STUDY ON THE

EFFECT OF FOLIAR APPLICATION OF UREA AND PLANOFIX ON THE GROWTH, YIELD AND QUALITY OF GINGER VARIETIES

(Zingiber officinale Roscoe)

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By

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CERTIFICATE

I certify that the thesis entitled "STUDY ON THE EFFECT OF FOLIAR APPLICATION OF UREA AND PLANOFIX ON THE GROWTH, YIELD AND QUALITY OF GINGER VARIETIES (Zingiber officinale Roscoe)" submitted in partial fulfilment of the requirements for the award of the degree of Master of Science in Agriculture (Horticulture) of the Orissa University of Agticulture and Technology, is a faithful record of bonafide research work carried out by SRI G. SREEKANDAN NAIR 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 all helps and sources of information availed during the course of investigation has been duly acknowledged.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is one of the most important of the spices as well as a medicinal plant grown in India and other Orient countries like China from time immemorial. It is believed to be a native of Tropical Asia. It appears to have first reached Rome, from where it spread to France and West Germany during the ninth century and probably reached last in England. The Spainards are said to have introduced in to Mexico and Jamaica about the sixteenth century. From Asia it spread to the West Indies, where it is now abundantly grown and from where it spread other parts of the world. At present ginger is grown in India, West Indies (Barbados and Jamaica), Africa (Sierra and Leone), Brazil, China, Japan and Indonesia.

Botanically ginger is the rhizome or the underground modified stem of the species *Zingiber officinale* Roscoe. It belongs to the family Zingiberaceae. It is a herbaceous perennial but commercially cultivated as an annual crop. The rhizome is used for propagation. The ginger of commerce is the dry product of the green underground stem or rhizome, which is valued as a spice and also for various medicinal preparations. Of late, new uses have been found through oleoresin ginger essential oils and dehydrated powders etc.

Ginger is mainly used as a spice in cookery as a flavouring agent in a wide variety of foods. The significance of ginger in the form of preserves and confectionaries such as candy, jelly, crystal ginger toffees and ginger biscuits can not be ignored. It is also used in the preparation of ginger wine, ginger beer, ginger carbonated water, etc. Pickled in salt it is largely used in Indian homes. Even the young shoots are used for pickling. In small quantities it is used in the cooking of vegetables, meat etc. The powdered dry ginger is an important component in curry powder. Small quantities are used to spice the animal food.

In addition it is valued for its medicinal properties. It is used in the preparation of tincture ginger, gengoal gingerine, digestive tablets, honey ginger, powder ginger and dry ginger.

Dry ginger contains one to three per cent of volatile oil and 50% of starch with fibre, protein, resin, fixed oils etc. as its other constituents. The volatile oil imparts a special aroma to ginger. Its pungent taste is due to the presence of a resin found disolved in the oil. Volatile oil obtained by distillation, is also used for flavouring and to a limited extent in perfumery.

Oleoresin of ginger is obtained by extraction with volatile solvents. This contains the aromatic and pungent principles of ginger in a highly concentrated form which is in greater demands in the world markets.

In the spice trade the dry ginger is the major item. The varieties are named after the place of production. Thus there is Jamaican ginger, Japanese ginger and Indian ginger (Calicut ginger, Cochin ginger) etc. The ginger is valued for their aromatic and pungent principles. The colour and fibre content are also important. The odour of Indian ginger is aromatic, the taste is strongly aromatic and pungent.

India is the largest producer and supplier of commercial dry ginger in the world. In India normally about 22,000 to 23,000 hectares are under the ginger crop extending in States like Kerala, Assam, Himachal Pradesh, Andhra Pradesh, Utter Pradesh, Tripura, Tamil Nadu, Maharastra, Mysore, Orissa etc. and producing about 21,000 to 22,000 tonnes of cured or dry ginger. One third of the total production is exported, the rest being consumed locally for various purposes. Western Countries such as U.S.A., U.S.S.R., Canada, U.K. and Australia import ginger from India. Aden Port, Saudi Arabia and other Middle East Countries prefer Indian product.

Though India still remains as the world's largest producer and exporter of ginger to the world market, the export of dry ginger declined considerably even to less than

50 percent of our one time peak export of 10,000 tonnes of 1957. The Marketing Research Corporation of India and other agencies like the Spices Export Promotion Council point out various reasons for the sharp decline in our export trade, as quoted below:

> "Indian ginger is reported to contain more fibre than ginger from certain other producing countires like Jamaica and Sierra Leone. There is, therefore, considerable market perference, abroad for ginger from these countries. The price of Indian ginger is also reported to be on the high side by about 20 - 30% when compared to the price of ginger produced in other countries"... These probably accounts for the sharp decline in our export trade in this commodity.

Improvement in the quality of ginger, reduction in the cost of production, and increase the yield per unit are etc. are, therefore, necessary to retrive the position in the export trade and to expand the foreign trade. Thus development programmes on hand are aimed at cultivation of varieties with less fibre content and increasing the per acre yield and outturn of dry ginger to reduce the cost of production. The other quality aspects such as oleoresin content, loss during storage etc. are also of prime importance.

It has been already found that Rio-de-Janeiro, Maran and China varieties are high yielding as compared to local varieties. These varieties are also have higher percent of oleoresin content coupled with comparatively lower fibre content. The Rio-de-Janeiro is characterised by high yield potential and high oleoresin content. China for its low fibre content and Maran for its higher dry ginger production and tolerance to rhizome rot.

Thus introducing these varieties in to general cultivation on a larger scale will be an immediate practical step to increase production. But the suitability of these varieties to general cultivation in new locations are to be tested before embarking upon a programme for large scale cultivation. Introduction of crop varieties to new locations calls for many consideration. Whenever, a crop is grown commercially, the factors that lead to its maximum economic return required to be identified with prime considerations. Besides assertaining the adaptability, the pattern of crop growth need to be fairly determined. Because under favourable environments the genetic potentialities are exhibited to a maximum extent while it remain latent where the environment is not suitable. So it is necessary to evaluate the suitable varieties possessing superior genotypes and their exploitation under the favourable Agroclimatic conditions because the final yield is the expression of the interaction between genotypes and the environment.

Moreover different varieties grown under the same climatic condition also differed markedly with respect to their expression of growth and consequently with the yield due to their genetic variability. This variability in growth and yield of plants are modified by external factors in several ways, but nutritional requirements as well as their nutrient uptake are being the main. Thus the capacity of a variety to utilize the optimum quantities of plant nutrients especially nitrogen is of prime importance.

The importance of nitrogen for increased yield of ginger have been reported by various workers. The response of ginger to nitrogen up to 21% has been reported by the Department of Agriculture Jamaica (1953). NPK trials conducted by Randhawa and Nandpuri (1966) reveals that a combination of 100 Kg. N. 50 Kg. P. and 50 Kg. K_2O per hectare proved best and produced significant increase in the height of plants, tiller numbers and yield. Even 100 Kg. N alone in the absence of phosphorus and Potash also proved best in modifying the growth and yield. It is also reported that the growth and yield was not very much influenced by application of P and K alone or in combination with each other.

Out of several advantages to foliar feeding especially with Urea, of which immediate availability of applied nutrient in the easily available from for development has been well recognised. As the nutrients are applied to the point of utilization, the over all process of foliar absorption is coupled with plant metabolism within a very short time. The high efficiency of utilization of foliar applied nutrients like Urea results in more economic use of fertilizers. In several crops, foliar application of lower levels of fertilizers especially Urea gives better yields as compared to soil application of a higher level of fertilizers. In addition foliar application helps to avoid the adverse effects of soil application such as increasing soil acidity as well as loss due to leaching etc. It also improves the quality of the produce. But in ginger no such work has been reported so far in India or abroad.

The use of growth substances like IAA, IBA, NAA for improving the growth and development as well as yield have been reported in other crops like, Tomato, Bhendi, Bringal, Potato etc., but no such work has been done in the case of ginger.

Ginger is cultivated in Orissa in districts like Koraput, Phulbani, Balasore, Cuttack. The extent of cultivation is limited. But the scope of development of ginger in Orissa is much more. But unfortunately no work have been done in the past with the improved varieties and improved techniques.

Under the above background a field trial was undertaken to assess the performance of improved ginger varieties like China, Maran, Rio-de-Janeiro, Thinladium and Sierra Leone with single and mixed application of Urea and Planofix with the following objectives:

(1) To determine the yield potential of different ginger varieties under Agro-climatic and soil conditions of Bhubaneswar.

(2) To study the interrelationship between different organs of the Plant and their relative contribution to yield.

(3) To screen the varieties for their resistance to rhizome rot.

(4) To find out the best suited variety for local. conditions.

(5) To study the compatibility of Urea and Planofix on ginger for further investigation.

(6) To study the effect of Urea and Planofix on the growth, yield and quality including the storage quality.

(7) To replace the 2nd schedule of soil application of fertilizers with the treatments.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The importance of ginger as a spice and medicinal crop is well known in India since the ancient time. Research informations on this crop is meagre and systematic research work was first undertaken in the country with the commencement of a Ginger Research Scheme in 1950 at Ambalavayal (Malabar region) in the composite Madras State. Subsequently research works were started in other regions of the country. Though few valuable results have been obtained from those research centres under the aegis of different organisations, yet the volume of work done on the improvements of the varieties, standardisation of agro-techniques for different agro-climatic regions are meagre. Though a few works have been reported on varietal trials and response to fertilizers, reports on the foliar application of Urea as well as growth substances are lacking. Therefore, an attempt have been made to review the research work so far reported in India and abroad, on varietal trials and on the effect of Urea (Nitrogen), and growth regulator Planofix on the growth, yield and quality of ginger alongwith other important crops.

Importance of Varieties

Germination : In their Germplasm collection and screening of ginger at the Central Plantation Crops Research Institute, Kasargod (Anon, 1972) they found that maximum germination was recorded in varieties like Maran (91%), Nadia (90.6%), Mysore (90%), Karakal (88.9%), Bajpai (88%), Poona (87.8%), Ernad Chernad (86.7%), U.P. (86.0%), among the 31 types of ginger maintained.

Growth : Thomas and Kannan (1969) reported that Rio-de-Janeiro variety was a vigorous growing plant with bigger sized and well formed rhizome, while, Pillai (1973) in his Germplasm collection and screening in Ginger at Central Plantation Crops Research Institute, Kasargod, pointed out that the 31 varieties tested there, showed significant difference in their characters such as number of tillers, height of plants and number of leaves. They also reported that plant height and leaf number were found to be associated with rhizome yield.

Yield of rhizome : Khan (1959) reported that of the 10 ginger varieties tried at Wynad the introduction from West Bengal known as "Burdwan" variety recorded the maximum yield of thirteen times the quantity of seed used while the variety from Brazil known as "Rio-de-Janeiro" excelled all other varieties in rhizome size, but its total yield amounted to eight times the seed rate.

Kannan and Nair (1965) reported that the high yielding varieties selected for general distribution include Rio-de-Janeiro yielding 25,000 - 30,000 Kg/ha and China yielding 18,000 - 20,000 Kg/ha.

The results of the studies conducted at the Agricultural Research Station, Ambalavayal (Kerala State), had shown athat considerable difference existed between various varieties of ginger in respect of quality and yield. Rio-de-Janeiro excelled all the other types in regard to yield. The average yield of this variety worked out to be 2 to 3 times the yield of Wynad local ginger and recorded the yield of 25,000 - 30,000 Kg per hectare, while China (18,000 - 20,000 Kg/ha) was the next best in this regard.

The results achieved by the scheme for Research on Ginger at Assam (as quoted by Aiyadurai, 1966) showed that Rio-de-Janeiro appeared promising in the priliminary tests.

Aiyadurai (1966) on reviewing the Ginger Development Scheme, Dadahoo (Himachal Pradesh) reported that the ginger types Rio-de-Janeiro and China recorded 25 to 30 percent more yield than the local types in their respective zone at low and mid elevations.

Systematic work in respect of improvement of ginger as reported from (Anon. 1965) Regional Research Station, Kandaghat (Simla Hills), situated at an elevation of about 1,500 metres above sea level, that, out of the varieties studied (Rio-de-Janeiro, China, Burdwan, U.P., Wynad Mentody, Bajpai, Mysore, Wynad Kunnamangalam, Karakal, Ernad Manjeri, Narasapatanam, Ernad Malabhar and Thodupuzha) the production capacity and resistance against pests and diseases, especially soft root (pythium aphanidermatum), it was observed that none could out yield the local type in green ginger production and other characters studied.

Thomas (1966) reported that in a trial of 18 varieties in Kerala, Rio-de-Janeiro yielded 32,550 lbs per acre with mean rhizome weight of 11 oz. as compared with variety China. This variety produced 16,758 lbs per acre with 9.1 oz of mean rhizome weight.

Nair (1969) reported that the experiments at Central Horticultural Research Station, Ambalvayal had shown that Maran and Assam type of ginger gave an equally good yield as that of Rio-de-Janeiro.

Thomas and Kannan (1969) reported that in a five year trial of 14 strains of ginger the Brazilian type Rio-de-Janeiro was significantly superior to all other strains except China type and gave an average yield of 25,000 lbs per acre. The yield of Sierra Leone type was about 14,565 lbs per acre.

Muralidharan (1972) reported that in his study on the comparative performance of 12 varieties of ginger, the variety Rio-de-Janeiro was significantly superior to all other varieties except the variety Assam for the yield of green ginger. In his report he recorded the yield of 21,801 Kg. for Rio-de-Janeiro Maran 15,392 Kg. Thinladium 11,869 Kg. and for Sierra Leone 9,776 Kg. of green ginger per hectare.

Pillai (1973) reported that ginger varieties Wynad Kunnamangalam, Wynad local, Tura and China were high yielding while poechi and Utter Pradesh were low yielding.

Quality: Kannan and Nair (1965) reported that the percentage of recovery of dry ginger to green ginger of Rio-de-Janeiro was 16-18 with a fibre content of 5.19% whereas Cultivar China gave the recovery of (dry ginger to green ginger) ranging from 13-15 percent only, with a low fibre content of 3.43 percent.

Thomas (1966) recorded a mean rhizome weight of 11 oz., ratio of dry to green ginger 16.25 percent and crude fibre content 5.19 percent to the variety Rio-de-Janeiro. The next best variety China yielded a mean rhizome weight of 9.1 oz with 15% of dry to green ginger and 3.43% fibre content.

The review of Aiyadurai (1966) on the Scheme for Research on Ginger in Wynad, Ambalavayal, recorded that the weight of dry ginger obtained was highest in Vengara, Ernad, Sierra Leone, Himachal Pradesh and Karakal varieties while, it was low in China and Rio-de-Janeiro. He also reported that the varieties Karakal, Burdwan, Ernad and China had the least fibre content and Himachal Pradesh, Mysore and Bajpai had the highest fibre content.

Nair (1969) reported Maran as a superior variety as this variety gave a higher percentage of dry ginger to green ginger which was quite important for the market.

Thomas and Kannan (1969) recorded Rio-de-Janeiro as a superior variety of ginger. According to him this variety gave bigger sized, well formed rhizomes, free and well set fingers (Mean weight of rhizome 11.8 oz and mean finger No.11.4).

Muralidharan (1972) reported that the percentage recovery of dry ginger from green ginger was the lowest in Rio-de-Janeiro while the variety Tura recorded the highest value. The maximum yield of dry ginger per hectare was also observed in the variety Rio-de-Janeiro though this was not significant over the varieties Maran, Nadia and Tingpuri. He recorded the percentage recovery of dry ginger and dry ginger production in Kilogram per hectare of Rio-de-Janeiro, Maran, Thinladium, Sierra Leone, Tura etc. as 14.93, 32,270; 19.83, 3,068; 21.03, 2,495; 19.23, 1,882 and 22.07, 2,654 respectively.

Natarajan *et al.* (1972) in their study on the chemical composition of ginger varieties and Dehydration studies on ginger observed that the varieties Thinladium, Jorhat and Assam were fibrous. The acetone extract (oleoresin) of the varieties China, Rio-de-Janeiro, Thinladium, Vengara and Maran were 5.8, 7.2, 5.9, 6.6 and 6.7 percent respectively. They also had the crude fibre of 8.00, 7.14, 9.60, 6.68 and 6.16 percent respectively. The results of maturity studies were also presented. Most of the constituents like volatile oil, acetone extract and crude fibre have been found to increase during the course of maturity.

Lewis *et al.* (1972) studied the various constituents of ginger (commercial varieties) and found that Cochin ginger was bold, light brown, partly peeled having Lemon like odour and flavour. They yield volatile oil of 2.2% , non-volatile extract (E.D.C.) 4.25%. Sierra Leone ginger was plump, dark partly peeled from sides having a pungent and slightly camphoraceous smell. They yield volatile oil of 1.6% non-volatile oil (E.D.C.) extract 7.2%. Jamaican variety was bold, very light Buff colour and clearly peeled with delicate aroma and flavour having 1% volatile oils and 4.4% Ethylene dichloride extract. Nigerian ginger was bold, light colour partly peeled, fibrus and they were very punget, camphoraceous flavour having 2.5% volatile oil and 6.5% Ethylene dichloride extract whereas, the Japanese variety was dark, bold and unpeeled having 0.5% volatile oil and 4.6% Ethylene dichloride extract.

They also presented the analysis datas for the various ginger varieties grown in India. According to them the variety Rio-de-Janeiro yielded 1.5% volatile oil, 3.67 Ethylene dichloride extract and 8.34% alcohol extract respectively. Maran gave 1.7% volatile oil, 3.64% Ethylene dichloride extract and 4.77% alcohol extract, varieties like China yielded 1.2% volatile oil, 3.29% Ethylene dichloride extract and 4.74% alchohol extract. Thinladium had 1.2% volatile oil, 2.38% Ethylene dichloride extract and 3.3% alchohol extract whereas, the variety Sierra Leone recorded 1.3% volatile oil 2.97% Ethylene dichloride extract and 5.47% alcohol extract. The authors also recorded the composition of Rio-de-Janeiro having moisture content of 7%, volatile oil 2.5%, Acetone extract 10.3%, Protein 11.1% Fibre 9.1%, Starch 43.4% and Ash 9.4% .

Jogi et al (1972) studied the changes in Crude fibre, fat and protein content of ginger at different stages of maturity of some important varieties. They showed that the moisture and crude protein of varieties Thinladium and Sierra Leone decreased with the advanced maturity whereas, the crude fibre showed an increasing trend, while the work done by Mathai and Prakash (1972) on the seasonal chemical changes in cultivars of ginger showed that the variety Rio-de-Janeiro gave the maximum yield of oleoresin followed by varieties Mananthody and Karakkal. No significant difference was however observed between Sierra Leone and Maran varieties. The studies carried on by the workers on the total ash content of the varieties revealed that, Rio-de-Janeiro and Wynad Mananthody samples gave the maximum amounts of total ash which were also the highest yielders of oleoresin. The China variety however had the lowest total ash content but the aforesaid higher yielders possessed the maximum fibre content.

Mathai (1973) in his Quality Studies on Spices analysed 20 varieties of ginger for their drymatter and oleoresin content. He found that drymatter varied from 11.1% in Rio-de-Janerio to 28.4% in Ernad Chernad. Acetone extracted oleoresin content was the highest in variety Jorhat (10.1%) followed by Thinladium, Sierra Leone (6.8%), Rio-de-Janeiro (6.6%) and Maran (5%). The dry matter content as reported by the author were Maran (16.1%), Sierra Leone 21.4% and with Thinladium it was 24.1%. He also pointed out that the yield of oleoresin was higher when alcohol was used as the solvent and the drymatter increased with the maturity of the rhizome while the crude fibre content decreased with age.

Muralidharan (1974a) in his trilas for selection of suitable varieties for the Spice Industry, recommended Rio-de-Janeiro, Assam, Utter Pradesh, Vengara, Wynad local (Sl.1), S.L. 2 a selection from Manantody for green ginger production. He has further explained that the maximum recovery (25.09) of dry ginger was noticed in the variety Tura in par with Nadia and Himachal Pradesh. But these varieties produced low yield of green ginger and hence the total dry ginger production was also low. He pointed out that the varieties Wynad local, Vengara, Rio-de-Janeiro, Assam, Manantody, Kuruppampady Valuvanand, Ernad Manchari were able to give more than 200 Kg. of oleoresin per hectare which are suitable for processing industry.

Bavappa (1974) stressed the importance of ginger varieties having low fibre content and high oleoresin.

Mathew _et al_ (1972) listed the essential oil content and odour characteristics of 5 commercial and 27 local varieties of ginger grown in India.

Pests and diseases: Kannan and Nair (1965) reported that the losses due to the attack of rhizome rot caused by _Pythium aphanidermatum_ to the crop even ranged from 80-90 percent in serious cases.

Nair (1969) expressed that the variety Maran was comparatively tolerant to the soft rot (rhizome rot) disease while Rio-de-Janeiro was quite susceptible to this disease. But the works done at the Regional Research Station, Kandaghat under the Punjab Agricultural University during 1962-63 (Anon 1965) found that none of the varieties screened for their production capacity and resistance against pests and diseases expecially soft rot (Pythium aphanidermatum) could out yield the local types in green ginger production and suffered heavily from the rhizome rot disease in the fields as well as in the storage. The varieties included were China, Rio-de-Janeiro, Ernad Malabar, Thodupuzha etc.

Effect of fertilizers: Experiments conducted in India and abroad showed that the yield of rhizomatous crops like turmeric and ginger could be increased by the application of fertilizers.

Miller (1938) stated that the rhizome being the region of food storage and the great bulk of foods which accumulate in plants were classified into carbohydrates, fats and proteins. According to Thomas and Richardson (1959) the cells of storage tissues were not passive reservoirs. In this the various compounds of carbohydrates were formed from primary sugars. Curtis (1959) reported that the development of storage organs was greatly influenced by day length, temperature and available nutrient supply.

Blackman (1948) reported that beneficial effects of soil fertilization were primarly due to the increase in foliar area and of assimilation tissue rather than to increase in efficiency of assimilation process.

Bakhuyzen (1937) observed that during the later phase of active vegetative growth, the plant rapidly accumulated carbohydrates and appeared to become relatively less efficient in Protein than in carbohydrate elaboration. Droyer and Hoagland (1943) reported that maximum rhizome formation occured when carbohydrate was not required for new tissue formation or maintainance of existing tissues. The inhibition of growth might be due to the lack of vigour or reduction of respiration. According to him the maximum rhizome development took place when there was intermediate long days, medium light intensity and abundant nitrogen supply, while long days high temperature and large nitrogen supply resulted in abundant shoot growth and poor rhizome development. Temperature, length of day and nitrogen supply significantly influenced rhizome top ratio. He has further stated that rhizome producing crops respond differently to fertilizers according to the soil and climatic condition.

Purewal (1957) showed that there was highly significant and possitive correlation between plant height and plant yield in tuberous plants like colocasia. Ihra (1959) reported that the growth of rhizome and tuber is closely associated with that of shoot.

Ashby (1948) reported that increased doze of nitrogen increased the rate of leaf production in all cultivated crops while insufficient nitrogen reduced the yield drastically and also decreased the quality of plant products whereas excess nitrogen delayed flowering. Further excess supply of nitrogen reduced cell thickness and hence the plants were more susceptible to the attack of insect pests and disease organisms.

Abraham (1960) reported that turmeric and ginger were supposed to be similar in their plant food requirements as they belong to the same family zingiberaceae. In the fertilizer trials conducted under the technical collaboration between Kerala Agricultural Department and Potash Scheme 1957-60, application of 50 lbs N 50 lbs P_2O_5 and 100 lbs. K_2O acre gave the maximum yield of ginger. The original trials conducted in 1959-60 at the Agricultural Research Station, Ambalavayal with N P_2O_5 alone showed that the application of N and P either alone or in combination had no response. Later series of experiments at Ambalavayal and Thodupuzha showed that the application of complete fertilizers was better than application of N, P_2O_5 and K_2O separately (Anon 1954).

In rhizomatous and tuberous crops the main constituent of which is carbohydrate, the benefit of nitrogen manuring is brought about by increased leaf area and consequent shoot growth. Russel (1961) reported that nitrogen was helpful for rhizome development of long duration crops. But in short duration crops the effect of nitrogen is only on the top.

Nojkn (1957) reported that the effect of P_2O_5 in rhizome of rhubarb was marked only in the presence of nitrogen. Sayed (1960) reported that the application of 10,000 lbs of powdered cattle manure to supply 50 lbs of nitrogen and the same effect of application of 10,000 lbs of green leaf at the time of planting and a second application of 5,000 lbs per acre about 45 days after planting. Sayed also recommended an application of 25 lbs of N in the form of Ammonium sulphate for maximum production of ginger and application of both organic and inorganic mannures were essential.

Kannan and Nair (1965) reported that ginger was an exhaustive crop and required heavy manuring containing 25-30 tons as cattle manure as basal dose and fertilizer mixture of NPK (8:8:16) at the rate of 450 Kg. per hectare for increased production. The response of ginger to nitrogen upto the extent of 21 percent has been recorded by the Department of Agriculture, Jamaica (Anon. 1953). Grosmann (1954) recommended a side dressing of 10:8:7 fertilizer mixture at the rate of 5 cwt per acre for higher yield of ginger. Loknath and Dash (1964) stressed the importance of split application of fertilizers.

Thomas (1965) found that for raising economic crops of ginger in virgin soils in Wynad, application of N and P_2O_5 is not necessary provided the crop was supplied with 10 tons of organic matter and 15,000 lbs of green leaf mulch per acre.

