PART - II

****

RESPONSE OF *Dioscorea floribunda* Mart. & Gall. TO DIFFERENT TIME OF PLANTING WITH DIFFERENT TYPE OF PLANTING MATERIALS .

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I N T R O D U C T I O N

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INTRODUCTION.

Various environmental factors such as precepitation, temperature, humidity etc. of a region play the most important role on maximization of crop production and specially on a remunerative harvest, of Dioscorea sp. (Enyi ; 1970, Gooding ; 1970).

In India and in abroad many authors (viz. Seale ; 1960, Cruzedo et al; 1965, Enyi ; 1970, Selvaraj et al ; 1972, Randhawa et al ; 1975) already attempted and recommended different planting time and duration of the crops for different region. In the hills of Darjeeling district (West Bengal), D.C.O.M.P. (Govt. of West Bengal) is cultivating Dioscorea composita during the last 10 years on a commercial scale but no attempt has so far been made to study in detail of the response of Dioscorea floribunda to different time of planting as well as to different type of planting materials in the agroclimatic condition of Darjeeling hills. In recent years it has been noted that duration of rainfall, day & night temperature, humidity varies abruptly from year to year rather from month to month in the hills of Darjeeling district especially in the region under study. Besides it has also been observed that various planting materials such as Crown, Middle and Tip parts of the yam of Dioscorea floribunda, the productivity of Yam with its diosgenin content varies according to the environmental condition of the experimental sites in various parts of India other than Darjeeling hill.

An attempt has been made to study the effect of planting time and types of planting materials on the productivity of yam and diosgenin yield in D. floribunda in the climatic condition of Darjeeling hills. So that informations derived out of which may be utilized for cultivation of the plants on commercial scale.

MATERIALS AND METHODS

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The investigation on the effects of different planting time (season) and types of planting materials in *Dioscorea floribunda* Mart. & Gall. were carried out at the Research Nursury of Govt. Ipecac Plantation, Gairibas, Darjeeling during 1984 to 1986 and repeated the same during the year 1986 to 1988. Experimental plots even topography and uniform fertility were selected and soil-type was sandy-loam, being acidic in reaction (pH 4.6 - 4.8). The results of mechanical and chemical analysis of representative soil samples collected from the plots (0 - 30 cm depth) are presented below :

Mechanical analysis (%)			Chemical constituents.		
Gravel	:	2.8	Total Nitrogen	:	0.070-0.079 (%)
Coarse sand	:	30.6	Available Nitrogen	:	0.009-0.01 (%)
Fine sand	:	35.7	Available Phosphorus	:	15.37-16.51 kg/ha.
Silt	:	14.8	Available potassium	:	205.62-218.35 kg/ha.
Clay	:	16.1	Organic Carbon	:	0.752-0.811 (%)
			pH	:	4.6 - 4.8

Five planting-time experiments with interval of 30 days were conducted viz. middle of April (P_1), May (P_2), June (P_3), July (P_4) and August (P_5) ; each experiment takes equal size of planting materials but from the different parts of tubers like such as Crown (PRC), Middle (PRM) and Tip (PRT) of the mother yam (tuber) of *Dioscorea floribunda*.

P_1 - Planted on 15.4.1984 - One set each with Crown (PRC), Middle (PRM) and Tip (PRT) plants i.e., plants raised from Crown, Middle & Tip portion of the yam (tuber).

P_2 - Planted on 15.5.1984 - One set each with PRC, PRM & PRT.

P_3 - Planted on 14.6.1984 - One set each with PRC, PRM & PRT

P_4 - Planted on 14.7.1984 - One set each with PRC, PRM & PRT.

P_5 - Planted on 13.8.1984 - One set each with PRC, PRM & PRT.

The initial soil preparation of experimental sites consisted of an uniform application of farm yard mannure (20 MT/ha) and a basal dose (one of the three split doses) of NPK at the rate of 250 kg/of N in the form of Urea ; 50 kg of P in the form of Superphosphate and 150 kg of K in the form of Murate of Potash per hectare basis. The first basal dose was applied during soil preparation, the second split dose was applied during the second year growth. The experiments were laid out essentially in Randomized Block Design, the details of the lay out were as follows :

1.	Gross plot sizes	:	6.0 m X 2.1 m = 12.6 sq. m
2.	Net plot size	:	5.4 m X 1.5 m = 8.1 sq. m
3.	Border between the plots	:	0.45 m
4.	Border between the replications	:	0.90 m
5.	Border of the experiment	:	1.20 m
6.	Replications	:	4 (four)

Layout of the plots were taken up according to the layout plan (Figure No.1) and average 60 gms pieces of Crown, Middle and Tip plants of mother tuber (yam) - 2½ to 3 years old of Dioscorea floribunda were used as planting materials. In order to control yam rot, the pieces were dipped for five minutes in 0.3 % Benlate

FIGURE 1.

REP = Replication.

PRC = Plants Raised from Crown portion.

PRM = Plants Raised from Middle portion.

PRT = Plants Raised from Tip portion.

P_1 = Indicates planting in the month of April.

P_2 = Indicates planting in the month of May.

P_3 = Indicates planting in the month of June.

P_4 = Indicates planting in the month of July.

P_5 = Indicates planting in the month of August.

FIG. 1.

LAYOUT PLAN

RANDOMIZED BLOCK DESIGN

SCALE = 1mm. = 30cm.

(EXPERIMENT No.1.)

	REP. I	REP. II	REP. III	REP. IV
PRC	P_1	P_5	P_1	P_5
	P_3	P_1	P_4	P_5
	P_5	P_2	P_3	P_4
	P_2	P_1	P_2	P_1
	P_4	P_3	P_5	P_2
	← CHANNAL →			
PRM	P_2	P_3	P_4	P_5
	P_1	P_2	P_3	P_2
	P_3	P_4	P_5	P_1
	P_4	P_5	P_1	P_3
	P_5	P_1	P_2	P_4
	← CHANNAL →			
PRT	P_4	P_2	P_1	P_3
	P_3	P_5	P_2	P_4
	P_1	P_3	P_4	P_5
	P_2	P_1	P_5	P_2
	P_5	P_4	P_3	P_1

← N

GROSS PLOT AREA = 6m. X 2·1 m.

NET " " = 5·4m. X 1·5m.

BORDER BETWEEN PLOTS = 0·45 m.

" " REPLICATION = 0·90m.

" OF THE EXPT. = 1·2m.

solution and were kept in raised beds (40 % soil + 60 % sand) for sprouts. After about 30 days when kept in raised beds were ready for sprouting, they were selected for transplanting and the sprouted yams from Crown, Middle and Tip portions were kept seperately. To ensure uniform spacing, the seed pieces were planted by hand in seperate plots, keeping the planting depth 15-20 cm and spacing 60 cm X 75 cm. planting experiments were conducted at intervals of 30 days in seperate plots and the interculture operations like weeding and hoeing were done when the plants were four weeks old. Daily meteoroligical data were recorded during the course of investigations.

Following observations were made for analysis in respect of growth, development and yield of the crop. 10(ten) plants were selected from each plot and growth parameters like leaf area index, crop growth rate, relative leaf growth rate, net assimilation rate, dry matter production were recorded during the course of investigations at every 60 days interval, until harvest of the three types of planting materials of each replication. Experimental data have been recorded at two stages :- during the 1st year growth (60 to 240 days) and 2nd year growth (360 to 540 days) following the dormant period from 180 to 360 days and 540 to 720 days.

1. <u>Leaf Area and Leaf Area Index (LA and LAI)</u> : Records on leaf area were taken from the selected plants from each plot under each replication. Maximum length and width of the leaves were recorded and the area of the leaves were calculated (Gomez : 1972 and Hegde : 1979) according to the following formula :

Simple leaf area = K X L X W where, K is the adjustment factor (Gomez ; 1972 and Hegde ; 1979). L is the length and W is the maximum width of the leaf.

$$LA\ plant^{-1} = \frac{\text{Sum of leaf area of the total samples}}{\text{Number of samples}}$$

$$L\ A\ I = \frac{\text{Sum of leaf area per plant X number of plants per unit area}}{\text{Ground area}}$$

2. Dry matter production : The plants were seperated into two parts (a) aerial parts with leaves and vines, (b) 'Yam' with secondary roots were dried into oven at a temperature of 80°C to 85°C for 48 hours. The materials were than kept in a desicator to attain a constant weight and the dried plant samples were weighed & dry weight was recorded. The leaf area in sq. cm per plant and the dry matter production in gram per plant were transferred into Naperian Logarithms & the values of the leaf area and dry matter thus obtained had been used in the computation of other growth characters.

3. Relative leaf Growth Rate (RLGR): Relative leaf growth rate was determined according to the formula (Gregory ; 1917, Blackman ; 1919, Briggs et al ; 1920) :

$$R\ L\ G\ R = \frac{Log_e L_2 - Log_e L_1}{t_2 - t_1}$$

Where, L_1 & L_2 represent leaf area at the time t_1 and t_2 respectively. RLGR is expressed as $cm^2\ day^{-1}\ plant^{-1}$.

4. <u>Crop Growth Rate (CGR)</u> : Crop Growth Rate was determined using the formula :

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the initial and final total dry weight ; $t_2 - t_1$ being the period of interval in days.

5. <u>Net Assimilation Rate (NAR)</u> : Using the following formula Net Assimilation Rate was computed :

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{Log_e L_2 - Log_e L_1}{L_2 - L_1}$$

Where, W_1 and W_2 are initial (t_1) & final (t_2) total dry weights respectively ; $t_2 - t_1$ being the period of interval expressed in days. L_1 represents intial (t_1)total leaf area and L_2 represents final (t_2) total leaf area and NAR has been expressed in gm $cm^{-2}day^{-1}plant^{-1}$.

6. <u>Biomass</u> : For measuring biomass, the plant samples were harvested at interval of 60 days during active growth period. All the samples from each treatment and replication were collected and the data for biomass both aerial and underground were expressed in terms of dry weight per plant. The different components were separated out and were dried in oven (at 80° - 85° C) for a period of 48 hours and final weight of each fraction of the dried samples was determined.

7. Estimation of N, P and K of plant materials : The effecacy of utilisation of nutrients (N P K) were screaned at different stages of plant growth and the plants were analysed for N, P & K during their developmental growth according to the methods described by Jackson (1967).

i) Estimation of total nitrogen (TN) : dried samples were powdered and seived through 60 mesh seive. 100 mgms of the powdered samples were weighed and digested with 4 ml. of distilled water, a pinch of reducing iron and 2 ml of 50 % H_2SO_4 and was later reduced by heating over the reducing flame for about 30 minutes till the contents become black and thick. The reduced black mass was allowed to be cooled sufficiently and a knife pointful mixture of 1:3 K_2SO_4 and $CuSO_4$ was added to the content of the digestion flask, followed by the addition of 1.5 ml of conc. H_2SO_4, 5 ml of 30 % perchloric acid and heated over the oxidising flame for about two hours till the solution became clear with a whitish residue settling below.

After digestion the content was cooled and the process of distillation was carried on by adding 10 ml of 40 % NaOH. Instantaneously, the ammonia which evolved was collected in a conical flask containing 10 ml of N/50 HCL and two drops of methyl red as indicator. The steam distillation was continued for 30 minutes to ensure complete evolution of ammonia. Finally the excess of N/50 HCL was titrated against N/50 NaOH and the methyl red acted as the indicator for determining the exact end point of the titration. The difference gave the quantity of HCL that reacted with the evolved ammonia (1 ml of N/50 HCL corresponds to 0.28 mgm of nitrogen.

ii) Estimation of total phosphorus and potassium : The percentage of total phosphorus present in the leaf was determined by the "Phosphomolibdate" method and total potassium by "flame photometer" method as determined as described by Jacson (1967).

100 mgm of dried powdered sieved sample was taken in a 50 ml volumetric flask follwed by 5 ml of conc. HNO_3 ; heated for about 30 minutes over a hot plate at a temperature 100°C till the content became yellow and later on cooled. After it was sufficiently cooled, 3 ml of tri-acid mixure (of perchloric acid - 60% , conc. HNO_3 and conc. H_2SO_4) were added and again heated on the hot plate for one hour till the content became 0.5 to 1 ml in volume.

After sufficient cooling, the volume was made upto 50 ml by adding distilled water. Suitable quantity of the aliquot was later taken for the estimation of potash by means of a flame Photometer. From the rest of the aliquot, 5 ml was taken in a volumetric flask and its pH was adusted at 3 by using 4(N)NH_4OH and 4(N) HCl ; adding two drops of 2-4 dinitrophenol as an indicator, followed by the addition of 5 ml of chloro-molybdic acid and 1 ml of stannous chloride acid reductant. The volume was made upto the mark by adding water. The optical density of the solution was recorded by a colorimeter and the concentration of phosphorus was calculated by comparing with the standard phosphorus chart. The percentage of phosphorus and potash was later calculated.

iii) Extraction and Estimation of Diosgenin : Diosgenin was extracted from the air dried tuber of *Dioscorea floribunda* following the method by Gandotra *et al* (1977) after suitable modifications (Panda and Chatterjee, 1978).

