficiently long period of grain filling and a restrictive amount of reproductive tissue.

The patterns and duration of assimilate deployment into the pods depend on the canopy architecture of the plants. Maintenance of photosynthetically active leaves as long as possible during pod filling and seed maturation, and efficient partitioning of dry matter into reproductive structures are factors identified to play major roles in seed production in cowpea (Ezedinma, 1973).

Hanway and Weber (1971) observed differences in the rates of dry matter accumulation (DMA) among eight soybean cultivars. Rates of DMA varied from 88 to 149 kg/ha per day among the cultivars. Egli and Leggeft (1973) also observed differences in patterns of DMA in the various plant components of determinate and indeterminate soybean cultivars. The determinate cultivar reached its maximum height faster, accumulated higher dry matter in the stems, and produced greater vegetative material at initial flowering than the indeterminate cultivar. In a study with dry bean (*Phaseolus vulgaris* L.) however, Robittaile (1978) observed similar patterns in DMA of three cultivars with varying growth habits, and suggested that plant type might not be an important factor in determining yield potential.

Recent research on cowpeas has involved screening germplasm collection for physiological characters that may be exploited to improve the rate of dry matter production and its partitioning into economic yield. This study was therefore conducted to determine the proportion of assimilates deployed into vegetative relative to reproductive parts of five cultivars of cowpea.

Materials and Methods

Five cowpea cultivars (TVu 1190E = Vita 3, TVu 1977 = Vita 4, Ife Brown, TVx 1193-9F, and TVx 1836 – 9G) were grown on sandy loam soil at the University of Ife Teaching and Research Farm during the late cropping season of 1978 The traits measured included days-to-flowering and days-to-podding; partitioning of dry matter into stems, leaves, and pods; pod and seed characteristics; and grain yield.

The experimental design was a randomised complete block with four replicates. Each replicate consisted of five 8-row plots measuring 8.1 x 6.0m per plot. Planting was done on the flat, following initial ploughing and harrowing at a spacing of 0.3m within the row and 0.75m between rows. Three or four seeds were planted per hill and thinned to two plants per stand at 9 days after sowing.

Plants were sprayed six times with lindane[1] (20% a.i.).at 0.57% field strength, beginning from flowering. A total of three manual weedings was done. Fertilizer (P and K) was applied at 32 days after planting (DAP) using single superphosphate and muriate of potash, at 45 and 60 kg/ha, respectively.

Sampling for DMA was done weekly from the second and seventh rows of each plot, beginning from 11 DAP until pod maturity. At each sampling, ten plants from five consecutive stands were uprooted, placed in labelled polythene bags, and transported to the laboratory. Roots of the plants were excised and discarded while the shoots were separated into stems, leaves, and pod fractions. Pods were not present until the 8th sampling date. Each component was bagged separately for each plot and oven-dried at 70 to 80°C for 48 to 72 hours. Dry weights were determined and analysed as means for single plants.

Five plants were randomly selected from the fourth and fifth rows of each plot and tagged prior to flowering for flower and pod counts. Counting commenced as soon as the first flowers were observed, and continued daily till about 70 DAP.

Mature pods were picked for grain yield determination from the fourth and fifth rows. Pod harvest extended over two to three weeks depending upon the cultivar. The harvest from each plot was sun-dried, weighed, and later pooled for determination of grain yield and shelling percentage. Also, harvest index was determined using the formula,

$$\text{Harvest index} = \frac{\text{Weight of grains}}{\text{Weight of tops at flowering} + \text{Weight of shell}} \times 100$$

All results were subjected to analysis of variance and significant means compared by the LSD test (Steel and Torrie, 1960).

Results and Discussion

Flowering and Podding

Table 1 shows the average numbers of flowers and pods produced per plant in the five cultivars. TVx 1193-9F and TVx 1836-9G were the earliest to flower. These cultivars produced the highest number of

[1]Formulated as Gammalin 20 (Chemicals & Allied Products Ltd.)

flowers up to 62 DAP, followed by TVu 1977 and Ife Brown, while TVu 1190E had the least number of flowers.

In general, Ife Brown produced the highest number of pods followed by TVx 1836-9G and TVx 1193-9F, while the lowest were produced by TVu 1977 and TVu 1190 E.

The differences in earliness to flower were not reflected in the duration of pod growth and maturity. Thus, Ife Brown which had set pods earliest among the cultivars, matured later than TVx 1193-9F. This confirms the findings of Wien and Ackah (1978) that pod development period (PDP) varies among cowpea cultivars.