N P K trials conducted at the Regional Research Station, Kandaghat for four years indicated that the combination of 100 Kg. N, 50 Kg. P and 50 Kg. K per hectare proved best and produced a significant increase in the height of plants, number of tillers and yield of rhizomes of ginger over control (Randhawa and Nandpuri, 1969c) . The application of 100 Kg. nitrogen in the absence of phosphorus or potash increased the height of plants, number of shoots and rhizome yield as compared to 50 Kg. of nitrogen, while, the growth or yield was not much influenced by the application of phosphorus and potash alone or in combination of both.

Aiyadurai (1966) in his review of the ginger development scheme, Himachal Pradesh showed that nitrogen fertilization of the crop with 50 to 100 lbs nitrogen per acre had significantly increased the yield by 18 to 32 percent more yield but also improved the dry matter content of rhizome. The influence of Nitrogen was evidenced by the trials conducted by the Jamaican Department of Agriculture as early in 1953 (in their trials on 1950-51). They got about 21%

response to nitrogen but no clear response to phosphorus and potash, at the other station there was no clear response to any fertilizer.

Pillai (1973) found that higher level of nitrogen produced significant effect on the number of leaves length of leaves, breadth of leves and number of tillers.

Muralidharan et al (1973b) reported that application of nitrogen, phosphorus and potash at the rate of 70+70+140 Kg./ha increased the height of plants and yield. The tiller number steadily increased upto the above levels of nutrient application but declined when applied beyond that level. They observed (1973c) that the yield of Rio-de-Janeiro variety reduced significantly with the application of nitrogen beyond 50 Kg. per hectare.

Muralidharan et al (1974b) revealed that 70 Kg. nitrogen per hectare increased significantly the number of tillers and yield of rhizome, but the application of phosphorus had no effect, while potash (K_2O) at the rate of 140 Kg. per hectare significantly reduced the yield of rhizome, other plant characters being remained unaffected. So they stated that the recommendations made by Nair (1969) and Paulose(1970) were on the higher side with respect to phosphorus and Potash.

Dasaradhi et al.(1971) stressed the importance of nitrogen at the active growth and tillering stage i.e., about a period between 120 to 135 days and a total of 200 to 210 days from sowing. At this time the nitrogen consumption was high which went up to 3%(leaves), which is normal at other times. They further stressed that readily available form of nitrogen should be applied during this stage.

<u>Effect of Urea</u>: The volume of work done on the soil application of Urea in general crops was much more than that on ginger. However, Rajan and Singh (1972) showed that though sawdust alone when used for soil amendment was harmful, yet with the application of Urea to saw dust amended soil resulted in a significant increased yield in the case of ginger. There were also increased growth characters such as tillers, leaves per plant and height of plants.

<u>Disadvantages of soil application of Urea</u>: The effects of several environmental factors on the volatalization of ammonia from the surface application of Urea on soil were studied by Ernest and Massey (1960). The reported that increasing temperature and/or pH markedly increased the ammonia volatalization under conditions of rapid drying. The soil became dry after 4 to 5 days of aeration and ammonia volatalization was markedly decreased because hydrolysis of Urea was retarded due to lack of moisture.

Brage <u>et al</u>. (1960) on investigation with barley and corn reported that when fertilizer Urea was mixed with the soil, considerable ammonia was evolved from the soil atmosphere by aeration. Ammonia gas formed from Urea was harmful to the germination of seeds.

Cumins and Parke (1961) reported that Urea was infurious to germination of wheat and corn at low concentrations (0.10 and 0.5%). The pronounced reduction of germination from Urea was probably due to the high concentration of ammonium irons in the visicinity of the seed, resulting from the reaction of water with Urea during Urea hydrolysis.

Low and Piper (1961) investigated the effects of Urea on grass and other crops and concluded that the principal factors in Urea toxicity to seeds and seedlings appeared to be ammonia formed during ammonification.

Cooke (1962) concluded that the roots of the seedlings can be damaged by the ammonia produced by the hydrolysis of Urea in the soil. Court et al. (1962) agreed with the above findings. Lower yield was obtained when Urea was placed near the seeds. They also showed that nitrate can accumulate in Urea treated soil and this nitrate accumulation cuased the marked phytotoxicity and reduction of plant yield.

Issacs and Hester (1953) reported that sprays applied in conjunction with normal spray programme of insecticides and fungicides have been effective to supply nitrogen to tomatoes and carrots. The yield of the carrot was significantly higher when nitrogen was applied as spray than when equivalent amounts were applied as basal dressing.

Ozaki and Crew (1954) observed in tomato and beans that Urea foliar spray improved the vegetative growth by making the plants taller and heavier than the untreated plants.

Foliar application of Urea and its limitations: The most widespread disorder of growing plants is nitrogen deficiency which results in a remarkable reductionof plant growth. The disorders of nitrogen deficiency were conveniently overcome by Urea sprays.(Yamada 1962). Gasser (1964) opined that Urea was an organic nitrogeneous fertilizer readily soluble in water. It produced no injury to the leaves and was rapidly absorbed by leaf cells than any other nutrient ions. It was considered as an efficient spraying material to supply nitrogen to the plants.

Yamada et al. (1965b) concluded that the effect of Urea on cuticular permeability was based upon loosening of membrane structure by changing ester, ether and diether bonds between macromolecules of cutin. Urea penetrates the cuticular membrane very rapidly and also facilitates the penetration and absorption of other materials supplied simultaneously (Yamada 1962, 1965, Wittwer Et al. 1967).

One of the limitations of foliar application of fertilizers is high concentration of the solution sprayed on the leaves, which was to be carefully controlled in order to avoid scorching of leaves. In contrast to the comparatively dilute state of nutrients around plant roots, quick evaporation of the aqueous phase of foliar spray lead to high concentrations and the consequent unusual conditions for nutrient absorption. Minsvark et al. (1953) suggested that plants most easily affected are apparently those which had the highest urease activity. Conduciveness towards Urea injury was indicative of rapid hydrolysis denoting rapid utilization and distingushed the plants most readily benefited when below toxic concentrations were employed.

To obviate the phytotoxic effects of Urea, comparatively dilute solutions and also split application should be resorted to, for achieving good results from foliar sprays (Boynton 1954 and Wittmer and Teubner 1959).

Foliar absorption of Urea: Theoretical aspects of nutrient uptake through plant leaves was studied by Wittwer and Teubner (1959), Yamada (1962), Wittwer (1964), Franke (1964, 1967), Yamada et al. (1965a), Wittwer et al. (1967). These authors have opined that the rate of foliar absorption was influenced by the wetting capacity, temperature, relative humidity, age, nitrogen status, texture and structure of leaves. The wetting capacity which depended on the contact angle of the fluid on the leaf surface, varied with the species of plants and for same species of plants with the age of the leaves.

Franke (1964) reported that guard cells were favoured sites for foliar absorption and were equiped by more ectodermata which definitely functioned as pathways for transport of foliar absorption. Micro-auto radiographic studies with labelled compounds by Wittwer et al. (1967) also revealed that penetration of nutrient ions through cuticular membrances was localised around stomatal pores and along periclinal walls.

Bullock and Benson (1952) obtained definite evidence of nitrogen absorption, from urea sprayed on peach leaves under green house conditions. Blasberg (1953) found that foliar spray of Urea on mature apple trees resulted in quick absorption and assimilation, thus minimising their dependence upon the translocation of absorbed nitrogen from the roots.

Boynton et al. (1953) treated MCIntosh apple leaves with 1% Urea and noticed about 91% absorption within 24 hours. Volk and MaAulifee (1954) recorded higher absorption of Urea sprayed on foliage within 24 hours by tobacco leaves and also noticed the marked dependence of absorption on high relative humidity. Absorption was higher at night than in day time.

Van Oberbeck (1956) reported that leaf absorbed nutrients were translocated through the phloem as against root absorbed nutrients moving through xylem.

Cain (1956) treated banana, coffee and cacao leaves with 5% Urea and studied the rate of absorption of the test solution. Absorption was most rapid in cacao with approximately 80% absorption in two hours, whereas, coffee averaged approximately 50% and banana only 20%. Young leaves of coffee absorbed much more rapidly than did older leaves. Virtually complete absorption was obtained in coffee and cacao leaves in less than 24 hours. Lower surface of leaves absorbed the solution much more faster than it was absorbed by the upper surface.

Burr *et al.* (1957) observed rapid absorption of N^{15} Urea sprayed on to a sugarcane plant. The tagged N was quickly translocated to all parts of the plant. Freiberg and Payne (1957) have confirmed the rapid absorption of Urea by banana leaves. About 65% of the applied Urea could be absorbed within 25 miniutes under humid conditions.

Penetration of C^{14} labelled Urea as intact molecules through cuticular membrances was confirmed by paper chromatographic procedures and autoradiography of chromatrograms (Yamada *et al.* 1965a).

Effect of Urea on Growth: Ozaki and Crew (1954) observed elongation of tomato and bean plants with the foliar application of Urea at 0.2 to 0.5% concentrations. Cunningham (1957) reported that spray application of Urea resulted in better growth of potato plant by supplying additional nitrogen. Rao (1961) reported progressive increase of plant height in 3 varieties of rice with foliar application of Urea at 15 lbs and 30 lbs of nitrogen per acre.

Varma *et al.* (1970) stated that foliar sprays of 1.25% Urea improved the growth of tomato plants. Das and Sahoo (1973) reported that the height of potato plant was significantly increased with 1.5% Urea alone as well as in combination with boron, molybdenum and calcium. The thickness of the stem was significantly increased in potato plants with the application of 1.5% Urea as reported by Das and Sahoo (1973). These workers have also observed significant increase in the leaf number and leaf area of potato plant with the foliar application of Urea 1.5% alone as well as in combinations with boron, calcium and molybdenum. However, they failed to get any significant increase in the number of main shoots, branch number per hill and leaf thickness of potato plants with the application of Urea.

Rao (1961) recorded progressive increase in earbearing tillers in varieties of rice due to foliar application of Urea at 15 lbs and 30 lbs nitrogen per hectare.

Humphries and French (1961) obtained an increase in total leaf area due to the increased production of leaves by Urea sprays on potato plants.

Das and Padhi (1974) found that Urea 2% alongwith other treatments showed increasing trend in the height of potato plant and thickness of main shoot, number of leaves, etc.

Effect of Urea on Yield: Fisher and Cooke (1950) found foliar application of Urea to be more effective in increasing the production of apple fruits. Mayberry (1952) obtained significantly increased yield of field tomato by four foliage application of 0.6% solution of Urea.

Mehrotra et al (1969) reported increased yields of potato by foliar application of Urea in two split dressings at sowing and again at the stage of active tuber formation. Verma, et al (1970) reported that foliar sprays of 1.25% Urea improved the yield of Marglobe tomatoes as compared to control. Mehrotra et al. (1970) observed that foliar sprays of Urea at the appropriate time increased the yields by 10-30% in cabbage, cauliflower and pea. Das and Sahoo (1973) reported significant increase in the yield of potato with foliar application of 1.5% Urea. They also reported that Urea applied alone as well as in combinations with boron, molybdenum and calcium yielded large proportion of large and medium sized tubers.

Das and Padhi (1974) observed that Urea 2% and its combinations with other chemicals and planofix increased the yield of potato plants. It also improved the grade of tubers i.e., percentage of large and medium sized tubers were increased due to the treatments.

<u>Effect of Urea on Quality</u>: Das and Sahoo (1973) observed significant increase in starch and ascorbic acid content of potato tubers with the application of 1.5% Urea. They also reported that the moisture content of potato tubers increased significantly with the application of Urea, while the specific gravity of potato did not increase significantly. Application of 1.5% Urea had no significant influence in reducing the rot percent of tubers in the storage under laboratory condition as reported by Das and Sahoo (1973).

Skvortosov and Shrinina (1971) reported increase in starch content of potato and sugar content of fodder beet with the spray of Urea. Varma *et al*.(1970)stated that foliar application of 1.25% Urea increased the sugar content nitrogen and vitamin C in Marglobe tomatoes.

Das and Padhi (1974) found an apparent increase in the specific gravity of potato tubers with Urea 2% and its combinations with Planofix 250 ppm (0.25 ml/l) alongwith other treatments. There was significant increase of Starch and Ascorbic acid content of tubers. They also reported increased moisture content of tubers and a reduced rottage due to the treatments.

<u>Effect of Planofix on Growth</u>: Singh and Upadhyay (1967) found that NAA when applied under field conditions

significantly increased the height and diameter of main shoot upto an application of 15 ppm, with a decrease at higher concentrations (30 and 50 ppm). They found that foliar application of NAA was more effective in increasing the number of leaves per plant and the highest number of leaves were produced with 30 ppm. Higher concentration of NAA especially when applied through foliage delayed flowering. The concentration of 50 ppm had an adverse effect on all characters studied.

Das and Sahoo (1973) reported that Planofix at 1000 ppm (1 cc/L) concentration had no significant effect in increasing the height of potato plant. They also reported that such high concentration of the chemical had no significant effect in increasing the stem thickness, number of mainshoots, branches per hill, number of leaves per hill as well as the leaf area and leaf thickness of potato plant.

Das and Padhi (1974) concluded that the foliar application of Urea, calcium, boron, molybdenum and Planofix and with most of their combinations had significant effect on the growth of Potato. The height was increased by 2% Urea combination of Urea with Planofix of 250 ppm (0.25 cc/l) closely followed by Planofix 250 ppm. combination of Planofix with boron, combination of Planofix with boron and molybdenum at successive stages of growth. Almost the same trend has been recorded in the thikness of the stem (Mainshoot). Urea 2% and its combination with 250 ppm Planofix apparently increased the branch number per hill. The number of leaves per hill also behaved just like the plant height. The above treatments also increased the leaf area of potato plant.

<u>Effect of Planofix on Yield</u>: Das and Sahoo (1973) had found that Planofix at 1000 ppm concentration had no significant effect in increasing the yield of potato tubers. They also observed that this chemical at such a concentration did not measurably affect the production of Grade I and II sized tubers and further concluded that the effects were not visible probably due to unsuitable concentrations.

Das and Padhi (1974) stated that 2% Urea, combination of Urea with Planofix at 250 ppm closely followed by Planofix 250 ppm combination of Planofix with boron, combination of Planofix with boron and molybdenum had increased the yield significantly in the order of merit. Urea at 2% and its combinations produced higher percentage of large and medium sized tubers.

<u>Effect of Planofix on Quality</u>: Das and Sahoo (1973) stated that no significant effect of Planofix at 1000 ppm was recorded in increasing the specific gravity of potato, starch content and ascorbic acid. They had also found no significant effect of this chemical on the moisture content of potato.

Das and Padhi (1974) agreed with the finding of Das and Sahoo (1973) in the specific gravity of tubers. But they got an apparent increase of specific gravity with 2% Urea and combination of Urea with 250 ppm of Planofix over control. They found Urea 2%, combination of Urea with Planofix 250 ppm alongwith other treatments increased the ascorbic acid content of tubers. The moisture content of tuber also measured almost in the same trend. They reported that the rotting of the tubers were significantly reduced with 2% Urea, combination of Urea with Planofix 250 ppm in the order of merit as compared to the control.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

A field trial was conducted during 1974-75 with an object to find out the differential response of five ginger varieties to the foliar applied Urea and Planofix with respect to their growth, yield and quality.

I. Experimental Site

The experiment was carried out in Plot No. 27(E) of the Horticultural Research Station of the Orissa University of Agriculture and Technology, Bhubaneswar, Orissa. The topography of the site was fairly level and uniform with good drainage conditions.

Soil: The soil type of the experimental plot was sandy loam. The mechanical and chemical composition of the soil as determined from the composite sample, collected before the laying out of the field from a depth up of 15 cms have been presented in Table - 1.

TABLE I. MECHANICAL AND CHEMICAL COMPOSITION OF THE SURFACE SOIL (15 cms)

(a) Mechanical Composition

Constituent	Percentage
Sand	75.60
Silt	12.90
Clay	11.50

Textural Class - Sandy loam

(b) Chemical Composition

Particulars	Quantity
Total Nitrogen	0.059%(1322.78kg/ha.
Available Phosphorus	30.60 Kg./ha.
Available Potash	64.00 Kg./ha.
Organic Carbon	0.58 %
PH	6.4
C:N ratio	9.99 : 1

The chemical analysis revealed that the nitrogen and phosphorus status of the field was medium and the potash content was low. The PH of the soil was 6.4 . The organic carbon of the soil was 0.58% which was a medium value.

The various standard methods adopted for mechanical and chemical analysis of soil are given below:

(a) Mechanical Analysis : Bouyoucos hydrometer method.

(b) Chemical Analysis:

(1) Soil reaction: Soil reaction of air dry soil was determined by electrometric method with the help of Backman's PH meter, with a soil water ratio of 1:2.5 as described by Piper (1950).

(2) Organic Carbon: Walkley and Black's method was followed for estimating the organic carbon content.

(3) Total Nitrogen: Total nitrogen was determined by modified Kjeldahl digestion and distillation method and expressed in percentage and Kilogram per hectare as oven dry basis.

(4) C:N ratio: The Carbon and nitrogen percentage of the soil was used to find out the C:N ratio.

(5) Available Phosphorus: Available Phosphorus in the soil was determined by Bray's method, using Bray's strong reagent as extractant and developing the molybdo-phosphoric blue colour whose intensity was measured by Photo-electric Colorimeter.

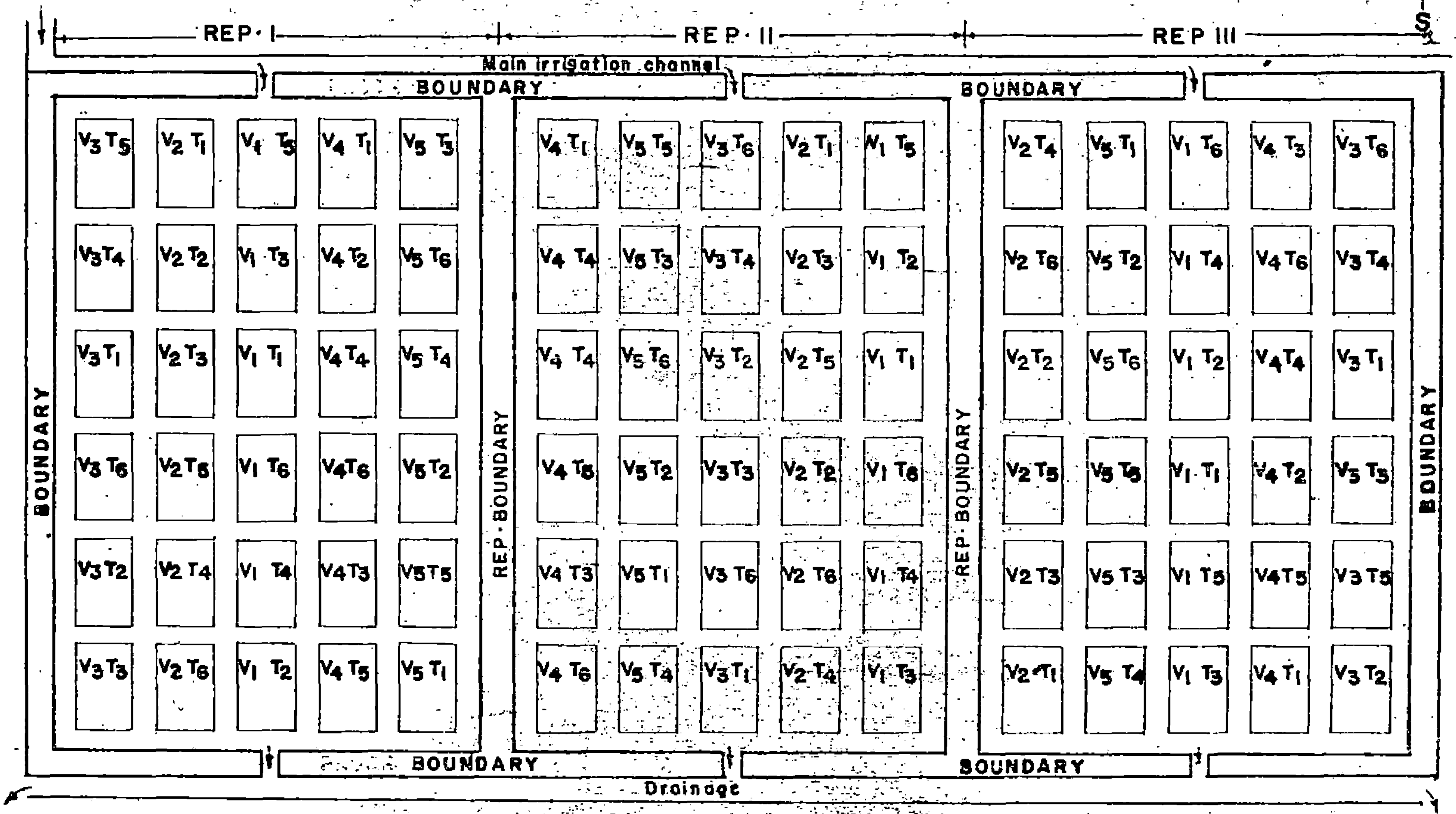
(6) Available Potash: Available Potash in the Soil was determined by using Ammonium acetate as extractant and estimating the Potash by the Flame Photometer.

<u>Climate and Weather Conditions</u>: The Horticultural Research Station is situated about 64 km West of Bay of Bengal and two miles away from Bhubaneswar town at an elevation of 25.5 meters above the mean sea level. Geographically, it is situated at 20° 15' North latitude and 85° 52' East longitude.

The mean annual precipitation is 1517 mm. of which 1128 mm is received from June to September and 389 mm from October to May. The mean maximum temperature varies from 36.3°c to 39.2°c during the hottest month of May. The mean minimum temperature ranges between 11.9°c to 18°c during the coldest month of December. The relative humidity varies from 86.5% in the month of August to 65% in the month of December.

The monthly meteorological data relating to crop season from June 1974 to February 1975 recorded at the Meteorological Observatory of the Orissa University of Agriculture and Technology, Bhubaneswar, together with the corresponding average figures calculated over last 10 years and the deviations from normal therefrom, are presented in Table 2.

FIG·I
PLAN OF LAYOUT



DESIGN: Split plot · MAIN PLOTS : Varieties; V_1, V_2, V_3, V_4 & V_5.

REPLICATION: 3 SUB PLOTS : Urea & Planofix; T_1, T_2, T_3, T_4, T_5 & T_6

GROSS PLOT: 1·5 X 1 M· NET PLOT : 0·25 X 0·2 X 5 M· Experimental area : 273·06 Sqm·

TABLE 2. METEOROLOGICAL DATA DURING THE CROP GROWING PERIOD (JUNE 1974 TO FEBRUARY 1975) WITH THE CORRESPONDING AVERAGE FOR PRECEEDING TEN YEARS (1964-1973) WITH DEVIATIONS IF ANY

	Rain fall in mm			No. of rainy days			Temperature in Centigrade						Sun shine hours			Relative Humidity		
							Maximum			Minimum								
	Average	Current	Deviation	Average	Current	Deviation	Average	Current	Deviation	Average	Current	Deviation	Average	Current	Deviation	Average	Current	Deviation
June	185.7	119.3	-66.4	16	16	0	35.2	36.2	+1	26.6	26.4	-0.2	5.6	7.1	+1.5	73.5	69.5	-4.0
July	360.5	231.5	-129.0	23	19	-4	31.2	32.7	+1.5	25.6	25.6	0	4.5	4.8	+0.3	85.5	81.0	-4.5
August	336.7	374.8	+38.1	23	18	-5	31.1	32.6	+1.5	25.5	26.0	+0.5	4.9	6.5	+1.6	86.0	81.0	-5.0
September	273.6	167.2	-106.4	20	15	-5	31.5	32.2	+0.7	25.2	25.4	+0.2	6.4	6.6	+0.2	85.5	82.0	-3.5
October	183.2	237.8	+54.6	11	18	+7	31.1	31.3	+0.2	23.0	23.9	+0.9	8.1	7.5	-0.6	79.5	83.0	+3.5
November	32.9	26.5	-6.4	3	4	+1	29.4	29.6	+0.2	18.3	18.8	+0.5	8.9	8.4	-0.5	70.0	66.5	-3.5
December	5.9	0.0	-5.9	1	0	-1	27.5	27.7	+0.2	14.6	13.2	-1.4	9.3	10.0	+0.7	65.0	61.0	-4.0
January	19.4	0.0	-19.4	2	0	-2	27.8	27.6	-0.2	15.4	14.3	-1.1	9.2	9.5	+0.3	67.5	65.5	-2.0
February	17.9	40.4	+22.5	3	4	+1	31.0	30.2	-0.8	18.5	18.9	+0.4	9.6	8.8	-0.8	67.0	68.5	+1.5
Total	1415.8	1197.5	-218.3	102	94	-8	275.8	280.1	+4.3	192.7	192.5	-0.2	66.5	69.2	+2.7	679.5	658.0	-21.5
Mean	157.3	133.0	-24.2	11.3	10.4	-0.9	30.6	31.1	+0.47	21.41	21.38	-0.02	7.38	7.68	+0.30	75.5	73.1	2.4

TABLE 3. CROPPING HISTORY OF THE EXPERIMENTAL FIELD

Year	Crops grown
1969	Cauliflower
1970	Fallow
1971	Brinjal
1972	Beans
1973	Sponge gourd

During 1974 June the Ginger experiment was laid out.