Fresh tubers (yam) were cleaned with running water after clipping the roots and the excess of water was removed. After drying in shade the tubers were chopped into thin & small pieces and dried in sun and later in the oven for 48 hours at 100°C to ensure uniform drying. The dried yams were grinded and 10 gms of the dried thoroughly grinded powder was taken in 500 ml flask and distilled water

was added and stirred for 10 minutes. To the slurry, 150 ml of distilled water and calculated amount of conc. HCL was added to maintain the required acid concentration of 5 % (w/v). Hydrolysis was conducted in autoclave for $\frac{1}{2}$ hour under 15 lbs/cm^2 pressure. After hydrolysis, the slurry was allowed to attain room temperature and filtered under vacuum. The residue was washed with distilled water till the filtrate was free from acid. The acid from residue was transferred to petridish and dried in an oven at 100°C for 6 hours. It was later extracted with hexane (boiling range 67° - 70°C) in a Soxhlet apparatus for 8 hours. The extracted solvent containing diosgenin was concentrated, chilled and filtered. The mother liquor obtained after filtering was again concentrated, chilled and a second crop of diosgenin (if any), was added to the first crop and the whole of diosgenin was weighed after drying in an oven for 2 hours at 80°C and the values were expressed in percent (dry weight basis).

The identity was confirmed through TLC and the purity was found to be 96.2 % of total sapogenin.

8. Soil Analysis : Composite soil samples from the plots receiving individual treatment were collected before setting up and at the expiry of the experiments and analysed for determination of residual fertility status in respect of nitrogen, phosphorus and potassium according to the methods developed by Jacson (1967).

From the composite samples 500 gms of soil were weighed seperately and spread on the floor under shade for 7 days for drying under room temperature. After drying, the weight was taken and the soils were seived through 0.5 m.s. seive & required quantities of soils were taken for further soil testing as follows :

i) Soil pH : To 10 gms of the seived soil 25 ml of distilled water was added and the suspension was stirred at regular intervals for 30 minutes and the pH was recorded immediately with a glass electrode pH meter.

ii) Organic Carbon : 1 gm of soil sample was taken in a 500 ml conical flask to which 10 ml of normal $K_2Cr_2O_7$ and 10 ml of conc. H_2SO_4 was added and allowed to stand for half an hour in the dark. Simultaneously a blank was maintained. Then in both the conical flasks 200 ml of distilled water was added followed by 10 ml of syrupy H_3PO_4 and 2 ml of di-phenyl amine indicator. It was finally titrated with standardised Mohr's salt solution. From the difference of blank and sample reading, the organic carbon percentage is calculated.

iii) Available phosphorus : For determination of available phosphorus 10 gms of air dried soil sample was taken in a conical flask to which 150 ml of Olsen's reagent (containing 0.5 normal $NaHCO_3$ at pH 8.5) and shaken for one hour with phosphate free charcoal powder. It was then filtered and the filtrate was collected and the phosphorus concentration was measured by the same chloro-molybdic method as described earlier in case of leaf analysis.

iv) Available potassium : 10 gms of dried soil sample was taken in a 500 ml conical flask ; added 250 ml of ammonium acetate 1 (N) and shaken for half an hour. It was later filtered and the filtrate was taken in a 250 ml volumetric flask and the volume was made upto the mark and the reading for potassium was taken by the help of a flame-photometer.

9. Economics : Economics of cost of tuber (yam) production of *Dioscorea floribunda* Mart. & Gall. was also worked out. Added cost-added return principle on yam and diosgenin yield under each treatment was adopted

to determine the optimum time of planting and its economic responses.

10. Co-rrelation studies : Total co-rrelation of important characters between various yield attributing characters and yield were measured by Karl Pearson's Co-efficient Co-rrelations as denoted by 'r' (Goulden : 1960, Panse & Sukhatme : 1978).

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R E S U L T S

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RESULTS

While ascertaining the growth and Yield responses of *Dioscorea floribunda* Mart. & Gall. in relation to different time of planting and types of planting materials, observations had been recorded on different plant characters, physiological parameters, yield attributes, periodic nutrient's accumulation and also residual nutrient status of soil during the course of investigation.

The data obtained were put to through statistical analysis and the mean values along with SE and CD values represented in Tables 2.a. to 12.c. and Fig. 2 to 7.

PHYSIOLOGICAL PARAMETERS

Leaf Area Index (LAI) : The results on leaf area index under different planting times and different types of planting materials have been presented in the Table 2.a. to 2.c. and Fig. 2.

In general, the LAI at the successive stages of growth and development showed significant influence on different planting time. The LAI values (mean) increased gradually from P_1 (April planting) to P_3 (June planting) whereas, a decreasing trend was noticed in P_4 (July planting) and P_5 (August planting) of Crown (PRC), Middle (PRM) and Tip (PRT) parts of plants.

The LAI in P_1 & P_2 planting increased steadily upto 180 days in all the cases of Crown, Middle and Tip plants (Table 2.a. to 2.c.) and there after decreasing trend were observed from 240 to 360 days. The augmentation of LAI values were observed steadily from 360 day to 480 days after planting and decreasing thereafter sharply. However in P_3 (June planting) LAI increased rapidly.

Table No.2.a Effects of Planting times on Leaf Area Index of *Dioscorea floribunda* Mart. & Gall..

PRC (Plants Raised from Crown)

Time of Planting.	Days after planting. 1st Year growth. 60	120	180	240	2nd year growth. 360	420	480	540	Mean
P_1	0.215	0.816	0.912	0.065	0.278	0.821	0.993	0.083	0.523
P_2	0.245	0.962	1.145	0.080	0.310	0.916	1.190	0.092	0.617
P_3	0.372	1.225	1.183	0.095	0.326	1.191	1.245	0.105	0.717
P_4	0.350	0.472	0.105	0.052	0.395	1.050	0.982	0.086	0.436
P_5	0.112	0.080	0.032	0.095	0.462	0.984	0.940	0.095	0.350
Mean	0.258	0.711	0.675	0.077	0.354	0.992	1.070	0.092	0.528
SE ±	0.047	0.199	0.252	0.008	0.033	0.062	0.061	0.003	0.064

Table No. 2.b. Effects of planting times on Leaf Area Index of *Dioscorea floribunda* Mart. & Gall.

P R M (Plants Raised from Middle)

Time of Planting	Days after Planting.								
	1st year growth.				2nd year growth				
	60	120	180	240	360	420	480	540	Mean.
P_1	0.220	0.765	0.872	0.055	0.213	0.750	0.916	0.071	0.482
P_2	0.307	0.912	1.108	0.072	0.295	0.876	1.117	0.082	0.596
P_3	0.439	1.196	1.145	0.085	0.301	1.165	1.206	0.096	0.704
P_4	0.410	0.425	0.092	0.050	0.375	0.932	0.918	0.075	0.409
P_5	0.148	0.072	0.030	0.085	0.442	0.815	0.802	0.088	0.310
Mean	0.305	0.674	0.649	0.069	0.325	0.907	0.991	0.082	0.501
SE ±	0.055	0.195	0.245	0.007	0.038	0.071	0.073	0.004	0.069

Table No. 2.c. Effects of planting times on Leaf Area Index of *D. floribunda*.

P R T (Plants Raised from Tip).

Time of Planting	Days after Planting.								
	1st year growth.				2nd year growth				
	60	120	180	240	360	420	480	540	Mean
P_1	0.285	0.790	0.900	0.061	0.258	0.794	0.962	0.078	0.516
P_2	0.326	0.955	1.130	0.075	0.306	0.895	1.163	0.085	0.616
P_3	0.457	1.203	1.176	0.088	0.318	1.186	1.222	0.100	0.718
P_4	0.425	0.428	0.095	0.052	0.387	0.945	0.908	0.080	0.415
P_5	0.152	0.076	0.033	0.090	0.451	0.824	0.806	0.091	0.315
Mean	0.329	0.690	0.667	0.073	0.344	0.928	1.012	0.087	0.516
S E ±	0.054	0.198	0.251	0.007	0.033	0.069	0.078	0.003	0.071

upto 120 days and later a periodic decrease was noticed till the commencement of the 2nd year growth. LAI in P_4 (July planting) and P_5 (August planting) showed a linear decline from 120 days and 60 days respectively. The augmentation of LAI in P_4 & P_5 plantings were observed from 360 days till the dormancy started from 480 days onwards.

In this initial stage of growth LAI values were recorded lowest in Crown plants (0.215, 0.245, 0.372, 0.350 and 0.112 in P_1, P_2, P_3, P_4, & P_5 respectively) in comparison to Middle and Tip plants. It was clearly evident (Table 2.a.) that the values of LAI were maximum during later stages of plants growth whereas Middle and Tip plants did not show appreciable differences. It was also been revealed that Crown, Middle and Tip plants had only attain the maximum LAI values in P_3 (June planting.).

Relative Leaf Growth Rate (RLGR) : The relative leaf growth rate presented in the Table 3.a. to 3.c. revealed that the rate varied distinctly with the time of planting and the type of planting materials during all the stages of growth & development. It was clearly evident that the rate of leaf growth considerably increased from P_1 (April planting) to P_3 (June planting) but decreasing trends were noticed in P_4 (July planting) and P_5 (August planting). It was also evident that P_1 ,P_2 & P_3 plantings of Crown, Middle and Tip plants (Table 3.a. to 3.c.) occured a gradual increase of RLGR upto 180 days and later sharply declined upto 360 days. The augmentation of the leaf growth rate re-occured from 360 days to 480 days. In P_4 & P_5 planting however RLGR gradually decreased upto 360 days and later increased from 360 days onwards. The negative values of RLGR during the periods 240 days to 360 days and 480 to 540 days in all the planting of Crown, Middle and Tip plants obviously indicated the initiation of ...

FIGURE 2

Effects of planting times and type of planting materials on Leaf Area Index of *D.floribunda*.

PRC = Represents Plants Raised from Crown portion.

PRM = Represents Plants Raised from Middle portion.

PRT = Represents Plants Raised from Tip portion.

Hollow Circles represents P_1 (April) planting.

Hollow traingles represents P_2 (May) Planting.

Hollow squares represents P_3 (June) planting.

Solid circles represents P_4 (July) planting.

' X ' represents . P_5 (August) planting.

FIG. 2.

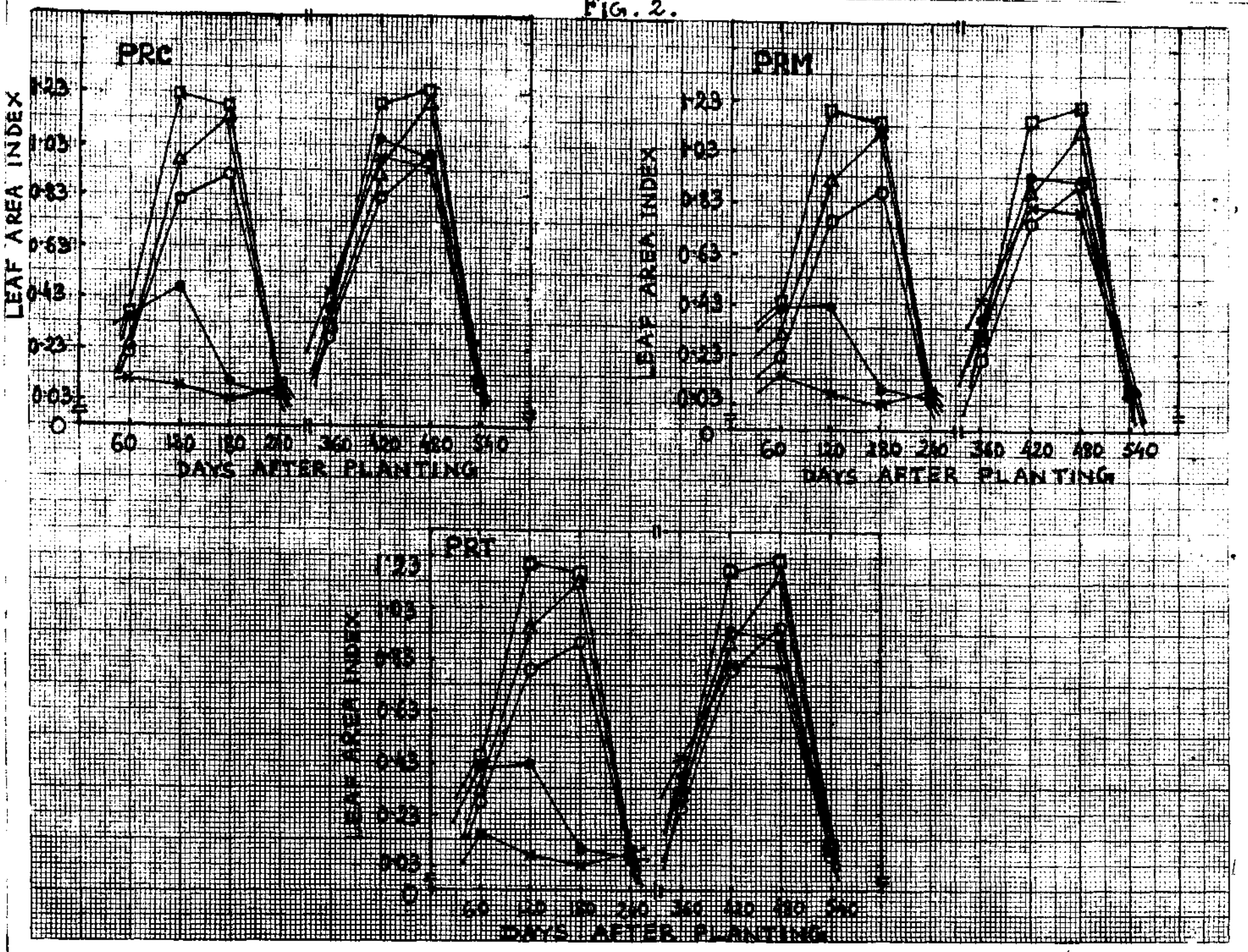

PRC
PRM
PRT
LEAF AREA INDEX
1·23
1·03
0·83
0·63
0·43
0·23
0·03
0
60
120
180
240
360
420
480
540
DAYS AFTER PLANTING

Table No. 3.a. Effects of Planting times on Relative Leaf Growth Rate ($cm^2 . day^{-1} plant^{-1}$) of *D. floribunda*.

