

**STUDIES ON AGRONOMY AND DEVELOPMENTAL PHYSIOLOGY OF
COMMERCIALY CULTIVATED DIOSGENIN YIELDING
Dioscorea sp. IN DĀRJEELING HILLS
WEST BENGAL**

**THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY IN SCIENCE (BOTANY)
OF THE
UNIVERSITY OF NORTH BENGAL**

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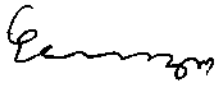
This is to certify that the research work embodied in the thesis "Studies on Agony and Developmental Physiology of Commercially Cultivated *Stemodia Toiding* *Stemodia* sp. in Darjeeling Hills, West Bengal" has been carried out by Sri Prashant Kumar Saha, M.Sc. (Ag.) under our joint guidance.

He has fulfilled the requirements relating to the nature and period of research. It is also certified that the thesis incorporates the results of original investigation made by Sri Saha in the Research Laboratory of the Directorate of Cinchona & Other Medicinal Plants West Bengal and in the Plant Physiology (Pharmacology) Laboratory, Centre for Life Science, University of North Bengal under our guidance and supervision and the thesis now submitted for the fulfillment for his Ph.D. degree in Science (Botany) of the University of North Bengal has not been submitted previously for any degree whatsoever.

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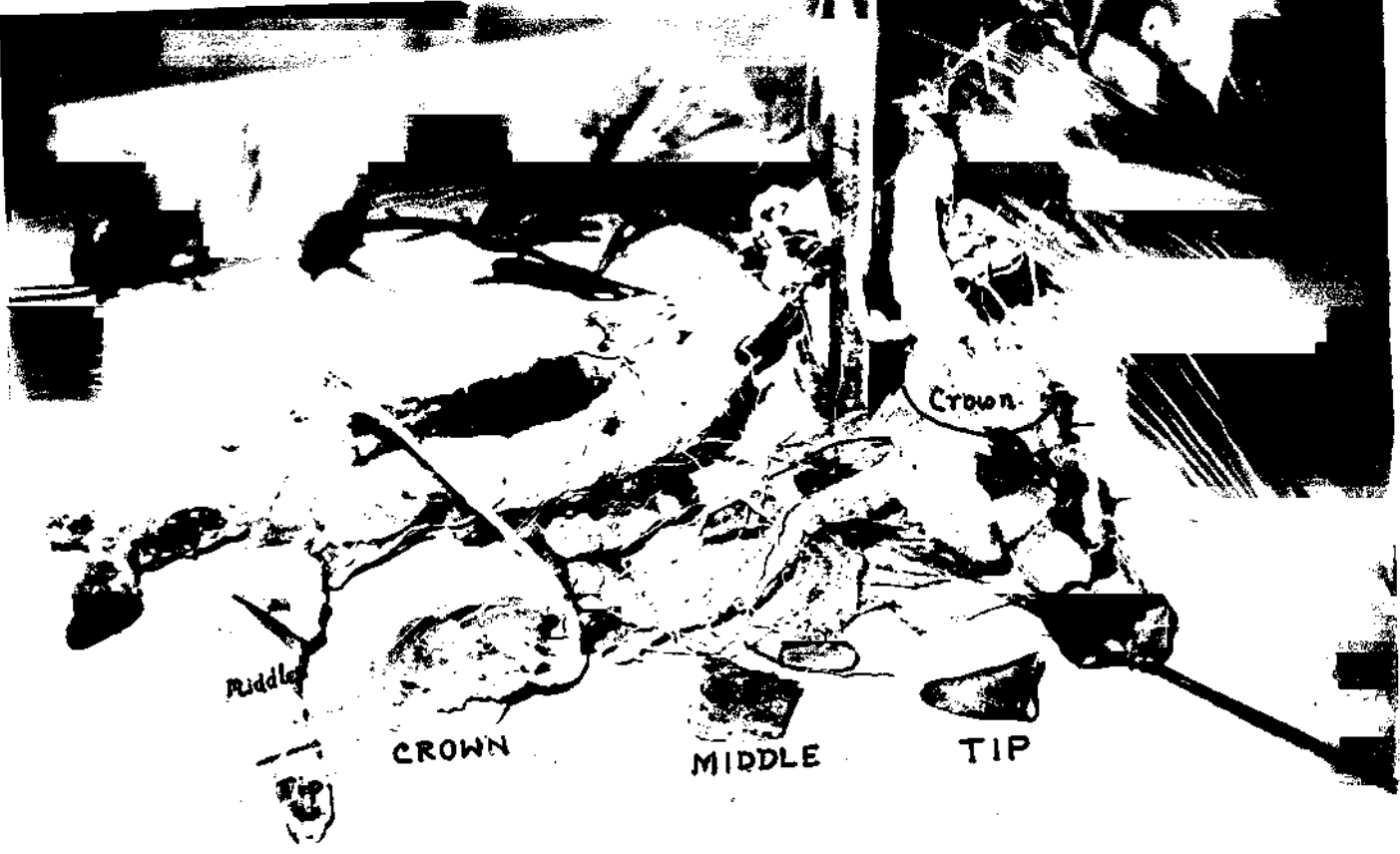
Lastly, I like to dedicate my findings to my beloved parents for their stead-fast encouragement.

Pranab Kumar Saha
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: ABBREVIATIONS :

CIMAP	Central Institute of Medicinal & Aromatic Plants.
C.D.	Critical difference.
C.S.I.R.	Council of Scientific & Industrial Research.
C G R	Crop Growth Rate.
D.C.O.M.P.	Directorate of Cinchona & Other Medicinal Plants.
DM	Dry Matter.
Fig.	Figure.
ha	hectare
lbs/cm ²	Pounds/square centimetre.
K	Potassium.
Kg.	Kilogramme
LA	Leaf Area.
LAI	Leaf area index.
ml	Mililitre.
m	metre.
MT	Metric tonne.
N	Nitrogen.
NAR	Net Assimilation Rate.
P	Phosphorus.
PRC	Plants Raised from Crown portion.
PRM	Plants Raised from Middle Portion.

PRT	Plants Raised from Tip Portion.
RLGR	Relative Leaf Growth Rate.
' r '	Co-efficient of Co-rrelation.
S.E.	Standard error.
TN	Total Nitrogen
W/V	Weight/Volume



Dioscorea floribunda Yam (Harvested after 720 days).



(PRC)

Plants Raised From Crown.
(1, 2, 3, 4, 5)

(PRM)

Plants Raised From Middle.
(6, 7, 8, 9, 10)

(PRT)

Plants Raised From Tip.
(11, 12, 13, 14, 15)

GENERAL INTRODUCTION

GENERAL INTRODUCTION

In India about 100 - 120 MT of diosgenin^{is} required annually to meet the demand of the country ; whereas the area under present cultivation, even on the basis of very liberal estimation, would hardly exceed 150 ha (courtesy - Prof. S.K.Chatterjee, D.C.O.M.P.; Govt. of West Bengal, India, 1985). Consequently fears on an early depletion of natural resources due to ruthless and indiscriminate exploitations might be ruled out.

It would be clear from the review of works done in Dioscoreas that though different aspects of agrotechnic, growth and diosgenin-formation in the genus Dioscorea have been undertaken from time to time, detailed analytical studies on climatic and soil factors in eastern Himalayan hilly regions of West Bengal affecting the growth and development of the species are limited.

Keeping all these facts in the forefront the Directorate of Cinchona & Other Medicinal Plants, West Bengal has taken up production of diosgenin from its own plantation. In recent years the Directorate has stressed^{on} the replacement of Dioscorea composita plantation by D. floribunda in this region with a view of producing high quality diosgenin and further downstream products of diosgenin. It has been noted that agronomic practices for successful cultivation of D. deltoidea are yet to be worked out ⁱⁿ this region. D. prazeri though naturalised in the North Eastern Himalayan regions but percentage & quality of diosgenin stand to be very poor in comparison to other species. In D. composita, though the yield of tubers is the highest than the other species, its commercial cultivation is rather expensive. Whereas in

D. floribunda, though the tuber yield is lower than D.composita but the content and quality of diosgenin is much higher.

Detailed experimental studies are not available on standardised agrotechnics for the commercial cultivation of Dioscorea floribunda Mart. & Gall., especially in Darjeeling hills though the species has been found to grow very well in this region on pilot-scale cultivation at the lower foot/hills.

The present thesis has dealt with studies on Dioscorea floribunda Mart. & Gall. (as introduced species) aiming to standardize agrotechnic for successful commercial cultivation of the species as well as to analyse developmental patterns of growth & development as related to different yield attributes and production of diosgenin under varying experimental conditions. Experiments undertaken in the present study have included varying conditions of planting time, size of planting materials, spacing and use of fertilizer & lime at altitude of 500-600 metres in Darjeeling hills. It is hoped that the present study will help to ascertain details of agronomic behaviour of the crop including its developmental physiology as reflected during commercial cultivation & replacement of other Dioscorea species in commercial venture by Dioscorea floribunda Mart. & Gall. under low altitude Eastern Himalayan conditions.

ABSTRACT

ABSTRACT

Cultivation of diosgenin yielding Dioscorea sp. and production of steroids have attracted the attention of different Govt. and Private organisation, for a long time past with the ^{growth in} demand of down-stream products of diosgenin. In India about 100-120 MT of diosgenin (Chatterjee, 1985) required annually to meet the demand of which the raw materials used mainly are Dioscorea prazeri, D. composita, D. deltoidea and D. floribunda. Among those species, Dioscorea deltoidea and Dioscorea floribunda have been reported only superior in quality and highest in diosgenin contents. But the adaptation and commercial cultivation of D. deltoidea are yet to be worked out in this region.

In India during the recent years only the Directorate of Cinchona & Other Medicinal Plants in West Bengal stressed the replacement of D. composita by D. floribunda as the raising cost of D. composita plantation is rather expensive in comparison to D. floribunda plantation.

Detail experimental studies ^{to} ~~on~~ standardize agrotechnics for the commercial cultivation of D. floribunda especially in Darjeeling hills are not worked out.

Thus the present study has been conducted with a view to standarize the agronomic practices for successive cultivation of the species in the agroclimatic condition of Darjeeling hills with a remunerative value.

Experiments undertaken in the present investigation have included varying conditions of time & type of planting materials, size of planting materials, spacing and use of fertilizers & lime.

Experimental results in respect to the effect of different planting times and the different type of planting materials on Dioscorea floribunda Mart. & Gall., reveals that the Leaf Area Index (LAI) increased gradually with the advancement of planting time from April to June, whereas, decreasing trend of LAI has been observed in late planting (July and August). The mean values of LAI of the initial stages has become lower in Crown plants (PRC) in comparison to Middle (PRM) and Tip (PRT) plants. LAI has been observed to show maximum values in Crown plants followed by Tip and Middle plants during the second year growth. The minimum LAI value has been recorded during the dormancy in all the treatments. The June (P₃) planting received the maximum precipitation and showed the highest LAI value in PRC followed by PRT and PRM.

Relative Leaf Growth Rate (RLGR) also showed a similar trend but during the early growth stage of Crown plants gives less number of leaves has been observed in comparison to Tip and Middle plants. The total leaf surface was maximum in Crown plants during the second year growth. June planting of the Crown plants showed the highest leaf growth rate. Senescence occurred early in the late (July & August) planting but delayed in the earlier planting.

Regarding the study of the effect of planting time on Crop Growth Rate (CGR), the results showed that the CGR reached its highest value in P₃(June) planting of Crown plants (PRC) followed by P₃ (June) planting Tip and Middle plants. The lowest value was observed in P₅ (August) planting for all the three types of planting materials.

In connection with the study on Net Assimilation Rate (NAR) it has been noticed that there was a linear increasing trend of NAR in P₁ to P₃

(April to June) planting of Crown plants. The delay in planting from P₄ to P₅ (July & August) showed the depression of NAR. The increasing trend of NAR during the successive stages of growth and development was inversely proportional to the planting time. Among the three types, June planting of Crown plants showed the highest NAR at 420 to 480 days of the second year growth period. The lower NAR was found to occur during the dormant stage in each year.

The dry matter production (DM) in plants ^{was low} at the very early stages of growth but during the maturity the plants have shown increased accumulation of dry matters. The highest value was recorded at the end of second year. The effect of planting times on dry matter production was significantly more pronounced as compared to the type of the planting materials. The DM was recorded to be the highest in P₃ (June) planting of Crown plants (PRC). Similar trend was also found in Middle (PRM) and Tip (PRT) plants.

Comparing the three types of planting materials, it was found that the yield in kg/plant did not very significantly between Crown and Middle plants and also with Tip and Middle plants. The results on interaction effects revealed that the P₃ planting both in Crown and Tip plants were the best for attaining the highest yam yield. It was revealed that there had been significantly increase in yam yield successively with the planting time from April to June. Yam yield had however declined under July and August planting. The highest yam yield (1.653 kg/plant) varies significantly with the yield under both early and late planting of Crown plants. Comparing the three types of planting materials it had been found that the Crown plants gives the maximum dry vine yield and the values were more closer to those of Tip raised

plants irrespective of the planting times.

The results of the present investigation revealed that the different planting time did not show significant variation on diosgenin content in yams, but the different types of the planting materials such as Crown, Middle and Tip portions showed a significant variation in their diosgenin content. Comparing the three types, the diosgenin content was to be maximum in Tip portion (3.84 %).

Considering the survival percentage, the highest value was noted to be in Crown plants followed by Tip and Middle plants. The actual yield on both fresh and dry weight basis was found to be the highest in P₃ planting of Crown plants followed by Tip and Middle plants.

In determining the optimum time of planting for a remunerative harvest of Dioscorea floribunda Mart. & Gall. crop, the marginal production and the cost of production have been considered. Considering the prevailing market price of D. floribunda dry yam (on an average 3 % diosgenin) the maximum magnitude of profitable yield was obtained in P₃ (June) planting of Crown (PRC) plants followed by Tip and Middle plants. In determining the economics of the different planting times, the actual yield has been considered. Higher margin of profit was recorded in June planting. The profit was the highest over the added cost of production for the individual treatment, recorded in P₃ of Crown plants. The maximum acceptable margin of profit is achieved in June planting of Crown plants per rupee investment followed by Tip plants. Considering the availability of the planting materials, June planting of Tip plants may be considered as the best for planting time and the planting materials.

Regarding the studies of nutrient accumulation (total nitrogen, phosphorus and potassium) in the plant as affected by the different planting times, the maximum accumulation of nitrogen was recorded during the second year growth but minimum amount of accumulation was found at the final stage of harvest during the dormant period in Crown plants followed by Tip and Middle plants. But phosphorus accumulation was noticed to be more pronounced in Crown plants during the first year growth, whereas, at the end of second year growth ^{the} decreasing trend was noticed in each planting time of Crown, Middle and Tip plants. Regarding the potassium accumulation, it has been found that the Crown plants showed maximum accumulation than the Middle and Tip plants. In all the cases of planting materials, June planting of Crown plants showed the highest nutrient accumulation.

The Crown portion is noted to be the best for planting materials which is to be planted in June for the commercial cultivation as a cash crop in the agroclimatic condition of Darjeeling hills. But due to the limitation of the availability of Crown parts of the yams, the Tip portion is considered to be the ^{second} best for its commercial utilization.

In connection with the responses of D. floribunda to different size of the planting materials with the different types ^{of planting material}, the results revealed that LAI increases correspondingly with the increase of the planting materials from 10 gms. to 90 gms (W_1 to W_5) during each year growth but a decreasing trend was noticed during the dormant period of each year of growth. At the initial stage of growth, the minimum value of LAI has been observed in W_1 but found maximum in W_5 of Crown plants. In all the treatments, the LAI took their momentum from the commencement of the second year growth.

^AThe similar trend also have been noticed in ^{growth of} the Middle and Tip plants. The highest value of LAI was recorded in W_5 (90 gms) of Crown plants followed by the Tip plants and Middle plants.

Statistical analysis revealed that Middle plants showed a significant difference with the Crown and Tip plants. Regarding the treatment effects W_1 and W_2 showed a significant differences with W_3 , W_4 and W_5 but W_4 and W_5 ^{are} not significant ^{from} to each other.

The results on RIGR showed that there has been no remarkable variations of the values between the Crown and the Tip plants but the Middle plants showed significant variation with Crown and Tip plants. The Maximum value have been observed in W_3 (50 gms) of Crown plants.

In connection with the responses of the different sizes on Crop Growth Rate (C G R), the result showed that the C G R increased gradually with the increase in sizes of the planting materials and also increased gradually in their successive stage of growth till the dormancy of the planting material started in each year. The mean values of C G R was found to be maximum in W_5 (90 gms) during the second year growth and the minimum value was observed in W_1 (10 gms) for all the cases. The highest C G R has been observed in W_5 (90 gms) of Crown plants. The interaction effects resulted a closer relation between Crown and Tip plants.

Variation in NAR revealed that W_5 of Crown plants showed the highest value during the period of 420 to 480 days followed by the Tip and Middle plants. The interaction results among Crown, Middle and Tip (PRC, PRM & PRT respectively) plants showed a closer relation between PRC and PRT.

The dry matter production (DM) in all the treatments varies

directly with the size of the planting materials during the subsequent stages of plant growth and development. The total dry matter increased gradually in each treatment and found to be the highest value at the harvest in W_5 of Crown plants followed by Tip plants and the lowest value was observed in W_1 in all the three types of the planting materials.

Regarding the correlation studies among CGR, NAR and DM production it has been found that all the treatments showed ~~the~~ strongly positive correlation among themselves.

Regarding the yield attributes it has been observed that the yam yield per plant increased successively with the size of the planting materials attaining a maximum value of 1.645 kg/plant in W_5 of Crown plants during two years of cropping season. The lowest was found in W_1 planting size. In general the increase in yam yield directly varies with the increase of dry vine yield in all the treatments.

Among the planting sizes there has been no appreciable variation in diosgenin percentage but among the different types the tip portion of the yam showed the highest diosgenin content (3.84 %).

Regarding the yield of yam and diosgenin per hectare under different sizes of the planting materials it has been found that the highest yield (35.254 MT/ha) was recorded in W_5 of Crown plants followed by Tip (32.937 MT/ha) and Middle (31.232 MT/ha) plants. The survival percentage was also the highest in Crown plants having the highest size of the planting materials followed by the Tip and Middle plants.

Though the W_5 (90 gm) of Crown plants has been recorded the highest yield but the cultivation cost especially the cost of planting materials are found to be higher in comparison to other sizes of the planting materials. Considering the added cost of production and the added return it has been

found that W_3 (50 gms) planting size of Crown plants gives the highest profit per rupee investment and found to be the best for its commercial utilization. But in consideration with the availability of the planting materials, W_3 of the Tip plants and 50 gms pieces of the tip portion was found the best for commercial utilisation.

Nitrogen, phosphorus and potassium content have been estimated in the serial parts of the plants at three different stages for all the planting materials. It has been noted that N P K content gradually rised during each year growth and there-after declined during the dormant period.

In conclusion of present investigation it has been revealed that the 50 gms pieces of Crown and Tip portion found to be the best for obtaining higher margin of profit per rupee investment for commercial utilization in the sandy-loam soil of Darjeeling hills.

The results on growth and development in respect of physiological parameters and yield attributes as affected by the different spacing of Dioscorea floribunda Mart. & Gall. revealed that the LAI inversely varies with the planting densities. The successive increment in planting densities from S_1 to S_7 showed corresponding decrease in LAI at all stages of growth period.

The rate of leaf growth was to be found to considerably decreased with the increase in planting densities. The highest RLGR was recorded in S_1 against the lowest in S_7 of Crown plants followed by Tip and Middle plants. The same trend also found in case of C G R and N A R as well as the dry matter accumulation.

Regarding the yield of yam per plant the highest yield was observed in S_1 spacing of Crown plants and the lowest was in S_7 followed by the Tip and Middle plants. Among all the spacing only S_4 spacing showed the significant differences with the other spacings.

Regarding the diosgenin content it has been observed that there was no significant variations rather there was no significant responses of spacing in the variations of diosgenin content.

Analysis of yield data revealed that the yam and diosgenin yield per hectare in consideration with the survival percentage was found to be the highest in S_4 (60 cm. X 75 cm) of Crown plants (PRC) followed by the Tip and Middle plants.

A perusal of net profit per rupee investment was found to be the highest in S_4 (60 cm X 75 cm) spacing of PRC followed by PRT. But in the Middle plants the maximum net profit was obtained in S_5 (60 cm X 60 cm) spacing.

The N P K analysis of plants revealed that the accumulation was maximum in the widest spacing and the minimum was in the closest planting in all the three types of the planting materials.

It may be concluded that the most remunerative ^{yield} harvest of the crop will be obtained in the plants having 60 cm X 75 cm spacing in case of Crown plants and Tip plants but for the Middle plants the maximum yield was obtained in the 60 cm X 60 cm spacing.

The investigation consisted of application of 5 levels of Nitrogen (0, 50, 150, 250 & 350 kg/ha) with fixed doses of phosphorus (50 kg/ha)

and Potash (150 kg/ha) in no lime and with lime (1.2 MT/ha) dressed soil has shown a number of encouraging features on the commercial cultivation of Dioscorea floribunda Mart. & Gall. in the marginal lands of Darjeeling hills at altitude of 500 to 600 metres.

The LAI, RLGR, CGR, NAR & DM have ^{been} measured. The highest magnitude (an average of two cropping seasons pooled data) have been recorded under N_4 (350 kg of N/ha) treatment in lime dressed soil, ^{which gave} with a maximum yam yield (an increase of 220 % over control).

A perusal of the profit and loss account has indicated that though the application of 250 kg of N/ha has been statistically significant so far as the yield of tuber^s concerned but for the commercial point of view 350 kg of N/ha in two split doses in lime treated soil has been ^{found} ~~suggested~~ to be of much economic return per rupee investment considering involvement of the cost during the commercial cultivation.

The co-rrrelation studies among CGR, NAR and DM production has shown that the co-rrrelation was strongly positive and the results ^{were} similar to positive co-rrrelation among the factors like dry vine, dry yam yield and diosgenin content.

In conclusion it can be mentioned that the present investigation regarding the planting time, size, spacing and uses of fertilizers with liming revealed that the June planting having 50 gms pieces of planting materials of tip portion and Crown portion with a spacing of 60 cm X 60 cm ; dressing with lime (1.2 MT/ha) in soil and a judicial dose of fertilizer (350 kg of N/ha, 50 kg of P/ha and 150 kg of K/ha) found to be the best for commercial utilization in the marginal lands of Darjeeling hills, West Bengal.

P A R T - I

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1. Importance of Diosgenin in steroid industry : Russel Marker of Pennsylvania State University discovered that the tubers of wild Mexican plant (Dioscorea mexicana), contain a steroidal sapogenin in large amount. Marker and his co-workers (1943) discovered that wild Mexican species of Dioscorea yield basic diosgenin. Marker (1943) published the process of breakdown of diosgenin to number of sex-hormones, including progesterone and testosterone. In a few years, this discovery led to increased availability of these drugs and their prices were greatly reduced. However, the use of diosgenin was limited to the production of only sex hormones as its molecule did not contain keto or hydroxy group in position 11 or 12 and hence could not be used to synthesize cortisone which was clinically more important. In 1949, an important discovery was made based on which, hydroxy group could be introduced in position 11 of the diosgenin molecule by micro-biological technique. This discovery led to transform diosgenin into a valuable starting material for cortisone or progesterone. Subsequently, cortisone was replaced by more advanced and more active corticosteroids like hydro-cortisone and prednisolone.

2. Importance of various plants with special emphasis on different Dioscorea sp. as the source of diosgenin : With the advancement of steroid technology there was a great demand of wild growing Dioscorea sps. in Mexico, and steroid drug was ^{produced} started, mainly in Mexico and in the ^{united} State in early fifties. During mid fifties, Dioscorea sp. containing diosgenin in appreciable amount became the main source for manufacture of various steroid hormones in different part of the world. There are various sources of diosgenin which can be obtained from different plant species listed in the Table 1.

Table No. 1. List of plants being used or under investigation
as source of diosgenin.

Name of the plant.	Percentage of diosgenin.	Habitat & Cycle.
1. <u>Dioscorea deltoidea</u> Wall.	3 - 5	Growing wild in the lower foot hills of Sub-Himalayan region; organised cultivation partially successful in some parts of India. Cycle 3 to 5 years (Chatterjee, 1978).
2. <u>D.prazeri</u> Prain & Burk. Upto 2.5	2.5	Naturally occurring in North Eastern Himalayan region and presently under cultivation in Darjeeling Hills. Cycle 3 years (Chatterjee <u>et al.</u> 1980).
3. <u>D.floribunda</u> Mart & Gall.	2 - 5	Central American species ; grows well in peninsular region and North-East Indian low altitude locations. Cycle 2 to 3 years (Randhawa, 1975, Husain, 1977).
4. <u>D. composita</u> Mems1.	2 - 4.5	Central American species. Can grow in low altitude of West Bengal and peninsular India. Cycle 2 to 4 years (Chatterjee & Nandi, 1977).

Contd.....

Name of the plant.	Percentage of diosgenin.	Habitat & Cycle.
5. <u>Costus speciosus</u> (koeng.) Sm.	1.5 - 3	Grows wild all over India especially in foot hills. Cycle 1 to 1½ years (Panda & Chatterjee, 1980).
6. <u>Trigonella foenumgraceum</u> Linn.	0.7-1.7	High sapogenin yielding under experimental cultivation. Cycle 3 to 6 years (Bluden <u>et al</u> , 1975, Khanna & Jain, 1975).
7. <u>Kallastroemia pubescence</u> (G.Don) Dandy.	0.5-1.5	Tropical American, naturalised in many parts of India. Cycle 6 months (Chakravarty <u>et al</u>) 1976
8. <u>Balanities segvntiaca</u> (Linn.) Delile	1 - 2.5	Perinial spring plant ; found mostly in semi-arid Zones (Hardman & Sofoworn, 1972).

To date almost all the supplies of Dioscorea raw materials come from the wild sources. The major producing countries are Mexico, Guatemala, India and China. In India species like D. deltoidea, D. floribunda, D. composita and D. prazeri are principally used for diosgenin extraction. However, the wild resources are getting rapidly depleted. Due to ^eover growing demand for steroid drugs (and for diosgenin), coupled with dwindling wild sources of this precursor and continued sprout in its price, research efforts were intensified all over the world to develop new sources of diosgenin with a special attention to find out alternate precursors with better route of production and cheaper end products.

3. Cultivation of Dioscorea sp. in India : At a symposium held in Lucknow in the year 1952, Dr. R.N.Chakravarty of the School of Tropical Medicine, Calcutta, was the first to suggest the possibility of exploitation of diosgenin containing Indian Dioscorea sp. He mentioned that D. deltoidea and D. prazeri growing wild in North-Western and North-Eastern Himalayan regions respectively contained appreciable amounts of diosgenin. The results made known in 1956, generated considerable interest in some pharmaceutical firms. An Indian Company CIPLA entered the steroid field and began producing diosgenin in 1961 and Wyeth in 1962. Subsequently, CIBA-Geigy, Searly and Organon also started manufacturing sex hormones. Glaxo (India) switched over to local diosgenin and subsequently to its intermediate for producing Beta-methasone. In 1966-67 CIMAP (CSIR) entered the commercial production of diosgenin in its drug factory, Jammu, utilising the wild D. deltoidea. It is for the first time that in Eastern India the Directorate of Cinchona & Other Medicinal Plants, Govt. of West Bengal has started on a commercial scale, production of diosgenin and also has entered to produce down stream products of diosgenin.

India depended almost entirely on the wild D. deltoidea. tubers for its diosgenin^{require}. The large scale collection of tubers has resulted in depletion of forest resources and in some areas complete eradication of the wild plant is well noticed. The natural regeneration of this species required more than 7 years and it has been felt necessary to bring it under cultivation. Successful cultivation of D. floribunda and D. composita in Bangalore, Jammu, Goa and other parts of the country is reported from 1973 onwards.

Cultivation of Dioscorea in India has been studied by Bammi and Randhawa. The wild sources of D. deltoidea are dwindling in India and supplies of wild material with optimum diosgenin content are becoming more and more scarce and expensive. In West Bengal D. prazeri a ^{native} wild species, which was under experimental cultivation at the foot-hills of the Eastern Himalayan region like in Darjeeling Terai, appeared less promising both in terms of tubers and diosgenin content. As such the emphasis has shifted to cultivation of Central American species, viz. D. composita and D. floribunda but D. floribunda ^{is} mostly preferred ^{due to} for the maximum return.

4. Biosynthesis, mobilization, estimation and factors affecting production of diosgenin in plant parts of Dioscorea sp. : The natural diosgenin (sapogenin) is obtained from the tuber of Dioscorea and extensively used ^{for production of} as several steroidal hormones including cortico-steroids, sex hormones and antifertility compounds.

The sapogenin was first discovered by Fuji and Matsukawa (1936) which remained dormant for some years, until Marker and his associates (1943) revealed the synthesis of cortisone and other drugs. Kennard and Norris (1956) developed cultural practices of D. floribunda who showed that plants on wire trellis with vines gave significantly higher yield of tuber than plants growing on poles only or without support. Bennett and Heffmann (1965) traced the bio-synthesis of

sapogenine of Dioscorea by incorporating the radio active mevalonic acid. Martin and Delphin (1965) estimated the sapogenin production and agronomical potential of D. speculiflora and Baker, Martin and Wilson (1966) observed that diosgenin occurred in the cotyledon-endosperm of the dormant seeds of D. deltoidea and D. sylvatica and in the tubers, roots, stems and leaves of those plants from the seedling stage onwards. Actively growing aerial tissues, such as leader shoots appeared to be the sites of formation, from which the diosgenin could be transmitted to the tubers. Martin and Deplin (1967) reported that soil and climatic factors governed the sapogenin production in D. composita and D. floribunda and suggested that the plants propagated from stem cuttings gave better results in D. floribunda.

Karnic^k (1975) reported that D. prazeri and D. deltoidea from different locations in India yielded varying percentage of sapogenin content at various stages of growth. Sapogenin concentration increased with the age of the tuber. The optimum sapogenin was found when the plants were just shedding ^{leaves} i.e. in dormant stage, which appeared to be the best for commercial exploitation.

Bammi and Randhawa (1975) reported germination of stem cutting of D. floribunda by usual horticultural methods. Chaturvedi (1975) demonstrated the possibilities of rapid clonal propagation of D. floribunda through tissue culture by achieving 100% rooting of single leaf-cuttings.

Nandi and Chatterjee (1977) pointed out that D. prazeri containing 2.0 to 4.0 percent diosgenin had been growing wild in Eastern Himalayan hills and Chatterjee (1980) described the detailed cultural practices of the plant. The effect of chemicals on three species of Dioscorea had been analysed by Nandi and Chatterjee (1977). Shelvaraj et al (1977) showed a co-rrrelation

between diosgenin content and dry matter production.

In 1979, Chatterjee et al. pointed out distinct effects of external and internal factors on productivity patterns of active principles in some medicinal plants including Dioscorea and such increase of productivity was found to be functions of topographical, ecological, environmental as well as of some biochemical factors. Shelvaraj and Subhas Chander (1977) reported that fresh tubers contained 4 - 6 percent more diosgenin than dry tubers.

Tal and Goldberg (1981) described the application of HPLC in quantitative analysis of diosgenin and stigmasterol from D. deltoidea.

5. Planting time and Type of planting materials, as factors affecting yam and diosgenin yield in Dioscorea sp. : Enyi, BAC (1970) found that there was a positive correlation between rainfall and vine growth, vine weight, and tuber yield in D. cavanensis which required a long growing season for maximum production ; whereas in D. alata, D. rotundifolia and D. esculanta, much shorter growing season was required. According to Gooding (1970), rainfall below 100 cm during the 8 months growing season appeared the limiting factor in D. alata. Wilson and Mapother (1969-70) concluded that in D. deltoidea plants raised from seedlings and set out in May, tuber yields were maximum at 17 to 19 months. Diosgenin percentage augmented during the first Year after which there was little change.

Seale (1960-61) claimed that D. floribunda gave highest yield when harvested at 31 months after planting. In this connection Selvaraj et al. (1972) found the diosgenin content was correlated with their dry matter content where the relationship was closer with 2 years old tubers in D. floribunda and D. deltoidea. Mehta and John reported that diosgenin was translocated into the tubers after biosynthesis principally in the aerial parts. Cruzedo et al. (1965) claimed in their experiments that in Dioscorea floribunda the sapogenin concentration increased

more rapidly than D. composita but due to more rapid tuber growth, D. composita out yielded other species in total content during 3rd season field growth. Decrease in sapogenin content during spring growth and increase in summer and fall were noted. D. floribunda could be harvested after 3 seasons of growth whereas 4 or 5 seasons of growth might increase average yearly yield of D. composita. Both species should be harvested during the winter season when sapogenin content was stable.

Shelvaraj et al (1972) investigated that the distribution of diosgenin in one year old tubers of three sapogenin bearing species viz. D. composita, D. floribunda and D. deltoidea. The intact tuber was separated into three different portion used generally for propagation i.e., Crown, Median and Tips. The sapogenin content was found to be more in the dorsal portion in the tuber than the ventral portion in D. composita and D. deltoidea in fresh weight basis. However in D. floribunda the ventral portion had the maximum content. Tip portion of the tuber in D. composita, the median portion of the tuber in D. floribunda, tuber portion without any sprouted buds in D. deltoidea had the maximum sapogenin content. They also reported that the diosgenin content of D. floribunda tuber have closer correlation with the dry matter production of 2 years old tuber. Randhawa et al (1968) claimed that D. floribunda, planted in April in Bangalore region, was best as it gave quicker sprouts and higher tuber yields. They also claimed that two year crop of D. floribunda in the same region yielded 60 MT/ha by using medians and tip portions of tuber as planting materials (which otherwise gave lesser yield during first year).

Randhawa et al (1975) also found in their experiments in IIHR (Bangalore, India) that diosgenin percentage on dry matter basis in D. floribunda tubers

were not affected by the agronomic treatments as it was a purely inherited character. The yield of diosgenin therefore depended on tuber yields. Diosgenin content varied from 0.3 to 6.77% on the dry weight basis in 612 samples of D. floribunda. They did not find any correlation between girth of tuber and diosgenin content but a positive correlation was obtained between available phosphorus in soil and diosgenin content in tuber, whereas the level of available potassium in the soil was negatively correlated with diosgenin content. The relationship obtained between dry matter and diosgenin contents in one year old tubers of D. floribunda was significantly varied but with low prediction index. The relationship improved substantially in two year old tubers. Regarding the distribution of diosgenin in tubers, they found that the 30 days after planting contained less diosgenin compared to median and tip portion. Regarding the economics of commercial cultivation they reported a net profit of about 10,000/- to Rs. 12,500/- per hectare for one year crop and Rs. 25,000/- to Rs. 30,000/- per hectare for two years crop.

Soderholm (1968) reported in the experiments that 2½ years crop of D. composita, gave the yield of 21 MT of dry tubers and 1049 lbs of crude sapogenins.

6. Size of planting materials as factor affecting yam and diosgenin yield in

Dioscorea sp. : Randhawa et al. (1975) suggested that 40 to 60 gms pieces of D. floribunda tuber as a planting materials were more economical. They also suggested in their experiments in IHR that as the Crown portion of the tuber contained less sapogenin compared to median and tip, the crown portions could be used as planting materials (having the maximum survival percentage) to get the maximum return.

Gregory (1968) claimed that D. floribunda propagated from segments of the dormant tuber rootstock resulted uneven sprouting with high loss from rot ; whereas stimulation was obtained by using rootstocks from active growth. A 31°C

temperature significantly stimulated bud development in the D.floribunda selections.

Sharma et al (1985) and Saha & Chatterjee, (1985 & 1989) claimed in their experiments that D. floribunda could be selected for commercial cultivation of due to less cost of maintenance and cultivation as compared to D. composita. They also found that D.floribunda planted in the middle of June with the Crown and tip portion as a planting materials having 50 gms pieces and uniform spacing was best as it gave quicker sprout, higher relative leaf growth rate, crop growth rate and tuber yield per hectare in 2½ years crop.

7. Spacing trial in connection with productivity of yam in Dioscorea sp.

Baker (1964) found that the yield response to population change was approximately linear and the slopes of the curves for different plant populations were themselves in linear relationship to the plant population per unit. Randhawa et al, (1968) observed that a spacing of 60 cm X 60 cm and 60 cm X 30 cm was optimum for one year and two years crop of D.floribunda respectively. Saha & Chatterjee (1985) claimed that the planting density with uniform fertilizer dose in D.floribunda would give highest yield. In other planting densities, the variation of yield was not significant.

8. Use of Fertilizers in connection with the production of yam in Dioscorea

sp. : Nutritional conditions effect the general growth of the plants as well as actual formation of active principles. Braun and Jorg (1964) reported that sieve tube bundles of the Dioscoreaceae showed high acid phosphatase localisation and which was argued for active transport of assimilates.

Cruzedo et al (1965) claimed that complete fertilization in D.composita increased diosgenin content. The fertilization affects had also been studied

by Ferguson and Hynes in D. esculanta and D. alata (1970). Nandi & Chatterjee (1975) showed the effect of phosphorus fertilization to enhance extension growth of Dioscorea. The same authors (1978) observed an enhancement in diosgenin content by phosphate and its decrease by nitrogen fertilizers in D. bulbifera var. pulchella, D. pentaphylla and in D. composita. Khan et al. (1978) observed that application of fertilizers NP and N gave higher Yield (2.27, 2.24 % respectively) as compared to P fertilizer (2.07 %).

Robinovich (1975) reported that in pot experiments with D. deltoidea, 60 kg of N + 100 kg of P_2O_5 + 60 kg of K_2O /ha and 100 kg of P_2O_5 + 60 kg of K_2O /ha stimulated growth and development of root system, the later increased by 63 % compared with the control. Liming aided D. deltoidea's development. Two years old seedlings showed 1.8 % - 2.2 % diosgenin content. Recently, Singh et al. (1981) observed significant interaction between N & P, N & K and N with P & K on diosgenin yield. The same authors also noted that the tuber yield/plant and tuber production per unit area of D. floribunda to be increasing significantly with increase in N & P dose.

Chatterjee et al (1985) found that 250 kg of N / ha yielded positive responses, while P & K had no significant responses in yield. Saha & Chatterjee (1989) reported that D. floribunda would have a good prospect for commercial cultivation around Darjeeling district on marginal land, having impact of Socio-economic condition of the hilly people.

P A R T - II

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

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

INTRODUCTION.

Various environmental factors such as precipitation, 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}The 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

MATERIALS AND METHODS

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 Nursery 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 :

<u>Mechanical analysis (%)</u>		<u>Chemical constituents.</u>	
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 (P₁), May (P₂), June (P₃), July (P₄) and August (P₅) ; each experiment takes equal size of planting materials but from the different parts of tubers line such as Crown (PRC), Middle (PRM) and Tip (PRT) of the mother yam (tuber) of Dioscorea floribunda.

- P₁ - 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).
- P₂ - Planted on 15.5.1984 - One set each with PRC, PRM & PRT.
- P₃ - Planted on 14.6.1984 - One set each with PRC, PRM & PRT
- P₄ - Planted on 14.7.1984 - One set each with PRC, PRM & PRT.
- P₅ - 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 manure (20 MT/ha) and a basal dose (one of the three split doses) of NPK at the rate of 250 kg/ha 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 Muriate 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.

P₁ = Indicates planting in the month of April.

P₂ = Indicates planting in the month of May.

P₃ = Indicates planting in the month of June.

P₄ = Indicates planting in the month of July.

P₅ = Indicates planting in the month of August.

Fig. 1.