II. Experimental Details

The experiment was designed to study the effect of Urea and Planofix as foliar application, on the growth, yield and quality of five ginger varieties, and the details of the experimental technique followed are given below:

Design and Layout: The experiment was carried out in a split plot design. The varieties were assigned to main plots, whereas the Urea and Planofix combinations were assigned to sub-plots. Both main plot and sub-plot treatments were allotted with the help of random numbers. The plan of layout is given in figure (1).

Details of Treatments

(a) Main plot treatments - 5 varieties

1) China

2) Maran

3) Rio-de-Janeiro

4) Thinladium

5) Sierra Leone

(b) <u>Sub-plot treatments</u> - Urea and Planofix

$T_1(U_0P_0)$ - Water Spray - Control

$T_2(U_1P_0)$ - Urea 2% spray

$T_3(U_0P_1)$ - Planofix 0.2 ml/litre of water (i.e. 200 ppm) spray

$T_4(U_1P_1)$ - Urea 2% + Planofix 200 ppm spray

$T_5(U_0P_2)$ - Planofix 0.4 ml/litre of water (i.e. 400 ppm) spray

$T_6(U_1P_2)$ - Urea 2% + Planofix 400 ppm spray

<u>Other Details:</u>

Number of replications	..	3
Number of main plot treatments	..	5
Number of sub-plot treatments	..	6
Number of treatment combinations	..	30
Total number of plots	..	90

<u>Size and Area of the Plot:</u>

Gross Sub-plot .. 1.5m x 1m = 1.5 Sq.m.

Net Sub-plot .. 0.25 Sq.m.

Total experimental area .. 273.06 Sq.m.
i.e. 0.027306 hectare

Spacing:

Row to Row	..	25 cm.
Plant to Plant	..	20 Cm.

A Brief Description of the Varieties:

The Ginger Varieties, China, Maran, Rio-de-Janeiro Thinladium and Sierra Leone were selected to study their performance under the influence of the various sub-plot treatments.

China

An exotic type from China. Fairly high yielder, with moderate growth performance. The rhizome of this variety has attractive sixe and colour.

Maren

An indigenous type of ginger, gives good yield as Rio-de-Janeiro and gives a higher percentage of dry ginger. Have impressive growth characters such as height, tiller numbers, leaf numbers, thickness etc.

Rio-de-Janeiro

An exotic type from Brazil. Gives high yields ranging from 17,000 to 24,000 Kg. of green ginger per hectare. Yields up to 30,000 Kg. have been obtained from this variety in certain areas. But the percentage of dry ginger is low. Have high oleoresin content.

Thinladium

An indigenous type. Good Yielder. Good growth characters, such as height, leaf numbers, tiller numbers, thickness etc.

Sierra Leone

An exotic type from Sierra Leone Island (Africa) having good yield and growth characters. Attractive skin characters.

Details of Sub-Plot Treatments:

$T_1(U_0P_0)$ - Distilled water was applied as foliar spray uniformly over the plants (control plots)

$T_2(U_1P_0)$ - Urea was applied as foliar spray in the form of Synthetic commercial Urea at 20% concentration.

$T_3(U_0P_1)$ - Planofix (a growth substance) was applied as foliar spray at a concentration of 0.2 ml in 1 litre of water i.e. 200 ppm concentration.

$T_4(U_1P_1)$ - Mixed application of Urea and Planofix were made through foliar spray in the above mentioned form and concentration.

$T_5(U_0P_2)$ - Planofix was applied as foliar spray at a concentration of 0.4 ml in 1 litre of water i.e. 400 ppm concentration.

$T_6(U_1P_2)$ - Mixed application of Urea and Planofix were made through foliar spray at T_2 and T_5 levels, respectively.

(Teepol 0.01% was added to the spray material as a sticking agent).

Details of Cultural Operations

(i) Preparatory Cultivation: The field was thoroughly ploughed for five times followed by planking after each ploughing during the first week of June 1974.

(ii) Layout: After thorough preparation of the field incorporating the basal doze of Farm yard mannures, the experiment was laid out on 15th June 1974. Beds of size 1.5 m length, 1 m wide and 25 cm height were prepared to accomodate the sub-plot treatments. Six of such plots constitute one major treatment plot. The spacing of 30 cm, 40 cm and 60 cm were given between the sub-plots, major plots and blocks respectively. A total of three blocks accomodating three replications as indicated before were laidout. Adequate facilities for irrigation and drainage were also provided.

(iii) Planting material and their planting: Ginger rhizomes were used for planting. Healthy best rhizomes free from pests and diseases were selected. The rhizomes were then cut into bits of 15 gm weight (1½" size) each bit having one or two viable, healthy buds. The bits of seed rhizomes were soaked for 30 minutes in 0.25% Ceresan wet solution and spread under the shade to drain the water and for air drying.

The treated rhizomes were used for planting which was completed on 16th June 1974. Small pits were made at a spacing of 25 cm x 20 cm at a depth of 5 cm and rhizomes were planted in the pits with the bud facing upward and covered with soil.

(iv) Mulching: Immediately after planting, the beds were mulched thickly with green leaves at a rate of 15,000 Kg. per hectare. Repeated mulching twice at a rate of 7,500 Kg. per hectare first alongwith first earthing up and second just before the spraying of sub-plot treatments were made.

(v) Application of mannures and fertilizers: Well decomposed farm yard manure was applied to the soil at the rate of 25 tonnes per hectare, before the preparation of the beds and mixed thoroughly with the soil.

Nitrogen was applied at the rate of 50 Kg. per hectare in the form of Calcium Ammonium Nitrate. Phosphorus was applied at the rate of 60 Kg. per hectare in the form of Single Super Phosphate and Potash at the rate of 120 Kg. per hectare in the form of Muriate of Potash was also applied.

The Phosphorus and Potash were applied at the 42nd day after planting whereas, Nitrogen was applied on the 72nd day after planting. The manures and fertilizers were applied equally to all the treatments.

(vi) Interculture: First weeding was given on 14th July 1974 i.e. one month after planting. Second weeding was done alongwith the second earthing up and application of Nitrogen. The third and fourth weedings were done on 2nd October and 3rd December 1974 respectively.

First earthing up was done alongwith the application of Phosphorus and Potash. The second earthing up was done alongwith the application of Nitrogen.

(vii) Application of Sub-plot treatments: The spraying operation of different treatments as per the treatment schedule was carried out on 18th October 1974, i.e. on 125th day of planting. Only one single spraying with these nutrients was given as per the schedule.

(viii) Irrigation: In the initial stages of growth one flood irrigation was given. After the growth has been advanced the crop was irrigated at an interval of 10 days. The irrigation was stopped 20 days before harvesting.

(ix) Plant Protection measures: Aldrin (5%) dust was applied to the soil at the rate of 50 kg. per hectare, to prevent the attack of White ants. Cheshnut compound was applied to the base of the plants against the suspected rhizome rot on 31st August and 1st September 1974. A second application of cheshnut compound was carried out during the 3rd week of November when a fresh rhizome rot was noticed.

(x) Harvesting: The crop was harvested on 17th February 1975, i.e. on the 247th days after planting. At this stage most of the pseudostems had driedup. The observation plants were lifted individually for further studies and then the rest of the plants were harvested for recording the final harvest.

III. Experimental Observations

Sampling Technique: The entire population was considered for recording the germination percentage and the rhizome rot infection. Random sampling technique was adopted to select the sample plants for studying the various growth characters such as plant height, thickness of the main pseudostem, number of tillers per clump, number of leaves per clump etc. Five plants were selected at random as observation plants using Fisher's Random number, for recording the different biometric observations at monthly intervals.

The boarder row of each plot was eliminated while selecting the observation plants. Pre-harvest observations started exactly 30 days after planting, and continued upto 180 days of planting. After this period no more growth observations were taken, since the drying up of the above ground parts had already started.

Pre-harvest Studies

(i) Germination: The number of plants germinated out of the 24 rhizome bits planted in the individual sub-plots were recorded to work out the germination percentage.

(ii) Height of the plant: The height of the main pseudostem of the selected five observation plants from each net plot was recorded by means of meter scale and was expressed in centimeters. Measurement was taken from the base of the main pseudostem up to the tip of the topmost leaf.

(iii) Thickness of the Main Pseudostem: The thickness was measured at the base of the pseudostem at a particular place i.e. at the base of the first leaf and expressed in centimeters.

(iv) Number of tillers per clump: The number of tillers were determined by counting the number of pseudostems that had come from each clump at each observation.

(v) Number of leaves per clump: The number of leaves per clump was determined by counting the number of leaves of all the tillers of each clump.

(vi) Leaf Area: The leaf area of the 5th leaf from top of the main pseudostem was taken. The area was estimated by sketching the leaf lets in the centimeter graph paper, and expressed in square centimeters. The leaf area was calculated only at the final growth stage of the plant.

(vii) Incidence of disease attack: The incidence of rhizome rot caused by Pythium Sp. was recorded, two times during the growth period. They were catagorized as incidence of rhizome rot at (1) Early stage of rhizome development (2) advanced stage of rhizome development and (3) total rhizome rot infection. The percentages of these infections were worked out noting the number of plants infected, out of the total number of plant population in each plot.

(viii) Compatibility of Urea and Planofix on Ginger: The possible scorching or purning symptoms due to the application of the chemical was observed for a week from the date of spraying of the chemicals.

Post harvest Study

(i) Yield of Rhizome: The yield of rhizome were taken under three heads.

(a) Individual plant yield: The individual plant yield was recorded by taking the average weight of rhizome obtained from the five observation plants and expressed in grams.

(b) Plot yield: The plot yield was recorded by taking the weight of the entire rhizome harvested from the observations plants and expressed in grams.

(c) Hectare yield: The hectare yield was obtained by convering the plot yield into hectare basis and expressed in quintals.

(ii) Specific gravity: Specific gravity of fresh rhizome was calculated by determining their weight and volume. 100 gm of fresh rhizome was used. The specific gravity was calculated by means of the formula

$$\text{Specific gravity} = \frac{\text{Weight of rhizome}}{\text{Volume of rhizome}}$$

(i.e. weight of equal volume of water).

(iii) Dry ginger production:

(a) Percentage of Dry ginger recovery: 100 gms of fresh rhizome was dried in the sun to get a constant weight and the final weight was expressed in percentage.

(b) Dry ginger production per Hectare: The dry ginger production per hectare was calculated using the percentage of dry ginger production multiplied by the hectare yield of green rhizome and the yield of dry rhizome was expressed in quintals.

(iv) Incidence of scale insect attack: The incidence of scale insect attack was noted in the fresh rhizomes at the time of harvest and expressed in percentage.

Storage Quality of Rhizome

300 gms of fresh rhizomes were stored in earthern pots lined with moist sand at the bottom and covered with another thick layer of moist sand. The weight loss, damage during storage (included dred and rotted rhizomes) and the volume loss during the three month storage were recorded. The percentages of the above characters were worked out.

(a) Weight loss during storage: The weight loss of the stored rhizome was measured and expressed in percentage.

(b) Volume loss during storage: The volume loss of the stored rhizome was measured and expressed in percentage.

(c) Damage during storage: The damage caused during the storage was worked out noting the weight of damaged rhizome over the fresh weight of rhizome and expressed in percentage.

Chemical Analysis

100 gms of the fresh rhizome was chopped to a thickness of about 1/8th inch. The chopped samples were dried to

a constant weight at 55 $\pm$ 2°c in Cross Flow air oven for 18 hours. The dried samples were ground to pass through mesh No. 60 and stored in glass stoppered bottles and used for chemical Analysis.

(i) Oleoresin Content: Oleoresin content in ginger was determined by adopting the official analytical methods of the American Spices Trade Association using 100% Acetone as solvent, in cold, using specially designed glass column.

Procedure: 10 gms of the ground sample was transfered to the specially designed columns, the outlet of which was plugged with cotton. 25 ml of 100% Acetone was added and allowed to mix well with the sample and was allowed to stand for about 16 hours (overnight). The drippings through the cotton plugg was collected into a flat bottomed evaporating dish. Extration was continued until the solvent around the samples became clear(Two more extractions). The solvent was allowed to evaporate under the fan to get some what thick and viscus oleoresin. The percentage of oleoresin on dry weight basis was then calculated.

(ii) Oleoresin Production per hectare: The percentage of oleoresin on dry weight basis was calculated as per the above procedure. The oleoresin production per hectare was calculated using the dry ginger production per hectare and the percentage recovery of oleoresin and expressed in Kilograms.

(iii) <u>Crude fibre</u>: The crude fibre was estimated using the defatted ginger powder left after the extraction of oleoresin. The composite samples were taken for analysis. For crude fibre analysis also the official Analytical methods of the American Spice Trade Association was followed.

<u>Procedure</u>: (1) Extracted 2 gms of sample with methylene chloride. Transfered the residue together with 0.5 gm of asbestos to the digestion flask (2) Added 200 ml 0.255 N H_2SO_4 solution and connected the digestion flask to the condenser and placed in a preheated hot plate so that the acid will boil within 5 minutes. Continued the boiling for 28 minutes with frequent rotation of the flask to ensure thorough wetting and mixing of the sample. (3) After boiling exactly for 28 minutes the contents were filtered through filter cloth. Washed the residue with boiling water until the washings were acid free. (4) Transfered the sample and asbestos quantitatively to the digestion flask washing the filter cloth with 200 ml of 0.312 N NaoH. (5) Connected the flask to the condenser and heated to boil within 5 minutes and continued boiling for exactly 28 minutes. (6) After 28 minutes removed the flask and immediately filtered through gooch crucible (7) washed the residue thoroughly with boiling water and then with 15 ml of ethyl alchohol. (8) Dried the crucibles and contents at $110^{\circ} \pm 2^{\circ}c$ to a constant weight (for one hour).

Cooled immediately in a desicator and weighed. (9) Ignited the crucibles and contents in an electric muffle furnace at $600^{\circ}c$ for 20 minutes. Cooled in a desicator and weighed. Determined the loss in weight on ignition. The crude fibre was calculated in percentage on dry weight basis by using the formula

$$\text{Crude fibre \%} = \frac{\text{Loss in weight on ignition}}{\text{weight of original sample}} \times 100$$

Statistical analysis of Data

All the biometric and other observations obtained from the experiment were arranged in appropriate tables to obtain thesum of squares due to different sources of variation. The data were analysed statistically. The standard errors and critical differences were calculated to compare the means of the various treatments and interactions to find out the best one.

Correlation Studies

Correlation coefficient between yield and growth characters such as height of the plant, thickness of pseudostem, number of tillers, number of leaves and leaf area were calculated using the standard statistical formula. The correlation coefficient between oleoresin percentage and crude ~~e percentage was also worked out.

CHAPTER IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

During the course of this investigation, observations on various plant characters including germination were recorded to assess the performance of ginger varieties, China, Maran, Rio-de-Janeiro, Thinladium and Sierra Leone and also to assess the effect of Urea and Planofix on the growth, yield and quality of the above five varieties of ginger. The findings of this experiment are presented in this Chapter and dealth under various heads. The data are presented in the respective tables with the relevant S.E. (m) and C.D. (0.05%) values. The table for analysis of variance for different characters are presented in the Appendix. These values are in percentages the corresponding Angular transformed values have been used for analysis to increase the efficiency of the analysis.

Pre-harvest Studies

(i) Study on germination of ginger - The percentage of germination is recorded in the Table - 4 and the data have been statistically analysed.

TABLE 4. GERMINATION PERCENTAGE OF VARIOUS VARIETIES OF GINGER

Sub-Plots	V_1	V_2	V_3	V_4	V_5
T_1 (Control Plot)	87.50 (6997)	100.00 (90.00)	97.22 (84.42)	97.22 (82.11)	88.89 (71.11)
T_2	83.33 (67.41)	100.00 (90.00)	94.45 (78.84)	98.61 (86.05)	81.94 (72.11)
T_3	93.06 (74.89)	97.22 (82.11)	93.06 (77.52)	97.22 (82.11)	94.44 (73.57)
T_4	84.72 (67.02)	98.61 (86.05)	87.50 (68.34)	94.44 (76.53)	90.28 (71.94)
T_5	91.67 (73.57)	100.00 (90.00)	93.05 (74.07)	97.22 (82.11)	86.11 (68.34)
T_6	94.45 (78.84)	95.83 (80.47)	97.22 (82.11)	98.61 (86.05)	87.50 (69.30)
Mean	89.12 (71.95)	98.61 (86.44)	93.75 (77.55)	97.22 (82.49)	88.19 (71.06)

F test significant

S.E. (m) ± 1.39

C.D. at (0.05) 4.54

(Figures in parenthesis represent angular transformed values)

The data in the Table 4 revealed that the variety V_2 (Maran) recorded the maximum percentage of germination (98.61%), closely followed by V_4 (Thinladium) with 97.22%. The other varieties V_3 (Rio-de-Janeiro) recorded 93.75%, whereas, the percentages of germination were lower in the cases of V_1 (China) 89.12% and V_5 (Sierra Leone) 88.19%.

-: PLATE :-

(1) A general view of the experiment

(2) Comparative growth performance of varieties, V_1 (China) V_2 (Maran).

(3) Comparative growth performance of varieties V_3 (Rio-de-Janeiro), V_5 (Sierra Leone) and V_4 (Thinladium).

The statistical analysis showed that V_2 is significantly superior to all other varieties in this regard except V_4. And variety V_4 is superior to all other varieties except V_2. And V_3 is superior to V_1 and V_5. But there is no significant difference between V_1 and V_5.

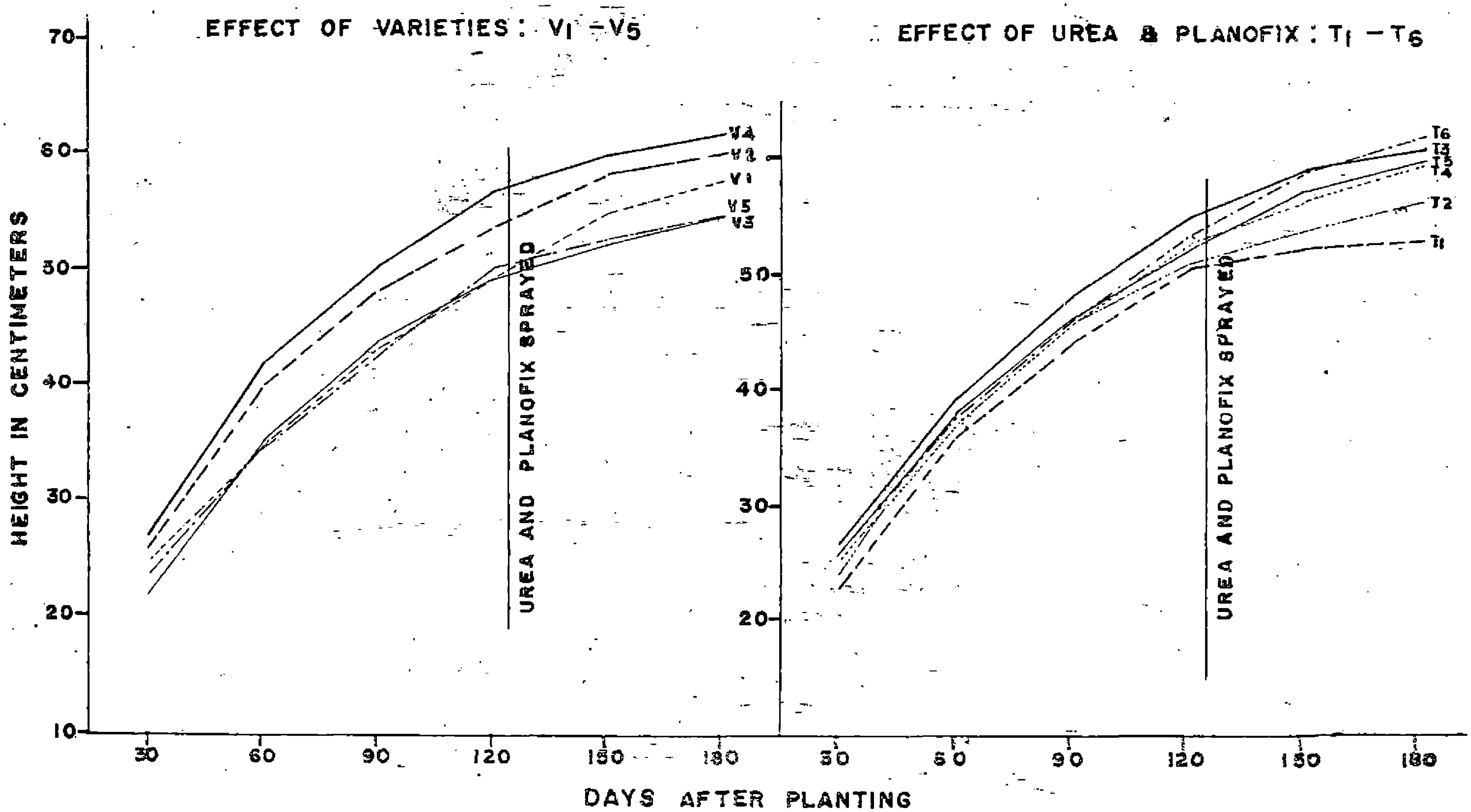
(ii) Height of the Plant - The height of the plants at successive stages of growth as affected by the different levels of Urea and Planofix with respect to different varieties was recorded at monthly intervals starting from 30 days after the planting. The results are presented in Table 5 (a),

TABLE 5(a) AVERAGE HEIGHT OF PLANT AT SUCCESSIVE STAGES OF GROWTH OF DIFFERENT VARIETIES OF GINGER (UNIT - CENTIMETERS)

Varieties	Before spraying				After spraying	
	Days after planting					
	30	60	90	120	150	180
V_1	24.88	35.37	43.51	49.57	55.39	58.00
V_2	26.02	40.12	48.45	54.33	58.53	60.74
V_3	22.41	35.61	44.40	49.54	52.75	55.20
V_4	27.36	42.23	50.62	56.98	60.34	62.20
V_5	24.00	35.41	43.00	50.54	53.11	55.38
'F'Test	Not sig.	Not sig	Sig	Not sig	Sig	Sig
S.E.(m) ±	-	-	1.530	-	1.503	1.544
C.D. at 0.05%	-	-	4.99	-	5.16	5.03

AVERAGE HEIGHT OF PLANTS AT SUCCESSIVE STAGES OF GROWTH

FIG. 2(a) FIG. 2(b)



(b) and (c) and the analysis of variance table under appendix, Table No. 3

The data in Table 5(a) shows the height of the five ginger varieties from 30 to 180 days after planting. In general, it is seen that vigorus growth was put up by variety V_4 followed by V_2, V_1, V_5 and V_3 (least height with V_3). The maximum ~~weight~~ height increase for all the varieties was noted between 30 and 60 days of planting. With the advance in age the increase in height of all the varieties were proportionately at a decreasing rate.

TABLE 5(b). AVERAGE HEIGHT OF PLANTS AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY SUB PLOT TREATMENTS: UREA AND PLANOFIX (UNIT - CENTIMETERS)

Sub Plot Treatment	Before spraying				After spraying	
	Days after planting					
	30	60	90	120	150	180
T_2. Urea 2%	23.90	37.99	45.77	50.76	53.54	56.21
T_3. Planofix 200ppm	26.53	39.32	48.21	54.65	58.57	60.53
T_4. Urea 2% + Planofix 200ppm	25.20	37.12	45.60	52.52	56.09	59.07
T_5. Planofix 400ppm	25.46	38.08	46.20	51.92	57.12	59.72
T_6. Urea 2% + Planofix 400ppm	25.66	37.89	46.11	52.88	58.66	61.60
T_1. Control	22.87	36.00	44.09	50.44	52.16	52.69
'F' test	Not sig	Not sig	Not sig	Not sig	Sig	Sig
S.E.(m) ±	-	-	-	-	1.364	1.382
C.D. at 0.05%	-	-	-	-	3.87	3.92

From Table 5(b) it is observed that in general, there was no significant difference between the sub-plots before the chemicals were applied but the significant difference in the height of the plants were recorded after the application of the sub-plot treatments were made. The cumulative increase in height from 120 to 180 days of growth in the case of control (T_1) was only 50.44 cms to 52.69 cms (2.25 cm) while in the case of T_2 (Urea 2%), T_3 (Planofix 200 ppm), T_4 (Urea 2% + Planofix 200 ppm), T_5 (Planofix 400 ppm) and T_6 (Urea 2% + Planofix 400 ppm) higher increase in height was noticed; viz. 50.76 cms to 56.21 cms (5.45 cms), 54.65 cms to 60.53 cms (5.88 cms), 52.52 cms to 59.07 cms (6.55 cms), 51.92 cms to 59.72 cms (7.80 cms), 52.88 cms to 61.60 cms (8.72 cms). It was also found that the rate of increase in height of the plants after the application of the treatments were appreciably higher in all cases compared to the control. But in the case of Urea 2% (T_2) the increase was gradual upto the 180 days after planting.