P R C

Time of planting.	Days after Planting.							
	1st year growth				2nd year growth			
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.022	0.050	0.028	-0.014	0.018	0.038	-0.011	0.018
P_2	0.024	0.060	0.030	-0.006	0.021	0.042	-0.003	0.024
P_3	0.028	0.075	0.042	-0.002	0.031	0.068	-0.001	0.034
P_4	0.052	0.039	0.006	-0.023	0.028	0.049	-0.002	0.021
P_5	0.025	0.002	-0.016	-0.029	0.024	0.040	-0.003	0.006
Mean	0.030	0.045	0.018	-0.014	0.024	0.047	-0.004	0.021
S E ±	0.005	0.012	0.010	+0.005	0.002	0.005	+0 .001	0.004

Table No. 3.b. Effects of planting times on Relative Leaf Growth Rate ($cm^2 . day^{-1}$ $Plant^{-1}$) of *D. floribunda.*

P R M

Time of planting	Days after planting							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.047	0.060	0.032	-0.012	0.022	0.062	-0.009	0.028
P_2	0.053	0.085	0.040	-0.003	0.023	0.088	-0.002	0.040
P_3	0.068	0.092	0.058	-0.002	0.033	0.096	-0.001	0.049
P_4	0.042	0.023	0.009	-0.022	0.028	0.044	-0.003	0.017
P_5	0.027	0.010	-0.012	-0.021	0.030	0.038	-0.004	0.009
Mean	0.047	0.054	0.025	-0.012	0.027	0.065	-0.003	0.028
S E ±	0.006	0.016	0.012	0.004	0.002	0.011	0.001	0.007

Table No. 3.c. Effects of planting times on Relative Leaf Growth Rate ($cm^2 . day^{-1} . plant^{-1}$) of *D. floribunda*.

P R T

Time of planting.	Days after planting.							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.048	0.062	0.039	-0.016	0.026	0.066	-0.006	0.031
P_2	0.054	0.088	0.043	-0.002	0.031	0.091	-0.003	0.043
P_3	0.069	0.094	0.058	-0.001	0.036	0.098	-0.001	0.050
P_4	0.042	0.025	0.012	-0.020	0.033	0.046	-0.002	0.019
P_5	0.022	0.012	-0.015	-0.020	0.032	0.040	-0.003	0.009
Mean	0.047	0.056	0.027	-0.012	0.031	0.068	-0.003	0.030
S E ±	0.007	0.016	0.013	0.004	0.001	0.011	0.0008	0.007

senescence phase in leaves. It was also evident that (Table 3.a. to 3.c.) P_3 planting in all the cases of Crown, Middle and Tip plants, showed maximum mean values of RLGR during the periods of 120 to 180 days and 420 to 480 days after planting.

Crop Growth Rate (C G R) : Crop Growth Rate values under different planting times and types of planting materials have been shown in Tables 4.a. to 4.c. and Fig. 3. It was revealed that C G R varies distinctively in all the cases of Crown, Middle and Tip plants with the advancement of growth. In general, mean C G R values of the individual planting increased gradually from P_1 to P_3 planting and thereafter the values decreased. But the treatment mean increased upto 180 days and thereafter declined. The highest C G R (0.945 gm day^{-1} $plant^{-1}$) observed in P_3 (June planting) of Crown plants (PRC) followed by P_3 planting of Middle and Tip plants, the values being 0.815 gm $plant^{-1}$ day^{-1} and 0.788 gm day^{-1} plant -1 .

Net Assimilation Rate (NAR) : The data indicated that(Table 5.a.to 5.c. and Fig. No.4) the variations in planting time and types of planting materials caused significant differences in NAR of *Dioscorea floribunda*. It was evident that P_1 & P_2 plantings of Crown plants showed maximum NAR between 360 to 420 days, whereas, P_3 , P_4 & P_5 plantings showed maximum NAR between 420 -480 days. The highest NAR in Crown plants was in the range of 3.62 X 10^{-4}gm cm^{-2} day^{-1} $plant^{-1}$ between 420-480 days in P_3 planting and the minimum was 0.62 X 10^{-4}gm $cm^{-2}day^{-1}plant^{-1}$ between 240 to 360 days. The values however increased from 360 days onwards upto the end of 2nd year growth.

The similar trend was also observed in P_3 planting of Middle plants and Tip plants. Of the three types (PRC, PRM & PRT) of planting materials, the P_3 planting of Crown (PRC) plants revealed highest Net Assimilation Rate

F I G U R E 3.

Effects of planting times and type of planting materials on Crop Growth Rate (CGR) of *D.floribunda.*

PRC = Represents Plants Raised from Crown portion.

PRM = Represents Plants Raised from Middle portion.

PRT = Represents Plants Raised from Tip portion.

Hollow Circles represents	P_1 (April) planting.
Hollow Tringles represents	P_2 (May) planting.
Hollow squares represents	P_3 (June) planting.
Solid Circles represents	P_4 (July) planting.
Solid traingles represents	P_5 (August) planting.

FIG. 3.

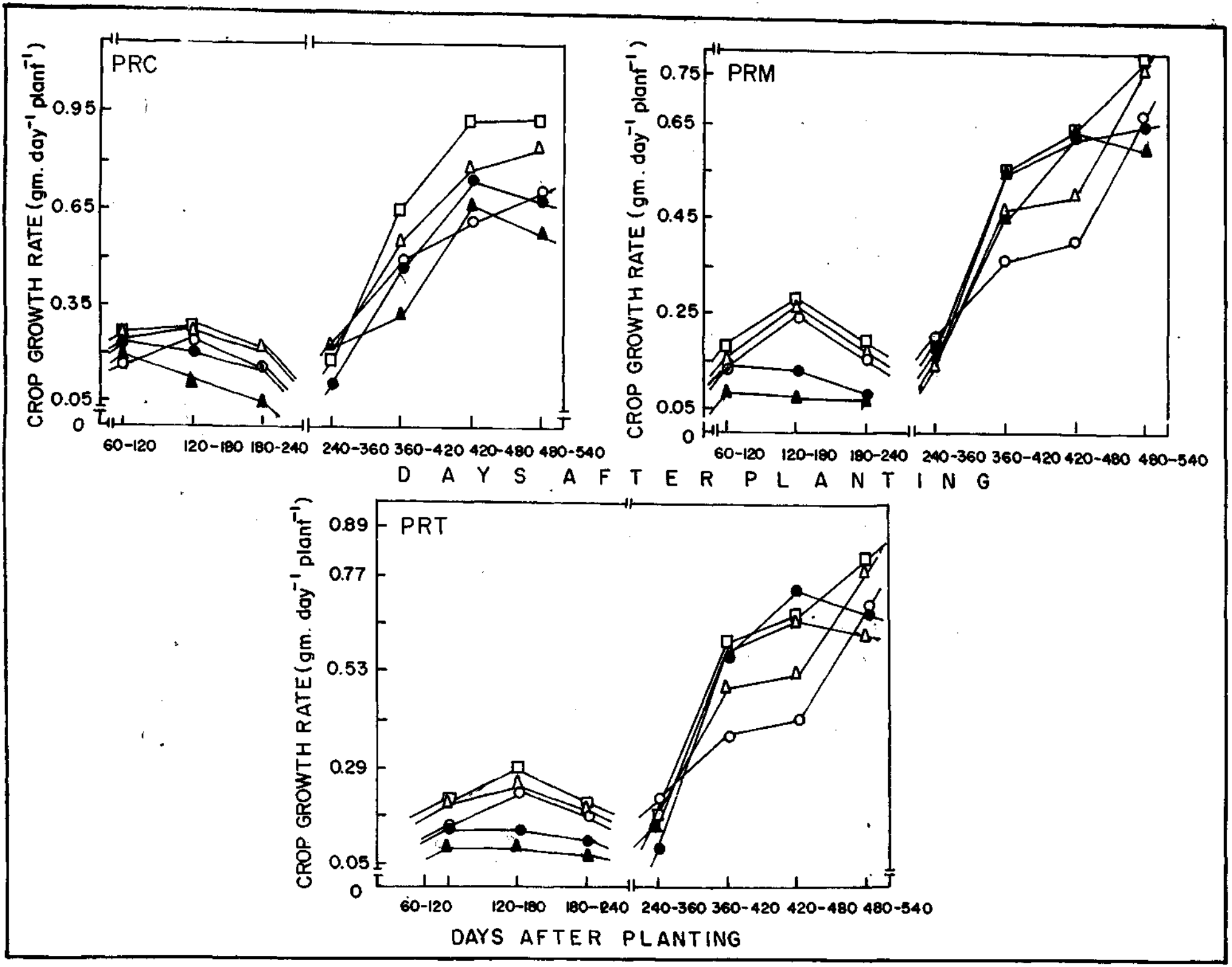

PRC
PRM
PRT
CROP GROWTH RATE (gm. day^{-1} plant^{-1})
0.95
0.65
0.35
0.05
0
0.75
0.45
0.25
0.89
0.77
0.53
0.29
60-120
120-180
180-240
240-360
360-420
420-480
480-540
DAYS AFTER PLANTING

Table No. 4 a. Effects of Planting times on Crop Growth Rate (gm. day^{-1} $plant^{-1}$) of *D. floribunda*.

P R C.

Time of planting.	Days after planting.							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.178	0.256	0.161	0.235	0.501	0.620	0.716	0.381
P_2	0.255	0.280	0.233	0.213	0.551	0.780	0.868	0.454
P_3	0.273	0.300	0.228	0.187	0.666	0.941	0.945	0.505
P_4	0.245	0.206	0.160	0.116	0.486	0.763	0.691	0.381
P_5	0.200	0.123	0.053	0.231	0.338	0.673	0.583	0.314
Mean	0.230	0.233	0.167	0.196	0.508	0.755	0.760	0.407
S E $\pm$	0.017	0.031	0.032	0.021	0.053	0.054	0.064	0.033

Table No. 4.b. Effects of planting times on Crop Growth Rate (gm. day^{-1} $plant^{-1}$) of *D. floribunda.*

P R M.

Time of planting.	Days after planting							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.136	0.245	0.156	0.201	0.360	0.398	0.671	0.309
P_2	0.150	0.258	0.163	0.139	0.473	0.493	0.766	0.348
P_3	0.185	0.278	0.196	0.187	0.558	0.638	0.788	0.404
P_4	0.141	0.131	0.085	0.149	0.550	0.628	0.650	0.333
P_5	0.085	0.075	0.071	0.177	0.445	0.638	0.591	0.297
Mean	0.139	0.197	0.134	0.170	0.477	0.559	0.693	0.338
S E ±	0.016	0.039	0.024	0.011	0.036	0.048	0.037	0.018

Table No. 4.c. Effects of planting times on Crop Growth Rate (gm. day^{-1}. $plant^{-1}$.) of *D. floribunda.*

P R T

Time of planting	Days after planting							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	0.155	0.228	0.171	0.211	0.373	0.416	0.691	0.320
P_2	0.205	0.231	0.180	0.152	0.496	0.520	0.780	0.366
P_3	0.208	0.298	0.205	0.177	0.603	0.670	0.815	0.425
P_4	0.150	0.135	0.110	0.092	0.573	0.735	0.675	0.352
P_5	0.095	0.091	0.075	0.133	0.586	0.661	0.621	0.323
Mean	0.162	0.196	0.148	0.153	0.526	0.600	0.716	0.357
S E ±	0.021	0.037	0.024	0.020	0.042	0.058	0.035	0.019

FIGURE 4.

Effects of Planting times on Net Assimilation Rate (NAR) of *D. floribunda*.

PRC = Represents Plants Raised from Crown portion.

PRM = Represents Plants Raised from Middle portion.

PRT = Represents Plants Raised from Tip portion.

Hollow Circles represents P_1 (April) planting.

Hollow Traingles represents P_2 (May) Planting.

Hollow squares represents P_3 (June) planting.

Solid circles represents P_4 (July) planting.

Solid Traingles represents P_5 (August) planting.

FIG. 4.