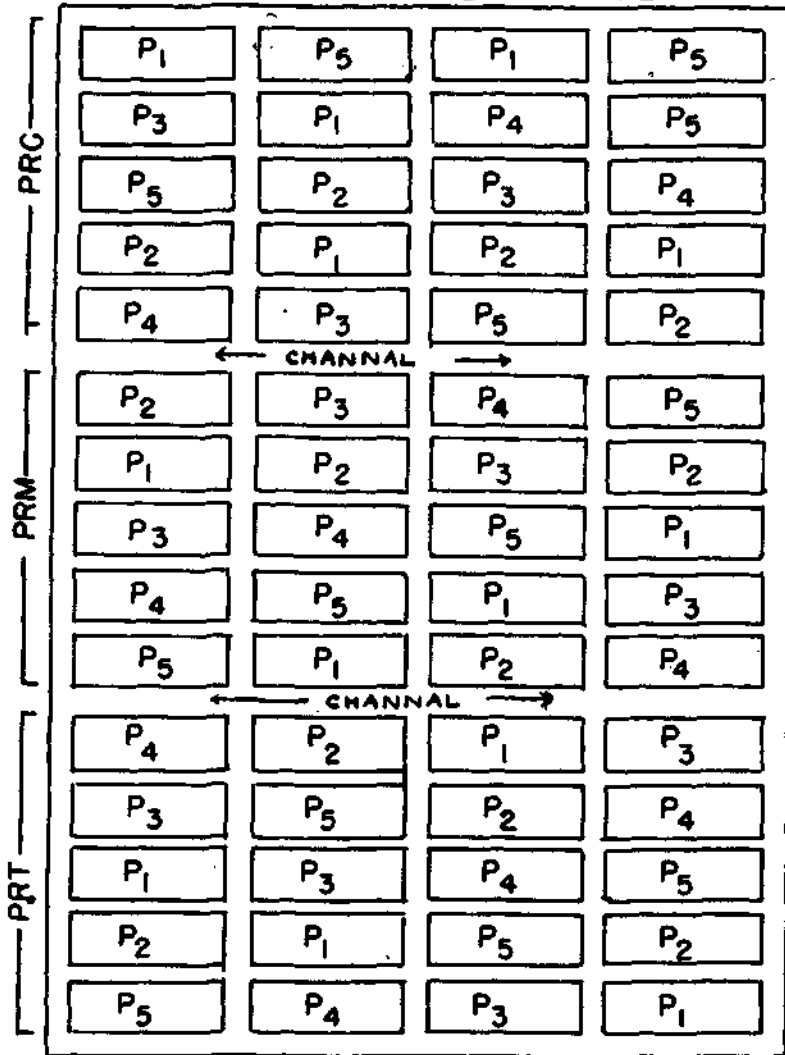
LAYOUT PLAN

SCALE = 1mm. = 30cm.

RANDOMIZED BLOCK DESIGN

(EXPERIMENT NO. 1)

REP. I REP. II REP. III REP. IV



← N

GROSS PLOT AREA = 6m. X 2.1m.
 NET " " = 5.4m. X 1.5m.
 BORDER BETWEEN PLOTS = 0.45m.
 " " 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 separately. To ensure uniform spacing, the seed pieces were planted by hand in separate 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 separate plots and the interculture operations like weeding and hoeing were done when the plants were four weeks old. Daily meteorological 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. Leaf Area and Leaf Area Index (LA and LAI) : 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 = $K \times L \times W$ where, K is the adjustment factor (Gomez ; 1972 and Hegde ; 1979). L is the length and W is the maximum width of the leaf.

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

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

2. Dry matter production : The plants were separated 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 then kept in a desiccator 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 Napierian 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) :

$$\text{RLGR} = \frac{\text{Log}_e L_2 - \text{Log}_e L_1}{t_2 - t_1}$$

Where, L_1 & L_2 represent leaf area at the time t_1 and t_2 respectively.

RLGR is expressed as $\text{cm}^2 \text{ day}^{-1} \text{ plant}^{-1}$.

4. Crop Growth Rate (CGR) : 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. Net Assimilation Rate (NAR) : 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 initial (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. Biomass : 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 $80^\circ - 85^\circ C$) 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 efficacy of utilisation of nutrients (N P K) were screened 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 sieved through 60 mesh sieve. 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 followed 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 mixture (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 $4(\text{N})\text{NH}_4\text{OH}$ and $4(\text{N})\text{HCl}$; 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 g(w/v). Hydrolysis was conducted in autoclave for $\frac{1}{2}$ hour under 15 lbs/cm² 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 separately 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 sieved through 0.5 m.s. sieve & required quantities of soils were taken for further soil testing as follows :

- i) Soil pH : To 10 gms of the sieved 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-rrrelation studies : Total co-rrrelation of important characters between various yield attributing characters and yield were measured by Karl Pearson's Co-efficient Co-rrrelations as denoted by 'r' (Goulden : 1960, Panse & Sukhatme : 1978).

R E S U L T S

RESULTS

While ascertaining the growth and Yield responses of Dioscorea flori-
bunda Mart. & Gall. in relation to different time of planting and types of
planting materials, observations had been recorded on different plant charac-
ters, physiological parameters, yield attributes, periodic nutrient's accumu-
lation and also residual nutrient status of soil during the course of investi-
gation.

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 2.c.
and Fig. 2 to 7.

PHYSIOLOGICAL PARAMETERS

Leaf Area Index (LAI) : The results on leaf area index under differ-
ent 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 P₁ (April planting) to P₃ (June planting) whereas, a
decreasing trend was noticed in P₄ (July planting) and P₅ (August planting) of
Crown (PRC), Middle (PRM) and Tip (PRT) parts of plants.

The LAI in P₁ & P₂ 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 P₃ (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.	1st Year growth.			Days after planting.					Mean
	60	120	180	240	360	420	480	540	
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.								Mean.
	1st year growth.				2nd year growth				
	60	120	180	240	360	420	480	540	
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.								Mean
	1st year growth.				2nd year growth				
	60	120	180	240	360	420	480	540	
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.) occurred 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 ...

F I G U R E 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 P₁ (April) planting.

Hollow triangles represents P₂ (May) Planting.

Hollow squares represents P₃ (June) planting.

Solid circles represents P₄ (July) planting.

' X ' represents . P₅ (August) planting.

FIG. 2.

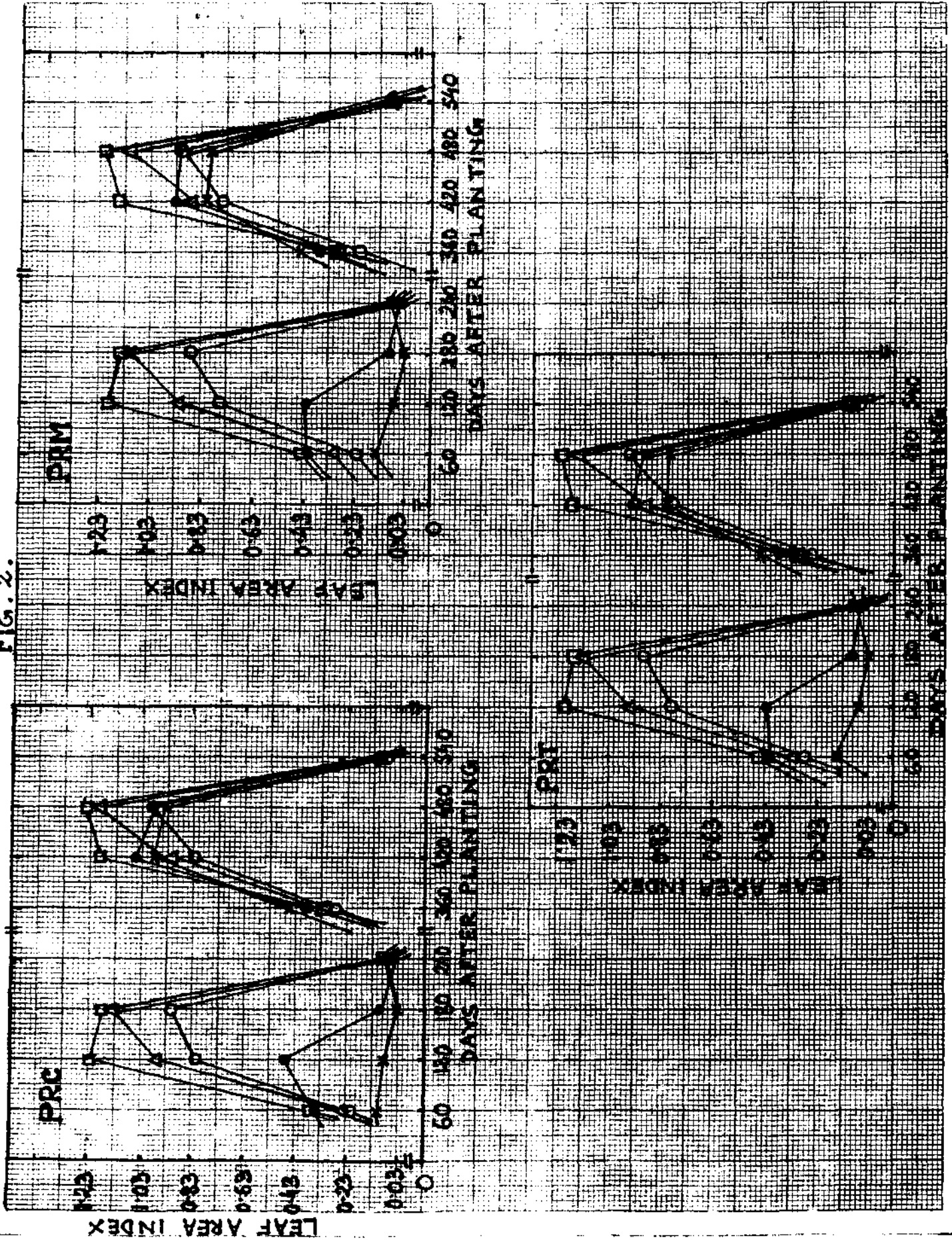


Table No. 3.a. Effects of Planting times on Relative Leaf Growth Rate ($\text{cm}^2 \cdot \text{day}^{-1} \text{ plant}^{-1}$) ofD. floribunda.P R C

Time of planting.	Days after Planting.							Mean
	1st year growth				2nd year growth			
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 \pm	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 ($\text{cm}^2 \cdot \text{day}^{-1} \text{ Plant}^{-1}$) of
D. floribunda.

P R M

Time of planting	Days after planting							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 ($\text{cm}^2 \cdot \text{day}^{-1} \cdot \text{plant}^{-1}$) ofD. floribunda.P R T

Time of planting.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 <u>+</u>	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.) P₃ planting in all the cases of Crown, Middle and Tip plants, showed maximum mean values of RIGR 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 P₁ to P₃ 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 P₃ (June planting) of Crown plants (PRC) followed by P₃ 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 P₁ & P₂ plantings of Crown plants showed maximum NAR between 360 to 420 days, whereas, P₃, P₄ & P₅ plantings showed maximum NAR between 420-480 days. The highest NAR in Crown plants was in the range of 3.62×10^{-4} gm cm⁻² day⁻¹ plant⁻¹ between 420-480 days in P₃ planting and the minimum was 0.62×10^{-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 P₃ planting of Middle plants and Tip plants. Of the three types (PRC, PRM & PRT) of planting materials, the P₃ planting of Crown (PRC) plants revealed highest Net Assimilation Rate

FIGURE 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

P₁ (April) planting.

Hollow Triangles represents

P₂ (May) planting.

Hollow squares represents

P₃ (June) planting.

Solid Circles represents

P₄ (July) planting.

Solid triangles represents

P₅ (August) planting.

FIG. 3.

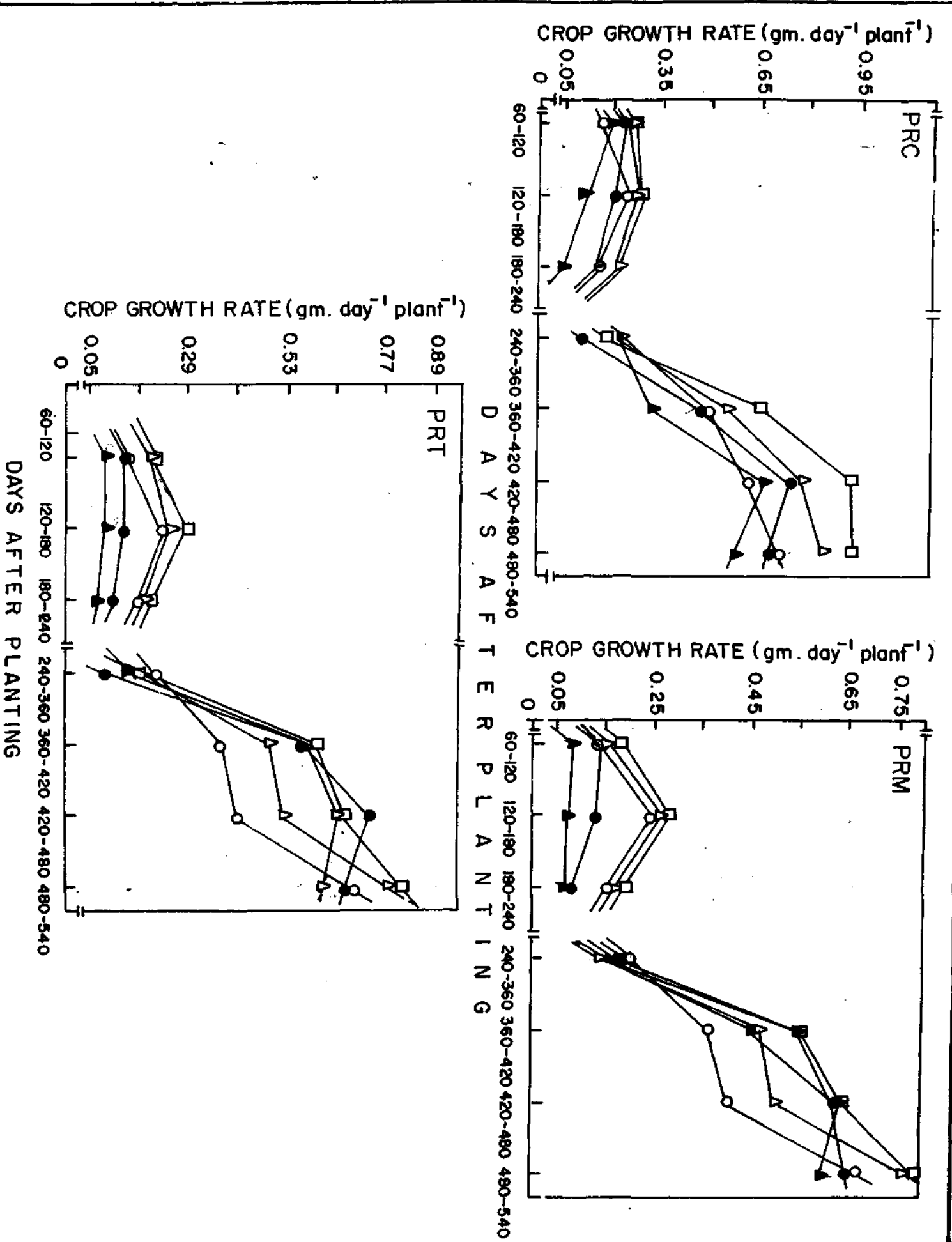


Table No. 4 a. Effects of Planting times on Crop Growth Rate (gm. day⁻¹ plant⁻¹) ofD. floribunda.P. R. C.

Time of planting.	Days after planting.							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 <u>±</u>	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) ofD. floribunda.P R M.

Time of planting.	Days after planting							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 <u>±</u>	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							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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

F I G U R E 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.

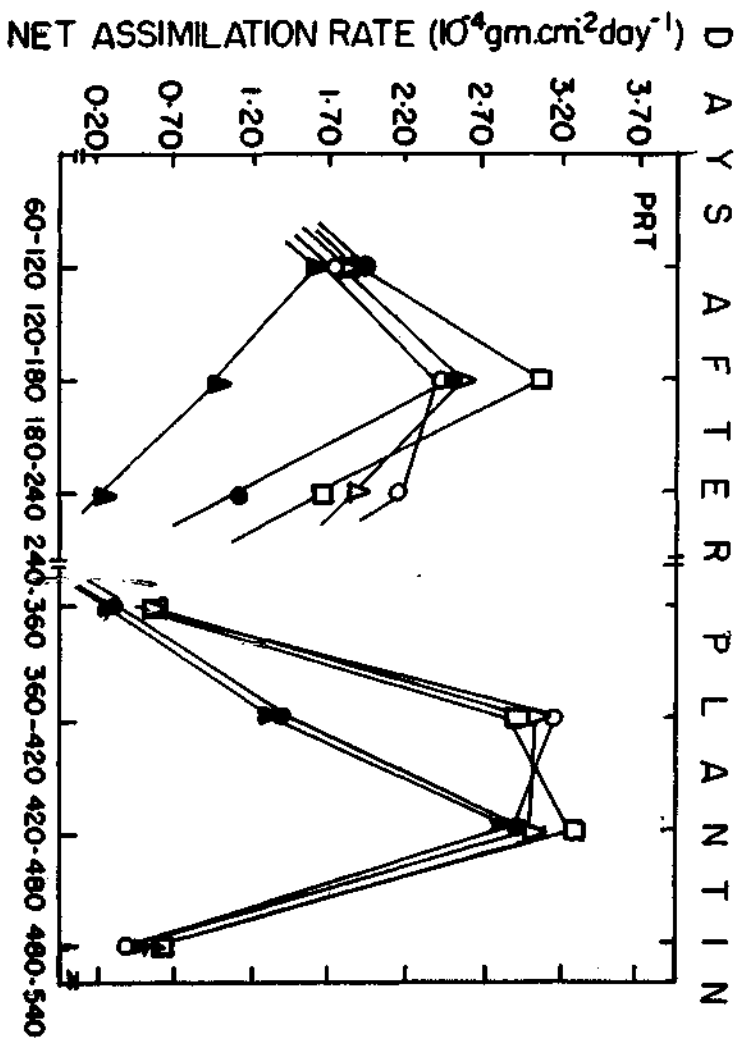
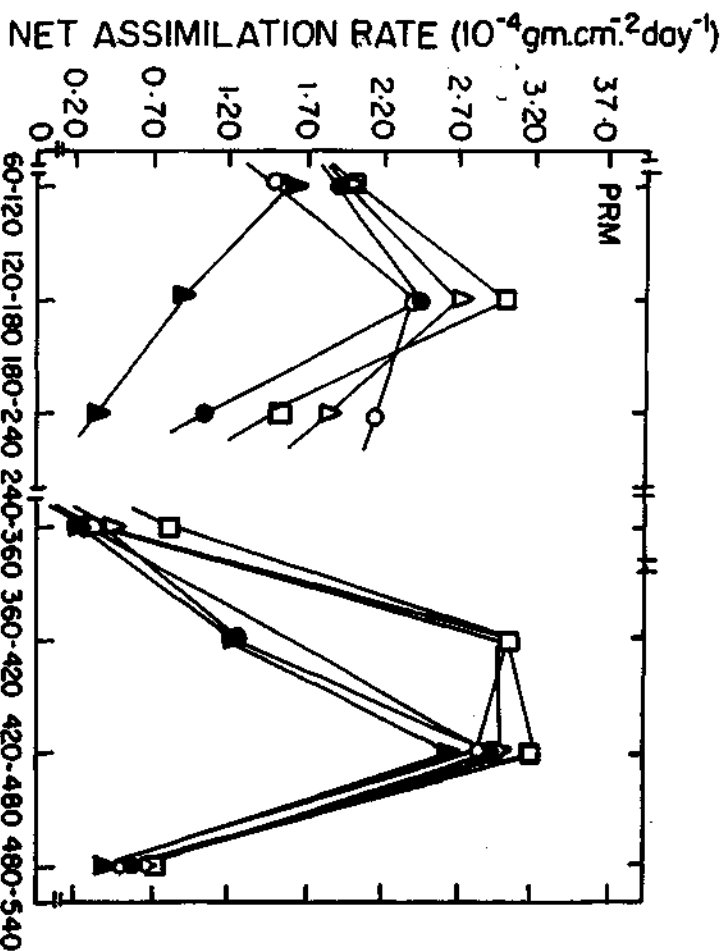
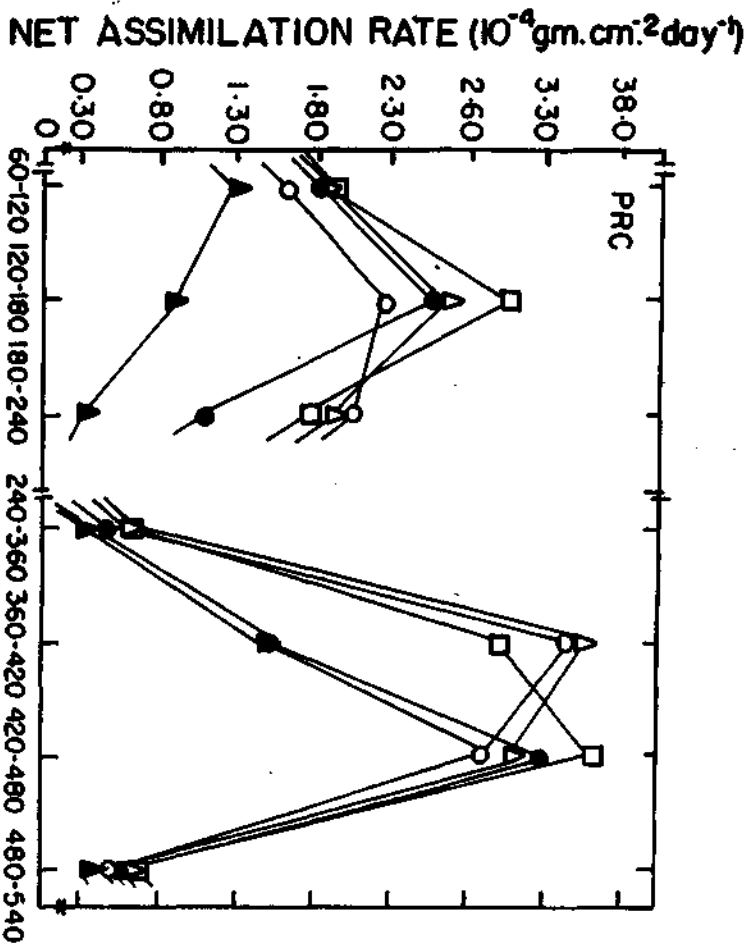


Table No. 5.a.

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.							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 \pm	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.							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 \pm	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..							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
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 \pm	0.052	0.347	0.343	0.071	0.408	0.067	0.035	0.158

$(3.62 \times 10^{-4} \text{ gm cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$ 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 very low in F₅ 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 F₃ of Crown plants. The lowest value was recorded in F₅ 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	<u>Days after planting</u>								Mean
	<u>1st year growth</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
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 \pm	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								Mean
	1st year growth.				2nd year growth.				
	60	120	180	240	360	420	480	540	
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
F 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								Mean
	1st year growth				2nd year growth				
	60	120	180	240	360	420	480	540	
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

F I G U R E 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.

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 $3.62 \times 10^{-4} \text{ gm cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$ in PRC. The increasing and decreasing 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 \pm	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 \pm	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 \pm	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.

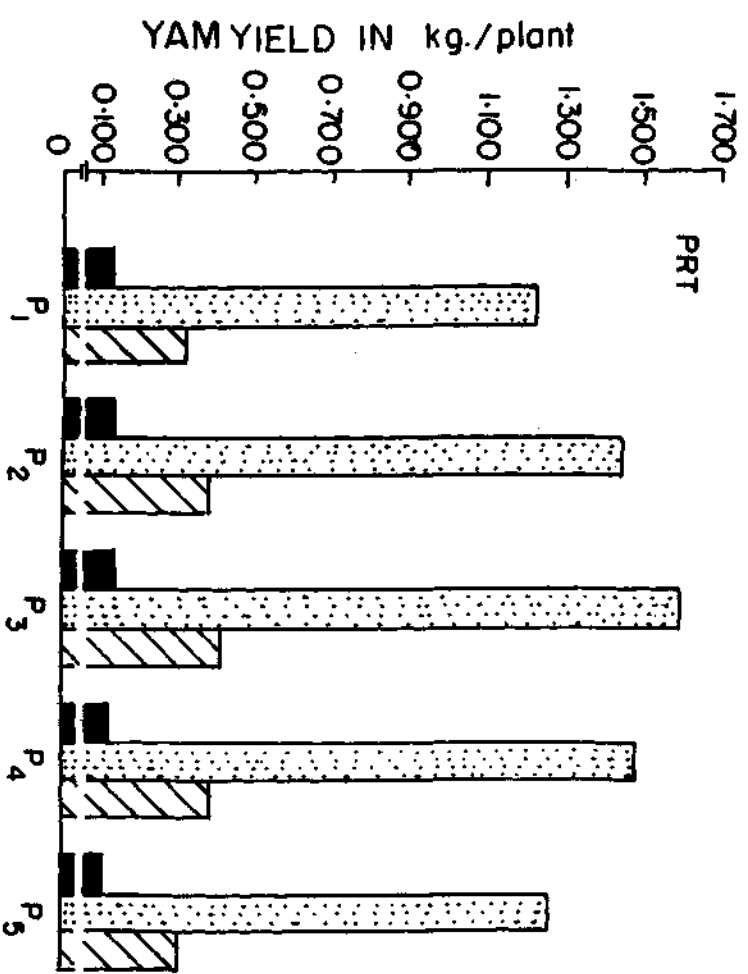
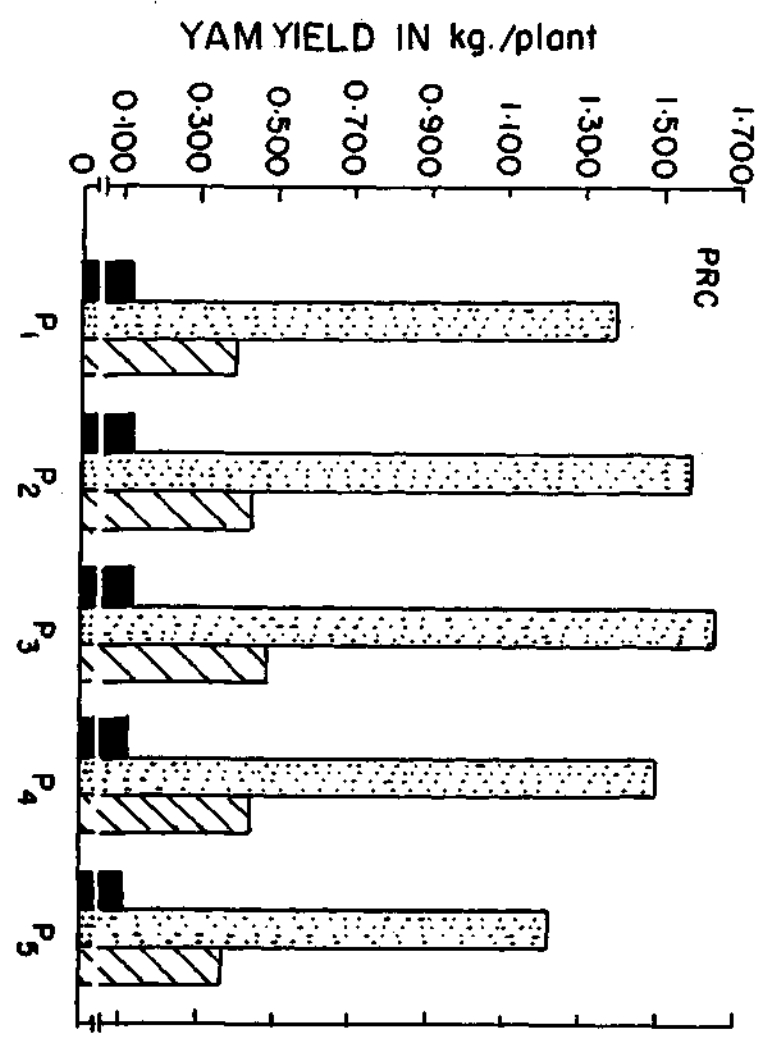
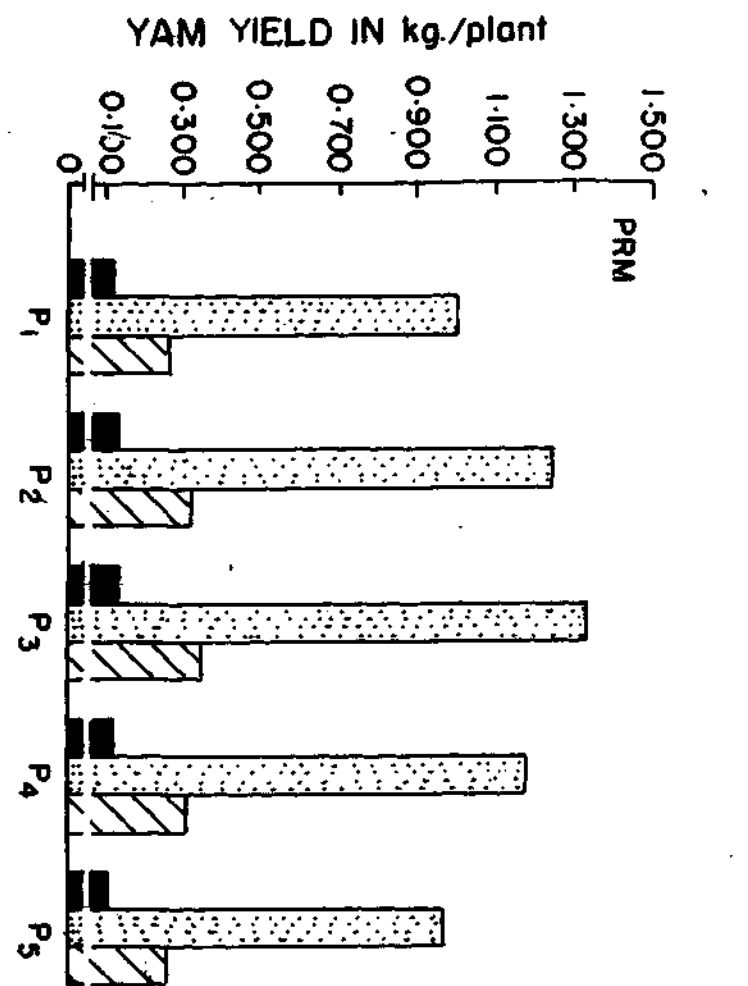
PRT = Represents Plants Raised from Tip portion.

Solid bar represents Dry vine yield.

Dotted bar represents Fresh yam yield.

Obliquely lined bar represents Dry yam yield.

FIG. 6.



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 P₃ (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 P₃ of Crown (PRC) plants and varies significantly over P₁, P₄ & P₅ planting but P₂ and P₃ 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 \pm	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 P₃ planting. But in PRT the diosgenin content in the Tip portion was recorded 3.836 % (mean value) in P₃ 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 P₃ (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 P₁ (April) to P₃ (June) planting and gradually decreased in late planting (P₄ to P₅ planting). The lowest yield amounted to 22.4 MT/ha (green) equivalent to 6.674 MT/ha of dry was recorded in P₅ (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 P₃ (June) planting also. In Tip plants (PRT) the highest yield was also recorded in P₃ planting. The lowest yield in both Tip and Middle plants was recorded in P₅ (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 P₃ (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.

Dotted bar represents the Fresh yam yield.

Obliquely lined bar represents the Diosgenin yield.

FIG. 7.

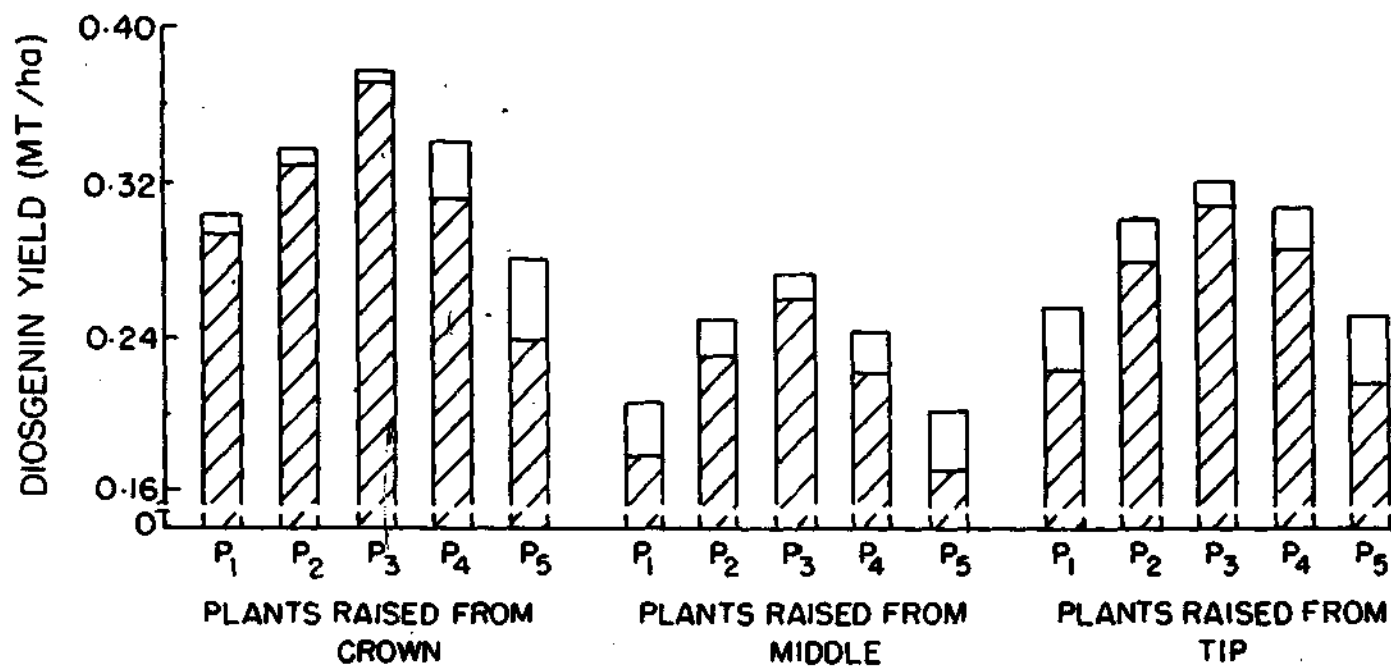
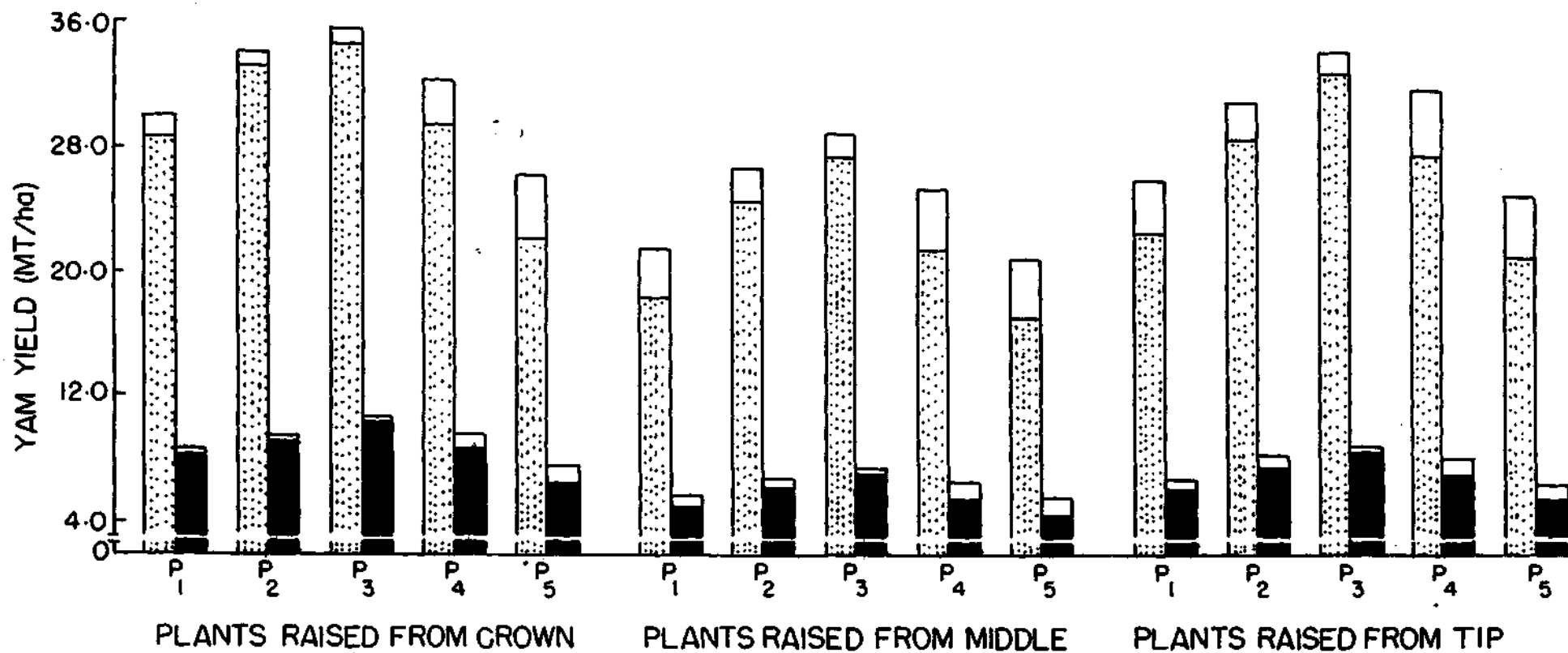


Table No. 9.a.

Effects of planting times on the production of "Yams" (fresh & dry)
and Diosgenin yield (MT/ha.) in P R C of D. floribunda

Time of planting	P R C				Diosgenin yield (MT/ha.)	% of survival
	Yam yield (MT/ha.)					
	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 ±	2.197	(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% =	3.642	(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

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 1.316 % 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
DIFFERENT PLANTING TIMES.

Table No. 10.a.

Time of planting.	<u>P R G</u>			Mean
	Successive stages of Plant's growth			
	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	<u>P R M</u>			Mean
	Successive stages of plant's growth			
	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	<u>P R T</u>			Mean
	Successive stages of plant's growth			
	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 P₅ (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 P₃ 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	<u>P R C</u>			Mean
	<u>Successive stages of plant growth</u>			
	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 \pm	0.002	0.001	0.001	0.001

Table No. 11.b.

Time of planting	<u>F R M</u>			Mean
	<u>Successive stages of plant's growth</u>			
	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 \pm	0.001	0.001	0.002	0.001

Table No. 11.c.

Time of planting	<u>P R T</u>			Mean
	<u>Successive stage of plant's growth</u>			
	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 \pm	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			Mean
	Successive stages of plant's growth			
	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	4.73	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			Mean
	Successive stages of plant's growth			
	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			Mean
	Successive stages of plant's growth			
	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

DISCUSSION

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 occurred 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 precipitation 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 compensated by the large number of leaves. Consistently 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 acceleration of CGR during the period of experimentation.

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 linear 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 P₃ planting of Crown plants (PRC) upto 120 days and gradually declines upto 240 days. But P₅ planting showed a linear fall in NAR from 60 days. Among the three types of planting materials, P₃ (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 lateritic 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 P₃ 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-rrrelation 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 P₃ 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 materials 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)	Net assimilation Rate (10 ⁻⁴ gm. cm ⁻² . day ⁻¹ . plant ⁻¹)	Dry Matter Production (DMP) (gm. plant ⁻¹)
	* (Mean values)	* (Mean values)	* (Mean value)
	1	2	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
<hr/>			
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
<hr/>			
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
<hr/>			
r(1,3) = 0.9735 **	r(2,3) = 0.8110 **		

Table No. 14.

Co-rrrelation 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	<u>Dry Vine yield</u> kg / plant (Mean values).	<u>Dry Yam yield</u> kg / plant. (Mean values).	<u>Diosgenin %</u> * (Mean values).
	1	2	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 P₃ 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 P₁ to P₃ has also been reported. Yam yield however declines under P₄ & P₅ planting. The highest yam yield (1.653 kg/plant) of fresh yam in P₃ of Crown plants varies significantly with the yield under both P₁ & P₂ and P₄ & P₅ planting. The lowest yield (1.225 kg/plant) has been recorded in P₅ planting. Strong positive co-rrrelation 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 beneficial 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 conformity with that of findings of Seale (1961); Randhawa et al (1968), Soderholm (1968); Enyi (1970) and Gooding (1970). Higher yields under P₃ 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 prevalence 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 maximum (3.84 %) in the Tip portion of yam and which is in conformity 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 metabolites, low susceptibility 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 (P₃) 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 precipitation. 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 P₃ (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.F R C

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.)
F ₁	8.211	8.83	+ 3.17	+ 0.36
F ₂	9.139	7.93	+ 4.07	+ 0.51
F ₃	10.352	7.01	+ 4.99	+ 0.71
F ₄	8.725	8.31	+ 3.69	+ 0.44
F ₅	6.674	10.87	+ 1.13	+ 0.10

P R M

F ₁	4.903	14.80	- 2.80	- 0.19
F ₂	6.371	11.38	+ 0.62	+ 0.05
F ₃	7.171	10.12	+ 1.88	+ 0.18
F ₄	5.673	12.79	- 0.79	- 0.06
F 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 P₅ 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^{n.c.}). In all the three types of planting materials, P₃ 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 adequately 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, RIGR, 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 precipitation 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 feasible therefore this should not be taken into consideration during the cultivation commercially.