The Table 5 (c) shows the effect of various main plot and sub-plot treatments on the height of the plant at 180 days after planting. Both varieties and the sub-plot treatments showed significant difference. The varieties V_4 and V_2 had significantly more linear plant growth than the varieties

TABLE 5(c). EFFECT OF VARIOUS SUB-PLOT TREATMENTS (UREA AND PLANOFIX) ON THE HEIGHT OF DIFFERENT VARIETIES OF GINGER PLANTS AT 180 DAYS AFTER PLANTING (UNIT - CENTIMETERS)

	Sub-Plot Treatments	Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	53.26	58.03	50.63	65.06	54.10	56.21
T_3	Planofix 200 ppm.	62.60	57.20	58.13	67.36	57.40	60.53
T_4	Urea 2% + P 200 ppm	6083	59.60	55.66	62.83	56.43	59.07
T_5	Planofix 400 ppm	60.73	62.03	61.43	56.90	57.53	59.72
T_6	Urea 2% + P 400 ppm	61.90	58.06	58.86	64.73	54.40	61.60
T_1	Control	48.73	59.53	46.50	56.36	52.36	52.69
Mean		58.00	60.74	55.20	62.20	55.38	

'F' test for main plot and sub-plot treatments are significant

S.E. (m) ± for main plot treatment is 1.544

S.E. (m) ± for sub-plot treatment is 1.382

C.D. for main plot treatment at 0.05% level is 5.03

C.D. for sub-plot treatment at 0.05% level is 3.92

(P = Planofix)

V_5 and V_3 but V_1 was parallel with V_4 and V_2. At the same time there was no significant difference between V_1, V_5 and V_3. Among the sub-plot treatments the effect of chemicals on the height increase were in the order of T_6, T_3, T_5, T_4, T_2 and T_1 respectively. Except T_2 all other treatments were signficantly superior to T_1 (control). However, T_6, T_3, T_5 and T_4 did not differ significantly from each other. There was no significant difference between T_5, T_4 and T_2 as well as between T_2 and T_1.

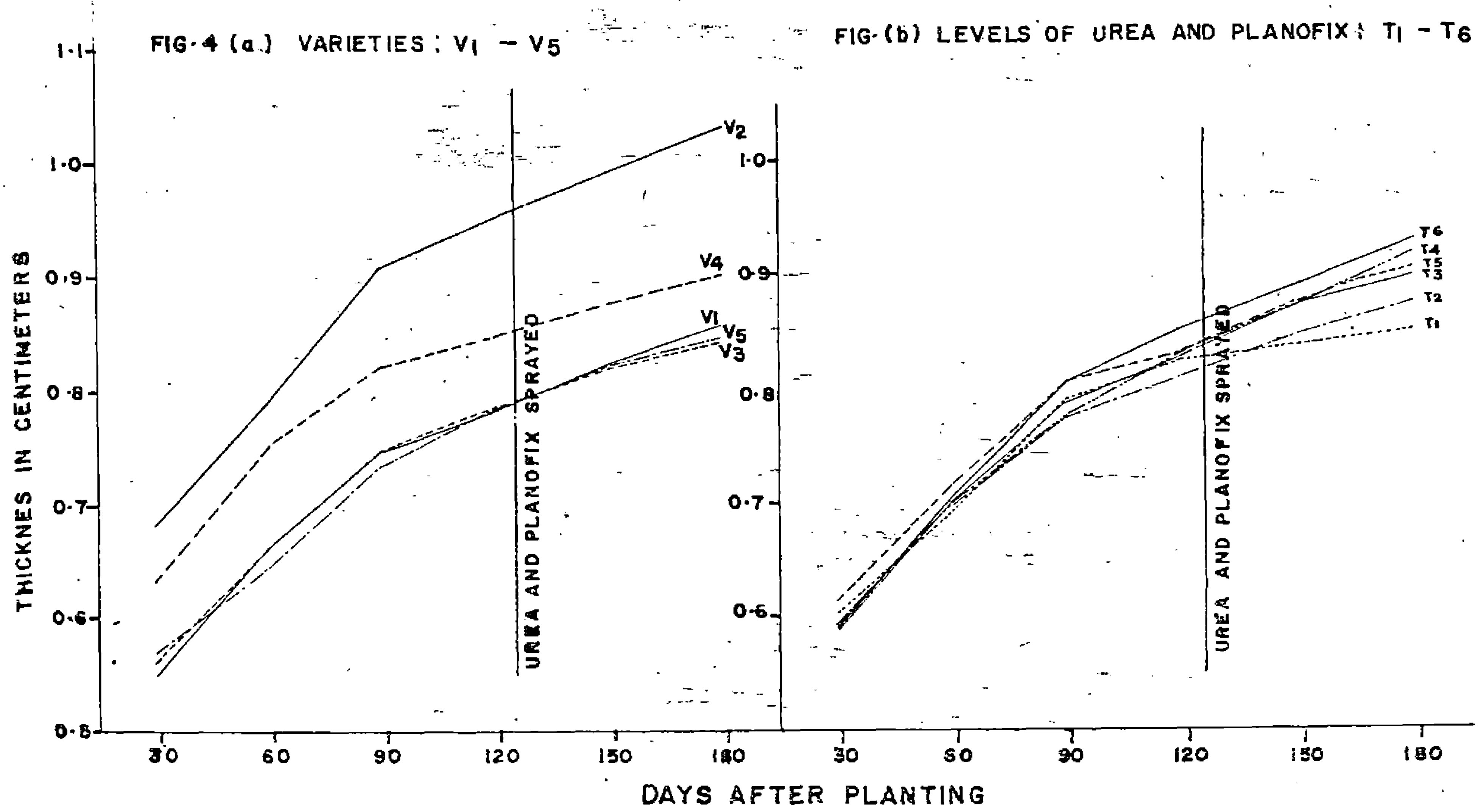
The interaction V x T was not significant.

(iii) Thickness of main Pseudostem: The thickness of the Pseudostem was measured at the same time when the height of the plant (Pseudostem) was measured. The results obtained are presented in Table 6(a), (b) and (c). The analysis of

TABLE 6(a). AVERAGE THICKNESS OF MAIN PSEUDOSTEM (TILLER) AT SUCCESSIVE STAGES OF GROWTH OF DIFFERENT VARIETIES OF GINGER (UNIT - CENTIMETERS)

Varieites	Before spraying				After spraying	
	Days after planting					
	30	60	90	120	150	180
V_1	0.569	0.646	0.734	0.784	0.822	0.846
V_2	0.683	0.789	0.906	0.950	0.993	1.029
V_3	0.561	0.662	0.747	0.784	0.818	0.844
V_4	0.663	0.750	0.823	0.847	0.875	0.901
V_5	0.547	0.662	0.747	0.782	0.820	0.857
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
S.E.(m) ±	0.0134	0.01303	0.01788	0.01516	0.01673	0.0176
C.D.at 0.05% level	0.044	0.042	0.058	0.049	0.054	0.057

THICKNESS OF MAIN PSEUDOSTEM AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY



variance table is also appended under the appendix and is further represented in the Figure No. 4

Even from the very early stage of 30 days of growth after planting the thickness of Pseudostem of the varieties were significantly different. V_2 and V_4 were significantly higher than the other varieties V_1, V_3 and V_5. At the time of application of the sub-plot treatments also the same trend of differences were noted. But in the final observation (180th day) V_2 was significantly superior in thickning, the stem having 1.029 cms over V_4, V_5, V_1 and V_3 which had 0.901, 0.857, 0.846 and 0.844 cms of stem thickness respectively.

The Table 6(b) shows that upto 25 days after the application of the sub-plot treatments (i.e. upto 150 days after planting) there was no significant difference between the sub-plots whereas in the final stage of 180 days after planting the sub-plots showed significant difference in the thickness of the stem. The treatments T_6, T_4, T_5, T_3, T_2 and T_1 recorded 0.928 cms, 0.915 cms, 0.907 cms, 0.897 cms, 0.874 cms and 0.851 cms respectively. The cumulative increase in the case of the sub-plot treatments after the spraying of the treatments is in the order of T_1 (control) 0.826 cms to 0.851 cms (0.025 cm), T_2 0.813 cms to 0.874 cms (0.061 cms),

TABLE 6(b). AVERAGE THICKNESS OF MAIN PSEUDOSTEM (TILLER) AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY SUB-PLOT TREATMENTS: UREA AND PLANOFIX (UNIT - CENTIMETERS)

Sub-plot Treatments		Before spraying				After spraying	
		Days after Planting					
		30	60	90	120	150	180
T_2	Urea 2%	0.603	0.695	0.775	0.813	0.845	0.874
T_3	Planofix 200 ppm	0.586	0.702	0.788	0.826	0.871	0.897
T_4	Urea 2% + P 200 ppm	0.593	0.702	0.787	0.829	0.872	0.915
T_5	Planofix 400 ppm	0.616	0.716	0.804	0.832	0.875	0.907
T_6	Urea 2% + P 400 ppm	0.589	0.705	0.805	0.851	0.890	0.928
T_1	Control	0.603	0.692	0.790	0.826	0.839	0.851
'F' test		Not sig	Not sig	Not sig	Not sig	Not sig	Sig
S.E.(m) ±		-	-	-	-	-	0.010
C.D. at 0.05% level		-	-	-	-	-	0.028
(P = Planofix)							

T_3 0.826 cms to 0.897 cms (0.071 cms). T_4 0.829 cms to 0.915 cms (0.086 cms) T_5 0.832 to 0.907 cms (0.075 cms) and T_6 0.851 cms to 0.928 cms (0.077 cms).

The data on the final observation on the stem thickness of different gigner varieties as affected by Urea and Planofix doses

TABLE 6(c). EFFECT OF UREA AND PLANOFIX ON THE THICKNESS OF MAIN PSEUDOSTEM OF DIFFERENT VARIATIES OF GINGER AT 180 DAYS AFTER PLANTING (UNIT - CENTIMETER)

Sub Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	0.805	0.983	0.816	0.943	0.823	0.874
T_3	Planofix 200 ppm	0.833	0.993	0.840	0.923	0.896	0.897
T_4	Urea 2% + P 200 ppm	0.906	1.066	0.873	0.883	0.870	0.915
T_5	Planofix 400 ppm	0.840	1.016	0.923	0.900	0.856	0.907
T_6	Urea 2% + P 400 ppm	0.896	1.113	0.863	0.896	0.876	0.928
T_1	Control	0.796	1.003	0.750	0.883	0.826	0.851
Mean		0.846	1.029	0.844	0.901	0.857	

'F' test for main plot treatment, sub-plot treatment and interaction are highly significant

	S.E.(m) ±	C.D. at 0.05% level
(1) Main plot treatment	0.0176	0.057
(2) Sub-Plot treatment	0.0100	0.028
(3) Sub-plot treatment at the same level of M.P.T.	0.02302	0.065
(4) Main plot treatment at the same level of S.P.T	0.04494	0.142

(P = Planofix)

are presented in the Table 6(c). The statistical analysis has revealed the existance of significant difference due to varieties and Urea and Planofix separately. The interaction between varieties and checmical is also significant. Thus in the case of variety V_1 variety treatment combination having $V_1 T_4$ gave the maximum thickness of 0.906 cms closely followed by $V_1 T_6$ with 0.896, $V_1 T_5$ with 0.840, $V_1 T_3$ 0.833, $V_1 T_2$ 0.806 and $V_1 T_1$ 0.796 cms, while in the case of variety V_2 as indicated before the treatment combination $V_2 T_6$ produced the maximum thickness of 1.113 cms which was significantly higher over other treatments except $V_2 T_4$. But there was no significant difference between $V_2 T_4$, $V_2 T_5$ and $V_2 T_1$ or between $V_2 T_5$, $V_2 T_1$, $V_2 T_3$ and $V_2 T_2$. Variety V_3 showed preference to $V_3 T_5$ though it was not significant over V_3T_4 and $V_3 T_6$. However, treatment combinations having V_3T_4, V_3T_6, $V_3 T_3$ and $V_3 T_2$ were similar in their behaviour and $V_3 T_1$ was significantly lower from all others. In the case of variety V_4, $V_4 T_2$ was superior to $V_4 T_4$ but not others($V_4 T_3$, V_4T_5, $V_4 T_6$ and $V_4 T_1$ as well as $V_4 T_3$, $V_4 T_5$, and $V_4 T_6$). $V_4 T_1$ and $V_4 T_4$ showed no significant difference between themselves. V_5 showed preference to $V_5 T_3$ which was significant over V_5T_1 and $V_5 T_2$ but not over other treatments. The relation between $V_5 T_3$, $V_5 T_6$, $V_5 T_4$ and $V_5 T_5$ as well as between $V_5 T_6$, V_5T_4, $V_5 T_5$, $V_5 T_1$ and $V_5 T_2$ not have any significance difference.

All the sub-plot treatments showed preference to the variety V_2 and thus $V_2 T_4$ and $V_2 T_6$ were significantly superior over all others. In other cases they go hand in hand with other varieties. Thus V_2 T_6 produced the maximum thickness of 1.113 cms while V_3 T_1 had the minimum thickness of 0.750 cms only.

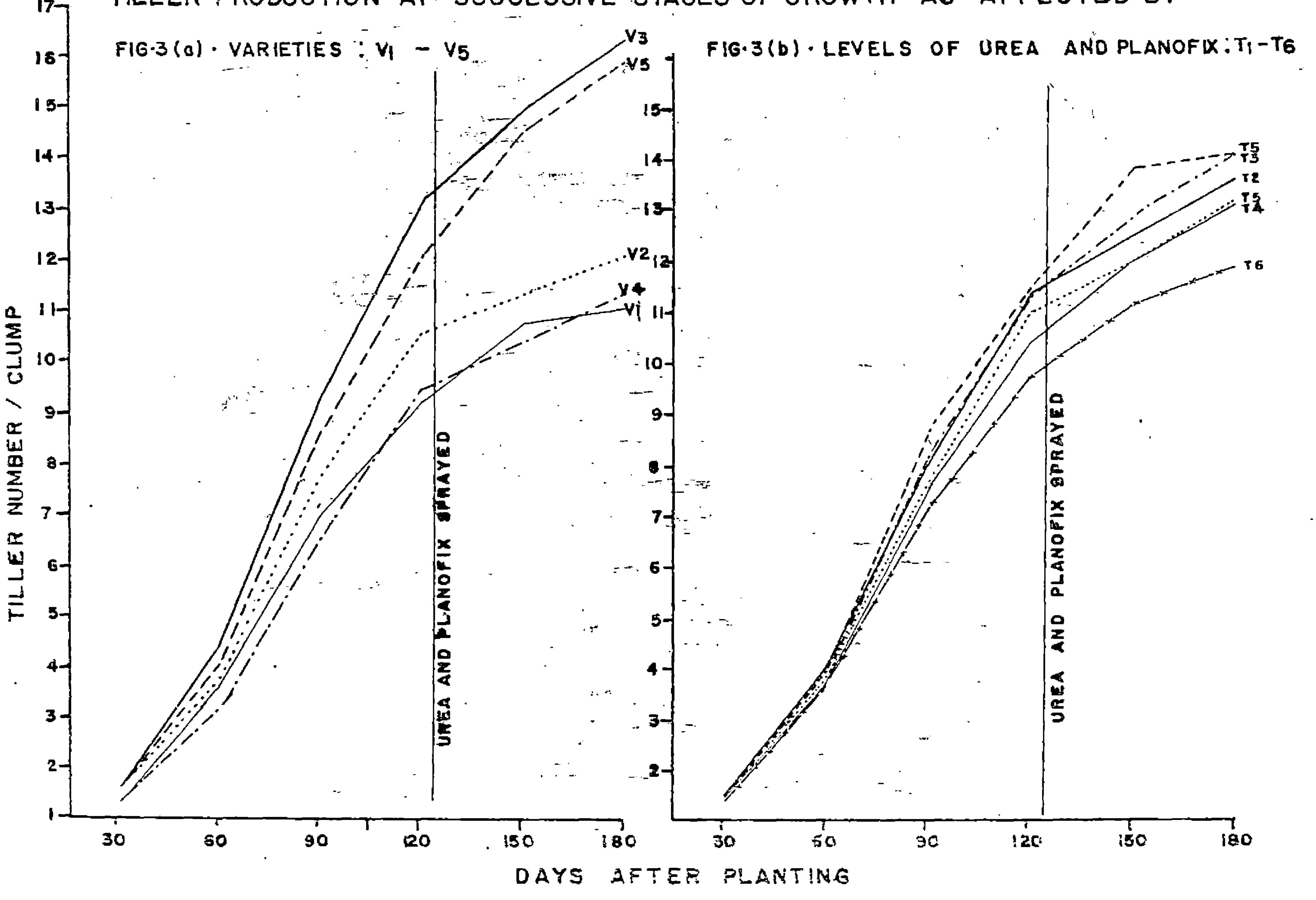
(iv) Number of tillers per clump: The number of tillers per clump were recorded in the same manner as in the case of height of the plants. The data were analysed statistically and are presented in Table 7(a), (b) and (c) and in figures 3(a) and (b).

TABLE 7(a). AVERAGE NUMBER OF TILLERS PER CLUMP AT SUCCESSIVE STAGES OF GROWTH OF DIFFERENT VARIETIES OF GINGER

Varieties	Before spraying				After spraying	
	Days after platnting					
	30	60	90	120	150	180
V_1	1.22	3.69	7.08	9.23	10.79	10.96
V_2	1.59	3.85	7.82	10.56	11.32	12.08
V_3	1.58	4.49	9.39	13.09	14.96	16.35
V_4	1.32	3.22	6.58	9.48	10.41	11.35
V_5	1.59	4.13	8.67	12.11	14.50	15.88
'F' test	Not sig	Sig	Sig	Sig	Sig	Sig
S.E.(m) ±	-	0.189	0.3274	0.591	0.464	0.505
C.D. at 0.05% level	-	0.62	1.07	1.93	1.51	1.65

FIG. 3

TILLER PRODUCTION AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY



The data in Table 7(a) showed that at the initial stages there was no significant difference between the five varieties. But the successive observations showed significant difference between varieties. Highest number of tillers were produced by V_3 followed by V_5 and these varieties were significantly different from other varieties in order of V_2, V_4 and V_1. The data showed that V_1 produced the least tillers per clump even from the early stages of development.

TABLE 7(b). AVERAGE NUMBER OF TILLERS PER CLUMP AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY SUB-PLOT TREATMENTS UREA AND PLANOFIX

Sub-plot Treatments		Before spraying				After spraying	
		Days after sowing					
		30	60	90	120	150	180
T_2	Urea 2%	1.55	4.11	8.07	11.40	12.51	13.63
T_3	Planofix 200 ppm	1.49	3.83	8.19	11.28	12.89	14.01
T_4	Urea 2% + P 200 ppm	1.41	3.71	7.61	10.44	12.04	13.10
T_5	Planofix 400 ppm	1.48	3.97	8.65	11.49	13.04	14.10
T_6	Urea 2% + P 400 ppm	1.44	3.89	7.69	10.98	12.04	13.22
T_1	Control	1.39	3.75	7.23	9.77	11.06	11.89
'F' test		Not sig	Not sig	Not sig	Not sig	Not sig	Not sig

(P = Planofix)

Table 7(b) showed no significant difference between the various sub-plots before or after the application of the treatments.

TABLE 7(c). EFFECT OF UREA AND PLANOFIX ON THE NUMBER OF TILLERS AT 180 DAYS AFTER PLANTING WITH RESPECT TO VARIOUS VARIETIES OF GINGER

Sub-plot Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	10.53	13.06	15.60	11.20	17.80	13.63
T_3	Planofix 200 ppm	12.06	12.60	17.73	10.80	16.86	14.01
T_4	Urea 2% + P 200 ppm	10.33	11.06	16.67	11.20	16.26	13.10
T_5	Planofix 400 ppm	11.06	11.60	20.80	12.13	14.93	14.10
T_6	Urea 2% + P 400 ppm	11.06	12.80	14.93	12.06	15.26	13.22
T_1	Control	10.73	11.40	12.40	10.73	14.20	11.89
Mean		10.96	12.08	16.35	11.35	15.88	

'F' test for (main plot treatments) varieties alone is significant.

S.E.(m) ± for main plot treatment is 0.505

C.D. for main plot treatment is 1.65

(P = Planofix)

The data on the final observation on the number of tillers of different ginger varieties and the effect of sub-plot treatments (Urea and Planofix) are presented in Table 7(c). The statistical analysis showed that only varieties differed significantly in tiller production. V_3 produced the maximum number of 16.35 tillers, closely followed by V_5 with 15.88 tillers and they significantly differed from other varieties (V_2, V_4 and V_1 having 12.08, 11.35 and 10.96 tillers per clump respectively).

Among the sub-plot treatments T_5 produced the maximum tillers (14.10) followed by T_3 with 14.01 tillers. The treatments T_2 produced 13.63 tillers; T_6, 13.22 tillers; T_4, 13.10 tillers and T_1, 11.89 tillers respectively.

(v) Number of leaves per clump : The number of leaves per clump were recorded at each observations alongwith height, thickness etc. and presented in Table 8(a), (b) and (c).

The Table 8(a) represents the production of leaf in the various varieties. The statistical analysis of the data revealed that the production of leaves in each variety was significant with the various stages of growth except at the 60th day. At 60th day the varieties were not significantly different, though there was numerical difference in the leaf production. The leaf production was highest for the variety

FIG· 5 (a)

EFFECT OF VARIETIES ON LEAF PRODUCTION

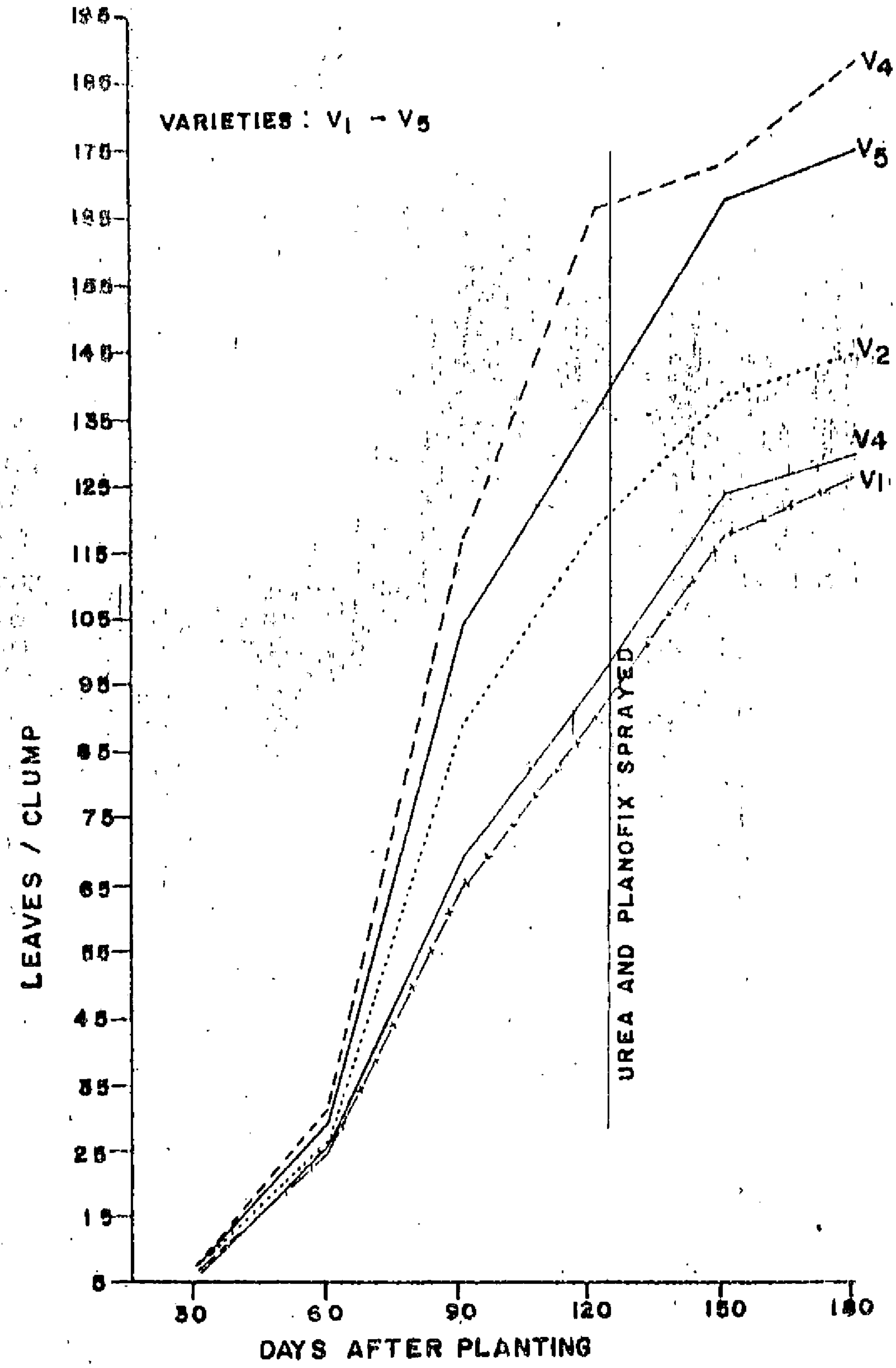


TABLE 8(a) . AVERAGE NUMBER OF LEAVES PER CLUMP (PLANTS) AT SUCCESSIVE STAGES OF GROWTH OF DIFFERENT VARIETIES OF GINGER

Varieties	Before spraying				After spraying	
	Days after planting					
	30	60	90	120	150	180
V_1	7.27	25.56	64.62	90.03	118.32	127.25
V_2	7.72	26.99	83.96	119.28	139.10	145.81
V_3	8.00	31.99	117.62	166.56	178.87	189.41
V_4	6.66	26.72	69.74	95.32	124.68	129.96
V_5	7.33	29.67	104.33	135.78	168.44	175.77
'F' test	Sig	Not sig	Sig	Sig	Sig	Sig
S.E.(m) ±	0.238	-	6.856	8.04	8.569	9.386
C.D. at 0.05% level	0.77	-	22.35	26.22	27.94	30.60

V_3 (189.41) closely followed by V_5 (175.77) and there was no significant difference between them. V_2 produced 145.81 leaves, V_4 129.96 and V_1 127.25 leaves which was the least. Between V_5 and V_2 there was no significant difference. V_2, V_4 and V_1 were also parallel in leaf production though there was an apparent difference. The rate of leaf production was maximum between 60th day and 90th day and afterwards there was gradual decrease in the rate of leaf production.