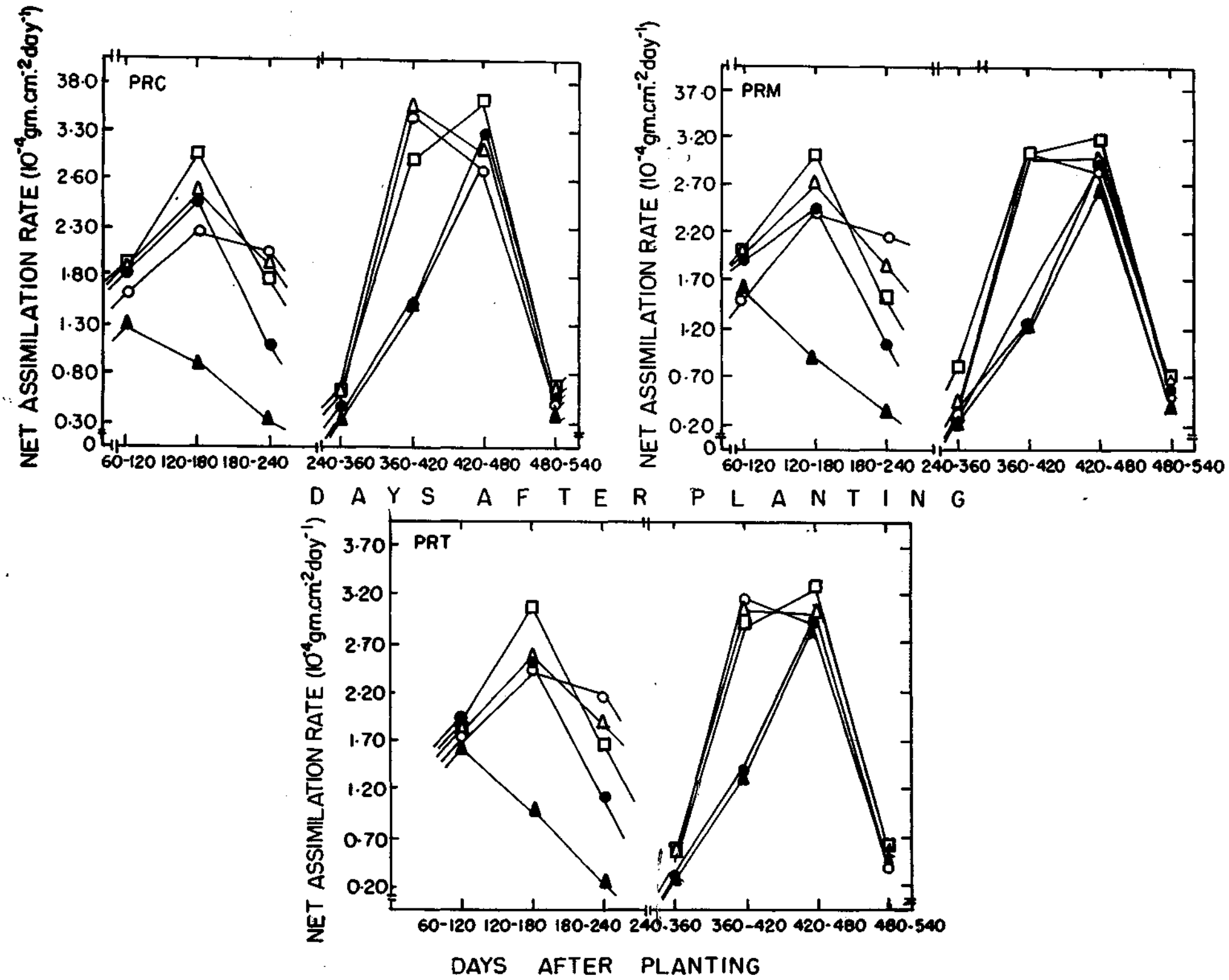

PRC
PRM
PRT
NET ASSIMILATION RATE (10^{-4}gm.cm.$^{-2}$day^{-1})
38·0
3·30
2·60
2·30
1·80
1·30
0·80
0·30
0
37·0
3·20
2·70
2·20
1·70
1·20
0·70
0·20
60-120 120-180 180-240 240-360 360-420 420-480 480-540
DAYS AFTER PLANTING

Table No. 5.a. Effects of planting times on Net Assimilation Rate (10^{-4} gm. cm^{-2}.day^{-1}.$plant^{-1}$)

P R C

Time of planting	Days after planting.							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	1.63	2.26	2.06	0.46	3.47	2.91	0.50	1.898
P_2	1.86	2.67	1.92	0.59	3.51	3.10	0.58	2.030
P_3	1.91	3.05	1.75	0.62	2.98	3.62	0.66	2.084
P_4	1.84	2.55	1.12	0.37	1.51	3.29	0.43	1.580
P_5	1.25	0.92	0.32	0.32	1.47	3.07	0.38	1.104
Mean	1.698	2.290	1.434	0.472	2.588	3.198	0.51	1.739
S E ±	0.121	0.365	0.321	0.059	0.458	0.121	0.050	0.181

Table No. 5.b. Effects of planting times on Net Assimilation Rate (10^{-4} gm. cm^{-2}. day^{-1} $plant^{-1}$)

P R M

Time of Planting.	Days after planting.							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	1.50	2.39	2.17	0.30	3.06	2.88	0.45	1.821
P_2	1.96	2.70	1.85	0.43	3.01	2.96	0.63	1.832
P_3	2.03	3.01	1.53	0.82	3.05	3.22	0.68	2.020
P_4	1.89	2.46	1.06	0.38	1.24	2.90	0.48	1.487
P_5	1.61	0.92	0.35	0.26	1.23	2.65	0.40	1.060
Mean	1.798	2.296	1.396	0.438	2.318	2.922	0.528	1.644
S E ±	0.103	0.360	0.319	0.100	0.442	0.091	0.052	0.169

Table No. 5.c. Effects of planting times on Net Assimilation Rate (10^{-4}gm. cm^{-2}.day^{-1} $plant^{-1}$)

P R T

Time of Planting.	Days after planting.							
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	Mean
P_1	1.69	2.40	2.17	0.37	3.15	2.91	0.41	1.786
P_2	1.80	2.55	1.87	0.62	3.05	3.02	0.48	1.913
P_3	1.88	3.05	1.66	0.59	2.90	3.27	0.62	1.995
P_4	1.91	2.51	1.10	0.32	1.40	2.98	0.52	1.534
P_5	1.64	0.98	0.22	0.27	1.35	2.90	0.46	1.117
Mean	1.784	2.298	1.404	0.434	2.370	3.016	0.498	1.669
S E ±	0.052	0.347	0.343	0.071	0.408	0.067	0.035	0.158

(3.62×10^{-4}gm cm^{-2} day^{-1} $plant^{-1}$ between 420 to 480 days) among Middle (PRM) and Tip plants (PRT).

Dry Matter Production (DM) : The dry matter production per plant under different planting time and different types of planting materials have been shown in Table 6.a. to 6.c.

The data revealed that there were corresponding increase in dry matter production with successive stages of growth&development. The rate of dry matter accumulation was rather low in the initial stage at 60 to 120 days in Crown, Middle & Tip plants (Table 6.a. to 6.c.) and the rate was vary low in P_5 planting. The rate of dry matter had taken momentum from the commencement of the 2nd year of growth and the trend found rapid till the period of harvesting.

In general it has been observed that the total DM accumulation in plants at the very early period of growth was less but with the age of plants have shown increased accumulation of DM in plants especially in the underground portion, with the highest value at harvest. The effect of planting times on DM production was significantly more pronounced than the types of planting materials. The highest value being 250.7 gms $plant^{-1}$ found in P_3 of Crown plants. The lowest value was recorded in P_5 planting of all the three types.

Inter-relationship between LAI, NAR and DM production at successive stages of growth and development under different planting times :

The Fig. 5 showing the variation in LAI, NAR and DM (based on mean values of five treatments & under different physiological parameters) and their inter-relationship between them during the different growth stages revealed that there has been steadily increased in dry matter production with

Table No. 6.a. Dry matter production (gm.plant^{-1}) of *D. floribunda* in respect of different planting times.

P R C (Plants Raised from Crown)

Time of Planting	Days after planting								
	1st year growth				2nd year growth				
	60	120	180	240	360	420	480	540	Mean
P_1	20.5	31.2	46.6	56.3	84.6	115.4	152.6	195.6	87.85
P_2	27.3	34.6	51.4	63.6	89.2	122.3	169.1	221.2	97.33
P_3	28.1	44.5	62.5	76.2	98.7	138.7	195.2	250.7	111.82
P_4	25.5	40.2	52.6	62.2	76.2	105.4	151.2	192.7	88.25
P_5	20.2	32.2	39.6	42.8	70.5	90.8	131.2	176.3	75.45
Mean	24.32	36.54	50.54	56.24	83.84	114.52	159.86	207.30	92.14
S E ±	1.675	2.528	3.763	6.220	4.932	8.037	10.685	13.015	6.026

Table No. 6.b, Dry matter production (gm. plant^{-1}) of *D. floribunda* in respect of different planting times.

P R M (Plants Raised from Middle)

Time of planting	Days after planting								
	1st year growth.				2nd year growth.				
	60	120	180	240	360	420	480	540	Mean
P_1	18.4	26.6	41.3	50.7	75.6	96.2	120.1	160.4	73.66
P_2	25.2	34.2	49.7	59.5	76.2	104.6	134.2	180.2	82.97
P_3	26.6	37.7	54.4	66.2	88.7	122.3	160.6	207.9	95.55
P_4	26.1	34.6	42.5	47.6	65.5	98.5	140.4	179.4	79.32
P_5	25.0	30.1	34.6	38.9	60.2	86.9	125.2	160.7	70.20
Mean	24.26	32.64	44.5	52.58	73.24	101.70	136.10	177.72	80.34
S E ±	1.494	1.934	3.444	4.737	4.915	5.883	7.061	8.687	4.397

Table No. 6.c. Dry matter production (gm. plant^{-1}) of *D. floribunda*. in respect of different planting times.

P R T (Plants Raised from Tip)

Time of planting.	Days after planting								
	1st year growth				2nd year growth				
	60	120	180	240	360	420	480	540	Mean
P_1	20.1	29.4	43.1	53.4	78.7	101.1	126.1	167.6	77.43
P_2	24.2	36.5	50.4	61.2	79.5	109.3	140.5	186.3	85.98
P_3	26.2	38.7	56.6	68.9	90.2	126.4	166.6	215.5	98.63
P_4	27.1	36.1	44.2	51.1	62.2	96.6	139.7	180.2	79.65
P_5	24.1	29.8	35.4	39.9	55.9	91.1	130.8	168.1	71.88
Mean	24.34	34.10	45.94	54.90	73.30	104.90	139.94	183.54	82.71
S E ±	1.207	1.891	3.575	4.885	6.242	6.145	7.085	8.754	4.575

FIGURE 5

Inter-relationship among LAI, NAR and DM at successive stages of growth of *D. floribunda* under different planting times and type of planting materials.

PRC = Represents Plants Raised from Crown portion.

PRM = Represents Plants Raised from Middle portion.

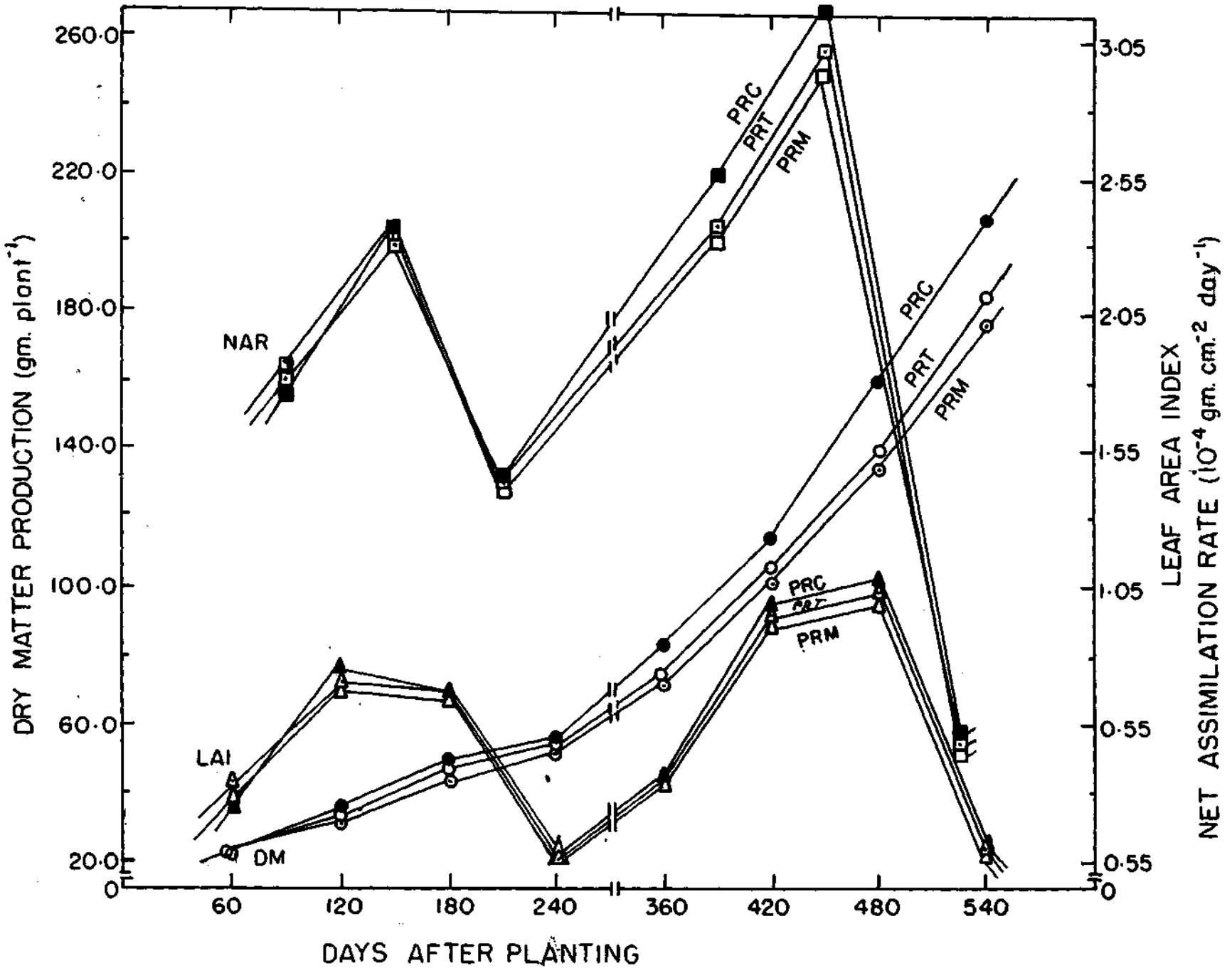
PRT = Represents Plants Raised from Tip portion.

