STUDY OF FEEDER ROOT SYSTEM OF SOME IMPORTANT VARIETIES OF SAPOTA

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BY

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C E R T I F I C A T E

This is to certify that the thesis entitled "STUDY OF FEEDER ROOT SYSTEM OF SOME IMPORTANT VARIETIES OF SAPOTA" submitted in the partial fulfilment of the requirements for the award of the degree of MASTER OF SCIENCE IN AGRICULTURE (HORTICULTURE) of the Orissa University of Agriculture and Technology, is a faithful record of bonafide research work carried out by Sri Gauranga Dash under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that such helps or informations as has been availed during the course of the investigation, has been duly acknowledged by him.

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ABBREVIATIONS

C.D.	...	Critical Difference
S.E.(m)	...	Standard Error of Means
C.M.	...	Centimeter(s)
m.	...	Meter(s)
Sq.cm.	...	Square centimeter
Sq.mt.	...	Square meter
cv.	...	Cultivar
E	...	East
W	...	West
N	...	North
S	...	South
et. al.	...	And others
Fig.	...	Figure
ha	...	Hactare
i.e.	...	I dest (that is)
No	...	Number
S.D.	...	Standard Deviation
Sig.**	...	Significant at 0.05 level and 0.01 level
Sig.*	...	Significant at 0.05 level
N.S.	...	Non-significant.
df.	...	Degrees of freedom
^{o}C	...	Degree on the centigrade scale
/	...	per
%	...	percent
±	...	Plus or minus

V_1	...	Variety Kalipatti
V_2	...	Variety Cricketball
V_3	...	Variety Chaatri
D_1	...	Depth at 0-30 cms.
D_2	...	Depth at 30-60 cms
D_3	...	Depth at 60-90 cms
gm	...	Gram
cu	...	Cubic

CHAPTER I

INTRODUCTION

INTRODUCTION

Through the centuries, the fascination for growing fruits and using them as a protective food needs no stress. Among various fruits the sapota belongs to family 'Sapotaceae' and it's botanical name is (Achras zapota, L) has got a very important place in diet. Sapota when fully ripe is delicious and is eaten as dessert fruit. The pulp is sweet and melting. The fruit skin can also be eaten since it is richer than pulp in nutritive value (Gopalan et al, 1981).

In the coastal areas, the fruits are soaked in melted butter for a night and eaten in the morning. It is said to be an excellent preventive against biliousness and febrile attacks. In the West Indies, seeds are known to be aperient and diuretic and the bark is reputed to be tonic and febrifuge. In Guinea, the bark is used as a tonic and antipyretic. The decoction is given in diarrhoea and in paludism (Kirthikar and Basu, 1975).

This belongs to a tropical fruit crop and can be grown from sea level upto 1200 m, it is grown through out India, occupying an area of nearly 2000 hectares (Shanmugavelu and Srinivasan, 1973.).

The states that are growing sapota on a commercial scale in India are Maharashtra, Gujarat, Andhra Pradesh, Karnataka, TamilNadu, Kerala, Uttar Pradesh, Punjab and Haryana (Cheema et al, 1954 and Purseglove, 1968).

It is also grown in Orissa and West Bengal. It's cultivation in humid tracts of south India as well as in dry zones of Deccan Plateau is important.In South India, particularly in the Western Ghates of Karnataka, Sapota is grown successfully on gravelly laterite soils (Anon; 1975, Cheema et al, 1954 Choudhury, 1954, Singh, 1964; and Singh et al, 1963.). The tree is ornamental and may well find a place in gardens even where conditions are not suitable for commercial production.

The unripe fruits and bamk yield a milky white latex which solidifies on exposure to air and this forms the base for making chickle. Immature fruits are astringent, while ripe fruits are sweet smelling and delicious. The mature fruits are also used for making mixed jams and they provide a valuable sources of raw materials for the manufacture of industrial glucose, pectin and natural fruit jellies. They are also canned as slices.

Besides these, in the Dutch East Indies, the young leafy shoots are frequently eaten raw or mixed with other vegetables like lab-lab and consumed as a vegetable after steaming.

To supply balanced and healthy diet daily to an individual three ounces of associated fruits have been recommended in India and the average consumption of fruits per adult is reported to be 80 grams only for a developing country while

191 grams and 362 grams are being used in a developed country. Since sapota produces heavy crops more than once a year it is worthwhile not only to extend the area under this crop as well as to improve the yield and quality of the fruits as the size and growth of the aerial parts are governed to a great by the extent and activity of root system.

Hence, information about the feeder root densities in different zones of soil is important for recommending efficient management of soil, water and fertilizers and other cultural practices for increasing production potentiality.

The root distributionof sapota tree may vary according to the type of soil, climate and season. The feeder roots are the growing fine rootlets of 0-1.5 mm size, playing an important role for rapid uptake of water, salts and nutrients.

Efficiency of orchard management can be brought to a great extent by periodically application of required amount of manures, fertilizers, irrigation and other inter-cultural operations if position of the availability of feeder roots are properly ascertained.

In view of the above stated factors, the present investigation was undertaken to study the feeder root system at various depths and positions of the soil surface in different months of a year as the information in case of sapota is very limited with the help of soil auger method as recommended by

Rao and Mukherjee (1985), Singh (1978), for searching out the most effective zone for economic application of fertilizers, irrigation and operation of other cultural practices through its proper utilization for getting uptimum production from every individual sapota trees of an orchard and with a future look of more coverage under this fruit crop in the country as a whole.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Growing plants require photosynthetically active radiation (PAR), water, 15 to 20 elements and the absence of lethal factors. As most of the water and mineral elements used by the plants is absorbed by roots, for which root systems have been studied and various aspects of the problem under investigation in sapota are reviewed in connection with relevant literatures as follows.

ROOT STUDIES :

The size and productivity of the aerial parts are governed to a great by the extent and activity of the root system of plants. Information relates to the study of root system particularly in tropical fruits like sapota are limited. Therefore, information on the rate of root spread and rooting depth, total volume of soil occupied by the root system, the feeder root densities in different soil zones, the total root surface and the root activity in different parts plays an important role for bringing about the most efficient management practices of soil, water and fertilizers etc.

In South England, Rogers (1939) reported that the active root growth in apple was observed in two months i.e. April and October.

Skovorchov(1948) noted that the great majority of thin fibrous (0.5 mm - 1 mm diameter) roots were present in a zone of 3.5 to 4.5 meters away from the trunk i.e. almost at the middle of the inter row space in the 20 year old apple trees.

Dzilianov and Penkov, (1965) studied the distribution of the fibrous roots of peach trees grown in a meadow-chernozem calcareous smolnitza over sandy clay in the upper 80 cm. layer and the majority of all the roots in the 40-60 cm zone. There was an even horizontal distribution of both skeletal and fibrous roots. In a humus calcareous soil over lime stone although the majority of the skeletal roots were in the 40-60cm zone, their distribution was uneven and both root and shoot growth were poor, where the trees were grown in a 115 cm deep layer of sand over meadow-chernozem smolnitza the greatest part of the strongly developed root system was in the 20-80 cm zone.

Ersov (1965) reported the growth of the root-systems which continued throughout the year was most vigorous from April to Mid-June and from October to December. The least root growth occurred from July to September during the period of intensive fruit growth and seed formation. Individual rootlets remained active for 3-10 days in the spring and summer and for 1½-2 months in the autumn and winter.

Spina (1966) studied the root systems and crown diameters were studied in sour orange root stocks grafted with mandarins and lemons. The lateral root system reached a depth of 1.2-1.4m and in some cases tap roots were present at lower levels. With mandarins as scions the diameter of the root system was considerably greater than that of the crown. Lemon crowns varied usually being equal to the root system in diameter. Root and crown extension were greatest in sandy soils.

Aiyappa and Srivastava (1966) stated that the roots of 1½ year-old seedling mandarin plants penetrated vertically to about 41 inch and spread laterally to about 63 inch in healthy trees, 45 in. and 57 in. in mildly chlorotic trees and 38 in. and 36 in. in severely affected trees. The lateral spread was far greater than the crown spread.

Rogers and Head (1968) found the fine fibrous roots of apple to be more densely concentrated in the surface soil and recorded about 30-50 percent of total fibrous roots (below 1 m. thickness) in the top soils upto 34 cm. soil depth only.

Aiyappa *et al.* (1968) opined that the presence of maximum quantity of feeder roots in soil layers upto 60 cm. depth in two and half year old chlorotic mandarin seedlings.

Stoev (1970) observed a large concentration of absorbing roots of old grape vine at soil depth of 15-20 cm.,

while in case of young vines the same was rooted in 30-40 cm. soil depths. The first 15 cm surface soil layer was thickly populated with most active absorbing roots and about 45 % of total absorbing roots was confined in a zone upto 30 cm. deep.

Yeh (1972) studied the root distribution of citrus trees by radiotracer method. 32p- Labalied orthophosphate solutions were injected into the soil to depths of 10-60 cms and at distances of 50-200 cm from the trunks of 8 and 12 year old citrus tankan trees. Leaf samples taken 10 to 60 days later showed that P uptake was greatest in roots situated at depths of 10-20 cm. about 150 cm. from the trunk.

Ghosh and Chattopadhyaya (1972) had the view that upto a soil depth of 50 cm. a 8 year old lemon tree raised from cutting could develop total roots to the extent of 2880 meters in length. The authors recorded that vast majority (75%) of thin fibrous roots (upto 1 mm.diameter) in lemon were concentrated only upto 25 cm. of soil depth.

Duplessis and Smith (1973) reported from their studies on mango at Letaba and Nelspruit areas that at least 80% of its fibrous roots are in the zone under the canopy of the tree to a depth of 1.0 meter, and this area is recommended for fertilizer and irrigation water applications.

Bhojappa and Singh (1973) reported on the root activity and soil feeding zone of mango using 32p. They observed

maximum root activity at 30 cm. below the surface and 240 cm. from the trunk, placing 32_p capsules at 30, 60, 90 cm depth and 120, 240, 360 cm. from the trunk of 18 year old mango trees and the maximum activity was observed at 15 cm depth and 120 cm from the trunk placing 32_p capsules at 15, 30 or 60 cm. depth and similar distance from the tree trunk. About 77% of the root activity was observed upto 60 cm. depth in the 1st trial and in second trial the value was 85% upto 30 cm. depth.

Purohit and Mukherjee (1974) studied that the root activity in guava tree was decreased with an increase in the depth (15, 30, 60 and 90 cm. depths) and distance (120, 240 and 360 cm) from the tree trunk. These results compared well with the actual distribution of feeder roots as determined by soil auger method.

Bojjappa and Singh (1974) studied on root activity of mango by radio tracer technique using 32_p. They observed that the highest observation occurred close to the trunk (120 cm.) at a soil depth of 15 cm., the second peak was near the periphery (300 cm.).

Atanasov (1974) investigated on the root system of apple trees on different root stocks. He studied on 7 year old trees cv. Red delicious grafted on M-9 or M-7 clonal root stocks. The majority of the roots of the trees on the clonal root stocks were found in the 10-30 cm. soil layer and on the seedling root-stocks in the 20-40 cm. layer. The bulk of the

roots lay within the crown projection and their members especially the seedling root stocks greatly diminished at a radius of 2-3 mt. from the trunk.

Danilova (1974) viewed on the distribution of the root system of prostrate apple trees on turfpadzolic soils. He found that in prostrate apple trees the majority of the roots were horizontal and confined to the 0-40 cm. soil layer.

Robinson (1977) studied the feeder roots at various depths upto 90 cm. at distances upto 3.6 m. from the citrus trees into the mid rows areas. The feeder roots were concentrated mainly from the dripping of the tree outwards at a depth of 15-60 cm.

Purohit, A.G. and Mukherjee, S.K. (1977) studied on root activity of guava trees by radio tracer technique using 32_p with 12 years old guava trees. 32_psolution was injected at 120-360 cm. from the trunk at depths of 15-90 cm. Label uptake was determined by leaf analysis. In the rainy season root activity was greater near the soil surface and mid way between the trunk and the drip line. Root activity during the dry season increased with depth and was greatest at 90 cm. and 240 cm. from the trunk.

Singh, R. N. (1978) from the preliminary studies reported from IARI that with the help of 32_p isotopes, had shown that most of the feeder roots of mango are located between 121.8 and 243.6 cm. (4 and 8 feet) radius from the trunk.

As far as depth is concerned, feeder roots are mostly found at 30, 60 and 90 cm. depth. He also reported in general that the fertilizers and manures are to be applied by making a ring 1 ft. away from the main trunk round the base of the tree of mango.

Avilan et al. (1979) studied the root system of mango and grape fruit trees cultivated on soils of the Venezuelan High Central plains. They observed that most of the roots of 17 years old mango trees, cv. Haden were in the top 40 cm. of soil and at a lateral distance of 70 cm. from the trunk. Root distribution was related to the physical and chemical properties of the soil, which changes from a loam in the top 40 cm. to a clay loam below.

Thakur et al. (1981) studied on root distribution in some fruits and observed that the greatest root activity was near the soil surface and beyond 1 meter from the trunk.

Hedge and Tiwari (1981) studied on root distribution in guava by a direct excavation method and noticed that the maximum concentration of roots occurred between 0-20 cm. soil depth indicating that the active absorption was close to the surface of the soil.

Patel and Amin (1981) studied the root system of a 12 year old grafted mango tree of kesar cultivar and observed that the development of tap root, anchoring (Primary and secondary) roots and effective roots started their development

at a depth of 18 cm. The secondary roots were observed growing within a soil depth of 20 to 45 cm. The tertiary roots were distributed a little in side from the periphery of the crown and at 25-40 cm. depth.

Rameswar et al. (1981) observed by auger method that the distribution of feeder roots (1.5 mm. diameter) of 18 years old Banganpally mango grafts growing in Andhra Pradesh extended upto canopy limits and the roots went down to a depth of 90 cm. In July-August, maximum concentration of feeder roots was found close to trunk in the top 0-15 cm. layer. The layer from the surface to a depth of 15 cm. contained about half of the feeder roots. In the next layer (15-30 cm.) there was a big fall in concentration, which was more gradual in the subsequent lower layers. From the trunk to the canopy limits the concentration gradually decreased.

Avilan et al. (1981) viewed on the root distribution of sapodilla and observed the root system are available at a depth of 100 cm. Sixty percent of roots were in the top 40 cm. of soil, the largest lateral concentration occurred at a distance corresponding to half the canopy radius.

Thakur, R.S.; Rajput, M.S.; Srivastava, K.C. (1982) concluded on root distribution pattern in the crops like mango, banana, guava, grape vine and citrus. They varied among the species. The majority of roots were found under the tree canopy. The greatest root activity was reported near the soil surface and beyond 1 m. from the trunk.

Khera, A. P.; Bisla, S.S. et al. (1983) studied the root activity in Ber of cv. Umran trees by radio active technique using P^{32}. They reported that most of the active roots of 10-year-old Ziziphus mauritiana trees were located at 2.35 m. from the trunk and 0.5 m deep but some active roots were also present at a depth of 1 m.

Dudkin, G.I. (1984) observed root distribution system in apricot and stated that the horizontal roots of 16-year old trees were mainly at 17-70 cm. depth and the vertical roots penetrated down to 184 cm. About 88 and 82 % of the respective root types were directly below the crown. Soil cultivation some 15-17 cm. deep under the crown and 25-28 cm. deep beyond the canopy spread is recommended under deeply saline heavy meadow serozem soils.

Avilan, L; Meneses, L; Sucre, R; Serpa, D.; (1984). studied the root distribution of avocados (cultivars pollock and Gil) in alluvial soils by trenching and excavation. They observed that the root system was superficial, most roots occurring in the first 20 cm. of soil, with a horizontal concentration halfway between the trunk and edge of the canopy.

Chandra, A; Yamdagni, R; (1984) studied the root distribution of 12 year old tangelo trees cv. pearl on the lemon rootstock by excavation method during summer and the post rainy season. They found that the amount of roots in a

radial direction (expressed on a dry wt. basis) was greatest at 0 to 60 cm. sampling distance and decreased regularly over the higher sampling distances and maximum amount of roots occurred at 0 to 25 cm depth and were greater at 50 to 75 cm than at 25 to 50 cm depth during summer months. During the post rainy season the amount of roots decreased regularly with sampling depth. Amount of roots were greater during post rainy season than in summer at all distances from the trunk and all soil depths. Feeder roots represented a greater proportion of the root-mass during post-rainy season.

Sathe, A.; Rao, A.P.; et al. (1984) studied the root distribution pattern of Anab-e-shahi Grape by using ^{32}P soil injection method. They found that some 70% of the roots were in a circle of 1.5 m. radius from the main trunk to a depth of 30 cm. and this area was suggested as optimal for fertilizer placement.

Correa, L.; De, S.; et al. (1985) studied the root distribution of avocado cultivars in a red-yellow podzolic soil. C.V.R. collinson produced the highest root weight followed in descending order by Simmonds, Wagner, Linda and Pollock. For each cultivar root weight diminished with depth For cv. Collinson and Pollock, root distribution was uniform down to 120 cm. For cvrs. Simmonds and Wagner it was uniform to 150 cm, and for Linda to 210 cm. The percentage of roots in the top 150 cm, were 83.85, 80.44, 74.70, 67.72 and 65.31

for pollock, Wagner, Collinson, Simmonds and Linda respectively. Cvs. Collinson, Linda and Pollock had similar root percentage at depths of 50, 150 and 250 cm.

Ruggiero, C; Andiloro, F (1985) studied the root distribution of valencia Late orange of ten to eleven-year-old trees. They were of the view about 75% of the roots were in the top 45 cm., but density at 165 cm. was still appreciable. Root density decreased with increasing volume of irrigation water.

Omoti, U; Ataga, D.O.; (1985) made investigation on the root activity with radio-active phosphorus-1 of 15 year-old palm, and the root activity was measured at 50-400 cm. from the trunk and at 15-90 cm. depths. The ^{32}P uptake was greatest at 50 cm from the trunk and at 15 cm. depth. It decreased at 200 cm. and increased again at 400 cm. from the trunk. It is recommended that for maximum efficiency and fertilizer utilization by adult palms the fertilizers should be applied on the surface in a 400 cm. radius from the trunk.

EL-Nokrashy, M.A.; Ala, M.H.S.; (1985) studied the root distribution of citrus in sandy soils. They found that the root horizontal spread was 120-450 cm (from the trunk) and vertical spread to a depth of 10-95 cm. The majority of roots were found on the east side of the trees.

Avilan, R.; et al. (1985) reported on root distribution of 14 year old citrus aurantifolia trees in a colluvial soil in centeral venezuela. They observed that the soil texture was the main limiting factor for root penetration due to the presence of a dense sand layer at the 30-60 cm. depth. Most of the roots were concentrated within the 0-30 cm layer.

Chandra, A.; Yamdagni, R.; (1985) studied the root distribution on 12 year old trees of kinnow mandarin and the tangelo cv. pearl (budded on rough lemon) during the summer and post rainy seasons. They found that the feeder roots (less than 0.2 cm in diameter) represented 84.69 % in kinnow and 83.15 % in pearl of the total root length during the summer season and 93.71 % in kinnow and 93.15 % in pearl in the post-rainy season. Most roots were in the 0-26 cm soil layer during summer and post-rainy seasons in both cultivars.

Medina, Urrutia, V.M. (1985) studied the root distribution of native mango grafted with three different cultivars. Root distribution was measured at various soil depths (0-80 cm) and distances from the tree (upto 6 m.). Total root density was similar with all cultivars. Seedling root stocks grafted with cultivars Haden, Diplomatico and kent had 61, 63 and 73 % of fibrous roots ($\leq$ 3 mm. in diameter) in the top 20 cm. of soil and with Haden at 20-40cm. depth.

Medina, Urrutia, V.M.; (1985) studied the root distribution of three mango cultivars in clay loam soil and observed that root distribution was similar in trees of Cvs. Carrie Irwin and Kent with the highest density of feeder roots (roots $\leq$2 mm. in diameter) 90-175 cm. from the trunk and at a soil depth of 0-20 cm. Tree of cv. Carrie possessed more feeder roots than trees of cv. Irwin or Kent.