FIG. 5 (b)

EFFECT OF UREA AND PLANOFIX LEVELS ON LEAF PRODUCTION

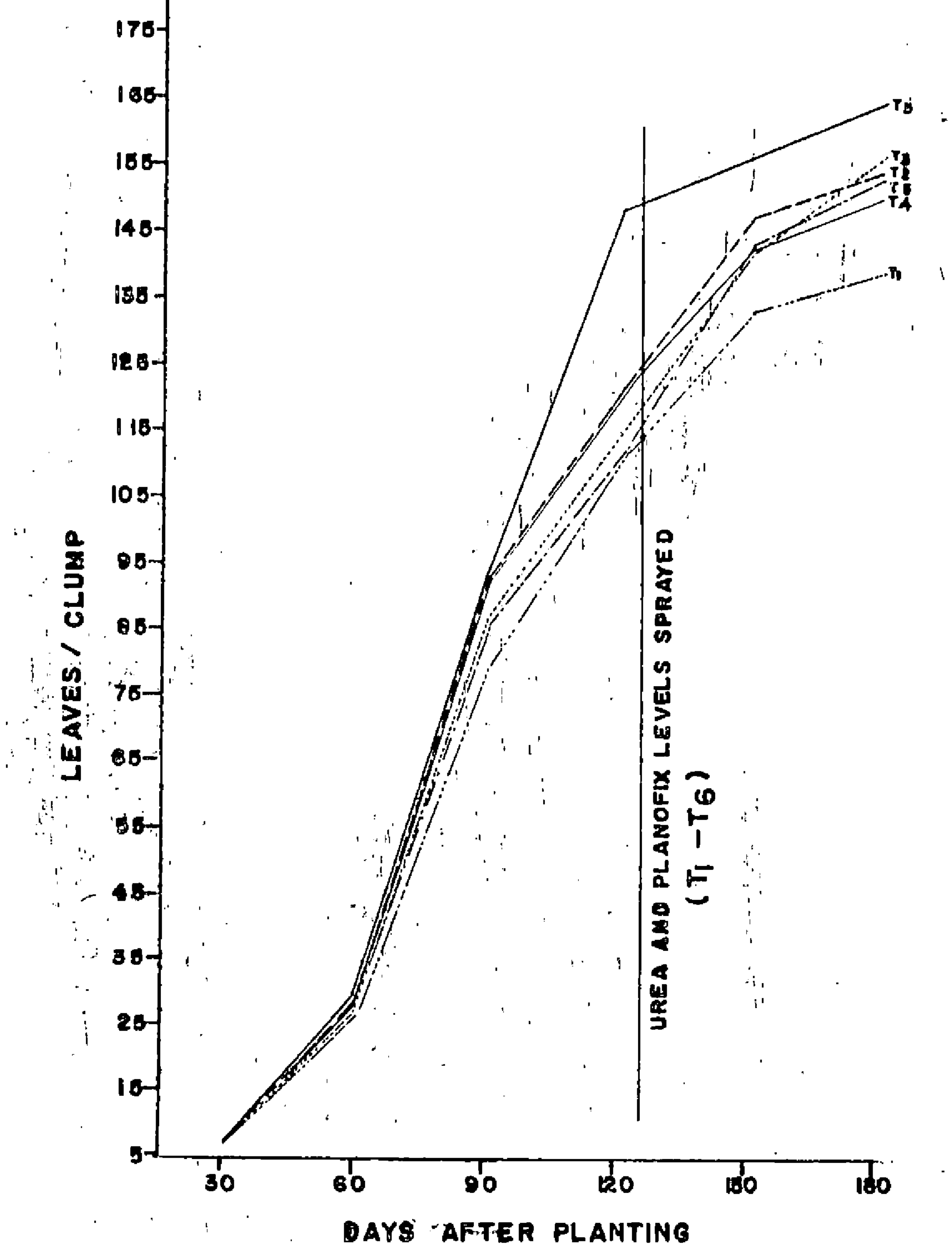


TABLE 8(b). AVERAGE NUMBER OF LEAVES PER CLUMP (PLANTS) AT SUCCESSIVE STAGES OF GROWTH AS AFFECTED BY SUB-PLOT TREATMENTS: UREA AND PLANOFIX

Sub-Plot Treatments		Before spraying				After spraying	
		Days after planting					
		30	60	90	120	150	180
T_2	Urea 2%	7.46	29.16	93.31	121.31	147.73	154.81
T_3	Planofix 200 ppm.	7.46	27.67	87.85	115.66	142.72	157.21
T_4	Urea 2% + P 200 ppm	7.46	28.34	92.27	121.04	143.93	151.07
T_5	Planofix 400 ppm	7.53	29.65	94.61	148.85	156.97	165.06
T_6	Urea 2% + P 400 ppm	7.46	27.56	86.43	113.27	144.24	154.11
T_1	Control	6.99	26.76	79.85	110.62	133.66	139.58
'F' test		Not sig	Not sig	Not sig	Not sig	Not sig	Not sig

(P = Planofix)

As shown in the Table 8(b) there was no significant difference between the sub-plots before or after the application of the chemicals.

Analysis of the data on leaf production at the final observation (180th day) as indicated from the Table 8 (c) showed

TABLE 8 (c). EFFECT OF UREA AND PLANOFIX ON THE NUMBER OF LEAVES AT 180 DAYS AFTER PLANTING WITH RESPECT TO THE VARIOUS VARIETIES OF GINGER

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Uria 2%	133.46	144.20	179.80	137.13	179.46	154.81
T_3	Planofix 200 ppm	142.06	140.13	206.53	105.93	191.40	157.21
T_4	Urea 2% + P 200 ppm	122.00	133.13	184.06	133.00	183.20	151.07
T_5	Planofix 400 ppm	118.06	146.67	259.86	134.13	166.60	165.06
T_6	Urea 2% + P 400 ppm	129.46	170.93	157.66	133.67	178.86	154.11
T_1	Control	118.46	139.80	148.60	135.93	155.13	139.58

'F' test for main plot treatments (varieties) highly significant

S.E.(m) ± for main plot treatments 9.386

C.D. for main plot treatments at 0.05% 30.60

(P = Planofix)

that only varietal difference existed in leaf production. The interaction of varieties with Urea and Planofix combinations were not, however, significant.

The data further revealed that in all varieties the rate of leaf production Table 8(b) was maximum between 60 and 90 days after planting. The next maximum increase was noted between

—: PLATE :—

(1) Variety V_2 (Maran) at its prime growth period.

(2) Variety V_2 (Maran) at its final stage of growth.

(3) The developing rhizome variety Rio-de-Janeiro(V_3).

90 and 120 days after planting and the rate of leaf production slowed down in the later stages of growth.

(vi) Leaf area : The data collected at the final observation is given in Table 9. The statistical analysis revealed

TABLE 9. EFFECT OF UREA AND PLANOFIX ON THE LEAF AREA AT 180 DAYS AFTER PLANTING WITH RESPECT TO VARIOUS VARIETIES OF GINGER (UNIT - Sq. Cm. SINGLE SIDE)

Sub-plot treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	38.93	39.82	32.13	44.78	40.29	39.19
T_3	Planofix 200 ppm	38.19	40.36	31.19	37.11	40.24	37.42
T_4	Urea 2% + P 200 ppm	43.25	40.45	33.39	44.12	42.91	40.82
T_5	Planofix 400 ppm	39.78	38.73	30.10	39.05	38.25	37.18
T_6	Urea 2% + P 400 ppm	43.65	41.65	32.89	41.84	42.09	40.54
T_1	Control	36.13	35.58	31.31	37.92	35.62	35.31

'F' test for sub-plot treatments alone significant

S.E. (m) ± for sub-plot treatments = 0.9279

C.D. for sub-plot treatments at 0.05% level = 2.63

(P = Planofix)

that there was significant difference between the leaf area of different sub-plot treatments. The varieties and interaction were however not significant. Among the sub-plot treatments there was no significant difference between T_4, T_6 and T_2 but T_4 and T_6 were significant over all other treatments except T_2. T_3, T_5 and T_1 were similar in their behaviour though the T_1 had the least value of 35.31 sq.cm.

(vii) Incidence of disease (rhizome rot): The data on the rhizome rot infection at the early stages of rhizome

TABLE 10(a). RHIZOME ROT INFECTION DURING THE EARLY STAGES OF RHIZOME DEVELOPMENT OF GINGER VARIETIES (BEFORE SPRAYING) (UNIT - PERCENTAGE)

Sub-Plot	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
T_2	13.10 (21.07)	0.0 (0.0)	11.46 (16.25)	1.43 (3.99)	10.20 (18.61)	7.24
T_3	10.36 (18.34)	1.36 (3.89)	4.53 (7.21)	1.43 (3.99)	11.80 (19.42)	5.90
T_4	8.16 (13.58)	4.20 (9.57)	6.56 (11.77)	2.86 (5.68)	9.10 (16.65)	6.18
T_5	9.10 (17.14)	2.73 (7.78)	13.53 (20.79)	2.80 (7.98)	11.33 (19.56)	7.91
T_6	7.40 (15.19)	1.43 (3.99)	5.63 (11.26)	2.80 (7.80)	15.83 (23.21)	6.62
T_1 (Control Plot)	12.86 (20.68)	4.13 (9.47)	0.0 (0.0)	2.80 (7.88)	9.33 (17.09)	5.82
Mean	10.16 (17.66)	2.30 (5.78)	6.95 (11.21)	2.36 (6.23)	11.26 (19.09)	

'F' test for main plot treatments (variety) is significant

S.C.(m) ± for main plot tretment is 1.99

C.D. at 0.05% level is 6.50

(Figures in parenthesis represent angular transformed values) development is given in Table 10(a). The statistical analysis showed the existance of significant difference between the varieties. Maximum attack was noticed with the variety V_5 (11.26%), followed closely by V_1 with 10.16%. There was no significant difference between these two varieties. Variety V_3 had 6.95% of infection while V_4 had only 2.36% infection, whereas variety V_2 had the least values (2.3%) of infection only. However, the last three varieties did not differ significantly in this regard.

TABLE 10(b). EFFECT OF UREA AND PLANOFIX ON THE RHIZOME ROT INFECTION DURING THE FINAL STAGE OF RHIZOME DEVELOPMENT WITH RESPECT TO VARIOUS VARIETIES (AFTER SPRAYING) (UNIT - PERCENTAGE)

Sub-Plot Treatments	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
T_2 Urea 2%	0.0 (0.0)	- -	0.0 (0.0)	4.10 (9.47)	-	1.37 (3.15)
T_3 Planofix 200 ppm	5.80 (8.21)	-	6.93 (9.04)	28.86 (32.00)	-	13.87 (16.41)
T_4 Urea 2% + P 200 ppm	3.33 (6.14)	-	0.0 (0.0)	4.33 (7.04)	-	2.55 (4.39)
T_5 Planofix 400 ppm	23.20 (18.84)	-	0.0 (0.0)	7.06 (12.62)	-	10.09 (10.48)
T_6 Urea 2% +P 400 ppm	22.23 (23.04)	-	3.03 (5.85)	2.90 (5.72)	-	9.39 (11.53)
T_1 Control	18.33 (15.95)	-	8.57 (17.01)	5.70 (13.60)	-	10.87 (15.52)
Means	12.14 (12.03)	-	3.08 (5.31)	8.82 (13.40)	-	

'F' test not significant either for main plot or sub plot treatments or interactions

(Figures in the parenthesis represent the angular transformed values) (P = Planofix)

FIG. 6

RHIZOME ROT INFECTION IN MAIN PLOTS AND SUBPLOTS (VISUAL SYMPTOM)

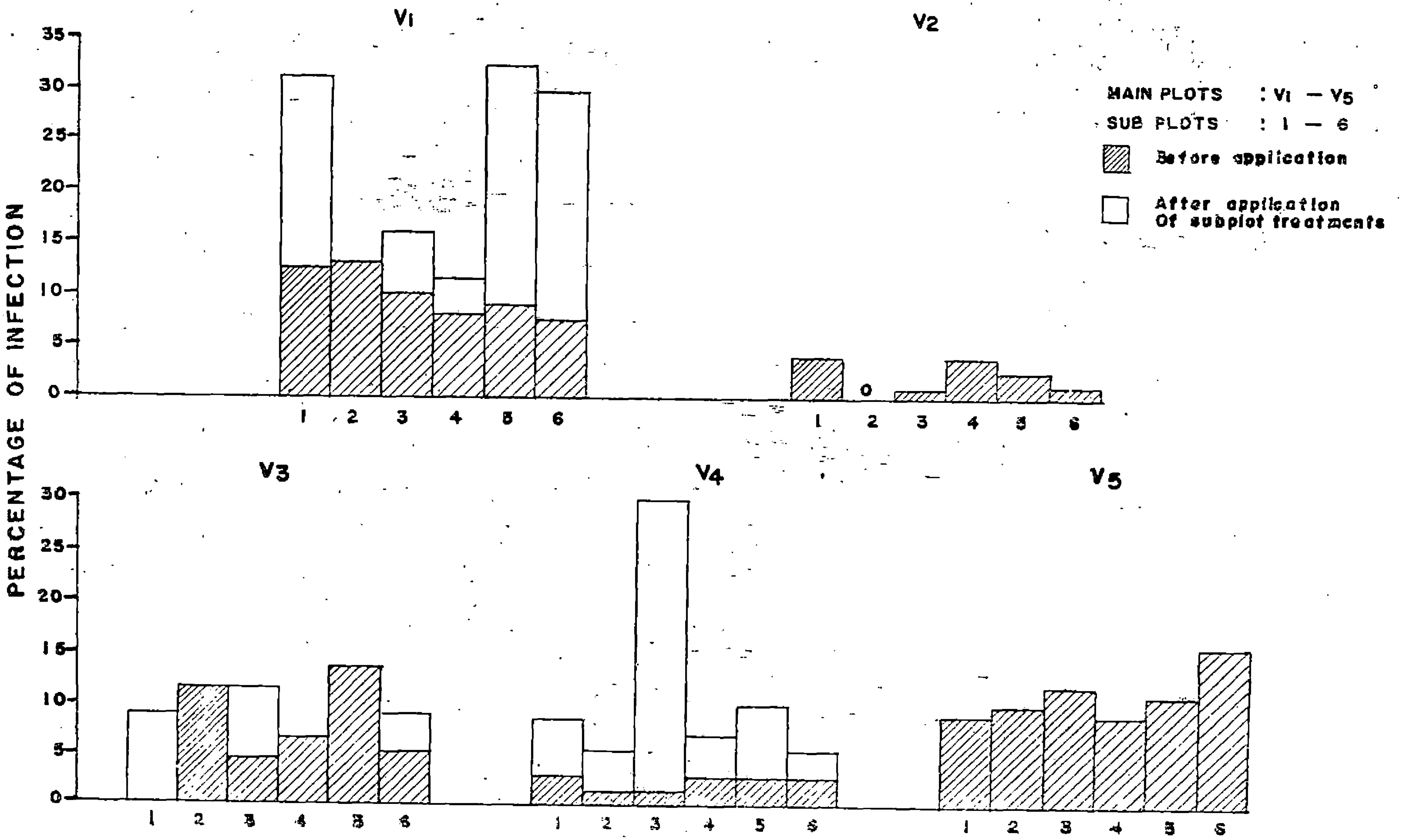


Table 10(b) represents the rhizome rot infection at the final stages of rhizome development. Only three varieties were affected viz. V_1, V_3 and V_4. V_2 and V_5 were completely free from the attack of rhizome rot. The analysed data of the affected 3 varieties (V_1, V_3 and V_4) indicated no significant differences between themselves or between sub-plot treatments or their interaction, though V_1 had the maximum infection of 12.14% followed by V_4(8.82%) and V_3(3.08%) respectively.

TABLE 10(c). THE TOTAL RHIZOME ROT INFECTION IN RESPECT OF VARIOUS VARIETIES (UNIT - PERCENTAGE)

Sub-Plots	Varieties					Mean
	V_1	V_2	V_3	V_4	V_5	
T_2	13.10 (21.07)	0.0 (0.0)	11.46 (16.26)	5.56 (13.46)	10.20 (18.61)	8.06 (13.88)
T_3	16.16 (22.45)	1.36 (3.87)	11.46 (16.26)	29.96 (32.83)	11.80 (19.42)	14.15 (18.97)
T_4	11.50 (19.72)	4.20 (9.57)	6.56 (11.77)	7.20 (12.72)	9.10 (16.65)	7.71 (14.09)
T_5	32.30 (32.18)	2.73 (7.78)	13.53 (20.79)	9.93 (17.93)	11.33 (19.56)	13.96 (19.65)
T_6	29.63 (32.11)	1.43 (3.99)	4.66 (17.11)	5.70 (10.93)	15.83 (23.21)	12.25 (17.47)
T_1 (Control plot)	31.20 (32.44)	4.13 (9.47)	8.56 (17.01)	8.56 (17.02)	9.33 (17.43)	12.36 (18.67)
Mean	22.31 (26.66)	2.30 (5.78)	10.03 (16.53)	11.15 (17.48)	11.26 (19.14)	

'F' test for main plot treatments is significant

S.E. (m) ± for main plot treatment is 3.13

C.D. for main plot treatment is 10.21

(Figures in parenthesis represent the angular transformed value)

-: PLATE :-

(1) Rhizome rot - visual symptoms under the field conditions - variety China(V_1).

(2) Rhizome rot - symptoms on the rhizomes - varieties China (V_1) and Thinladium (V_4)

(3) Scale insect infestation on rhizome - varities China (V_1), Thinladium (V_4) and Sierra Leone (V_5).

The analysed data of the total infection as shown in Table 10(c) revealed the existance of signficant difference between varieties. The variety V_1 was the most affected on (22.31%), followed by V_5 (11.26%), V_4(11.15%) V_3 (10.03%) and V_2 (2.30%) respectively. V_2 was significantly superior to all other varieties with regards to its tolerance to the rhizome rot. However, varieties V_1, V_5, V_4 and V_3 though indicated differences in the degree of rhizome rot incedence, were not so statistically.

<u>Incidence of Scale Insect Attack</u>: The table 11 represents the data on scale in sect attack. The statistical analysis revealed that there was significant difference between the main plot treatments (varieties). The sub-plot treatments and interaction were not significant. The variety V_2 was the least affected variety with 4.17% of attack, while V_4 recorded maximum damage (25.6%). Between these varieties there existed significance difference, while, V_4 was closely followed by V_5(20.14%), V_1(16.67%) and V_3 (4.17%). Among V_4, V_5, V_1 and V_3 as well as between V_5, V_1 V_3 and V_2 there were no significant difference on the attack of scale insect.

Though there was no significant difference between the treatments there existed an apparent difference. Thus T_3 had the maximum attack (24.17%) while T_6 had the least attack (9.17%).

FIG·9

EFFECT OF VARIETIES, UREA AND PLANOFIX ON SCALE INSECT INFESTATION

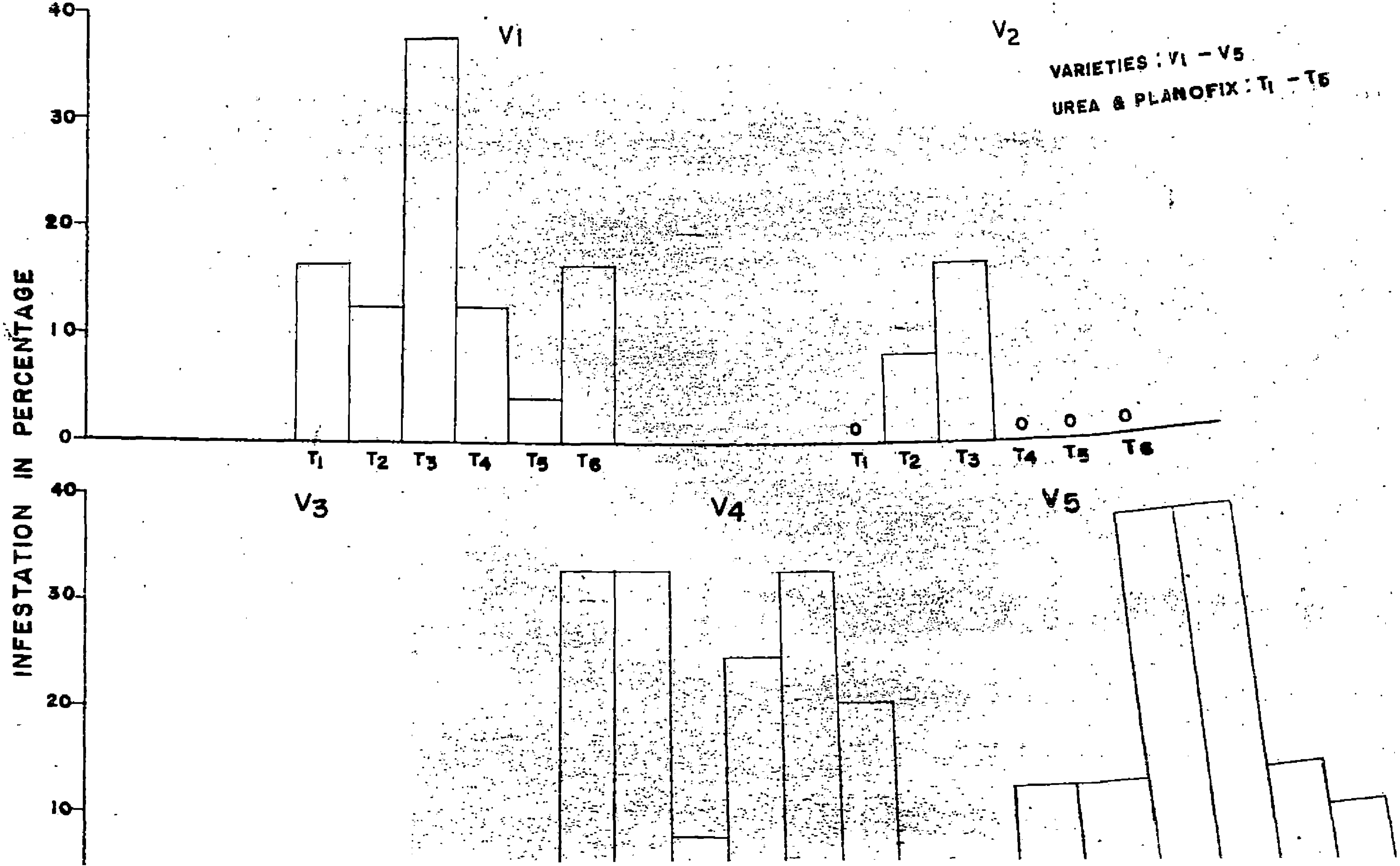


TABLE 11. EFFECT OF UREA AND PLANOFIX ON THE INFESTATION OF SCALE INSECT WITH RESPECT TO VARIOUS VARIETIES OF GINGER (UNIT - PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	12.50 (16.90)	8.33 (30.00)	0.0 (0.0)	33.33 (34.48)	12.50 (16.90)	13.33 (19.65)
T_3 Planofix 200 ppm	37.50 (37.58)	16.67 (45.00)	20.83 (65.70)	8.33 (13.80)	37.50 (36.90)	24.17 (39.79)
T_4 Urea 2% + P 200 ppm	12.50 (16.90)	0.0 (0.0)	0.0 (0.0)	25.00 (25.00)	37.50 (36.90)	15.00 (15.76)
T_5 Planofix 400 ppm	4.17 (6.90)	0.0 (0.0)	0.0 (0.0)	33.33 (35.00)	12.50 (16.90)	10.00 (11.76)
T_6 Urea 2% + P 400 ppm	16.67 (15.00)	0.0 (0.0)	0.0 (0.0)	20.83 (21.90)	8.33 (10.00)	9.17 (9.38)
T_1 Control	16.67 (20.00)	0.0 (0.0)	4.17 (20.70)	33.33 (35.17)	12.50 (16.90)	13.33 (18.55)
Mean	16.67 (18.88)	4.17 (12.50)	4.17 (14.40)	25.69 (27.55)	20.14 (22.41)	

'F' test in the case of main plot treatment (varieties) is significant

S.E. (m) ± for main plot treatment is 4.0917

C.D. 0.05% for main plot treatment is 13.34

(Figures in the parenthesis represent the Angular transformed values) (P = Planofix)

Regarding the treatment combinations, V_1 T_3, V_5 T_3, V_5 T_4 and the maximum infestation of scale insect (37.50%)while, in case of V_2 T_4, V_2 T_5,V_2 T_6, V_2 T_1, V_3T_2, V_3 T_4, V_3 T_5 and V_3 T_6 practically had no attack. Among the infested ones V_1T_5 and V_3 T_1 showed the least value of 4.17% each.