DM = Represents Dry matter production.

LAI = Represents Leaf Area Index.

NAR = Represents Net Assimilation Rate.

FIG. 5.


DRY MATTER PRODUCTION (gm. plant^{-1})
260·0
220·0
180·0
140·0
100·0
60·0
20·0
0
NAR
PRC
PRT
PRM
LAI
DM
PRC
PRT
PRM
PRC
PRT
PRM
3·05
2·55
2·05
1·55
1·05
0·55
0·55
0
LEAF AREA INDEX
NET ASSIMILATION RATE (10^{-4} gm. cm.$^{-2}$ day^{-1})
60
120
180
240
360
420
480
540
DAYS AFTER PLANTING

the plants' age. LAI showing increased upto 120 days and then sharply declined upto 180 days and thereafter again increasing trend observed upto 480 days and again declined.

The NAR values reaches its highest limit being 3.62×10^{-4} gm cm^{-2} day^{-1} $plant^{-1}$ in PRC. The increasing and decresing rate of NAR was more or less in parallel way with LAI as shown in the Fig. 5. The dry matter production (DM) found highest rate at the highest rate of NAR at 480 days. The same trend also found in Middle and Tip plants (PRM & PRT). The highest values found in Crown plants followed by Tip and Middle plants.

: YIELD ATTRIBUTES :

Yam yield : The yam yield (in kg.) per plant under different planting time and planting types were presented in the Table 7.a. to 7.c. and Fig.6. revealed that there had been significant increase in yam yield successively with the planting time in P_1 to P_3 . Yam yield had, however declined under P_4 & P_5 planting. The highest yam yield in P_3 planting of Crown (PRC) plants being 1.653 kg/plant (fresh) which varies significantly from the yield under both early (P_1 & P_2) and late (P_4 & P_5) planting. The lowest yield being 1.225 kg/plant (green/fresh) was observed in P_5 (August planting) of Crown (PRC) plants.

The similar trend had been observed both in Middle and Tip plants (Table 7.b. & 7.c.), whereas in Tip plants the highest yield was observed in P_3 planting.

Comparing the three types of planting materials it had been found that the yield in kg/plant did not varies significantly between Crown and

Table No. 7.a. Effects of planting times on "Yam" yield and dry vine yield (Kg./plant) at the final stage of harvesting (720 days) in P R C (Plants raised from crown portion) of D. floribunda.

P R C

Time of planting.	Dry vine yield (kg./plant)	Yam yield (kg./plant)		Moisture %
		Fresh	Dry	
P_1	0.129	1.388	0.396	71.4
P_2	0.139	1.582	0.438	72.3
P_3	0.145	1.653	0.489	71.6
P_4	0.128	1.505	0.443	70.5
P_5	0.112	1.225	0.365	70.2
Mean	0.130	1.470	0.426	71.2
SE ±	0.005	0.075	0.021	0.380
C.D. at 5 % level	= 0.013	0.143	0.042	

Table No. 7.b. Effects of planting times on "Yam" yield and dry vine yield (kg./plant) at the final stage of harvesting (720 days) in P R M of *D. floribunda*.

P R M

Time of planting.	Dry vine yield (kg./plant)	Yam yield (kg./plant)		Moisture %
		Fresh	Dry	
P_1	0.126	1.005	0.265	73.6
P_2	0.130	1.248	0.321	74.2
P_3	0.138	1.350	0.351	74.0
P_4	0.120	1.190	0.311	73.1
P_5	0.108	0.980	0.259	73.5
Mean	0.124	1.154	0.301	73.8
S E ±	0.005	0.071	0.017	0.128
C.D. at 5 % level =	0.012	0.142	0.035	

Table No. 7.c. Effects of planting times on "Yam" and dry vine yield (kg./plant) at the final stage of harvesting (720 days) in P R T of *D. floribunda*.

P R T

Time of planting	Dry vine yield (kg./plant)	Yam yield (kg./plant		Moisture %
		Fresh	Dry	
P_1	0.128	1.220	0.323	73.5
P_2	0.131	1.455	0.379	73.9
P_3	0.139	1.607	0.416	74.1
P_4	0.127	1.490	0.388	73.9
P_5	0.110	1.176	0.308	73.8
Mean	0.127	1.389	0.362	73.8
S E ±	0.004	0.082	0.020	0.097
C. D. at 5 % level	= 0.008	0.154	0.042	

FIGURE 6

Effects of Planting times and type of Planting materials on Yam yield and dry vine yield (kg/plant) at the final stage of harvesting (720 days) in *D. floribunda*.

PRC = Represents Plants Raised from Crown portion.

PRM = Represents Plants Raised from Middle portion.

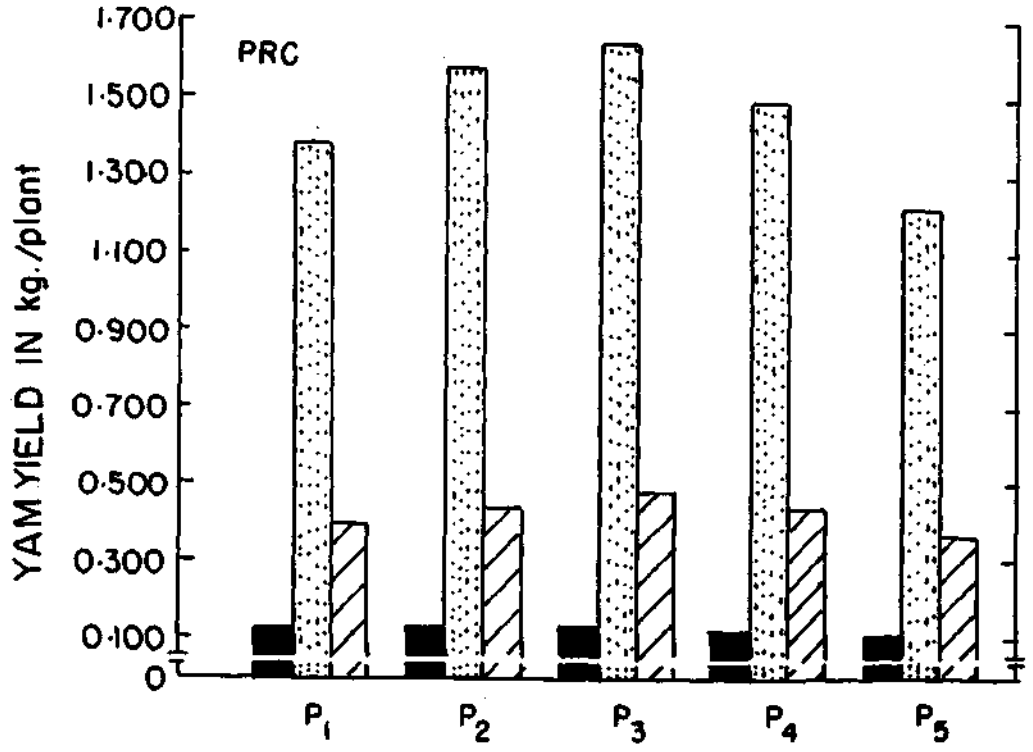
PRT = Represents Plants Raised from Tip portion.

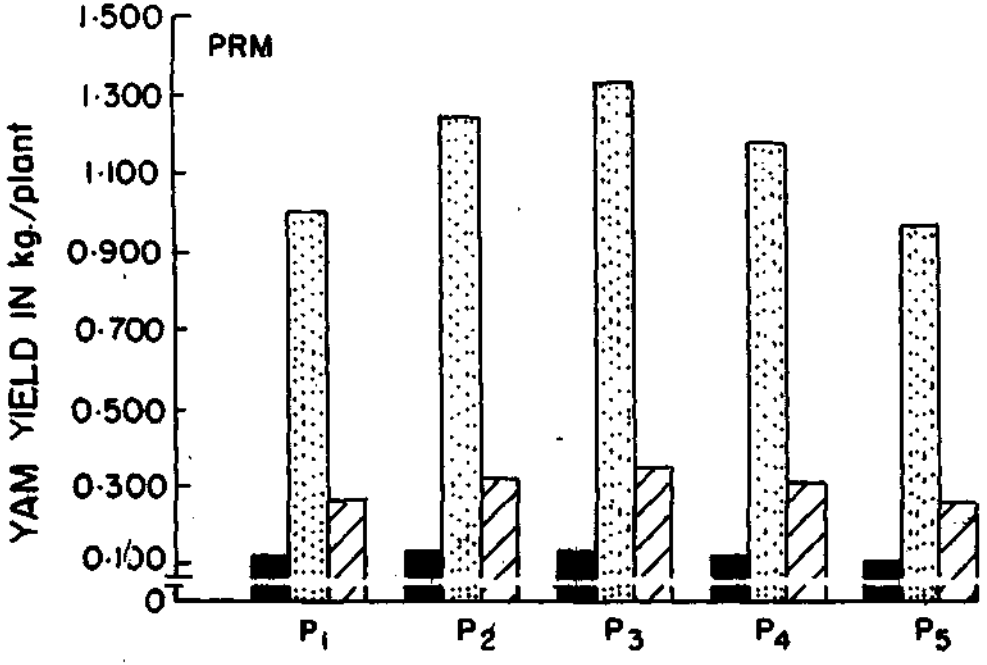
Solid bar represents Dry vine yield.

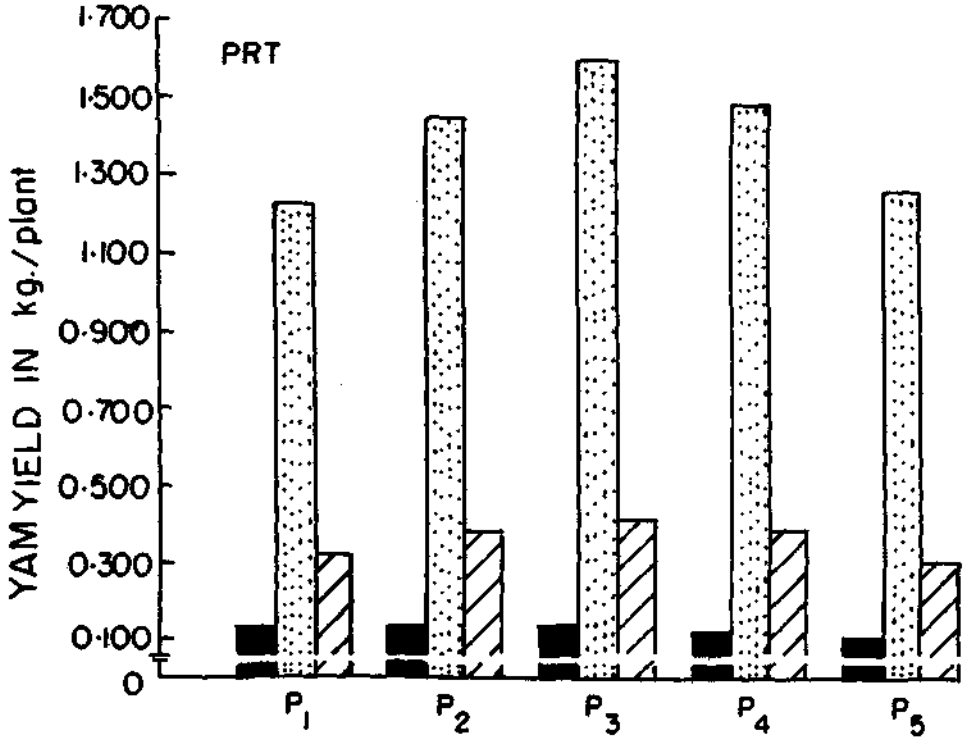
Dotled bar represents Fresh yam yield.

Obliquely lined bar represents Dry yam yield.

FIG. 6.


PRC
YAM YIELD IN kg./plant
1·700
1·500
1·300
1·100
0·900
0·700
0·500
0·300
0·100
0
P1
P2
P3
P4
P5


PRM
YAM YIELD IN kg./plant
1·500
1·300
1·100
0·900
0·700
0·500
0·300
0·100
0
P1
P2
P3
P4
P5


PRT
YAM YIELD IN kg./plant
1·700
1·500
1·300
1·100
0·900
0·700
0·500
0·300
0·100
0
P1
P2
P3
P4
P5

and Tip plants but there was significant variation between Crown and Middle plants and also between Tip and Middle plants. The interaction effects resulted that the P_3 (June planting) both in Crown and Tip plants (Table 7.a. to 7.c.) were the best in yam yield.

Dry vine yield : The variation in dry vine yield were noted under different planting time and planting materials (Table 7.a. to 7.c. and Fig. 6.). The data indicated that (Table 7.a.) the maximum dry vine yield being 0.145 kg/ plant found in P_3 of Crown (PRC) plants and varies significantly over P_1, P_4 & P_5 planting but P_2 and P_3 planting did not vary significantly. The similar trend also found in Middle and Tip plants (Table 7.b. & 7.c.). Comparing the three types it has been found that the Crown plants yielded maximum vine and the values are more closer to the values of Tip plants irrespective of the planting times.