S U M M A R Y

S U M M A R Y

In connection with the response of Dioscorea floribunda Mart. & Gall. on time of planting and types of planting materials, the LAI, RIGR, OGR, 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 become lower in Crown plants (PRC) in comparison to Middle and Tip (PRM & PHT) plants. LAI has been observed to show maximum value in June (P₃) 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 August (P₅) planting of Middle plants.

OGR value has been noted to reach maximum also in P₃ 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 hectare has been calculated and found to be the highest in June (P₃) 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.

P A R T - III

RESPONSE OF Dioscorea floribunda Mart. & Gall. TO DIFFERENT
SIZE OF PLANTING MATERIALS.

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

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

The consideration of the size of the planting materials is an important factor in connection with the cultivation of commercially important plant material. From review of literature it appears that various authors have already attempted to study the effect of size of the planting materials in connection with the cultivation of Dioscorea floribunda (Randhawa, et al; 1975), Sharma, et al ; 1985).

In connection with the investigation on the same line of work, 40, to 60 gms of yams of Dioscorea floribunda has been recommended by Randhawa et al ; 1975, to be the optimum for its commercial utilization.

Moreover they studied the cultivation of the plant in the climatic condition of Bangalore (Karnataka) and Jorhat (Assam) in India. But no attempt has so far been made to study the same in environmental situation in Darjeeling hills (West Bengal). Thus attempt has been made to worked out the optimum size of planting materials (that) to be utilised for the cultivation of Dioscorea floribunda in the region under study.

FIG. 8.

LAYOUT PLAN

RANDOMIZED BLOCK DESIGN

SCALE = 1 mm. = 30 cm.

REP. I REP. II REP. III REP. IV

PRC	W ₂	W ₃	W ₄	W ₅
	W ₁	W ₂	W ₃	W ₂
	W ₃	W ₄	W ₅	W ₁
	W ₄	W ₅	W ₁	W ₃
	W ₅	W ₁	W ₂	W ₄
PRM	W ₄	W ₂	W ₁	W ₃
	W ₃	W ₅	W ₂	W ₄
	W ₄	W ₃	W ₄	W ₅
	W ₂	W ₁	W ₅	W ₂
	W ₅	W ₄	W ₃	W ₁
PRT	W ₁	W ₁	W ₁	W ₅
	W ₃	W ₂	W ₄	W ₃
	W ₅	W ₅	W ₃	W ₄
	W ₂	W ₄	W ₂	W ₁
	W ₄	W ₃	W ₅	W ₂

← N

GROSS PLOT AREA = 6 m. X 2.1 m.
 NET " " = 5.4 m. X 1.5 m.
 BORDER BETWEEN PLOTS = 0.45 m.
 " " REPLICATION = 0.90 m
 " OF THE EXPERIMENT = 1.2 m.

M A T E R I A L S A N D M E T H O D S

MATERIALS AND METHODS

The present investigation designed to study the response of Dioscorea floribunda Mart & Gall. to different size of planting materials and the type of planting materials on upland sandy loam soil of Darjeeling hills, West Bengal.

The experiments were carried out at the Research Nursery of Govt. Ipecac Plantation, Gairibas, Darjeeling during 1984 to 1986 and repeated the same during 1986 to 1988. The soil of the experimental plots were sandy-loam type, acidic in reaction (pH 4.6 to 4.8). The average mechanical analysis and chemical constituents of initial soil samples collected from the plots (0.30 cm depth) are presented below :

<u>Mechanical analysis (%)</u>		<u>Chemical analysis</u>	
Gravel	: 3.1	Total Nitrogen	: 0.068 - 0.078 (%)
Coarse sand	: 29.5	Available Nitrogen	: 0.009-0.011 (%)
Fine sand	: 35.4	Available Phosphorus	: 16.01-16.70 kg/ha
Silt	: 16.2	Available Potassium	: 211.30-221.25kg/ha
Clay	: 15.8	Organic Carbon	: 0.748-0.802 (%)
		pH	: 4.6 - 4.8

The experiments were conducted in three separate sets viz. Plants Raised from Crown (PRC), Middle (PRM) and Tip (PRT) as reported in the previous experiment (Part-II). Each of the sets had five different sizes of planting materials such as Size of the planting materials (each set with Crown, Middle and Tip plants-PRC, PRM & PRT respectively) 10 gms - W₁, 30 gms - W₂, 50 gms - W₃, 70 gms - W₄ and 90 gms - W₅.

The plots were prepared according to the layout plan (Fig. 8). Basal dose of farm-yard manure and NPK were applied at the same rate of the experiment no. 1 (page 13.). For planting, mother tubers (yam) of Dioscorea floribunda were separated into Crown, Middle and Tip portions. From each type of planting materials were again separated into 10 gms., 30 gms, 50 gms, 70 gms and 90 gms. To avoid yam rot, the yam pieces were dipped into 0.3 % Benlate solution and were kept in raised beds for sprouting. After about 30 days the sprouting yams selected for transplanting and then the sprouted Crown, Middle and Tip portions of 10 gms, 30 gms, 50 gms, 70 gms and 90 gms were transplanted separately with uniform spacing of 60 cm X 75 cm. The first interculture operation were done when the plants were four weeks old in the plots.

Daily meteorological data were recorded. The studies on the physiological parameters like LAI, RIGR, CGR and NAR were recorded and calculated on sample plants under each plot receiving individual treatments as in the same manner as indicated under the previous experiment. The data in respect of physiological parameters were computed according to Gregory (1917), Blackman(1919).

In sixty days interval the randomly selected plant samples were uprooted from each plot and replication and were kept in an oven at 80° C to measure the accumulation of dry matter. The dried plant materials were powdered and were used for analysis to trace the accumulation of NPK in plant body at subsequent stages of growth according to the methods by Jackson (1967).

To find out the optimum and actual yield the plants were harvested at 720 days after planting. Like previous experiment the average yield per plant and yield per hectare were calculated. Yam of every selected plant

samples were dried and moisture percentage were calculated. Diosgenin percentage (on dry weight basis) calculated as previous experiment by solvent extraction method after acid hydrolysis.

Total co-rrrelation of important characters were measured by Karl Pearson's Co-efficient co-rrrelation as denoted by 'r' (Goulden; 1960, Panse & Sukhatme ; 1978). Composite soil samples of plots of each treatment were collected and analysed for total nitrogen, available phosphorus and potassium at the expiry of the experiment.

Economics of cost of yam production, loss of profit of the cultivation of Dioscorea floribunda was recorded by applying the added-cost-added return principle. The optimum size of planting materials were computed for perceptible economic response.

R E S U L T S

RESULTS

Vegetative growth and physiological parameters : Growth and Development of Dioscorea floribunda plants, developed from planting materials of different sizes revealed significant variations as shown in Table 16.a. to 26 and Fig. 9 to 14.

Leaf Area Index (LAI) : Data on LAI under different size of planting materials revealed that the LAI were increased correspondingly with the increase of sizes of the planting materials (W_1 to W_5) and a linear increase occurred upto 180 days but thereafter sharply declined till the commencement of 2nd year growth in all the planting sizes.

In all the treatments, the LAI again increased from 360 days and onwards and thereafter again declined during the end of 2nd year of growth. In Crown plants the minimum (0.262) value of LAI in the initial stage has been observed in W_1 but the highest value (1.295) was in W_5 at 480 days. The similar trend was also observed in Middle and Tip plants (Table 16.b. & 16.c.) where the maximum values were 1.222 and 1.269 respectively at 480 days. Comparing the LAI during the successive stages of growth and development in Crown, Middle and Tip plants have been revealed that W_1 & W_2 varies significantly with W_3 , W_4 & W_5 in all the types but W_5 only did not varied significantly with W_4 . Regarding the types of planting materials Middle plants varied significantly with Crown and Tip plants.

Relative Leaf Growth Rate (RIGR) : The relative leaf growth rate under different sizes of planting materials have been presented in the Table 17.a. to 17.c. The data indicated that there were no remarkable variations in RIGR in Crown, Middle and Tip plants. In each type the values of RIGR

Table No. 16.a.

Effects of the size of the planting materials on Leaf Area Index.

P R C

Size of the planting materials.	<u>Days after planting.</u>								Mean
	<u>1st year growth.</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
W ₁	0.262	0.725	0.830	0.060	0.282	0.714	0.975	0.092	0.492
W ₂	0.302	0.968	1.092	0.094	0.322	0.875	1.193	0.103	0.618
W ₃	0.363	1.137	1.202	0.102	0.343	1.053	1.253	0.112	0.695
W ₄	0.382	1.250	1.276	0.121	0.369	1.118	1.288	0.131	0.742
W ₅	0.390	1.255	1.288	0.142	0.372	1.121	1.295	0.148	0.751
Mean	0.339	1.070	1.137	0.104	0.337	0.976	1.201	0.117	0.659
S E \pm	0.025	0.099	0.034	0.013	0.016	0.079	0.059	0.010	0.048

Table No. 16.b. Effects of the size of the planting materials on Leaf Area Index.

P R M

Size of the Planting materials.	Days after planting.								Mean.
	1st year growth.				2nd year growth.				
	60	120	180	240	360	420	480	540	
W ₁	0.226	0.605	0.309	0.060	0.269	0.608	0.788	0.077	0.430
W ₂	0.244	0.861	1.052	0.072	0.308	0.720	0.955	0.033	0.537
W ₃	0.305	1.026	1.185	0.085	0.315	0.936	1.196	0.096	0.643
W ₄	0.365	1.065	1.209	0.092	0.325	1.025	1.215	0.105	0.675
W ₅	0.370	1.022	1.215	0.108	0.331	1.112	1.222	0.118	0.687
Mean	0.302	0.915	1.094	0.083	0.309	0.880	1.075	0.095	0.596
S E \pm	0.029	0.085	0.077	0.008	0.011	0.094	0.087	0.007	0.049

Table No. 16.c.

Effects of the size of the planting Materials on Leaf Area Index.

Time of the planting materials.	<u>P R T</u>								Mean
	Days after planting.								
	1st year growth.				2nd year growth.				
	60	120	180	240	360	420	480	540	
W ₁	0.248	0.616	0.341	0.075	0.280	0.645	1.090	0.084	0.485
W ₂	0.323	0.945	1.082	0.086	0.317	0.906	1.158	0.098	0.614
W ₃	0.380	1.140	1.194	0.095	0.331	1.025	1.215	0.105	0.685
W ₄	0.386	1.225	1.245	0.108	0.348	1.098	1.244	0.117	0.721
W ₅	0.394	1.243	1.267	0.116	0.350	1.113	1.269	0.128	0.735
Mean	0.346	1.033	1.126	0.096	0.325	0.957	1.195	0.106	0.648
S E \pm	0.027	0.117	0.078	0.007	0.013	0.086	0.034	0.007	0.045

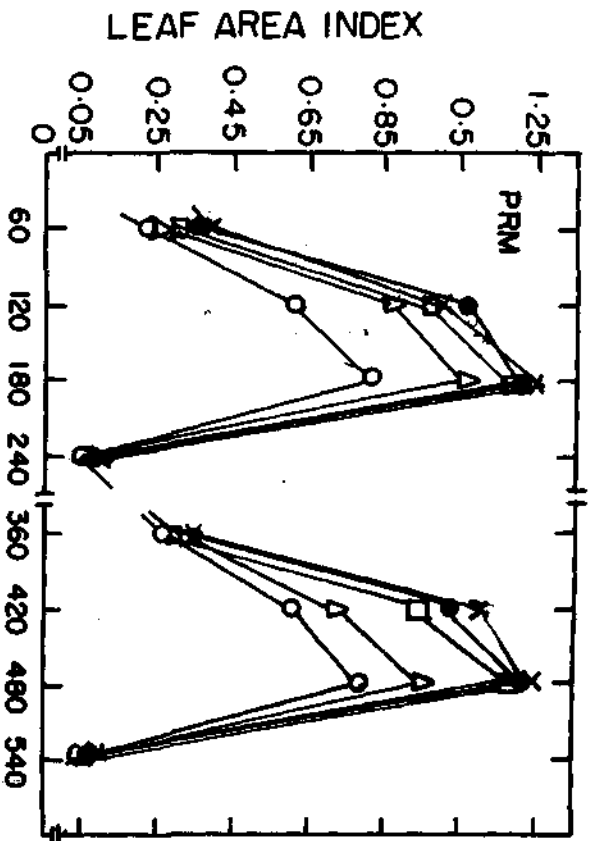
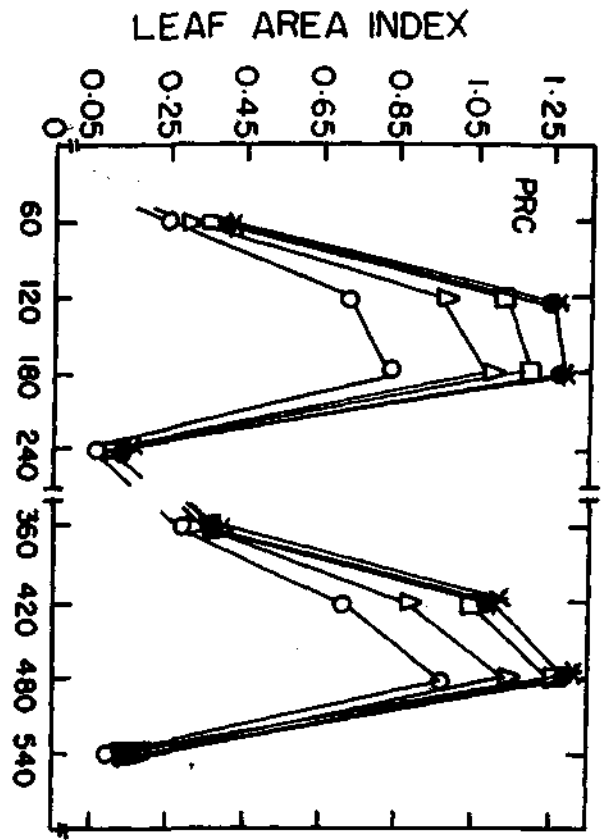
F I G U R E 9.

Effects of size and type of Planting materials on
Leaf Area Index of D. floribunda.

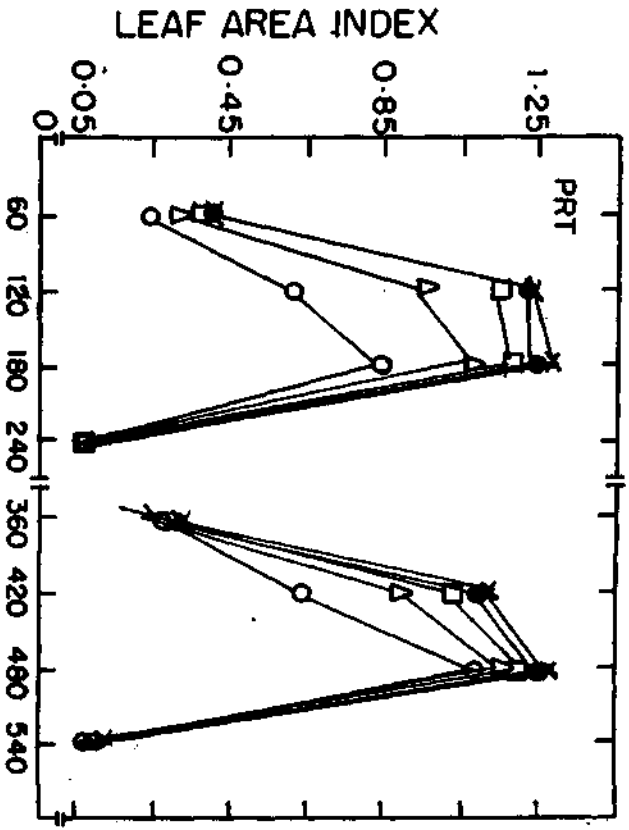
P R C = Represents Plants Raised from Crown portion.
P R M = Represents Plants Raised from Middle portion.
P R T = Represents Plants Raised from Tip portion.

Hollow Circles represents	W_1	(10 gms) Sizes of planting materials.
Hollow Traingles represents	W_2	(30 gms) Sizes of planting materials.
Hollow Squares represents	W_3	(50 gms) Sizes of planting materials.
Solid Circles represents	W_4	(70 gms) Sizes of planting materials.
' X ' represents	W_5	(90 gms) Sizes of planting materials.

FIG. 9.



D A Y S A F T E R P L A N T I N G



D A Y S A F T E R P L A N T I N G

Table No. 17.a.

Effects of the size of the planting materials on
Relative Leaf Growth Rate ($\text{cm}^2 \cdot \text{day}^{-1} \text{plant}^{-1}$).

P R C.

Size of the Planting materials	<u>Days after planting.</u>							Mean.
	60 - 120	120-180	180-240	240-360	360-420	420-480	480-540	
W_1	0.026	0.049	0.022	-0.022	0.033	0.052	-0.011	0.021
W_2	0.027	0.058	0.031	-0.011	0.034	0.062	-0.005	0.028
W_3	0.035	0.066	0.036	-0.006	0.038	0.073	-0.002	0.034
W_4	0.044	0.068	0.037	-0.002	0.047	0.078	-0.001	0.038
W_5	0.050	0.072	0.040	-0.001	0.054	0.081	-0.001	0.042
Mean	0.036	0.062	0.033	-0.008	0.041	0.069	-0.004	0.032
SE \pm	0.004	0.004	0.003	+0.003	0.004	0.005	0.001	0.003

Table No. 17.b.

Effects of the Size of the planting Materials on
Relative Leaf Growth Rate ($\text{Cm}^2 \cdot \text{day}^{-1} \text{ plant}^{-1}$)

P R M.

Size of the planting materials.	<u>Days after planting</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	0.020	0.040	0.014	-0.026	0.021	0.044	-0.012	0.014
W ₂	0.029	0.044	0.016	-0.018	0.026	0.055	-0.008	0.020
W ₃	0.036	0.049	0.024	-0.010	0.031	0.062	-0.004	0.026
W ₄	0.038	0.052	0.030	-0.006	0.036	0.067	-0.002	0.031
W ₅	0.044	0.057	0.032	-0.004	0.041	0.069	-0.002	0.034
Mean	0.034	0.048	0.023	-0.012	0.031	0.059	-0.005	0.025
SE \pm	0.004	0.002	0.003	0.004	0.003	0.004	0.001	0.003

Table No. 17.c.

Effects of the size of the planting materials on
Relative Leaf Growth Rate ($\text{Cm}^2 \cdot \text{day}^{-1} \text{plant}^{-1}$).

P R T

Size of the planting materials	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W_1	0.023	0.041	0.018	-0.024	0.024	0.046	-0.012	0.016
W_2	0.026	0.052	0.026	-0.018	0.033	0.055	-0.008	0.024
W_3	0.030	0.059	0.028	-0.010	0.037	0.062	-0.002	0.029
W_4	0.039	0.065	0.032	-0.008	0.041	0.069	-0.001	0.033
W_5	0.046	0.070	0.035	-0.004	0.044	0.075	-0.001	0.038
Mean	0.033	0.057	0.027	-0.013	0.035	0.061	-0.004	0.028
SEt	0.004	0.005	0.002	0.003	0.003	0.005	0.002	0.003

increased upto 180 days but certain decreasing trend observed from 180 days till the commencement of the 2nd year growth. The negative values from 240 to 360 days and 480 to 540 days in all the treatments obviously indicated the initiation of senescence in leaves. In all the planting types the values increased gradually with the increased size of the planting materials (W_1 to W_5) and maximum values were observed in W_3 of PRC being the value $0.081 \text{ cm}^2 \text{ day}^{-1} \text{ plant}^{-1}$.

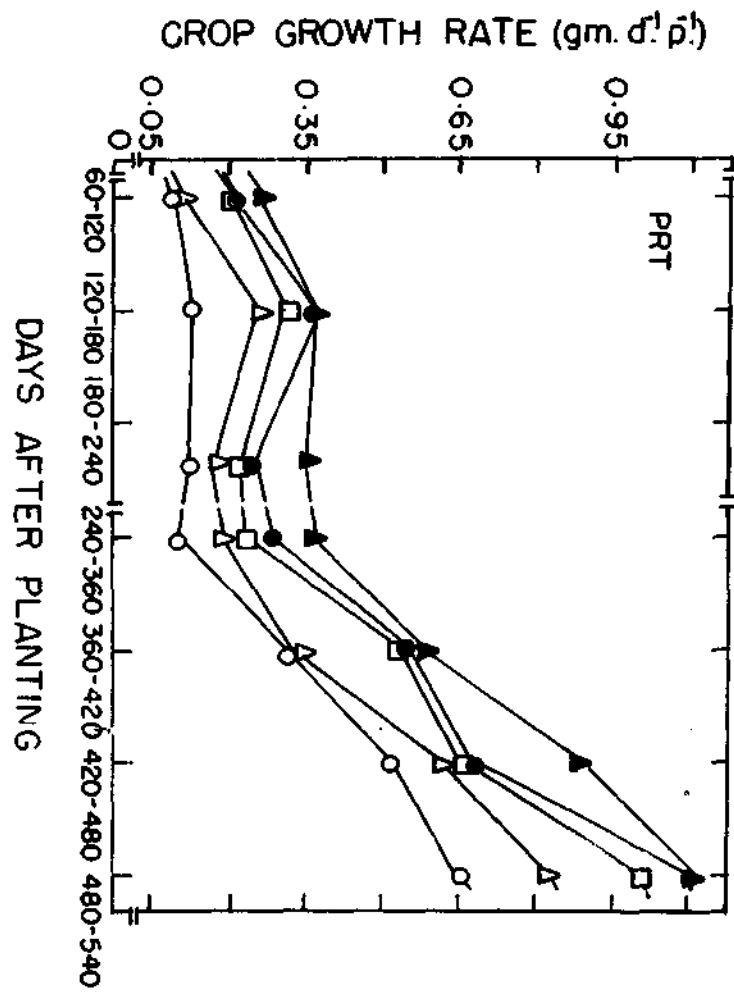
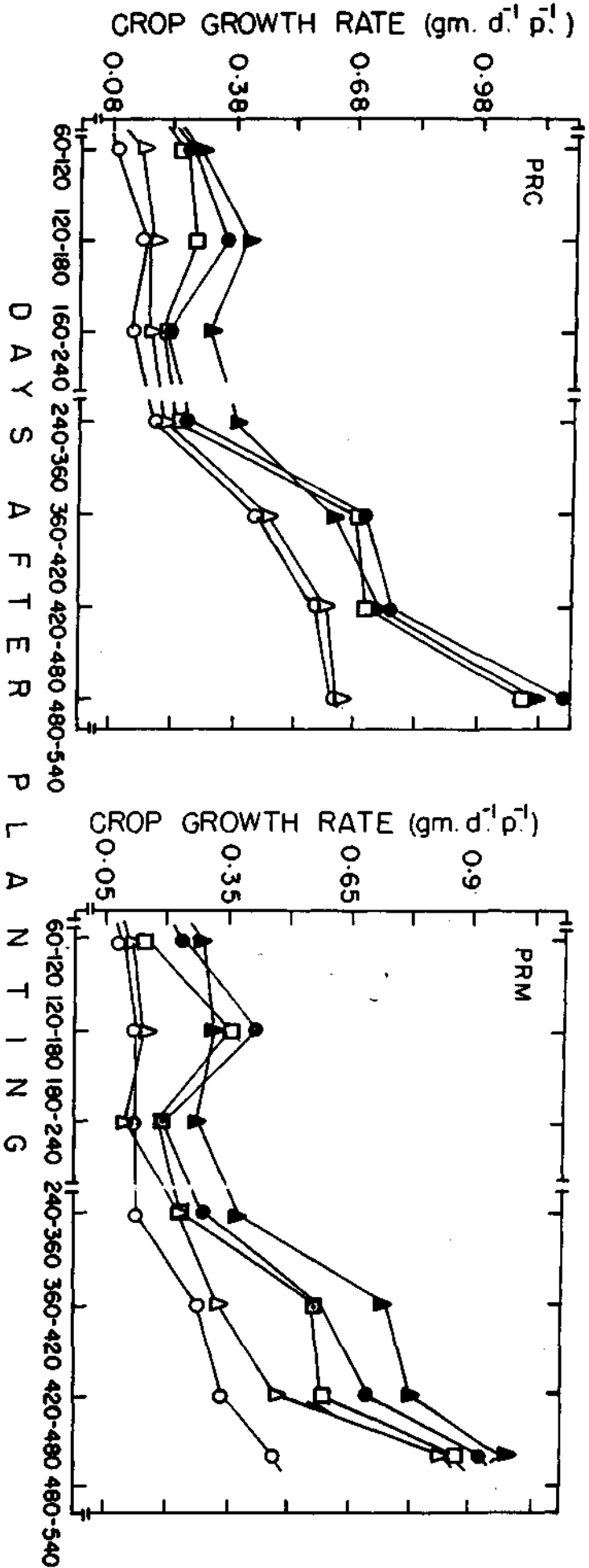
Crop Growth Rate (CGR) : It was evident from the data presented in the Table 18.a. to 18.c. and Fig. 10. that the crop growth rate in PRC, PRM and PRT increased gradually with the size of the planting material (W_1 to W_5) and also increased gradually in their successive stages of growth upto 180 days and thereafter declined till 360 days after planting. Again the CGR gradually increased upto 480 days and thereafter declining trend was noticed.

The maximum values were $1.180 \text{ gm day}^{-1} \text{ plant}^{-1}$ in Crown plants followed by Middle and Tip plants (Table 18.b. & 18.c.) under W_5 planting size. The mean values were observed maximum in W_5 and minimum in W_1 size of the planting materials.

Net Assimilation Rate (NAR) : Variation in net assimilation rate due to different size of the planting materials (W_1 , W_2 , W_3 , W_4 & W_5) have been presented in the Table 19.a. to 19.c. and Fig. 11.

It was evident from the data that W_5 of PRC (Table 19.a) showed highest NAR between 420 to 480 days during the cropping season. During the 1st year growth NAR increased steadily upto 180 days and thereafter declined in all the treatments but the rate was lower in W_1 & W_2 in comparison to W_3 , W_4 & W_5 whereas, during the 2nd year growth NAR were minimum between 480 to 540 days.

FIG. 10.



F I G U R E 10.

P R C = Represents Plants Raised from Crown portion.
P R M = Represents Plants Raised from Middle portion.
P R T = Represents Plants Raised from Tip portion.

Hollow Circles represents W_1 (10 gms) Sizes of planting materials.
Hollow Traingles represents W_2 (30 gms) Sizes of planting materials.
Hollow Squares represents W_3 (50 gms) Sizes of planting materials.
Solid Circles represents W_4 (70 gms) Sizes of planting materials.
Solid Traingles represents W_5 (90 gms) Sizes of planting materials.

Table No. 18.a

Effects of the size of the planting materials on
Crop Growth Rate ($\mu\text{m. day}^{-1} \text{ plant}^{-1}$).

P R C

Size of the planting materials.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	0.093	0.168	0.131	0.186	0.430	0.578	0.621	0.315
W ₂	0.158	0.181	0.176	0.206	0.465	0.606	0.628	0.345
W ₃	0.265	0.291	0.205	0.239	0.686	0.708	1.088	0.497
W ₄	0.275	0.360	0.215	0.276	0.701	0.773	1.180	0.540
W ₅	0.295	0.410	0.321	0.384	0.626	0.740	1.090	0.552
Mean	0.217	0.282	0.209	0.258	0.581	0.681	0.921	0.449
SE _t	0.039	0.047	0.031	0.035	0.056	0.038	0.122	0.049

Table No. 18.b.

Effects of the size of the planting materials on
Crop Growth Rate (gm. day⁻¹plant⁻¹); ,

P R M

Size of the planting Materials	<u>Days after planting</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	0.095	0.128	0.115	0.126	0.276	0.338	0.460	0.219
W ₂	0.113	0.133	0.095	0.236	0.325	0.471	0.893	0.323
W ₃	0.156	0.356	0.181	0.236	0.561	0.583	0.915	0.427
W ₄	0.243	0.415	0.190	0.294	0.580	0.701	0.976	0.485
W ₅	0.285	0.318	0.273	0.370	0.740	0.800	1.028	0.545
Mean	0.178	0.270	0.171	0.252	0.496	0.578	0.854	0.399
SE ±	0.037	0.059	0.031	0.040	0.086	0.081	0.101	0.058

Table No. 18.c.

Effects of the size of the planting material on
Crop Growth Rate (gm. day⁻¹plant⁻¹).

P. R. T.

Size of the planting materials.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	0.095	0.143	0.133	0.112	0.321	0.520	0.654	0.282
W ₂	0.121	0.263	0.171	0.190	0.326	0.615	0.821	0.358
W ₃	0.205	0.311	0.221	0.240	0.541	0.660	1.008	0.455
W ₄	0.208	0.371	0.251	0.285	0.553	0.680	1.096	0.492
W ₅	0.265	0.373	0.348	0.364	0.585	0.893	1.108	0.562
Mean	0.178	0.292	0.225	0.238	0.465	0.674	0.937	0.429
SE \pm	0.031	0.042	0.037	0.042	0.058	0.061	0.087	0.049

Table No. 19.a.

Effects of the size of the planting materials on
Net Assimilation Rate (10^{-4} gm.. cm⁻²day⁻¹ plant⁻¹).

P R C.

Size of the planting materials.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	1.58	2.34	2.01	0.42	1.82	2.43	0.51	1.58
W ₂	1.81	2.55	2.15	0.51	2.02	2.76	0.63	1.77
W ₃	1.97	3.07	2.72	0.69	2.89	3.64	0.72	2.24
W ₄	2.05	3.21	2.82	0.76	3.05	3.75	0.87	2.36
W ₅	2.17	3.37	2.93	0.88	3.33	3.87	0.95	2.50
Mean	1.91	2.90	2.526	0.65	2.62	3.29	0.73	2.09
SE \pm	0.102	0.197	0.186	0.063	0.297	0.290	0.079	0.177

Table No. 19.b.

Effects of the size of the planting materials on
 Net Assimilation Rate (10^{-4} gm. cm.⁻² day⁻¹ plant⁻¹) .

P. R. M

Size of the planting materials.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-36	360-420	420-480	480-540	
W ₁	1.35	2.20	1.78	0.36	1.66	2.21	0.42	1.42
W ₂	1.58	2.43	1.96	0.42	1.91	2.45	0.53	1.61
W ₃	1.77	2.85	2.46	0.55	2.57	3.08	0.66	1.99
W ₄	1.90	3.04	2.62	0.65	2.85	3.65	0.78	2.21
W ₅	2.06	3.24	2.71	0.77	3.05	3.72	0.85	2.34
Mean	1.73	2.75	2.30	0.55	2.41	3.02	0.64	1.91
SE ±	0.123	0.192	0.184	0.074	0.268	0.306	0.078	0.174

Table No. 19.c.

Effects of the size of the planting materials on
Net Assimilation Rate (10^4 gm. cm^2 day^{-1} plant^{-1}).

P R T

Size of the planting materials.	<u>Days after planting</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
W ₁	1.40	2.26	1.82	0.39	1.72	2.25	0.47	1.473
W ₂	1.71	2.47	2.01	0.46	1.94	2.50	0.56	1.660
W ₃	1.80	2.93	2.52	0.60	2.60	2.54	0.69	1.954
W ₄	1.98	3.10	2.58	0.69	2.90	3.69	0.82	2.251
W ₅	2.09	3.27	2.78	0.80	3.16	3.78	0.90	2.397
Mean	1.79	2.80	2.34	0.58	2.46	2.95	0.68	1.947
SE \pm	0.119	0.191	0.182	0.074	0.275	0.324	0.079	0.173

FIGURE 11.

Effects of different size and types of planting materials
on Net Assimilation Rate of D.floribunda.

P R C = Represents Plants Raised from Crown portion.

P R M = Represents Plants Raised from Middle portion.

P R T = Represents Plants Raised from Tip portion.

Hollow Circles represents W_1 (10 gms) Sizes of planting materials.

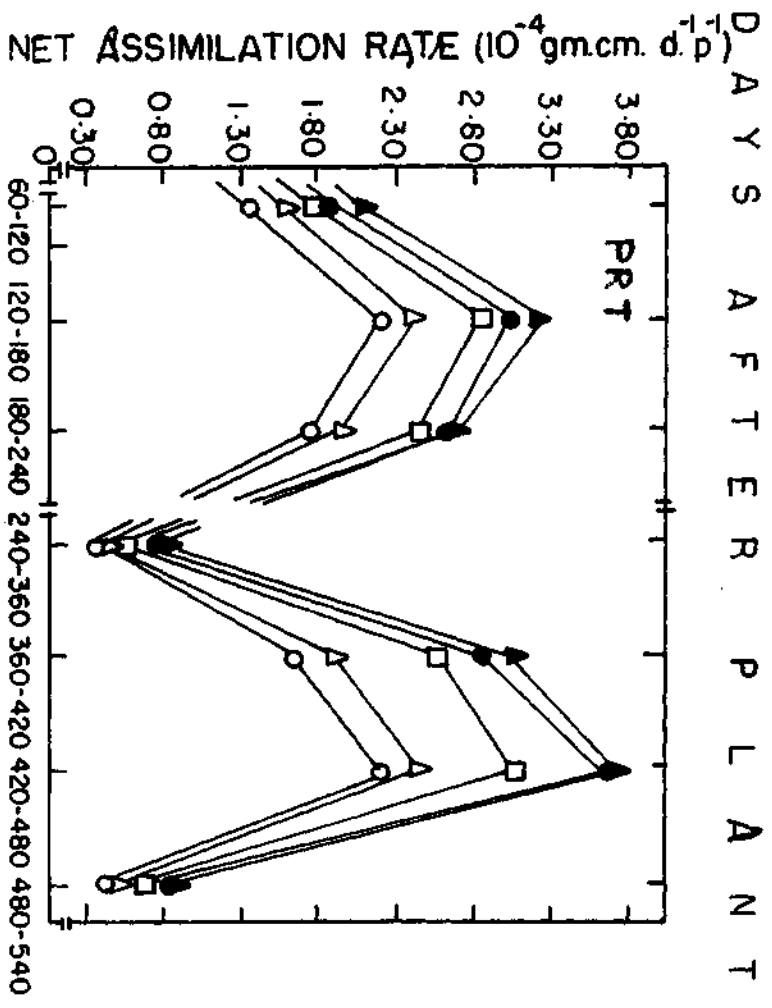
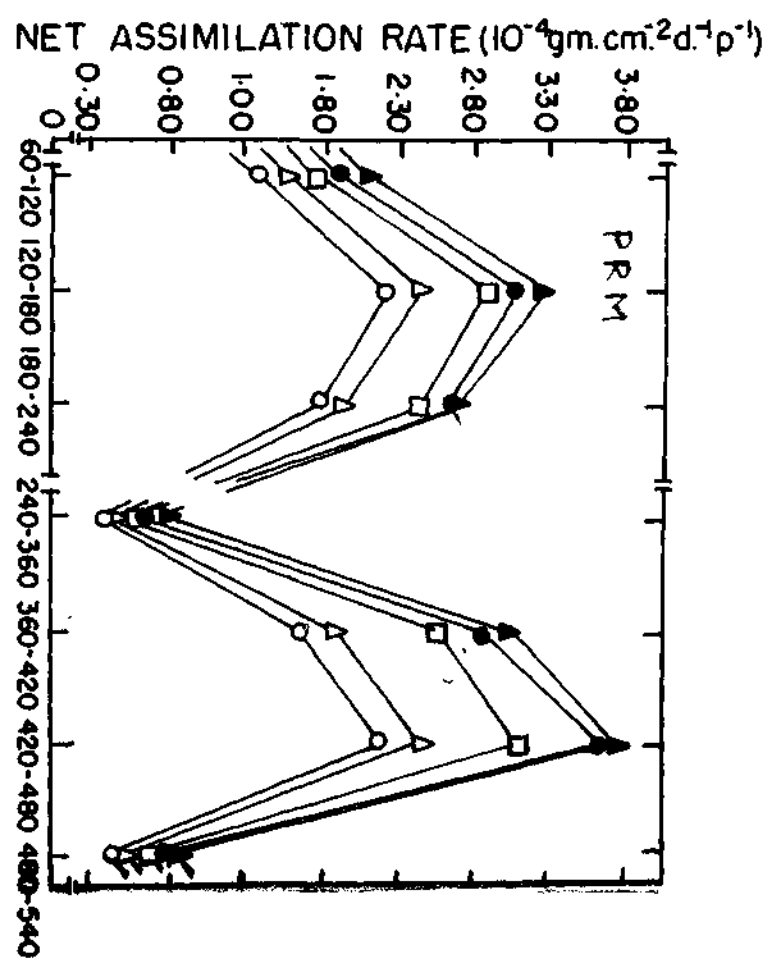
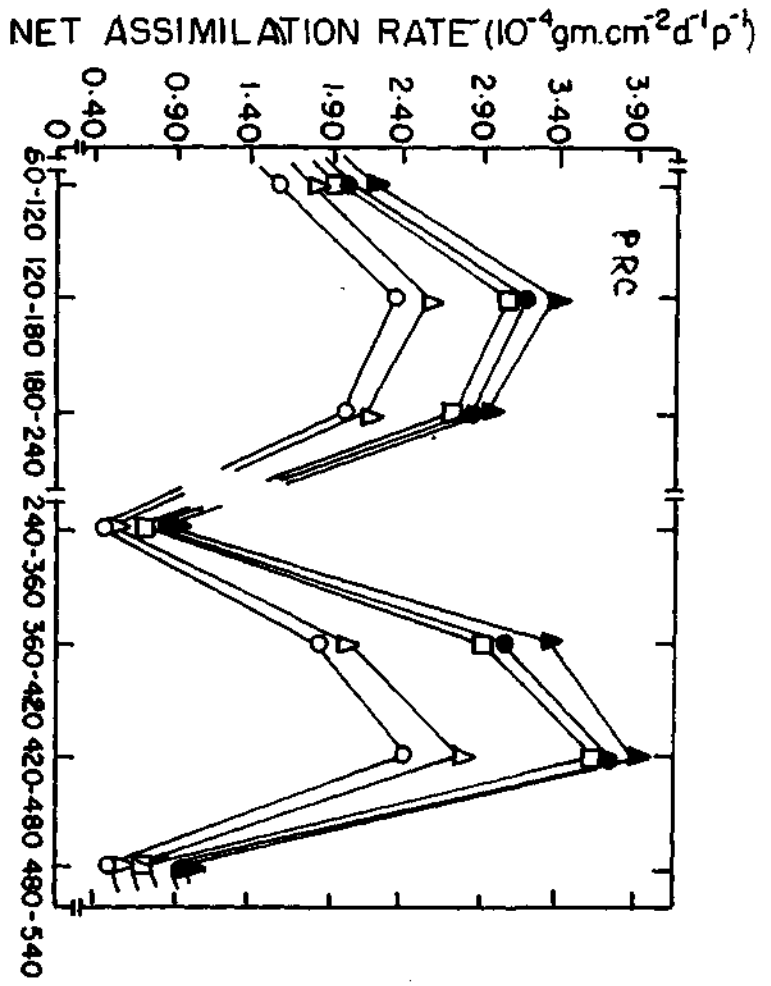
Hollow Traingles represents W_2 (30 gms) Sizes of planting materials.

Hollow Squares represents W_3 (50 gms) Sizes of planting materials.

Solid Circles represents W_4 (70 gms) Sizes of planting materials.

Solid Traingles represents W_5 (90 gms) Sizes of planting materials.

FIG. 11.



DAYS AFTER PLANTING

The highest NAR recorded in W_5 of Crown plants being the value $3.87 \times 10^{-4} \text{ gm cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$. The similar trend was also observed in PRM and PRT (Table 19.b. & 19.c. But the interaction results among PRC, PRM & PRT showed closer relation between PRC & PRT.