FIG·9

EFFECT OF VARIETIES, UREA AND PLANOFIX ON SCALE INSECT INFESTATION

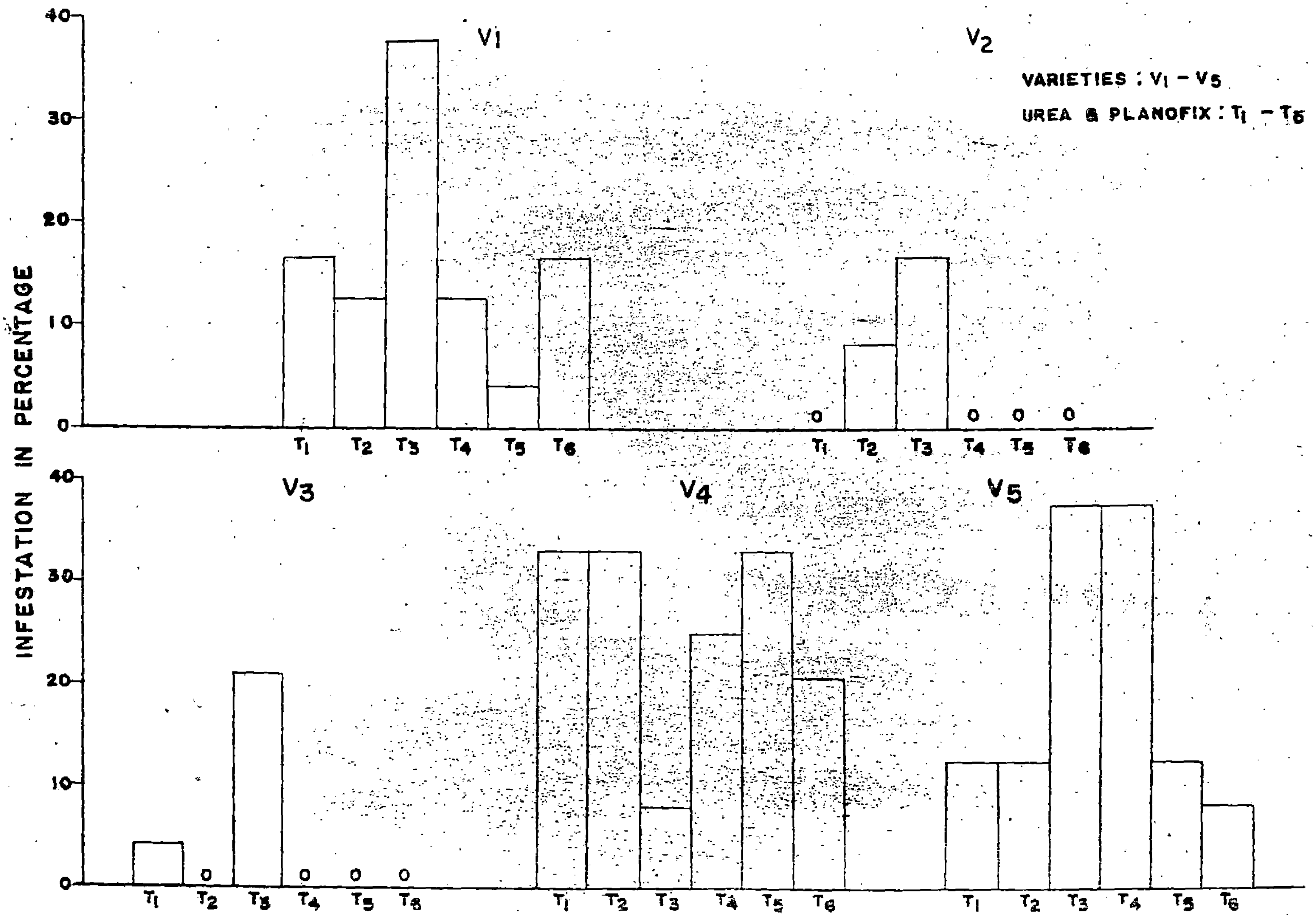


TABLE 11. EFFECT OF UREA AND PLANOFIX ON THE INFESTATION OF SCALE INSECT WITH RESPECT TO VARIOUS VARIETIES OF GINGER (UNIT – PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	12.50 (16.90)	8.33 (30.00)	0.0 (0.0)	33.33 (34.48)	12.50 (16.90)	13.33 (19.65)
T_3 Planofix 200 ppm	37.50 (37.58)	16.67 (45.00)	20.83 (65.70)	8.33 (13.80)	37.50 (36.90)	24.17 (39.79)
T_4 Urea 2% + P 200 ppm	12.50 (16.90)	0.0 (0.0)	0.0 (0.0)	25.00 (25.00)	37.50 (36.90)	15.00 (15.76)
T_5 Planofix 400 ppm	4.17 (6.90)	0.0 (0.0)	0.0 (0.0)	33.33 (35.00)	12.50 (16.90)	10.00 (11.76)
T_6 Urea 2% + P 400 ppm	16.67 (15.00)	0.0 (0.0)	0.0 (0.0)	20.83 (21.90)	8.33 (10.00)	9.17 (9.38)
T_1 Control	16.67 (20.00)	0.0 (0.0)	4.17 (20.70)	33.33 (35.17)	12.50 (16.90)	13.33 (18.55)
Mean	16.67 (18.88)	4.17 (12.50)	4.17 (14.40)	25.69 (27.55)	20.14 (22.41)	

'F' test in the case of main plot treatment (varieties) is significant

S.E. (m) $\pm$ for main plot treatment is 4.0917

C.D. 0.05% for main plot treatment is 13.34

(Figures in the parenthesis represent the Angular transformed values) (P = Planofix)

Regarding the treatment combinations, $V_1 T_3$, $V_5 T_3$, $V_5 T_4$ and the maximum infestation of scale insect (37.50%) while, in case of $V_2 T_4$, $V_2 T_5$, $V_2 T_6$, $V_2 T_1$, $V_3 T_2$, $V_3 T_4$, $V_3 T_5$ and $V_3 T_6$ practically had no attack. Among the infested ones $V_1 T_5$ and $V_3 T_1$ showed the least value of 4.17% each.

(ix) Compatibility of Urea and Planofix on Ginger: No sorching or any other damage on the arial part of the plants were noticed due to the spraying. This indicated that these chemicals were compatible and they have no phytotoxic effects at the applied concentrations.

Post Harvest Studies

Yield of rhizome: Soon after the harvest, the yield per plant (clump) and yield per plot were recorded and the yield per Hectare was calculated using the plot yield. The data were statistically analysed and presented in Tables 12 (a), (b) and (c).

The performance of the five varieties have shown that there was no significant difference between the varieties, though there was apparent difference between the various varieties. The three tables revealed (Table 12 a, b, and c) that variety V_3 (Rio-de-Janeiro) gave the maximum yield 161.23 gms per plant, 806.13 gms per net plot and 322.45 quintals per hectare closely followed by V_1 (China) with 155.26 gms, 776.31 gms and 310.53 quintals etc. respectively. Variety V_2 (Maran) had 142.24 gms as individual plant yield, 711.18 gms as net plot yield and 284.47 quintals as hectare yield. The variety V_5 (Sierra Leone) produced 133.95 gm of plant yield, 669.73 gms of net plot yield and 267.89 quintals of

TABLE 12(a). EFFECT OF UREA AND PLANOFIX ON PLANT YIELD WITH RESPECT TO VARIETIES OF GINGER (UNIT - GRAMS)

	Treatments	Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	152.06	137.86	159.93	138.26	132.93	144.20
T_3	Planofix 200 ppm	152.20	141.73	163.80	128.46	134.46	144.13
T_4	Urea 2% + P 200 ppm	161.80	148.66	168.53	136.93	138.33	150.85
T_5	Planofix 400 ppm	155.66	145.26	167.20	131.26	134.66	146.80
T_6	Urea 2% + P 400 ppm	166.66	157.73	177.20	145.13	142.80	157.90
T_1	Control	143.20	122.20	130.73	121.20	120.53	127.57
Mean		155.26	142.24	161.23	133.54	133.95	

'F' test for sub-plot treatment only is significant

S.E.(m) $\pm$ for sub-plot treatments 1.5496

C.D. at 0.05% level for S.P.T. 4.40

S.E.(m) for sub-plot treatments at same level of M.P.T.$\pm$ 3.4650

C.D. at 0.5% level for S.P.T.at the same level of M.P.T 9.84

(P = Planofix)

hectare yeild closely followed by the variety V_4 (Thinladium) having 133.54 gms of plant yield 667.68 gms plot yield and 267.07 quintals of hectare yield respectively.

TABLE 12 (b). EFFECT OF UREA AND PLANOFIX ON NET PLOT YIELD WITH RESPECT OF DIFFERENT VARIETIES OF GINGER (UNIT - GRAMS PER PLOT)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	760.3	689.3	799.6	691.3	664.6	721.02
T_3 Planofix 200 ppm	761.0	708.6	819.0	642.3	672.3	720.64
T_4 Urea 2% + P 200 ppm	809.0	743.3	842.6	684.6	691.6	754.22
T_5 Planofix 400 ppm	778.3	726.3	836.0	656.3	673.3	734.04
T_6 Urea 2% + P 400 ppm	833.3	788.6	886.0	725.6	714.0	789.50
T_1 Control	716.0	611.0	653.6	606.0	602.6	637.84
Mean	776.31	711.18	806.13	667.68	669.73	

'F' test for sub-plot treatment alone is significant

S.E.(m) ± for sub-plot treatment = 7.7488

S.E.(m) ± for sub-plot treatment at the same level of M.P.T. = 17.3268

C.D. at 0.05% level for S.P.T. 22.000

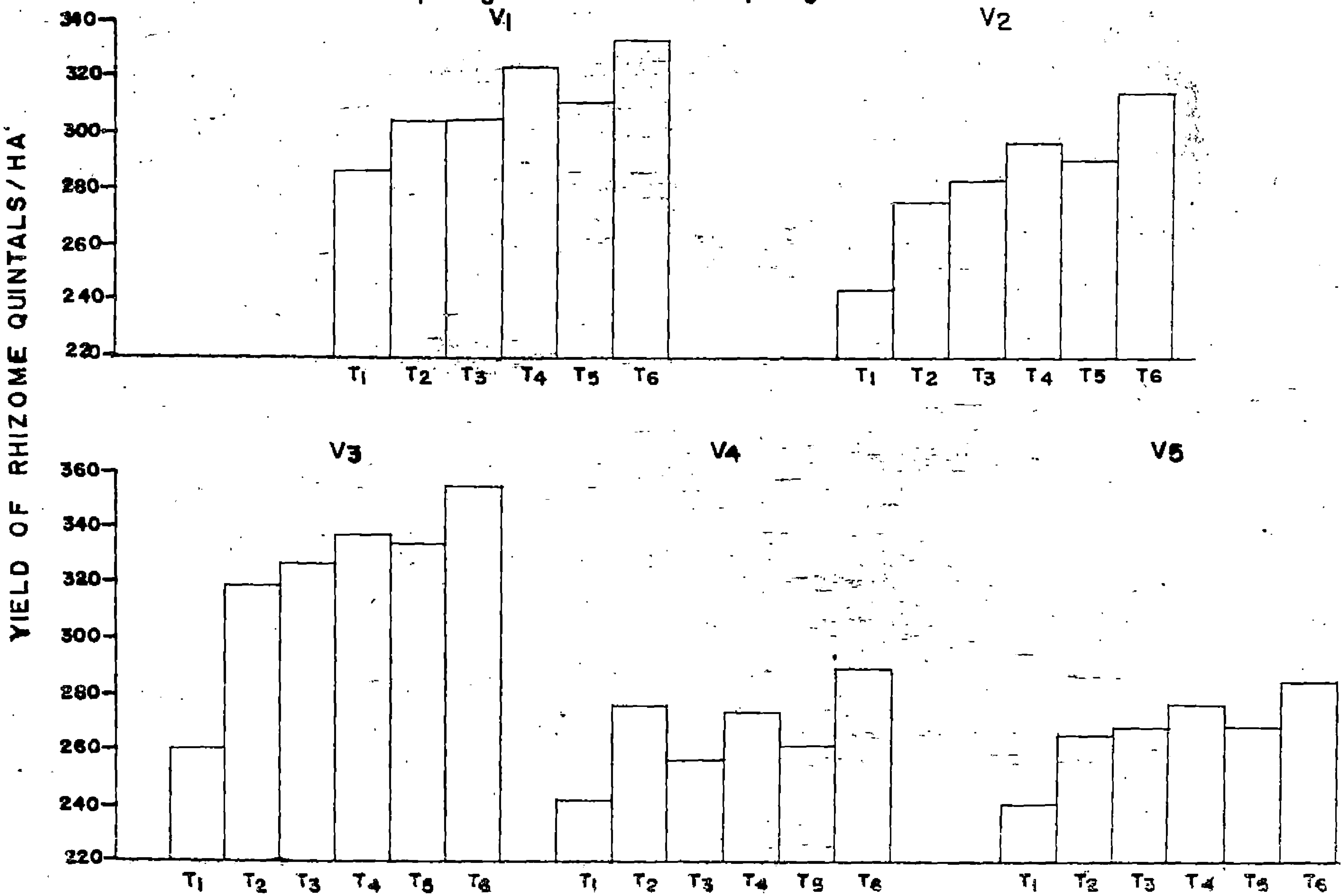
C.D.at 0.05% level for S.P.T. at the same level of M.P.T. 49.196

(P = Planofix)

FIG· 7

EFFECT OF VARIETIES, UREA AND PLANOFIX ON YIELD

Varieties: $V_1 - V_5$ · Urea & Planofix : $T_1 - T_6$



:- PLATE :-

(1) Fresh rhizome (500gms/variety) of varieties V_1 (China) V_2 (Maran), V_3 Rio-de-Janeiro, V_4 (Thinladium) and V_5 (Sierra Leone).

(2) Rhizome yield/plant of variety V_1 (China) as influenced by the various sub-plot treatments: Urea and Planofix.

(3) Rhizome yield/Plant of variety V_2 (Maran) as influenced by the various sub-plot treatments: Urea and Planofix.

-: PLATE :-

(1) Rhizome yeild/Plant of variety V_3 (Rio-de-Janeiro) as influenced by the various sub-plot treatments: Urea and Planofix.

(2) Rhizome yeild/Plant of variety V_4 (Thinladium) as influenced by the various sub-plot treatments: Urrea and Planofix.

(3) Rhizome yield/ Plant of variety V_5 (Sierra Leone) as influenced by the various sub-plot treatments: Urea and Planofix.

TABLE 12 (c). EFFECT OF UREA AND PLANOFIX ON THE HECTARE YIELD WITH RESPECT TO THE DIFFERENT VARIETIES (UNIT - QUINTALS PER HECTARE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	304.12	275.72	319.84	276.52	265.84	288.41
T_3 Planofix 200 ppm	304.40	283.44	327.60	256.92	268.92	288.26
T_4 Urea 2% + P 200 ppm	323.60	297.32	337.04	273.84	276.64	301.69
T_5 Planofix 400 ppm	311.32	290.52	334.40	262.52	269.32	293.62
T_6 Urea 2% + P 400 ppm	333.32	315.44	354.40	290.24	285.60	315.80
T_1 Control	286.40	244.40	261.44	242.40	241.04	255.14
Meand	310.53	284.47	322.45	267.07	267.89	

C.D. for sub-plot treatments at 0.05% level 8.80

C.D. for sub-plot treatments at the same level of M.P.T. at 0.05% level 19.68

(P = Planofix)

With regards to the effects due to the sub-plot treatments (Urea and Planofix) Table 12(a) the maximum yields were recorded by T_6, which was significantly superior to all other treatments, followed by T_4, T_5, T_2, T_3 and T_1. However, T_5, T_2 T_3 remained parallel, though they remained significantly superior to T_1 (Control). It was further observed that the same pattern was maintained in the cases of per Plant yield (12(a)). Net plot (Table 12 b) yield and hecatre yield (Table 12 c). The hectare yield for T_6 was 315.80 quintals followed by T_4 with 301.69 quintals, T_5 with 293.62 quintals, T_2 with 288.41 quintals T_3 with 288.26 quintals. While, T_1 (control) gave only 255.14 quintals per hecatare.

The interaction between the varieties and Urea and Planofix was not significant. The treatment V_3 T_6 produced the maximum recorded yield of 354.40 quintals per hectare and V_5 T_1 produced the minimum yield 241.04 quintals per hectare.

Volume of fresh ginger:

Volume of fresh ginger was calculated to find out the specific gravity and as a measure to compare the shrinkage during storing if any. The data are represented in Table 13.

The statistical analysis showed that there was no significant difference either between the varieties or between the sub-plot treatments. However, there were apparent differences noticed (Table 12). Thus V_1 had the maximum volume of 91.09 ml, followed by V_3 with 89.85 ml, V_2 with 88.54 ml, V_5 with 87.95 ml and V_4 showed only 86.64, which was the least value obtained. In the case of sub-plot treatments, T_6 recorded the maximum volume of 90.33 ml T_5

TABLE 13 . EFFECT OF UREA AND PLANOFIX ON VOLUME OF FRESH GINGER WITH RESPECT TO VARIETIES (UNIT-VOLUME OF 100 GRAMS)

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	92.51	86.59	89.44	86.01	89.16	88.74
T_3	Planofix 200 ppm	90.03	88.13	90.02	86.42	87.39	88.40
T_4	Urea 2% + P 200 ppm	90.06	87.16	91.21	86.42	86.06	88.18
T_5	Planofix 400 ppm	92.21	89.88	88.79	85.49	89.48	89.17
T_6	Urea 2% + P 400. ppm	92.94	91.73	89.97	87.86	89.16	90.33
T_1	Control	88.81	87.78	89.66	87.61	86.45	88.06
Mean		99.09	88.54	89.85	86.64	87.95	

'F' test not significant
(P = Planofix)

89.17 ml, T_2 88.74 ml, T_3 88.40 ml, T_4 88.18 ml and T_1 88.06 ml which was the lowest.

Specific gravity of rhizome: The data represented in Table 14 showed the specific gravity of rhizomes of different varieties under the influence of Urea and Planofix. But there was no significant difference between them. Thus variety V_4

TABLE 14. SPECIFIC GRAVITY AS AFFECTED BY UREA AND PLANOFIX WITH RESPECT TO DIFFERENT VARIETIES OF GINGER.

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	1.082	1155	1.118	1.162	1.123	1.128
T_3	Planofix 200 ppm	1.113	1.136	1.108	1.161	1.144	1.132
T_4	Urea 2% + P 200 ppm	1.103	1.148	1.099	1.156	1.162	1.134
T_5	Planofix 400 ppm	1.081	1.112	1.126	1.136	1.117	1.114
T_6	Urea 2% + P 400 ppm	1.076	1.091	1.111	1.138	1.121	1.107
T_1	Control	1.126	1.140	1.115	1.142	1.156	1.136
Mean		1.097	1.130	1.113	1.149	1.137	

'F' test not significant

(P = Planofix)

recorded special gravity of 1.149, followed by V_5 with 1.137, V_2 with 1.130, V_3 with 1.113 and V_1 with 1.097. Among the sub-plot treatments T_1 (control) recorded the maximum specific gravity of 1.136, followed T_4 with 1.134, T_3 with 1.132, T_2 with 1.128 and T_6 with 1.107 which is the lowest value.

Recovery of Dry Ginger: Table 15 represents the data on the recovery of dry ginger from green ginger in percent-

TABLE 15. PERCENTAGE RECOVERY OF DRY GINGER AS AFFECTED BY UREA AND PLANOFIX WITH RESPECT TO VARIOUS VARIETIES OF GINGER (UNIT- PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	19.16 (26.10)	23.76 (29.17)	18.70 (25.62)	23.76 (29.17)	22.60 (28.38)	21.60 (27.68)
T_3 Planofix 200 ppm	19.70 (26.34)	23.26 (28.83)	18.06 (25.15)	22.93 (28.61)	24.00 (29.31)	21.59 (27.64)
T_4 Urea 2% + P 200 ppm	20.90 (27.20)	24.06 (29.37)	18.30 (25.32)	21.36 (27.53)	23.56 (29.04)	21.64 (27.69)
T_5 Planofix 400 ppm	18.63 (25.57)	23.66 (29.10)	16.60 (24.03)	21.96 (27.93)	24.06 (29.37)	20.98 (27.20)
T_6 Urea 2% + P 400 ppm	18.03 (25.12)	22.53 (28.33)	17.16 (24.47)	20.53 (26.94)	24.06 (29.37)	20.46 (26.84)
T_1 Control	24.16 (29.44)	24.00 (29.33)	17.46 (24.68)	24.13 (29.39)	24.20 (29.46)	22.79 (28.46)
Mean	20.09 (26.62)	23.54 (29.02)	17.71 (24.87)	22.44 (28.26)	23.75 (29.12)	

'F' test for main plot, sub-plot treatments and their interactions are highly significant

	S.E.(m) ±	C.D.at 0.05%
(1) For main plot treatment	0.230	0.75
(2) For sub-plot treatment	0.223	0.63
(3) For sub-plot treatment with the same level of M.P.T.	0.499	1.42
(4) For main plot treatments with the same level of S.P.T	0.690	2.12

(Figures in parenthesis indicate angular transformed values)

(P = Planofix)

age as affected by Urea and Planofix with respect to different varieties.

The statistical analysis revealed that varieties, sub-plot treatments (Urea and Planofix) and their interaction were significant. Among the varieties, V_5 recorded the maximum percentage recovery of 23.75% closely followed by V_2 with 23.54. These varieties showed no significant difference between themselves but superior to all other varieties in the order of V_4(22.44%)V_1 (20.09%) and V_3 (17.71%). V_4, V_1 and V_3 showed significant difference between themselves.

In the case of sub-plot treatments control had significantly superior values over all other treatments with 22.79% of recovery, followed by T_4 with 21.64, T_2(21.60%) T_3 (21.59%), T_5(20.98%) and T_6 (20.46%). Among these, T_4, T_2, T_3 and T_5 did not show any significant difference between themselves.

Table 13 indicated that the interaction was significant showing the differential response between the varieties to different sub-plot treatments. Thus V_5 T_1 recorded the maximum recovery (24.20%) and V_3 T_5 recorded the minimum of 16.60%. In the case of sub-plot treatments with respect to variety V_2 and V_5 there was no significant difference. With respect to variety V_1 there were significant differences between the treatment and V_1T_1(24.10) was superior to all of them. However, V_1 T_6 recorded 18.03% of recovery. In the variety V_2, V_2 T_4 and V_2 T_6 had 24.06% and 22.53% respectively. With regards to V_3, V_3T_5 (16.60%) was significantly inferior to all other treatments. Though V_3T_2 recorded 18.70% of recovery of dry ginger there was no significant difference between V_3 T_2, T_3 T_4, V_3T_3, V_3 T_1 and V_3 T_6 in the order of merit. In the case of V_4, V_4T_1 gave 24.13% recovery which was the maximum and V_4 T_6 with 20.53% as the minimum value. There is no significant difference between V_4 T_1, V_4 T_2 and V_4 T_3 and between V_4 T_2, V_4 T_3 and V_4 T_5 as well as V_4T_3, V_4 T_5 and V_4 T_4 did not show any significant difference between themselves. V_4T_5, V_4 T_4 and V_4 T_6 were also similar in their effect. Under the variety V_5, V_5 T_1 gave the maximum of 24.20% and V_5 T_2 with 22.60% as the minimum percentage of recovery.

The response of V_5, V_1, V_4 and V_2 with respect to T_1 was significantly different from V_3. In this case V_3T_1 gave the minimum recovery of 17.46% . The response of V_2, V_4 and V_5 to the treatment T_2 was superior than that of V_1 and V_3. Varieties V_5, V_2 and V_4 showed preference to T_3 than that of V_1 and V_3. Almost same trend of effect was recorded in the case of other treatment also, but the order of preference in the case of T_4 was V_2, V_5 and V_4

instead of V_5, V_2, V_4 for T_5 and in the case of T_6, V_5 was superior to all other except V_2 whereas there was no significant difference between V_2 and V_4 or V_4 and V_1 or V_1 and V_3.

Dry Ginger Production per Hectare: The data on dry ginger production per hectare is represented in Table 16 and figure No . The statistical analysis showed that only the sub-plot treatments and interaction were significant but not the varieties. Among varieties V_2 produced the maximum dry ginger of 66.94 quintals whereas the next best variety V_5 produced 63.68 quintals only. The dry ginger production of other varieties were to the tune of 62.16 quintals (V_1), 59.69 quintals (V_4) and 57.19 quintals (V_3) i.e. V_3 produced the lowest quantity of dry ginger as observed from the table indicated before.

Among the sub-plot treatments, T_4 producing 64.85 quintals per hectare was significantly superior to T_5 (61.04 quintals/ha) and T_2 (61.75 quintals/ha) but between T_4, T_6, T_3 and T_2 as well as between T_6, T_3 and T_2 and between T_3 and T_2 as well as between T_6, T_3 and T_2 and between T_5 and T_1 there were no significant difference. However, T_1 produced the minimum quantity of 58.03 quintals per hectare of dry ginger.