Moisture percentage in yam : The moisture percentage of the individual treatment of PRC, PRM and PRT revealed that (Table 7.a. to 7.c.) all the planting season in PRC showed less moisture content in comparison to PRM & PRT. Among the different planting time in each type of planting materials showed the less moisture content in the late plantings but higher in earlier planting. The moisture percentage in all the treatments varied from 70.2 to 74.2 percent. It has also been revealed that moisture percentage in each planting time did not varied significantly in PRM & PRT.

Diosgenin percentage : The data (Table 8.a. to 8.c.) revealed that the different planting time did not show any significant variation on diosgenin percentage in yams. But the plants raised from different portion of yam such as Crown, Middle and Tip plants showed a significant variation in their diosgenin content also with a variation in diosgenin content in the Crown, Middle

Table No. 8.a. Variation in Diosgenin percentage (Dry wt. basis) in P R C (Plants raised from crown) under different times of planting in *Dioscorea floribunda* Mart.& Gall.

P R C

Time of planting	% of Diosgenin in			Mean
	Crown	Middle	Tip	
P_1	3.36	3.62	3.73	3.570
P_2	3.39	3.63	3.75	3.590
P_3	3.39	3.65	3.75	3.596
P_4	3.38	3.61	3.83	3.573
P_5	3.36	3.64	3.83	3.576
Mean	3.376	3.630	3.838	3.581
S E ±	0.006	0.007	0.004	0.005

Table No. 8.b. Variation in Diosgenin percentage (dry wt. basis)in P R M under different planting times of *D. floribunda*

P R M

Time of planting	% of Diosgenin in			Mean
	Crown	Middle	Tip	
P_1	3.42	3.69	3.78	3.630
P_2	3.40	3.68	3.79	3.623
P_3	3.43	3.69	3.80	3.640
P_4	3.42	3.68	3.80	3.633
P_5	3.42	3.68	3.80	3.633
Mean	3.418	3.684	3.794	3.631
S E ±	0.004	0.002	0.004	0.002

Table No. 8.c. Variation in Diosgenin percentage (dry wt. basis) in P R T of *D. floribunda* under different times of planting

P R T

Time of planting	% of Diosgenin in			Mean
	Crown	Middle	Tip	
P_1	3.50	3.73	3.83	3.686
P_2	3.51	3.75	3.84	3.700
P_3	3.52	3.75	3.84	3.703
P_4	3.50	3.75	3.84	3.696
P_5	3.52	3.75	3.83	3.700
Mean	3.510	3.746	3.836	3.697
S E ±	0.004	0.004	0.002	0.002

and Tip portion of the tubers. The maximum 3.83 % found in Tip portion. The mean highest value being 3.5965 % of diosgenin recorded in Tip portion of Crown plants under P_3 planting. But in PRT the diosgenin content in the Tip portion was recorded 3.836 % (mean value) in P_3 planting (Table 8.c.).

YIELDS

Yield of yam and diosgenin per hectare : Analysis of the yield data under different planting time revealed (Table 9.a. to 9.c. and Fig. 7) significant variations. The data revealed that P_3 (June) planting of Crown (PRC) plants, the yield was maximum amount to 34.995 MT/ha (green) equivalent to 10.352 MT/ha of dry yams and calculating the diosgenin content yielded 0.3722MT/ha. It was also revealed that the yield gradually increased from P_1 (April) to P_3 (June) planting and gradually decreased in late planting (P_4 to P_5 planting). The lowest yield amounted to 22.4 MT/ha (green) equivalent to 6.674 MT/ha of dry was recorded in P_5 (August) planting.

In Middle plants (PRM), the highest yield being 27.584 MT/ha (green) equivalent to 7.171 MT/ha of dry was recorded in P_3 (June) planting also. In Tip plants (PRT) the highest yield was also recorded in P_3 planting. The lowest yield in both Tip and Middle plants was recorded in P_5 (August) planting.

By computing the yield attributes with three types of planting materials during the different planting times it could be ascertained that the tuber yield as well as diosgenin content were highest in P_3 (June) planting of Crown (PRC) plants where the survival percentage of the plants were also found maximum, followed by the Tip (PRT) and Middle (PRM) plants.

F I G U R E 7.

Effects of planting times and type of planting materials on the production of "yam" (fresh & dry) and Diosgenin yield (MT/ha) in *D.floribunda*.

Filled bar represents the actual yield.

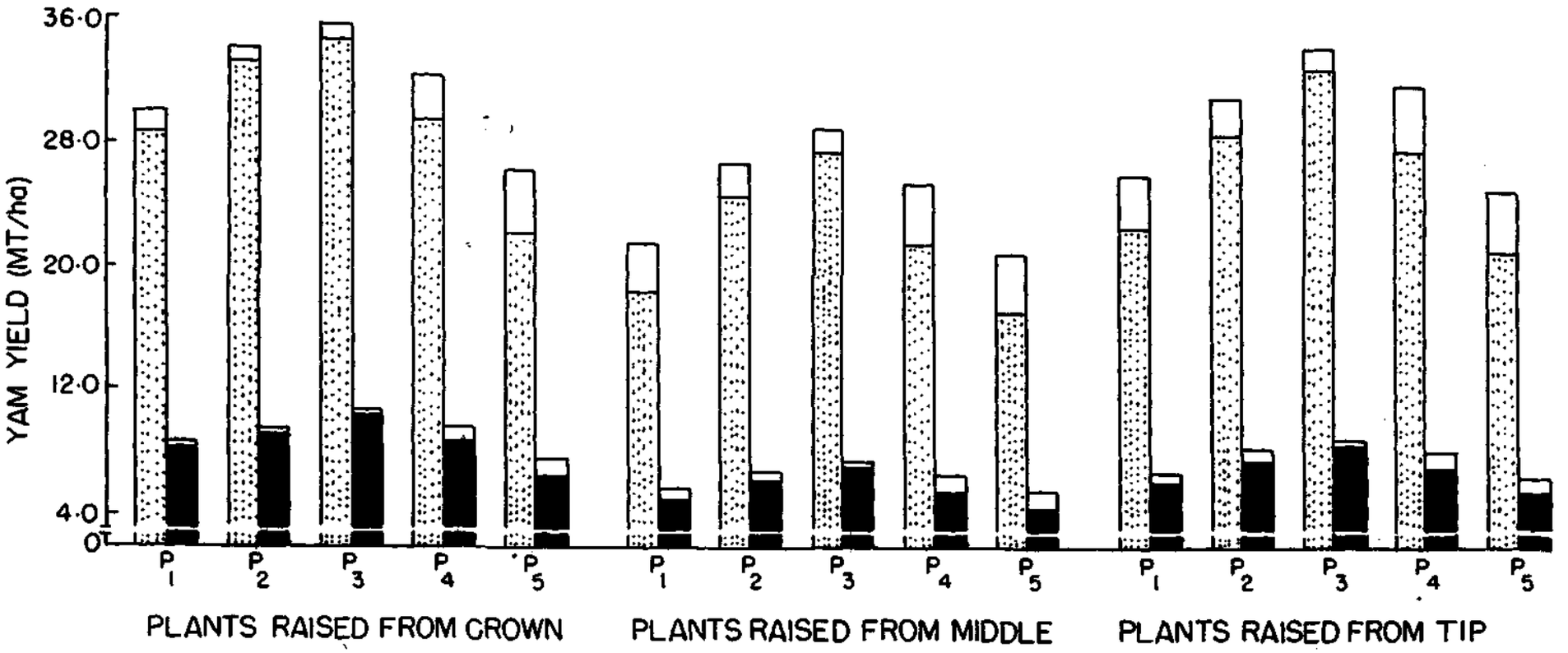
Empty bar represents the potential yield.

Solid bar represents the Dry yam yield.

Dotled bar represents the Fresh yam yield.

Obliquely lined bar represents the Diosgenin yield.

FIG. 7.


YAM YIELD (MT/ha)
36·0
28·0
20·0
12·0
4·0
0
P1 P2 P3 P4 P5
PLANTS RAISED FROM CROWN
PLANTS RAISED FROM MIDDLE
PLANTS RAISED FROM TIP

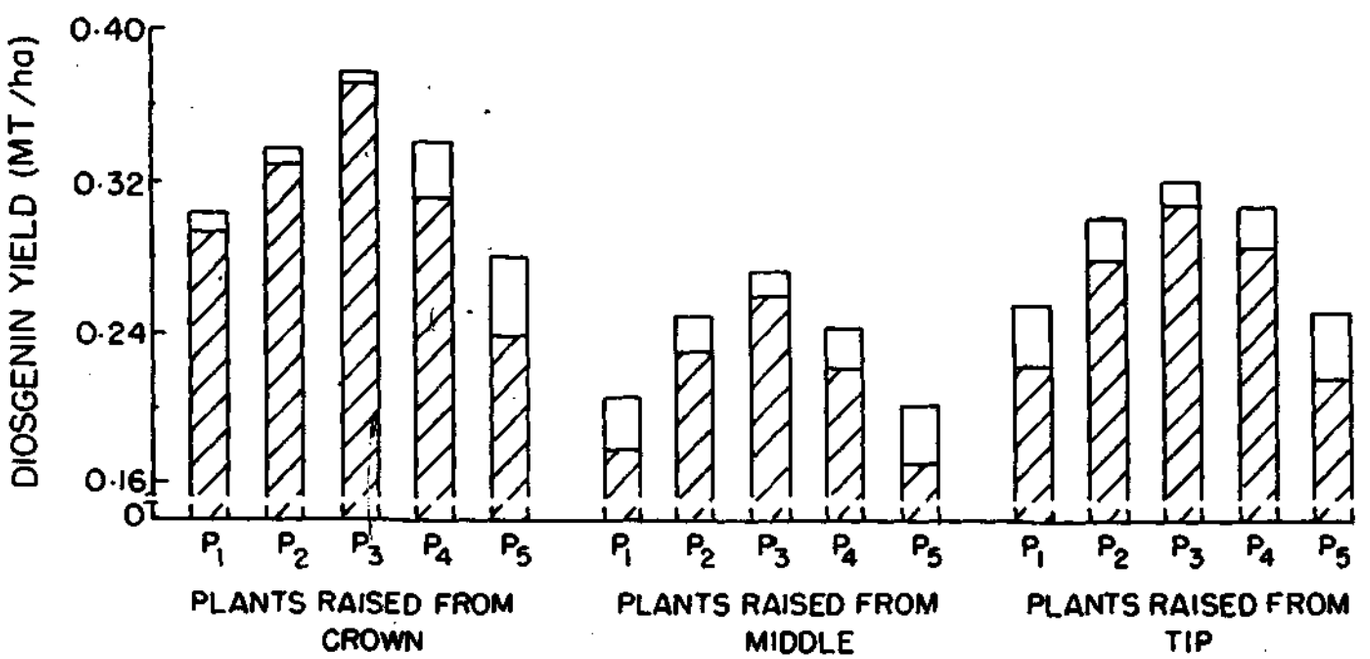

DIOSGENIN YIELD (MT/ha)
0·40
0·32
0·24
0·16
0
P1 P2 P3 P4 P5
PLANTS RAISED FROM CROWN
PLANTS RAISED FROM MIDDLE
PLANTS RAISED FROM TIP

Table No. 9.a. Effects of planting times on the production of "Yams" (fresh & dry) and Diosgenin yield (MT/ha.) in P R C of D. floribunda

P R C

Time of planting	Yam yield (MT/ha.)				Diosgenin yield (MT/ha.)	% of survival
	Fresh		Dry			
P_1	28.783	(29.869)	8.211	(8.521)	0.2931	95.6
P_2	33.011	(34.044)	9.139	(9.425)	0.3280	96.2
P_3	34.995	(35.372)	10.352	(10.523)	0.3722	97.6
P_4	29.642	(32.387)	8.725	(9.533)	0.3123	90.8
P_5	22.400	(26.362)	6.674	(7.854)	0.2389	84.3
Mean	29.766	(31.606)	8.620	(9.171)	0.3089	92.9
S E ±	2.157	(1.600)	0.601	(0.457)	0.0218	2.43

P R C = Plants Raised from Crown portion of the mother Yam.

Figures in parenthesis = Potential yield.

Table No. 9.b. Effects of planting times on the production of "Yams" (fresh & dry) and Diosgenin yield (MT/ha.) in P R M of D. floribunda

P R M

Time of planting	Yam yield (MT/ha.)				Diosgenin yield (MT/ha.)	% of Survival
	Fresh		Dry			
P_1	18.595	(21.627)	4.903	(5.702)	0.1779	85.3
P_2	24.770	(26.856)	6.371	(6.907)	0.2306	91.5
P_3	27.584	(29.052)	7.171	(7.553)	0.2610	94.2
P_4	21.707	(25.608)	5.673	(6.692)	0.2211	84.1
P_5	17.133	(21.089)	4.528	(5.573)	0.1702	80.6
Mean	21.957	(24.846)	5.729	(6.485)	0.2121	87.14
S E ±	1.926	(1.529)	0.480	(0.374)	0.0169	2.49
C.D. at 5% =	3.842	(3.148)	0.600	(0.546)	0.0328	

P R M = Plants Raised from Middle portion of the mother Yam.

Figures in parenthesis = Potential yield.