TABLE 1 – AVERAGE NUMBER OF FLOWERS AND PODS PER PLANT IN FIVE COWPEA CULTIVARS (LATE SEASON, 1978)

Cultivars	*Flowers*				*Pods*			
	Days after planting				*Days after planting*			
	58	*62*	*66*	*70*	*58*	*62*	*66*	*70*
TVu 1190 E	2.7	5.7	7.7	5.1	1.0	3.8	6.0	7.3
TVu 1977	3.7	5.8	7.8	4.8	1.0	4.6	9.3	10.5
Ife Brown	3.7	6.7	4.6	2.0	2.3	7.7	14.4	17.2
TVu 1193-9F	1.9	7.3	5.0	2.9	1.9	6.7	10.2	11.7
TVu 1836-9G	4.1	8.9	7.6	4.4	1.4	5.8	10.4	13.4
$LSD_{(0.05)}$	0.4	0.6	0.7	0.6	0.3	0.7	1.3	1.6

Partitioning of Dry Matter (DM)

Total DM accumulated into stems, leaves, and pods differed significantly among the five cultivars (Table 2). Partitioning of assimilates into roots was not considered because of the uncertainty of quantitative recovery of plant roots from field soil. In all five cultivars, the DM accumulated in the stems remained low from 11 until 32 DAP (Fig. 1). Thereafter, it increased in all cultivars, with TVu 1190E and TVu 1977 showing a more precipitous increase. At 81 DAP, the percentage of DM deployed into the stems ranged from a low of 11.8 in TVx 1836-9G to a high of 27.5 in TVu 1977 (Table 2).

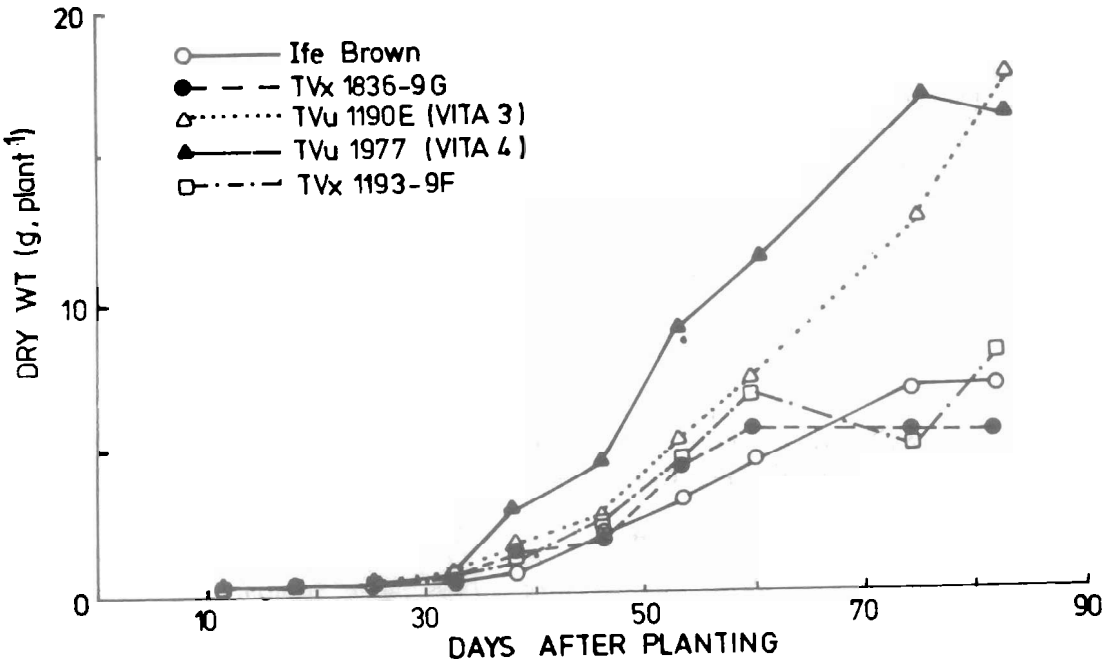

Fig. 1: Partitioning of dry matter into stems of five cowpea cultivars at weekly intervals.