FIG·8

DRY GINGER PRODUCTION AS AFFECTED BY VARIETIES, UREA AND PLANOFIX

(Varieties: $V_1 - V_5$ · Urea & Planofix: $T_1 - T_6$)

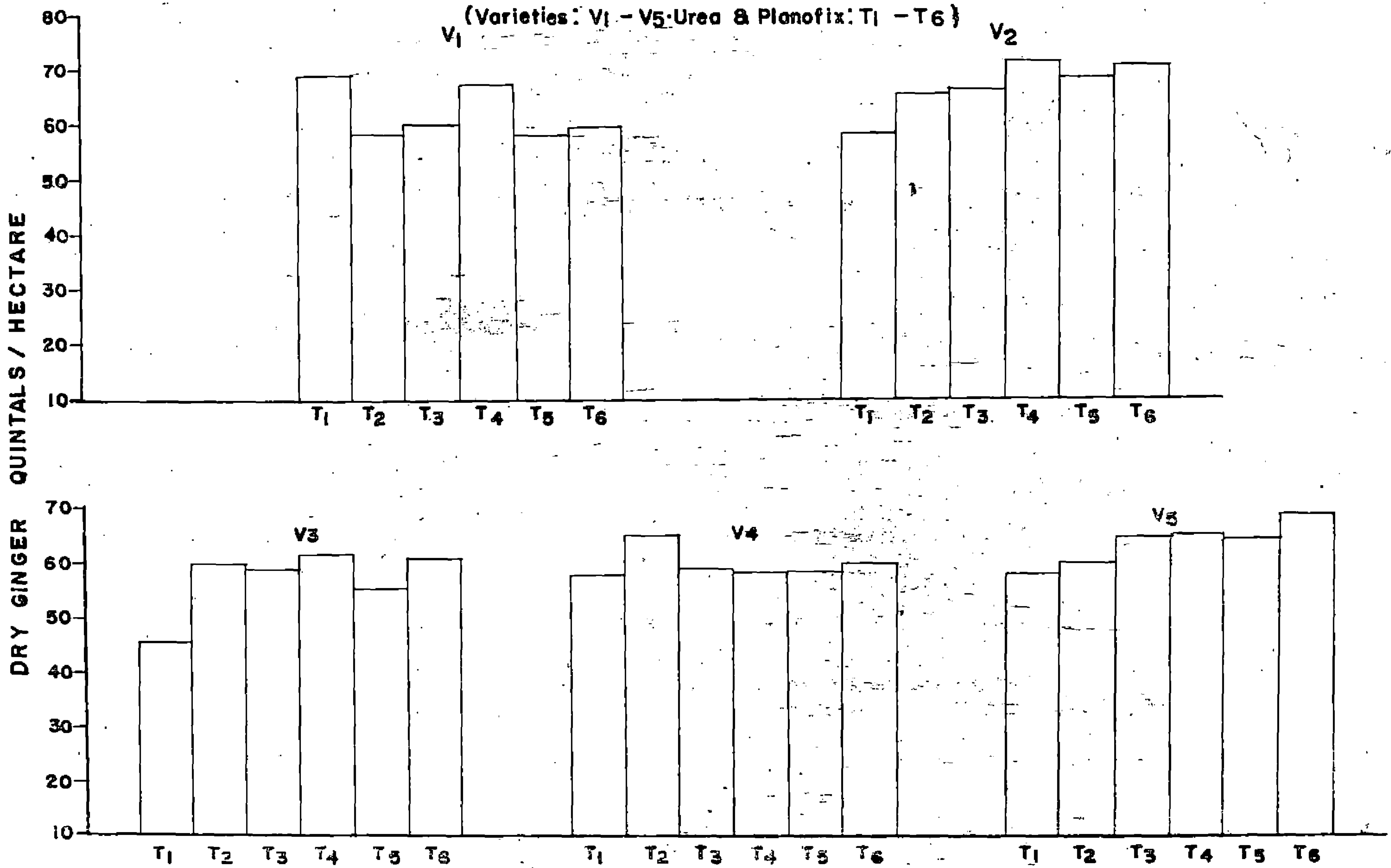


TABLE 16. DRY GINGER PRODUCTION AS AFFECTED BY UREA AND PLANOFIX WITH RESPECT TO DIFFERENT VARIETIES OF GINGER (UNIT - QUINTALS PER HECTARE)

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	58.10	65.52	59.86	65.21	60.06	61.75
T_3	Planofix 200 ppm	60.22	66.00	59.10	58.99	64.93	61.85
T_4	Urea 2% + P 200 ppm	67.47	71.57	61.80	58.10	65.29	64.85
T_5	Planofix 400 ppm	57.98	68.78	55.52	58.24	64.66	61.04
T_6	Urea 2% + P 400 ppm	59.95	71.08	60.98	59.62	68.80	64.09
T_1	Control	69.22	58.69	45.87	57.99	58.37	58.03
Mean		62.16	66.94	57.19	59.69	63.68	

'F' test for sub-plot treatments and interaction are highly significant.

	S.E.(m) ±	C.D.at 0.05%
(1) For sub-plot treatments	1.1130	3.16
(2) For sub-plot treatments with same level of M.P.T.	2.4886	7.07
(3) For mainplot treatment with same level of S.P.T.	9.5960	31.06

(P = Planofix)

Further the data on the production of dry ginger at the ultimate plot level represented that, the maximum dry ginger production was recorded by the treatment combination V_2T_4 (71.57 quintals) and the minimum by V_3 T_1 (45.87 quintals). The data given under each of the main plot treatment revealed that under the variety V_1 the treatment combination V_1 T_1 recorded the maximum dry ginger production (69.22 quintals) closely followed by V_1 T_4 with 67.47 quintals though they did not differ significantly with each other. Similarily, treatment combinations V_1T_3, V_1 T_6, V_1 T_2 and V_1 T_5 followed in the order of merit to the above treatment combination which were not significantly different. However, they were inferior to V_1 and T_1 and V_1 T_4 in the production of dry ginger. In the case of variety V_2 the treatment combination V_2 T_4 produced 71.57 quintals/ha of dry ginger followed by V_2 T_6, V_2 T_5, V_2T_3, V_2 T_2 and V_2 T_1. However, between V_2 T_1 and V_2 T_2 there was no significant difference. The effect of chemicals (sub-plot treatments) on the variety V_3 revealed that treatments V_3 T_4, V_3 T_6, V_3 T_2, V_3 T_3 and V_3 T_5 were significantly superior to V_3 T_1 (45.87 quintals) though there was no significant difference between themselves. The variety V_4 showed more variation in this regard. Thus V_4 T_2 (65.21 quintals) was superior to V_4 T_6, V_4 T_3 and to V_4 T_5 and was significantly superior to V_4 T_4 and V_4 T_1. Under the variety V_5, the treatment combination V_5 T_6 had 68.80 quintals which was significantly superior to V_5 T_2 and V_5 T_1 (60.06 and 58.37 quintals respectively).

but among $V_5 T_6$, V_5T_4, $V_5 T_3$ and $V_5 T_5$ as well as between $V_5 T_4$, $V_5 T_3$, $V_5 T_5$ and $V_5 T_2$ and $V_5 T_1$ to $V_5 T_5$ there were no significant difference.

When the effect of individual treatments on the varieties were compared it was seen that in the case of T_1, V_1T_1 produced the maximum dry ginger (69.22 quintals) whereas, $V_3 T_1$ produced the minimum quantity of 45.87 quintals per hectare. For treatment T_2, $V_2 T_2$ produced the maximum quantity (65.92 quintals)while $V_1 T_2$ the minimum of 58.10 quintals of dry ginger per hectare. In all the other chemical treatments (T_3 to T_6) also V_2 recorded the higher production of dry ginger. In the interaction between different varieties with chemical treatment T_3, T_4 and T_6, treatment combination $V_4 T_3$, $V_4 T_4$ and $V_4 T_6$ produced the minimum dry ginger while in the case of T_5, treatment combination $V_1 T_5$ produced the minimum dry ginger per hectare. Thus the varieties showed differential response to various sub-plot treatments.

Storage Studies

Weight loss during storage: Data on the weight loss of ginger during storage in the laboratory conditions are presented in the Table 17. The statistical analysis proved the existance of significance difference with the varieties and the interaction whereas, the sub-plot treatment is not significant.

TABLE 17. EFFECT OF UREA, PLANOFIX ON WEIGHT LOSS DURING STORAGE WITH RESPECT TO THE DIFFERENT VARIETIES OF GINGER (90 DAYS OF STORAGE) (UNIT-PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	46.93 (42.65)	46.47 (42.93)	48.60 (44.18)	52.60 (46.49)	47.13 (43.34)	48.15 (43.91)
T_3 Planofix 200 ppm	51.70 (45.98)	40.60 (39.57)	58.13 (49.73)	30.90 (33.74)	50.03 (45.02)	46.27 (42.80)
T_4 Urea 2% + P 200 ppm	36.27 (36.92)	35.03 (36.26)	52.40 (46.38)	38.80 (38.43)	51.67 (45.96)	42.83 (40.79)
T_5 Planofix 400 ppm	44.60 (41.88)	29.13 (32.65)	50.57 (45.31)	52.03 (46.17)	41.47 (40.07)	43.56 (41.21)
T_6 Urea 2% + P 400 ppm	38.13 (38.07)	42.83 (40.80)	46.33 (42.89)	42.13 (40.42)	43.70 (41.37)	42.62 (40.71)
T_1 Control	41.33 (40.58)	36.60 (37.21)	49.37 (44.63)	47.27 (43.42)	40.57 (39.49)	43.23 (41.06)
Mean	43.16 (41.01)	38.44 (38.23)	50.90 (45.52)	43.95 (41.44)	45.76 (42.54)	

'F' test for main plot treatments (varieties) and interaction are significant

	S.E.(m) ±	C.D. at 0.05% level
(1) Main plot treatment	1.291	4.21
(2) Sub-plot treatment	1.071	3.04
(3) Sub-plot treatments with same level of M.P.T	2.396	6.80
(4) Main plot treatment with same level of S.P.T	3.622	11.17

(Figures in parenthesis represent the angular value)

(P = Planofix)

As seen from the Table 17 it is noticed that the weight loss of rhizomes was the maximum with the variety V_3 (50.90%) followed by V_5 (45.76%), V_4 (43.95%), V_1 (43.16%) and V_2 (38.44%). The weight loss of variety V_3 was significantly higher than those of V_1 and V_2 whereas V_4 and V_5 were closer to that of V_3 as they did not differ significantly.

Among the sub-plot treatments there were no significant difference existed among themselves. However T_2 (48.15%) had the maximum loss of rhizome weight followed by T_3 (46.27%) T_5 (43.56%), T_1 (43.23%), T_4 (42.83%) and T_6 (42.62%). Thus the weight loss in T_6 was the lowest and T_2 the highest.

The data on the ultimate plot as presented in Table 17 indicated that V_3 T_3 recorded the maximum weight loss (58.13%) of the rhizome while treatment combination V_2 T_5 recorded the minimum (29.13%) value. Within the variety, the weight loss of variety V_1 (China) as effected by the Chemicals had the highest percentage for V_1 T_3 (51.70%) while for V_2, V_2 T_2 (46.47%), for V_3, V_3 T_3 (58.13%), for V_4, V_4 T_2 (52.60%) and for V_5, V_5 T_4 (51.67%). While the corresponding minimum loss were recorded by V_1T_4(36.27%). However there were no significant difference among the sub-plot treatments with respect to the variety V_1.

With regards to variety V_2, the treatment combinations did not differ significantly as compared to the control. However, $V_2 T_5$ had the minimum loss (29.13%) whereas, $V_2 T_2$ had the maximum loss (46.47%). With regards to V_3, there were no significant difference of various treatments with the control ($V_3 T_1$) but V_3T_6 had the lowest percentage and $V_3 T_3$ had the highest percentage of weight loss of the rhizomes. Under variety V_4 treatment combination $V_4 T_3$ had significantly lower weight loss compared to the control (V_4T_1) and $V_4 T_2$ had the highest percentage of weight loss. With regards to variety V_5, there were no significant differences among the treatment combination. However, control (V_5T_1) had the lowest value whoreas, V_5T_4 had the highest value.

The maximum weight loss in T_1, T_3,T_4 and T_6 were recorded by V_3, and V_4 had registered the maximum loss in T_2 and T_5. However, the minimum values were recorded with V_2 having T_1, T_4 and T_5 treatments. The effect of chemical treatment T_2 and T_6 on various varieties indicated that variety V_1 had the minimum weight loss whereas treatment T_3 could minimise the weight loss of variety V_4 as compared to the rest of the four varieties.

Volume Loss During Storage: Table 18 represents the volume loss during storage. In this case also like the weight loss of the rhizomes, the varieties and interactions

TABLE 18. EFFECT OF UREA AND PLANOFIX ON VOLUME LOSS DURING STORAGE WITH RESPECT TO DIFFERENT VARIETIES OF GINGER (UNIT - PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	44.03 (41.55)	41.20 (39.82)	42.23 (40.52)	52.03 (46.17)	40.53 (39.50)	44.00 (41.52)
T_3 Planofix 200 ppm	47.20 (43.38)	36.27 (37.02)	47.50 (43.56)	21.80 (27.53)	39.47 (38.88)	38.45 (38.07)
T_4 Urea 2% + P 200 ppm	31.37 (34 .03)	29.87 (33.08)	48.67 (44.23)	33.07 (35.00)	45.13 (42.19)	37.62 (37.70)
T_5 Planofix 400 ppm	40.80 (39.66)	29.27 (32.64)	47.37 (43.46)	40.87 (39.70)	38.47 (38.33)	39.36 (38.75)
T_6 Urea 2% + P 400 ppm	35.93 (36.74)	34.93 (36.10)	42.00 (40.39)	41.67 (40.19)	37.80 (37.90)	38.47 (38.26)
T_1 Control	37.93 (38.00)	32.63 (34.70)	46.73 (43.12)	44.30 (41.71)	31.83 (34.18)	38.68 (38.34)
Mean	39.54 (38.69)	34.03 (35.56)	45.75 (42.54)	38.96 (38.42)	38.87 (38.49)	

'F' test varieties main plot treatments and interaction are significant.

	S.E.(m) ±	C.D. at 0.05%
(1) Main plot treatments	1.074	3.49
(2) Sub-plot treatments with same level of main plot treatment	2.384	6.76
(3) Main plot treatments with the same level of sub-plot treatments	3.242	9.94

(Figures in the parenthesis represent the angular transformed values)

(P = Planofix)

were significantly different whereas, treatments (chemical) alone were not significantly different with each other.

Among the varieties V_3 recorded the maximum volume loss (45.75%), followed by V_1 (39.54%). However, the minimum volume loss was registered by V_2 (34.03). But there was no significant difference noted between V_3, V_1, V_5 and V_4 as well as V_1, V_5, V_4 and V_2.

Among chemicals, T_2 (44.00%) ranked highest loss and T_4 (37.62%) ranked the least.

Varietal response to various chemical treatments revealed that in the case of V_1, V_1T_3 (47.20%) had the maximum loss of volume while V_1T_4 (31.37%) the least value. While, with V_2 variety, the maximum volume loss was with the treatment combination V_2 T_2 and V_2 T_5 was the least. Under variety V_3, the maximum loss was recorded with V_3T_4 and the minimum with V_3T_6. As regards variety V_4, the maximum loss was found with the treatment combination V_4T_2, and the minimum loss with V_4 T_3 whereas, with variety V_5, the highest volume loss was with V_5T_4 while, V_5 T_1 had the minimum. The response of varieties to individual treatments (Chemical) accounted the following results. In the case of T_1, T_2 and T_6 there was no significant prefernce shown in any of the varieties. With regards to treatment combinations V_3 T_1 (46.73%), V_5T_1 (31.83%), V_4T_2 (52.03%), V_5 T_2 (40.53%); V_3 T_3 (47.50%); V_4 T_3 (21.80%); V_3 T_4 (48.67%);

$V_2 T_4$(29.87%); V_3T_5(47.37%); V_2T_5(29.27%); V_3T_6(42.00%); and V_2T_6(34.93%) had maximum and minimum values due to the chemical treatments (T_1 to T_6) as indicated above with respect to each of the varieties.

Damage during Storage (Rottage + Driage):

The data is presented in Table 19. The statistical analysis revealed that only varieties and interaction were significant and sub-plot treatment effects were not significant.

Among the varieties V_4 recorded the maximum loss (59.64%) followed by V_5 (43.97%). These figures were significantly higher than the other varieties (V_1, V_2, V_3). V_2 registered the minimum damage loss of 7.90% only. However, there was no significant differences between V_4 and V_5, V_3 and V_2, and V_1 and V_2.

The effect of chemical on the storage loss indicated that there were no significant differences among themselves. Thus T_2 (36.95%) registered the maximum loss while, the minimum was with T_4 (25.48%) and T_6 (24.97%).

The interaction between varieties and chemical were significant. V_4 T_5 recorded the maximum damage (100%) whereas, in the case of V_2 T_5 practically no loss was recorded. V_1 T_6 (40.66%), V_2 T_2(16.33%), V_3 T_3 (53.33%), V_4 T_5(100%) and V_5 T_2 (63.44%) were recorded in varieties V_1, V_2, V_3, V_4 and V_5 as the maximum damage figures, the corresponding least figures were V_1 T_4(3.55%) V_2 T_5(0%), V_3 T_2(13.88%), V_4 T_3(18.99%) and V_5 T_1(22.44%).

FIG·11

EFFECT OF VARIETIES, UREA AND PLANOFIX ON DAMAGE DURING STORAGE

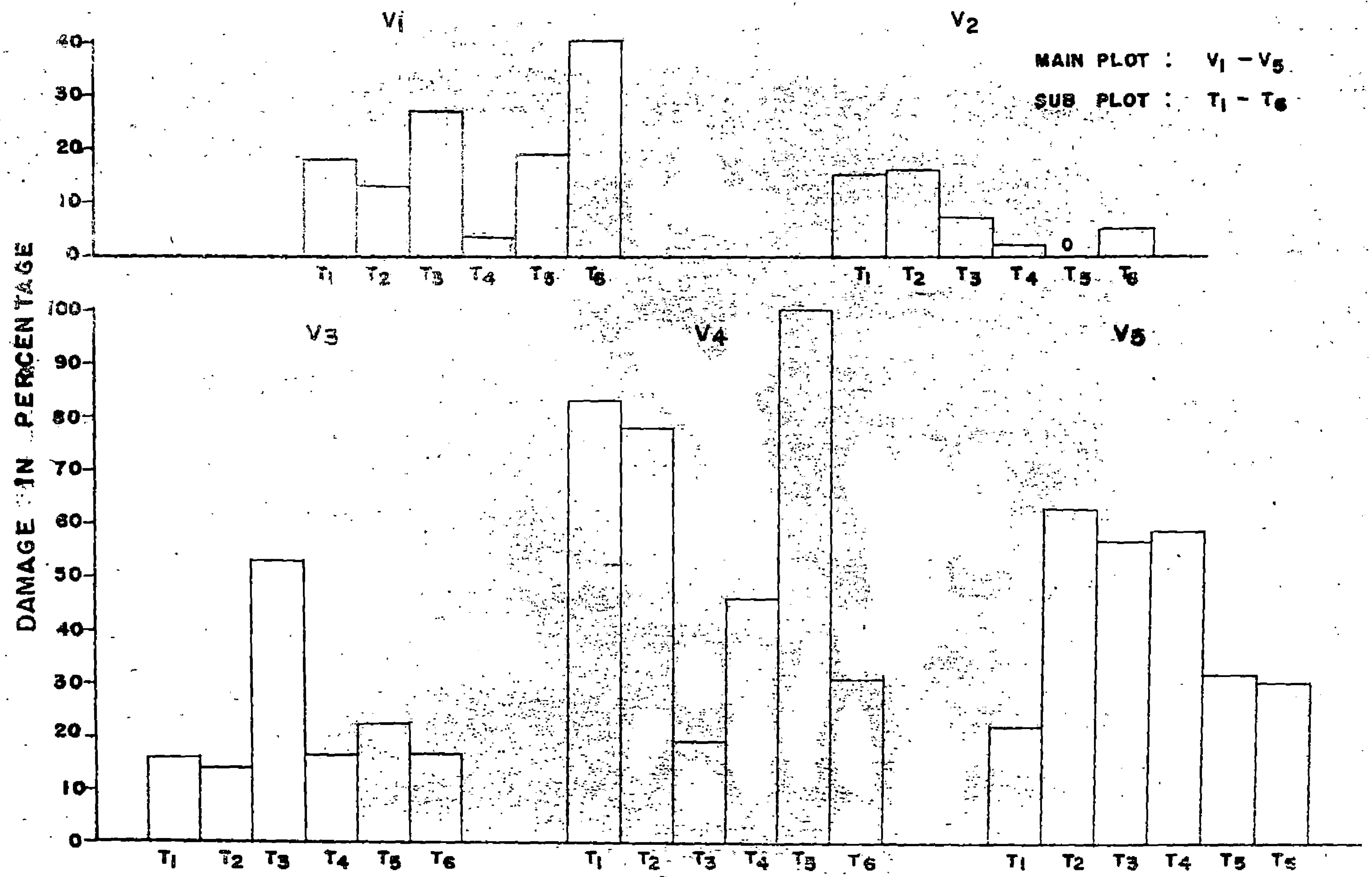


TABLE 19. EFFECT OF UREA AND PLANOFIX ON DAMAGE (ROTTAGE AND DRIAGE OF RHIZOMES) WITH RESPECT TO DIFFERENT VARIETIES OF GINGER DURING STORAGE (UNIT - PERCENTAGE)

Treatments	Varieties					
	V_1	V_2	V_3	V_4	V_5	Mean
T_2 Urea 2%	13.10 (16.62)	16.33 (22.41)	13.88 (17.84)	78.00 (71.89)	63.44 (58.13)	36.95 (37.37)
T_3 Planofix 200 ppm	26.88 (30.05)	7.77 (13.27)	53.33 (52.14)	18.99 (25.13)	56.66 (53.93)	32.73 (34.90)
T_4 Urea 2% + P 200 ppm	3.55 (6.36)	2.22 (6.98)	16.66 (23.70)	46.11 (45.88)	58.88 (55.46)	25.48 (27.67)
T_5 Planofix 400 ppm	19.10 (24.94)	0.0 (0.0)	22.77 (27.69)	100.00 (90.00)	31.88 (34.04)	34.75 (35.33)
T_6 Urea 2% + P 400 ppm	40.66 (39.32)	5.55 (11.16)	16.66 (24.02)	31.44 (34.07)	30.55 (33.18)	24.97 (28.35)
T_1 Control	18.10 (24.96)	15.55 (22.41)	16.10 (23.24)	83.33 (75.00)	22.44 (25.87)	31.10 (34.29)
Mean	20.23 (23.70)	7.90 (12.70)	23.23 (28.10)	59.64 (56.99)	43.97 (43.43)	

'F' test for main plot treatment and interaction are significant

	S.E.(m) ±	C.D. at 0.05% level
(1) Main plot treatment	4.68	15.26
(2) Sub-plot treatments with same level of M.P.T.	8.73	24.79
(3) Mainplot treatments with same level of S.P.T	13.15	40.83

(Figures in the parenthesis represent the angular transformed values)

(P = Planofix)

The varietal response to the individual treatments revealed the following. V_4 T_1(83.33%) showed significant difference to all other varieties, though there was no statistical difference among the other varieties and V_2T_1 recorded the minimum damage (15.55%) in case of T_1. V_4T_2 (78.00%) and V_1T_2(13.10%) recorded the maximum and minimum damage loss with T_2. The corresponding items in the case of T_3 was secured by V_5 T_3 (56.66%) and V_2 T_3 (7.77%) . V_5 again registered the maximum loss for V_5 T_4 (58.88%) and V_2 T_4(2.22%) as the minimum for T_4. In the case of T_5, V_4 T_5 with 100% damage ranked first which was significant over all other varieties. V_2 T_5 recorded practically no damage loss ()%). V_1T_6 accounted maximum damage loss(40.66%) and V_2 T_6 the minimum loss (5.55%) in case of T_6. But practically there was no significant difference between the five varieties in their response to T_6.

Chemical Analysis

Recovery of Oleoresin: Recovery of oleoresin from the various ginger varieties as effected by the chemical treatments (sub-plot) are represented in Table 20. The statistical analysis registered a high degree of significant difference among the varieties, sub-plot treatments and their interactions. Among the five varieties V_3 (Rio-de-Janeiro) accounted the highest percentage of oleoresin (6.86%) content which was significantly superior

TABLE 20. PERCENTAGE RECOVERY OF OLEORESIN AS AFFECTED BY UREA AND PLANOFIX WITH RESPECT TO VARIOUS GINGER VARIETIES (UNIT-PERCENTAGE)

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	5.74 (13.81)	5.70 (13.73)	6.41 (14.65)	4.33 (11.96)	4.99 (12.83)	5.43 (13.39)
T_3	Planofix 200 ppm	6.06 (14.22)	6.20 (14.40)	6.99 (15.23)	4.71 (12.47)	5.22 (13.23)	5.84 (13.91)
T_4	Urea 2% + P 200 ppm	5.55 (13.56)	5.68 (13.75)	677 (15.07)	5.40 (13.37)	6.04 (14.17)	5.89 (13.98)
T_5	Planofix 400 ppm	6.66 (14.95)	6.07 (14.25)	7.05 (15.32)	5.01 (12.87)	5.89 (13.97)	6.14 (14.27)
T_6	Urea 2% + P 400 ppm	7.35 (15.71)	7.24 (15.58)	8.00 (15.99)	4.45 (12.15)	5.42 (13.39)	6.49 (14.56)
T_1	Control	5.44 (13.47)	5.51 (13.43)	5.97 (14.04)	4.61 (12.38)	5.16 (13.09)	5.34 (13.28)
Mean		6.13 (14.28)	6.06 (14.19)	6.86 (15.05)	475 (12.53)	5.45 (13.44)	

'F' test for main plot, sub-plot treatments at their interactions are highly significant

	S.E (m) ±	C.D. at 0.05%
(1) For main plot treatment	0.14	0.46
(2) For sub-plot treatment	0.13	0.37
(3) For sub-plot treatment with same level of M.P.T.	0.29	0.82
(4) For main plot treatment with same level of S.P.T.	0.41	1.25

(Figures in parenthesis represent the angular values)

(P = Planofix)

to the rest of the varieties. However, variety V_1 (6.13%) was the next in the order of importance followed by V_2 (6.06%). Between V_1 and V_2 there was no significant difference. Further variety V_5, produced only 5.45% whereas V_4 accounted 4.75% of oleoresin which was the minimum value, having significantly inferior value than all other varieties.