Table No. 9.c. Effects of planting times on the production of "Yam " (fresh & dry) and Diosgenin yield (MT/ha) in P R T of D. floribunda

P R T

Time of planting	Yam yield (MT/ha.)				Diosgenin yield (MT/ha.)	% of survival
	Fresh		Dry			
P_1	22.944	(26.254)	6.074	(6.950)	0.2236	87.6
P_2	28.846	(31.311)	7.514	(8.156)	0.2779	91.4
P_3	33.393	(34.582)	8.644	(8.952)	0.3092	95.8
P_4	27.892	(32.064)	7.263	(8.349)	0.2862	86.3
P_5	21.114	(25.307)	5.538	(6.628)	0.2163	82.9
Mean	26.837	(29.903)	7.006	(7.807)	0.2626	88.62
S E ±	2.191	(1.774)	0.549	(0.438)	0.0182	2.25
C.D. at 5% =	4.282	(3.448)	1.088	(0.866)	0.0264	

P R T = Plants Raised from Tip portion of the mother Yam.

Figures in parenthesis = Potential yield.

NUTRIENT ACCUMULATION

At various stages of growth of Dioscorea floribunda , plant parts were analysed chemically to study the effects of different planting times on Nitrogen, Phosphorus and Potassium accumulation.

Nitrogen accumulation : A perusal of the data (Table 10.a. to 10.c.) revealed that the nitrogen percentage accumulation progressively increased in successive stages of growth and development irrespective of the different planting time. Nitrogen accumulation, however declined sharply at the final stage of harvesting at 720 days after planting.

The Crown plants N accumulation gradually increased in P_1 , P_2 & P_3 planting during the 1st year growth - the values were 1.0003, 1.122 and 1.316 percent respectively. It was also revealed that the late planting P_4 (July) and P_5 (August) had less accumulation of N than P_3 (June) planting. The maximum value was found 1.1316 % in P_3 planting. The similar trend also observed during the 2nd year growth and was highest (1.405 %) in P_3 planting.

The results also enlightened that though the different planting times showed linear increase in N accumulation in successive stages of growth but sharply declined at the final stages of harvesting. The mean value also found highest in P_3 planting and the lowest (1.009 %) value was in P_5 planting.

In Middle and Tip plants the similar trend was observed but the values of individual planting time found highest in Crown plants followed by Middle and Tip plants. The mean values being 1.295 %, 1.230% and 1.279 %were found to be maximum in P_3 of Crown (PRC), Middle (PRM) and Tip (PRT) plants respectively.

NITROGEN ACCUMULATION (in percentage) IN WHOLE PLANT IN DIFFERENT STAGES OF GROWTH AS AFFECTED BY DIFFERNT PLANTING TIMES.

Table No. 10.a.

Time of planting.	P R C Succesive stages of Plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	1.003	1.142	0.959	1.034
P_2	1.122	1.216	1.011	1.116
P_3	1.316	1.405	1.164	1.295
P_4	1.214	1.328	1.021	1.163
P_5	1.032	1.122	0.875	1.009
Mean	1.137	1.242	1.006	1.123
S E ±	0.057	0.054	0.047	0.051

Table No. 10.b.

Time of planting	P R M Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	0.975	1.102	0.903	0.993
P_2	1.106	1.185	1.002	1.097
P_3	1.261	1.323	1.106	1.230
P_4	1.109	1.290	1.005	1.134
P_5	1.062	1.089	0.807	0.986
Mean	1.123	1.102	1.197	0.964
S E ±	0.046	0.047	0.050	0.045

Table No. 10.c.

Time of planting	P R T Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	0.990	1.134	0.910	1.011
P_2	1.120	1.193	1.010	1.107
P_3	1.304	1.376	1.158	1.279
P_4	1.209	1.307	1.019	1.178
P_5	1.009	1.111	0.871	0.997
Mean	1.126	1.224	0.993	1.114
S E ±	0.059	0.050	0.049	0.052

Phosphorus accumulation : The data presented in Table 11.a. to 11.c. revealed that the P_5 (August) planting accumulated more phosphorus than the other planting during the 1st year of growth whereas during the 2nd year growth the phosphorus accumulation did not varied significantly among the different planting times in all the cases of Crown, Middle and Tip plants. The decreasing trend of accumulation was revealed at the final stage of harvesting in all the cases of Crown, Middle and Tip plants. There were no significant variation of phosphorus accumulation among the different types of planting materials.

Potassium accumulation as effected by different planting time :

The data presented in Table 12.a. to 12.c. revealed that the uptake and accumulation of potassium showed a variation with the time of planting. Among the different planting time of PRC, PRM & PRT showed a similar tendency of potassium accumulation where P_3 gives the maximum accumulation in comparison to others. Among the different types it has been found that PRC showed maximum potassium accumulation than the PRM and PRT. It was also evident that the Crown plants (PRC) accumulated more potassium followed by Tip and Middle plants.

PHOSPHORUS ACCUMULATION (in percentage) IN WHOLE PLANT IN DIFFERENT STAGES OF GROWTH AS AFFECTED BY DIFFERENT PLANTING TIMES.

Table No. 11.a.

Time of planting	P R C Successive stages of plant growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	0.132	0.167	0.153	0.150
P_2	0.134	0.169	0.158	0.153
P_3	0.137	0.176	0.164	0.159
P_4	0.138	0.175	0.160	0.157
P_5	0.145	0.176	0.161	0.160
Mean	0.137	0.172	0.159	0.156
S E ±	0.002	0.001	0.001	0.001

Table No. 11.b.

Time of planting	P R M Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	0.131	0.165	0.150	0.148
P_2	0.132	0.167	0.155	0.151
P_3	0.134	0.170	0.161	0.155
P_4	0.135	0.171	0.159	0.155
P_5	0.137	0.171	0.160	0.156
Mean	0.133	0.168	0.157	0.153
S E ±	0.001	0.001	0.002	0.001

Table No. 11.c.

Time of planting	P R T Successive stage of plant's growth			Mean
	1st year growth	2nd year growth	final stage of Harvesting.	
P_1	0.131	0.166	0.152	0.149
P_2	0.133	0.167	0.158	0.152
P_3	0.136	0.173	0.162	0.157
P_4	0.136	0.175	0.160	0.157
P_5	0.142	0.175	0.161	0.159
Mean	0.135	0.171	0.158	0.154
S E ±	0.001	0.001	0.001	0.001

POTASSIUM ACCUMULATION (in percentage) IN WHOLE PLANT IN DIFFERENT STAGES OF GROWTH AS AFFECTED BY DIFFERENT PLANTING TIMES.

Table No. 12.a.

Time of planting	P R C Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	2.75	3.75	2.17	2.88
P_2	3.70	4.31	3.01	3.67
P_3	3.45	4.78	3.40	3.88
P_4	3.01	4.56	2.99	3.52
P_5	2.21	3.55	2.19	2.63
Mean	2.926	4.190	2.754	3.319
S E ±	0.304	0.237	0.244	0.238

Table No. 12.b.

Time of planting	P R M Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting.	
P_1	2.71	3.71	2.15	2.85
P_2	3.01	4.30	3.00	3.43
P_3	3.41	4.77	3.39	3.86
P_4	2.99	4.56	2.98	3.51
P_5	2.20	3.51	2.17	2.63
Mean	2.86	4.17	2.74	3.26
S E ±	0.200	0.241	0.246	0.225

Table No. 12.c.

Time of planting	P R T Succesive stages of plant's growth			Mean
	1st year growth	2nd year growth	Final stage of Harvesting	
P_1	2.74	3.73	2.16	2.87
P_2	3.01	4.31	3.01	3.44
P_3	3.43	4.77	3.40	3.87
P_4	3.00	4.56	2.99	3.51
P_5	2.20	3.54	2.18	2.64
Mean	2.87	4.18	2.75	3.27
S E ±	0.202	0.238	0.246	0.223

D I S C U S S I O N

DISCUSSION

In connection with the treatment of different time of planting with different type of planting materials in Dioscorea floribunda Mart. & Gal.; the results of the present investigation indicated many points of interests.

The rate and amount of photosynthesis occured during the growth period of the crop is closely related with the amount of dry matter production in a crop at final stage of harvest to agricultural yield. The total photosynthesis in its term, however, is dependent on the size of the photosynthetic system and efficiency of the crop at successive stages (Morton and Watson, 1948). The photosynthetic size of a crop can conveniently be measured by the total leaf surface at the plants per unit area, since photosynthesis takes place mainly on leaves. In view of the above consideration, the growth of leaf surface under different time of planting and type of planting materials have been studied and the growth of leaves have been measured in terms of Leaf Area Index (LAI) and the Relative Leaf Growth Rate (RLGR) during the cropping season.

In the present investigation it has been found that the leaf area index increases gradually with the advancement of planting time in P_2 to P_3 i.e. April to June planting, whereas, decreasing trend has been noticed in late planting - P_4 & P_5 i.e., July and August planting. The results also indicates that the mean values of LAI in the initial stage becomes lower in Crown plants (PRC) in comparison to Middle and Tip plants (PRM) & PRT) at 60 days but showed higher values in the Crown plants in the later stages of growth and development. By far the highest LAI values (1.245) have been recorded (Fig. 2.) in the June planting (P_3). Declination of LAI during the dormant period in each year growth is attributed to the senescence of older leaves suggesting an interplay of

competition between the 'source' and the 'sink' i.e., between leaves and the enlarging tubers, when the expanded leaves export increasing proportion of substrate to the tubers (Baker et al, 1966). In connection with estimation of LAI at various time period (P_1 to P_5), Fig. 7. indicates the optimum planting time corresponding to P_3 planting in June to yield maximum of yam production out of all the cases of planting materials.

LAI in early planting i.e., the April and May planting (P_1 and P_2) and also the late planting i.e., the July and August planting (P_4 and P_5) in all the three types of planting materials (PRC, PRM & PRT) may be accounted for reduced leaf number and size of leaves and which are mainly due to reduction in cell numbers (Watson, 1958). The decreased number of leaves of the plants have largely been influenced the results of more rapid death of lower leaves, however, the late planting covered a minimum growth period during the 1st year growth, resulting into early dormancy. But at the end of 2nd year leaf growth rates (RLGR) have been noted to be more-or-less the same in all the three types of planting materials.

The observation made under the present investigation indicates that both the leaf number and also the size attributes were greatly dependent on the planting times and the type of the planting materials. The value of LAI has been noted to be minimum in Crown plants during the early growth and the values sharply increases from 120 days (Fig. 2) whereas in the Middle plants and Tip plants some what higher values have been registered as compared to the Crown plants. When the three types of the planting materials have been compared the highest value (1.245) at 480 days was observed.

It has been observed that the early planting (P_1 & P_2) delayed the hastening of leaf formation due to less pricipitation and received a hardship

to establish for the new growth resulting the less amount of above ground biomass (Fig. 5). Thus photosynthetic surface is very much reduced during that period. This is also supported by earlier observation made by Morton (1948) who concluded that the LAI was dependent on leaf growth. Similarly the late planting (P_4 & P_5) received least precipitation during the 1st year growth and resulting in lower LAI values. Whereas, the P_3 planting received the maximum amount of precipitation resulting the highest values of LAI in all the three types of planting materials. The late planting (P_4 & P_5) received least precipitation during the 1st year growth resulting the least LAI values. Whereas during the 2nd year growth in all the planting types received more-or-less equal amount of precipitation.

The highest Relative Leaf Growth Rate (RLGR) found in P_3 planting of Tip plants may be due to the fact that the Tip portion of the yams has highly differentiated zones for the initiation of leaf primordia in comparison to those Crown and Middle plants and thereby the large number of leaves have been produced. But in this case the area per leaf has been noted to be minimum as compared to Crown plants. The total leaf area in P_3 planting of Tip plants has probably been compenseted by the large number of leaves. Consistantly increased rate of leaf growth has been noted in P_3 planting of Crown plants in comparison to other planting times of Middle and Tip plants due to production of total leaf surface. This observation is in confirmity with that of others (Mertin and Watson, 1948) who observed the same phenomenon in plants other than Dioscorea.

The accelerated Crop Growth Rate (CGR) under different planting time and the types of planting materials can be attributed to parallel increase in dry matter production. Various environmental factors like rainfall,humidity, temperature etc. may be considered to influence the accelaration of CGR during the period of experimentation which is

The experimental results represented in the Fig. 5. suggest that Crop growth rate is directly proportional to LAI. The lower value of CGR may be due to reduced leaf area index and leaf growth rate on account of leaf senescence at older stages. The crop growth rate in the early plantings (P_1 & P_2) has been observed to increase steadily and reaches its maximum at 60 to 120 days and 120 to 180 days respectively. A linear fall was recorded thereafter since the commencement of the 2nd year growth reaching minimum at the dormant stage. This may be due to linier decrease in leaf area index. But the increasing trend of CGR value has been noticed during the advancement of 2nd year growth with a corresponding increase in LAI (Fig. 5.). The late plantings showed a linear fall in CGR during the 1st year growth but gradually increased during the 2nd year growth till the dormancy starts in all the three types of planting materials.

Comparing the three types of planting materials, P_3 planting of Crown plants have been recorded to show maximum CGR value and may be due to receipt of maximum amount of precipitation and longer growth period. This observation is similar to those of earlier findings by Seale (1960 - '61); Enyi (1970), Gooding (1970) and Randhawa et al (1972). According to them plants raised from Crown seemed to receive the longer growth periods and sprouted earlier which helped in accumulating more chlorophyll in the leaves and which might increase of the rate of LAI, CGR and dry matter production.