Dry Matter Production (DM) : Variation in the dry matter production in Dioscorea floribunda revealed from the data that there were corresponding increase in dry matter production with the increase in the size of the planting materials as well as with the subsequent stages of plant growth. The rate of DM rather accumulation found vary slow during the first year growth which increased from 360 days onwards till the harvest.

In general, it has been observed that the rate of total dry matter production in plants at the early period of growth were less but with the age of the plants the accumulation occurred maximum in the underground portion. The effect of the size of planting materials on dry matter production was significantly more pronounced than the types of the planting materials. Among the three types only PRC & PRT revealed pronounced effects. The highest DM value was recorded in W_5 and the lowest was in W_1 planting sizes among all the types of planting materials.

YIELD ATTRIBUTES

Results on Yam yield : Data on yam yield (Table 21.a. to 21.c. and Fig. 13.) under different size and type of planting materials clearly showed that the yam yield was increased successively with the size of the

F I G U R E 12.

Inter-relationship among LAI, NAR and DM production of
D. floribunda under different planting Sizes
and type of planting materials.

- P R C = Represents Plants Raised from Crown portion.
P R M = Represents Plants Raised from Middle portion.
P R T = Represents Plants Raised from Tip portion.
L A I = Represents Leaf Area Index.
N A R = Represents Net Assimilation Rate.
D M = Represents Dry matter production.

Hollow Circles represents Leaf Area Index.

Solid Cirles represents Dry matter production.

Hollow Traingles represents Net Assimilation Rate.

FIG. 12.

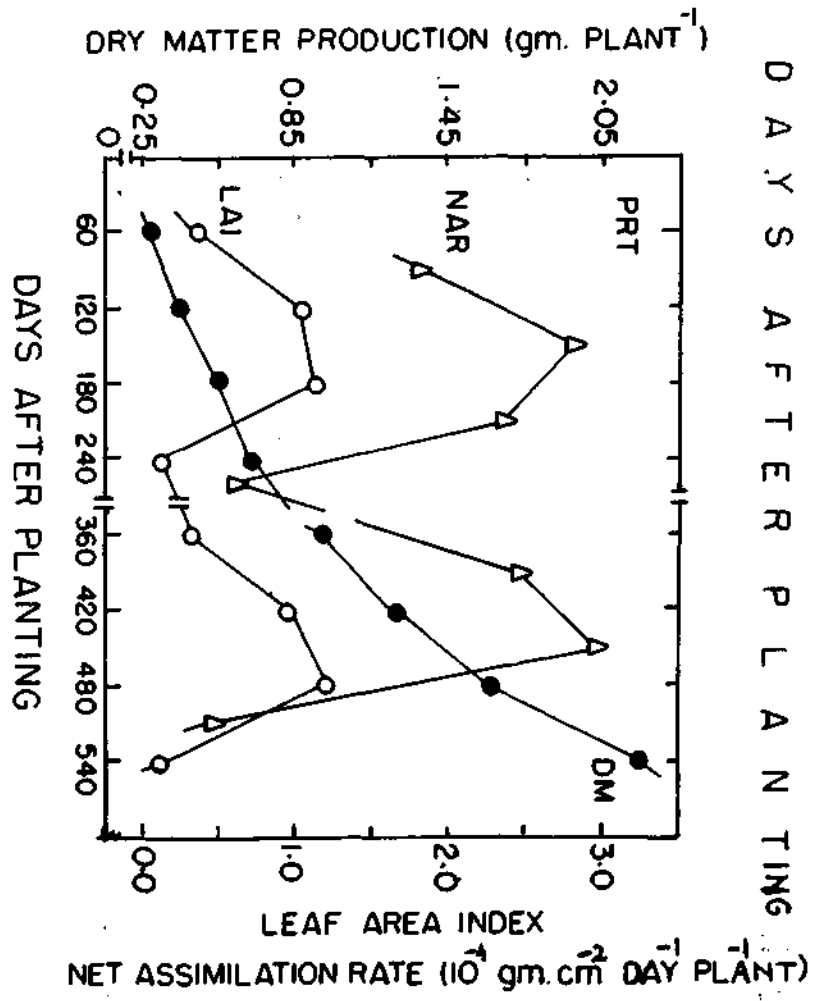
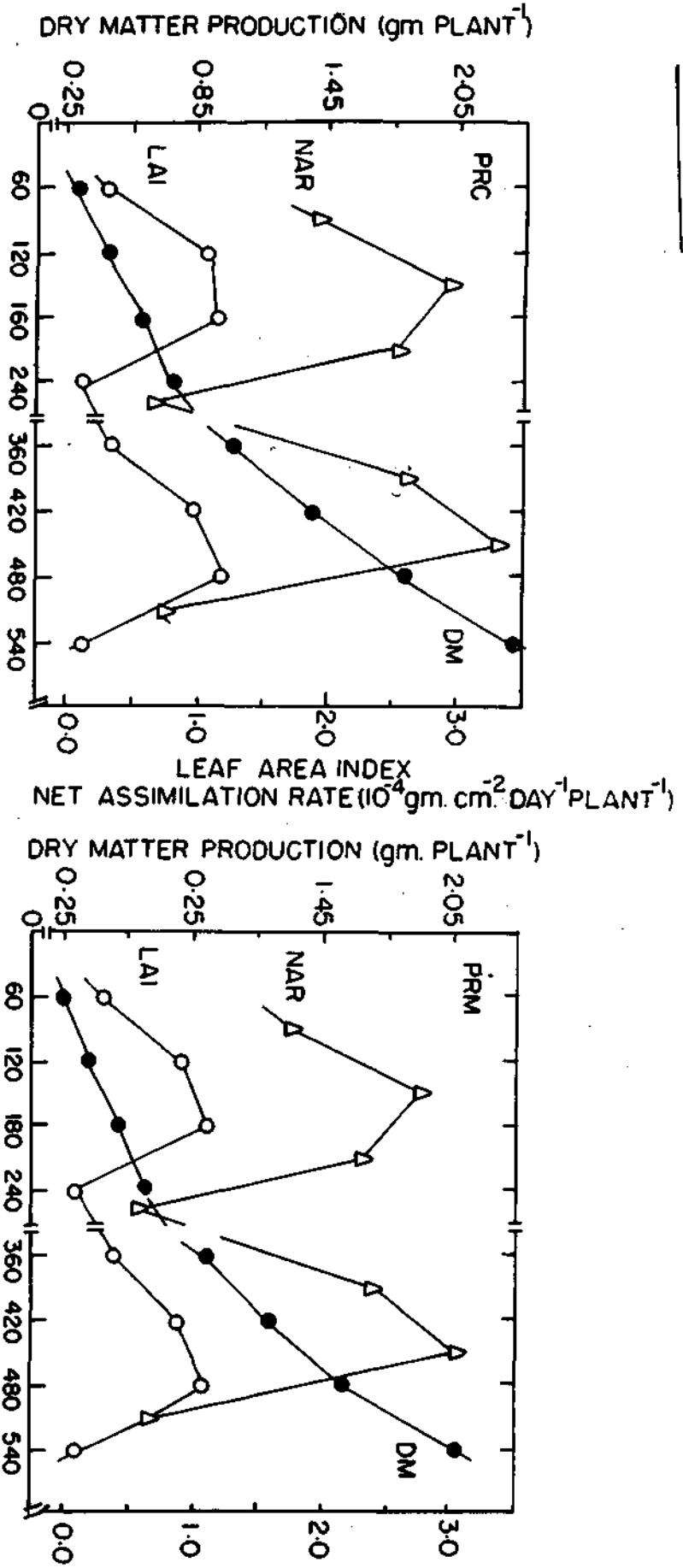


Table No. 20.a.

Dry matter production (gm. plant⁻¹) in D. floribunda under
different size of the planting materials.

P R C.

Size of the planting materials.	<u>Days after planting.</u>								
	<u>1st year growth</u>				<u>2nd year growth.</u>				Mean
	60	120	180	240	360	420	480	540	
W ₁	16.7	22.3	32.4	40.3	62.7	88.5	123.2	160.5	68.32
W ₂	24.6	34.1	45.0	55.6	80.4	108.3	144.7	182.4	84.38
W ₃	30.1	46.0	66.5	75.8	104.5	145.7	188.2	253.5	113.78
W ₄	37.2	53.7	75.3	88.1	121.3	163.4	209.8	271.6	127.55
W ₅	43.9	61.6	86.2	105.5	151.6	189.2	233.6	299.0	146.32
Mean	30.50	43.54	61.08	73.06	104.10	139.06	179.90	233.40	108.07
SE \pm	4.74	6.98	9.86	11.54	15.53	18.22	20.37	26.53	14.17

Table No. 20.b.

Dry matter production (gm. plant⁻¹) in D.floribunda
under different size of the planting materials.

P R M.

Size of the planting materials.	<u>Days after planting</u>									
	60	<u>1st year growth</u>				360	<u>2nd year growth</u>			Mean
		120	180	240	420		480	540		
W ₁	12.8	18.5	26.2	33.1	48.2	64.8	85.1	112.7	50.17	
W ₂	20.3	27.1	35.1	40.8	69.2	88.7	117.0	170.6	71.10	
W ₃	26.4	35.8	57.2	68.1	96.5	130.2	165.2	220.1	99.93	
W ₄	30.5	45.1	69.0	80.4	115.7	146.2	188.3	256.9	116.51	
W ₅	38.1	55.2	74.3	90.7	135.2	172.6	220.6	282.3	133.62	
Mean	25.62	36.34	52.36	62.62	92.96	120.50	155.24	208.52	94.26	
SE \pm	4.31	6.46	9.39	11.14	15.62	19.47	24.33	30.44	15.09	

Table No. 20.c.

Dry matter production (gm. plant⁻¹) in D. floribunda
under different size of the planting materials.

P R T

Size of the planting materials.	<u>Days after planting.</u>								
	60	120	180	240	360	420	480	540	Mean
W ₁	14.8	20.5	29.1	37.1	50.6	70.0	101.2	140.5	57.97
W ₂	23.1	30.4	39.2	49.5	72.3	91.9	128.8	178.2	76.67
W ₃	28.5	40.8	59.5	72.8	98.1	130.6	170.2	230.7	103.90
W ₄	35.2	48.7	71.0	86.1	120.3	153.5	194.3	260.1	108.65
W ₅	40.1	58.1	80.5	96.4	140.1	175.2	228.9	295.4	139.33
Mean	28.34	39.70	55.86	68.38	96.28	124.24	164.68	220.98	97.30
SE ±	4.45	6.61	9.60	11.07	16.06	19.34	22.75	27.81	13.98

Table No. 21.a.

Effects of the size of planting materials on "Yam" yield and
Vine yield (kg./plant) at the final stage of
harvesting (720 days) in D.floribunda.

P R C

Size of planting material	Dry vine yield (kg./plant)	"Yam" yield (kg./plant)	
		fresh	Dry
W ₁	0.085	0.690	0.193
W ₂	0.104	1.255	0.357
W ₃	0.119	1.623	0.457
W ₄	0.136	1.640	0.460
W ₅	0.142	1.645	0.470
Mean	0.117	1.371	0.388
SE ±	0.010	0.185	0.052
C.D. at 5% =		0.350	0.104

Table No. 21.b.

Effects of the size of planting materials on "Yam" yield and
dry vine yield (kg./plant) at the final stage of harvesting
(720 days) in D. floribunda.

P R M

Size of planting material	Dry vine yield (kg./plant)	"Yam" yield (kg./plant)	
		fresh	Dry
W ₁	0.076	0.578	0.163
W ₂	0.098	1.103	0.308
W ₃	0.107	1.510	0.421
W ₄	0.113	1.528	0.427
W ₅	0.126	1.538	0.426
Mean	0.104	1.251	0.349
SE †	0.008	0.187	0.051
C.D. at 5% =		0.264	0.102

Table No. 21.c.

Effects of the size of planting materials on "Yam" yield and dry
vine yield (kg./plant) at the final stage of harvesting
(720 days) in D. floribunda.

P R T

size of the planting material.	Dry vine yield (kg./plant)	"Yam" yield (kg./plant)	
		fresh	dry
W ₁	0.080	0.605	0.165
W ₂	0.101	1.190	0.325
W ₃	0.109	1.588	0.432
W ₄	0.121	1.600	0.436
W ₅	0.132	1.612	0.441
Mean	0.108	1.319	0.359
SE ±	0.008	0.195	0.053
C.D. at 5% =		0.282	0.106

F I G U R E 13.

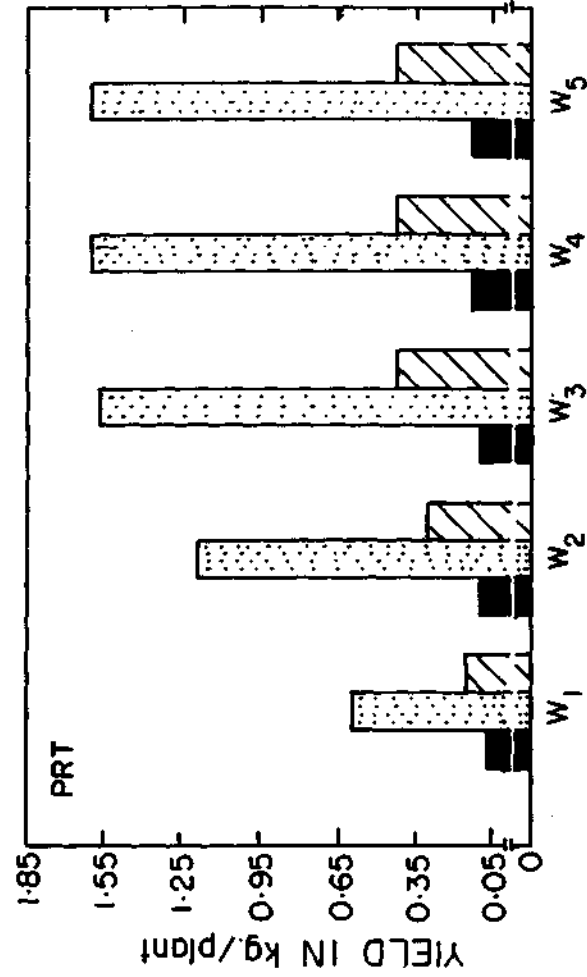
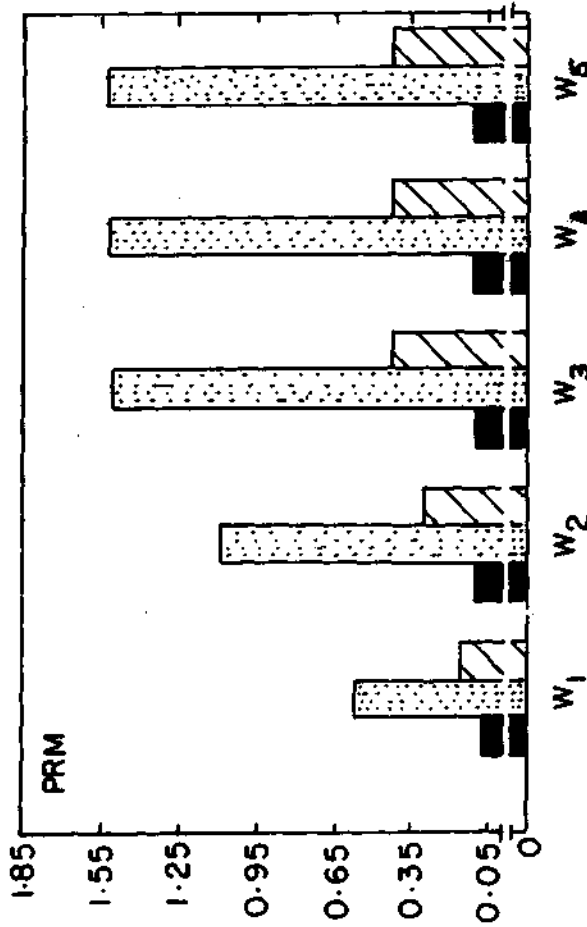
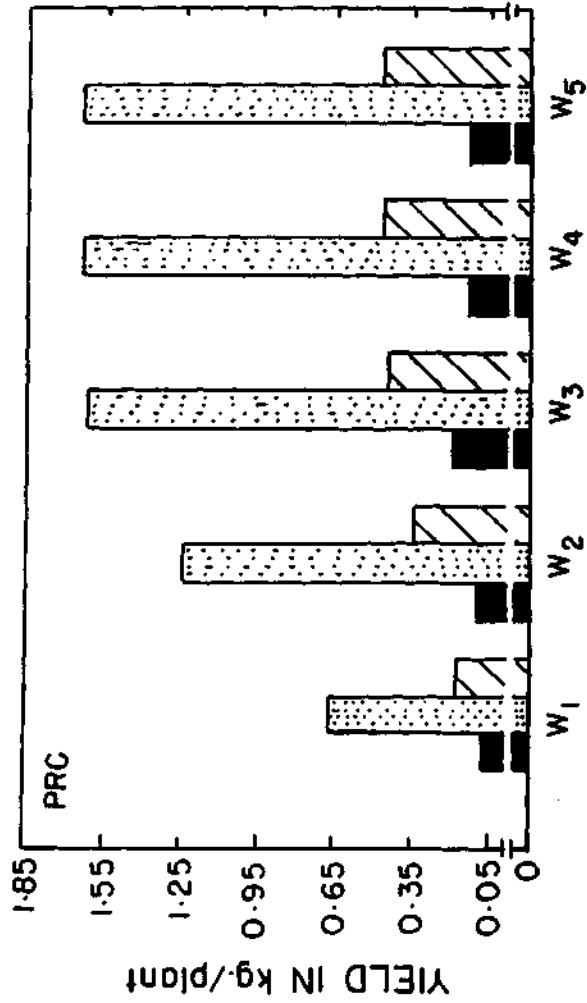
Effects of different Size and type of planting materials on "yam" yield and dry vine yield (kg/plant) at the final stage of harvesting (720 days) in D.floribunda.

- P R C = Represents Plants Raised from Crown portion.
P R M = Represents Plants Raised from Middle portion.
P R T = Represents Plants Raised from Tip portion

Solid bar represents Dry vine yield.

Dotted bar represents Fresh yam yield.

Obliquely lined bar represents Dry yam yield.



planting materials attaining a maximum fresh weight of 1.645 kg/plant in W₅ (90 gms pieces) planting size of plants developed from Crown (PRC) after 720 days. Data from W₄ & W₅ planting sizes did not reveal any significant variations whereas W₃ planting size showed marked variation as compared to W₁ & W₂ planting size of Crown plants, having maximum fresh wt. of 1.623 kg/plant. The lowest yield was recorded in W₁ of Middle plants (PRM) in comparison to Crown (PRC) & Tip (PRT) plants (Table 21.a. & 21.c.)

Vine yield : Data on vine yield presented in the Table 21.a. to 21.e. indicated that it was also increased successively with the increase of the size of the planting materials in all the planting types. It was also revealed that increase in vine yield directly varied with yam yield and in all the cases, the highest vine yield matched with maximum yam yield.

Diosgenin content : Variation in diosgenin content on dry weight basis of different experimental materials have been shown in Table 22. The data revealed that the different planting size did not affect significantly on diosgenin content. The highest mean value of diosgenin content was found in Tip portion of the yam (3.71 %).

YIELDS

Yield of tuber (yam) and diosgenin yield : Total yield data per hectare have been presented in Table 23.a. to 23.c. and Fig. 14. The data revealed that the W₅ planting size in Crown plants yielded maximum amount to 35.254 MT/ha equivalent to 10.072 MT/ha of dry yam and calculating the diosgenin content 0.3604 MT/ha (Table 23.a.)

Table No. 22.

Variation in Diosgenin percentage (dry wt. basis) in respect of different SIZE OF PLANTING materials and different type of planting materials.

Type of planting materials.	Treatments	Crown	Middle	Tip	Mean
		% of Diosgenin	% of Diosgenin	% of Diosgenin	
Plants	W ₁	3.34	3.60	3.74	3.560
Raised	W ₂	3.36	3.61	3.75	3.573
from	W ₃	3.39	3.62	3.76	3.590
Crown	W ₄	3.39	3.62	3.76	3.590
Portion	W ₅	3.39	3.62	3.76	3.590
	Mean	3.374	3.61	3.75	3.580
	SE \pm	0.010	0.004	0.004	0.006
Plants	W ₁	3.40	3.69	3.78	3.623
Raised	W ₂	3.43	3.68	3.78	3.630
from	W ₃	3.45	3.69	3.80	3.646
Middle	W ₄	3.45	3.69	3.79	3.643
Portion	W ₅	3.46	3.68	3.79	3.643
	Mean	3.438	3.686	3.788	3.637
	SE \pm	0.010	0.002	0.003	0.004
Plants	W ₁	3.51	3.74	3.80	3.683
Raised	W ₂	3.53	3.75	3.81	3.696
from	W ₃	3.54	3.75	3.84	3.710
Tip	W ₄	3.54	3.74	3.84	3.706
Portion	W ₅	3.55	3.75	3.83	3.710
	Mean	3.534	3.746	3.824	3.701
	SE \pm	0.006	0.002	0.008	0.005

FIGURE 14.

Effects of the different size and type of Planting materials
on the production of 'yam' and Diosgenin yield.

Filled bar represents the Actual yield.

Empty bar represents the potential yield.

Dotted bar represents Fresh yam yield.

Solid bar represents Dry yam yield.

Obliquely lined bar represents Diosgenin yield.

FIG. 14.

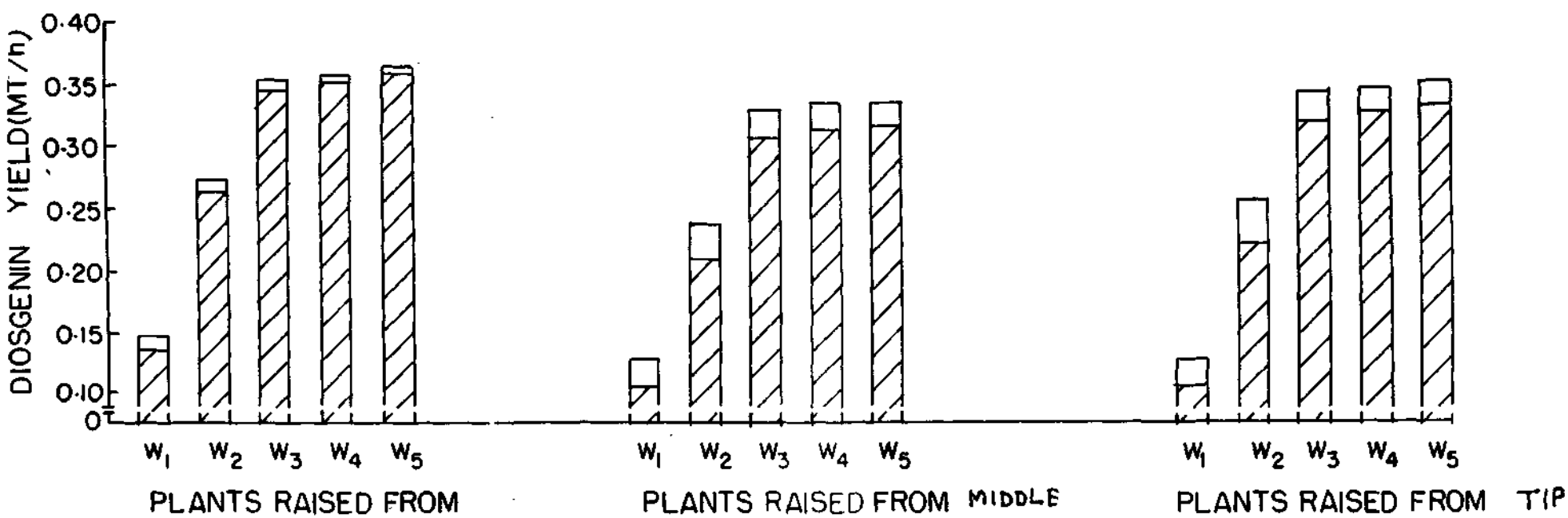
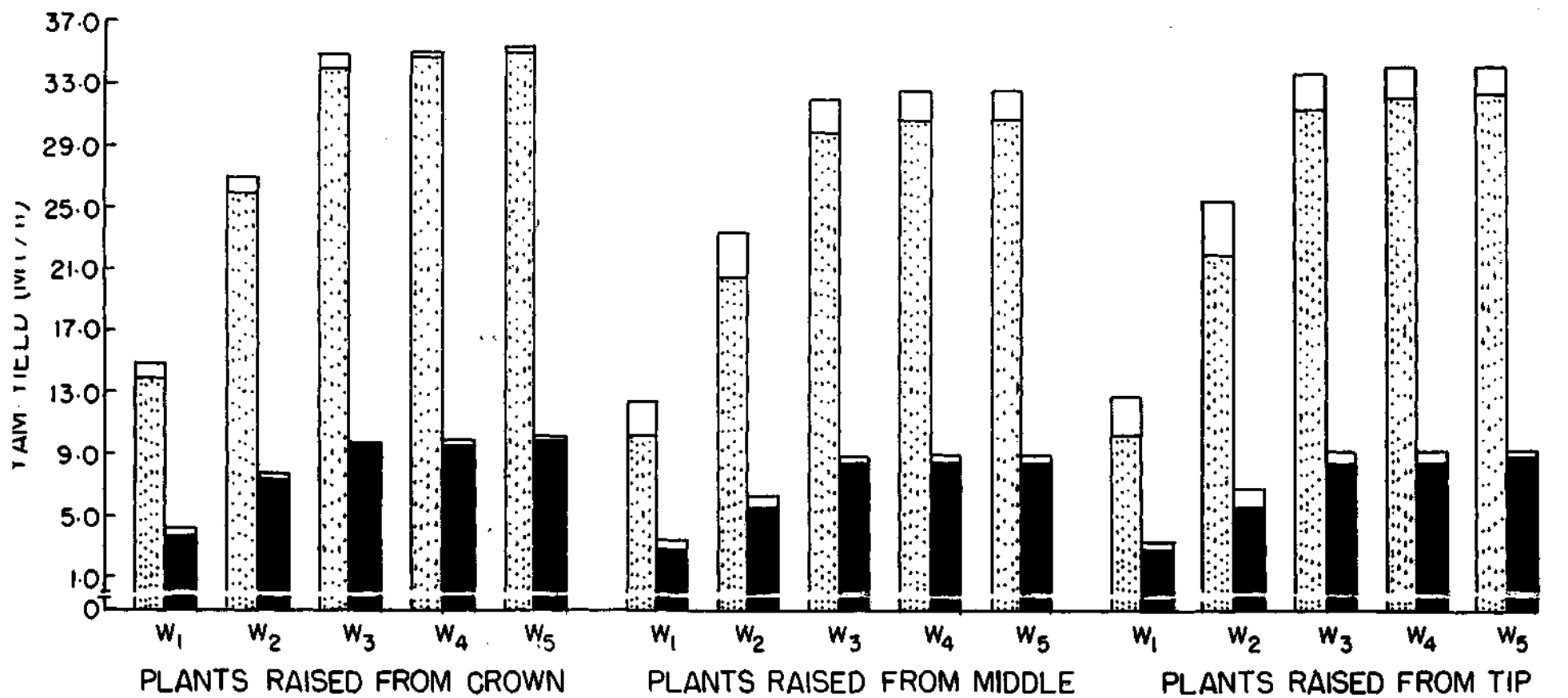


Table No. 23.a.

Effects of the different size of planting materials on the production of "Yam" (fresh & dry) and diosgenin yield(MT/ha)

P R C

Size of the planting materials.	Yam yield (MT / ha.)		Diosgenin yield (MT/ha.)	% of Survival
	Fresh	Dry		
W ₁	13.919 (14.848)	3.893 (4.153)	0.1385 (0.1478)	93.0
W ₂	26.080 (27.007)	7.418 (7.682)	0.2649 (0.2744)	95.8
W ₃	34.185 (34.926)	9.625 (9.834)	0.3455 (0.3530)	97.1
W ₄	34.933 (35.292)	9.798 (9.899)	0.3516 (0.3553)	98.2
W ₅	35.254 (35.400)	10.072 (10.147)	0.3604 (0.3631)	98.8
Mean	28.874 (29.494)	8.161 (8.343)	0.2929 (0.2987)	96.58
SE \pm	4.105 (3.992)	1.167 (1.137)	0.0420 (0.0410)	1.030

Figures in Parenthesis = Potential Yield.

Table No. 23.b.

Effects of the different size of planting materials on the production of "Yam" (fresh & dry) and diosgenin yield (MT/ha).

P R M

Size of the planting materials.	Yam yield (MT/ha).		Diosgenin yield (MT/ha).	% of Survival
	Fresh	Dry		
W ₁	10.368 (12.436)	2.924 (3.507)	0.1058 (0.1270)	82.7
W ₂	20.648 (23.736)	5.765 (6.628)	0.2092 (0.2406)	86.3
W ₃	30.329 (32.495)	8.456 (9.059)	0.3083 (0.3303)	92.6
W ₄	30.990 (32.882)	8.660 (9.169)	0.3154 (0.3347)	93.5
W ₅	31.232 (33.033)	8.667 (9.167)	0.3156 (0.3339)	93.8
Mean	24.713 (26.916)	6.894 (7.510)	0.2508 (0.2733)	89.78
SE ±	4.097 (4.024)	1.134 (1.113)	0.0415 (0.0407)	2.230

Figures in parenthesis = Potential yield .

Table No. 23.c.

Effects of the different planting size on the production of "Yam" (fresh & dry) and Diosgenin yield (MT/ha.).

P R T

Size of the planting materials	Yam yield (MT/ha.)		Diosgenin yield (MT/ ha.)	% of Survival
	Fresh	Dry		
W ₁	10.682 (13.019)	2.913 (3.550)	0.1072 (0.1307)	81.4
W ₂	22.224 (25.734)	6.069 (6.994)	0.2243 (0.2885)	86.1
W ₃	31.863 (34.173)	8.668 (9.296)	0.3215 (0.3448)	92.5
W ₄	32.520 (34.432)	8.861 (9.382)	0.3284 (0.3477)	93.7
W ₅	32.937 (34.690)	9.011 (9.490)	0.3342 (0.3520)	94.2
Mean	26.045 (28.410)	7.104 (7.742)	0.2631 (0.2867)	89.58
SE ±	4.323 (4.201)	1.179 (1.146)	0.0439 (0.0427)	2.508

Figures in parenthesis = Potential yield.

The lowest yield was recorded in W_1 being the value 13.919 MT/ha equivalent to 3.893 MT/ha of dry yam. In Middle & Tip plants similar trend was observed but the yields of the individual treatment of both Middle and Tip plants were more or less identical and there were no marked variation. Among the three types the highest yield and highest survival percentage was recorded in W_5 of Crown plants.

NUTRIENTS ACCUMULATION

Nitrogen accumulation : A perusal of data in Table 24 revealed that the accumulation of nitrogen in all the treatments of PRC, PRM and PRT increased steadily in each year growth and declined at the dormant stage. The maximum nitrogen accumulation ^{was} in W_5 treatment in all the types. The minimum was recorded in W_1 treatment.

Phosphorus accumulation : The data on the accumulation of the phosphorus has been represented in Table 25 revealed that the phosphorus accumulation steadily increased with the increase of the size of the planting materials in all the types of planting materials. The maximum value was observed during the 2nd year growth in W_5 whereas the minimum was observed in W_1 .

Potassium accumulation : A perusal of the data in Table 26. revealed that potassium accumulation increased steadily with the increase of the size of the planting materials in all the cases of PRC, PRM & PRT. The maximum value was recorded in W_5 and the minimum was recorded in W_1 in all the planting types. During the final stage of harvesting at 720 days the highest potassium accumulation ^{also} was recorded in W_5 planting size of PRC, PRM & PRT.

Table No. 24

Nitrogen Accumulation (in %) in whole plant in
different stages of growth under different
size of the planting materials.

F R C

Size of the planting materials.	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting.	
W ₁	1.508	1.516	1.285	1.436
W ₂	1.673	1.685	1.408	1.618
W ₃	1.828	1.839	1.610	1.759
W ₄	1.859	1.891	1.654	1.801
W ₅	1.882	1.997	1.689	1.856
Mean	1.750	1.785	1.529	1.694
SE ±	0.070	0.084	0.078	0.075

P R M

Size of the planting materials.	Successive stages of growth			Mean
	1st year growth	2nd year growth	final state of harvesting	
W ₁	1.297	1.475	1.219	1.330
W ₂	1.402	1.669	1.376	1.482
W ₃	1.671	1.762	1.585	1.672
W ₄	1.710	1.818	1.601	1.709
W ₅	1.753	1.887	1.647	1.762
Mean	1.566	1.722	1.485	1.591
SE ±	0.091	0.071	0.081	0.080

P R T

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting	
W ₁	1.301	1.480	1.225	1.335
W ₂	1.570	1.678	1.390	1.546
W ₃	1.720	1.783	1.594	1.699
W ₄	1.786	1.826	1.620	1.744
W ₅	1.815	1.905	1.662	1.794
Mean	1.629	1.731	1.498	1.623

Table No. 23.

Phosphorus Accumulation (in %) in whole plant in different stages of growth under different size of the planting materials.

P R C

Size of the planting materials	Successive stages of growth			Mean
	last year growth	2nd year growth	final stage of harvesting.	
W ₁	2.927	3.765	3.004	3.232
W ₂	3.235	4.320	3.365	3.640
W ₃	3.456	4.589	3.502	3.849
W ₄	3.469	4.623	3.524	3.872
W ₅	3.475	4.641	3.560	3.892
Mean	3.312	4.387	3.391	3.607
SE ±	0.106	0.166	0.102	0.124

P R M

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting	
W ₁	2.900	3.713	2.986	3.199
W ₂	3.186	4.295	3.170	3.550
W ₃	3.407	4.566	3.397	3.786
W ₄	3.432	4.590	3.462	3.828
W ₅	3.455	4.618	3.485	3.852
Mean	3.276	4.356	3.300	3.643
SE ±	0.105	0.171	0.096	0.123

P R T

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting	
W ₁	2.917	3.735	2.988	3.213
W ₂	3.195	4.304	3.175	3.558
W ₃	3.423	4.573	3.408	3.801
W ₄	3.445	4.601	3.475	3.840
W ₅	3.461	4.620	3.521	3.867
Mean	3.288	4.366	3.313	3.656
SE ±	0.104	0.168	0.101	0.123

Table No. 26.

Phosphorus Accumulation (in %) in whole plant in different stages of growth under different size of the planting materials.

P R C

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting	
W ₁	0.136	0.167	0.141	0.148
W ₂	0.139	0.169	0.145	0.151
W ₃	0.143	0.173	0.149	0.155
W ₄	0.145	0.176	0.152	0.157
W ₅	0.146	0.178	0.153	0.159
Mean	0.142	0.172	0.148	0.154
SE \pm	0.001	0.002	0.002	0.002

P R M

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting	
W ₁	0.134	0.160	0.137	0.143
W ₂	0.138	0.163	0.141	0.147
W ₃	0.140	0.165	0.146	0.150
W ₄	0.141	0.166	0.148	0.151
W ₅	0.142	0.167	0.151	0.153
Mean	0.139	0.164	0.144	0.143
SE \pm	0.001	0.001	0.002	0.001

P R T

Size of the planting materials	Successive stages of growth			Mean
	1st year growth	2nd year growth	Final stage of harvesting.	
W ₁	0.135	0.165	0.138	0.146
W ₂	0.138	0.168	0.139	0.148
W ₃	0.141	0.170	0.143	0.151
W ₄	0.143	0.171	0.144	0.152
W ₅	0.144	0.175	0.149	0.156
Mean	0.140	0.169	0.142	0.150
SE \pm	0.001	0.001	0.001	0.001

DISCUSSION

DISCUSSION

Experimental results on the effect of the different size of the planting materials with the type of the planting materials of Dioscorea floribunda Mart. & Gall. reveals that the LAI increases correspondingly with the increase of the sizes of the planting materials from W_1 to W_5 (i.e.; 10 gms to 90 gms) upto 180 days and thereafter sharply declined till the commencement of the 2nd year growth in all the planting sizes. The increasing trend was again observed during the 2nd year growth till the dormancy starts. In all the treatments, the LAI took their momentum from 360 days and onwards till the 2nd year dormancy starts followed by declining trend thereafter. During the early stages of growth the minimum value (0.262) of LAI has been observed in W_1 and reaches the highest value in W_5 of Crown plants. This trend was probably due to less reserve food materials (carbohydrates) in the small yams when planted, resulting the thin plants and big yams gives the vigorous growth due to more reserve food. The studies of Koch and Brauhn (1962) suggested that the secondary meristem is present only in the upper region of the tuber. It may be assumed that the Crown plants give earlier sprouting due to secondary meristematic zones and higher carbohydrate reserves. But the formation of leaves delayed probably due to compensation of the leading shoots and the leaves are reduced to scales resulting a lower values of LAI and RIGR initially but gives the highest values of LAI and RIGR in Crown plants followed by the Tip and Middle plants during their 2nd year growth. Total leaf area in Crown plants has been compensated by the largest leaves but in the Tip plants the total leaf area has been

compensated by the greater number of leaves. With the increase in size of the planting materials from 10 gms to 90 gms, the growth of the aerial parts was noted to be most vigorous in W_3 of Crown plants (PC), resulting in the highest leaf growth rate (Watson, 1958) associated with maximum of total leaf surface. This observation also is in confirmity with that of the findings of Martin and Watson, 1948. No reports are available in this line of the same crop under the agroclimatic condition of Darjeeling hills. In connection with the Crop Growth Rate (CGR) it has been found that CGR varies directly with the size of the planting materials in the successive stages of growth till the commencement of dormant period in each year. The mean values have been found to be maximum in W_5 at the end of 2nd year and lowest value was observed in W_1 of all the planting types. The values of CGR in Middle plants showed a significant differences over Crown and Tip plants and the interaction effects resulted a closer relation between the Crown and Tip plants. The higher CGR which resulted into the higher dry matter accumulation and higher yield with the increase of the size of the planting materials is in confirmity with the findings of Randhawa et al (1972), Sharma ; Chatterjee; Panda; Saha and Mandal (1985) in the same crop.

Variation in NAR under the different size of the planting materials revealed that lower values of W_1 & W_2 was obtained in comparison to W_3 , W_4 & W_5 during each year growth but found to be minimum during the dormant period and which was probably due to the drying of the older leaves and shoots. Whereas, the value of NAR was found to be maximum during the 2nd year growth in all the three types of planting materials. The highest NAR value was found in W_5

of Crown plants at the end of 2nd year growth followed by Tip and Middle plants. No reports are available in this line under the agroclimatic condition of Darjeeling hills. The higher NAR in the larger size of the planting materials may probably due to higher LAI and CGR. The lower NAR during the dormant period was mainly on account of $\frac{C}{A}$ delination in the expansion of the leaf surface due to senescence and death of the older leaves. This is suggestive to be due to competition between the 'source' and 'sink' i.e., between the aerial parts and the ~~parts~~ and the underground portion as the later increase in size when expanding leaves export an increasing proportion of substrate to the tubers.

A co-rrrelation studies among values CGR, NAR and DM production (Table 27.) showed a strongly positive values in all the cases. An attempt has been made in this regard to make an understanding in the discussion of the previous part.

The dry matter production in all the treatments varies directly with the size of the planting materials in all the three types. The relative changes in dry matter accumulation during the ontogeny of plants, increases linearly with the increased size of the planting materials. The dry matter accumulation was however noted to be more pronounced as the plant reached advanced stage of maturity. The continuous increase in dry matter production of the plant untill harvest may be accounted for its genetic ability to absorb inorganic and organic materials and to synthesise carbohydrates untill it reaches maturity (Pal,1966). The effect of the size of the planting materials on dry matter production was significantly more pronounced than the types of the planting materials. Among

Table No. 27.

Co-rrrelation among C G R, N A R and D M P under different spacing/planting densities of D.floribunda.

F R C (Plants raised from Crown)

Size of the planting materials.	C G R (gm.day ⁻¹ plant ⁻¹)	NAR(10 ⁻⁴ gm.cm ⁻² day ⁻¹ plant ⁻¹)	DMP (gm.plant ⁻¹)
	* Mean values	* Mean values	* Mean values
	1.	2	3
W ₁	0.315	1.58	68.32
W ₂	0.345	1.77	84.38
W ₃	0.497	2.24	113.78
W ₄	0.540	2.36	127.55
W ₅	0.552	2.50	146.32

$$r(1,3) = 0.9780$$

$$r(2,3) = 0.9906$$

* Pooled mean upto 540 days.