Rao, D. P. and Mukherjee, S.K. (1985) reported that in April feeder root density was found to be highest at mid-point in the surface soil (0-30 cm) as compared to other locations. It decreased with depth and laterally from the trunk to the drip line; High yielding plants at all depths in the drip line as well as the mid point in April in case of different cultivars such as Himsagar, Fazli, Langra Gopal Bhog and Aswina of mango in West Bengal.

Roy R. N. et al. (1987) reported that the feeder root density was highest in April in mid point in surface soil (0-30 cm.) It decreased with a depth and from trunk to drip line, and was positively significantly correlated with quantities measured at all the situations i.e. depth, surface position and seasons as in case of Litchi.

Avilan, R.; Meneses, L. et al. (1985) studied the root distribution in sapodilla detected to a depth of 100 cm. They found that sixty percent of roots were in the top 40 cm.

of soil, the largest lateral concentration occurring at a distance corresponding to half the canopy radius.

Leaf nutrient status and Leaf nutrient standard :-

Since it has been a continuous process in Horticulture to quest for the optimum yield, it necessitates sound knowledge on various aspects of sapota and other fruit crops. The works done in this line eg. nutritional status of leaves and methods of sampling for evaluating nutritional status etc. relating to yield factor are reviewed below.

Pathak and Pandey (1978) studied the floctuation of leaf nutrient levels at different developmental stages of mango. They opined all the nutrients to be higher before flowering and lower during flowering and fruit growth excepting calcium which accumulated in leaves at various stages.

In a similar study, Samra at al. (1981) found higher N, P, K, Mg, S,Fe contents at flowering than at harvest. In leaves of both flowering and non-flowering shoots of mango varietal differences in nutrient levels were also noted. Thus leaves of Bashehari variety of mango had higher N, B,Ca and Mg contents than those ofChausa and Lucknow safeda cultivars.

Rajput et al. (1981) reported that the yield increased (number of fruits) significantly with N fertilization. One kg. N/tree was noted to produce maximum number of fruits/tree

where the leaf N level was 1.40 % in cv. Dashehari of mango in a growers orchard.

Nijjar et al. (1981) made opinion that the lowest levels of N, P. and K i.e. 100 gm, each of which was sufficient to meet the requirement of mango trees and produced the highest yield of fruits and leaf analysis values of N,P and K were 1.65, 0.106 and 0.5 percent respectively in mango cv. Dashehari.

Rameswar and Sultan (1981) reported positive correlation between leaf nutrient levels and yield in cv. Banganpalli of mango and suggested tentative leaf nutrient standards as N 1.00-1.25 %, P 0.07-0.10 %, K 0.60-0.73 %. Highest yields were noted at 1.02-1.30 % N levels.

Durrani, S.M.; Patil, V.K.; Kadam, B.A. (1982) studied the effect of N, P K on growth, yield, fruit quality and leaf composition of sapota. Two year trials were carried out with 8 year old trees of the sapodilla cv. Kalipatti receiving N at 200 or 400 g/tree, P_2O_5 at 88 or 176 g/tree and/or K_2O at 83 or 166 g/tree (in the 2nd year these rates were doubled). Of the three nutrients applied iindividually, N at 800 g/tree had the greatest effect on the yield (48.8-55.2 kg/tree) number of fruits (495/tree) and T.S.S. 19.2% the respective figures in the no.N control were 26.6-34.5, 318 and 17.1. The interactions of N x P, P x K and N x P X K were significant and the data are tabulated on trunk girth,

yield, number of fruits, pulp: seed ratio, TSS and acidity contents and on N, P and K contents in the leaves of bearing and non-bearing shoots.

Sampling Techniques for assessing mineral nitrient status of Sapota

Gopalkrishna, N.; and Gotmare, S.B. (1963) studied on the seasonal variation in leaf mineral composition of Chiku (Achras sapota L.). Analysis of leaf samples from 12 year old sapodillas showed that age of leaf and date of sampling had a pronounced effect on mineral composition.Root stocks also exerted a marked influance on leaf composition and yield. Preliminary studies of the N, P, K, ca and Mg contents of leaves indicated that sampling of 3-5 months old leaves initiated during winter flush could be reliable guide for assessing the nutrient status of the tree.

Lefevere, P. (1974) reported on the leaf sampling methods on Golden Delicious apple. In a comparison of several methods of sampling apple leaves, carried out in a 15-year-old Golden Delicious Orchard on 3 dates there was no significant differences between the methods in the figures obtained for N, P, K, Mg, Fe and Mn. Only Ca showed marked differences between the methods of sampling. The position of the leaf on the stem and the presence of the petiole tended to influence the values obtained.

Sen (1973) viewed the changes in nitrogen in mango leaves during early spring growth. Leaf N declined during the 4 weeks period, but total N content rose.

Pathak and Pandey (1976) suggested sampling of mango leaves from 4th and 5th positions of the shoot.

Devrani and Santram (1980) suggested that leaves of the first flush (6-8 months old) were most suitable for sampling in "on" year in mango.

Chadha et al. (1981) suggested that 6 to 7 months old leaves collected from middle of the non-fruiting shoots sampled from all directions and heights were the ideal ones for assessing the nutritional status of mango leaves.

Singh and Rajput (1981) studied on leaf analysis of guava for nitrogen nutrition. The best leaf sampling time of N, P, K was either August or January/February and 1.36-1.91 % N was considered the optimal level.

Chadha et al. (1984) reported on leaf nutrient status of three mango cvs. at flowering and post harvest stages. Leaf N, P, K, Ca, Mg and S contents were determined in March and June in cvs. Dasheri, Chausa and Lucknow safeda. The contents of all nutrients declined during post harvest in all cultivars and this was attributed to earlier translocation into the developing fruits.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment entitled "Study of feeder root system of some important varieties of sapota" was carried out at Bhubaneswar during October, 1986 to May, 1987 in which 3 (three) cultivars were taken for study.

EXPERIMENTAL SITE :

The experiment was conducted at Horticultural Research Station, O.U.A.T., Bhubaneswar.

SOIL :

The soil of the experimental plot is found to be sandy loam and lateritic in nature. Composite soil samples (from depth of 15 cm to 90 cm) were taken from different pockets of the experimental plot under study and the samples were analysed following standard laboratory procedure. The mechanical and chemical composition of the soil samples were shown in Table 2(a) and 2(b) respectively.

TABLE-2(a). MECHANICAL COMPOSITION OF SOIL SAMPLES OF THE EXPERIMENTAL PLOT.

Mechanical constituents		Percentage on air dry basis
Coarse sand	-	50.27
Fine sand	-	29.23
Silt	-	11.00
Clay	-	9.50
Textural class	-	Sandy loam

TABLE-2(b) CHEMICAL COMPOSITION OF SOIL SAMPLES OF THE EXPERIMENTAL PLOT

Chemical constituents			Amount present on oven dry basis.
(i)	pH	-	5.9
(ii)	Organic carbon	-	0.56 %
(iii)	Total nitrogen	-	963.2 kg/ha.
(iv)	Available nitrogen	-	235.8 kg/ha.
(v)	Available Phosphorus		11.5 kg/ha
(vi)	Available Potash	-	98 kg/ha.
(vii)	C/N ratio	-	11.6

Soil sampling :-

Soils were collected in polythene bags from surface soil viz. 6-9" depth from 15 different spots of the experimental plot by digging with an iron spade and uniformly mixed together. And at last a mixture of one kg. was taken for analysis.

Soil Analysis :-

(i) pH by Backman's pH meter (Piper, 1966).

(ii) Organic carbon by Walkley and Black's rapid titration method. (Walkley and Black, 1934).

(iii) Total nitrogen - Total soil nitrogen was estimated by modified Kjeldahl's (macro) method as given in (Jackson, 1962).

(iv) Available Nitrogen - Available nitrogen was estimated by Potassium Permanganate ($KMnO_4$) method outlined by "Subbiah and Asija, 1956".

(v) Available Phosphorus - Available phosphorus was extracted by

0.5 N sodium bicarbonate solution (pH 8.5) and estimated by chlorostannous reduced molybdophosphoric blue colour method (by ~~Bray's~~ Olsen's strong reagent (Bray, ~~1948~~ 1940).

(vi) Available Potash estimated by flame photometry and by Morgan's reagent (Jackson, 1962.)

Mechanical constituents by Bouyoucos Hydrometer (Bouyoucos, 1962).

CLIMATE :

Bhubaneswar is located at 20-15°North latitude and 85-52°East Longitude and is situated at an altitude of 25.5 meters above the sea level. It is situated 62 km. west of Bay of Bengal in the State of Orissa. It gets a mean annual precipitation of about 1646.43 mm of which 1216.04 mm is received mainly from June to September and 430.39 mm in the rest part of the year. The average maximum temperature ranges from 35°C to 39°C during May and June, while average minimum temperature varies from 13°C to 15°C during December to January. The meteorological data obtained from the University Observatory, Bhubaneswar was shown in Table-1.

TABLE - 1

Monthly meteorological data recorded at Bhubaneswar observatory from June, 1986 to May, 1987.

Month	Temperature °(C)			Relative humidity (%)			Wind velocity(km/hr)	Rainfall (mm)	No.of rainy days	Mean sunshine hr/day
	Max.	Min.	Mean	Morn. 7 A.M	A.N 4 P.M	Mean				
June '86	34.4	26.0	30.2	86	68	77	10.6	267.7	18	5.3
July'86	32.4	25.4	28.9	89	75	82	8.9	393.3	23	5.1
Aug.'86	32.3	26.7	29.5	89	73	81	7.3	288.7	22	5.8
Sept.'86	32.8	25.0	28.9	91	71	81	5.0	273.8	19	6.3
Oct.'86	31.5	22.6	27.05	90	68	79	4.5	187.5	10	7.9
Nov.'86	29.8	19.4	24.6	92	58	75	3.9	173.9	8	7.9
Dec.'86	28.6	17.0	22.8	91	51	71	4.3	8.4	2	8.3
Jan.'87	28.3	15.3	21.7	88	43	65	3.9	5.4	1	9.0
Feb.'87	31.5	17.5	24.5	90	36	63	4.1	-	-	9.8
March'87	34.1	21.2	27.7	90	42	66	7.1	10.2	5	8.9
April'87	36.2	24.9	30.5	89	54	71	13.4	19.4	4	8.5
May '87	40.8	26.1	33.4	84	50	67	11.9	56.0	6	8.8

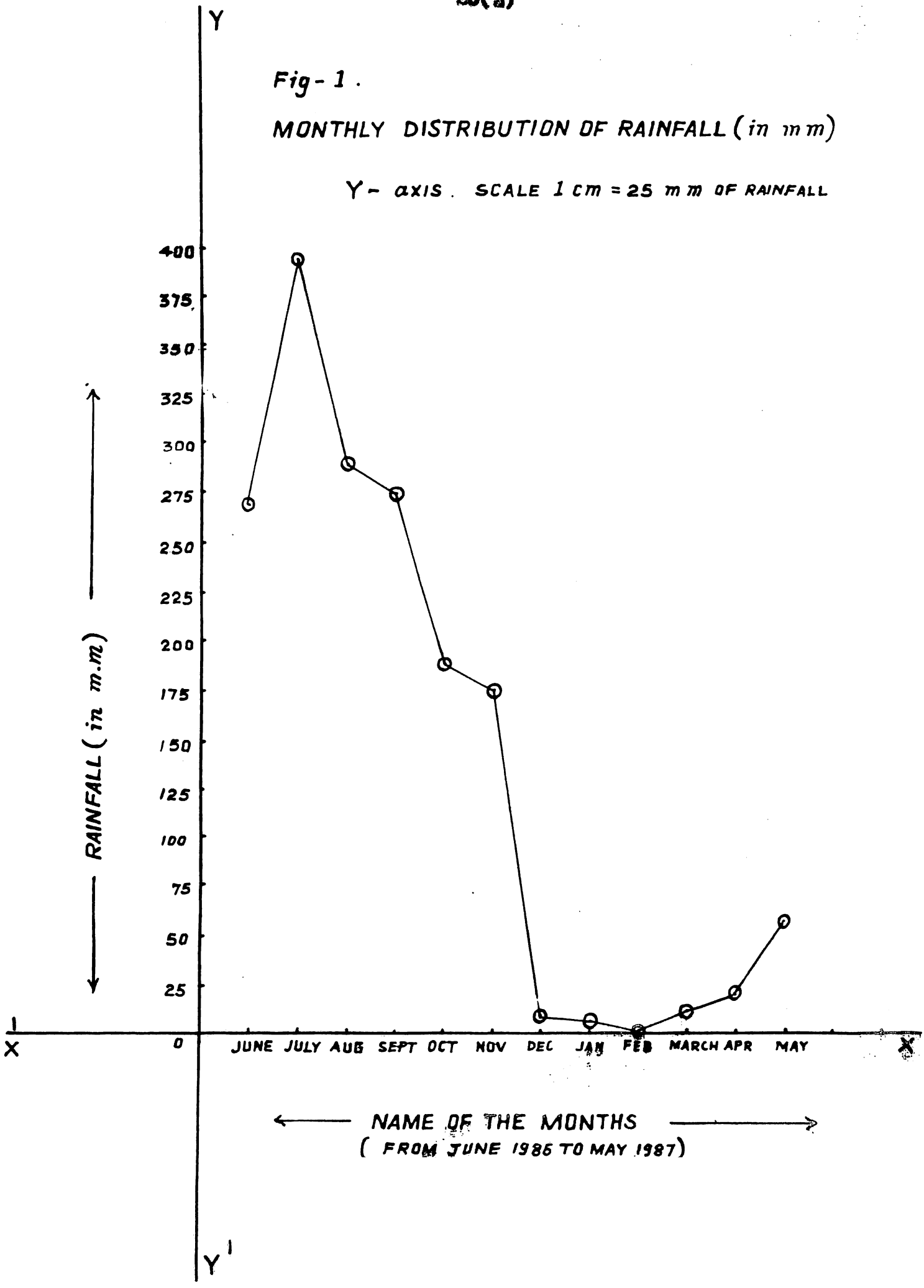
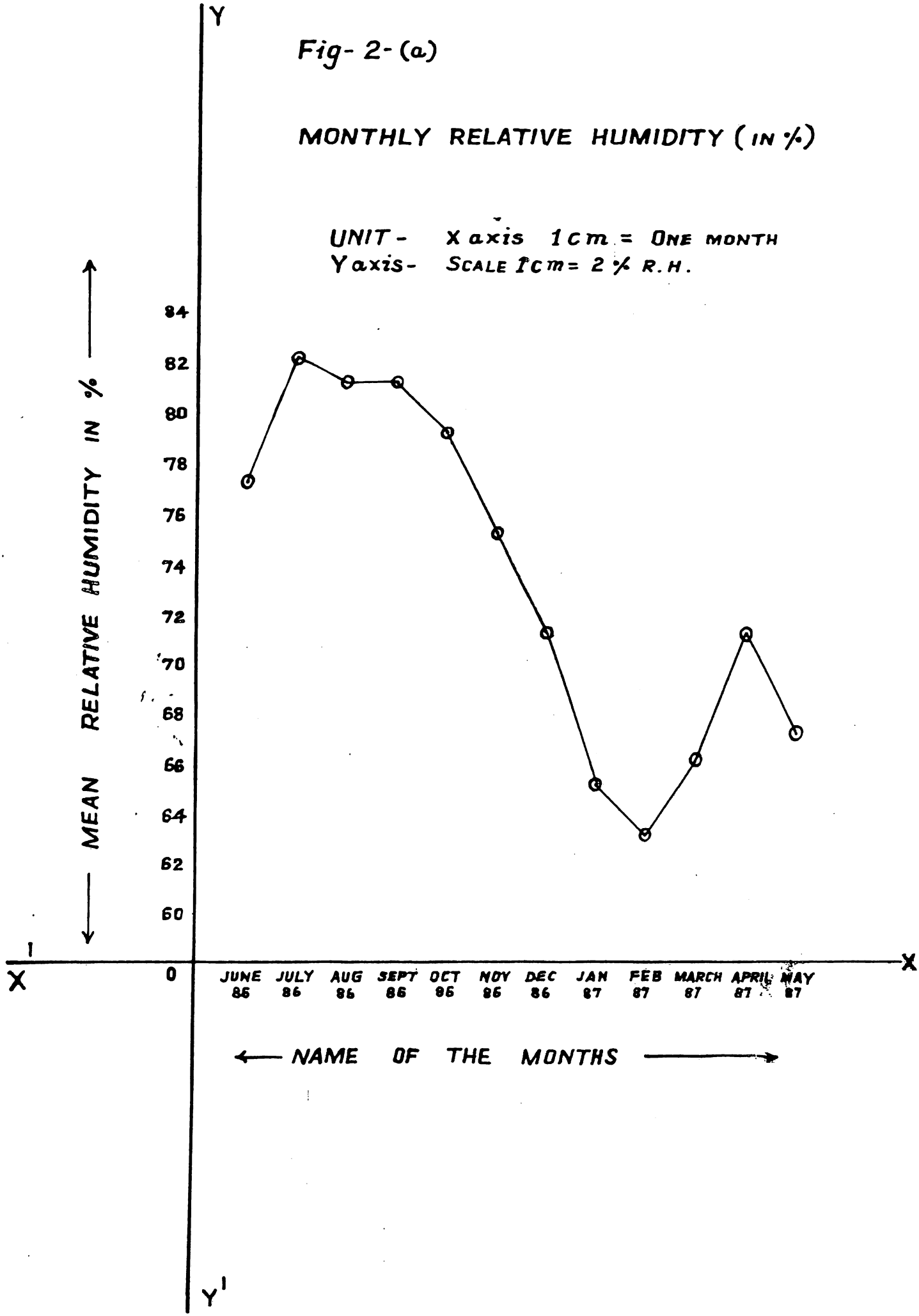
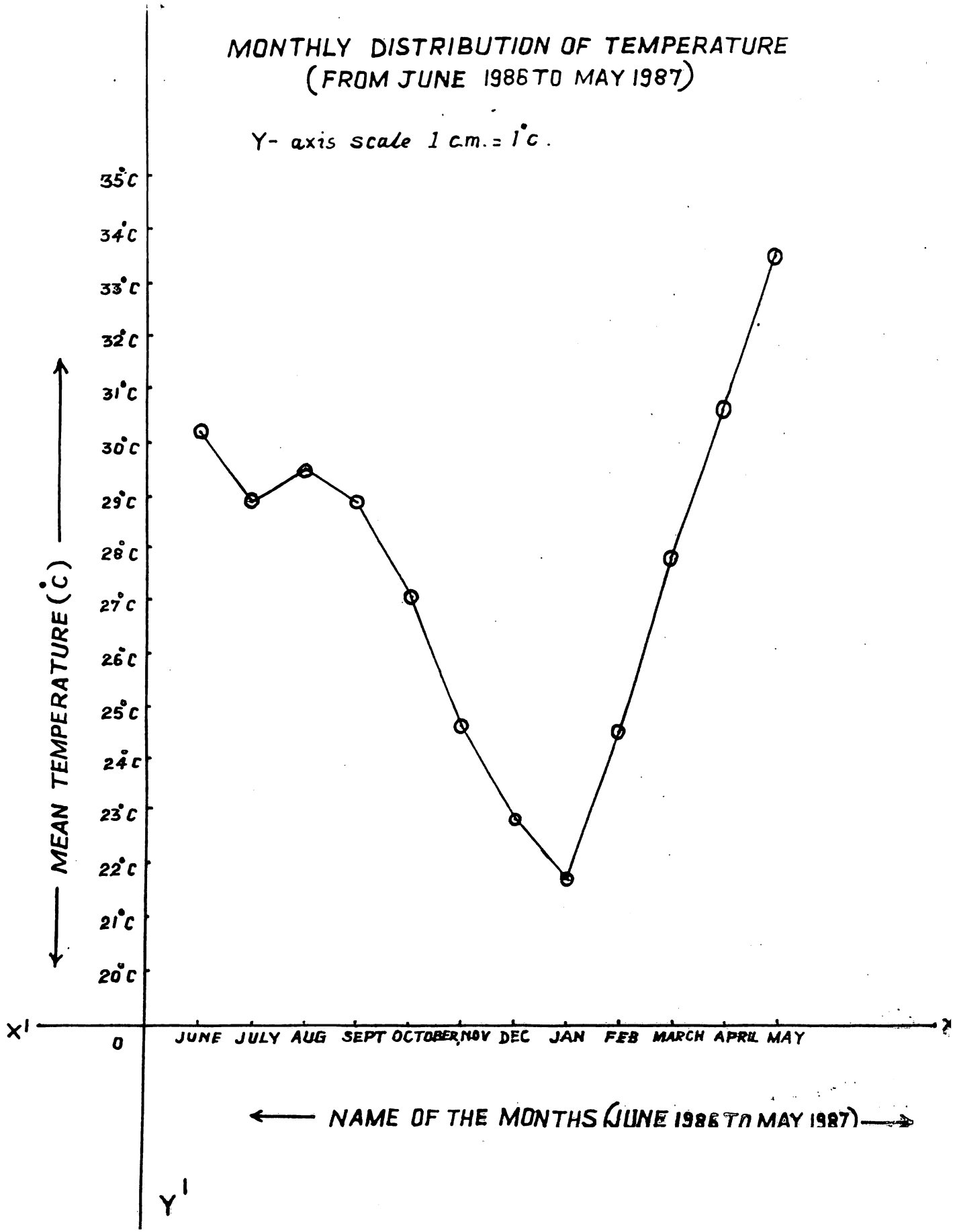