TABLE 2 – DRY MATTER ACCUMULATION AND ITS PERCENTAGE DISTRIBUTION IN THE STEMS, LEAVES AND PODS OF FIVE COWPEA CULTIVARS AT 81 DAP

Cultivar	*Dry weight (g/plant)*						
	Stems		*Leaves*		*Pods*		*Total*
TVu 1190 E	17.4	(23.2)	10.2	(13.6)	47.3	(63.1)	74.9
TVu 1977	16.7	(27.5)	5.8	(9.6)	38.2	(63.0)	70.7
Ife Brown	7.0	(18.1)	5.9	(15.3)	25.7	(66.6)	38.6
TVx 1193-9F	8.0	(15.9)	4.4	(8.8)	38.0	(75.3	50.4
TVux 1836-9G	5.6	(11.8)	3.4	(7.2)	38.0	(81.0	47.0
L.S.D. (0.05)	2.5	(2.8)	1.2	(1.5)	3.4	(3.6)	

Figures in parentheses refer to percent of total accumulation and their LSD values.

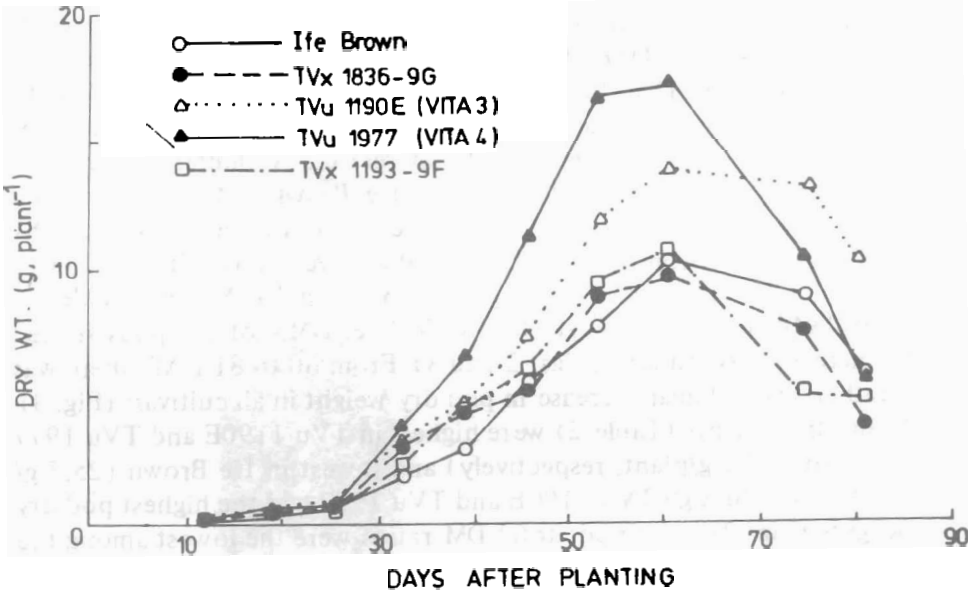

Fig. 2: Partitioning of dry matter into leaves of five cowpea cultivars at weekly intervals.

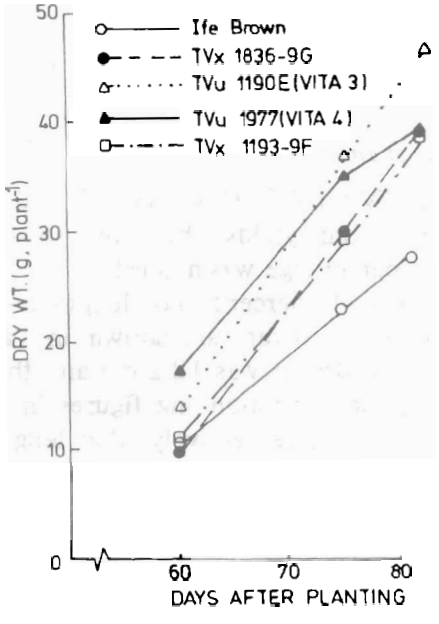

Fig. 3: Partitioning of dry matter into pods of five cowpea cultivars at weekly intervals.

DM accumulation in the leaves of all cultivars increased slowly between 11 and 25 DAP (Fig. 2). Thereafter, the pattern of accumulation changed. In TVu 1977, it increased sharply from 25 to 53 DAP, levelled off between 53 and 60 days which corresponded to the onset of pod filling, and declined rapidly thereafter. A similar pattern was also observed in TVu 1190E (Fig. 2). Ife Brown, TVx 1193-9F and TVx 1836-9G generally accumulated less DM in their leaves. At 81 DAP, the proportion of total DMA in the leaves ranged from a low of 7.2% in TVx 1836-9G to a high of 15.3% in Ife Brown (Table 2).