F R M (Plants Raised from Middle)

W ₁	0.219	1.42	50.17
W ₂	0.323	1.61	71.10
W ₃	0.427	1.99	99.93
W ₄	0.485	2.21	116.51
W ₅	0.545	2.34	133.62

$$r(1,3) = 0.9970$$

$$r(2,3) = 0.9960$$

F R T (Plants Raised from Tip).

W ₁	0.282	1.47	57.97
W ₂	0.358	1.66	76.67
W ₃	0.455	1.95	103.90
W ₄	0.492	2.25	108.65
W ₅	0.562	2.39	139.33

$$r(1,3) = 0.9922$$

$$r(2,3) = 0.9674$$

the three types only Crown and Tip plants were noted to response well. The highest DM was found in W_5 and lowest in W_1 (plants raised from 90 gms and 10 gms respectively) among all the types of the planting materials as evident from the higher value of RIGR, OGR and NAR.

Regarding the yield attributes the results shows that the smaller sizes of the planting materials gives the thinner shoots. It was probably due to less number of meristematic zones but the higher number of meristematic zones are in the greater sizes of the planting materials gives the vigorous growth of the shoots. Due to the presence of greater number of meristematic zones in Crown plants the yield per plant was also found higher in Crown plants followed by Tip and Middle plants. This observation is in conformity with the findings of earlier workers like Randhawa et al (1972), Shelvaraj et al (1972), Sharma et al (1985). The highest yield (35.254 MT/ha) has been recorded in W_5 of Crown plants followed by Tip and Middle plants. The increase in yam yield in all the treatments has shown a strong positive co-rrrelation among them (Table 28.).

Among the planting sizes there have been no appreciable variation in diosgenin content. It may probably due to the inherent characters of diosgenin content followed by Middle and Tip portion of the yam of the individual treatment of the plants. This similar observations have also been recorded by Bammi at el (1969), Randhawa et al (1972).

In connection with the yam and diosgenin yield it has been found that the highest yield was obtained in W_5 of Crown plants followed by Tip and Middle plants. The survival percentage was also highest in Crown plants and was probably due to the maximum number of meristematic zones in the planting materials. The same type of observations regarding the yield and survival

Table No. 28.

Co-rrrelation among Dry Vine yeild, Dry Yam yeild and Diosgenin percentage at the final stage of harvesting of D.floribunda.

P R C (Plants Raised from Crown)

Size of the planting materials	<u>Dry Vine yield</u> kg./plant * Mean values 1	<u>Dry Yam yield</u> kg./plant * Mean values. 2	* Diosgenin percentage Mean values 3
W ₁	0.081	0.123	3.563
W ₂	0.104	0.357	3.573
W ₃	0.119	0.457	3.590
W ₄	0.136	0.460	3.590
W	0.142	0.470	3.590
	$r_{(1,2)} = 0.9351$	$r_{(2,3)} = 0.9939$	

* Pooled mean values.

P R M (Plants Raised from Middle)

W ₁	0.076	0.163	3.623
W ₂	0.098	0.308	3.630
W ₃	0.107	0.421	3.646
W ₄	0.113	0.427	3.643
W ₅	0.126	0.426	3.643

$$r_{(1,2)} = 0.9558$$

$$r_{(2,3)} = 1.025$$

P R T (Plants Raised from Tip)

W ₁	0.080	0.165	3.683
W ₂	0.101	0.325	3.696
W ₃	0.109	0.432	3.710
W ₄	0.121	0.436	3.706
W ₅	0.132	0.441	3.710

$$r_{(1,2)} = 0.9344$$

$$r_{(2,3)} = 1.024$$

percentage is in conformity with the findings of Randhawa et al (1972) where the authors claimed that the findings of Crown portion of the tuber contained less sapogenin as compared to median and tip. Considering all the facts it is successively the Crown portion could be used as planting material (40 to 60 gms) having the maximum survival percentage to get the maximum return. Plants raised from the medians and Tips, the actual yield found to be less than the plants raised from Crown portion and the variation was found to be significant. The actual yield in W₃, W₄ & W₅ did not show significant differences among them. The yield in the smaller size of the planting materials became lower as the plants required the maximum time to be established and resulting in less number of meristematic zones. The rate of yam growth was lower in the smaller sizes of the planting materials resulting the lower survival percentage and low yield per hectare.

During estimation of the marginal cost of production for the determination of the optimum size of the planting materials for remunerative harvest of Dioscorea floribunda crop ; it has been found that the maximum magnitude of yam yield was obtained in W₅ (90 gms) of Crown plants followed by the Tip and Middle plants. Earlier investigation by Randhawa et al (1972) suggested that pieces of 40 to 60 gms of D. floribunda yams was noted to be profitable for planting materials economising the cost of cultivation. A perusal of the net profit and loss account has indicated (Table 29.) a considerable higher margin of profit under W₃ (50 gms) of Crown plants and which is in conformity with the observation of ^{Sharma} et al (1985). Though the W₅ planting size gave the maximum yield but the cost of cultivation was

Table No. 29.

Economics of Yam production under different
size of planting materials of D.floribunda.

Type of planting materials	Size of the planting materials	Mean Yam yield (dry) (kg./ha)	Cost of production (Rs./kg.)	Profit(+) or Loss(-) (Rs./kg.)	Net profit or loss per rupee investment. (Rs.)
P R C	W ₁	3,893	17.61	-5.61	-0.32
	W ₂	7,418	9.46	+2.54	+0.26
	W ₃	9,625	7.45	+4.55	+0.61
	W ₄	9,798	7.48	+4.52	+0.60
	W ₅	10,072	7.54	+4.46	+0.59
P R M	W ₁	2,924	23.45	-11.45	-0.48
	W ₂	5,765	12.17	- 0.17	-0.01
	W ₃	8,456	8.48	+ 3.52	+0.41
	W ₄	8,660	8.47	+ 3.53	+0.41
	W ₅	8,667	8.76	+ 3.24	+0.37
P R T	W ₁	2,913	23.53	-11.53	-0.49
	W ₂	6,069	11.56	+ 0.44	+0.04
	W ₃	8,668	8.28	+ 3.72	+0.45
	W ₄	8,861	8.28	+ 3.72	+0.45
	W ₅	9,011	8.43	+ 3.57	+0.42

A.I.A. Price = Rs. 12/- per kg.

found to be higher in comparison to other treatments due to the higher cost of planting materials. The profit per rupee investment under W_3 of PRC has been calculated to be Re.0.61. The profit has higher over the added cost of production for treatments individual. The W_1 (10 gms) of all the types of the planting materials showed the maximum loss due to low yield and higher cost of production as the survival percentage were minimum. Regarding the Middle plants, the same profit was obtained for W_3 and W_4 followed by W_5 . In PRT the maximum net loss has been obtained in W_1 and the lowest profit has obtained in W_2 , whereas, the maximum net profit was obtained in W_3 and W_4 being the same amount (45 paise) per rupee investment. Comparing the three types of the planting materials, W_3 (50 gms) of Crown plants can be suggested to be the best for commercial utilization. But in consideration with the availability of the planting materials, W_3 of Tip portion can be regarded as the best for commercial utilization as obtained in the present investigation. The profit no doubt is subjected to the variation of the fluctuation of prices of the produce and the materials used for the cultivation of this crop.

S U M M A R Y

SUMMARY

The investigation has been carried out to find out the responses of Dioscorea floribunda with special reference to different size of the planting materials (viz., 10 gms, 30 gms, 50 gms, 70 gms and 90 gms) of Crown, Middle and Tip plants.

The results revealed that the highest value of LAI has been recorded in W₅ (90 gms) of Crown plants followed by Tip and Middle plants. The results on RLGR showed significant variation between Crown and Tip plants.

The highest CGR and NAR have been observed in W₅ of Crown plants. The Middle plants showed a significant variation over Crown and Tip plants and the interaction effects resulted a closer relation between Crown and Tip plants.

The effect of the size of the planting materials on dry matter production has been found significantly more pronounced than the types of the planting materials.

Co-rrrelation studies among CGR, NAR and DM Production, it has been found that all the treatments showed strongly positive among themselves.

Regarding the yield of yam and diosgenin, the highest yield has been recorded in W₅ of Crown plants followed by Tip and Middle plants.

Nutrient uptake has been found to be much less in W₁ & W₂ (10 and 30 gms) as compared to W₃ (50 gms), W₄ (70 gms) and W₅ (90 gms).

Regarding the economics, it has been found that W₃ planting size gives the highest profit per rupee investment for Crown plants and found

to be the best for its commercial utilization. But in consideration with the availability of the planting materials, W_3 of the Tip plants and 50 gms pieces of the tip portion were found to be the best for commercial utilization.

P A R T - IV

RESPONSE OF Dioscorea floribunda Mart, & Gall. To
DIFFERENT SPACING FOR COMMERCIAL UTILIZATION

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

INTRODUCTION

The yield responses of a crop to the population change was observed to be approximately linear and the slopes of the curves for the different plant populations were themselves in linear relationship to the plant population per unit area (Baker, 1964).

Different organisation tried with the different planting densities for Dioscorea sp. cultivation in different agroclimatic condition. In India Randhawa et al (1975) tried in I. I. H. R. (Bangalore) with a spacing of 60 cm X 30 cm and 60 cm X 60 cm and found to be optimum for one year and two years of crop of D. floribunda respectively.

To get the remunerative harvest of Dioscorea floribunda, the present investigation has been carried out in the Darjeeling hills with a different spacing condisering the optimum time of planting, size of planting materials and the type of the planting materials and the information out of which will be of much help during commercial utilization of the plant in the region under study.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation designed to study the response of Dioscorea floribunda Mart. & Gall. to different spacing on upland sandy-loam soil of Darjeeling hills, West Bengal. The experiment were carried out at the Research Nursery, Govt. Ipecac Plantation, Gairibas, Darjeeling in the year 1984 to 1986 and repeated the same in the year 1986 to 1988. The soil of the experimental plots were sandy loam type, acidic in reaction (pH 4.6 to 4.8). The average mechanical and chemical constituents of initial soil samples collected from the plots (0-30 cm) as presented as follows :-

<u>Mechanical analysis (%)</u>		<u>Chemical constituents.</u>	
Gravel	: 3.6	Total Nitrogen	: 0.065 - 0.081 (%)
Coarse sand	: 28.7	Available Phosphorus	: 15.78 - 16.53 kg/ha
Fine sand	: 35.1	Available nitrogen	: 0.0096 - 0.0112 (%)
Silt	: 16.5	Available Potassium	: 208.5 - 215.45 kg/ha
Clay	: 16.1	Organic Carbon	: 0.754 - 0.813 (%)
		pH	: 4.6 - 4.8

The experiment were conducted in three separate sets viz., PRC, PRM & PRI as reported as previous experiments. Each of the sets had seven different spacing viz.

S ₁	= 90 cm X 90 cm.	S ₅	= 60 cm X 60 cm
S ₂	= 75 cm X 90 cm.	S ₆	= 45 cm X 60 cm
S ₃	= 75 cm X 75 cm.	S ₇	= 45 cm X 45 cm.
S ₄	= 60 cm X 75 cm.		

F I G U R E 15.

- R E P = Indicates Replication.
- P R C = Represents Plants Raised from Crown portion.
- P R M = Represents Plants Raised from Middle portion.
- P R T = Represents Plants Raised from Tip portion.
- S₁ = Indicates the spacing of 90 cm. X 90 cm.
- S₂ = Indicates the spacing of 75 cm. X 90 cm.
- S₃ = Indicates the spacing of 75 cm. X 75 cm.
- S₄ = Indicates the spacing of 60 cm. X 75 cm.
- S₅ = Indicates the spacing of 60 cm. X 60 cm.
- S₆ = Indicates the spacing of 45 cm. x 60 cm.
- S₇ = Indicates the spacing of 45 cm. X 45 cm.

FIG. 15.

LAYOUT PLAN

RANDOMIZED BLOCK DESIGN

SCALE = 1 mm. = 30 cm.

REP. I REP. II REP. III

S ₁	S ₂	S ₇
S ₄	S ₃	S ₆
S ₂	S ₆	S ₅
S ₅	S ₇	S ₃
S ₃	S ₄	S ₁
S ₆	S ₅	S ₂
S ₇	S ₁	S ₄
S ₄	S ₅	S ₃
S ₆	S ₂	S ₅
S ₂	S ₁	S ₇
S ₇	S ₄	S ₁
S ₁	S ₇	S ₄
S ₃	S ₆	S ₂
S ₅	S ₃	S ₆
S ₆	S ₄	S ₂
S ₃	S ₅	S ₁
S ₂	S ₁	S ₇
S ₅	S ₂	S ₃
S ₄	S ₇	S ₅
S ₇	S ₃	S ₆
S ₁	S ₆	S ₄

PRC

PRM

PRT

← N

GROSS PLOT AREA = 6 m. x 2.1 m.

NET " " = 5.4 m. x 1.5 m.

BORDER BETWEEN PLOTS = 0.45 m.

" " REPLICATION = 0.90 m.

" " EXPERIMENT = 1.2 m.

The experiments were conducted adopting randomized block design with three replications in all the types of spacing. The experimental plots were prepared same as previous experiments described earlier. The experimental layout were as follows :

1. Gross plot size = 6.0 m X 2.1 m
2. Net plot size = 5.4 m X 1.5 m
3. Border between plots = 0.45 m
4. Border between replications = 0.9 m
5. Border of the experimental plot = 1.2. m
6. Replications = 3.

When the field was brought into appropriate tith, lay-out of the plots were taken up according to the layout plan (Fig. 15). For planting Crown, Middle and Tip plant the same procedure was taken as the previous experiments. The plants raised from Crown, Middle and Tip portion of the yams were transplanted in different spacing as prescribed in the experiment under study. The inter culture operation, manure application were applied as previous experiment in a fixed dose. Daily meteorological data were recorded.

Studies on physiological parameters like LAI, RLGR, NAR, CGR and DM were recorded on sample plants under each plot receiving individual treatment in the same as previous experiments.

To find out the yield per plant, the plants were harvested at 720 days after transplanting together with vine yield, moisture percentage and diosgenin content. The periodic accumulation of NPK in plants part were analysed according to the method described by Jackson (1967).

Economics of cost of production was worked out and the optimum spacing was computed for perceptible economic response.

R E S U L T S

RESULTS

Vegetative and physiological parameters : The results on growth and development in respect of physiological parameters under different spacing of Dioscorea floribunda ; have been presented in Table 30.a. to 40 and Fig. 16 to 19.

Leaf Area Index (LAI) : A critical examination of the results on LAI under different spacing have been presented in Table 30.a. to 30.c. and Fig. 16. revealed that the values of LAI in all the three types (PRC, PRM & PRT) increased successively with the advancement of the growth till 180 days during the 1st year growth and thereafter declining trend was noticed, whereas increasing trend again recorded from 360 days and onwards with a declining trend at the end of 2nd year growth.

The successive increments in planting densities from S_1 to S_7 shown corresponding decrease in LAI at all growth stages. The values under S_1 , S_2 , & S_3 , however did not show appreciable difference between them.

It was also seen that the plant has attained the maximum LAI at 480 days of plant growth under PRC, PRM & PRT irrespective of spacings. The highest LAI being 1.294, 1.285 and 1.286 were recorded respectively in S_1 planting density of PRC followed by PRM & PRT.

Relative Leaf Growth Rate (RLGR) : It was evident from the results presented in Table 31.a. to 31.b. that the different spacing or planting densities have appreciable effects on the RLGR at all the phases

FIGURE 16.

- A. Effect of different spacing on Leaf Area Index of D.floribunda.
- B. Effect of different spacing on Crop Growth Rate of D.floribunda.
- C. Effect of different spacing on Net Assimilation Rate of D.floribunda.

Obliquely lined bar represents Plants Raised from Crown portion.

Dotted bar represents Plants Raised from Middle portion.

Empty bar represents Plants Raised from Tip portion.

FIG. 16.

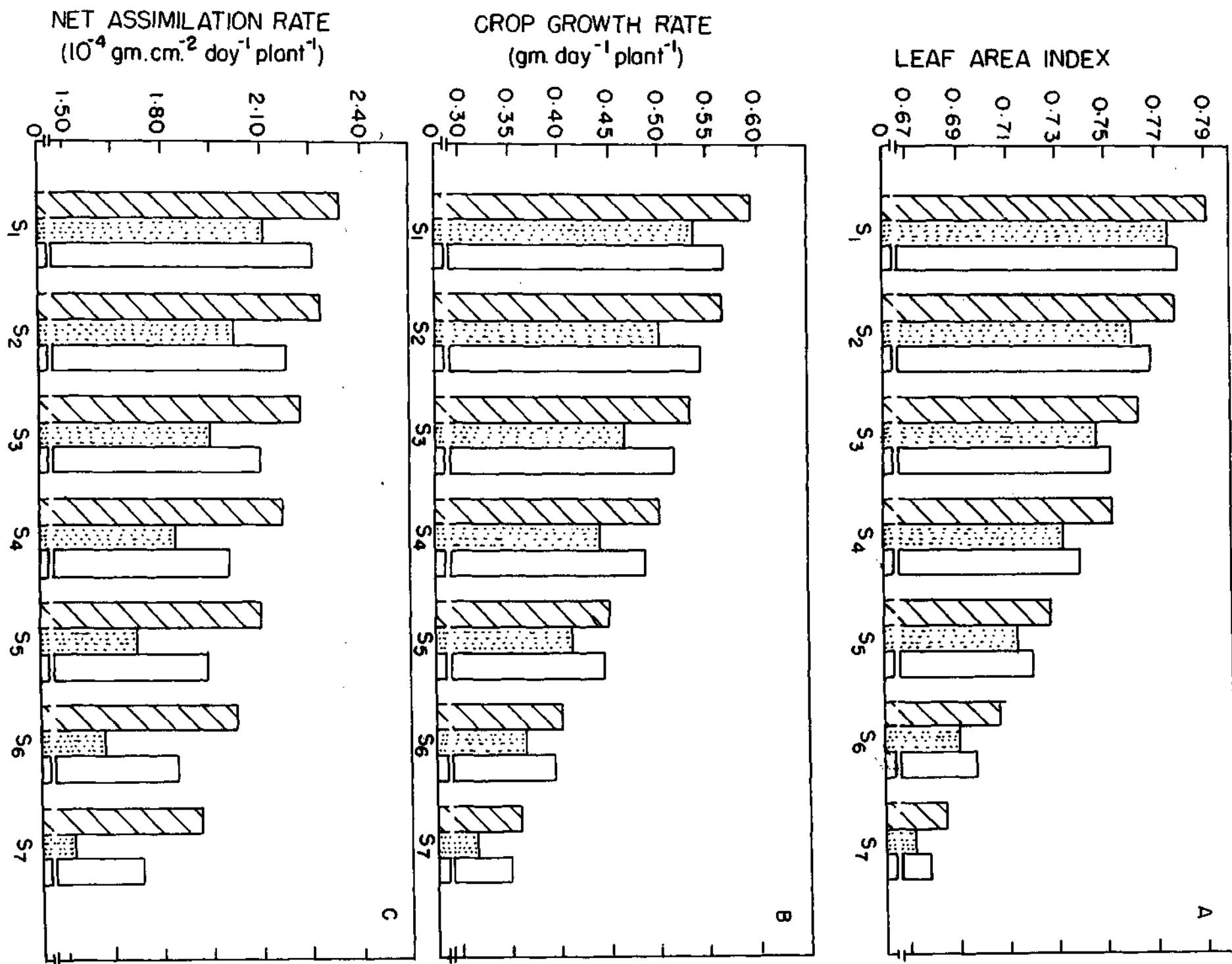


Table No. 30.a.

Effects of the planting densities on Leaf Area Index of D. floribunda.P R C

Planting densities.	Days after planting								Mean
	1st year growth				2nd year growth				
	60	120	180	240	360	420	480	540	
S ₁	0.394	1.281	1.290	0.152	0.485	1.285	1.294	0.161	0.792
S ₂	0.383	1.266	1.278	0.140	0.450	1.270	1.286	0.152	0.778
S ₃	0.370	1.250	1.262	0.123	0.432	1.258	1.273	0.136	0.763
S ₄	0.358	1.242	1.255	0.118	0.408	1.251	1.268	0.128	0.753
S ₅	0.342	1.215	1.227	0.094	0.380	1.226	1.232	0.112	0.728
S ₆	0.325	1.185	1.202	0.075	0.366	1.195	1.216	0.090	0.706
S ₇	0.301	1.169	1.175	0.062	0.340	1.182	1.185	0.071	0.685
Mean	0.353	1.229	1.241	0.109	0.408	1.238	1.250	0.122	0.743
SE \pm	0.012	0.115	0.015	0.012	0.019	0.014	0.015	0.012	0.014

Table No. 30.b.

Effects of the planting densities on Leaf Area Index of D. floribunda.P R M

Planting densities.	<u>Days after planting.</u>								Mean
	<u>1st year growth</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
S ₁	0.357	1.268	1.282	0.138	0.435	1.275	1.285	0.142	0.775
S ₂	0.360	1.251	1.265	0.126	0.422	1.260	1.272	0.135	0.761
S ₃	0.347	1.236	1.248	0.112	0.405	1.245	1.258	0.120	0.746
S ₄	0.338	1.226	1.235	0.095	0.385	1.238	1.246	0.102	0.733
S ₅	0.325	1.208	1.219	0.073	0.362	1.215	1.226	0.088	0.714
S ₆	0.302	1.175	1.185	0.058	0.346	1.188	1.190	0.072	0.689
S ₇	0.281	1.154	1.163	0.043	0.320	1.172	1.181	0.058	0.671
Mean	0.332	1.216	1.228	0.092	0.382	1.227	1.237	0.102	0.727
SE \pm	0.012	0.015	0.016	0.013	0.015	0.014	0.015	0.012	0.014

Table No. 30.c.

Effects of the planting densities on Leaf Area Index of D. floribunda.P R T

Planting densities.	<u>Days after planting.</u>								
	<u>1st year growth.</u>				<u>2nd year growth.</u>				Mean
	60	120	180	240	360	420	480	540	
S ₁	0.380	1.275	1.285	0.144	0.446	1.278	1.286	0.145	0.779
S ₂	0.366	1.260	1.273	0.132	0.434	1.265	1.275	0.140	0.768
S ₃	0.352	1.242	1.254	0.118	0.412	1.249	1.260	0.125	0.751
S ₄	0.346	1.231	1.247	0.100	0.392	1.238	1.249	0.112	0.739
S ₅	0.330	1.214	1.222	0.082	0.370	1.222	1.225	0.095	0.720
S ₆	0.312	1.183	1.190	0.068	0.355	1.199	1.196	0.082	0.697
S ₇	0.292	1.162	1.173	0.055	0.328	1.174	1.178	0.065	0.678
Mean	0.339	1.223	1.235	0.099	0.391	1.231	1.238	0.109	0.733
SE \pm	0.011	0.015	0.016	0.012	0.016	0.014	0.015	0.011	0.014

Table No. 31.a.

Effects of the planting densities on Relative Leaf
Growth Rate ($\text{cm}^2 \text{ day}^{-1} \cdot \text{plant}^{-1}$).

P R C

Planting densities.	Days after planting.							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.038	0.075	0.045	-0.002	0.046	0.078	-0.001	0.039
S ₂	0.037	0.068	0.038	-0.004	0.042	0.072	-0.002	0.036
S ₃	0.035	0.062	0.030	-0.005	0.042	0.069	-0.002	0.033
S ₄	0.032	0.055	0.025	-0.005	0.046	0.062	-0.002	0.030
S ₅	0.028	0.042	0.021	-0.009	0.040	0.055	-0.003	0.025
S ₆	0.025	0.033	0.016	-0.009	0.031	0.046	-0.005	0.019
S ₇	0.022	0.028	0.011	-0.012	0.028	0.039	-0.008	0.015
Mean	0.031	0.051	0.026	-0.006	0.039	0.060	-0.003	0.028
SE _±	0.002	0.006	0.004	0.001	0.002	0.005	0.009	0.003

Table No. 31.b.

Effects of the planting densities on Relative Leaf
Growth Rate ($\text{cm}^2 \text{ day}^{-1} \text{ plant}^{-1}$).

P R M

Planting densities.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.031	0.060	0.031	-0.005	0.032	0.065	-0.003	0.030
S ₂	0.029	0.055	0.026	-0.008	0.032	0.058	-0.006	0.026
S ₃	0.028	0.048	0.015	-0.011	0.030	0.052	-0.008	0.022
S ₄	0.028	0.045	0.008	-0.014	0.028	0.049	-0.009	0.019
S ₅	0.026	0.036	0.005	-0.016	0.027	0.042	-0.012	0.015
S ₆	0.025	0.027	0.004	-0.021	0.027	0.038	-0.014	0.012
S ₇	0.020	0.022	0.001	-0.024	0.027	0.031	-0.018	0.008
Mean	0.026	0.042	0.013	-0.014	0.028	0.047	-0.010	0.018
SE \pm	0.001	0.005	0.004	0.002	0.001	0.004	0.001	0.002

Table No. 31.c.

Effects of the planting densities on Relative Leaf
Growth Rate ($\text{cm}^2 \text{ day}^{-1} \text{ plant}^{-1}$).

P R T.

Planting densities	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.033	0.063	0.036	-0.003	0.036	0.069	-0.002	0.033
S ₂	0.031	0.058	0.030	-0.006	0.038	0.062	-0.004	0.029
S ₃	0.029	0.050	0.022	-0.008	0.033	0.058	-0.005	0.025
S ₄	0.028	0.048	0.018	-0.009	0.032	0.052	-0.008	0.023
S ₅	0.027	0.042	0.012	-0.012	0.030	0.046	-0.009	0.019
S ₆	0.027	0.035	0.009	-0.016	0.029	0.042	-0.009	0.016
S ₇	0.022	0.026	0.003	-0.018	0.027	-0.039	-0.011	0.012
Mean	0.028	0.046	0.018	-0.010	0.032	0.052	-0.006	0.022
SE \pm	0.001	0.004	0.004	0.002	0.001	0.004	0.001	0.002

of ontogeny. It was clearly seen that the rate of leaf growth was considerably decreased with an increase in planting densities. The highest rate of leaf growth, have been recorded under S_1 planting density against the minimum values in S_7 . Amongst all the planting densities S_7 have given the least response in this respect. The values of RLGR, irrespective of treatments have reached the peak at 120-180 days during 1st year growth and at 420-480 days during 2nd year growth and thereafter declined, The negative values of RLGR towards the end of each year growth in all the treatments obviously indicated the initiation of senescence in leaves.

Crop Growth Rate (CGR) : Variation in Crop Growth Rate (CGR) due to different planting densities is evident from the results presented in Table 32.a. to 32.b. and Fig. 16.

Decreasing trend of CGR has been noticed with the increased planting densities from S_1 to S_7 . The maximum CGR have been recorded at 120 to 150 days during 1st year growth and thereafter declined with the advancement of age reaching the minimum values at 180 - 240 days after planting, but again there was the augmentation of CGR during the 2nd year of growth and attained the maximum values at 480 - 540 days after planting. However, the highest CGR being the values $1.235 \text{ gm. day}^{-1} \text{ plant}^{-1}$ (Table 32.a.), $1.035 \text{ gm. day}^{-1} \text{ plant}^{-1}$ (Table 32.b.) and $1.068 \text{ gm. day}^{-1} \text{ plant}^{-1}$ (Table 32.c.) have been recorded under S_1 treatment of PRC, PRM & PRT respectively. CGR recorded minimum in S_7 planting density in all the three types of planting materials.

Table No. 32.a.

Effects of planting densities on Crop Growth Rate

 $(\text{gm. day}^{-1} \text{ plant}^{-1})$ P R C

Planting densities.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.290	0.576	0.268	0.285	0.730	0.868	1.135	0.593
S ₂	0.270	0.533	0.225	0.249	0.716	0.846	1.108	0.564
S ₃	0.251	0.460	0.233	0.235	0.630	0.833	1.085	0.532
S ₄	0.235	0.360	0.225	0.233	0.580	0.801	1.065	0.499
S ₅	0.210	0.305	0.195	0.188	0.533	0.725	1.003	0.451
S ₆	0.170	0.250	0.163	0.155	0.505	0.658	0.926	0.403
S ₇	0.118	0.186	0.145	0.128	0.461	0.623	0.861	0.360
Mean	0.220	0.381	0.207	0.210	0.593	0.765	1.026	0.486
SE [†]	0.022	0.055	0.016	0.021	0.039	0.036	0.038	0.032

Table No. 32.b.

Effects of planting densities on Crop Growth Rate
(gm.day⁻¹ plant⁻¹).

P R M

Planting densities.	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.266	0.420	0.240	0.297	0.671	0.830	1.035	0.537
S ₂	0.240	0.383	0.210	0.248	0.665	0.743	1.008	0.499
S ₃	0.211	0.361	0.235	0.240	0.576	0.698	0.936	0.465
S ₄	0.201	0.341	0.226	0.201	0.566	0.628	0.920	0.440
S ₅	0.175	0.331	0.171	0.173	0.540	0.626	0.876	0.413
S ₆	0.118	0.290	0.165	0.155	0.473	0.535	0.820	0.365
S ₇	0.083	0.191	0.143	0.101	0.461	0.505	0.720	0.314
Mean	0.184	0.331	0.198	0.202	0.564	0.652	0.902	0.433
SE ±	0.024	0.028	0.014	0.024	0.031	0.043	0.041	0.029

Table No. 32.c.

Effects of planting densities on Crop Growth Rate

(gm. day⁻¹ plant⁻¹).P R T

Planting densities	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	0.276	0.500	0.251	0.280	0.733	0.870	1.068	0.568
S ₂	0.256	0.485	0.245	0.265	0.686	0.835	1.050	0.546
S ₃	0.241	0.413	0.210	0.256	0.638	0.805	1.046	0.515
S ₄	0.238	0.361	0.208	0.218	0.556	0.793	1.041	0.488
S ₅	0.180	0.311	0.205	0.190	0.535	0.696	0.996	0.444
S ₆	0.155	0.260	0.175	0.154	0.505	0.630	0.881	0.394
S ₇	0.126	0.190	0.138	0.124	0.450	0.573	0.831	0.347
Mean	0.210	0.360	0.204	0.212	0.600	0.743	0.987	0.472
SE ±	0.021	0.043	0.014	0.022	0.039	0.042	0.035	0.030

Net Assimilation Rate (NAR) : Variation in different spacing/plant-

ing densities has caused significant difference in NAR (Table 33.a. to 33c.).

The highest NAR has been recorded during the 2nd year growth between 420-480 days. NAR declined sharply at the end of each year growth. The same trend has been observed in PRC, PRM & PRT. It has also noted that with the increase in planting densities (S_1 to S_7) there were corresponding decrease in NAR values.

The highest NAR being the values $3.72 \times 10^{-4} \text{ gm. cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$, $3.52 \times 10^{-4} \text{ gm. cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$ and $3.68 \times 10^{-4} \text{ gm. cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1}$. in S_1 of PRC, PRM & PRT have been attained at 420 - 480 days after planting. The net assimilation rate declined with the advancement of growth reaching the minimum values at the end of each year growth.

Dry Matter Production (DM) : The data on dry matter production in

gm. per plant under different planting densities have been presented in Table 34.a. to 34.c.

The data revealed that there were corresponding decrease in dry matter production with the increase in planting densities in all the three types (PRC, PRM & PRT) ; however, increased in DM irrespective of the treatments with the advancement of growth. The rate of dry matter production has taken a momentum from 360 days and onwards.

In general, it has been observed that the rate of total dry matter production in plants at the very early period of growth was less but with the age the plants have shown increased accumulation of dry matter with the highest values at harvest. In all the three types S_1 planting density gives the highest dry matter at 540 days against the lowest in S_7 . The same trend was observed in PRC, PRM, & PRT.

FIGURE 17.

Inter-relationship among Leaf Area Index, Net Assimilation Rate and
Dry matter Production under different spacing of D.floribunda.

P R C = Represents Plants Raised from Crown Portion.

P R M = Represents Plants Raised from Middle Portion.

P R T = Represents Plants Raised from Tip Portion.

Solid Circles represents Dry matters production (DM).

Hollow Circles represents Leaf Area Index (LAI).

Hollow Traingles represents Net Assimilation Rate (NAR).

FIG. 17.

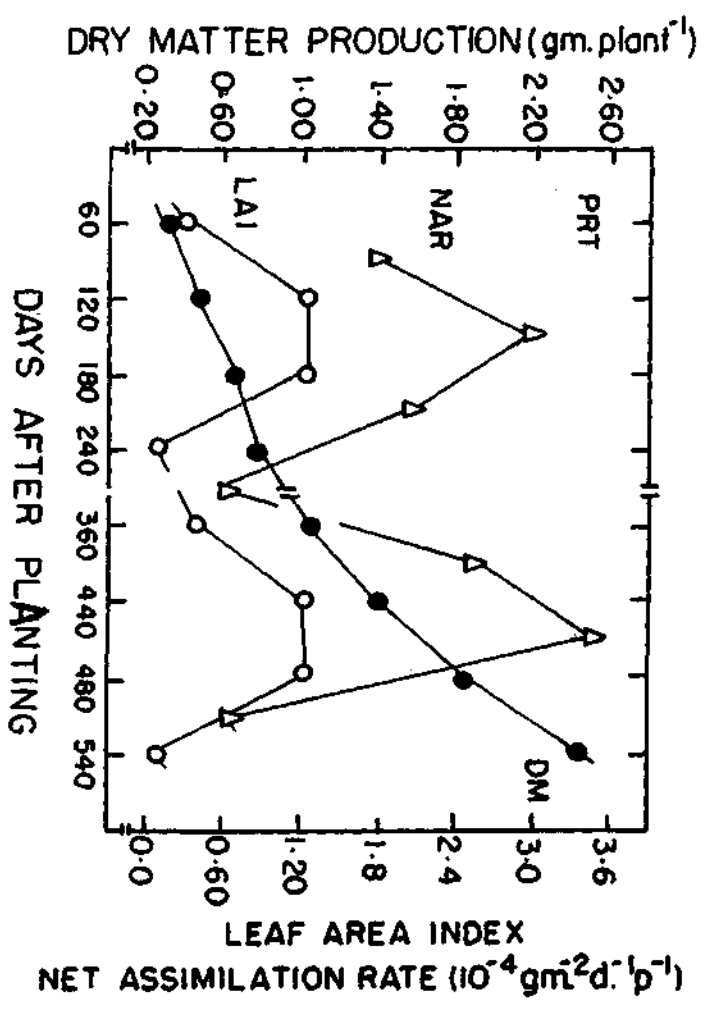
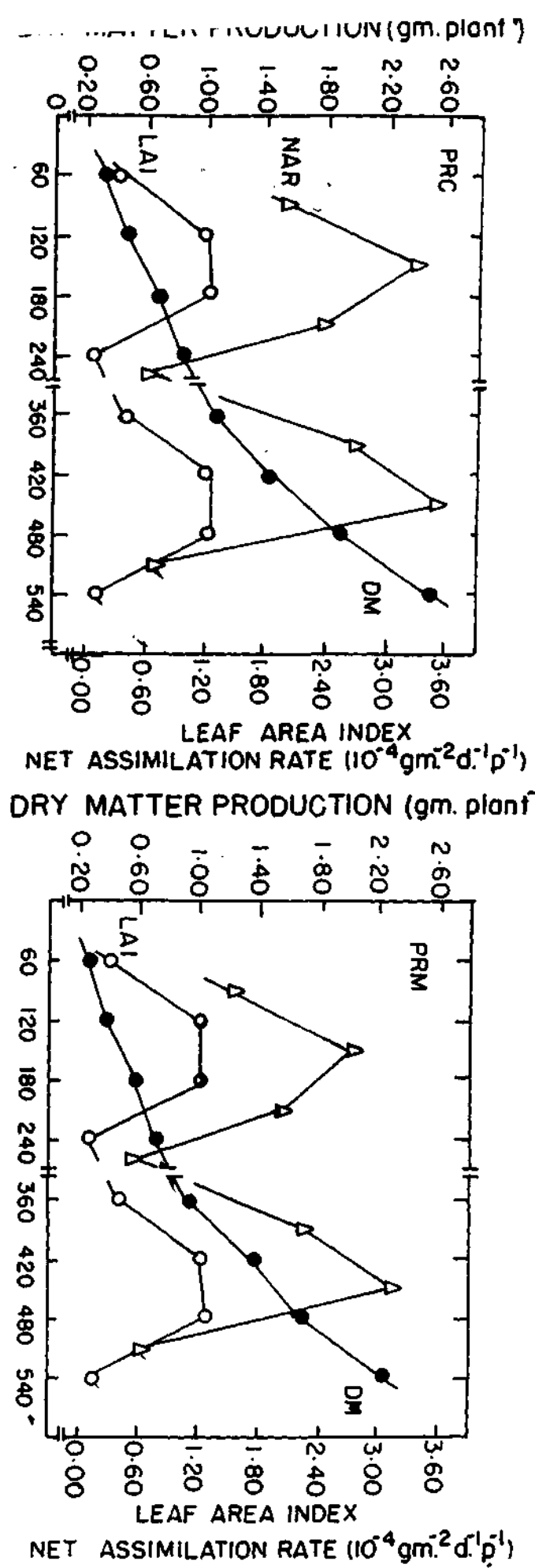


Table No. 33.a.

effects of planting densities on Net Assimilation Rate
 (10^{-4} gm.cm⁻² day⁻¹ plant⁻¹) of D. floribunda.

P R C

Planting densities	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	2.20	3.46	2.48	0.82	2.85	3.72	0.86	2.34
S ₂	2.21	3.42	2.44	0.75	2.80	3.65	0.80	2.29
S ₃	2.05	3.35	2.43	0.67	2.73	3.57	0.77	2.22
S ₄	1.95	3.30	2.41	0.62	2.66	3.51	0.73	2.17
S ₅	1.88	3.21	2.37	0.55	2.61	3.45	0.67	2.10
S ₆	1.80	3.10	2.28	0.47	2.54	3.36	0.58	2.02
S ₇	1.72	3.01	2.19	0.42	2.46	3.24	0.51	1.93
Mean	1.97	3.26	2.37	0.614	2.66	3.50	0.70	2.15
SE ±	0.071	0.062	0.038	0.054	0.052	0.062	0.047	0.055

Table No. 33.b.

Effects of planting densities on Net Assimilation Rate

 $(10^{-4} \text{ gm. cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1})$ of D. floribunda.P R M

Planting densities	<u>Days after planting.</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	1.85	3.05	2.31	0.73	2.62	3.52	0.76	2.12
S ₂	1.72	2.92	2.20	0.68	2.52	3.41	0.73	2.02
S ₃	1.61	2.85	2.10	0.62	2.40	3.33	0.68	1.94
S ₄	1.52	2.77	2.05	0.55	2.21	3.18	0.60	1.84
S ₅	1.40	2.73	1.92	0.49	2.06	2.95	0.54	1.72
S ₆	1.28	2.65	1.81	0.42	1.95	2.80	0.48	1.62
S ₇	1.19	2.56	1.68	0.36	1.80	2.72	0.43	1.53
Mean	1.51	2.79	2.01	0.55	2.22	3.13	0.60	1.82
SE ±	0.089	0.062	0.083	0.051	0.115	0.117	0.047	0.081

Table No. 33.c.

Effects of planting densities on Net Assimilation Rate

 $(10^{-4} \text{ gm. cm}^{-2} \text{ day}^{-1} \text{ plant}^{-1})$ D. floribunda.P R T

Planting densities	<u>Days after planting</u>							Mean
	60-120	120-180	180-240	240-360	360-420	420-480	480-540	
S ₁	2.05	3.32	2.40	0.78	2.78	3.68	0.82	2.26
S ₂	1.96	3.20	2.34	0.72	2.70	3.62	0.76	2.18
S ₃	1.88	3.08	2.25	0.65	2.61	3.55	0.70	2.10
S ₄	1.80	2.95	2.14	0.60	2.50	3.48	0.66	2.01
S ₅	1.71	2.86	2.05	0.54	2.41	3.39	0.62	1.94
S ₆	1.66	2.80	1.95	0.43	2.33	3.28	0.54	1.85
S ₇	1.52	2.71	1.88	0.38	2.20	3.05	0.48	1.74
Mean	1.79	2.99	2.14	0.58	2.50	3.43	0.654	2.01
SE \pm	0.069	0.083	0.074	0.055	0.078	0.082	0.045	0.069

Table No. 34.a.