The data analysed statistically, in connection with the effect of Net Assimilation Rate (NAR), it has been noticed that there was a linear increasing trend of NAR in P_1 to P_3 planting of Crown plants . However, more delay planting (P_4& P_5) over the June planting (P_3) showed a depression in NAR. Similar trend also have been observed in Middle and Tip plants. The increasing trend of NAR during the successive stages of growth inversely varies with the planting time. Thus more early the planting time resulted the late in decreasing trend of NAR,

trend. The rapid increase in NAR has been recorded in P_3 planting of Crown plants (PRC) upto 120 days and gradually declines upto 240 days. But P_5 planting showed a linear fall in NAR from 60 days. Among the three types of planting materials, P_3 (June planting) of PRC (Crown plants) showed the highest value of NAR. In all the planting times the lower NAR found to occur during the dormant stage of each year growth (Fig. 4.). No reports have been found in this line of works on Dioscorea floribunda in the agroclimatic condition of Darjeeling hills, but has been supported by Sarker and Bhattacharya (1976 and 1985) in other crops in the lataritic upland soil of West Bengal.

The dry matter production in plants at the very early period of growth was less but with the age of the plants have shown increased accumulation of dry matter in plants with the highest value at the time of harvest. This type of observation also has been supported by Seale (1960); Selvaraj et al (1972). The effect of planting times on dry matter production in successive growth stages was significantly more pronounced than the types of the planting materials. The highest dry matter production was found in P_3 planting of PRC followed by PRT and PRM. This has been found in confirmity with the findings of Randhawa et al (1968) in the same crop though there was a remarkable variation in yield due the climatic factors.

The Fig. 5. represents the variation in LAI, NAR and DM and their inter relationship among themselves. The co-rrelation studies (Table 13 & 14) in all the three types of planting materials have been strongly positive and is in confirmity with the findings of Shelvaraj and Randhawa (1972) ; Martin and Cabanillas (1967). The increasing or decreasing trend of NAR was found to be more-or-less parallel with LAI (Fig. 5.). The dry matter production was found highest in P_3 planting of PRC followed by PRT and PRM.

Table No. 13.

Correlation among Crop Growth Rate (C G R), Net assimilation Rate (NAR) and Dry Matter Production (DMP) under different planting time and the different type of planting meterials of D. floribunda.

P R C (Plants Raised from Crown)

Time of planting (No.of observations)	Crop Growth Rate (CGR) (gm. day^{-1}.Plant^{-1}) * (Mean values) 1	Net assimilation Rate (10^{-4}gm.cm^{-2}.day^{-1}plant^{-1}) * (Mean values) 2	Dry Matter Production (DMP) (gm.plant^{-1}) * (Mean value) 3
1. P_1	0.381	1.898	87.85
2. P_2	0.454	2.030	97.33
3. P_3	0.505	2.084	111.82
4. P_4	0.381	1.580	88.25
5. P_5	0.314	1.104	75.45

$r_{(1,3)}$ = 0.9874 ** $r_{(2,3)}$ = 0.8616 ** (* Pooled mean up to 540 days).

(** Significant at 1% level).

P R M (Plants Raised from Middle).

1. P_1	0.309	1.821	73.66
2. P_2	0.348	1.832	82.97
3. P_3	0.404	2.020	95.55
4. P_4	0.333	1.487	79.32
5. P_5	0.297	1.060	70.20

$r_{(1,3)}$ = 0.9921 ** $r_{(2,3)}$ = 0.7462 **

P R T (Plants Raised from Tip)

1. P_1	0.320	1.786	77.43
2. P_2	0.366	1.913	85.98
3. P_3	0.425	1.995	98.63
4. P_4	0.352	1.534	79.65
5. P_5	0.323	1.117	71.88

$r_{(1,3)}$ = 0.9735 ** $r_{(2,3)}$ = 0.8110 **

Table No. 14.

Co-rrelation among Dry-Vine yield, Dry Yam yield and Diosgenin percentage at the final stage of Harvesting of D. floribunda.

P R C (Plants Raised from Crown)

Time of planting	Dry Vine yield kg / plant (Mean values). 1	Dry Yam yield kg / plant. (Mean values). 2	Diosgenin % * (Mean values). 3
P_1	0.129	0.396	3.570
P_2	0.139	0.438	3.590
P_3	0.145	0.489	3.596
P_4	0.128	0.443	3.573
P_5	0.112	0.365	3.576

$r_{(1,2)}$ = + 0.8400 ** $r_{(2,3)}$ = 0.6716 (** Significant at 5 %)

(* Pooled mean values of Crown, Middle & Tip).

P R M (Plants Raised from Middle)

P_1	0.126	0.265	3.630
P_2	0.130	0.321	3.623
P_3	0.138	0.351	3.640
P_4	0.120	0.311	3.633
P_5	0.108	0.259	3.633

$r_{(1,2)}$ = 0.8441 ** $r_{(2,3)}$ = 0.1868 ** Significant at 5 %

P R T (Plants Raised from Tip)

P_1	0.128	0.323	3.686
P_2	0.131	0.379	3.700
P_3	0.138	0.416	3.703
P_4	0.127	0.388	3.696
P_5	0.110	0.308	3.700

$r_{(1,2)}$ = 0.8136 ** $r_{(2,3)}$ = 0.4864 (** Significant at 5 %).

Comparing the three types of planting materials it has been found that the yield per plant does not vary significantly between Crown and Tip plants but significant variation has been noticed between Crown and Middle plants. The result on interaction effect shows that the P_3 planting of both Crown and Tip plants are the best to show the highest yield per plant. Significant increase in Yam yield successively with the planting time from P_1 to P_3 has also been reported. Yam yield however declines under P_4 & P_5 planting. The highest yam yield (1.653 kg/plant of fresh yam in P_3 of Crown plants varies significantly with the yield under both P_1 & P_2 and P_4 & P_5 planting. The lowest yield (1.225 kg/plant) has been recorded in P_5 planting. Strong positive co-rrelation have been recorded (Table 13 & 14) between yield of dry vine and yam in all the planting types. Comparing the three types it has been found that the PRC gives maximum dry vine yield and the values have been noted to be close to those of PRT irrespective of the treatments. The benificial role of rainfall, growth period, proper planting time in augmenting the yam yields in Dioscorea floribunda Mart. & Gal. as recorded under the present investigation is in confirmity with that of findings of Seale (1961): Randhawa et al (1968), Soderholm (1968); Enyi (1970) and Gooding (1970). Higher yields under P_3 of Crown (PRC) plants followed by Tip (PRT) and Middle (PRM) plants have been resulted from a favourable interplay of environmental factors and natural soil moisture, the prevelence of relative warmer temperature, sufficient supply of rain water and high humid conditions during the active phases of vegetative growth.

The results of the present investigation revealed that the different planting time does not show significant variation on diosgenin content in yam. but among the different type of the planting materials, the diosgenin content

varies significantly. Comparing the three types, the diosgenin content has been noted to be mixmum (3.84 %) in the Tip portion of yam and which is in confirmity with the findings of Randhawa et al (1972).

The survival percentage has been observed to be the highest in Crown plants followed by Tip and Middle plants. In all the planting time of plants raised from Middle (PRM), the survival percentage has been found to be lower than those of Plants Raised from Tip (PRT) and Plants Raised from Crown (PRC). This may be due to an attack of pathogen to the maximum area of exposed tissues, low number of secondary meristematic zone, depletion of inorganic and organic metabolities, low suceptibility and the least amount of anthocyanin content and other related phenolic compounds which acts as phytoalexin (Harborne,1980). considering the survival percentage, the yield, calculated per hectare basis, found to be the highest in June planting (P_3) of Crown (PRC) plants followed by Tip (PRT) and Middle(PRM) plants. The diosgenin yield was also noted to have the same trends and which is probably due to more synthesis of diosgenin in the leader shoots that were sprouted earlier in Crown plants and subsequent transmission of diosgenin to the tubers as proposed by Baker, Martin and Wilson (1966).

A perusal of the profit and loss account has indicated that there is a considerable higher margin of profit in Crown plants followed by Tip and Middle plants for the 2 years crop (Table 15). Earlier investigators like Randhawa et al (1972) recorded higher net profit in two years crop when the plants received the good amount of precepitation. Considering the prevailing market price of Dioscorea floribunda dry yam Rs. 12.00 per kg (on an average 3 % diosgenin content), the maximum net profit (Rs.0.71) per rupee investment has been obtained under P_3 (June planting) of Crown plants. In Crown plants all the planting

Table No. 15 Economics of Yam production under different planting times of *D. floribunda*.

Time of planting	Mean Yam yield (dry) (Kg./ha)	Cost of Production (Rs./Kg.)	Profit (+) or Loss (-). (Rs./Kg.)	Net profit per rupee investment. (Rs.)
		L R C		
P_1	8.211	8.83	+ 3.17	+ 0.36
P_2	9.139	7.93	+ 4.07	+ 0.51
P_3	10.352	7.01	+ 4.99	+ 0.71
P_4	8.725	8.31	+ 3.69	+ 0.44
P_5	6.674	10.87	+ 1.13	+ 0.10
		P R M		
P_1	4.903	14.80	- 2.80	- 0.19
P_2	6.371	11.38	+ 0.62	+ 0.05
P_3	7.171	10.12	+ 1.88	+ 0.18
P_4	5.673	12.79	- 0.79	- 0.06
P_5	4.528	16.02	- 4.02	- 0.25
		P R T		
P_1	6.074	11.94	+ 0.06	+ 0.005
P_2	7.514	9.65	+ 2.35	+ 0.24
P_3	8.644	8.39	+ 3.61	+ 0.43
P_4	7.263	9.99	+ 2.01	+ 0.20
P_5	5.538	13.10	- 1.10	- 0.08

times have recorded profits per rupee investment. But in Middle plants, the early planting as well as late planting records a considerable loss per rupee investment (Table. 13). Whereas in Tip plants, all the planting times showed considerable profits except P_5 planting though these profits are subject to vary with fluctuating in prices of the produce and the materials to be used during the cultivation on commercial scale.

The results on plant analysis in respect to nutrient accumulation reveal that the maximum accumulation of nitrogen has been recorded during the 2nd year growth but noted to be minimum during the dormant period. A similar trend in nitrogen accumulation in various species of Dioscorea have also been supported by Jorg (1964), Nandi and Chatterjee (1975) and Robinovich (1972). Phosphorus accumulation has been observed to be more pronounced in Crown plants (PRC) than the Middle (PRM) and Tip (PRT) plants, whereas, at the end of 2nd year the decreasing trend of phosphorus accumulation has been noticed in each planting time of PRC, PRM and PRT. Regarding the potassium accumulation it has been found that the PRC showed maximum amount of potassium accumulation as compared to PRM and PRT (Table 12 a,b,c). In all the three types of planting materials, P_3 planting of PRC showed the highest accumulation of nitrogen, phosphorus and potassium followed by PRT and PRM.

The variable trend of nutrients accumulation at various growth stages of the present experimental crop leads to suggest that the crop is to be adequetly fertilized during the each year of plants growth.

From the review of literature it approves that no report is available in connection with the study on LAI, RLGR, CGR and NAR of D. floribunda in the climatic condition of Darjeeling hills and the data available in connection with the study of economics on the cash crop is especially for this region only.

Thus the data in this line of work is supposed to be report for the first time from this region and this may be helpful for utilization of the crop from commercial point of view.

The results of the present investigation thus demonstrate that diosgenin yielding crop like Dioscorea floribunda Mart. & Gal. accrue greater benefits providing the optimum time of planting i.e.; the June planting and the total precepitation be taken into consideration as important factors in Darjeeling hills for maximization of crop production and finally a remunerative return from this cash crop is possible. Regarding the type of the planting materials, the Crown portion has been noted to be the best followed by Tip and Middle portion but considering the availability of large number of tip and middle portion, the Tip portions may be considered as the best for its commercial utilization. But from the Table. 15 . it appears that the Middle portion may not be economically fisible therefore this should not be taken into consideration during the cultivation commercially.

S U M M A R Y

SUMMARY

In connection with the response of Dioscorea floribunda Mart. & Gall. on time of planting and types of planting materials, the LAI, RLGR, CGR, NAR have been worked out with special emphasis on the productivity of the yam yield.

The mean values of LAI of the initial stages of the plant growth has became lower in Crown plants (PRC) in comparison to Middle and Tip (PRM & PRT) plants. LAI has been observed to show maximum value in June (P_3) planting of Crown (PRC) plants followed by Tip and Middle plants (PRT & PRM) during the 2nd year of growth. The minimum LAI has recorded in Agust (P_5) planting of Middle plants.

CGR value has been noted to reach maximum also in P_3 planting of PRC followed by PRT and PRM. The lowest value has recorded in August planting for all the types of planting materials.

The NAR values have been observed to show a linear increasing trend from March to June planting of Crown plants. The increasing trend of NAR during the successive stages of growth and development has been noted to become inversely proportional to the planting time.

The effect of planting times on dry matter production has been noted to be significantly more pronounced as compared to the type of planting materials.

The yield attributes have been revealed that the yield per plant varies significantly between Crown and Middle plants, and also with Tip and Middle plants. The interaction effects revealed that the June planting both in Crown and Tip

plants have been noted to be the best for attaining the highest yam yield.

Significant variation in diosgenin content has not been observed under different planting times though the highest value of it has been noted in the Tip portion of the yam.

In respect of survival percentage the highest value has also been observed in Crown plants in comparison to those of Middle and Tip plants. The actual yield per hactare has been calculated and found to be the highest in June (P_3) planting of Crown plants followed by the Tip and Middle plants.

Nutrient uptake by the plants from the soil has been also found to be a similar linear trend. The detail economics has also been worked out. Crown plants has been noted to be the best for commercial cultivation in Darjeeling hills that to be planted in the month of June but due to the limitation of the availability of the planting materials like Crown plants, the Tip portion of the yam as Tip plants are considered to be the best for commercial utilization.