Y
Fig - 1 .
MONTHLY DISTRIBUTION OF RAINFALL (in mm)
Y - axis . SCALE 1 cm = 25 mm OF RAINFALL
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
RAINFALL (in m.m)
1
X
0
JUNE JULY AUG SEPT OCT NOV DEC JAN FEB MARCH APR MAY
X
NAME OF THE MONTHS
(FROM JUNE 1986 TO MAY 1987)
Y'

Fig- 2- (a)

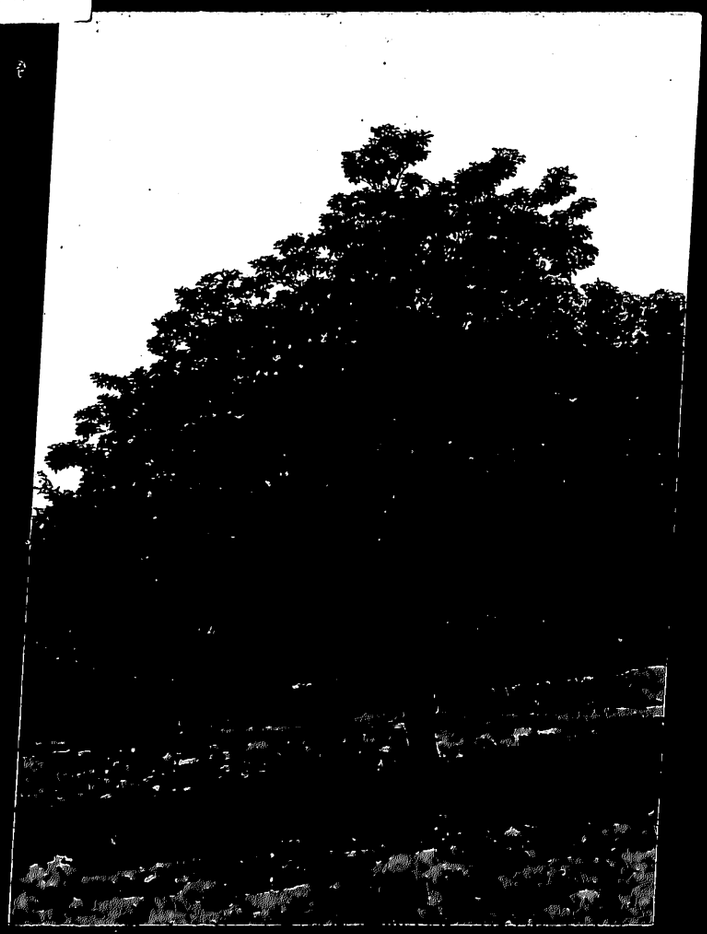
MONTHLY RELATIVE HUMIDITY (IN %)

UNIT - X axis 1 cm = ONE MONTH
Y axis - SCALE 1 cm = 2 % R.H.




MONTHLY DISTRIBUTION OF TEMPERATURE
(FROM JUNE 1986 TO MAY 1987)
Y- axis scale 1 c.m. = 1°c.
35°C
34°C
33°C
32°C
31°C
30°C
29°C
28°C
27°C
26°C
25°C
24°C
23°C
22°C
21°C
20°C
MEAN TEMPERATURE (°C)
X¹
0
JUNE JULY AUG SEPT OCTOBER NOV DEC JAN FEB MARCH APRIL MAY
X
NAME OF THE MONTHS (JUNE 1986 TO MAY 1987)
Y¹

cv.Kalipatti



cv. Cricket ball

cv. Chaatri

EXPERIMENTAL DESIGN WITH OBSERVATION TECH.

The experiment was laid out in a R.B.D.(Randomised Block Design) with 3 treatments in 3 replications. The treatments were varieties such as 1) Kalipatti, 2) Cricketball 3) Chaatri. For collecting data on various biometric observations, three plants of each cultivars in a replication were selected at random. The selected plants were tagged and labelled. The average value of three plants per replication of each treatment for each character were subjected to statistical analysis, for determining the feeder root system etc. Total 27 numbers of trees were taken for the experiment purpose.

CHARACTER STUDIED -

Observations were recorded on various aspects such as -

1. Feeder root distribution at different depths i.e. (0-30 cm), (30-60 cm), (60-90 cm) at different positions like Mid point and Drip line in every month (i.e. from October, 1986 to May, 1987).
2. Collection of Leaf samples for leaf tissue analysis (i.e. N,P,K,)
3. Height of the tree
4. Canopy area.
5. Soil N, P, K status at the begining of the experiment.

SELECTION OF TREES -

In the experimental research station the sapota trees were planted in the year 1961. The trees were of hearly

25 years old. The trees which have been selected for the experiment were healthy, disease free and well spread in all directions, equally vigorous and of same age, size and shape. The trees were availing equal sunshine, temperature, relative humidity and wind velocity etc. and grown under equal cultural and management conditions. The selected plants for experimental purpose were manured in the month of July, 1986 at the rate of 250 grams of CAN, 500 grams of single super Phosphate and 500 grams of M.O.P. and half basket of F.Y.M. per plant per year. The fertilizers used have been applied in a single split dose to the base of the plants in circular rings. The base of the trees were digged properly and kept out of weed growth. The varieties for the experimental findings were 1) V_1-Kalipatti 2) V_2- Cricketball 3) V_3 - Chaatri.

HEIGHT OF THE PLANT -

The height of the plant from the ground level upto the tip of the main trunk was recorded by means of a meter scale in C.M. in monthly interval from October, 1986 to May, 1987.

CANOPY AREA -

The canopy area or spread of tree was measured in all directions i.e. N/S spread and E/W spread with the help of following formula πr^2 (Where π = 22/7 and r = radius of the canopy area (taking the mean value from trunk to East to West, to North and to South respectively.)

The observations were obtained at an interval of one month starting from October, 1986 to May, 1987.

FEEDER ROOT DISTRIBUTION OF DIFFERENT DEPTHS -

The feeder roots were collected by soil auger method as this method is easy and convenient for estimating the vertical distribution of feeder roots in the soil. Soil cores are extracted along with the feeder roots at three depths i.e. 0-30 cm, 30-60 cm, 60-90 cms. in the profile and at two positions. (Mid point between trunk and at drip line and drip line) in monthly interval i.e. from October, 1986 to May, 1987. Feeder roots of viz. 0-15 m.m. size on four sides were collected from soil core. Roots were collected separately from each point and at each depth after washing out the soil by water clean debris on fine mershed wire net seives. Then the fresh weight of the roots were taken. The roots thus collected were dried for 24 hours in an oven at 80°C and their dry weights were recorded.

LEAF SAMPLING FOR N, P, K ANALYSIS -

Leaf samples were collected for estimation of leaf nutrient status at monthly interval i.e. from October, 1986 to May 1987 as suggested by Gopalkrishna, N, (1963), Chapman (1964), Chadha et al. (1981) and Jackson (1973). Leaves were collected from the latest mature flush of growth i.e. from the middle (5th and 6th leaves of whorl) of terminal growth. Sampling was done from the non-flowering terminals of branches and 20 leaves

in all were collected at the rate of 5 leaves from each compass side of the plant selected for experimental purpose.

PLANT ANALYSIS :

(i) Total plant nitrogen was determined by the help of microkjeldahl apparatus modified by parnas and wagner as described by Pregl (1930).

(ii) Plant Phosphorus was determined on wet digest by colorimetric methods.

(iii) Plant Potassium was determined on wet digest by flame photometric methods.

Colorimetric and flame photometric methods on wet digest for determination of plant phosphorus and Potassium respectively was given in "Diagnosis and Improvement of saline and Alkaline Soils" (Agricultural Hand Book No.60) by united states Salinity Laboratory (1964).

STATISTICAL ANALYSIS -

The data obtained on different experimental findings in the different treatments of the study were subjected to statistical analysis in R.B.D. (Randomised Block Design). For testing the significance of the findings, 'F' test was seen at 5 % level.

To compare the two treatment means and to compare the standard error for each factor, appropriate standard error for each factor was worked out. The critical differences (C.D.) was calculated at 5 % level of significance by using the formula as follows.

1. S.E.(m) $\pm = \sqrt{\frac{EMS}{r}} = \sqrt{\frac{EMS}{3}}$

where, EMS = Error Means sum of squares.

r = Number of replications.

2. S.E.(m) $\pm$ for variety or treatment (v) $= \sqrt{\frac{EMS}{rd}} = \sqrt{\frac{EMS}{9}}$

where EMS = Error Means sum of squares.

r = Number of replications

d = Number of depths

3. S.E.(m) $\pm$ for Depth (D) $= \sqrt{\frac{EMS}{rv}} = \sqrt{\frac{EMS}{9}}$

where EMS = Error means sum of squares

r = Number of replications

v = Number of variety.

4. S.E.(m) for (V x D) $= \sqrt{\frac{EMS}{r}} = \sqrt{\frac{EMS}{3}}$

Where EMS = Error Mean sum of squares.

r = Number of replications.

5. C.D. at 5 % = S.E.(m) x 1.414 x 't' value at error degrees of freedom.
(4 df value = 2.776
16 df value = 2.120)

CHAPTER IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

In the present study, feeder roots with various biometric observations such as height of the tree, canopy area were recorded in sapota varieties Kalipatti, Cricketball and Chaatri. The results are mentioned in tabular forms and illustrated in graphical presentations.

Feeder roots :-

(a) Root density distribution of sapota cultivars at mid-point

(i) Root density distribution of sapota cultivars on various months (Fresh weight):-

Observations were taken on fresh weight of the root from October 1986 to May, 1987 at mid point of the sapota trees and Table-3 may be perused in connection to it. It is revealed from the Table-3 that, significant differences were observed in the months of October, 1986 and from December, 1986 to May, 1987. But there was no significant difference among the treatments in the month of November, 1986. In the month of October, V_1 was significantly superior to V_3, V_2 was also significantly superior to V_3. Highest fresh weight was recorded in V_1 (i.e. 0.90 gm). In the month of November, the highest fresh weight of roots was recorded in V_1 i.e. 1.04 gm. followed by the treatments V_2 and V_3. In the month of December, V_1 was significantly superior to all the varieties V_2 and V_3. V_2 was also significantly superior to V_3. The varieties themselves were significantly different.

In the month of January, V_1 was significantly superior to V_3, and V_2 was also significantly superior to V_3. In the month of February, V_1 was significantly superior to V_3, and also V_2 was significantly superior to V_3. But there was no significant difference recorded between V_1 and V_2.

In the month of March, V_1 was significantly superior to all varieties i.e. V_2 and V_3. V_2 was also significantly superior to V_3. In the month of April, V_1 was found significantly superior to other two treatments i.e. V_2 and V_3. V_2 was also found significantly superior to V_3. In the month of May, V_1 was found significantly superior to V_3, and also significant difference was observed between V_2 and V_3, and V_2 was significantly superior to V_3.

It is seen from the Table 3 and Fig.3 that in each treatment the fresh weight of the roots were increased from October 1986 to May, 1987 and then it declined in the month of April, 1987 and May, 1987 and highest fresh weight of roots were observed in the month of March, 1987. More roots were found in V_1 (Kalipatti) as compared to other two varieties. In V_3 least fresh weight of roots were recorded.

(ii) Root density distribution of sapota cultivars on various months (Dry weight) :-

The dry weight of roots were recorded to be maximum in V_1 (0.98 gm) followed by V_2 and V_3. It is revealed from

the Table-4 and Fig.4, that significant difference was observed in all months under report except in the month of December, 1986. In the month of October and November, 1986, V_1 was significantly superior to V_3,and V_2 also significantly superior to V_3.

In the month of January, 1987, V_1 was significantly superior to other varieties and V_2 was also significantly superior to V_3. In the month of February, V_1 was significantly superior to V_2 and V_3. From March to May significant difference was observed among the treatments, but V_1 was significantly superior to other two varieties.

(iii) Root density distribution of sapota cultivars on various months and depths (Fresh weight) :-

It is observed from the Table-5 and Fig.5 that, maximum fresh weight of the roots, were recorded at D_1 i.e. 0-30 cm. depth and it decreased with an increase of depths. Significant difference was observed among the treatments. At D_1 (0-30 cm) maximum fresh weight of the roots were observed i.e. 1.09 gm. followed by D_2 i.e. 0.56 gm, and D_3 i.e. 0.37 gm. during the month of October and there was significant difference among the treatments itself and in the month of October, 1986 to May, 1987 significant difference was observed among the treatments. D_1 was significantly superior to D_2 and D_3 and D_2 was significantly superior to D_3 .

TABLE - 3

Average root density distribution of Sapota cultivars on various months at Mid Point (Fresh weight) (Gram fresh wt. per cubic decimeter)

Month/ variety	October	November	December	January	February	March	April	May
V_1	0.90	1.04	1.25	1.30	1.33	1.43	1.40	1.34
V_2	0.87	1.03	1.17	1.27	1.29	1.38	1.32	1.29
V_3	0.73	0.89	1.04	1.11	1.17	1.29	1.19	1.17
'F' test	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE(m) ±	0.016	0.034	0.018	0.016	0.019	0.0163	0.0202	0.0166
C.D.(0.05)	0.0628	-	0.07068	0.0628	0.0745	0.06398	0.0792	0.06515

Sig - Significant at 1 % Level.

NS - Non-significant.

Fig.3. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AT MID POINT. (FRESH WEIGHT)

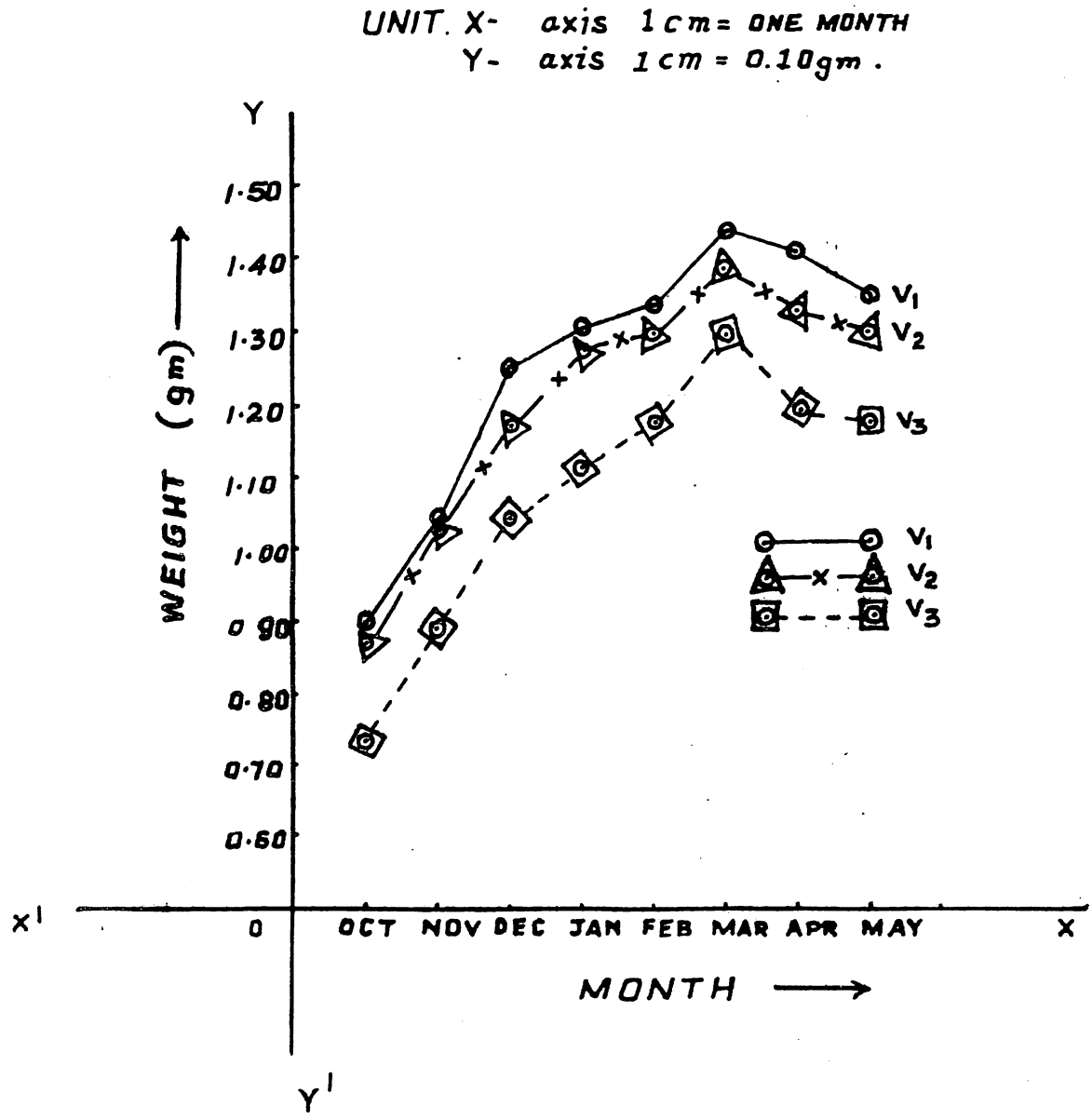


TABLE - 4

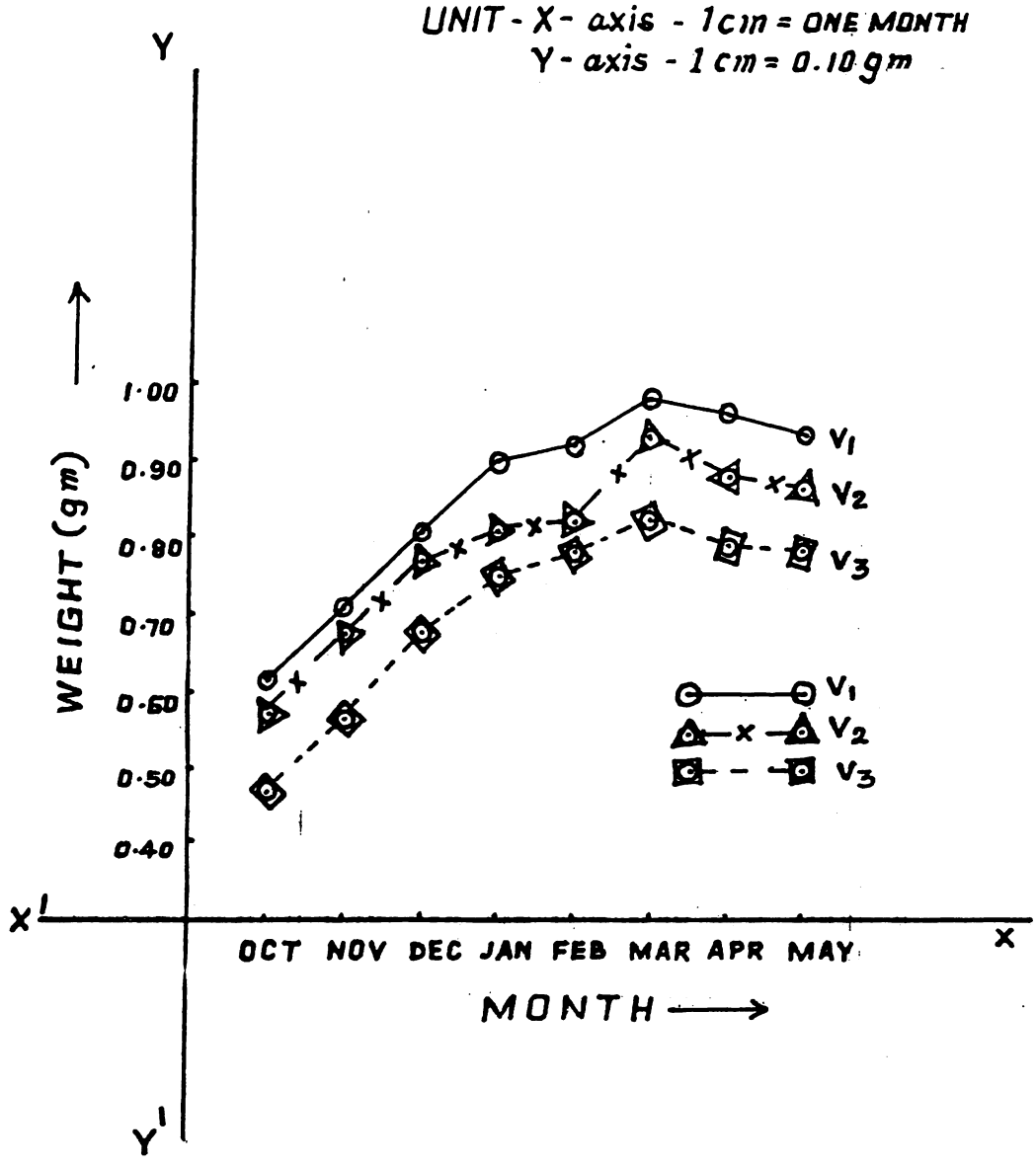
Average root density distribution of Sapota cultivars on various months at Mid point (Dry wt.)(Gram dry wt./cubic decimenter)

Month/ variety	October	November	December	January	February	March	April	May
V_1	0.62	0.71	0.81	0.90	0.92	0.98	0.96	0.93
V_2	0.58	0.68	0.77	0.81	0.82	0.93	0.88	0.86
V_3	0.47	0.57	0.68	0.75	0.78	0.82	0.79	0.78
'F' test	Sig.**	Sig.**	N.S.	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.016	0.017	0.034	0.016	0.015	0.015	0.0203	0.015
C.D.(0.05)	0.0628	0.0667	-	0.0628	0.0588	0.0588	0.0785	0.0588

Sig. - Significant at 1 % Level

N.S. - Non-significant.