Dry matter production (gm. plant⁻¹) of D. floribunda
in respect of different planting densities.

P R C

Planting densities	<u>Days after planting</u>								Mean
	<u>1st year growth</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
S ₁	38.2	55.6	90.2	106.3	140.6	184.4	236.5	304.6	144.55
S ₂	37.9	53.1	85.1	98.6	128.5	171.5	222.3	288.8	135.72
S ₃	37.5	52.6	80.2	94.2	122.4	160.2	210.4	275.5	129.12
S ₄	36.4	50.5	72.1	85.6	113.6	148.4	196.5	260.4	120.43
S ₅	33.6	46.2	64.5	76.2	98.7	130.7	174.2	234.4	107.31
S ₆	31.4	41.6	56.6	66.4	86.1	116.4	155.9	211.5	35.73
S ₇	28.1	35.2	46.4	55.1	70.5	98.2	135.6	187.3	82.05
Mean	34.73	47.82	70.72	83.20	108.62	144.25	190.20	251.78	116.41
SE ±	1.454	2.756	5.990	6.932	9.375	11.656	13.832	16.095	8.498

Table No. 34.b.

Dry matter production (gm. plant⁻¹) of D. floribunda
in respect of different planting densities.

P R M

Planting densities	<u>Days after planting.</u>								Mean
	<u>1st year growth</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
S ₁	31.2	47.2	72.4	86.8	118.5	158.8	203.6	270.7	124.27
S ₂	30.4	44.8	67.8	80.4	110.2	150.1	194.7	255.2	116.70
S ₃	29.8	42.5	65.2	79.3	108.0	142.6	184.5	240.7	111.57
S ₄	28.3	40.4	60.5	74.1	98.5	132.5	170.2	225.4	103.73
S ₅	26.7	37.2	57.1	67.4	88.2	120.6	158.2	210.8	95.77
S ₆	25.5	32.6	50.0	59.8	78.5	106.9	139.0	188.2	85.06
S ₇	25.1	30.1	41.6	50.2	62.4	90.1	120.4	163.6	72.93
Mean	28.14	39.25	59.23	71.14	94.90	136.47	167.94	222.08	101.43
SE ±	0.919	2.380	4.037	4.848	7.469	9.427	11.793	14.237	6.857

Table No. 34.c.

Dry matter production (gm. plant⁻¹) of D. floribunda
in respect of different planting densities.

P R T

Planting densities	<u>Days after planting.</u>								Mean
	<u>1st year growth</u>				<u>2nd year growth</u>				
	60	120	180	240	360	420	480	540	
S ₁	36.8	53.4	83.4	98.5	132.2	176.3	228.5	292.6	137.71
S ₂	35.6	51.0	80.1	94.8	126.7	167.9	218.0	281.0	131.88
S ₃	34.1	48.6	73.4	86.0	116.8	155.1	203.4	266.2	122.95
S ₄	32.5	46.8	68.5	81.0	107.2	140.6	188.2	250.7	114.43
S ₅	31.7	42.5	61.2	73.5	96.4	128.5	170.3	230.1	104.27
S ₆	29.4	38.7	54.3	64.8	83.3	113.6	151.4	204.3	92.47
S ₇	27.0	34.6	46.0	54.3	69.2	96.2	130.6	180.5	79.80
Mean	32.44	45.08	66.70	78.98	104.54	139.74	184.34	243.63	111.93
SE ±	1.301	2.567	5.162	6.025	8.701	10.989	13.479	15.483	7.958

YIELD ATTRIBUTES

Yam yield : Variation in yam yield kg. per plant under different spacing have been presented in Table 35.a. to 35.c and Fig. 18.

It has been clearly evident from the Table 35.a. to 35.c. and Fig.18. that the yam yield decreased correspondingly with the increase of planting densities from S_1 to S_7 in PRC, PRM & PRT. The highest yield per plant recorded in S_1 of PRC being the value 1.886 kg. (fresh). The S_1 , S_2 & S_3 treatment only varies significantly with the other treatments but S_5 , S_6 & S_7 treatment does not varies significantly with each other. However the S_4 planting density showed significant difference with the other planting densities. The lowest yield found in S_7 planting density of PRC.

The similar trend also observed in PRM & PRT (Table 35.b. & 35.c.) where the highest fresh yam yield were also recorded in S_1 treatment being the values 1.795 kg/plant and 1.842 kg. per plant respectively.

It had been found that the S_1 spacing of PRC and PRT (Table 35.a. & 35.c.) were the best for attaining the highest yam yield per plant basis.

Dry Vine yield : The data presented in the Table 35.a. to 35.c. & Fig. 18 revealed that the dry vine yield in kg./plant also decreased correspondingly with the increase in planting densities from S_1 to S_7 both in PRC, PRM & PRT. It was also evident from the data (Table 35.a.) that the vine yield increased with the decrease in planting density. The highest dry vine yield correspondingly gives highest yam yield in minimum planting population per unit area.

F I G U R E 18.

Effects of planting densities on 'yam' yield and dry vine yield (Kg/Plant)
at the final stage of harvesting (720 days) of
D. floribunda.

Obliquely lined bar represents Plants Raised from Crown portion.

Dotted bar represents Plants Raised from Middle portion.

Empty bar represents Plants Raised from Tip portion.

FIG. 18:

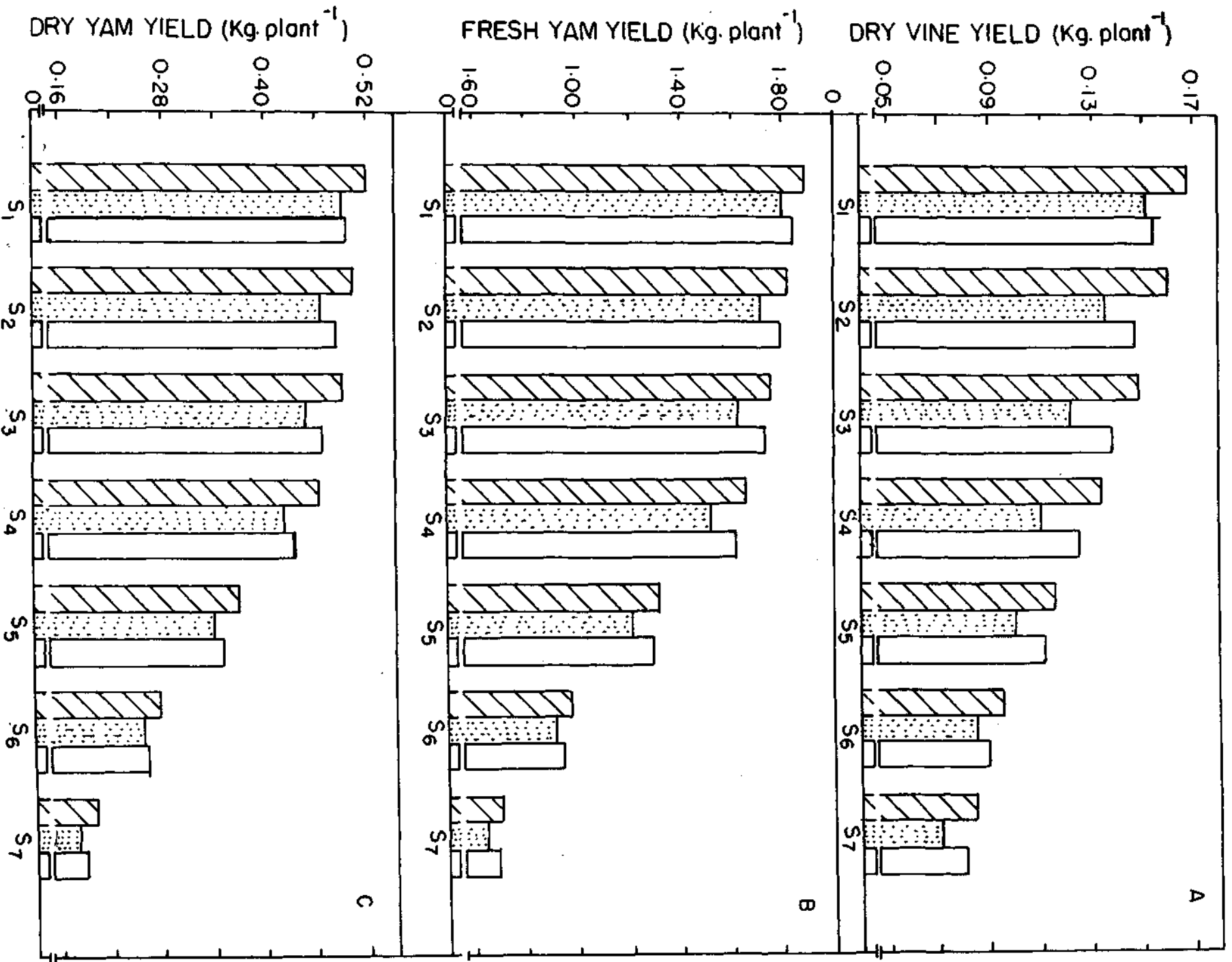


Table No. 35.a.

Effects of planting densities on "Yam" yield and dry Vine
yield (kg./plant) at the final stage of harvesting (720 days).

P R C.

Planting densities.	Dry vine yield (kg./plant).	Yam yield (kg./plant)		Percentage of moisture.
		Fresh	Dry	
S ₁	0.168	1.886	0.518	72.5
S ₂	0.160	1.825	0.503	72.4
S ₃	0.148	1.758	0.490	72.1
S ₄	0.134	1.656	0.463	72.0
S ₅	0.116	1.320	0.370	71.9
S ₆	0.096	0.980	0.276	71.8
S ₇	0.085	0.705	0.201	71.4
Mean	0.129	1.447	0.403	72.01
SE †	0.012	0.173	0.047	0.14

Table No. 35.b.

Effects of planting densities on "Yam" yield and dry vine yield (kg./plant) at the final stage of harvesting (720 days).

P R M

Planting densities.	Dry vine yield	Yam yield (kg./plant)		Percentage of moisture.
		Fresh	Dry	
S ₁	0.151	1.795	0.488	72.8
S ₂	0.135	1.714	0.468	72.7
S ₃	0.122	1.630	0.448	72.5
S ₄	0.110	1.525	0.421	72.3
S ₅	0.100	1.220	0.340	72.1
S ₆	0.085	0.920	0.257	72.0
S ₇	0.071	0.646	0.182	71.8
Mean	0.110	1.350	0.372	72.31
SE \pm	0.010	0.164	0.044	0.140

Table No. 35.c.

Effects of planting densities on "Yam" yield and dry vine yield (kg./plant) at the final stage of harvesting (720 days).

P R T

Planting densities	Dry vine yield (kg./plant)	Yam yield (kg./plant)		Percentage of moisture.
		Fresh	Dry	
S ₁	0.154	1.842	0.493	73.2
S ₂	0.147	1.796	0.484	73.0
S ₃	0.138	1.735	0.468	73.0
S ₄	0.125	1.610	0.436	72.9
S ₅	0.112	1.300	0.353	72.8
S ₆	0.090	0.951	0.258	72.8
S ₇	0.081	0.694	0.189	72.7
Mean	0.121	1.418	0.397	72.91
St ±	0.010	0.170	0.036	0.063

Diosgenin percentage : Variation in diosgenin percentage (dry weight basis) of individual spacing treatment have been presented in the Table 36.

The data revealed that the none of the spacing treatment showed remarkable variation in the diosgenin content, but varies significantly in diosgenin content in PRC, PRM & PRT. The highest diosgenin content recorded in PRT followed by PRM & PRC. The diosgenin percentage was measured in an individual treatment on an average and found minimum 3.32 % (Table 36.) in Crown of PRC and the maximum was 3.84 % in Tip portion of PRT.

Comparing all the spacing treatments and the types of planting materials, the diosgenin content found maximum in the Tip portion.

Yam yield and diosgenin yield per hectare : Analysis of yield data per hectare basis have been presented in Table 37.a. to 37.c. Fig. 19. under different spacing showed significant variations among themselves.

In PRC, the maximum potential yield both in fresh & dry yam yield and diosgenin yield were found in S_4 planting densities having the values 36.799 MT/ha (fresh) and 0.3683 MT/ha (dry weight basis) respectively. Considering the survival percentage (97.1 %) in S_4 of PRC, the actual yield in yam and diosgenin was recorded 35.732 MT/ha(fresh) and 0.3576 MT/ha (dry weight basis) respectively. With the increase in planting densities the yam yield also increased upto S_4 treatments but decreased from S_5 to S_7 of PRC.

The similar trend also observed in PRM & PRT. Comparing the three types (PRC, PRM & PRT), the highest yield observed in S_4 of PRC followed by PRT & PRM.

Table No. 36.

Variation in Diosgenin percentage (dry wt. basis)
under different planting densities.

Type of planting materials	Planting densities	% of Diosgenin			Mean
		Crown	Middle	Tip	
F R G	S ₁	3.36	3.62	3.75	3.576
	S ₂	3.37	3.62	3.74	3.576
	S ₃	3.37	3.62	3.75	3.580
	S ₄	3.36	3.63	3.75	3.580
	S ₅	3.35	3.63	3.76	3.580
	S ₆	3.32	3.61	3.73	3.553
	S ₇	3.32	3.61	3.72	3.550
	Mean	3.35	3.62	3.94	3.570
SE ±	0.008	0.003	0.005	0.005	
P R M	S ₁	3.45	3.68	3.77	3.633
	S ₂	3.43	3.68	3.77	3.626
	S ₃	3.45	3.67	3.77	3.630
	S ₄	3.46	3.69	3.78	3.643
	S ₅	3.44	3.68	3.76	3.626
	S ₆	3.44	3.69	3.77	3.633
	S ₇	3.42	3.67	3.78	3.623
	Mean	3.44	3.68	3.77	3.630
SE ±	0.005	0.003	0.002	0.002	
F R T	S ₁	3.54	3.75	3.83	3.706
	S ₂	3.55	3.75	3.83	3.710
	S ₃	3.55	3.74	3.83	3.706
	S ₄	3.56	3.76	3.84	3.720
	S ₅	3.53	3.75	3.82	3.700
	S ₆	3.55	3.76	3.83	3.713
	S ₇	3.54	3.74	3.82	3.700
	Mean	3.545	3.75	3.82	3.707
SE ±	0.003	0.003	0.002	0.002	

F I G U R E 19.

Effects of Planting densities on the production of 'yam' (fresh and dry)
and diosgenin yield (MT/ha) of D. floribunda.

Filled bar represents the actual yield.

Empty bar represents the potential yield.

Obliquely lined bar represents Plants Raised from Crown portion.

Dotted bar represents Plants Raised from Middle portion.

Solid bar represents Plants Raised from Tip portion.

FIG. 19.

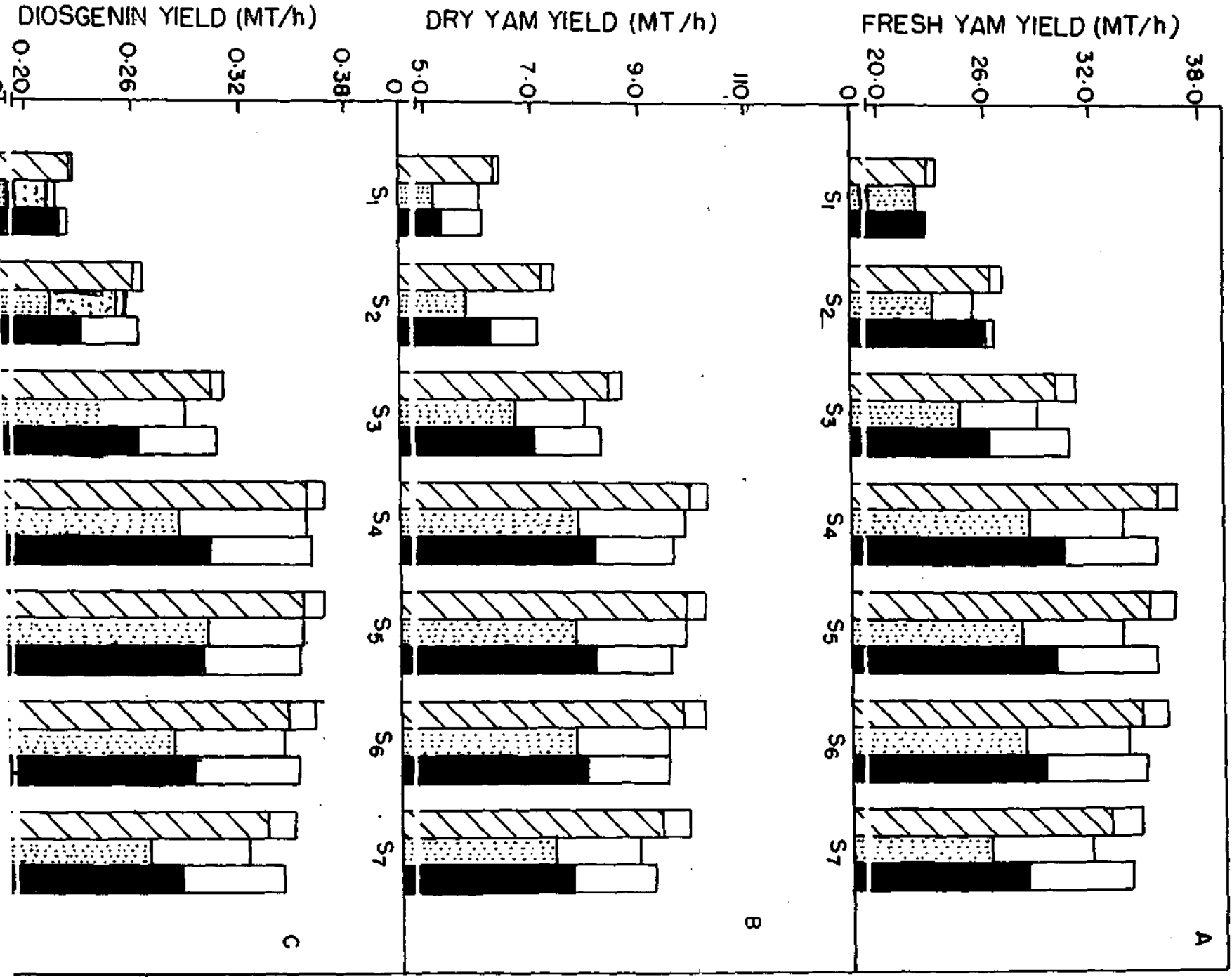


Table No. 37.a.

Effects of planting densities on the production of "Yam"
(fresh and dry) and Diosgenin yield (MT/ha.).

P R C

Planting densities.	Potential yield			Actual yield			
	Yam yield (MT/ha.)		Diosgenin yield (MT/ha.)	Yam yield (MT/ha)		Diosgenin yield (MT/ha)	% of Survival
	Fresh	Dry		Fresh	Dry		
S ₁	23.282	6.394	0.2286	22.910	6.292	0.2250	98.4
S ₂	27.035	7.451	0.2664	26.548	7.317	0.2616	98.2
S ₃	31.280	8.718	0.3121	30.404	8.474	0.3033	97.2
S ₄	36.799	10.288	0.3683	35.732	9.990	0.3576	97.1
S ₅	36.665	10.277	0.3679	35.382	9.917	0.3550	96.5
S ₆	36.296	10.222	0.3631	34.844	9.813	0.3486	96.0
S ₇	34.814	9.925	0.3523	33.178	9.459	0.3357	95.3
Mean	32.310	9.039	0.3226	31.285	8.751	0.3124	96.95
SE ±	2.021	0.595	0.0211	1.865	0.549	0.019	0.424

Table No. 37.b.

Effects of planting densities on the production of "Yam"
(Fresh and dry) and Diosgenin yield (MT/ha.).

P R M

Planting densities.	Potential yield			Actual yield			
	Yam yield (MT/ha.)		Diosgenin yield (MT/ha.)	Yam yield (MT/ha.)		Diosgenin yield (MT/ha.)	% of Survival
	Fresh	Dry		Fresh	Dry		
S ₁	22.159	6.024	0.2188	18.990	5.162	0.1875	85.7
S ₂	25.391	6.934	0.2514	21.580	5.893	0.2136	85.0
S ₃	29.002	7.971	0.2893	24.536	6.743	0.2447	84.6
S ₄	33.888	9.865	0.3588	28.500	7.868	0.2866	84.1
S ₅	33.887	9.860	0.3575	28.194	7.857	0.2849	83.2
S ₆	34.074	9.518	0.3457	28.281	7.800	0.2833	83.0
S ₇	31.900	8.987	0.3256	26.350	7.423	0.2689	82.6
Mean	30.043	8.451	0.3067	25.204	6.963	0.2527	84.02
SE ±	1.787	0.573	0.0208	1.404	0.407	0.0148	0.432

Table No. 37.c.

Effects of planting densities on the production of "Yam"
(Fresh and dry) and Diosgenin yield (MT/ha.)

F R T

Planting densities	Potential yield.			Actual yield			
	Yam yield (MT / ha.)		Diosgenin yield (MT/ha)	Yam yield (MT/ha.)		Diosgenin yield (MT/ha.)	% of Survival
	Fresh	Dry		fresh	Dry		
S ₁	22.739	6.086	0.2255	19.827	5.306	0.1966	87.2
S ₂	26.606	7.169	0.2659	23.040	6.209	0.2303	86.6
S ₃	30.371	8.327	0.3086	26.302	7.094	0.2629	85.2
S ₄	35.776	9.688	0.3604	30.411	8.235	0.3063	85.0
S ₅	35.710	9.605	0.3553	30.188	8.197	0.3032	83.6
S ₆	35.222	9.555	0.3547	29.375	7.969	0.2958	83.4
S ₇	34.271	9.333	0.3453	28.445	7.746	0.2866	83.0
Mean	31.599	8.537	0.3165	26.798	7.251	0.2688	84.85
SE ±	1.943	0.535	0.0198	1.518	0.423	0.0157	0.613

NUTRIENT ACCUMULATION

Nitrogen accumulation : A perusal of data in Table 38 revealed that the accumulation of Nitrogen in all the treatments of PRC, PRM & PRT decreased correspondingly with the increase of planting densities from S_1 to S_7 and in each year of growth. A declining trend observed at final stage of harvesting. The minimum nitrogen accumulation observed in S_7 and maximum in S_1 of both PRC, PRM & PRT.

Phosphorus accumulation : It has been revealed from the data presented in Table 39. that there was a trend towards the increase in phosphorus content of whole plant with the decrease in planting densities during the 2nd year growth. Notwithstanding that there has been considerable fall in phosphorus accumulation at the final stage of harvesting. The same trend was observed in PRC, PRM & PRT. However, there was no significant difference with PRG & PRT but PRM have significant difference with PRC & PRT.

Potassium accumulation : The data revealed that from the Table 40. that the potassium accumulation increased with the advancement of growth but declining trend was noticed during the end of 2nd year growth and found significant difference in potassium accumulation. With the decrease in planting densities correspondingly decreased in potassium accumulation in all the three types - PRC, PRM and PRT. The highest value have been recorded in S_1 planting density in each type whereas lowest values have been observed in S_7 planting density.

Table No. 38.

Nitrogen Accumulation (in %) in whole plant in different stages of growth under different planting densities.

Type of planting materials.	Planting densities	Successive stages of growth			Mean.
		1st year growth	2nd year growth	Final stage of harvesting.	
P R C	S ₁	1.768	1.964	1.495	1.742
	S ₂	1.724	1.935	1.452	1.703
	S ₃	1.683	1.902	1.408	1.664
	S ₄	1.638	1.825	1.396	1.619
	S ₅	1.569	1.738	1.352	1.553
	S ₆	1.405	1.632	1.321	1.452
	S ₇	1.387	1.504	1.300	1.397
	Mean	1.596	1.769	1.389	1.590
	SE \pm	0.057	0.059	0.026	0.048
P R M	S ₁	1.720	1.782	1.368	1.623
	S ₂	1.692	1.755	1.350	1.599
	S ₃	1.583	1.698	1.289	1.523
	S ₄	1.504	1.675	1.222	1.467
	S ₅	1.492	1.582	1.175	1.416
	S ₆	1.366	1.437	1.150	1.317
	S ₇	1.237	1.396	1.118	1.250
	Mean	1.513	1.618	1.238	1.456
	SE \pm	0.065	0.057	0.037	0.052
P R T	S ₁	1.725	1.802	1.385	1.637
	S ₂	1.681	1.783	1.360	1.608
	S ₃	1.633	1.742	1.316	1.563
	S ₄	1.598	1.690	1.289	1.525
	S ₅	1.524	1.637	1.252	1.471
	S ₆	1.380	1.592	1.205	1.392
	S ₇	1.300	1.450	1.182	1.311
	Mean	1.550	1.671	1.284	1.501
	SE \pm	0.060	0.046	0.028	0.044

Table No. 39.

Phosphorus Accumulation (in %) in whole plant in different stages of growth under different planting densities.

Type of planting materials.	Planting densities	Successive stages of growth			Mean
		1st year growth	2nd year growth	Final stage of harvesting.	
P R C	S ₁	0.155	0.179	0.145	0.159
	S ₂	0.149	0.166	0.142	0.152
	S ₃	0.142	0.153	0.137	0.144
	S ₄	0.131	0.145	0.136	0.139
	S ₅	0.129	0.140	0.133	0.134
	S ₆	0.125	0.137	0.128	0.130
	S ₇	0.112	0.132	0.120	0.121
	Mean	0.135	0.150	0.134	0.139
SE ±	0.005	0.006	0.003	0.004	
P R E	S ₁	0.151	0.152	0.143	0.148
	S ₂	0.145	0.149	0.140	0.144
	S ₃	0.140	0.145	0.134	0.139
	S ₄	0.128	0.140	0.135	0.134
	S ₅	0.125	0.138	0.132	0.131
	S ₆	0.122	0.133	0.125	0.126
	S ₇	0.109	0.130	0.118	0.119
	Mean	0.131	0.141	0.132	0.134
SE ±	0.005	0.003	0.003	0.003	
P R T	S ₁	0.143	0.162	0.142	0.120
	S ₂	0.142	0.155	0.138	0.126
	S ₃	0.140	0.148	0.135	0.133
	S ₄	0.127	0.144	0.136	0.135
	S ₅	0.126	0.139	0.134	0.141
	S ₆	0.120	0.135	0.124	0.145
	S ₇	0.110	0.130	0.121	0.149
	Mean	0.129	0.144	0.133	0.135
SE ±	0.004	0.004	0.002	0.003	

Table No. 40.

Potassium Accumulation (in %) in whole plant in different stages of growth under different planting densities.

Type of planting materials.	Planting densities	Successive stages of growth			Mean
		1st year growth	2nd year growth	Final stage of harvesting.	
F R C	S ₁	3.270	4.680	3.572	3.840
	S ₂	3.263	4.673	3.569	3.835
	S ₃	3.251	4.651	3.565	3.822
	S ₄	3.240	4.646	3.523	3.803
	S ₅	3.235	4.635	3.500	3.790
	S ₆	3.142	4.603	3.475	3.740
	S ₇	3.027	4.625	3.461	3.704
	Mean	3.204	4.644	3.523	3.790
	SE ±	0.033	0.010	0.017	0.019
F R H	S ₁	3.267	4.672	3.534	3.824
	S ₂	3.254	4.661	3.528	3.814
	S ₃	3.242	4.642	3.506	3.796
	S ₄	3.233	4.631	3.495	3.786
	S ₅	3.227	4.625	3.470	3.774
	S ₆	3.135	4.608	3.447	3.730
	S ₇	3.018	4.601	3.435	3.684
	Mean	3.196	4.634	3.487	3.772
	SE ±	0.034	0.009	0.014	0.018
F R T	S ₁	3.264	4.702	3.569	3.845
	S ₂	3.258	4.668	3.561	3.829
	S ₃	3.249	4.649	3.550	3.816
	S ₄	3.237	4.637	3.518	3.797
	S ₅	3.221	4.621	3.492	3.778
	S ₆	3.140	4.610	3.451	3.733
	S ₇	3.022	4.602	3.433	3.685
	Mean	3.198	4.641	3.510	3.783
	SE ±	0.018	0.013	0.020	0.021

DISCUSSION

DISCUSSION

In respect to the responses of Dioscorea floribunda Mart. & Gal. to different spacing for commercial utilization, the results revealed that the successive increments in planting densities from S_1 to S_7 showed corresponding decrease in LAI at all the growth stages. The highest LAI value was recorded in S_1 (90 cm X 90 cm) spacing of Crown plants followed by Tip and Middle plants. It has been observed that closer planting from S_5 to S_7 delayed the hastening of leaf formation due to more competition among the plants and probably received a hardship to be established for new growth to get the maximum surface area for photosynthesis resulting the less amount of above ground biomass. Thus photosynthetic surface is very much reduced in the closer planting having the longer shoots and less number of leaves with smaller sizes. This is also supported by Morton (1948) who concluded that LAI is dependent on leaf growth. Similarly the widest spacing received the least competition among the plants to establish was resulting in higher LAI values and RLGR values. The values of RLGR found to be higher probably due to the earlier sprouting and maximum of total leaf surface in Crown plants followed by Tip and Middle plants. This observations also is in conformity with Martin and Watson (1948).

The accelerated OGR under different spacing can be attributed to parallel increase in dry matter production, probably due to maximum photosynthetic surface, available in connection with widest spacing. The responses of OGR, NAR and DM production to population changes was approximately linear and the slopes of the curves for the different plant population were themselves in linear relationship to the plant population per unit area.

Table No. 41.

Correlation among C G R, N A R and D M P under different spacing/planting densities of D. floribunda.

P R C (Plants Raised from Crown)

Planting densities.	C G R (gm.day plant)	NAR(10^{-4} gm.cm ⁻² day ⁻¹ plant ⁻¹)	D M P (g.plant ⁻¹)
	* Mean values	* Mean values	* Mean values
	1	2	3
S ₁	0.593	2.34	144.55
S ₂	0.564	2.29	135.72
S ₃	0.532	2.22	129.12
S ₄	0.499	2.17	120.43
S ₅	0.451	2.10	107.31
S ₆	0.403	2.02	95.73
S ₇	0.360	1.93	82.05
$r(1,3) = 1.001$			$r(2,3) = 1.007$
			* Pooled mean upto 540 days.

P R M (Plants Raised from Middle)

S ₁	0.537	2.12	124.27
S ₂	0.499	2.02	116.70
S ₃	0.465	1.94	111.57
S ₄	0.440	1.84	103.73
S ₅	0.413	1.72	95.77
S ₆	0.365	1.62	85.06
S ₇	0.314	1.53	72.93

$r(1,3) = 1.048$

$r(2,3) = 0.9935$

P R T (Plants Raised from Tip)

S ₁	0.568	2.26	137.71
S ₂	0.546	2.18	131.88
S ₃	0.515	2.10	122.95
S ₄	0.488	2.01	114.43
S ₅	0.444	1.94	104.27
S ₆	0.394	1.85	92.47
S ₇	0.347	1.74	79.80

$r(1,3) = 1.011$

$r(2,3) = 0.9987$

The similar observation was recorded by Baker (1964). The lower values of CGR may be due to reduced leaf area index and leaf growth rate on account of leaf senescence at older stages. The CGR value in the widest spacing has been found to be the highest in S_1 of Crown plants followed by Tip and Middle plants. More closer planting showed a linear fall in CGR and which may be due to a limitation in the supply of light to the lower leaves at the advanced stages of growth bringing in an unproportional RIGR even at equal level of fertilizer supplied.

The data was analysed statistically in connection with the effect of NAR and it has been noticed that there was a linear declination of NAR from S_1 to S_7 of all the three types of the planting materials. However more closer planting showed a depression in NAR. The increasing trend of NAR was noted to vary directly with the spacings. Thus more closer planting resulted into the decreasing trend of NAR, whereas more widest spacing gives the highest NAR. No reports are available in this line of works in the hills of Darjeeling.

The data on DM production revealed that there is a corresponding decrease in dry matter accumulation with the increase in planting densities in all the planting types. Increase in DM has been observed irrespective of the treatments with the advancement of growth. The rate of dry matter accumulation has taken a momentum from 360 days onwards. In all the three types the widest spacing gives the highest dry matter production and the lowest was recorded in the closest planting. This has also been observed by Cruzado, Delpin and Roark (1964), Randhawa et al (1968).

Variation in yam yield per plant under different spacing have been found clearly and the yam yield was noted to decrease correspondingly

Table No. 42.

Co-rrrelation 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)

Planting densities	Dry Vine yield	Dry Yam yield	Diosgenin percentage
	kg./plant (Mean values)	kg./plant (Mean values)	* (Mean values)
	1	2	3.
S ₁	0.168	0.518	3.576
S ₂	0.160	0.503	3.576
S ₃	0.148	0.490	3.580
S ₄	0.134	0.463	3.580
S ₅	0.116	0.370	3.580
S ₆	0.096	0.276	3.553
S ₇	0.085	0.201	3.550

$r(1,2) = 0.8400$

$r(2,3) = 0.6716$

• Pooled mean values of
Crown, Middle & Tip

PRM (Plants Raised from Middle)

S ₁	0.151	0.488	3.633
S ₂	0.135	0.468	3.626
S ₃	0.122	0.448	3.630
S ₄	0.110	0.421	3.643
S ₅	0.100	0.340	3.626
S ₆	0.085	0.257	3.633
S ₇	0.071	0.182	3.623

$r(1,2) = 0.8441$

$r(2,3) = 0.1868$

P R T (Plants Raised from Tip)

S ₁	0.154	0.493	3.706
S ₂	0.147	0.484	3.710
S ₃	0.138	0.468	3.706
S ₄	0.125	0.436	3.720
S ₅	0.112	0.353	3.700
S ₆	0.090	0.258	3.713
S ₇	0.081	0.189	3.700

$r(1,2) = 0.8136$

$r(2,3) = 0.4663$

with the increase of planting densities from S_1 to S_7 of PRC, PRM and PRT. The S_1 , S_2 and S_3 spacing showed a significant variation as compared to other spacings but S_5 , S_6 and S_7 spacing did not show any variation significantly with the other spacings. The similar trend have also been observed in Middle and Tip plants. The low yield per plant may probably due to the reduced size of the tubers for competition of the plants in the same agro-climatic condition (Cruzado et al, 1964). The widest spacing gives the higher rate of vine growth with larger leaves resulting in downward translocation of carbohydrates. The highest dry vine yield correspondingly given the highest yam yield in minimum planting population per unit area. The diosgenin percentage was not affected by the planting densities probably due to the inherited characters of the diosgenin content in the yam and which remained unchange through vegetative propagation (Cruzado et al, 1964 ; Randhawa et al , 1972).

Calculating the number of plants per hectare according to the spacing from S_1 to S_7 , the survival percentage was determined. Considering the survival percentage, the survived planting population and the yam yield per plant on an average, it has been found that S_4 (60 cm X 75 cm) spacing of Crown plants showed the highest yield per hectare followed by the Tip and middle plants. The actual yield in S_4 , S_5 , S_6 and S_7 spacings did not show any significant differences among themselves. So, the optimum spacing has been recorded in S_4 spacing of Crown plants followed by Tip and Middle plants for the remunerative harvest of the crop. Whereas in geological condition of Bangalore, Randhawa et al (1968 and 1972) in their experiment suggested 60 cm X 60 cm spacing in two years crop of D. floribunda.

The maximum magnitude of yield has been found in S_4 spacing of Crown plants but in the Middle plants the maximum yield has been recorded in S_5 (60 cm X 60 cm) spacing. A persual of net profit or loss indicated a higher margin of profit (table 43) in S_4 spacing of Crown plants and Tip plants but in case of Middle plants the spacing was S_5 . The profit per rupee investment is found highest in S_4 of PRC followed by PRT and PRM. In all the spacing of Crown plants does not show any loss per rupee investment. Comparing the three types of planting materials and different planting densities, the best spacing may be recorded as S_4 (60 cm X 75 cm) both in case of Crown and Tip plants for a remunerative harvest and in the case of Middle plants the best spacing is found S_5 (60 cm X 60 cm). Though the S_5 , S_6 and S_7 spacing of Crown plants showed the higher margin of profit than any spacing of Middle and Tip plants but due to the limited availability of the Crown plants these may not be acceptable for the planting materials for commercially. Considering the availability of the planting materials the maximum acceptable margin of profit is achieved in S_4 spacing of Tip plants per rupee investment. This type of findings are found to be very much similar that of the findings of Randhawa et al(1972).

Analysis of N P K accumulation in the plants revealed that the accumulation was found maximum in the widest spacing probably due to less competition among the plants resulting the uptake of higher amount of available nutrients in the soil. But the minimum accumulation was recorded in the close plantings due to much competition among the greater number of plants per unit area. The accumulation was lower in the early stages of growth but found maximum during the 2nd year of growth followed by the least during the dormancy in all the three types of the planting materials. The maximum value were always found in the Crown plants.

Table No. 43.

Economics of Yam production under different planting
densities of D. floribunda.

Type of planting materials	Planting densities	Mean yam yield (dry) (kg./ha.)	Cost of production (Rs./kg.)	Profit (+) or Loss (-) (Rs./kg.)	Net profit per rupee investment. (Rs.)
P R C	S ₁	6,292	11.25	+ 0.75	+ 0.06
	S ₂	7,317	9.73	+ 2.27	+ 0.23
	S ₃	8,474	8.47	+ 3.53	+ 0.41
	S ₄	9,990	<u>7.26</u>	+ <u>4.74</u>	+ <u>0.65</u>
	S ₅	9,917	7.42	+ 4.58	+ 0.61
	S ₆	9,813	7.66	+ 4.34	+ 0.56
	S ₇	9,459	8.18	+ 3.82	+ 0.46
P R M	S ₁	5,162	13.71	- 1.71	- 0.12
	S ₂	5,893	12.08	- 0.08	- 0.006
	S ₃	6,743	10.64	+ 1.36	+ 0.13
	S ₄	7,868	10.56	+ 1.44	+ 0.13
	S ₅	7,857	<u>9.36</u>	+ <u>2.64</u>	+ <u>0.28</u>
	S ₆	7,800	9.64	+ 2.36	+ 0.24
	S ₇	7,423	10.43	+ 1.57	+ 0.15
P R T	S ₁	5,306	13.34	- 1.34	- 0.10
	S ₂	6,209	11.47	+ 0.53	+ 0.04
	S ₃	7,094	10.11	+ 1.89	+ 0.18
	S ₄	8,235	<u>8.81</u>	+ <u>3.19</u>	+ <u>0.36</u>
	S ₅	8,197	8.97	+ 3.03	+ 0.33
	S ₆	7,969	9.44	+ 2.56	+ 0.27
	S ₇	7,746	9.99	+ 2.01	+ 0.20

S U M M A R Y

S U M M A R Y

In connection with the responses of D. floribunda to different spacing and the types of planting materials, the results revealed that the LAI, CGR, NAR and DM accumulation has been found to be considerably decreased with the increase in planting densities.

Analysis of yield data revealed that the yam and diosgenin yield in consideration with the survival percentage was found to become highest in S_4 (60 cm X 75 cm) of Crown plants followed by Tip and Middle plants.

Maximum nutrient accumulation has been observed in widest spacing and the minimum was in the closest planting in all the three types of planting materials.

Out of the economical analysis, it appeared that the ^{most} acceptable profit was found to be the highest in S_4 spacing of Crown plants in the environmental situation of Darjeeling hills.

P A R T - V

RESPONSE OF Dioscorea floribunda Mart. & Gail. TO DIFFERENT
LEVELS OF NITROGEN WITH AND WITHOUT LIME.

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

INTRODUCTION

Nutritional conditions effects the general growth of the plants as well as the actual formation of the active principles (Braun & Jorg, 1969). Different authors claimed complete fertilization by NPK in different dose which increased the production of yams and diosgenin content in the agroclimatic condition of the different region in India.

The soil in Darjeeling hill has been noted to be very much acidic in nature and according to different authors the acid soil is not congenial for the growth of various plants and for which liming or other processes are necessary to correct the soil pH. According to Steinberg (1953), Sarker (1976) the 100 % productivity could be possible by the correction of the soil pH through liming.