As DMA in the leaves started to decline, DMA of the pods started to increase very rapidly (Figs. 2 and 3). From 60 to 81 DAP, there was a rather sharp, linear increase in pod dry weight in all cultivars (Fig. 3). Grain dry weights (Table 2) were highest in TVu 1190E and TVu 1977 (47.3 and 38.2 g/plant, respectively) and lowest in Ife Brown (25.7 g/plant). Even though TVu 1190E and TVu 1977 had the highest pod dry weights (Fig. 2), their pod: total DM ratios were the lowest among the five cultivars. The proportion of total DMA in the pods was highest in TVx 1836-9G and TVx 1193-9F (78.0 and 75.3 percent respectively) and intermediate in Ife Brown (66.0 percent), while TVu 1190E and TVu 1977 had 63.1 and 63.0 percent respectively. Thus, those cultivars which had higher DMA in their stems showed corresponding reduction of DMA in the pods. However, on pod-weight-per-plant basis, TVu 1190E accumulated the highest dry matter, and its husk rather than its seeds, accumulated a relatively high proportion of the pod DM.

Grain Yield and Harvest Index

Table 3 shows that TVu 1977, TVx 1836-9G and TVu 1190E, gave the highest and similar grain yields while Ife Brown gave the lowest. However, the shelling percentage was highest in Ife Brown (61 percent) and lowest in TVu 1190E (46 percent). Pod length and number of seeds per pod in the different cultivars are shown in Table 3. While the average pod length in Ife Brown was 12.2 cm and the average number of seeds/pod was 8.5, the corresponding figures in TVu 1190E were 20.0cm and 11.3 seeds/pod, respectively. Pod lengths in TVu 1977, TVx 1193-9F and TVx 1836-9G were 12.7c, 12.7 and 14.2 cm respectively, and their corresponding number of seeds/pod were 12.7, 10.0 and 9.6, respectively. Thus, TVu 1190E generally had the lowest efficiency with regard to number of seeds per pod. Table 3 further shows that TVu 1190E and TVu 1977 had low harvest indices (18 and 20 percent, respectively; Ife Brown was intermediate (23 percent), while

TVx 1193-9F and TVx 1836-9G were relatively high (26 and 30 percent, respectively). This is in agreement with results obtained at the International Institute of Tropical Agrciulture (IITA) on these cultivars (Dr. Pulver, pers. comm.).

Grain yield at 81 DAP was positively, though not significantly, correlated with DMA (r = 0.44). It was not correlated with harvest index (r = 0.00). DMA however, was negatively but significantly correlated with harvest index (r = 0.89*). For these five cowpea cultivars therefore, the higher the dry matter, the lower the harvest index. In other words, a high dry matter yield does not necessarily give high grain yield in.cowpeas. Similar conclusions were reached on soybeans by Hanway and Weber (1971)

Harvest index measures the proportion of the economic yield in relation to total biological yield. Thus, it is a very useful tool in determining the physiological efficiency of crops in terms of total DMA in a plant relative to seed yield. Singh et al. (1980) determined harvest indices in several varieties of three grain legumes and obtained an average value of 35 percent for mung bean, 22 percent for pigeon pea and 21 percent for urd bean. In the present study, the average value obtained for the five cowpea cultivars was 23 percent (Table 3). It would appear therefore, that tropical grain legumes have low harvest indices which seem to be a limiting factor to high grain yield.

This study shows that cowpea seed yields are not limited because of low dry matter production. Wien and Ackah (1978) have suggested that low seed yields may result from insufficiently long period of grain filling and a restrictive amount of reproductive tissue. Since cultivar differences occur in the patterns of DMA and harvest index rating, breeding efforts should be directed at obtaining cultivars with high harvest index and increased sink capacity in order to obtain high grain yield.

TABLE 3 – YIELD AND SOME YIELD DETERMINANTS IN FIVE COWPEA CULTIVARS

Cultivar	*Pod wt (kg/ha)*	*Grain wt (kg/ha)*	*Shelling %*	*Pod length (cm)*	*No. of Seeds per pod*	*Harvest Index %*
TVu 1190 E	1091.0	5.5.0	46.3	20.0	11.3	17.9
TVu 1977	880.0	528.0	60.0	12.7	12.7	19.6
Ife Brown	592.0	359.0	60.7	12.2	8.5	22.5
TVx 1193-9F	875.0	472.0	53.9	12.7	10.0	26.4
TVx 1836-9G	876.0	516.0	59.0	14.2	9.6	29.9
$LSD_{(0.05)}$	129.0	34.0	2.7	1.4	0.7	

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