Fig-4. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AT MID-POINT (DRY WEIGHT)



It is seen from the Table-5 (Fig.5), that maximum fresh weight of roots were recorded at D_1 i.e. (0-30 cm) followed by D_2 (30-60 cm) and D_3 (60-90 cm) respectively.

(iv) Root density distribution of sapota cultivars on various months and depths (Dry weight) :-

It is seen from the Table-6 and Fig.6 that significant difference was recorded with respect to depths of the sapota root system. From October'86 to May'87, D_1 was found significantly superior to D_2 and D_3 and also D_2 was significantly superior to D_3. The quantities of feeder roots in dry weight available were 0.78 to 1.15 gms. in D_1, 0.34 to 0.62 in D_2 and 0.21 to 0.44 gm, in D_3 from October, 1986 to May, 1987.

(v) Root density distribution of Sapota cultivars on various months and depths (Fresh weight):-

It is revealed from the Table-7 that, significant difference was observed in the month of October, 1986 and December, 1986 to May 1987. And in the month of November, 1986, there was no significant difference among the treatments. In the month of October, 1986, it is observed that V_1D_1 was significantly superior to all other treatments

TABLE - 5

Average root density distribution of Sapota cultivars on various months and depths at Mid point (Fresh wt.) (Gram fresh wt. per cubic decimeter)

Month/ Depth	October	November	December	January	February	March	April	May
D_1	1.09	1.20	1.54	1.54	1.61	1.68	1.63	1.55
D_2	0.56	0.73	0.91	0.92	1.02	1.07	1.02	0.98
D_3	0.37	0.49	0.70	0.72	0.77	0.85	0.80	0.77
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.02	0.025	0.021	0.024	0.029	0.028	0.027	0.025
C.D.(0.05)	0.0785	0.0981	0.0824	0.0942	0.1138	0.1099	0.1059	0.0981

Sig.** Significant at 1 % Level.

Fig-5. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS MONTHS AND DEPTHS AT D POINT. (FRESH WEIGHT)

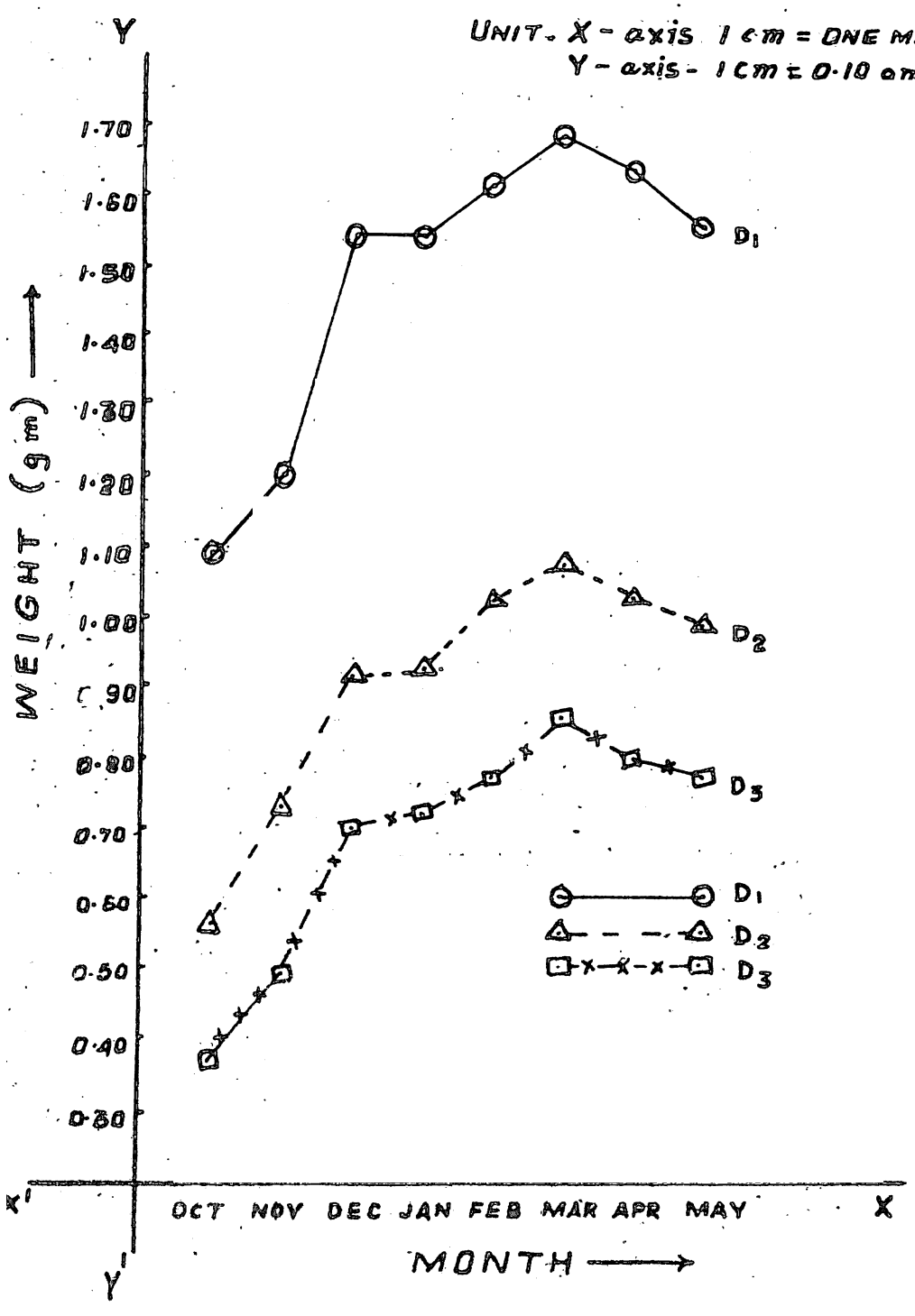


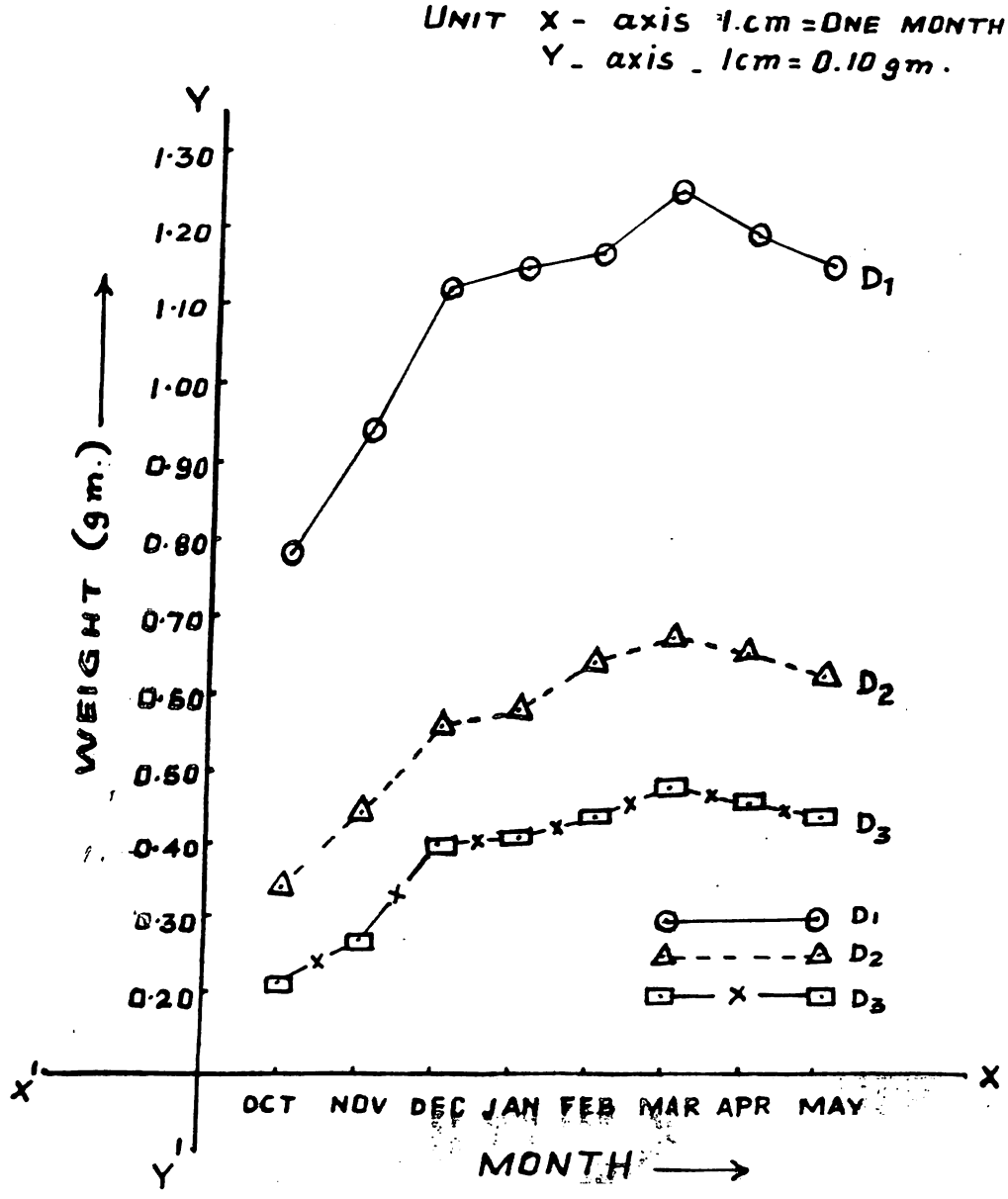
TABLE - 6

Average root density distribution of Sapota cultivars on various months and depth at Mid point (Dry wt.)
(Gram Dry wt. per cubic decimeter)

Month/ Depth	October	November	December	January	February	March	April	May
D_1	0.78	0.94	1.12	1.15	1.17	1.25	1.19	1.15
D_2	0.34	0.45	0.56	0.58	0.64	0.67	0.65	0.62
D_3	0.21	0.27	0.40	0.41	0.44	0.48	0.46	0.44
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.022	0.025	0.0^{20}	0.023	0.025	0.028	0.028	0.029
C.D.(0.05)	0.0863	0.0981	0.07$_{85}$	0.0902	0.0981	0.1099	0.1099	0.1138

Sig - Significant at 1 % Level.

Fig. 6. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AND DEPTHS AT MID POINT. (DRY WEIGHT).



followed by V_3D_1, V_2D_1, V_2D_2 and V_3D_2 and the least weight was observed in V_1D_3 and V_3D_3. In the month of November, the maximum fresh weight of the roots were observed in V_1D_1 i.e. 3.15gms. followed by V_2D_1, V_3D_1, V_2D_2 and V_3D_2 and the least weight was observed in V_1D_3 (0.63 gm). In the month of December, the treatment V_1D_1 was found significantly superior to all other treatments followed by V_2D_1, V_3D_1, [illegible], V_3D_2 and V_2D_2, V_1D_2 and V_3D_3 were at par and least weight was recorded in V_1D_3. In the month of January, 1987 V_1D_1 has become significantly superior to all other treatments followed by V_3D_1, $V_2D_1$and V_2D_2 and least weight was observed in V_1D_3 and V_2D_3. In the month of February, V_1D_1 become significant over all other treatments followed by V_2D_1, V_3D_1 V_3D_2, V_2D_2 and the least was observed in V_1D_3. In the month of March, V_1D_1 was significantly superior to all other treatments followed by V_2D_1, V_3D_1, V_2D_2 and V_3D_2 and the least was observed in V_1D_3. In the month of April, V_1D_1 was significantly superior to all other treatments followed by V_2D_2, V_3D_1, V_2D_2 and V_1D_2 and least was observed in V_1D_3 and V_3D_3. In the month of May, V_1D_1 was significantly superior to all other treatments followed by V_2D_1, V_3D_1, V_2D_2 and V_3D_2 and the least weight was observed in V_1D_3.

It is seen from the Table-7 that the fresh weight of the roots were increased from October, 1986 to March, 1987 in each treatment and then it declined in the month of April, 1987 and May, 1987.

TABLE - 7

Average root density distribution of sapota cultivars on various months and depths at mid point (Fresh weight) (Gram fresh wt. per cubic decimeter)

Month/ Treatment	October	November	December	January	February	March	April	May
V_1D_1	2.97	3.15	3.57	3.74	3.75	3.84	3.72	3.60
V_1D_2	0.78	0.93	1.14	1.26	1.41	1.53	1.47	1.32
V_1D_3	0.42	0.63	0.70	1.05	0.87	1.11	1.17	1.05
V_2D_1	1.50	1.82	2.37	2.28	2.52	2.52	2.49	2.31
V_2D_2	1.26	1.53	1.23	1.67	1.44	2.04	1.98	1.86
V_2D_3	0.48	0.93	1.20	1.05	1.20	1.32	1.50	1.17
V_3D_1	1.68	1.56	2.28	2.34	2.43	2.49	2.40	2.31
V_2D_2	1.08	1.08	1.89	1.26	1.95	1.59	1.44	1.38
V_3D_3	0.46	0.84	1.14	1.20	1.32	1.32	1.17	1.17
'F' test	Sig.**	N.S.	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.0089	0.053	0.0078	0.0073	0.0069	0.0086	0.0076	0.0069
C.D.(0.05)	0.0266	-	0.0234	0.0218	0.0207	0.0257	0.0228	0.0207

Sig** - Significant at 1 % Level.

N.S.- Non-significant.

TABLE - 7a

Effect of feeder root system of different varieties of sapota with respect to depths on various months at mid point(Fresh wt.)(gram fresh wt.per cubic decimeter)

	October	November	December	January	February	March	April	May
Variety								
V_1(Kalipatti)	0.463	0.523	0.601	0.672	0.67	0.72	0.707	0.663
V_2(Cricketball)	0.360	0.475	0.533	0.555	0.573	0.653	0.66	0.593
V_3(Chaatri)	0.391	0.387	0.59	0.533	0.633	0.60	0.557	0.54
'F' test	Sig.**	NS	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.0089	0.053	0.0078	0.0073	0.0069	0.0086	0.0076	0.0069
C.D.(0.05)	0.0266	-	0.0234	0.0218	0.0207	0.0257	0.0228	0.0207
Depth.								
D_1(0-30 cm)	0.676	0.725	0.913	0.928	0.966	0.983	0.957	0.913
D_2(30-60cm)	0.346	0.393	0.47	0.465	0.533	0.573	0.54	0.507
D_3(60-90 cm)	0.151	0.267	0.337	0.366	0.376	0.416	0.427	0.377
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0089	0.053	0.0078	0.0073	0.0069	0.0086	0.0076	0.0069
C.D.(0.05)	0.0266	0.1589	0.0234	0.0218	0.0207	0.0257	0.0228	0.0207

Sig** - Significant at 1 % Level.

N.S.- Non-significant.

(vi) Root density distribution of Sapota cultivars on various months and depths (Dry weight):-

The dry weight of roots were recorded at monthly intervals. It is seen from the Table-8 that significant difference was observed among the treatments in each and every month.

In the month of October, 1986 V_1D_1 (2.16 gm) was significantly superior to all other treatments, and there was significant difference among the treatments, and the least dry weight was observed in V_1D_3 (0.24gm) and V_3D_3(0.33 gms). In the month of November, V_1D_1 was significantly superior to all other treatments followed by V_2D_1, V_3D_1, V_2D_2 and the least dry weight was observed in V_1D_3((0.34 gm) and V_3D_3 (0.48 gm). In the month of December, 1986 and January, 1987 in case of V_1D_1 dry weight (2.61 gm and 2.77 gm respectively) was significantly superior to all other treatments followed by V_2D_1, V_3D_1 in December and January and V_3D_2 in December and V_2D_2 in January, 1987 and the least dry weight was observed in V_1D_3 (0.41 gm and 0.61 gm respectively).

In the month of February, 1987, V_1D_1 was significantly superior to all other treatments followed by V_2D_1, V_3D_1, V_3D_2 and V_1D_2 and the least weight was observed in V_1D_3. All other treatments were significantly superior to V_1D_3.

TABLE - 8

Average root density distribution of Sapota cultivars on various months and depths at mid point (Dry weight) (gram dry wt. per cubic decimeter)

Month/ treatment	October	November	December	January	February	March	April	May
V_1D_1	2.16	2.28	2.61	2.77	2.80	2.87	2.75	2.65
V_1D_2	0.46	0.58	0.71	0.82	0.89	0.95	0.92	0.87
V_1D_3	0.24	0.34	0.41	0.61	0.51	0.50	0.67	0.61
V_2D_1	1.10	1.31	1.68	1.73	1.87	1.88	1.83	1.73
V_2D_2	0.78	0.98	0.77	1.07	0.89	1.28	1.23	1.17
V_2D_3	0.27	0.52	0.69	0.61	0.69	0.76	0.87	0.67
V_3D_1	1.16	1.12	1.66	1.70	1.68	1.84	1.77	1.70
V_3D_2	0.66	0.67	1.18	0.80	1.22	1.02	0.93	0.87
V_3D_3	0.33	0.48	0.66	0.69	0.76	0.77	0.67	0.67
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0073	0.008	0.0073	0.0062	0.0078	0.0075	0.0075	0.0078
C.D.(0.05)	0.02188	0.02398	0.0239	0.0185	0.02338	0.02248	0.02248	0.02338

Sig.* - Significant at 1 % Level.