As no report is available to study the effect of liming on the productivity of yam and diosgenin yield of Dioscorea floribunda in acid soil of Darjeeling hills, the same line of investigation has been carried out.

M A T E R I A L S A N D M E T H O D S

MATERIALS AND METHODS

The present investigation included studies on the affects of varying levels of nitrogen on Dioscorea floribunda Mart. & Gal. grown with and without pre-treatment of lime on upland sandy soil of Darjeeling hills, West Bengal.

The present investigation was carried out at the Research Nursery of Govt. Ipecac Plantation, Gairibas, Darjeeling in the year 1982 to 1984. The soil of the experimental plots were sandy-loam type, acidic in reaction. The average analytical results of initial soil samples collected from the plots (0 - 30 cm. depth) are presented as follows :

Mechanical analysis. (%).

Gravel	: 4.2
Coarse sand	: 28.8
Fine sand	: 37.2
Silt	: 10.5
Clay	: 19.3

Chemical constituents.

Total Nitrogen	: 0.053 - 0.062 (%)
Available Nitrogen	: 0.0116- 0.0131 (%)
Available Phosphorus	: 15.47 -16.65 kg./ha
Available Potassium	: 213.60 -221.80 kg/ha.
Organic Carbon	: 0.692 - 0.782 (%)

pH : 4.6 - 4.8

The experiments were conducted in two separate sets viz. one 'with lime' and the other 'without lime' pre-treatment. Each set of experiment received five levels of nitrogen and fixed doses of phosphorus and potassium as follows :

1. " With lime " treatment = Lime applied at the rate of 1.2 MT/

F I G U R E 20.

R E P = Indicates Replication.

No = Represents 0 Kg. Nitrogen per hectare.

N₁ = Represents 50 Kg. Nitrogen per hectare.

N₂ = Represents 150 Kg. Nitrogen per hectare.

N₃ = Represents 250 Kg. Nitrogen per hectare.

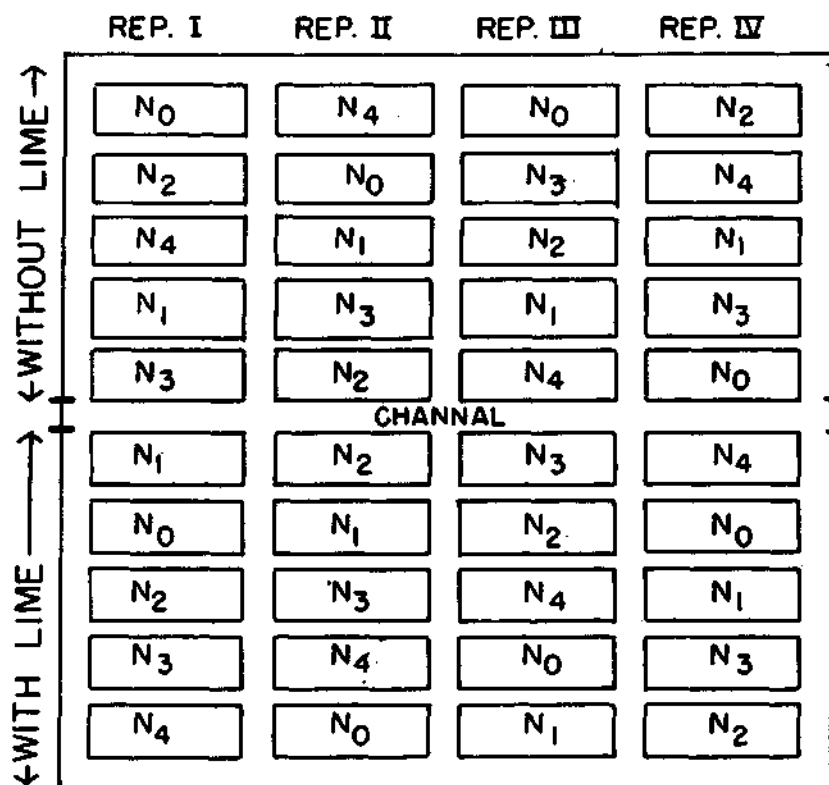
N₄ = Represents 350 Kg. Nitrogen per hectare.

FIG. 20.

LAYOUT PLAN (EXPERIMENT No. 4)

RANDOMIZED BLOCK DESIGN

SCALE = 1 mm. = 30 cm.



← N

GROSS PLOT AREA = 6n. X 2.1m.
 NET PLOT AREA = 5.4 X 1.5 Sq.m.
 BORDER BETWEEN PLOTS = 0.45m.
 " " REPLICATION = 0.09m.
 " OF THE EXPERIMENT = 1.2m.

2. Each set of "without lime" and with lime" - phosphorus was applied in the form of single super phosphate (16 % P_2O_5); at the rate of 50 kg./ha. and potassium in the form of murate of potash (60 % K_2O); at the rate of 150 kg./ha. as a fixed dose.

3. Five levels of nitrogen in the form of Urea (45 %N) were applied as follows :

- | | |
|----------------------------|---------|
| i) 0 kg. N per hectare | = N_0 |
| ii) 50 kg. N per hectare | = N_1 |
| iii) 150 kg. N per hectare | = N_2 |
| iv) 250 kg. N per hectare | = N_3 |
| v) 350 kg. N per hectare | = N_4 |

The two sets of experiments were conducted adopting randomized block design with four replications for both "with lime and without lime" treatments. The field allotted for the experiment was divided into two equal parts with 1.2 metres broad channel. The western half between two such field sections was always allotted to 'with lime' and the eastern one to 'without lime' experiment. Each half of the plot was then cut into four equal size blocks by 0.9 m. and thus forming four replications. The experimental plots were prepared as in the previous experiment (Fig. 20)

The land was ploughed repeatedly and lime at the rate of 12 quintals per hectare was applied between the first and second ploughing and thoroughly incorporated into the soil in the western half of the field representing land for 'with lime' experiment. When the field was brought into appropriate tilth, layout of plots were taken up according to the layout plan (Fig.20.).

The entire quantity of superphosphate and murate of potash together with one third of urea of the respective nitrogen doses were mixed up with equal volume of soil and uniformly distributed on corresponding plots as per layout plan. Top dressing of remaining two third urea were applied in two split doses - one dose applied after 90 days of transplanting and the other split dose applied during the 2nd year of growth.

For transplanting the mother tubers of Dioscorea floribunda Mart. & Gal. were separated into average 50-60 gms pieces in sufficient quantity and kept in the sand bed for sprouting. After about 60 days the sprouted yams were selected randomly with uniform height for transplanting, keeping a uniform spacing (60 cm. x 75 cm.) the sprouted yams were transplanted by hand in the respective plots with 15-20 cm. depth.

The interculture operations like hoeing and weeding were done from time to time.

Daily meteorological data on rainfall (cm) maximum and minimum temperature (C) and relative humidity (%) were recorded at the research centre during the period of experimentation and presented in the ^{Page No. 237.} ~~Table No. 2.~~ ~~of the previous experiment No. 1.~~

The studies on the physiological parameters like LAI, RLGR, CGR; and NAR were recorded on sample plants under each plot receiving individual treatment in the same manner as indicated in the experiment No. 1.

The data in respect of physiological parameters were computed according to the formulae given by Gregory (1917), Blackman (1919), Briggs et al ; (1920) as described in the previous experiments.

The dry matter production during the successive stages of growth & development were measured as in the same manner described in the previous experiments.

To find out the yield per plant and per hectare, the plants were harvested at 720 days after transplanting. Dry vine weight, dry yam yield, moisture percentage and diosgenin percentage were calculated as in the same manner described in the previous experiments. The periodic accumulation of NPK in plant body were analysed according to the methods by Jackson (1967).

Total correlation of important characters between various plant characters were measured by Karl Pearson's co-efficient of co-rrrelation as denoted by 'r' (Panse and Sukhatme, 1978 and Goulden, 1960).

Composite soil samples of plots receiving individual levels of nitrogen fertilizer with common doses of phosphorus and potassium fertilizers, were collected and analysed for total nitrogen, available phosphorus and potassium at the expiry of the experiments. Such soil analysis were done for both 'lime' and 'without lime' experiments seperately.

Economics of fertilizer application on Yam yield of Dioscorea floribunda was worked out applying the added-cost-added - return principle. The yam yield under each fertilizer level, the optimum level of nitrogen fertilization was computed for perceptible economic responses.

R E S U L T S

RESULTS

Vegetative and physiological parameters : The results on growth and development in respect of physiological parameters under lime and without lime pre-treatments on sandy-loam soil (highly acidic) to varying levels of nitrogen, have been greatly influenced and represented in Table 44.a. to 55.b. and Fig.21 to 26.

Leaf Area Index (LAI) : The results on leaf area index under different nitrogen levels for both lime and without lime treatments have been presented in Table 44.a. to 44.b. (Fig. 21). The data presented in the Table revealed that with successively increased doses of nitrogen a linear trend of increase in LAI in both lime and without lime sets of experiments.

The course of LAI with the time followed more-or less, parabolic pattern but the magnitude of variation at each stage of growth was increased due to application of nitrogen. LAI increased steadily upto 120 days after planting but declining trend initiated from 150 days after planting. The augmentation of LAI again observed from 340 days upto 480 days and thereafter again declined.

The lowest LAI have been recorded, being the values 0.098 and 0.090 under lime and without lime respectively in control plants. The highest magnitude of LAI being the values 1.324 and 1.293 have been recorded under 350 kg. nitrogen (N_4 treatment) per hectare respectively in lime and without lime treated plots. Under each of the nitrogen levels the values of LAI were higher in lime treatment than the without lime treatment.

F I G U R E 21.

Effects of different levels of Nitrogen with and without Liming on
Leaf Area Index of D.floribunda .

A. Continuous lines represents treatment with Lime.

B. Broken lines represents treatment without Lime.

Hollow Circles represents N_0 (0 kg Nitrogen per hectare).

Solid Traingles represents N_1 (50 kg Nitrogen per hectare).

Hollow Squares represents N_2 (150 kg Nitrogen per hectare).

Solid Circles represents N_3 (250 kg Nitrogen per hectare).

Hollow Traingles represents N_4 (350 kg Nitrogen per hectare).

FIG. 21.

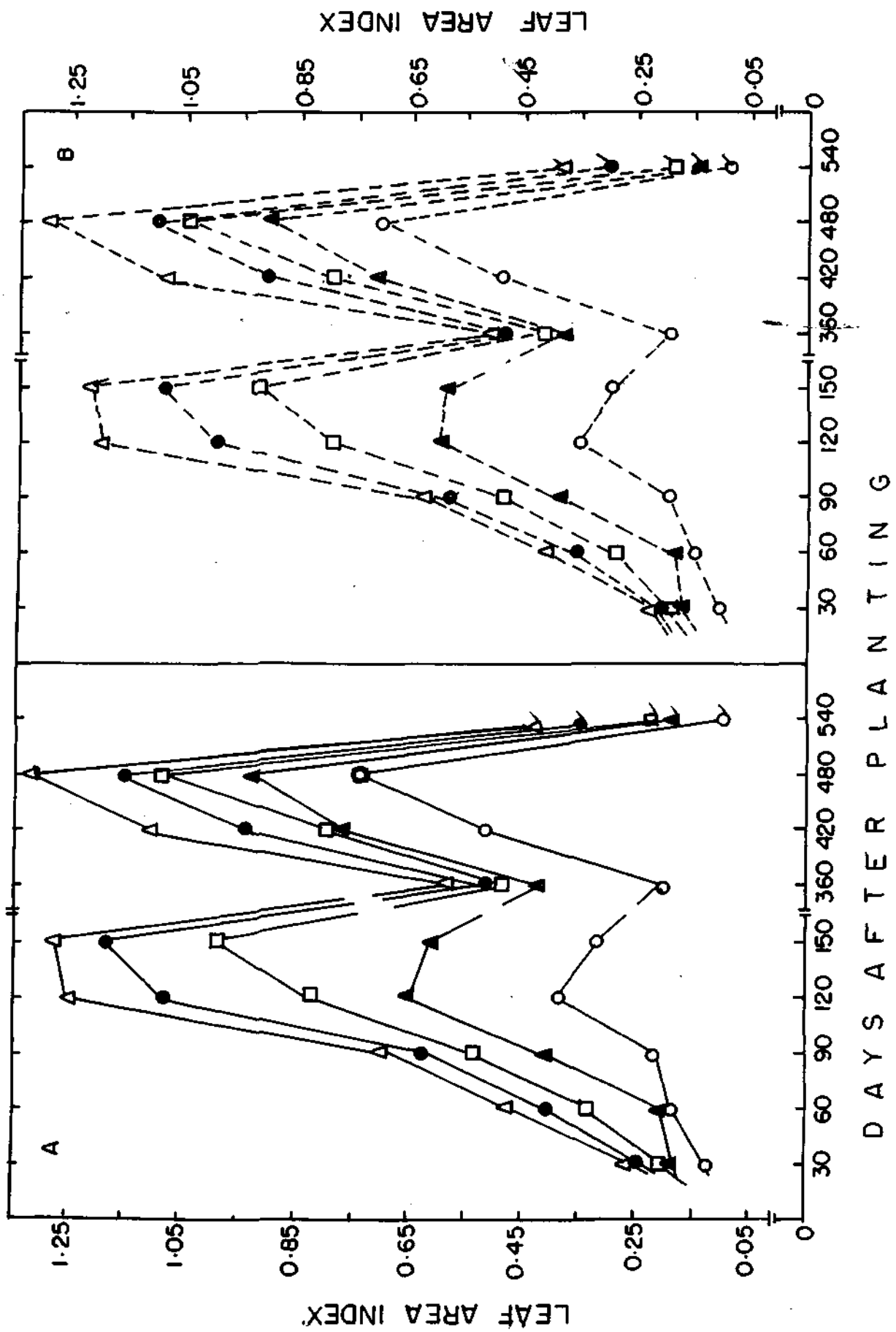


Table No. 44.a.

Effects of Nitrogen levels with and without liming
on Leaf Area Index of D. floribunda.

With Lime

Nitrogen level (kg./ha)	Days after planting.									Mean
	1st year growth				2nd year growth					
	30	60	90	120	150	360	420	480	540	
N ₀ (0)	0.125	0.184	0.215	0.387	0.316	0.206	0.518	0.736	0.098	0.309
N ₁ (50)	0.183	0.208	0.410	0.653	0.610	0.425	0.770	0.928	0.186	0.485
N ₂ (150)	0.206	0.335	0.535	0.825	0.992	0.481	0.801	1.083	0.215	0.608
N ₃ (250)	0.243	0.406	0.624	1.080	1.186	0.520	0.935	1.155	0.330	0.719
N ₄ (350)	0.260	0.472	0.696	1.252	1.274	0.571	1.102	1.324	0.416	0.818
Mean	0.203	0.231	0.496	0.839	0.875	0.440	0.825	1.045	0.249	0.587
SE \pm	0.023	0.055	0.086	0.152	0.180	0.036	0.096	0.100	0.055	0.089

Table No. 44.b.

Effects of Nitrogen levels with and without liming
on Leaf Area Index of D. floribunda.

Without Lime.

Nitrogen level (kg./ha)	Days after planting.									Mean
	1st year growth					2nd year growth				
	30	60	90	120	150	360	420	480	540	
N ₀ (0)	0.105	0.150	0.193	0.350	0.290	0.190	0.486	0.705	0.090	0.284
N ₁ (50)	0.171	0.184	0.386	0.602	0.592	0.385	0.710	0.900	0.137	0.452
N ₂ (150)	0.190	0.295	0.486	0.790	0.920	0.416	0.792	1.045	0.186	0.568
N ₃ (250)	0.212	0.364	0.593	0.995	1.090	0.488	0.904	1.108	0.300	0.672
N ₄ (350)	0.227	0.405	0.630	1.200	1.215	0.509	1.090	1.293	0.382	0.772
Mean	0.181	0.279	0.457	0.787	0.281	0.397	0.796	1.010	0.219	0.549
SE ±	0.021	0.049	0.078	0.148	0.169	0.056	0.100	0.099	0.053	0.085

Relative Leaf Growth Rate (RLGR) : The relative leaf growth rate (RLGR) as presented in Table 45.a. to 45.b. showed considerable variations with regards to stages of growth and soil conditions. Under both lime and no lime treatment the crop has shown an increasing trend in RLGR upto 150 days but sharply declined after 150 days till the end of the 2nd year growth and again declined from 480 days. Leaf growth Rate during the 2nd year growth delay the augmentation under low nitrogen level and attain the lowest in control. The highest RLGR observed under N_4 treatment at 480 days both lime and without lime treatments. The negative values indicated that the senescence of leaves occurred.

Effects on Crop Growth Rate (CGR) : The crop growth Rate (CGR) gm. per day per plant under various levels of nitrogen with and without lime pretreatment have been presented in Table 46.a. to 46.b. (Fig. 22). The data revealed that there had been a corresponding increase in CGR with successive increase in nitrogen levels for both lime and without lime treated plots. The crop irrespective of nitrogen levels have shown the maximum C G R between 480 - 540 days during the 2nd year growth both under lime and without lime treatment. But the Highest CGR recorded under 350 kg. nitrogen per hectare (N_4 treatment) pre-treated with lime at 480 to 540 days. The values were 1.165 gm. per day per plant and 1.105 gm. per day per plant respectively. The increase in CGR with higher levels of nitrogen in fact is more conspicuous irrespective of soil treatments.

Table No. 45.a.

Effects of Nitrogen levels on Relative Leaf Growth Rate ($\text{cm}^2\text{day}^{-1}\text{plant}^{-1}$)
of D. floribunda.
With Lime.

Nitrogen Level (kg./ha)	<u>Days after planting</u>								Mean
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	
N ₀ (0)	0.020	0.031	0.038	0.048	-0.015	-0.001	0.038	-0.002	0.019
N ₁ (50)	0.031	0.044	0.052	0.063	-0.005	0.001	0.061	-0.001	0.031
N ₂ (150)	0.032	0.047	0.061	0.069	-0.002	0.008	0.076	-0.001	0.036
N ₃ (250)	0.035	0.051	0.068	0.073	-0.001	0.026	0.083	+0.002	0.042
N ₄ (350)	0.039	0.056	0.076	0.078	-0.001	0.039	0.090	0.006	0.047
Mean	0.031	0.046	0.059	0.066	-0.004	0.014	0.069	0.008	0.035
SE \pm	0.003	0.004	0.006	0.005	0.002	0.007	0.009	0.001	0.004

Table No. 45.b.

Effects of nitrogen levels on Relative Leaf Growth Rate

($\text{Cm}^2 \text{ day}^{-1} \text{ plant}^{-1}$) of D. Floribunda.Without Line

Nitrogen Level (kg/ha.)	<u>Days after planting.</u>								Mean
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	
N ₀ (0)	0.016	0.026	0.035	0.046	-0.018	-0.002	0.035	-0.004	0.016
N ₁ (50)	0.028	0.038	0.047	0.058	-0.009	-0.001	0.056	-0.002	0.026
N ₂ (150)	0.030	0.041	0.050	0.064	-0.005	0.005	0.075	-0.001	0.032
N ₃ (250)	0.033	0.044	0.055	0.068	-0.002	0.020	0.080	0.002	0.037
N ₄ (350)	0.035	0.046	0.057	0.074	-0.001	0.031	0.086	0.004	0.041
Mean	0.028	0.039	0.048	0.062	-0.007	0.010	0.066	-0.002	0.030
SE [†]	0.003	0.003	0.003	0.004	0.003	0.006	0.009	0.001	0.004

F I G U R E 22.

Effects of different levels of Nitrogen on Crop Growth Rate
with and without Lime of D.floribunda.

- A. Continuous lines represent treatments with Lime.
B. Broken lines represent treatments without Lime.

Hollow Circles represents N_0 (0 Kg. Nitrogen per hectare).
Solid Traingles represents N_1 (50 Kg Nitrogen per hectare).
Hollow Squares represents N_2 (150 Kg Nitrogen per hectare).
Solid Circles represents N_3 (250 Kg Nitrogen per hectare).
Hollow Traingles represents N_4 (350 Kg Nitrogen per hectare).

FIG. 22.

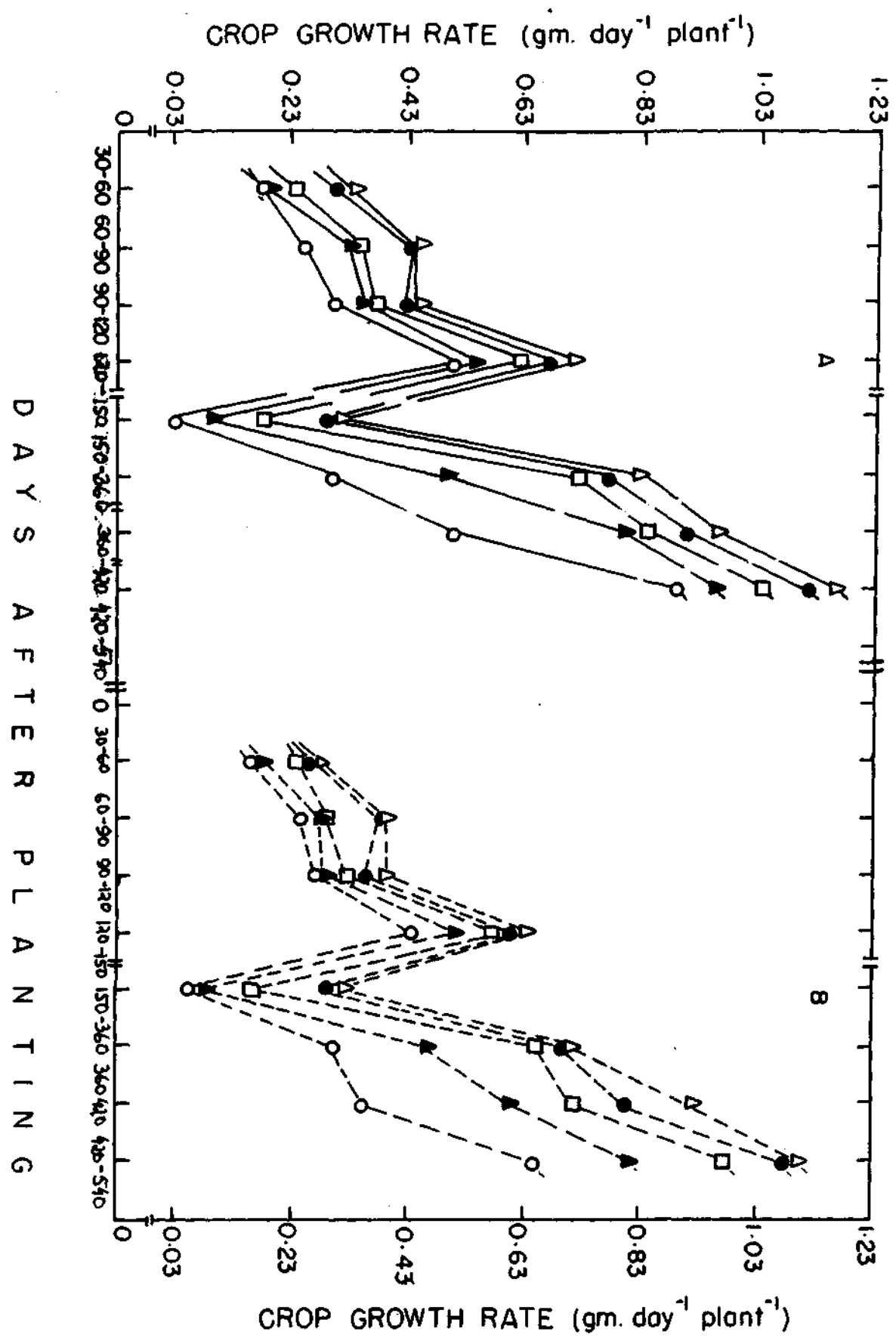


Table No. 46.a.

Effects of nitrogen levels on Crop Growth Rate (gm.day⁻¹plant⁻¹)of D. floribunda.With Lime

Nitrogen level (kg/ha.)	<u>Days after planting</u>								Mean
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	
N ₀ (0)	0.180	0.253	0.303	0.510	0.030	0.305	0.505	0.888	0.371
N ₁ (50)	0.190	0.330	0.356	0.546	0.098	0.491	0.801	0.953	0.470
N ₂ (150)	0.243	0.353	0.373	0.620	0.178	0.721	0.845	1.031	0.545
N ₃ (250)	0.306	0.433	0.420	0.676	0.283	0.770	0.903	1.110	0.625
N ₄ (350)	0.333	0.440	0.440	0.720	0.319	0.831	0.956	1.165	0.650
Mean	0.250	0.362	0.378	0.614	0.181	0.623	0.802	1.029	0.465
SE \pm	0.030	0.034	0.024	0.039	0.054	0.096	0.078	0.050	0.111

Table No. 46.b.

Effects of Nitrogen levels on Crop Growth Rate (gm.day⁻¹ plant⁻¹)
of D. floribunda.

Without Lime

Nitrogen level (kg/ha)	<u>Days after planting.</u>								Mean
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	
N ₀ (0)	0.160	0.246	0.273	0.446	0.054	0.301	0.351	0.645	0.309
N ₁ (50)	0.186	0.276	0.286	0.516	0.083	0.460	0.605	0.818	0.403
N ₂ (150)	0.240	0.293	0.326	0.580	0.167	0.655	0.710	0.970	0.492
N ₃ (250)	0.270	0.380	0.356	0.606	0.285	0.696	0.801	1.070	0.558
N ₄ (350)	0.276	0.390	0.396	0.633	0.317	0.711	0.918	1.105	0.593
Mean	0.226	0.317	0.327	0.556	0.182	0.564	0.677	0.921	0.471
SE ±	0.023	0.028	0.022	0.033	0.052	0.079	0.096	0.085	0.051

Effects of Nitrogen levels on Net Assimilation Rate (NAR) :

The Net Assimilation Rate (NAR) i.e., increase in dry weight per unit area of leaf surface per unit time have been presented in Table 47.a. to 47.b. (Fig. 23) showed pronounced increase between 120 - 150 days during the 1st year growth both under lime and no lime treatments but the values were more pronounced under lime treatment. At the end of each year growth NAR declined both in lime and without lime treatments but more declining trend observed in without lime treatment. The highest NAR observed in lime treated under 350 kg. nitrogen per hectare N_4 (treatment) being the value 4.01×10^{-4} gm. cm^{-2} day $^{-1}$ plant $^{-1}$, between 420 - 480 days against the lowest value in control.

Dry Matter Production (DM) : The dry Matter production (DM) in gm. per plant as obtained under different levels of nitrogen under lime and no lime treatment have been presented in Table 48.a. to 48.b.

The dat revealed that there has been corresponding increase in dry matter production with successive increase of nitrogen fertilization in subsequent stages both under lime and without lime treatments. It was also noticed that the nitrogen level at 350 kg. per hectare has given correspondingly higher dry-matter production in both lime and without lime treatment. It was clearly indicated that liming alone has exerted its effects on dry matter accumulation on nitrogen treatment on lime treated soil but without lime treated soil, the percentage were 184 %, 111 % and 47 % respectively

FIGURE 23.

Effects of different levels of Nitrogen with and without Lime
on Net Assimilation Rate of D. floribunda.

A A. Continuous lines represents treatment with Lime.

B B. Broken lines represents treatment without Lime.

Hollow Circles represent N_0 (0 Kg Nitrogen per hectare).

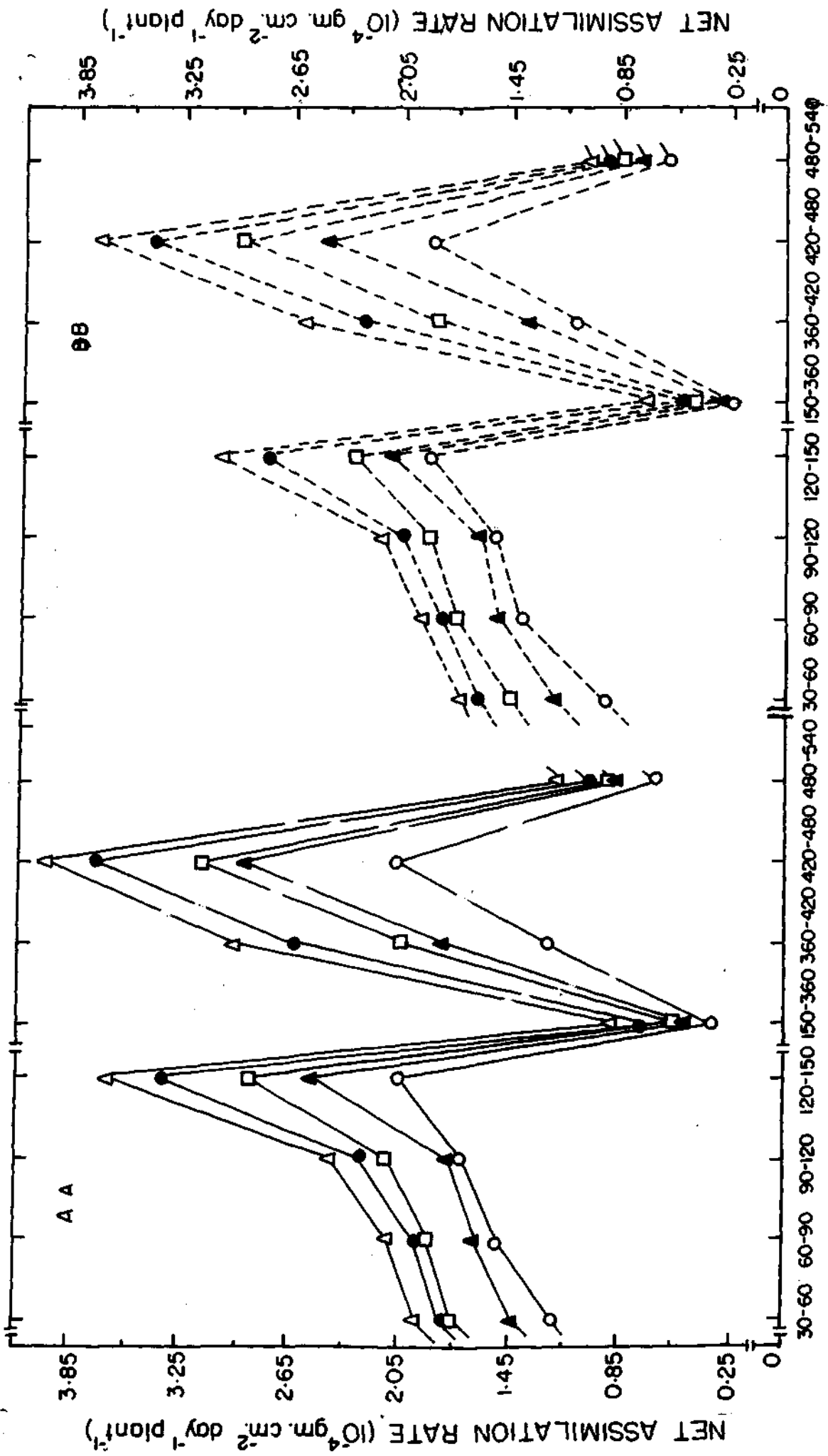
Solid Traingles represent N_1 (50 Kg Nitrogen per hectare).

Hollow Squares represent N_2 (150 Kg Nitrogen per hectare).

Solid Circles represent N_3 (250 Kg Nitrogen per hectare).

Hollow Traingles represent N_4 (350 Kg Nitrogen per hectare).

Fig. 23.



DAYS AFTER PLANTING

Table No. 47.a.

Effects of nitrogen levels on Net Assimilation Rate
 (10^{-4} gm.cm⁻² day⁻¹ plant⁻¹) of D. floribunda.

With Lime.

Nitrogen level (kg/ha)	<u>Days after planting.</u>								Mean
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	
N ₀ (0)	1.20	1.51	1.70	2.05	0.35	1.25	2.08	0.65	1.35
N ₁ (50)	1.43	1.63	1.78	2.51	0.48	1.81	2.90	0.88	1.67
N ₂ (150)	1.75	1.88	2.10	2.86	0.56	2.02	3.15	0.92	1.90
N ₃ (250)	1.82	1.96	2.26	3.35	0.72	2.62	3.72	1.02	2.18
N ₄ (350)	1.95	2.10	2.42	3.62	0.85	2.96	4.01	1.15	2.38
Mean	1.63	1.816	2.05	2.87	0.59	2.13	3.17	0.924	1.896
SE ±	0.137	0.108	0.137	0.282	0.088	0.301	0.336	0.082	0.182

Table No. 47.b.

Effects of nitrogen levels on Net Assimilation Rate
(10^{-4} gm. cm^{-2} day $^{-1}$ plant $^{-1}$) of D. floribunda.

Without Lime.

Nitrogen level (kg/ha).	<u>Days after planting.</u>								
	30-60	60-90	90-120	120-150	150-360	360-420	420-480	480-540	Mean
N ₀ (0)	0.95	1.40	1.55	1.90	0.25	1.09	1.90	0.60	1.205
N ₁ (50)	1.21	1.52	1.63	2.11	0.32	1.36	2.48	0.73	1.420
N ₂ (150)	1.46	1.75	1.90	2.30	0.46	1.87	2.93	0.88	1.690
N ₃ (250)	1.63	1.83	2.05	2.81	0.53	2.26	3.45	0.93	1.936
N ₄ (350)	1.72	1.95	2.16	3.05	0.70	2.60	3.75	1.02	2.118
Mean	1.394	1.690	1.858	2.434	0.452	1.836	2.902	0.826	1.673
SE \pm	0.141	0.101	0.117	0.215	0.079	0.278	0.331	0.074	0.166

Table No. 48.a.

effects of nitrogen levels on periodic dry matter production

(gm.plant⁻¹) of D. floribunda.With lime.

Nitrogen level (kg/ha)	Days after planting									
	30	1st year growth				2nd year growth				Mean
		60	90	120	150	360	420	480	540	
N ₀ (0)	20.4	25.8	33.4	42.5	57.8	64.2	82.5	112.8	166.1	67.27
N ₁ (50)	22.5	28.2	38.1	48.8	65.2	85.8	115.3	163.4	220.6	87.54
N ₂ (150)	25.1	32.4	43.0	54.2	72.8	110.2	153.6	204.3	266.2	106.86
N ₃ (250)	28.3	37.5	49.6	62.2	82.5	142.0	188.2	242.4	308.0	126.74
N ₄ (350)	30.2	40.2	53.4	66.6	88.2	155.3	205.2	262.6	332.5	137.13
Mean	25.30	31.82	43.50	54.86	73.30	111.50	148.96	197.10	258.68	105.11
SE ±	1.801	2.712	3.651	4.368	5.536	16.953	22.665	27.053	29.967	12.722

Table No. 48.b.

Effects of nitrogen levels on periodic dry matter production
(gm.plant⁻¹) of D. floribunda.

Without Lime.

Nitrogen level (kg/ha)	Days after planting.									
	30	1st year growth				2nd year growth				Mean
		60	90	120	150	360	420	480	540	
N ₀ (0)	15.2	20.0	27.4	35.6	49.0	60.4	78.5	100.6	139.3	58.44
N ₁ (50)	17.6	23.2	31.5	40.1	55.6	73.2	100.8	137.1	186.2	73.92
N ₂ (150)	20.2	27.4	36.2	46.0	63.4	98.5	138.0	180.6	238.8	94.34
N ₃ (250)	22.1	30.2	41.6	52.3	70.5	130.4	172.2	120.3	284.5	102.67
N ₄ (350)	24.5	32.8	44.5	56.4	75.4	142.0	184.7	239.8	306.1	122.91
Mean	19.92	26.72	36.24	46.08	62.78	100.90	134.84	155.68	230.98	90.46
SE †	1.035	2.314	3.143	3.183	4.799	15.768	20.279	24.828	30.806	11.217

F I G U R E 24.

Inter-relationship among Leaf Area Index, Net Assimilation Rate and Dry matter production of D. floribunda under different levels of Nitrogen with and without Lime.

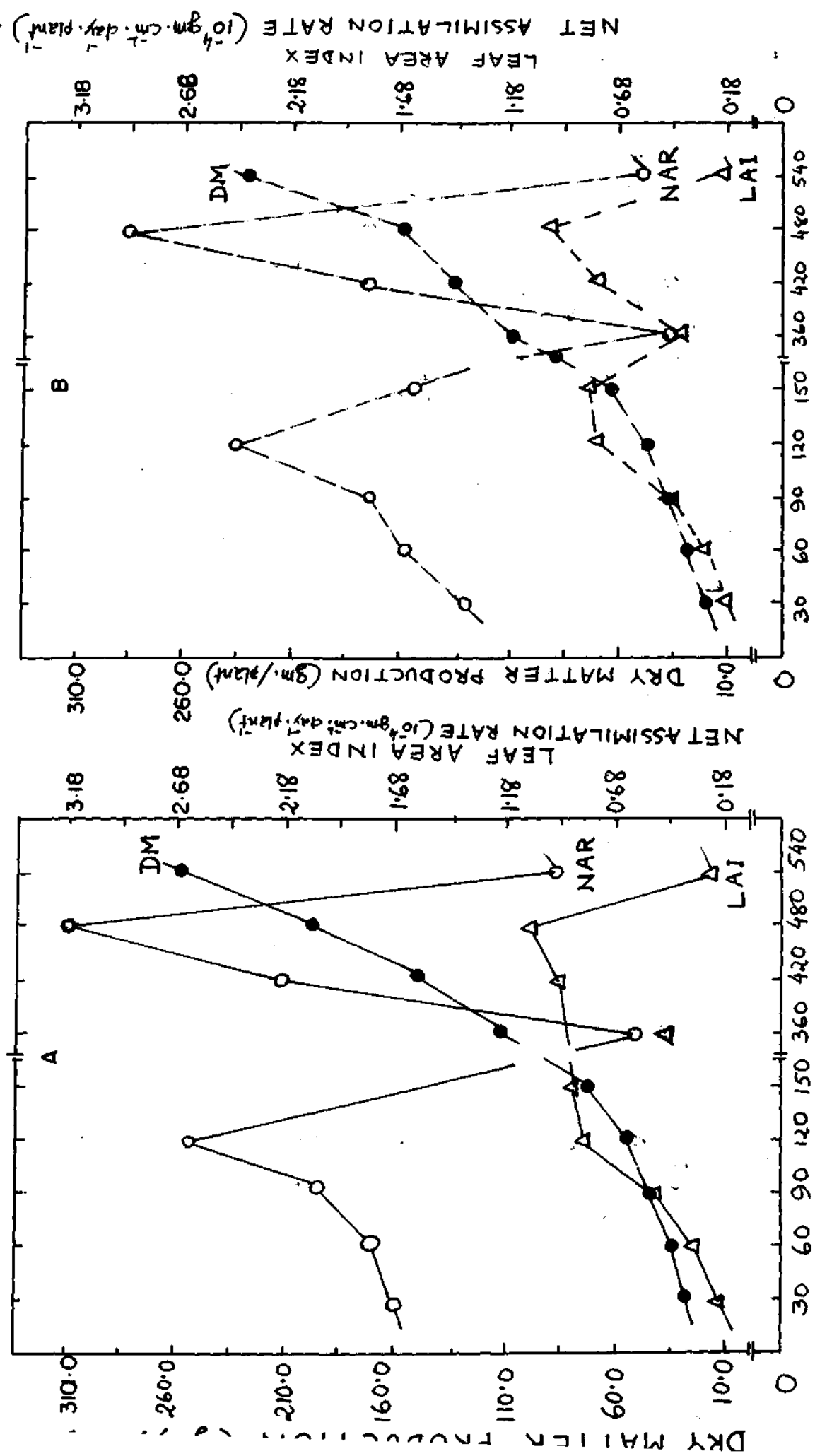
- A. Continuous lines represent treatment with Lime.
B. Broken lines represent treatment without Lime.

Hollow Traingles represent Leaf Area Index (LAI).

Solid Circles represent Dry matter production (DM).

Hollow Circles represent Net Assimilation Rate (NAR).

FIG. 24.



DAYS AFTER PLANTING

under 250, 150 and 50 kg. nitrogen per hectare. The results also explained that the responses of nitrogen levels towards yam yield is linear in nature.

Dry Vine yield : The results represented in Table 49. & Fig. 25. revealed that progressive increase in dry vine yield has been noticed with successive increment of nitrogen fertilization showing a significant linear response to nitrogen levels under lime and no lime. The highest dry vine yield recorded in N_4 treatment under lime treated soil.