TABLE - 8a

Effect of feader root system of different varieties of sapota with respect to depths on various months at mid point (Dry weight) (gram dry wt. per cubic decimeter)

	October	November	December	January	February	March	April	May
Variety								
V_1 (Kalipatti)	0.3177	0.355	0.414	0.467	0.467	0.48	0.482	0.459
V_2 (Cricketball)	0.238	0.312	0.349	0.378	0.383	0.435	0.437	0.397
V_3 (Chaatri)	0.238	0.252	0.388	0.354	0.407	0.403	0.374	0.36
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0073	0.008	0.0073	0.0062	0.0078	0.0075	0.0075	0.0078
C.D.(0.05)	0.02188	0.02398	0.0239	0.0185	0.02338	0.02248	0.02248	0.02338
Depth								
D_1 (0-30 cm)	0.491	0.523	0.661	0.688	0.705	0.732	0.705	0.675
D_2 (30-60 cm)	0.211	0.248	0.295	0.299	0.333	0.361	0.342	0.323
D_3 (60-90 cm)	0.093	0.149	0.194	0.212	0.217	0.225	0.245	0.217
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0073	0.008	0.0073	0.0062	0.0078	0.0075	0.0075	0.0078
C.D.(0.05)	0.02188	0.02398	0.0239	0.0185	0.02338	0.02248	0.02248	0.02338

** - Significant at 1 % Level.

In the month of March, V_1D_1 (2.87 gms) was significantly superior to all other treatments followed by V_2D_1 (1.88 gms), V_3D_1 (1.84 gms) and the least dry weight was observed in V_1D_3 (0.50 gm) and all other treatments were significantly superior to it.

In the month of April and May, 1987, in case of V_1D_1, the dry weight (2.75 gm, 2.65 gms respectively) was significantly superior to all other treatments followed by V_2D_1, V_3D_1, V_2D_2 and V_3D_2 and the least dry weight was observed in V_1D_3 (0.67 gm and 0.61 gms) and V_3D_3(0.67 gm and 0.67 gm) respectively. There was no significant difference between V_3D_3 and V_1D_3, V_3D_2 and V_1D_2.

(b) Root density distribution of sapota cultivars at Drip Line :-

(i) Root density distribution of sapota cultivars on various months (Fresh wt.)

It is revealed from the Table-9 that, the fresh weight of the roots were minimum in case of variety V_1(Kalipatti) In the month of October, 1986, maximum fresh weight of roots were observed in variety V_3(Chaatri) i.e. 0.47 gm. followed by V_2 (Cricketball) i.e. 0.37 gm. and the least was in V_1 (Kalipatti) i.e. 0.23 gm. There was significant difference among the varieties and V_3 was found significantly superior over all two treatments.

In the month of November, the significant difference was observed among the treatments. In V_3 maximum fresh weight of roots were observed i.e. 0.64 gm. and least was observed in V_1, i.e. 0.41 gm, V_3 and V_2 both were significantly superior over V_1. In the month of December, V_3 was significantly superior over V_1 and also V_2 was significantly superior over V_1. Highest fresh wt. was observed at Var. V_3 0.78 gm. with lowest wt. at V_1 i.e. 0.54 gm.

In the month of January, highest weight of roots were observed in V_2 i.e. 0.91 gms. followed by V_3 and least weight was observed in V_1 i.e. 0.77 gm. There was no significant difference among the treatments. In the month of February V_2 was significantly superior to other two treatments. Least weight of roots was recorded at V_1 i.e. 0.80 gm. In the month of March, V_2 was significantly superior over all other two treatments with least wt. V_1 i.e. 0.87 gm. In the month of April V_2 was significantly superior over V_1, and V_3 also was significantly superior over V_1. The least weight was recorded in V_1 i.e. 0.88 gm. There was no significant difference between V_2 and V_3, In the month of May, V_2 was significantly superior to V_1 and V_3 also significantly superior over V_1. The least weight recorded at V_1 was 0.81 gm. But there was no significant difference between V_2 and V_3;

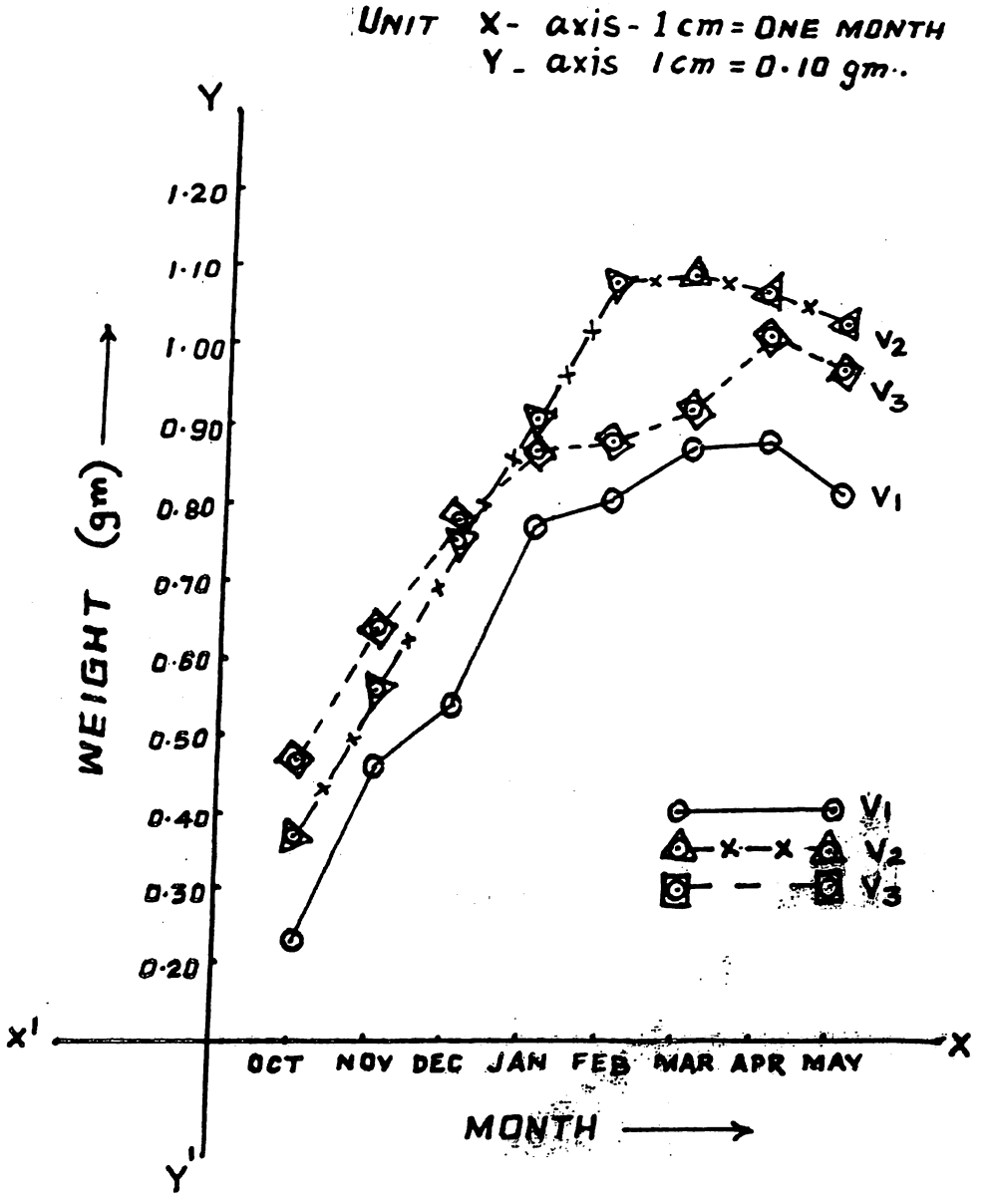
Average root density distribution of Sapota cultivars on various months at Drip Line (Fresh weight) (Gram fresh wt.per cubic decimetor)

Month/ variety	October	November	December	January	February	March	April	May
V_1	0.23	0.46	0.54	0.77	0.80	0.87	0.88	0.81
V_2	0.37	0.56	0.75	0.91	1.08	1.09	1.07	1.03
V_3	0.47	0.64	0.78	0.87	0.88	0.92	1.01	0.97
'F' test	Sig.**	Sig.**	Sig.**	N.S.	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.019	0.016	0.018	0.034	0.025	0.0163	0.022	0.018
C.D.(0.05)	0.0745	0.0628	0.0706	-	0.0981	0.0639	0.0863	0.0706

Sig.** - Significant at 1 % Level

N.S. -Non-significant.

Fig. 7. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AT DRIP LINE (FRESH WEIGHT).



From the Table-9 it was revealed that the fresh weight for Var.V_2 (Cricket ball) increased from October to March, 1987 and it decreased in the month of April and May. But in case of Var. V_3 (Chaatri) and V_1 (Kalipatti) fresh weight increased from October to April and there after it declined in the month of May. (Fig.7)

(ii) Root density distribution of Sapota cultivars on various months (Dry weight).

The dry weight of roots were taken at monthly intervals beginning from October, 1986 to May, 1987. It is revealed from the Table-10 and Fig.8 that significant difference between the varieties with respect to dry weight of the roots was observed from November, 1986 to April, 1987 but not in the month of October and May.

In the month of October, highest weight (0.32 gm) was observed in V_3 with lowest weight (0.15 gm) in V_1. In the month of November, V_3 was significantly superior to all other two varieties and maximum dry weight observed to be (0.40 gm) in V_3, and V_2 also was significantly differing and superior over V_1. Least dry weight was observed in V_1 i.e. 0.22 gm. In the month of December, V_3 was significantly superior to V_1 and V_2 also was significantly superior to V_1. In the month of January and February as in the case of V_2 i.e. (0.66 gm. and 0.71 gm. respectively) was significantly superior to V_3 and V_2. V_2 also differs significantly and found also superior to V_1. Least dry

TABLE - 10

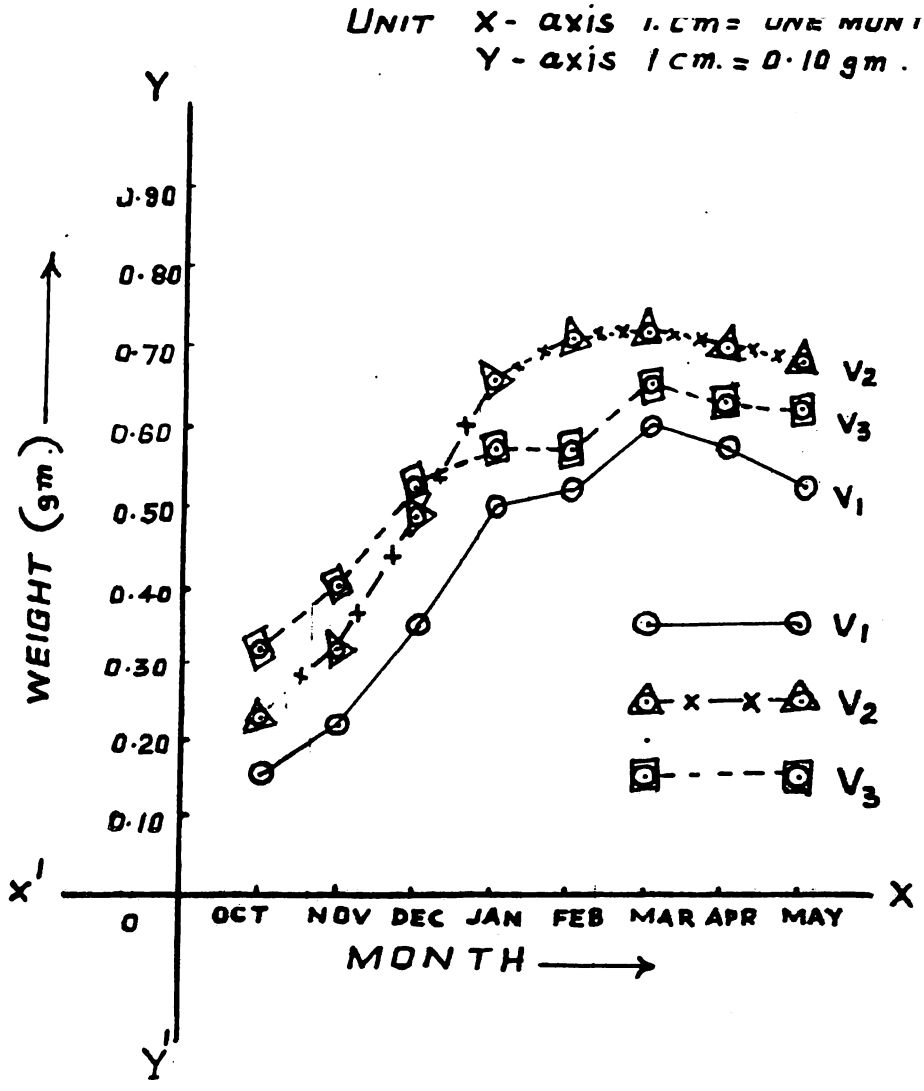
Average root density distribution of Sapota cultivars on various months at Drip line (Dry wt.) (Gram dry wt. per cubic decimeter)

Month/ variety	October	November	December	January	February	March	April	May
V_1	0.15	0.22	0.35	0.50	0.52	0.60	0.57	0.52
V_2	0.23	0.32	0.49	0.66	0.71	0.72	0.70	0.68
V_3	0.32	0.40	0.53	0.57	0.57	0.65	0.63	0.62
'F' test	N.S.	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	N.S.
S.E(m) ±	0.035	0.018	0.021	0.015	0.014	0.01	0.013	0.057
C.D.(0.05)	-	0.0706	0.0824	0.0588	0.0549	0.03925	0.051	-

Sig.** Significant at 1 % Level

N.S. Non significant.

Fig. 8. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AT DRIP-LINE (DRY WEIGHT).



weights were observed in V_1 i.e. (0.50 gm. and 0.52 gm. respectively. In the month of March, V_2 was significantly superior to V_3 and V_2. V_3 also was significantly superior to V_1. In the month of April, V_2 was significantly superior to V_3 and V_1. And V_3 also differs significantly to V_1. In the month of May, 1987 there was no significant difference among the varieties. Highest dry weight of roots was observed in V_2 i.e. 0.68 gm. and lowest dry wt. observed in V_1 i.e. 0.52 gm.

(iii) Root density distribution of Sapota cultivars on various months and depths (Fresh weight).

Observations were recorded at various depths i.e. 0-30 cm, 30-60 cm, 60-90 cm. of dripline of the Sapota trees. It is revealed from the Table-11 that significant difference among the treatments were observed from October, 1986 to May, 1987. The distribution of feeder roots at various depths varied from D_1 to D_3. The fresh height of the roots declined with increase of depth.

In the month of October, D_1 was found significantly superior over D_2 and D_3 and also D_2 was significantly superior to D_3. In the month of November, D_1 was significantly superior to D_2 and D_3, and also D_2 was significantly superior to D_3. In the month of December, D_1 was significantly superior to D_2 and D_3 and also significant difference was observed between D_2 and D_3. In the month of January, 1987, D_1 was significantly superior to D_2 and D_3. But there was no significant difference

between D_2 and D_3. In the month of February, D_1 was significantly superior to D_2 and D_3 and also there was significant difference between D_2 and D_3. In the month of March, D_1 was also significantly superior to D_2 and D_3. And also significant difference was observed between D_2 and D_3. In the month of April, D_1 was significantly superior to D_2 and D_3 and significant difference was also observed between D_2 and D_3. In the month of May, similar trend was also observed as observed in the month of March and April, D_1 was significantly superior to D_2 and D_3 and also D_2 was significantly superior to D_3.

It is seen from the Table-11 and Fig.9 that, the fresh weight of roots increased from October to March (0.52 gm. to 1.11 gm., 0.31 gm. to 0.90 gm.,0.20 gm. to 0.78 gm, in case of D_1, D_2, D_3 respectively) and decreased during April and May in all the treatments.

(iv) Root density distribution of Sapota cultivars on various months and depths(Dry weight):-

It is seen from the Table 12 and Fig.10 that significant difference was observed among D_1, D_2 and D_3 from November 1986 to May, 1987, except in the month of October, 1986, where D_1 was found to be significantly superior to D_2 and D_3. In all the months under report highest dry weight of roots was recorded in D_1 (0.37 to 0.82 gm.) followed by D_2 (0.19 to 0.56 gm.) and D_3 (0.11 to 0.44 gm.). In the month of April and May, there was decrease in all the treatments.

TABLE - 11

Average root density destribution of Sapota C.V.R.S. on various months and depth at Drip Line (Fresh wt.) (Gram fresh wt. per cubic decimeter)

Month/ Depth	October	November	December	January	February	March	April	May
D_1	0.52	0.71	0.93	1.00	1.07	1.11	1.09	1.04
D_2	0.31	0.46	0.68	0.77	0.84	0.90	0.89	0.85
D_3	0.20	0.35	0.51	0.67	0.72	0.78	0.75	0.71
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.025	0.021	0.022	0.031	0.027	0.03	0.026	0.029
C.D.(0.05)	0.09813	0.0824	0.0863	0.1216	0.1059	0.1177	0.1020	0.1138

Sig.** Significant at 1 % Level.

Fig. 9. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AND DEPTHS AT DRIP LINE (FRESH WEIGHT)

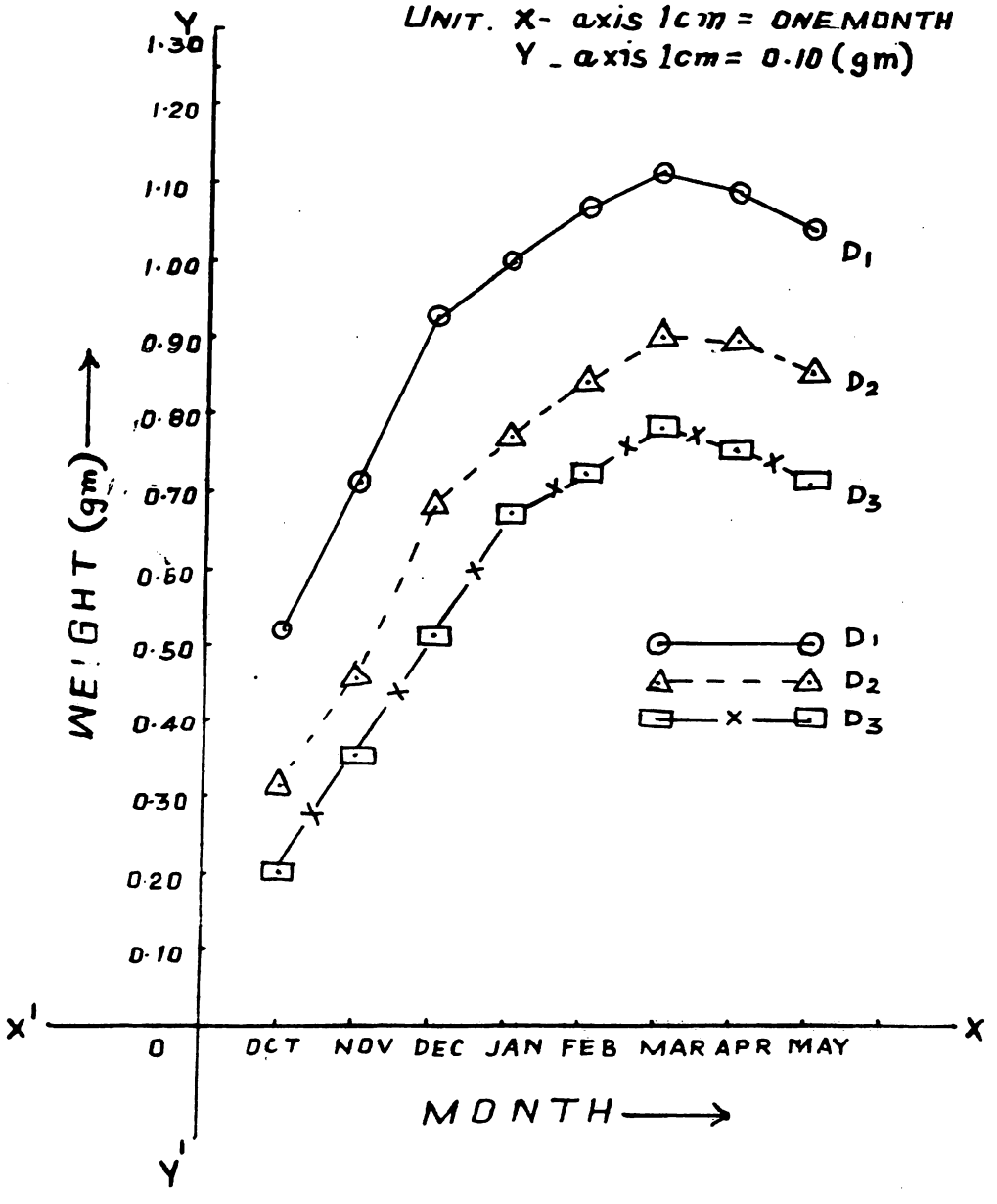


TABLE - 12

Average root density distribution of Sapota C.V.R.S. on various months and depths at Drip Line (Dry wt.) (Gram dry wt. per cubic decimeter)

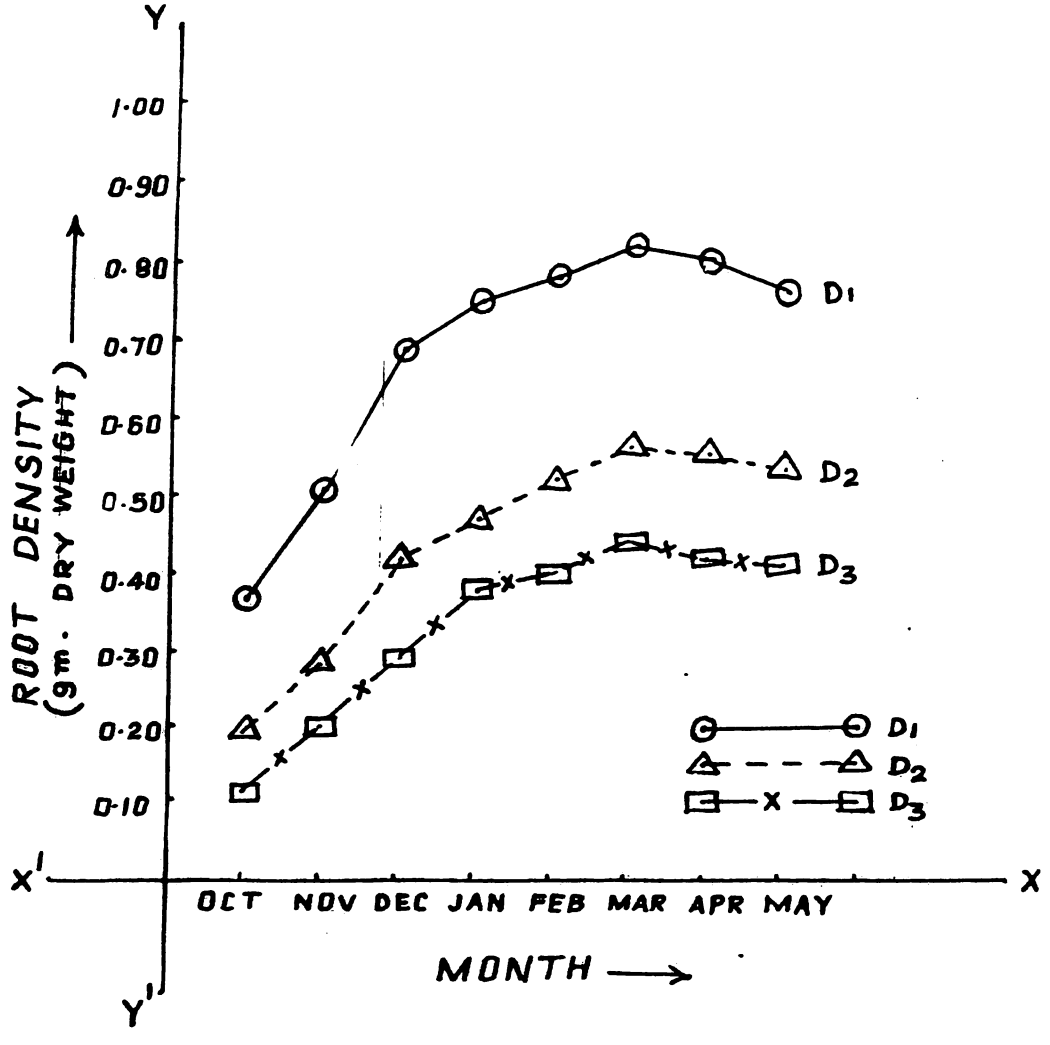
Month/ Depth	October	November	December	January	February	March	April	May
D_1	0.37	0.51	0.69	0.75	0.78	0.82	0.80	0.76
D_2	0.19	0.28	0.42	0.47	0.52	0.56	0.55	0.53
D_3	0.11	0.20	0.29	0.38	0.40	0.44	0.42	0.41
'F' test	Sig.*	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.035	0.02	0.023	0.22	0.029	0.027	0.022	0.023
C.D.(0.05)	0.1373	0.0785	0.0902	0.0863	0.1138	0.1059	0.0863	0.0902

Sig.* Significant at 5 % Level

Sig.** Significant at 1 % Level.

Fig. 10. AVERAGE ROOT DENSITY DISTRIBUTION OF SAPOTA CULTIVARS ON VARIOUS MONTHS AND DEPTHS AT DRIP LINE (DRY WEIGHT).

UNIT. X axis 1 cm = ONE MONTH.
Y axis 1 cm = 0.10 gm.



(v) Root density distribution of sapota cultivars on various months and depths (Fresh weight) :-

It is revealed from the Table-13 that, significant difference was observed in the month of October, 1986 to February, 1987 and in May, 1987. And in the months of March, 1987 and April, 1987 there was no significant difference among the treatments. In the month of October, 1986, highest fresh weight was observed in the treatment V_3D_1 i.e. 0.96 gm. followed by V_2D_1, V_3D_2, V_1D_1 and least weight was observed in treatment V_1D_3 i.e. (0.25 gm). In the month of November, highest fresh weight of roots was observed in the treatment (V_3D_1 (1.38 gm) followed by V_2D_1 (1.32 gm) and V_1D_1 (0.75 gm) and least weight was observed in the treatment V_1D_3 (0.39gm), V_3D_2 (0.54 gm) and V_3D_3 (0.54 gm).

In the month of December, highest fresh weight was recorded in treatment V_3D_1 (1.62 gm) followed by V_2D_1 (1.58 gm) and V_1D_1 (1.11 gm) and the least weight was observed in V_1D_3 (0.51gm). In the month of January, the highest fresh weight was recorded in the treatments V_3D_1 (1.74 gm), V_2D_1 (1.74 gm) closely followed by V_2D_2 (1.29 gm) and V_1D_1 (1.26 gm). Least weight was observed in V_3D_3 (0.96 gm) and V_1D_3 (0.99 gm). In the month of February, highest fresh weight of roots were observed in the treatment V_2D_1 i.e. (1.89 gm) followed by V_3D_1 (1.83 gm) and V_1D_1 (1.50 gm.) The treatment V_2D_1 and V_3D_1 were found to be significantly superior to all other treatments and the least weight was recorded in the treatment V_3D_3 i.e. 1.10 gm. followed by V_1D_3 (1.14 gm.)

In the month of March, highest fresh weight was observed in the treatment V_2D_1 i.e. 1.92 gms. followed by V_3D_1 (1.88 gms.) and V_1D_1 (1.56 gm) and the least weight was recorded in the treatment V_1D_3 and V_3D_3 i.e. (1.20 gm) in each. In the month of April, also the highest fresh weight of roots were recorded in the treatment V_3D_1 i.e. 1.86 gms. and followed by V_2D_1 (1.83 gms.) and V_1D_1 (1.50 gm) and the lowest fresh weight was recorded in the treatment V_3D_3 i.e. 1.04 gms. In the month of May, the highest fresh weight was observed in the treatments V_3D_1 (1.77 gms.) and V_2D_1 (1.70 gms) followed by V_3D_2 (1.43 gms) and V_1D_1 (1.38 gms). The treatments V_3D_1 and V_2D_1 were found to be significantly superior to all other treatments and the least weight was recorded in the treatment V_3D_3 i.e. 1.08 gms followed by V_2D_3 i.e. 1.10 gms.

The fresh weight of the roots were increased from October, 1986 to March 1987 and again decreased in the month of April and May as it was revealed from Table-13.

(vi) Root density distribution of sapota cultivars on various months and depths (Dry weight).

It is seen from the Table-14 that significant difference was not observed among the treatments starting from October 1986 to May, 1987.

TABLE - 13

Average root density distribution of Sapota cultivars on various months and depths at drip line (Fresh weight) (gram fresh wt. per cubic decimeter)

Month/ treatment	October	November	December	January	February	March	April	May
V_1D_1	0.57	0.75	1.11	1.26	1.50	1.56	1.50	1.38
V_1D_2	0.40	0.57	0.81	1.11	1.32	1.41	1.34	1.12
V_1D_3	0.25	0.39	0.51	0.99	1.14	1.20	1.10	0.98
V_2D_1	0.87	1.32	1.58	1.74	1.89	1.92	1.83	1.70
V_2D_2	0.54	0.81	1.05	1.29	1.44	1.47	1.42	1.36
V_2D_3	0.30	0.54	0.84	1.11	1.20	1.26	1.20	1.10
V_3D_1	0.96	1.38	1.62	1.74	1.83	1.88	1.86	1.77
V_3D_2	0.72	0.54	1.05	1.08	1.23	1.40	1.40	1.43
V_3D_3	0.48	0.54	1.02	0.96	1.10	1.20	1.04	1.08
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.*	N.S.	N.S.	Sig.**
S.E.(m) ±	0.0059	0.0066	0.0081	0.0072	0.0159	0.0179	0.016	0.0181
C.D.(0.05)	0.0176	0.01978	0.02428	0.02158	0.04766	-	-	0.054258

Sig** - Significant at 1 % Level

N.S.- Non-significant.

TABLE - 13 a

Effect of feeder root system of different varieties of sapota with respect to depths on various months at drip line (Fresh wt.) (gram fresh wt. per cubic decimeter).

	October	November	December	January	February	March	April	May
Variety								
V_1 (Kalipatti)	0.24	0.273	0.41	0.373	0.44	0.463	0.437	0.386
V_2 (Cricket ball)	0.19	0.296	0.385	0.46	0.503	0.516	0.494	0.462
V_3 (Chaatri)	0.135	0.19	0.27	0.42	0.462	0.504	0.477	0.475
'F' test Sig.	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	N.S.	N.S.	Sig.**
S.E.(m) ±	0.00059	0.0066	0.0081	0.0072	0.0159	0.0179	0.016	0.0181
C.D.(0.05)	0.0176	0.01978	0.02428	0.02158	0.0476	-	-	0.054258
Depth								
D_1 (0-30 cm)	0.266	0.383	0.478	0.526	0.58	0.595	0.576	0.538
D_2 (30-60 cm)	0.184	0.213	0.323	0.386	0.443	0.475	0.462	0.434
D_3 (60-90 cm)	0.114	0.163	0.263	0.34	0.382	0.413	0.371	0.351
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0059	0.0066	0.0081	0.0072	0.0159	0.0179	0.016	0.0181
C.D.(0.05)	0.0176	0.01978	0.02428	0.02158	0.0476	0.0536	0.0479	0.054258

Sig.** - Significant at 1 % level

N.S. Non-significant.

54(a)

TABLE - 14

Average root density distribution of sapota cultivars on various months and depths at drip Line (Dry weight) (Gram dry wt. per cubic decimeter)

Month/ Treatment	October	November	December	January	February	March	April	May
V_1D_1	0.50	0.55	0.75	0.95	1.10	1.14	1.11	1.05
V_1D_2	0.28	0.36	0.48	0.70	0.83	0.87	0.83	0.72
V_1D_3	0.16	0.22	0.35	0.58	0.66	0.70	0.64	0.56
V_2D_1	0.60	0.68	0.88	1.18	1.24	1.26	1.20	1.17
V_2D_2	0.30	0.46	0.58	0.76	0.85	0.88	0.86	0.81
V_2D_3	0.18	0.29	0.41	0.65	0.68	0.72	0.68	0.59
V_3D_1	0.58	0.72	0.90	1.22	1.21	1.24	1.22	1.20
V_3D_2	0.38	0.32	0.57	0.68	0.80	0.85	0.84	0.83
V_3D_3	0.24	0.24	0.47	0.55	0.62	0.71	0.61	0.57
'F' test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
S.E.(m) ±	0.0119	0.0115	0.0132	0.011	0.011	0.0105	0.0105	0.0093
C.D.(0.05)	-	-	-	-	-	-	-	-

N.S. - Non-significant.

TABLE-14(a)

Effect of feeder root system of different varieties of sapota with respect to depths on various months at drip line (Dry weight) (gram dry wt. per cubic decimeter)

	October	November	December	January	February	March	April	May
Variety								
V_1 (Kalipatti)	0.104	0.124	0.175	0.247	0.287	0.301	0.286	0.258
V_2 (Cricketball)	0.12	0.158	0.207	0.287	0.307	0.317	0.304	0.285
V_3 (Chaatri)	0.133	0.142	0.215	0.272	0.292	0.311	0.296	0.288
'F' test	N.S	N.S.	N.S.	N.S	N.S.	N.S.	N.S.	N.S.
S.E.(m) ±	0.0119	0.0115	0.0132	0.011	0.011	0.0105	0.0105	0.0093
C.D.(0.05)	-	-	-	-	-	-	-	-
Depth								
D_1 (0-30 cm)	0.186	0.216	0.281	0.372	0.394	0.404	0.392	0.380
D_2 (30-60 cm)	0.106	0.125	0.181	0.237	0.275	0.288	0.281	0.262
D_3 (60-90 cm)	0.064	0.083	0.136	0.197	0.217	0.236	0.214	0.191
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m) ±	0.0119	0.0115	0.0132	0.011	0.011	0.010	0.0105	0.0093
C.D.(0.05)	0.0356	0.03447	0.03956	0.03297	0.0329	0.03147	0.03147	0.02787

Sig.** - Significant at 1 % Level.

N.S. - Non-significant.

In the month of October and November, highest dry weight of roots was observed in the treatments V_2D_1 i.e. (0.60 gms) and V_3D_1 i.e. (0.72 gms) respectively followed by V_3D_1 (0.58 gm) and V_2D_1 (0.68 gms.) Least weight was recorded in the same treatment V_1D_3 i.e. 0.16 gm and 0.22 gm respectively. In the month of December and January, 1987 the highest dry weight was recorded in the treatment, V_3D_1 i.e. (0.90 gm and 1.22 gms) followed by V_2D_1 i.e. (0.88 gm. and 1.18 gms) and least weight was recorded in V_1D_3 and V_3D_3 i.e. 0.35 gm and 0.55 gms respectively. In the month of February and March, 1987, the highest dry weight of roots was observed in the treatment V_2D_1 (1.24 and 1.26 gms) followed by V_3D_1 (1.21 and 1.24 gms) and minimum weight was recorded in V_3D_3 i.e. 0.62 gms and V_1D_3 i.e. 0.70 gms respectively. In the month of April, 1987 and May, 1987 highest dry weight of roots were observed in the treatment V_3D_1 followed with V_2D_1 during both the months and the least weight was observed in V_3D_3 and V_1D_3 respectively.

Leaf Nutrient status (N,P,K) of sapota cultivars in different months :-

(1) Leaf Nitrogen :- The data relating to nitrogen content of the sapota leaf from October, 1986 to May, 1987 are presented in Table-15 and Fig.11. A perusal of the data in Table-15 revealed that the nitrogen content of the leaf decreased from October, 1986 to May, 1987. The significant difference among the treatments were recorded in all the months excepting in the months of December and April. In the month of October and November, the nutrient content was maximum i.e. (1.31 gm and 1.28 gms) in Cricketball closely followed by Kalipatti. There was significant difference among the treatments and the treatment Cricketball is significantly superior to all other treatments. In the month of December, no significant difference was observed among the treatments, i.e.Cricketball, Kalipatti and Chaatri. In the months of January, February and March, 1987, nitrogen content of cultivar Cricketball was found significantly superior to all other varieties and the difference between them were significant. In the month of April, 1987, no significant difference was observed between the treatments like Cricketball Kalipatti and Chaatri. In the month of May, 1987, the highest nitrogen content of leaf was observed in treatment Cricketball, i.e. (1.18 %), significantly superior to other varieties and significant difference was also observed within the varieties.

(ii) Leaf Phosphorus :-

The data relating to the percentage of phosphorus in leaves of different varieties were recorded from October 1986 to May, 1987 and are presented at Table-16 and Fig.12. Significant difference was observed with respect to Phosphorus content in percent in the leaves of different varieties excepting in the months of November, and January, 1987 to May, 1987. But the Phosphorus content was highest in variety Cricketball followed by var. Kalipatti and least percent of Phosphorus content was in variety Chaatri. The least Phosphorus content (0.16 to 0.10 %) was found in variety Chaatri during October to May and there was gradual decrease in Phosphorus content in all the treatments from October, 1986 to May, 1987.

(iii) Leaf Potassium :-

The data relating to the percentage of Potassium in leaves of different varieties recorded from October,1986 to May, 1987 and are presented at Table-17 and Fig.13. The significant difference was observed among the varieties in each month, starting from October, 1986 to May, 1987. The Potassium content of variety cricketball was significantly superior over all other varieties. In the month of October and November, variety Cricketball was found to be significantly superior to Kalipatti and Chaatri and also there was significant difference was observed between Kalipatti and

Chaatri. Similarly in the month of December and January, the variety Cricketball was found to be significantly superior to Kalipatti and Chaatri and also there was significant difference observed between Kalipatti and Chaatri.

In the month of February and March, 1987, the variety Cricketball was found significantly superior to Chaatri, and also variety Kalipatti became significantly superior to Chaatri. The significant difference was not observed between varieties Cricketball and Kalipatti. In the month of April, 1987 Kalipatti was significantly superior to Chaatri and also the variety Cricketball was found to be significantly superior to Chaatri. But there was no significant difference observed between Kalipatti and Cricketball. In the month of May, 1987 the variety Kalipatti i.e. (0.77 %) was found to be significantly superior to Chaatri (0.66%) and also Cricketball i.e. 0.72 % was significantly superior to Chaatri. But there was no significant difference between the variety Kalipatti and Cricketball. The Potassium content of sapota leaf was found in a decreasing manner from October, 1986 to May, 1987.

The leaf N, P and K content of all the three varieties as observed from the Table 15, 16 and 17 found to be decreased gradually from October, 1986 to May, 1987.

TABLE - 15

Nitrogen content of Leaves of Sapota cultivars in different months (Percentage on dry weight basis)

Month/ variety	October	November	December	January	February	March	April	May
Kalipatti	1.24	1.23	1.21	1.20	1.18	1.16	1.13	1.12
Cricket ball	1.31	1.28	1.24	1.25	1.23	1.22	1.19	1.18
Chaatri	1.18	1.17	1.17	1.15	1.15	1.09	1.08	1.04
'F' test	Sig.**	Sig.*	N.S.	Sig.**	Sig.**	Sig.**	N.S.	Sig.**
S.E.(m)±	0.017	0.017	0.018	0.011	0.008	0.015	0.021	0.016
C.D.(0.05)	0.0667	0.667	-	0.0431	0.0314	0.0588	-	0.0628

Sig.* - Significant at 5 % Level.

Sig.** - Significant at 1 % Level

N.S. - Non-Significant.

TABLE - 16

Phosphorus content of leaves of Sapota cultivars in different months (Percentage on dry wt. basis)

Month/ variety	October	November	December	January	February	March	April	May
Kalipatti	0.19	0.18	0.17	0.16	0.15	0.15	0.13	0.12
Cricket ball	0.21	0.20	0.20	0.19	0.19	0.18	0.14	0.13
Chaatri	0.16	0.16	0.15	0.15	0.15	0.14	0.12	0.10
'F' test	Sig.*	NS	Sig.*	NS	NS	NS	NS	NS
S.E.(m) ±	0.0097	0.01	0.0091	0.014	0.0105	0.013	0.007	0,009
C.D.(0.05)	0.038	-	0.0357	-	-	-	-	-

Sig* - Significant at 5 % Level.

NS - Non-significant.