Moisture percentage : Moisture percentage under different levels of nitrogen with and without lime revealed that (Table 49.) the moisture percentage increased linearly with the increment of nitrogen level both in lime and without lime treated soil. The highest moisture percentage in yam was observed in N_4 treatment over control.

Diosgenin percentage : Variation in diosgenin percentage (dry weight basis) of individual treatment have been recorded and presented in Table 50. The data revealed that the diosgenin percentage under different level of nitrogen did not shown significant difference under lime treated soil but there were significant differences in diosgenin content in Crown, Middle and Tip portion of the yam with and without lime treated soil irrespective of nitrogen levels. soil has given higher quantum of dry matter over without lime treated soil. Both the rate of increase and production of dry matter is significantly higher in 350kg . nitrogen per hectare over control under lime and without lime conditions.

The accumulation of dry matter manifestation shown a rapid increase during 2nd year growth. The highest value recorded under lime treated soil under 350 kg. nitrogen per hectare (N₄ treatment) being the value 332.5 gms. per day per plant (Table 48.a.).

YIELD ATTRIBUTES.

Yam yield : The yam yield as obtained under varying levels of nitrogen in both lime and without lime sets of experiments have been analysed statistically and presented in Table 49. & Fig. 25.

The effects of nitrogen levels on yield under both lime and without lime are statistically significant. Successive increase in nitrogen application from 0 - 350 kg. per hectare manifested a corresponding increase in yam yield per plant.

Apparently the highest level of nitrogen per hectare has proved its greater effectiveness in yam production than other lower levels in both lime treated and untreated soils.

Thus the highest yam yield per plant being 2.304 kg. (fresh) under liming and 2.068 kg. under no liming have been recorded under application of 350 kg. nitrogen per hectare. The crop has shown about 220 % increase in yam yield under lime treated soil with maximum level of nitrogen per hectare but in no lime soil the increase was recorded 211% over control. Nitrogen levels of 250 kg. 150 kg. and 50 kg. per hectare were recorded 189 % 112 % and 44 % increase in yam yield over control in lime.

Table No. 49

Effects of nitrogen levels with and without liming on
yield attributing characters of D.floribunda.

Nitrogen level (kg./ha.)	Dry vine yield (kg./plant).		Yam yield (kg./plant).				% of moisture	
	With lime	Without lime	Fresh		Dry		With lime	Without lime.
			With lime	without lime	With lime	Without lime		
N ₀ (0)	0.075	0.062	0.720	0.665	0.204	0.192	71.6	71.0
N ₁ (50)	0.096	0.089	1.042	0.984	0.288	0.277	72.3	71.8
N ₂ (150)	0.144	0.125	1.526	1.405	0.406	0.380	73.4	72.9
N ₃ (250)	0.165	0.148	2.083	1.890	0.531	0.499	74.5	73.6
N ₄ (350)	0.190	0.177	2.304	2.068	0.571	0.531	75.2	74.3
Mean	0.134	0.120	1.535	1.402	0.400	0.367	73.40	72.72
SE ±	0.021	0.020	0.299	0.264	0.069	0.064	0.667	0.596.

F I G U R E 25.

Effects of different levels of Nitrogen with and without Lime
on yield attributing characters of D.floribunda.

- A. Histograms represent treatment with Lime.
B. Histograms represent treatment without Lime.

Obliquely lined bar represent Dry vine yield.

Dotted bar represent Fresh yam yield.

Empty bar represent Dry yam yield.

FIG. 25.

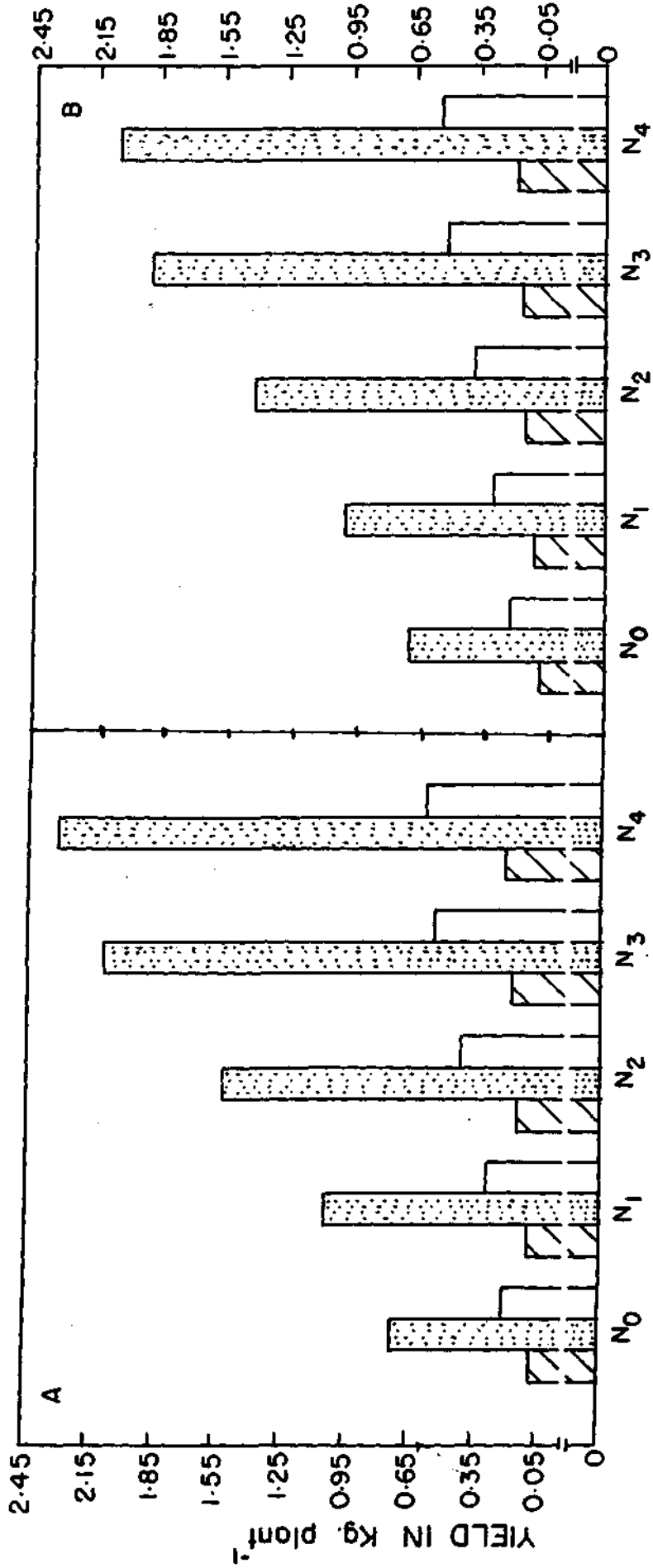


Table No. 50

Variation in Diosgenin percentage under different levels
of nitrogen with and without liming

Nitrogen level (kg./ha)	Crown		Middle		Tip		Mean	
	With lime	Without lime	With lime	Without lime	With lime	Without lime	With lime	Without lime
N ₀ (0)	3.75	3.70	3.82	3.75	3.84	3.80	3.803	3.750
N ₁ (50)	3.76	3.71	3.85	3.75	3.86	3.81	3.823	3.756
N ₂ (150)	3.78	3.72	3.85	3.76	3.88	3.82	3.836	3.766
N ₃ (250)	3.81	3.73	3.88	3.76	3.92	3.85	3.870	3.780
N ₄ (350)	3.84	3.73	3.90	3.77	4.10	3.92	3.946	3.806
Mean	3.788	3.718	3.860	3.758	3.920	3.840	3.855	3.791
SE ±	0.016	0.005	0.013	0.003	0.046	0.021	0.025	0.009

Yam yield and Diosgenin yield per hectare : Analysis of yield

data per hectare basis have been presented in Table 51 & 52 and Fig. 26. under various level of nitrogen with and without lime treated soil revealed significant variations amongst themselves.

The maximum potential yield and diosgenin yield were found at 350 kg. nitrogen per hectare with lime treated soil being the value 51.199 MT/ha. equivalent to 12.688 MT/ha. of dry yam. However considering the survival percentage highest was recorded in N_4 treatment being the value 98.5 %. The actual yam yield per hectare was also recorded higher in N_4 treatment under lime treated soil, being the value 50.431 MT/ha. equivalent to 12.497 MT/ha. The lowest yield found in control under both lime and without lime treated soil. The increase of yam yield per ha. under 350 kg., 250 kg., 150 kg. and 50 kg. nitrogen per ha. over control were observed 282 %, 235 %, 134 % and 50 % more respectively in lime treated soil whereas, 279 %, 234 %, 134 % and 55 % respectively over control in original soil. It was also revealed that though the levels of nitrogen has shown correspondingly higher yam yield , the two higher levels 350 and 250 kg. nitrogen have not shown significant variation in respect of yam yield both in lime and without lime treated soil. The yam yield under 250 kg. nitrogen per hectare showed significant difference on other levels of nitrogen under both lime and without lime treatment.

F I G U R E 26.

Effects of different levels of Nitrogen with and without Lime on production of 'yam' and Diosgenin yield (MT/ha) of D. floribunda.

Empty bar represent the potential yield.

Filled bar represent the Actual yield.

Dotted bar represent Fresh yam yield with Lime.

Obliquely Lined bar represent Fresh yam yield without Lime.

Solid bar represent Dry yam yield with Lime.

Vertical lined bar represent Dry yam yield without Lime.

Double dotted bar represent Diosgenin yield with Lime.

Parallel lined bar represent Diosgenin yield without Lime.

FIG. 26.

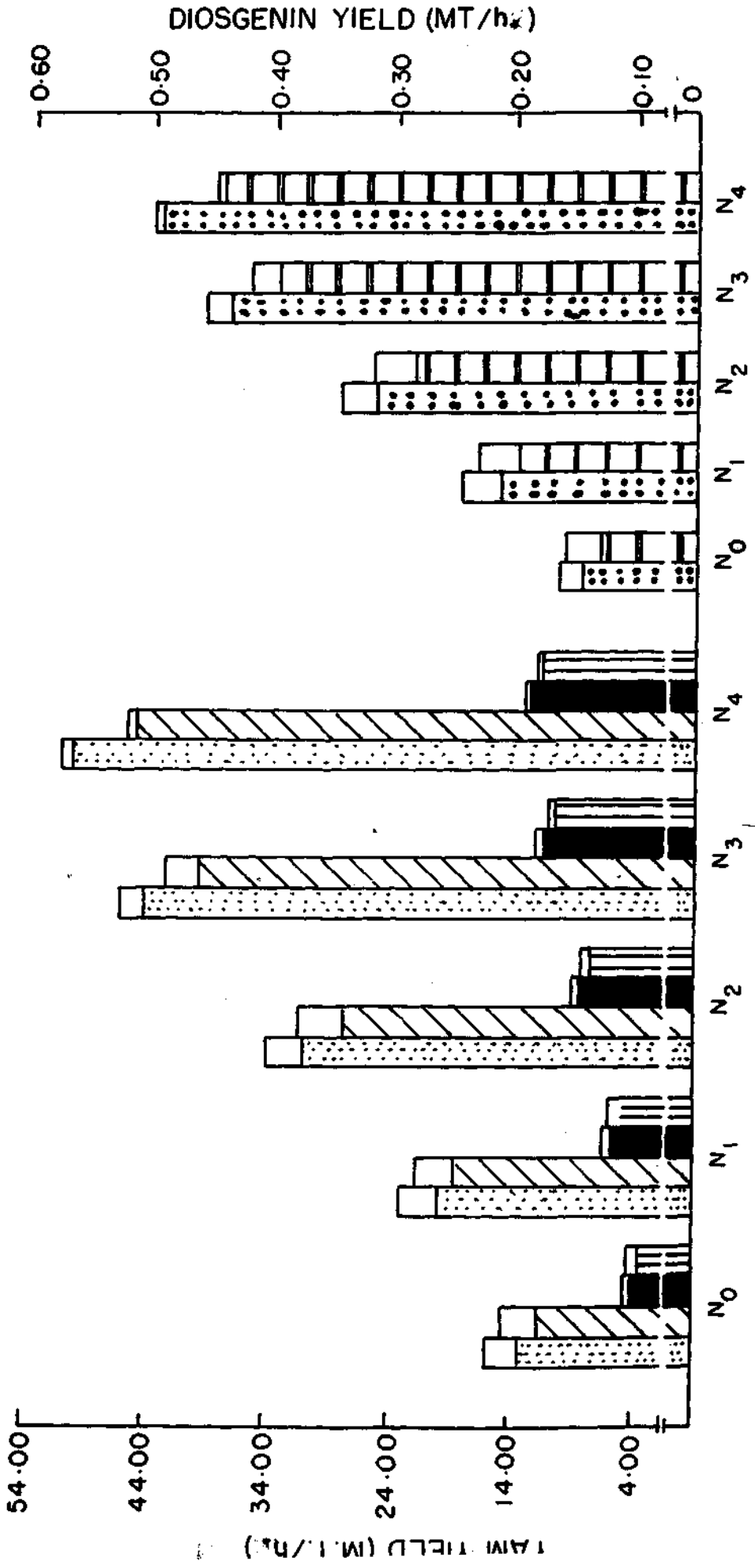


Table No. 51.

Effects of nitrogen levels with and without liming on the production
of Yam and Diosgenin (MT/ha.) of D. floribunda.

Actual yield.

Nitrogen level (kg/ha.)	Yam yield (MT/ha.)				Diosgenin yield (MT/ha.)		Survival percentage	
	Fresh		Dry		With lime	Without lime	With lime	without lime.
	With lime	Without lime	With lime	Without lime				
N ₀ (0)	13.199	11.881	3.79 ³ _A	3.430	0.1422	0.1285	82.5	80.4
N ₁ (50)	19.913	18.520	5.504	5.213	0.2104	0.1958	86.0	84.7
N ₂ (150)	30.960	27.849	8.237	7.532	0.3159	0.2836	91.3	89.2
N ₃ (250)	44.205	39.731	11.268	10.489	0.4360	0.3964	95.5	94.6
N ₄ (350)	50.431	45.127	12.497	11.587	0.4931	0.4410	98.5	98.2
Mean	31.741	28.621	8.249	7.650	0.3195	0.2890	90.76	89.42
SE ±	7.032	6.240	1.658	1.538	0.0659	0.0587	2.945	3.221
C.D. at 5% =	14.062	12.460	3.220	3.120	0.130	0.126		

Table No. 52.

Effects of nitrogen levels with and without liming on the
production of yam and diosgenin (MT/ha.)

Potential yield.

Nitrogen level (kg./ha.)	Yam yield (MT/ha.)				Diosgenin yield (MT/ha.)	
	Fresh		Dry		With lime	Without lime.
	With lime	Without lime	With lime	Without lime		
N ₀ (0)	15.999	14.777	4.533	4.266	0.1622	0.1599
N ₁ (50)	23.155	21.866	6.399	6.155	0.2446	0.2311
N ₂ (150)	33.910	31.221	9.022	8.444	0.3461	0.3180
N ₃ (250)	46.288	41.999	11.799	11.088	0.4566	0.4191
N ₄ (350)	51.199	45.955	12.688	11.799	0.5006	0.4490
Mean	34.110	31.163	8.888	8.350	0.3420	0.3154
SE \pm	6.665	5.878	1.550	1.430	0.0532	0.0547

NUTRIENTS ACCUMULATION

Nitrogen Accumulation : A perusal of data presented in Table 53. revealed that nitrogen percentage in whole plant at 2nd year growth showed comparatively higher under both lime and no lime treated soil.

The highest concentration of nitrogen has been observed in N_4 treatment during 2nd year growth both under lime and no lime treated soil. Thereafter its concentration steadily declined at the harvest.

In case of pre-treatment with lime the percentage uptake of nitrogen is higher than without lime plots under every levels of nitrogen. It was also revealed that (Table 47.) the nitrogen content in plant has a direct linear relationship with the yield of yam. Higher nitrogen percentage in the plant corresponds with higher yam yield.

Phosphorus Accumulation : The data presented in Table 54. revealed that progressive increase of phosphorus in plant corresponds with increased nitrogen levels during all the growth phases.

The trend towards the increase in phosphorus content of whole plant also noticed during the advancement of growth. The trend in accumulation pattern in both original and lime pre-treated soil is similar but accumulation of phosphorus content at advanced stages of growth correspond with higher yam yield.

Potassium Accumulation : A perusal of data in Table 55. revealed that uptake of potassium was maximum during the 2nd year growth and minimum at the harvest. There has been gradual increase in potassium content in plants with subsequent increase in nitrogen levels. The effect, however, is more pronounced in lime pre-treated soil.

Table No. 53

Nitrogen Accumulation (in %) in *D. floribunda* in different stages of growth as effected by different levels of nitrogen with and without liming.

Nitrogen level (kg./ha.)	Successive stages of growth.						Mean	
	1st year growth		2nd year growth		Final stage of harvest		With lime	Without lime
	With lime	Without lime	With lime	Without lime	With lime	Without lime		
N ₀ (0)	1.024	0.965	1.245	1.235	1.015	0.908	1.094	1.036
N ₁ (50)	1.362	1.322	1.635	1.608	1.250	0.992	1.415	1.307
N ₂ (150)	1.660	1.640	1.905	1.886	1.552	1.480	1.705	1.666
N ₃ (250)	1.855	1.836	2.268	2.247	1.800	1.750	1.974	1.944
N ₄ (350)	2.089	2.055	2.530	2.510	2.018	1.815	2.212	2.126
Mean	1.598	1.563	1.916	1.897	1.527	1.389	1.680	1.615
SE ±	0.186	0.192	0.226	0.225	0.180	0.188	0.197	0.200

Table No. 54.

Phosphorus Accumulation (in %) in *D. floribunda* in different stages
of growth as affected by different levels of nitrogen
with and without liming.

Nitrogen level (kg./ha.)	Successive stages of growth						Mean.	
	1st year growth		2nd year growth		Final stages of harvesting		With lime	Without lime
	With lime	Without lime	with lime	Without lime	With lime	Without lime		
N ₀ (0)	0.85	0.078	0.140	0.131	0.151	0.145	0.125	0.118
N ₁ (50)	0.115	0.010	0.163	0.151	0.175	0.160	0.151	0.107
N ₂ (150)	0.140	0.133	0.185	0.175	0.200	0.182	0.175	0.163
N ₃ (250)	0.162	0.150	0.208	0.190	0.222	0.195	0.197	0.178
N ₄ (350)	0.178	0.169	0.240	0.226	0.255	0.248	0.224	0.214
Mean	0.136	0.108	0.187	0.174	0.200	0.186	0.174	0.156
SE †	0.016	0.028	0.017	0.016	0.018	0.017	0.017	0.019

Table No. 55.

Potassium Accumulation (in %) in *D. floribunda* as affected by
different levels of nitrogen with and without lime.

Nitrogen level (kg/ha.)	Successive stages of growth						Mean.	
	1st year growth		2nd year growth		Final stages of harvesting.		With lime	Without lime
	With lime	Without lime	With lime	Without lime	With lime	Without lime		
N ₀ (0)	2.950	2.908	3.826	3.805	2.653	2.646	3.143	3.119
N ₁ (50)	3.285	3.262	4.405	4.382	3.158	3.145	3.616	3.596
N ₂ (150)	3.468	3.427	4.631	4.610	3.307	3.295	3.802	3.777
N ₃ (250)	3.637	3.605	4.750	4.722	3.512	3.498	3.966	3.941
N ₄ (350)	3.805	3.782	4.875	4.838	3.690	3.677	4.123	4.099
Mean	3.429	3.396	4.497	4.471	3.264	3.252	3.730	3.706
SE \pm	0.147	0.149	0.184	0.182	0.177	0.176	0.169	0.169

DISCUSSION

DISCUSSION

The present investigation on the effects of varying levels of nitrogen without lime and with lime dressed soil have shown a number of encouraging features on the commercial cultivation of Dioscorea floribunda Mart. & Gal. under sandy loam acidic soil of Darjeeling hills as a cash crop on the marginal land.

The results (Table 44a. to 55c & fig. 21 to 26) suggested that the growth of leaves (both in number and size) is significantly influenced by different levels of nitrogen and that the responses are more prominent in lime dressed soil than without liming. The course of LAI with the time followed more-or-less parabolic pattern but the magnitude of variation at each stage of growth was increased steadily upto 120 days but declining trend initiated from 150 days after planting. The augmentation of LAI again observed from 360 days to 480 days and thereafter again declined. Thus decline in LAI during the dormancy may be due to the production of less number of leaves and senescence of existing older leaves at the end of each year growth. The rapid increase of LAI during the 2nd year growth due to the rapid elongation of stem and is the result of expansion of existing leaves. This is also in conformity with the findings of Nandi and Chatterjee (1975). The increased LAI under increased doses of nitrogen may be attributed to greater cell division and elongation at the leaf apex of plants receiving higher levels of Nitrogen (Morton and Watson, 1948). Under control treatment receiving no nitrogen and at lower levels of nitrogen, the LAI

manifestation was meagre. Moreover, in no liming the magnitude of LAI is comparatively low than the lime dressed soil. Though there have been number of investigators carried out by the several authors on fertilizer trials for the successful cultivation of D. floribunda, the review of literature, it appears that no report is available in connection with the study on LAI, OGR, NAR etc. of D. floribunda in the agroclimatic condition of Darjeeling hills. Thus the data in this line of work is supposed to be the report for the first time in this region and this may be helpful for utilization of the crop from the commercial point of view.

1. The rate of leaf growth also increase steadily with increase in the levels of nitrogen and more so, when the nitrogen applied in soil pretreated with lime. The higher rate of leaf growth under increased doses of nitrogen might have helped in accumulating more chlorophyll in their leaves and thereby increase the rate of photosynthesis. The retarded rate of growth under lower levels of nitrogen supply arrests cell division within the developing leaves. Thus the accelerating effect of developing effect of nitrogen and lime on the leaf area might have effected through greater rate of expansion of leaves and through production of greater number of new leaves. Humphries and French (1963) who also observed the similar effect of nitrogen on leaf growth rate in a number of crop plants.

2. It has been noted that, although nitrogen produced predominant effect on crop growth rate, the plants growth on lime - dressed soil can accrue greater benefits over crop growth rate for nitrogen fertilization in sandy-loam acidic soil. The crop irrespective of nitrogen levels have shown the maximum OGR at 480 to 540 days (Table 46 .) during the

2nd year growth, both under lime and without lime treatment. The highest CGR is recorded under 350 kg. nitrogen per hectare (N_4). The increase in CGR with higher levels of nitrogen in fact is more conspicuous irrespective of soil treatments. The NAR values also have been recorded the similar trend.

3. The maximum value of NAR has been recorded during the active phase of growth and at dormancy low NAR is mainly on account of decline in the expansion of leaf surface due to senescence and death of older leaves and twigs. This is a suggestive of competition between the "source and sink" i.e., between the aerial portion and the continuous growing underground tubers as the later increase in size, expanding leaves export an increasing proportion of substrates to the tubers.

The rate of production and relative change in dry matter accumulation during the successive stages of growth, more-or less in a linear form at each level of nitrogen and with greater magnitude in lime-dressed soil.

4. The continuous increase in dry matter accumulation of the D. floribunda plants till harvest may be accounted for its genetic ability to absorb inorganic materials and synthesize carbohydrates and transfer of the substrate to the underground parts throughout the growing season. It seems that the ultimate gain in total dry matter content per plant and the dry vine yield resulted from increased rate of dry matter production, at an instant time, under higher level of nitrogen.

5. Increased dry matter production under successive increased levels of nitrogen application reflects the efficient photosynthetic activity through nitrogen fertilization. This increased accumulation of dry matter is found to be associated with the greater net assimilation rate as caused by

Table No. 56

Co-rrrelation among C G R, NAR, and DMP under different levels
of Nitrogen with and without lime of D. floribunda.

With lime.

Levels of Nitrogen	OGR (gm.day ⁻¹ plant ⁻¹)	NAR(10 ⁻⁴ gm.cm ⁻² day ⁻¹ plant ⁻¹)	DMP(gm.plant ⁻¹)
	* Mean values 1	* Mean values 2	* Mean values. 3
N ₀	0.371	1.35	67.27
N ₁	0.470	1.67	87.54
N ₂	0.545	1.90	106.86
N ₃	0.625	2.18	126.76
N ₄	0.650	2.38	137.13
$r_{(1,3)} = 1.003$		$r_{(2,3)} = 0.9983$	

Without lime.

N ₀	0.309	1.20	58.44
N ₁	0.403	1.42	73.92
N ₂	0.492	1.69	94.34
N ₃	0.558	1.93	102.67
N ₄	0.593	2.12	122.91
$r_{(,3)} = 0.9811$		$r_{(2,3)} = 0.9919$	

* Pooled mean upto 540 days.

nitrogen nutrition. Higher amount of nitrogen produces favourable effects on the cumulative growth in the aerial parts and the responses are linear in nature. The increased dry matter with higher doses of nitrogen may also be attributed to joint effect of greater uptake of nutrients and subsequent assimilation of the same leading to maximum expression of dry matter accumulation. Under increased doses of nitrogen there have been increased in concentration of nitrogen as also higher uptake of phosphorus and potassium. It is thus presumed that under the influence of nitrogen there has been a greater accumulation of metabolites from a more efficient leaf surface, and there is a predominant role of the size of photosynthetic surface in plants on increased dry matter accumulation. As nitrogen has got a prominent influence on the total photosynthesis of plants through its effects on leaf area (Watson, 1958), it is thus evident that nitrogen determines dry matter production chiefly by changing leaf area (Watson, 1963).

The results (Table 51.) on the yam yield, as obtained under varying levels of nitrogen with or without lime sets of experiments showed a corresponding increase in nitrogen application from 0-350 kg nitrogen per hectare with a constant dose of phosphorus (50 kg per hectare) and potassium (150 kg per hectare). Apparently the highest level of nitrogen per hectare has proved its greater effectiveness in yam production than other lower levels in both lime-treated and untreated soils. Thus the highest yam yield per plant being 2.304 kg (fresh) under lime have been recorded under the application of 350 kg nitrogen per hectare. The crop showed an increase of 220 % of yam yield under lime treated soil with the highest level of nitrogen per hectare but in the soil without lime the increase of 211 % was

Table No. 57

Co-rrrelation among Dry vine yield, Dry yam yield and Diosgenin percentage at the Final stage of harvesting under different level of Nitrogen with and without lime of D.floribumba.

With lime.

Levels of Nitrogen	<u>Dry vine yield</u>	<u>Dry yam yield</u>	* Mean	<u>Diosgenin %</u>
	(kg./plant) *Mean values	(kg./plant) values	values	*Mean values.
	1	2		3.
N ₀	0.075	0.204		3.803
N ₁	0.096	0.288		3.823
N ₂	0.144	0.406		3.836
N ₃	0.165	0.531		3.870
N ₄	0.190	0.571		3.946
$r(1,2) = 0.8400$		$r(2,3) = 0.6716$		*pooled mean values of Crown, Middle & Tip.

Without lime.

N ₀	0.062	0.192		3.750
N ₁	0.089	0.277		3.756
N ₂	0.125	0.380		3.766
N ₃	0.148	0.499		3.780
N ₄	0.177	0.531		3.806
$r(1,2) = 0.8441$		$r(2,3) = 0.1868$		

recorded over control. Nitrogen levels of 250 kg, 150 kg and 50 kg per hectare showed corresponding increase of 189 %, 112 % and 44 % in yam yield over control in lime treated soil, whereas, in soil without lime the percentage was noted to be 184 %, 111 % and 47 % respectively during the cropping season. The results (Table 49.) also suggests that the responses of nitrogen levels towards yam yield is linear in nature. Similar observation have also been recorded by the authors like Khan et al, Robinovich, (1975) and Singh et al (1975) in their experiment found maximum tuber yield with application of 200 kg of nitrogen per hectare with 50 kg. phosphorus per hectare in D. floribunda. The same authors also found that the tuber yield per plant was increased significantly with the increased dose of nitrogen and phosphorus. Randhawa et al (1972) from Bangalore reported that D.floribunda responded well upto the maximum of nitrogen of 300 kg per hectare. No response was noticed in connection with the application of phosphorus and potassium and their experimental results are very much similar to that of present investigation. Chakraborty et al (1961), Bhattacharya and Sarkar (1976, 1985) demonstrated that liming exerted a considerable influence to increase the yield per plant other than Dioscorea.

6. No reports are available earlier regarding the effect of liming on D. floribunda and the results out of this present investigation is probably the first time to be reported in the agroclimatic condition of Darjeeling hills. Thus dressing of lime in the present experimental soil produced a favourable soil reaction, which was noted to enhance the availability, efficient absorption and utilization of nutrients (elements) by plants. The results of the present investigation thus suggests that a

pre-treatment with lime is essential for successful cultivation of Dioscorea floribunda in acidic soil of sandy - loam in Darjeeling hills. Thus the increased yield with the higher nitrogen levels may be due to the pronounced positive influence of nitrogen on yield by producing and mobilizing the greater proportion of substrate to the yam through enhanced productive (source) and storage (sink) capacity. It may thus be suggested that any factor which may increase the "source capacity" of the plants would also help in developing an equally efficient "sink strength" so that the increasing amount of available carbohydrates leads to proper storage and gives a better economic return. The increased dry matter and yield of the plants under high nitrogen rates and liming may be attributed to relatively higher production and assimilation in the aerial parts and mobilizing proportion of substrates to yams.

The results shows that progressive increase in dry vine yield with the successive increase in nitrogen dose showing a significant linear response to nitrogen levels with and without lime conditions. The highest dry vine yield was recorded under 350 kg nitrogen per hectare with lime dressed soil. Such a significant response to nitrogen level on dry vine yield under both the soil reaction is due to the fact that the plant have luxuriant growth and development under enhanced uptake of plant nutrients for normal functioning of plants. It seems likely that the soil of the present experimental site is poor in available nutrients. As application of more nitrogen leads to more uptake and greater photosynthetic activity and hence greater vegetative growth. This type of observations are in conformity with the findings of Cruzado et al (1965), Nandi and Chatterjee (1975).

Cruzado et al (1965) also claimed that the complete fertilization in D. composita increased the diosgenin content. Nandi and Chatterjee (1975) observed the enhancement of diosgenin content by phosphate fertilizers, whereas, Chatterjee and Chatterjee (1980) showed that N, K and bacterial fertilizers inhibited diosgenin biosynthesis in D. prazeri and D. composita. But no remarkable variation in diosgenin content has been recorded during the present investigation with D. floribunda in the agroclimatic condition of Darjeeling hills. A significant difference was only obtained among Crown, Middle and Tip portion of the yam in lime dressed and untreated soil. This observation is also supported by Randhawa et al (1972) who considered the same crop in Bangalore region of South India.

7. Successive crop production depends on the effective exploitation of photosynthesis to achieve maximum biological yield. Nitrogen in this regard played an important role in plants. The results of the present experiment revealed that the highest actual yield per hectare and also the diosgenin yield were found at 350 kg nitrogen per hectare with lime treated soil considering the highest survival percentage over control. Though the levels of nitrogen has shown correspondingly higher yam yield, the two higher levels of 350 kg and 250 kg nitrogen per hectare did not show significant variation in yam yield both in lime and without lime treated soil. The yam yield under 250 kg nitrogen per hectare showed significant differences with the other levels of nitrogen in both lime and without lime treated soil. The observation on the increased rate of nitrogen application resulted to maximum yield is also in conformity with the findings of Shigh et al (1966), Robinovich (1975), Randhawa et al (1977) and Chatterjee et al (1985).

A perusal of the profit and loss account has indicated the higher margin of profit on the application of nitrogen in lime dressed soil as compared to without lime treated soil. The maximum net profit is observed in lime dressed soil under 350 kg nitrogen application per hectare. But the net profit obtained under 250 kg nitrogen have exceeded the net profit obtained under 350 kg nitrogen application to the soil without liming. The results on nitrogen application in lime dressed soil thus indicate that lime alone has given a margin of profit obtained in comparison to the soil without liming.

Though the Tables 50, 51, 56, 57 & 58 suggested that the application of 250 kg nitrogen per hectare was statistically significant so far as the yield of tuber is concerned. But from the commercial point of view 350 kg nitrogen per hectare in lime dressed soil has been suggested to be of much economic return per rupee investment considering the involvement of the cost during the commercial cultivation.

8. The results on plant analysis in respect to nutrients accumulation revealed that increasing rates of nitrogen application corresponds with the increasing accumulation of nitrogen in whole plant. Each increasing level has progressively increased the uptake of nitrogen in plants. The concentration of nitrogen has, however noted the highest during the 2nd year growth till the commencement of 2nd year's dormancy and there after it has gradually declined. Furthermore, application of increasing levels of nitrogen has also exhibited increasing trend of both phosphorus and potassium concentration in whole plants. Braun and Jorg (1964) reported that in the sieve-tube bundles of Dioscoreaceae, there are some group of cells which show high acid phosphates in the sieve-tube elements themselves

Table No. 58.

Economics of nitrogen application with liming on

D. floribunda.

Nitrogen level (kg.ha)	Bean yam yield(dry) (kg.ha)	Extra yield over control (kg./ha.)	Value of Extra yield (Rs.)	Cost of Nitrogen (Rs.)	Cost of lime (Rs.)	Profit (+) or Loss (-) Rs.
N ₀	3,739					-26,199.52
N ₅₀	5,504	1,765	21,180.00	288.88	2,436.00	- 7,744.40
N ₁₀₀	8,237	4,498	53,976.00	866.64	2,436.00	+24,473.34
N ₂₅₀	11,268	7,529	90,348.00	1,444.40	2,436.00	+60,268.08
N ₃₅₀	12,497	8,758	1,05,096.00	2,022.16	2,436.00	+74,438.32

and supposed active transport of assimilates takes place by means of those cells. Thus the higher uptake of phosphorus under added levels of nitrogen may be due chemical effects of nitrogen. The effect of nitrogen is increasing the relative absorption of phosphorus is possibly due to chemical interaction between nitrogen and phosphorus rather than the physiological effect of nitrogen on plant. The application of nitrogen has appreciably increased potassium uptake, at maximum concentration of potassium in presence of nitrogen have observed at maximum nitrogen level irrespective of stages of plant growth.

It is further revealed that the accumulation of nutrients under lime-dressed soil irrespective of levels of nitrogen and seasons of cultivation has remarkably higher than that under original soil. The increased concentration of nitrogen under lime-dressed soil is attributed to the fact that liming in the present experimental soil has produced a favourable soil reaction, which may finally have resulted in increased microbial activity and reduced nitrogen into beneficial form for absorption and utilization by the plants. Similarly the increased uptake of phosphorus in ~~lime~~ dressed soil may be due to the fact that the incorporation of lime in acid soil has acted as a catalytic agent in releasing inherent insoluble form of phosphorus to the form that is readily available to the plants. The increased uptake of potassium in lime treated soil is due to restoration of greater availability of the element on liming.

The variable trend of nutrients accumulation at various stages of growth of the present investigation of *D. floribunda* under varying levels of nitrogen with lime or no lime indicates that the crop should be adequately

fertilized during the early stages of growth and should be provided in split dose, where the last split dose should be during the commencement of the 2nd year growth of the crop. To sufficiently specify on the beneficial effects of liming as an essential package of practice in enhancing growth and development of the crops to accrue the full benefits out of the added fertilizers to maximisation of soil fertility and finally a remunerative harvest as a cash crop in the agroclimatic condition of the Darjeeling hills.

S U M M A R Y

S U M M A R Y

The present investigation on the responses of varying levels of nitrogen without lime and with lime-dressed soil revealed that the responses were more prominent in lime-dressed soil (1.2 MT/ha) and the results suggested that the acceleratory effect of nitrogen and lime was due to production of greater photosynthetic area in the plant caused by the treatment.

LAI, RLGR, OGR, NAR and DM were measured for both in lime dressed and without lime soil and their co-rrrelation were worked out. The highest magnitude have been recorded under N_4 (350 kg of N/ha) in lime dressed soil with a maximum yield of yam (an increase of 220% over control).

A perusal of the profit and loss account has indicated that though the application of 250 kg of N/ha was statistically significant but higher margin of profit by application of nitrogen in lime dressed soil was observed ^{in N_4 (350 kg. of N/ha)} as compared to that without lime. The maximum net profit was observed in lime dressed soil under 350 kg. of nitrogen per hectare.

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A P P E N D I X I

Meteorological Data during the Cropping seasons.

Months	Temperature (in °C)						Total Rainfall (in mm.)			Relative humidity (%)		
	Max.	Min.	Max.	Min.	Max.	Min.	1984-85	1985-86	1986-87	1984-85	1985-86	1986-87
	1984 - 85		1985-86		1986-87							
January	20.1	11.6	20.5	11.5	19.0	11.8	50.5	35.5	75.5	50.1	52.8	51.2
February	20.5	12.5	21.1	10.7	22.2	11.2	127.2	95.5	15.0	56.1	59.8	58.7
March	25.8	16.5	25.3	15.5	26.2	16.6	63.0	58.5	16.5	60.5	60.2	59.8
April	28.8	18.5	26.6	18.6	27.2	19.0	311.0	378.2	173.0	65.3	70.5	66.2
May	29.3	20.4	32.4	21.3	27.5	20.7	572.4	642.2	860.0	70.5	72.4	68.4
June	30.5	23.2	30.6	22.7	29.8	22.8	798.0	871.7	1123.0	75.2	76.5	72.0
July	31.4	23.1	29.4	22.8	29.2	23.3	1323.0	1299.0	1369.0	79.5	76.2	75.5
August	32.2	22.4	30.1	23.1	29.6	23.6	775.6	725.0	913.0	72.5	78.6	75.3
September	28.9	20.8	29.8	21.5	27.6	22.6	799.0	666.5	1048.0	70.6	66.1	70.2
October	26.5	18.0	28.6	20.0	27.0	20.7	138.2	61.0	224.0	65.4	59.5	60.0
November	25.0	17.5	26.6	16.5	25.7	16.5	14.0	84.0	9.0	59.2	56.4	55.3
December	20.5	13.7	21.2	14.6	20.1	13.2	9.0	39.5	23.0	50.2	50.1	48.5

A P P E N D I X I I

-: PUBLICATIONS :-

List of Publications :

1. Mukherjee, S.K., D.P. Rao & P.K. Saha - "Prospect of Pineapple cultivation in South Bengal." Proc : Sem. Pineapple production & utilization (A.F.S.T.) 1980.
2. Chatterjee, B.K.: P.K.Saha - " A note on effect of different concentrations of NAA on Tomato" - Proc: 68th Ind. So. Cong. Sec.; Agril. Sc., P-15-28 (1981).
3. Mukherjee, S.K. : D.P. Rao, C.S. Das and P.K.Saha - "Effect of NPK on growth yield and quality of Pineapple cv. kew in South Bengal" - Ind. J. Horti, vol - 38, No. 3 & 4, P - 141-147 (1981)
4. Mukherjee, S.K. : D.P. Rao C.S. Das and P.K. Saha - "Effect of planting density on growth, yield and fruit quality of Pineapple cv. Queen [Ananas Comosus (L) Merr] in South Bengal".- Ind. J. Horti. vol - 39. No. 1 & 2. P-1-8 (1982).
5. Banerjee, D.P., B.K. Chatterjee and P.K.Saha - "Air layering of Camphora by Phenolic Compounds" - Science and Culture : Vol-49. P-100-101 (1983).
6. Mukherjee, S.K.; S.Chakraborty. S.K. Sadhukhan and P.K.Saha - "Survey of Mangoes of West Bengal" - Ind. J.Horti. (1984).
7. Saha, P.K., T.K. Bose and B.K. Chatterjee -
"Prospects of Coriander (Coriandrum sativum Linn.)
Cultivation in North Bengal - Abst. No. D-11., Proc: vth I.S.H.S. Symp. on Med., Aro. and Spices Plants, Darjeeling, West Bengal (1985).
8. Sharma, P., S. Chatterjee, A. Mandal, P.K. Saha and S.K.Chatterjee-
"Improvement studies of Dioscorea growing in Darjeeling Hills".- Abst. No'D-9., Proc: Vth I.S.H.S. Symp. on Med., Aro.and Spices Plants, Darjeeling, West Bengal (1985).
9. Saha, P.K. and Chatterjee. S.K. - " Responses of Dioscorea floribunda Mart & Gall. to different level of NPK with & without lime