Fig. 11. NPK CONTENTS OF THE LEAES.

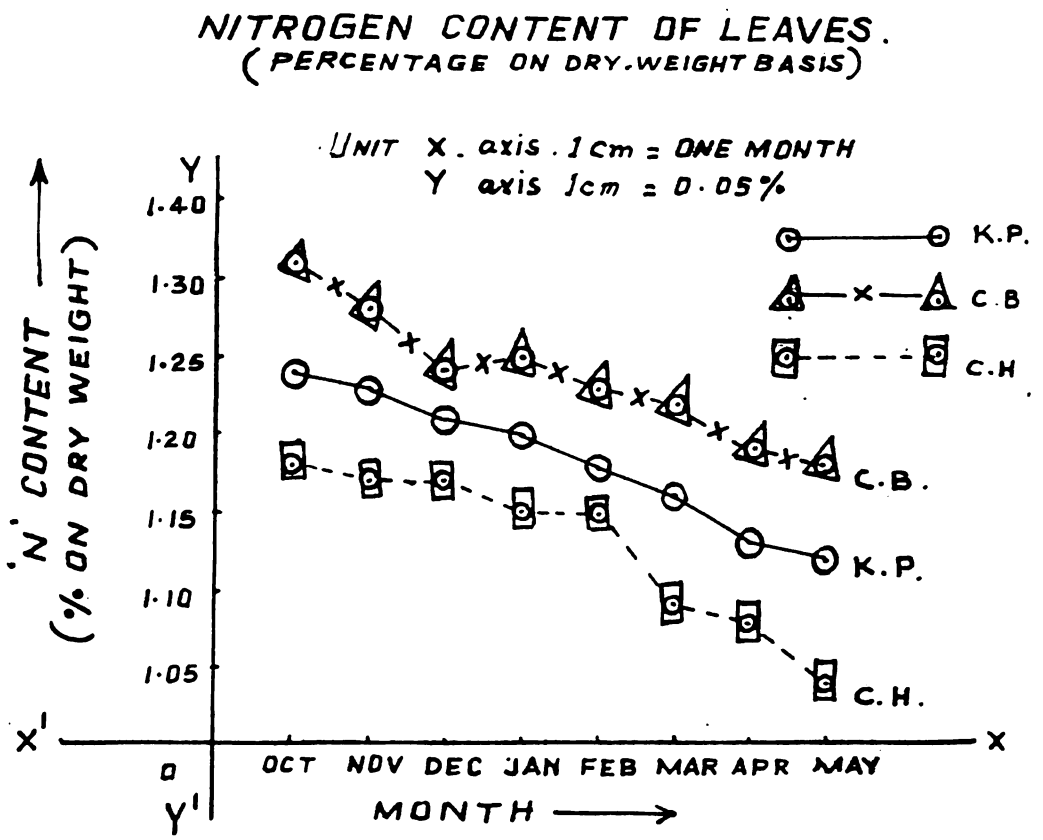


Fig. 12. PHOSPHORUS CONTENT OF LEAVES
(PERCENTAGE ON DRY WEIGHT BASIS)

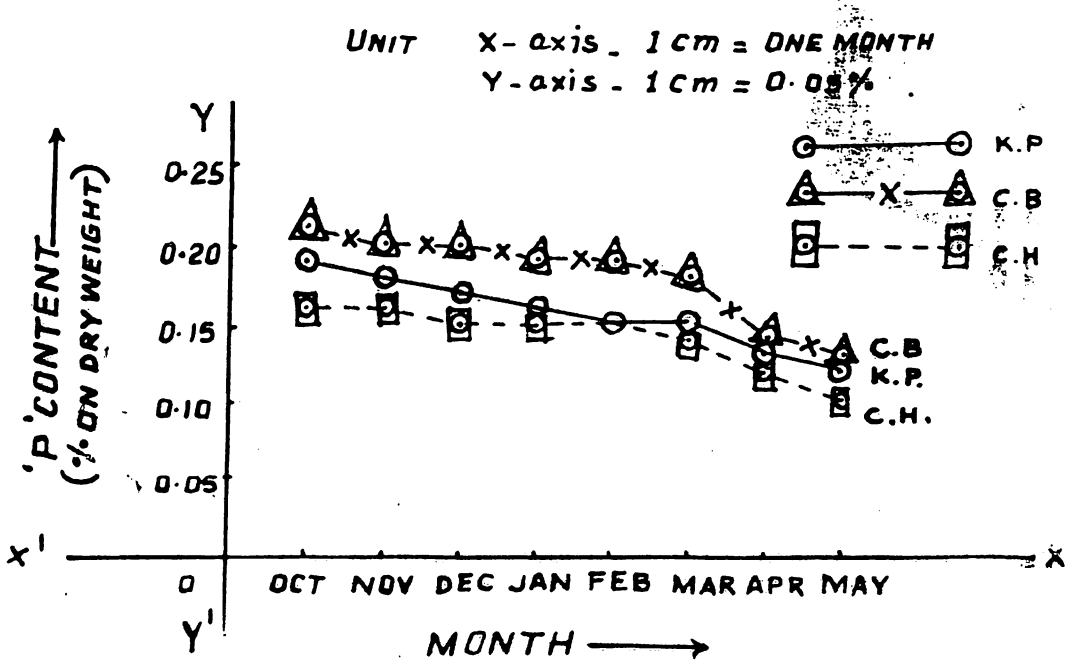


TABLE - 17

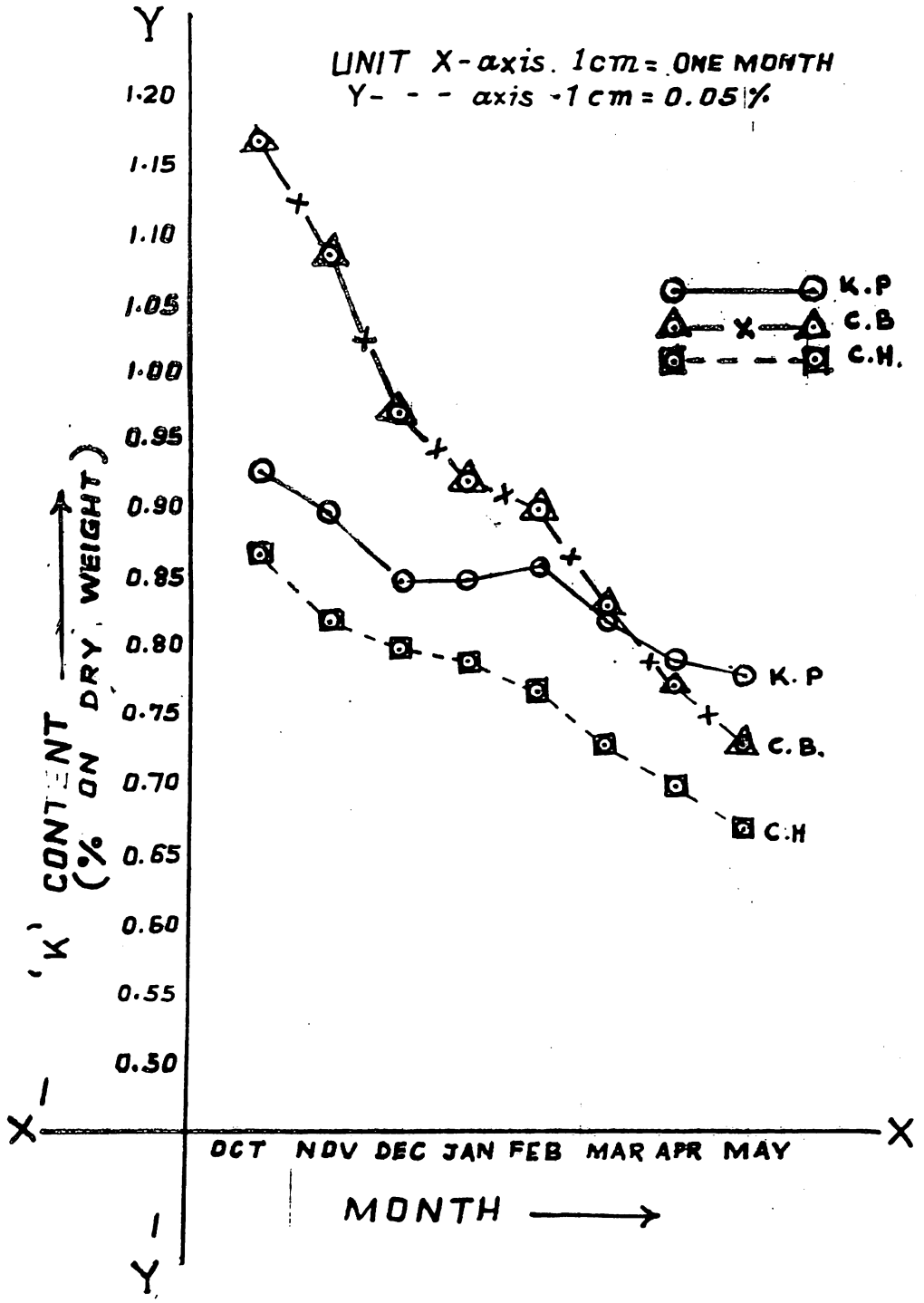
Potash content of leaves of Sapota cultivars in different months.

(Percentage on dry wt.basis)

Month/ variety	October	November	December	January	February	March	April	May
Kalipatti	0.92	0.89	0.84	0.84	0.85	0.81	0.78	0.77
Cricket ball	1.16	1.08	0.96	0.91	0.89	0.82	0.76	0.72
Chaatri	0.86	0.81	0.79	0.78	0.76	0.72	0.69	0.66
'F' test	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**	Sig.**
S.E.(m)±	0.0176	0.016	0.016	0.014	0.014	0.012	0.008	0.019
C.D.(0.05)	0.0690	0.0628	0.0628	0.0549	0.0549	0.0471	0.0314	0.0745

Sig.** - Significant at 1 % Level.

Fig. 13. POTASSIUM CONTENT OF LEAVES
(PERCENTAGE ON DRY WEIGHT BASIS)



3. Plant Height :

The data on the height of the sapota plant with respect to variety was recorded at monthly interval i.e. from October, 1986 to May, 1987 in Table 18. It is very clear from the Table-18 that, significant difference was observed among all the treatments in every month.

In the month of October, 1986 the height of the plant in variety Kalipatti (515 cms), which was significantly superior to other two varieties followed by Cricketball (502 cm) and Chaatri (492 cm). In all the months under report the height of the var. Kalipatti plant was found to be significantly superior to Cricketball and Chaatri and so also Cricketball was significantly superior to Chaatri. It is seen from the Table-18 and Fig. 14 that the height of the plant with all the three varieties increased with an increasing trend from October, 1986 to May, 1987.

From the Table-18, it is observed that the maximum height was observed in the cultivar Kalipatti and minimum was in the cultivar Chaatri and the cultivar Cricketball was in between of these two varieties.

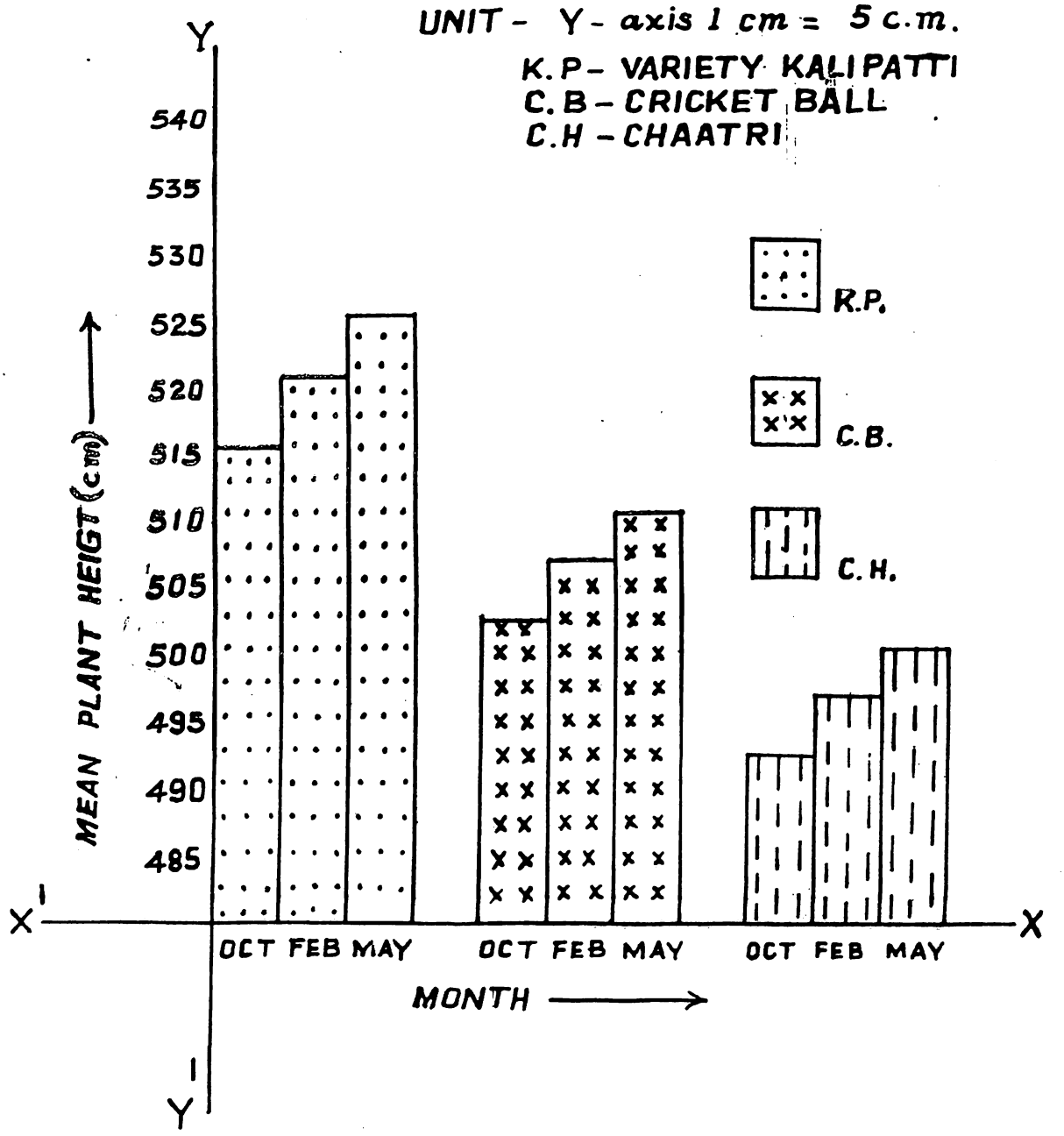
TABLE - 18

Mean plant height of different varieties of Sapota at monthly intervals. (Fig.in cms.)

Month/ variety	October	November	December	January	February	March	April	May
Kalipatti	515.00	516.50	517.80	519.00	520.60	522.00	523.40	525.00
Cricket ball	502.00	503.10	504.30	505.50	506.70	508.00	509.00	510.00
Chaatri	492.00	493.00	494.20	495.30	496.50	498.00	499.00	500.00
'F'test	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.
S.E.(m)±	1.527	1.231	1.538	1.087	1.023	1.056	1.158	1.533
C.D.(0.05)	5.9938	4.8319	6.037	4.2667	4.0155	4.145	4.5454	6.0174

** Sig-Significant at 1 % Level.

Fig - 14. MEAN PLANT HEIGHT (cm.) OF DIFFERENT VARIETIES OF SAPOTA TAKEN IN DIFFERENT MONTHS



4. Canopy area :-

The data in connection with canopy area was presented after pentaining its measurement at an interval of one month i.e. from October, 1986 to May, 1987 and Table-19 may be perused. It is revealed from the Table-19 that the Canopy area of trees varies from variety to variety and increased with an increase of the age of the trees.

In the month of October, 1986, significant difference was observed among all the treatments. Highest canopy area was observed in variety Chaatri (107.15 sq.mt.) which was varied significantly and also superior over Cricketball and Kalipatti and also the var. Cricketball (53.85 sq.mt.) was significantly superior to Kalipatti i.e(50.52 sq.mt.). In the month of November, Chaatri and Cricketball were found to be significantly superior to Kalipatti and significant difference was also found in case of Chaatri and Cricketball. In the month of December, the canopy area of the cultivar Chaatri was maximum i.e. 108.26 sq.mt. which was significantly superior to all other two treatments i.e. Cricketball and Kalipatti and also Cricketball was found to be significantly superior over Kalipatti. In the months of January and February, 1987, Chaatri was found to be significantly superior to all other two cultivars i.e. Cricketball and Kalipatti and also the Cricketball was significantly superior to Kalipatti. In the month of March, maximum canopy area was recorded in Chaatri i.e. 110.48 sq.mt. which was varied significantly superior over Cricketball and

Kalipatti and so also the Cricketball was significantly superior over Kalipatti. In the month of April, the canopy area of Chaatri was found to be significantly superior to Cricketball and Kalipatti. Significant difference was observed among the varieties Cricket-ball and Kalipatti of which Cricketball was significantly superior. In the month of May, 1987, significant difference among the varieties were recorded but in Chaatri maximum canopy area (111.98 sq.mt.) was noted which was significantly superior to all other treatments i.e. in Cricketball (57.55 sq.mt) and in Kalipatti (53.59 sq.mt.). Variety Cricketball also differed significantly to Kalipatti.

From the Table-19 and Fig.15 it was observed that the canopy area of Chaatri was comparatively greater than Cricketball and Kalipatti. All the varieties became significant in the months i.e. from October, 1986 till May, 1987.

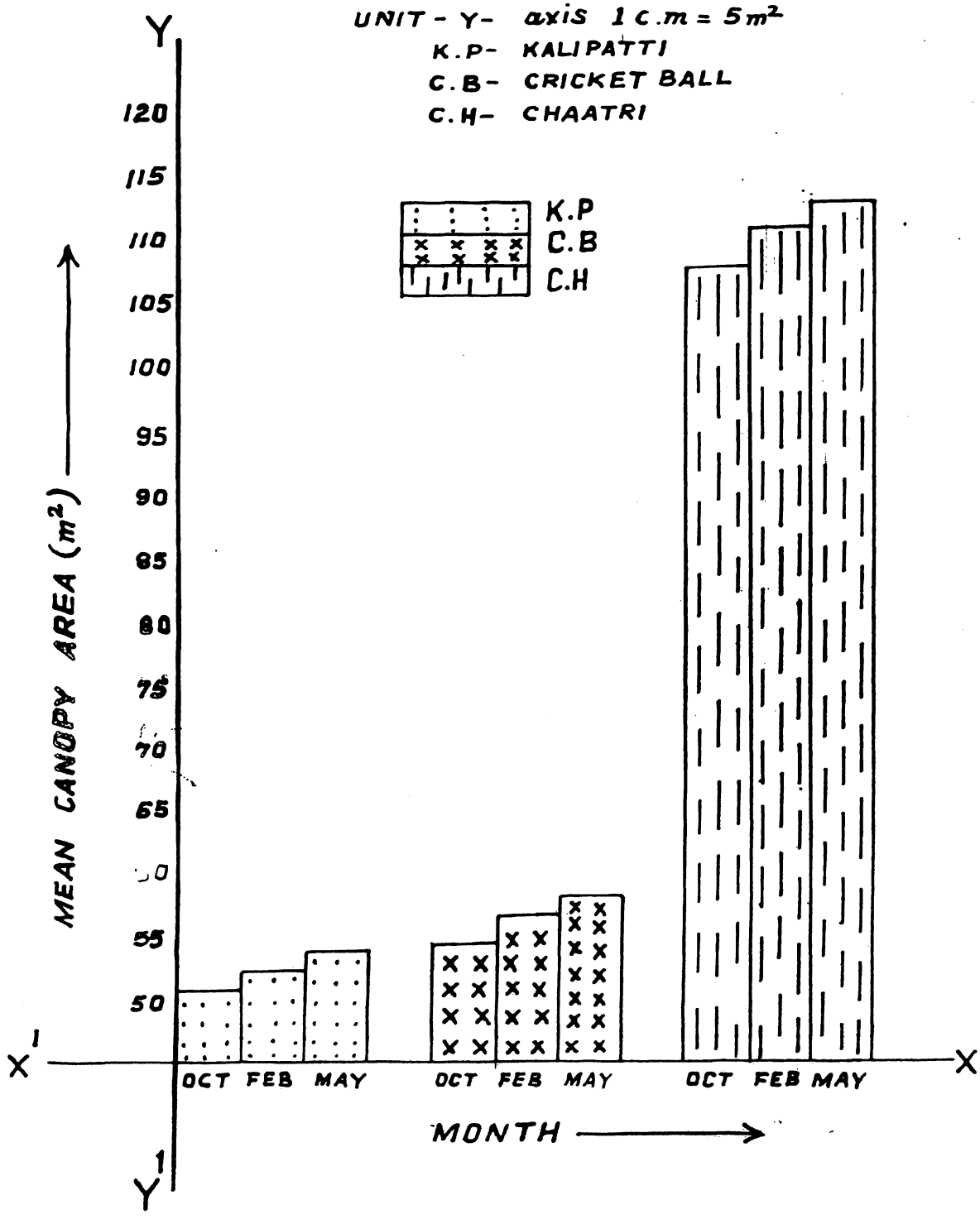
TABLE - 19

Mean canopy area of different Sapota varieties at monthly intervals. (Fig. in Sq.mt.)

Month/ Variety	October	November	December	January	February	March	April	May
Kalipatti	50.52	50.77	51.02	51.53	52.04	52.55	53.07	53.59
Cricket ball	53.85	54.37	54.89	55.42	55.95	56.48	57.01	57.55
Chhatri	107.15	107.52	108.26	109.00	110.11	110.48	111.23	111.98
'F' test -	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.	** Sig.
S.E.(m) ±	0.785	0.904	0.692	0.75	0.90	0.707	0.551	1.003
C.D.(0.05)	3.081	3.548	2.7162	2.9439	3.5327	2.7751	2.1628	3.937

** Sig. Significant at 1 % Level.

Fig-15. MEAN CANOPY AREA OF SEVERAL VARIETIES OF SAPOTA TAKEN IN DIFFERENT MONTHS.



CHAPTER V

DISCUSSION

D I S C U S S I O N

A well developed root system for a plant is of prime importance as most of the water, nutrients and mineral elements used by the plant are absorbed by roots. The size and productivity of the aerial parts are governed mostly by the extent and activity of the root system. The distribution of roots and their densities are often influenced by the moisture and nutrient status of the soil. Root density studies from Table-3 revealed that under the position mid point, highest fresh weight of roots were recorded in variety V_1 (Kalipatti) followed by V_2 and V_3. Likewise, it is very clear from the (Table-9) that the fresh weight of feeder roots at dripline were found to be maximum in variety V_2 (Cricketball) followed by V_3 and V_1.

It is revealed that the fresh weight of the roots of emery variety increased from October, 1986 to March, 1987 and decreased in the month of April, 1987 and May, 1987 under mid point, whereas fresh weight of the feeder roots for variety V_2 (Cricketball) only increased from October, 1986 to March, 1987 and decreased in the month of April and May, 1987 and variety V_3 (Chaatri) and V_1 (Kalipatti) were increased from October, 1986 to April, 1987 and decreased in the month of May, 1987 under drip line.

From Table-4 and 10, it is revealed that the significant difference was recorded with respect to dry weight

of the roots at mid point and drip line. Maximum dry weight of roots were observed in variety V_1 (kalipatti) followed by V_2 and V_3 and also highest dry weight was observed at V_2 (Cricketball) followed by V_3 and V_1 at mid point and drip line respectively. It is clear that the root densities are situated comparatively more at mid point than at drip line. These results supports with the findings of Skovorchov (1948), Atanasov (1974), Rao and Mukherjee (1985) and Ray et al.(1987), Avilan R; Meneses et al. (1985) etc. Skovorchov (1948) noted that the great majority of thin fibrous (0.5 mm - 1 mm diameter) roots were present almost at the middle of the trees. Atanasov (1974) found that of majority roots of the trees available in the 10-30 cms soil layer at a radius of 2-3 meter from the trunk.

Rao and Mukherjee (1985) and Ray et al. (1987) reported that the feeder root density was found to be highest at mid point as compared to other locations in Mango and Litchi.

Avilan, R; Menses et al. (1985) found that sixty percent of feeder roots were in the top 40 cm. of soil, the largest lateral concentration occurring at a distance corresponding to half of the canopy radius of sapodilla.

The fresh and dry weight of the sapota roots decreased with an increase of depth. The significant differences were observed between D_1, D_2 and D_3. Highest weight of

feeder roots were found at D_1 (0-30 cm) depth as compared to D_2 (30-60 cm) and D_3 (60-90 cm) depth at both the positions of mid point and drip line Table (5, 6, 11, 12). With increase of depths feeder root density decreases.

It is very clear from the effect of main factors viz. seasons, depths and positions and their interactions for variation in the root density (Table 7, 8, 13, 14) that all the main factors were different in their levels. The maximum 'F' value was obtained with depth followed with their interaction and variety, seasons and positions (at mid point and dripline) also showed differences. Most of the 'F' values for the main factors were significant at 1% level. The root density was concentrated more at mid point at the depth of 0-30 cm. The findings of Rogers and Head (1968), Stoev (1970), Ghosh and Chattopadhyaya (1972), Duplessis and Smith (1973), Danilova (1974), Purohit and Mukherjee (1974), Hedge and Tiwari (1981), Patel and Amin (1981) and Avilan *et al.* (1981) on sapota support the findings of this investigation. Purohit and Mukherjee (1974) found that the root activity was decreased with an increase in depth. Avilan *et al.*(1981) found an sapodilla that the maximum percentage of roots were situated in the top 40 cm. of soil.

The results of present investigation also supported by the findings of Rameswar *et al.* (1981) in mango and Ray *et al.* (1987) in litchi; who showed maximum feeder root intensity at 0-15 cm with further increases in depth, feeder root density declined and most of the feeder roots are

concentrated half way between trunk and drip line at 30 cm. below the surface soil.

It is also revealed that the maximum feeder root density was situated at a depth of 0-30 cm. at mid point between trunk and drip line in all the months starting from October, 1986 to May, 1987 in both the cases of fresh and dry weight samplings as compared to other depths viz. (30-60cms) and (60-90 cms) and the feeder root density decreased with the advancement to periphery, as reported by Duplessis and Smith (1973), Singh (1978), Rameswar et al. (1981), Rao (1981) and Purohit and Mukherjee (1974) in guava.

It is well evident that feeder root density of a mature tree is minimal in the vicinity of the trunk, which then slowly increases to a maximum from mid way between mid-point and drip line and then slowly falls down. This confirms the importance of the top dressing of nitrogen in the form of shallow circular trench of 60-90 cm. away from and around the trunk followed with irrigation as per recommendations of Singh et al. (1963) in sapota.

It is seen from the present investigation that maximum feeder root densities on fresh weight and dry weight at mid point and dripline occurred mostly in the month of March, 1987 and thereafter decreased which supports the findings of Soong (1977) in rubber.

Soong, (1977) observed that the maximum root development occurred in February/March corresponding to the period of active refoliation and peak uptake of moisture and nutrients by the tree. Minimum root development was observed during August to December when leaf senescence sets in.

Leaf Nutritional Status of Sapota cultivars:

It is seen from the (Table-15) that, the nitrogen content of the leaves of sapota was observed to be significant among all the three varieties. The nitrogen content was highest in the variety Cricket ball and closely followed by Kalipatti and haatri. The optimum dose of fertilizers were applied in the month of July, 1986 to all the plants in a single split dose per year.

It is revealed from Table-16 that, significant difference was not recorded with respect to percentage of phosphorus in the leaves of all the three varieties during most of the months.

Phosphorus content was maximum in the variety Cricket ball followed by Kalipatti and haatri. From Table-17 it was reported that significant difference was observed among all three varieties.

Potassium content of Cricketball was found to be highest and followed by Kalipatti and Chaatri. The leaf N,P,K, content was found to be highest in the month of

October, 1986 and decreased gradually till May, 1987.

Similar decline in fluctuation of leaf N,P,K content from flowering to harvest was noticed by Pathak and Pandey (1978) and Durrani (1982) Patil, V. K. (1982) in Sapota and found that the effect of N.P.K. on growth, yield, fruit quality and leaf composition.

In the present study the leaf nutrient content showed variation with the different sapota varieties. The findings of this investigation is also in agreement with Chadha et al. (1984) and Thakur et al. (1985). It is revealed that the concentration of leaf nutrients in all the three varieties declined from October, 1986 to May 1987 i.e. due to commencement of vegetative growth. Leaf N, P, K. levels were highest at the time of before flowering and fruit formation in case of sapota as reported by Gopalkrishna, (1963) and Sen (1973), which also supports the above findings of this investigation.

From the present investigation, it is indicated that, the fertilizers should be applied at the root zone starting from $\frac{1}{4}$ r and extending to $\frac{3}{4}$ r (r, the distance between trunk and drip line), to ensure quick and maximum utilization of the fertilizers and manures. Irrigation should also be given at the place of fertilizer application to minimise the loss of water.

Growth character :

From the (Tables 18, 19 and Fig.14, 15), it is revealed that the height of the sapota plants have been increased slowly from October, 1986 to May, 1987. The cultivar Kalipatti became the tallest plant (515 cms) followed by Cricketball (502 cm) and dwarfest Chaatri (492 cms.)

Similarly, it is found out in case of canopy growth (Table-19, Fig.15), that there is slow in increase in all the three varieties from the month of October, 1986 to May, 1987.

The canopy area was more in the cultivar Chaatri as compared to other varieties and the least was in Kalipatti followed by Cricketball.

There was mere correlation between height of the plant and canopy area found in this experiment but no such relation exists between these growth characters with respect to densities in all the three varieties due to variation between plant characters.

CHAPTER - VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Feeder root system of different commercial varieties of sapota explains to the cause of a wide variation in productionpotentiality of an orchard. Feeder roots also efficiently and rapidly absorbs necessary nutrients from the fertilizers applied, water and other salts and minerals, ultimately leading to better production in sapota. Because of its prime importance, the present investigation was undertaken to study the feeder root system at various depths and positions of the soil surface and its correlation with growth in different months of the year 1986-87.

Fromm the study, it was realised that the maximum feeder root density was situated at a depth of 0-30 cm. at mid point between trunk and dripline in all the months starting from October, 1986 to May, 1987 in both the cases of fresh and dry weight samplings as compared to other depths viz. 30-60 cm. and 60-90 cm. The fresh and dry feeder roots were maximum in the surface soil and it varied significantly in both at dripline and mid point in all the varieties taken.

Feeder root densities were situated comparatively more at mid point than at drip line. With the increase of depth, feeder root densities, their fresh weight and dry weight as well as their activity declined which directly linked with the reduction in yield.

Maximum feeder root density on fresh and dry weight at mid point and drip line was occurred in the month of March, 1987 and decreased gradually thereafter. Among the three varieties taken, highest fresh weight of roots were observed under mid point in variety Kalipatti followed by varieties Cricketball and Chaatri. The fresh weight of roots were found to be increased gradually from October, 1985 to March, 1987 and showed declined trend in the months of April and May, 1987.

The significant difference was observed among the three varieties with respect to the leaf nutritional status. The leaf N, P, K content of all the varieties have declined gradually from October, 1986 to May, 1987 due to commencement of vegetative growth.

From the angle of growth characters, there was gradual increment in height and canopy area of the plants. But no positive relationship was marked between growth parameters and feeder root densities in all the three varieties.

The work was also revealed the method of fertilizer application and irrigation for maximum utilization for boosting up the production which will lead to a definite recommendation to the extension workers, Horticulturists for further improvement in production of sapota in the country.

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APPENDIX

APPENDIX (i)

Analysis of variance of root density distribution of Sapota at Mid point (Fresh wt.)

Source	df	Mean square							
		October	November	December	January	February	March	April	May
Replication	2	0.0042	0.0003	0.00043	0.0013	0.00093	0.0004	0.00083	0.00223
Treatment	2	0.0247**	0.0211	0.0337**	0.0313**	0.0208**	0.0151**	0.0337**	0.0229**
Error	4	0.00075	0.00355	0.00103	0.0008	0.00113	0.0008	0.00123	0.00083

Analysis of variance of root density at Mid point dry weight.

Source	df.	October	November	December	January	February	March	April	May
Replication	2	0.00423	0.00413	0.0003	0.0013	0.00123	0.00123	0.00413	0.00023
Treatment	2	0.0181**	0.0163**	0.0133	0.0171**	0.0156**	0.0201**	0.0217**	0.0169**
Error	4	0.00073	0.0009	0.0035	0.0008	0.00063	0.00063	0.00118	0.00063

APPENDIX (iii)

Analysis of variance of root density at Drip Line(Fresh wt.)

Mean square

Source	df	October	November	December	January	February	March	April	May
Replication	2	0.0019	0.0021	0.00253	0.0003	0.00063	0.002	0.00103	0.00043
Treatment	2	0.0436**	0.0244**	0.0513**	0.0156	0.0624**	0.0399**	0.0283**	0.0388**
Error	4	0.0011	0.00075	0.00093	0.0035	0.00193	0.0008	0.00143	0.00093

Analysis of variance of root density at Drip Line (Dry wt.)

Replication	2	0.000	0.0001	0.0016	0.0012	0.0014	0.0009	0.0014	0.000
Treatment	2	0.0217	0.0244**	0.0268**	0.0193**	0.0291**	0.0109**	0.0127**	0.00725
Error	4	0.0037	0.00095	0.00143	0.00065	0.00058	0.00035	0.00053	0.0098

APPENDIX (iii)

Analysis of variance of root density on various months and depths at Mid point (Fresh wt.)

Source	df.	Mean square							
		October	November	December	January	February	March	April	May
Replication	2	0.00063	0.0001	0.0001	0.00023	0.000033	0.0009	0.000033	0.00063
Treatment	2	0.4177**	0.3913**	0.5733**	0.5484**	0.5581**	0.5547**	0.5547**	0.4887**
Error	4	0.00128	0.0019	0.0013	0.00173	0.00173	0.0024	0.00223	0.00193

Analysis of variance of root density on various months and depths at Mid point (Dry wt.)

Replication	2	0.00023	0.0001	0.00013	0.00013	0.00003	0.0009	0.0001	0.00013
Treatment	2	0.2677**	0.3607**	0.4288**	0.4507**	0.4269**	0.4827**	0.4303**	0.4087**
Error	4	0.00148	0.0019	0.00118	0.00163	0.00188	0.0024	0.0023	0.00253

APPENDIX (iv)

Analysis of variance of root density on various months and depth at Drip Line (Fresh wt.)

Source	df	Mean square							
		October	November	December	January	February	March	April	May
Replication	2	0.000033	0.0033	0.003	0.000133	0.00163	0.00103	0.0012	0.00143
Treatment	2	0.0793**	0.1021**	0.1339**	0.0859**	0.0949**	0.0837**	0.0876**	0.0823**
Error	4	0.00193	0.00135	0.0015	0.00303	0.00218	0.00288	0.0021	0.00253

Analysis of variance of root density distribution on various months and depths at Drip Line (Dry wt.)

Replication	2	0.000	0.0012	0.0014	0.001	0.0014	0.0019	0.0017	0.001
Treatment	2	0.0532*	0.0777**	0.1249**	0.1117**	0.1132**	0.10485**	0.1119**	0.0949**
Error	4	0.0037	0.0012	0.0016	0.0015	0.00255	0.00232	0.00145	0.0017

APPENDIX (V)

Analysis of variance of fresh wt. at Mid point

Mean square

Source	df	October	November	December	January	February	March	April	May
Replication	2	0.0001	0.00009	0.00024	0.00017	0.00059	0.00005	0.00036	0.00031
Variety	2	0.03505**	0.0433	0.0119**	0.0501**	0.02195**	0.03255**	0.05305**	0.03445**
Depth	2	0.63505**	0.5055**	0.81458**	0.81084**	0.84065**	0.77065**	0.70105**	0.70545**
V X D	4	0.10347**	0.1198**	0.12087**	0.0993**	0.1053**	0.09817**	0.0838**	0.0906**
Error	16	0.00072	0.0254	0.00056	0.00049	0.00043	0.00068	0.00053	0.00043

Analysis of variance of Dry wt. at Mid point.

Replication	2	0.00008	0.00001	0.00013	0.000075	0.00036	0.00016	0.000116	0.00008
Variety	2	0.01868**	0.02423**	0.0098**	0.03134**	0.01665**	0.0133**	0.0263**	0.0225**
Depth	2	0.37576**	0.3388**	0.54245**	0.5802**	0.58476**	0.6192**	0.52945**	0.519**
V X D	4	0.0545**	0.06122**	0.05895**	0.0503**	0.60375**	0.059**	0.0445**	0.426**
Error	16	0.00049	0.00058	0.00048	0.00035	0.00055	0.00051	0.00052	0.00055

APPENDIX (vi)

Analysis of variance of fresh wt. at Drip Line

Mean square

Source	df.	October	November	December	January	February	March	April	May
Replication	2	0.0004	0.00017	0.00005	0.00000025	0.000075	0.00007	0.00054	0.00004
Variety	2	0.0246**	0.0283**	0.0503**	0.01695**	0.0093*	0.007	0.0076	0.0207**
Depth	2	0.05225**	0.1197**	0.1114**	0.08495**	0.0923**	0.0772**	0.0954**	0.0797**
V x D	4	0.0014*	0.0109**	0.0026*	0.0075**	0.0049	0.0034	0.0042	0.0018
Error	16	0.000319	0.0004	0.0006	0.00047	0.0023	0.0029	0.0025	0.00295

Analysis of variance of Dry wt. at Drip Line

Replication	2	0.00005	0.0005	0.00005	0.0005	0.0012	0.000	0.00005	0.000025
Variety	2	0.00138	0.0027	0.00405	0.0036	0.00101	0.00065	0.00075	0.00245
Depth	2	0.0347**	0.0418**	0.04925**	0.0751**	0.073**	0.0663**	0.0726**	0.0819**
V x D	4	0.000275	0.0011	0.000175	0.00245	0.00064	0.000425	0.00045	0.0009
Error	16	0.0029	0.0012	0.00159	0.0011	0.00109	0.001	0.001	0.00078

APPENDIX (viii)

Analysis of variance of Leaf Nitrogen content.

Mean square value

Source	df.	October	November	December	January	February	March	April	May
Replication	2	0.00103	0.00103	0.00043	0.0014	0.0004	0.0008	0.000033	0.00083
Treatment	2	0.0177**	0.009*	0.0037	0.0075**	0.0049**	0.0127**	0.0090	0.0148**
Error	4	.000835	0.00083	0.00093	0.0004	0.0002	0.0007	0.0015	0.00078

Analysis of variance of Leaf Phosphorus content

Replication	2	0.001	0.002	0.0014	0.000033	0.00003	0.00013	0.00003	0.00003
Treatment	2	0.0019*	0.0012	0.0019*	0.0013	0.0016	0.0013	0.0003	0.0007
Error	4	0.0002	0.0003	0.00025	0.00058	0.00033	0.00053	0.00013	0.00023

Analysis of variance of Leaf Potassium content.

Replication	2	0.00083	0.00083	0.0007	0.00063	0.00063	0.00093	0.00303	0.00191
Treatment	2	0.0756**	0.0577**	0.0229**	0.0127**	0.0133**	0.0091**	0.0067**	0.01031**
Error	4	0.00093	0.00078	0.0008	0.00058	0.00058	0.00043	0.00018	0.00056

APPENDIX (Page)

Analysis of variance of Plant Height.

Mean Square

Source	df	October	November	December	January	February	March	April	May
Replication	2	3.00	6.65	2.15	6.05	0.30	0.30	0.30	8.30
Treatment	2	390.00**	416.95**	420.60**	424.00**	439.05**	436.00**	451.40**	450.00**
Error	4	7.00	4.55	7.10	3.55	3.125	3.35	4.025	7.35

Analysis of variance of canopy area

Replication	2	1.79	0.769	0.362	0.985	1.783	0.696	0.309	0.426
Treatment	2	3029.466	3029.22	3069.874	3094.374	3160.356	3143.663	3168.957	3193.843
Error	4	1.851	2.456	1.439	1.688	2.435	1.501	0.913	3.020