In the case of sub-plot treatment, T_6 registered the maximum recovery (6.49%) of oleoresin content which was closely followed by T_5 (6.14%). The minimum recovery of oleoresin was recorded with treatment T_1 (5.34%). But there existed no significant difference between T_6 and T_5; T_5 T_4 and T_3; and T_2 and T_1.

The interaction (Table 20) between varieties with the chemicals was significant. In the case of varieties V_1, V_2 and V_3 the treatment combinations V_1 T_6, V_2 T_6 and V_3 T_6 respectively recorded the maximum recovery of oleoresin while with V_4, V_4 T_4 had the maximum content and in the case of V_5 also V_5 T_4 had the maximum oleoreasin content. However, V_4 T_2 and V_5 T_2 accounted the least recovery of oleoresin in (4.33%) and (4.99%) in case of varieties V_4 and V_5. it was further observed that in all cases (Table 20) V_3 having the chemical treatments invariably had the superior effect while , V_4 with such chemical treatment were inferior even when compared with the control. However, for treatments T_3 and T_4 the varieties V_3 V_2 and V_1 and V_5 were better than the V_4.

Oleoresin Production on Hectare Basis : Table 21 represented the oleoresin production per hecare. The statistical analysis showed that varieties, sub-plot treatments and interactions are significant.

The variety V_2 accounted the maximum production of oleoresin (408.27Kg./ha) which was significantly superior to V_4 (284.33 Kg./ha) but not significant over other varieties V_3 (390.22 Kg./ha), V_1 (378.83 Kg./ha) and V_5 (347.83 Kg./ha). There was no significant difference existed between V_5 and V_4.

Among the sub-plot treatments, T_6 registered the maximum production of 411.73 Kg./ha which was significantly superior to all the other treatments. T_1 accounted the least oleoresin 309.46 Kg./ha. There was no significant difference between T_4, T_5 and T_3, T_3 and T2 as well as between T_2 and T_1.

As observed from the Table 21, it is also further noticed that, the treatment combination V_2 T_6 recorded the maximum (517.33 Kg./ha) and V_4 T_6 the minimum (260 Kg./ha) of oleoresin when all the individual plots were compared.

FIG·10

EFFECT OF VARIETIES, UREA AND PLANOFIX ON OLEORESIN PRODUCTION

(Varieties : V_1 – V_5 → Urea & Planofix : T_1 – T_6)

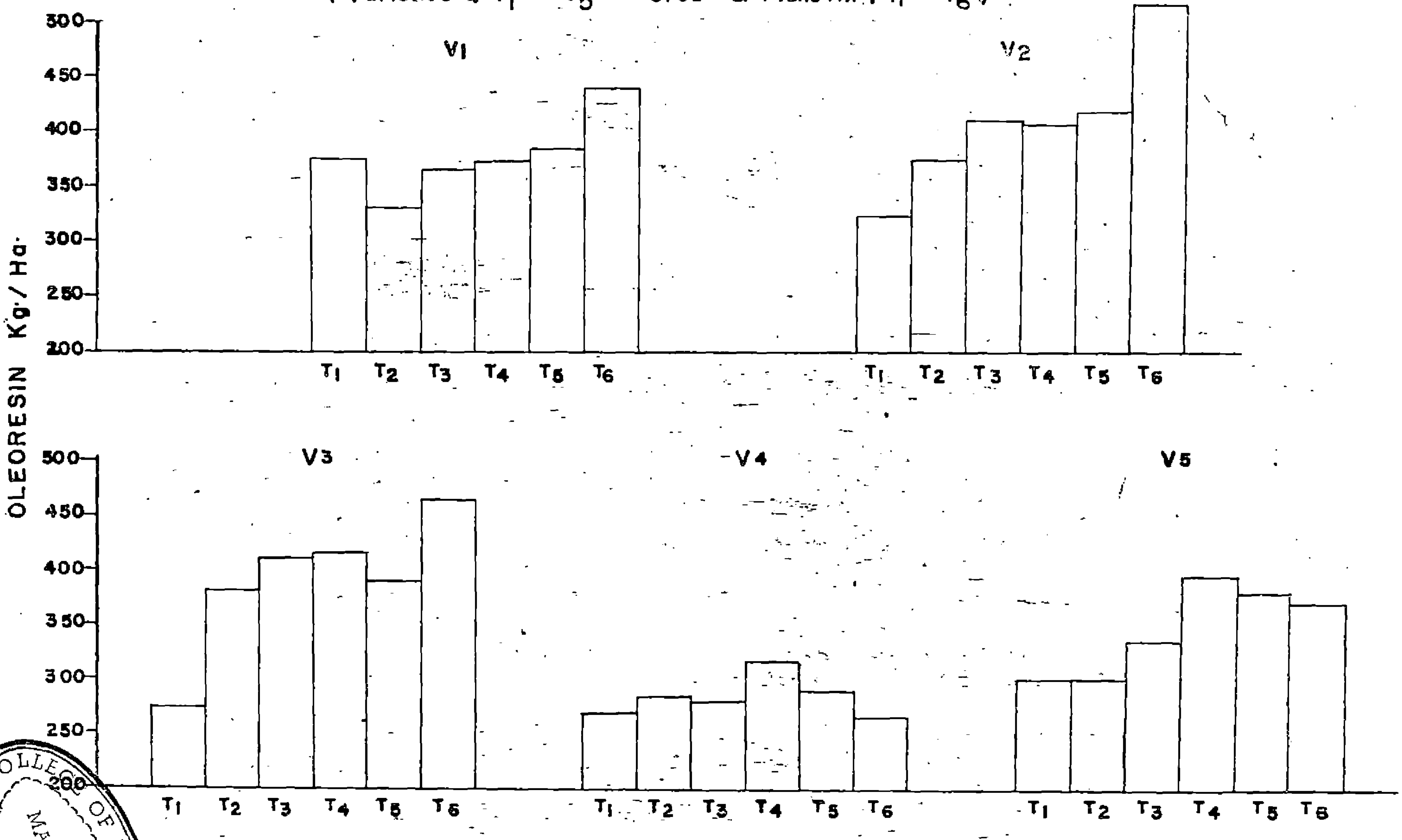


TABLE 21. EFFECT OF UREA AND PLANOFIX ON THE OLEORESIN PRODUCTION WITH RESPECT TO VARIOUS VARIETIES OF GINGER (UNIT - KILOGRAMS PER HECTARE)

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	333.33	373.33	383.33	284.00	300.67	334.93
T_3	Planfofix 200 ppm	365.00	410.33	412.00	280.33	336.33	360.79
T_4	Urea 2% + P 200 ppm	373.67	407.67	416.67	317.00	395.67	382.13
T_5	Planofix 400 ppm	384.33	417.33	390.00	290.33	379.67	372.33
T_6	Urea 2% + P 400 ppm	440.00	517.33	464.00	266.00	371.33	411.73
T_1	Control	376.67	323.67	275.33	268.33	303.33	309.46
Mean		378.83	408.27	390.22	284.33	347.83	

'F' test for main plot treatment, sub-plot treatment and interaction are significant.

	S.E.(m) ±	C.D.at 0.05%
(1) Main plot treatment	24.504	79.89
(2) Sub-plot treatment	9.59	27.03
(3) For sub-plot treatment with same level of M.P.T	21.285	60.43
(4) For main plot treatment with same level of S.P.T	58.136	186.82

(P = Planofix)

within the main plot treatment as indicated in the table, higher oleoresin production was registered for variety V_1 with treatment combination $V_1 T_6$, for variety V_2 it was with $V_2 T_6$ and for V_3 it was with $V_3 T_6$ and for V_4 and V_5 these were with $V_4 T_4$ and $V_5 T_4$ with regards to the corresponding minimum values $V_1 T_2$ in case of V_1, $V_2 T_1$ in case of V_2, $V_3 T_1$ in case of V_3, $V_4 T_6$ in case of V_4 and $V_5 T_2$ in case of V_5 were recorded. When the preference of varieties to the various sub-plot treatments were examined, the treatment combinations T_1 to T_5 there were no significant difference noticed.

Crude fibre content of rhizomes

Crude fibre content of composite samples is represented in Table 22.

Among the varieties, V_3 accounted the maximum crude fibre (4.58%) content closely followed by V_4 (4.45%, V_1 and V_5 (4.33%) and the least crude fibre content was recorded with the variety V_2 (4.29%).

The crude fibre content of the sub-plot treatments showed that T_6 accounted 4.32% which is the least value compared to the other. The maximum fibre content was recorded with T_3 and T_4 (4.44% each) whereas, T_5, T_1 and

TABLE 22. CRUDE FIBRE PERCENTAGE AS AFFECTED BY UREA AND PLANOFIX (COMPOSIT SAMPLES) WITH RESPECT TO DIFFERENT VARIETIES OF GINGER (UNIT - PERCENTAGE)

Treatments		Varieties					
		V_1	V_2	V_3	V_4	V_5	Mean
T_2	Urea 2%	4.90	4.25	4.10	4.60	4.30	4.43
T_3	Planofix 200 ppm	4.10	4.50	4.80	4.30	4.50	4.44
T_4	Urea 2% + P 200 ppm	4.50	4.30	5.00	4.40	4.00	4.44
T_5	Planofix 400 ppm	4.20	4.00	4.90	4.40	4.20	4.34
T_6	Urea 2% + P 400 ppm	4.10	4.30	4.30	4.20	4.70	4.32
T_1	control	4.20	4.40	4.40	4.80	4.30	4.42
Mean		4.33	4.29	4.58	4.45	4.33	

(P = Planofix)

T_2 produced 4.34%, 4.42% and 4.43% of crude fibre respectively.

The average data presented on crude fibre content of the rhizome (table 22) indicated that there was difference among the five varieties studied and the application of chemicals (sub-plot treatment)had some effect on the fibre content. Thus, V_2 T_5, V_5 T_4 had only 4.00% of fibre compared to their respective control V_2 T_1 and V_5 T_1 having 4.29 and

4.33 respectively. However, V_3 T_4 had the maximum fibre content of 5.00% as compared to all the 29 ultimate plots included in the experiment.

Correlation Studies

Yield and growth characters : The correlation coefficient for various growth characters and yield of fresh rhizomes were worked out and presented in Table 23. None of the correlations had significant effect between the characters studied. Yield and height of plant, yield and

TABLE 23. CORRELATION BETWEEN YIELD AND GROWTH CHARACTERS AND OLEORESIN AND CRUDE FIBRE

Characters	Correlation Coefficient
(1) Yield and height of plant	+ 0.182
(2) Yield and tiller number/clump	+ 0.256
(3) Yield and leaf number/clump	+ 0.302
(4) Yield and pseudostem thickness	+ 0.014
(5) Yield and leaf area	- 0.067
(6) Oleoresin and crude fibre %	- 0.019

tiller number, yield and leaf number, yield and thickness of pseudostem were not significant whereas the yield and leaf area showed negative correlation.

Oleoresin and Crude fibre

The correlation Table 23 item (6) showed that these characters showed negative correlation which was not significant.

CHAPTER V

DISCUSSION

DISCUSSION

There are three groups of complex biological factors which control the growth and yield of a plant. These are conveniently designated as Nutritional, Harmonal and Genetic factors of growth. A dynamic balance between these factors is needed to obtain the optimum growth of plants. Research works have proved that by manipulating these factors in conjunction with the environment under which the plants are grown, a regulation of the sequential steps in plant life cycle can be brought about. Thus crop yields are the results of the interaction of biological and physical factors. To increase the yields of crops, it is necessary to optimize the combination of these factors.

The response of a plant to a particular treatment, the adaptability of the varieties, the pattern on crop growth etc. are important. The response of the whole plant to a particular treatment is the resultant effects on its component parts. In ginger crop, the main components are height of plants, number of tillers, leaf number and rhizome characters. In this present investigation an attempt has been made to study the interrelationship between different organs of the plant and their relative contribution to yield and quality under the influence of various treatments. The finding of the above investigation has been presented in the preceding chapter. In this chapter a critical analysis of the findings has being made to establish a cause and effect relationship between the treatments and their performance.

Pre Harvest Studies

(i) Study on germination of ginger : The present investigation revealed (Table 4) that variety Maran (V_2) is significantly superior to all other varieties with respect to germination except Thinladium (V_4). However, variety V_4 is superior to the other varieties like Rio-de-Janeiro (V_3), V_1 (China and Sierra Leone (V_5). But there is no significant difference between V_1 and V_5. The superiority of Maran on germination has been reported (Anon 1972) from Central Plantation Crop Research Institute.

Thus differential performance of varieties may be due to the hereditary as well as the physiological characters of the varieties. The condition of the seed materials may also influence germination. When size of the gingers are different, the number of effective buds available within the size of the seed rhizome may be varying, this may also cause the differential germination rate. Further in big fingored varieties like China (V_1), when pieces are made for planting the cut surface which will come in contect with the soil is likely to be damaged by high temperature or other adverse soil conditions including incidence of disease and pest, may effect the germination of that particular variety than small or medium fingered ones. Evenson et al.(1970) have reported that temperature at/or above 35°C may adverseely affect the germination.

(ii) Height of the Plant : The studies on the linear growth of ginger pseudostem as affected by various treatments revealed significant effect (Table 5 a, b, c and Fig No. 2 a and b). It is further observed that varieties V_4 and V_2 had significantly more linear growth than varieties V_5 and V_3 but V_1 behaved similiar to V_4 and V_2. All sub-plot treatments except T_2 (Urea 2%) were significantly superior to the control (T_1) . Further there was no significant difference between the varieties as well as between the sub-plots before the application of the sub-plot treatments were made and the maximum height of the plants increased between 30 and 60 days after planting.

Significant difference in height of various varieties is in confirmity with the findings of Pillai (1973) who reported the existence of significant difference between the varieties of gingerl. The height was also influenced by Planofix and combinations of Planofix with Urea (T_4 and T_6), but the effect of Urea (T_2) was not significant over the control. The effect of NAA in smaller concentrations have been reported by Singh and Upadhyay (1967) on Okra and Das and Padhi (1974) reported increase in height with Potato Plants by the application of Urea 2% and Planofix 250 ppm as well as their combinations.

From the above it is obvious that the varietal difference in height might be due to thevarietal of the characters of the individual varieties. The effect of Planofix alone and in combinations with Urea is likely to stimulate the harmonal mechanism of the plant. Thus helping to stimulate the linear growth of the ginger pseudostems. The effect of Urea is not prounced in the present study, this may be due to the fact that the easily available nitrogen was utilised for the rhizome development rather than for linear growth, since the spraying of Urea was done at the 125th day after planting which is normally the active rhizome development period rather than the active growth of the pseudostems. Further, the stem length is a complex character influenced by various factors in the order—rate of leaf emergence > maximum temperature > Tissue moisture > minimum temperature > Total sugars > green weigth of sheaths > age > soil moisture > leaf nitrogen > light. And dominent factors are rate of leaf emergence, maximum temperature and minimum temperature according to clements (1964) as reported by him on cereal crops. So the interaction of these various factors with the variety and chemicals sprayed may be the reason for differential linear growth of the ginger plant.

(iii) Thickness of main Pseudostem: From the very early stage of growth as observed from the Table No. 6 (a,b,c) and Figure No. 4(a,b) thevarieties indicated significant difference among themselves but the varieties, sub-plots and their interaction had significant differences in the final stage (180th day) eventhough the varieties had such effects soon after planting. As evident from the data it is observed that V_2 and V_4 are definitely superior to all other varieties. Further the sub-plot treatments, as evident from the final observation showed that these two varieties had better growth (Thickness of pseudostem) when Urea and Planofix were applied rather than single applications of Urea, which did not show any significant increase in thickning the plant pseudostem, possibly due to the application of Urea when the plants have reached the rhizome development stage. But Planofix alone has significantly increased the thickness of pseudostem over the control. Further the interaction between the varieties with the chemicals also indicated that variety V_2 was better than V_4 eventhough these two varieties were superior to the other three varieties (V_1, V_3 and V_5).

The existance of varietal difference in growth character was pointed by Pillai (1972). Response of Urea 2% and its combination with Planofix was observed by Das and Padhi (1974) in their study on Potato.

From the study it is obvious that the varieties showed preferential response to the treatments. The varieties which showed better performance in their early stages, responded well to the treatments also. The response of Urea in this regard was also not pronounced which may be dut to similar reasons indicated under the linear growth of the pseudostem Further the stem grith is influenced by various factors such as Tissue moisture > age > light > leaf nitrogen > soil moisture > maximum temperature > rate of leaf emergence > total sugars > minimum temperature (Clements 1964). And moisture, age, light, and level of nitrogen etc. are dominent. The interaction of these factors with the varieties and treatments might have produced the difference in stem thickness.

(iv) Number of tillers per clump : The observations revealed that (Table No. 7 a, b, c , Fig No. 3 a, b) the number of tiller production per plant significantly differed among the varieties. Variety V_3 (Rio-de-Janeiro) produced the maximum number of tillers followed by V_5 (Sierra Leone). V_2 (Maran) produced medium tiller numbers but V_1 (China) produced the least number. The effect of the chemicals on the tiller number per plant were however, not significant, but an apparent increase in tiller production was noticed with the treatments having the planofix alone followed by Urea 2% and Planofix Urea combinations.

Increase in branch number per hill in the case of Potato Plant treated by Urea 2% and its combination with Planofix 250 ppm was reported by Das and Padhi (1974). The increase in tiller production has also been reported in other crops like rice by the application Urea sprays (Rao, 1961). Further the effect of soil applied nitrogen have been reported by various workers, Randhawa and Nandpuri (1969), Pillai (1973), Muralidharan et al. (1973)and (1974), Dasaradhi et al. (1971) also stressed the importance of nitrogen from the planting upto 200 - 210 days of growth of ginger because during this period the nitrogen consumption is more.

From the above it is clear that nitrogen or Urea helps to increase the tillor number of the plants. Planofix also helped to increase the tiller production. It is presumed that the Urea and Planofix alone might have stimulated the underground parts to putforth more vegetative shoots, than the combinations of these chemicals. It is interesting to note that, the varieties which have more tiller numbers in the early stages of growth continued to produce more tillers in their successive stages of growth and development.

The Urea and Planofix and their combination did not significantly effect the production of more tillers compared to the control possibly due to late application(25th day) of such chemicals.

(v) Number of leaf production: The observations (Table No. 8 a,b,c and Fig No. 5 a,b) on the various stages of leaf production revealed the fact that, almost the same pattern of growth as that of tiller production was also followed. The variety V_3 (Rio-de-Janeiro) produced the maximum number of leaves closely followed by V_5. They were significantly superior over others varieties and V_1 (China) produced the minimum number of leaves. The sub-plot treatments failed to produce any significant increase in the leaf production. But there was an apparent difference in leaf production. The Planofix 400 ppm (T_5), Planofix

200 ppm (T_3) and Urea 2% (T_2) had increased leaf production, followed by the combinations of these two chemicals.

These findings are in agreement with the findings of Das and Sahoo (1973) and Das and Padhi (1974) who reported such effects in the case of Potato. Pillai(1973) working with ginger stressed the importance of nitrogen for better leaf production.

(vi) Leaf area : The studies on the leaf area (Table 9) indicated that all the varieties did not differ among themselves significantly. But it is observed that the leaf area in the final stages of growth and development were influenced by Urea as well as Urea and Planofix combinations. However, Planofix alone have no pronounced results on the leaf area over that of the control. The varieties as well as interactions failed to produce any significant difference in leaf area in the final stages of development.

The effect of Urea on the leaf area increase have been reported by Das and Sahoo (1973) and the effect of Urea and Planofix by Das and Padhi (1974) with Potato. But in this observation Planofix alone had no significant effect on leaf area even in the final stage of growth of ginger plant. It is noticed that the varieties growing under similar environment behaved similarly on leave area in the case of ginger. The application of Urea + Planofix and even Urea alone significantly increased the leaf area compared to the control, which may possibly be due to the availability of easily available nitrogen and stimulation caused by the growth substance Planofix.

(vii) <u>Incidence of Pests and Diseases</u> : (1) Incidence of Rhizome rot : Varieties V_5 (Sierra Leone) and V_1 (China) were the maximum affected varieties in the early stages of rhizome development while, variety Maran (V_2) had the least incidence. Further it is also observed that when the plants of varieties Maran (V_2) and Sierra Leone (V_5) crossed the early growth cycle and as they reached the final growth stage all the plants were (Rhizome ro attack) free of the disease. As evident from the Table No. 19(a, b, c), China (V_1) was the maximum affected variety during the final stage of growth. Thinladium (V_4) and Rio-de-Janeiro however, were bettern than China though not significantly. There were no significant effect existed among the chemicals (sub-plot treatments) or with their interactions.

The above findings on rhizome rot infection are in agreement with the findings of Nair (1969) who has reported about the tolerance of the variety Maran and susceptibility of Rio-de-Janeiro. Earlier reports on varieties China and Rio-de-Janeiro (Anon - 1965) with respect to rhizome rot are also in agreement with the present work.

It is quite likely that varities China and Sierra Leone might have carried the disease organisms through the seed materials and even could thrive after the seed treatment was done, thus causing the rhizome rot in the early stages. Another possibility is that as the rhizome size of these varieties are comparatively bigger, the cut surface of the planting material is more exposed in the soil for the disease organisms enter and thereby the more severe attack might have been caused. Further the pronounced failure of germination might have helped ultimately for the severe attack of rhizome rot in these varieties, because the rotting of ungerminated pieces might have helped the colonization of the disease organisms, which in turn started attacking the plants adjoining to it. The rainfall prevailed in this season must have aggrevated the situation further. The treatment with the chesnut compound prevented further spread and saved the plants from complete destruction. The variety Maran may be a tolerant to the attack of the rhizome rot caused by pythiumspecies.

The attack of the disease in the later stages also revealed that Maran is tolerant and variety Sierra Leone also might have some resistance to such an attack due to which these two varieties were free from rhizome rot in the later stages, whereas, the other three varieties showed lesser resistance.

(2) Scale insect attack : Maximum scale insect incidence was observed (Table 11, Fig 9) with V_4 (Thinladium) followed by V_5 (Sierra Leone), V_1 (China) and V_3 (Rio-de-Janeiro). The least attack was noticed with the variety V_2 (Maran). Though the various sub-plot treatments and their interactions showed varying extents of damage, they were not significantly so.

The differential performance in the attack of scale insect by the various varieties may be due to various reasons. The first possibility is that the insect pests might have been transmitted through the seed materials. As there was no notable symptoms at the time of planting, the seed materials are not disinfected against the scale insects. Thus what ever scale insect colonies were present hidden with these seed material might have been the source of further attack on the plant having varying resistance with different varieties.

It is interesting to note that almost the same trend was maintained in the case of scale insect indidence as like the rhizome rot.

(viii) Compatibility of Urea and Planofix on Ginger: No scarching or any other burning symptoms due to the spray of Urea, Planofix and its combination were noticed during the course of the present investigation. Tho may be due to the fact that Urea and Planofix combinations are compatible and they are not phytotoxic to the ginger plant at the concentrations.

Post Harvest Studies.

(1) Yield of Rhizome: There was no significant difference between the five varieties studied with respect to yield, though there was considerable variation between the yield performance of the five varieties tested (Table 12 a,b and c). However, Rio-de-Janeiro yielded the maximum rhizome, followed by China. The variety Maran ranks third, Sierra Leone fourth and Thinladium the fifth with respect to yield. Among the sub-plot treatments T_6 (Urea 2% + Planofix 400 ppm) recorded significantly superior yield. Further all the treatments were significantly superior to control(T_1). T_4(Urea 2% + Planofix 200 ppm) also recorded better yields next to T_6 though not significantly. However, T_4 was nearer to T_5 (Planofix 400 ppm). There was no significant difference between T_5 (Planofix 400 ppm), T_2 (Urea 2%) and T_3 (Planofix 200 ppm) and the interaction between variety and chemical was not significant. It is further noted that the treatment

combination V_3 T_6 produced the maximum yield and V_5 T_1 produced the minimum as observed from this level.

The high yielding capacity of Rio-de-Janeiro and China were reported by some workers (Khan 1959, Kannan and Nair 1965; Thomas 1966; Thomas and Kannan 1969; Muralidharan 1972; Pillai 1973). The studies made at the Agricultural Research Station, Ambalavayal, Kerala; Assam as well as Himachal Pradesh also reaffirmed the superiority of those two varieties over others and existance of variation between the various varieties of ginger. But works done at the Punjab Agricultural University from 1953-64 to 1966-67 did not confirm the results in this regard. Nair (1969) reported that variety Maran was superior like that of Rio-de-Janeiro. Thomas and Kannan (1969) recorded the yield of variety Sierra Leone as 14,565 lbs per acre while Muralidharan (1972) recorded the yield of Maran as 15,392 Kg., Thinladium 11,869 Kg. and for Sierra Leone 9,776 Kg. of green ginger per hectare.

Thus it is observed that all the five varieties studied under Bhubaneswar Agro-climatic conditions had varying yields, which was non significant, yet the differences are visible. This may be explained by the fact that errectness of leaves, height of plant, thickness of pseudostem, leaf angle etc. might be the accelerating factors which may influence the yield of ginger variety. Thus in the case of variety V_2 (Maran) the yield contributing factors might be the height of the plants, optimum number of leaves, optimum tillers per plant and leaf area. The improvement in thickness of the stem also might have contributed in improving the yield. Similarly in the case of variety V_3 (Rio-de-Janeiro), the optimum height, more number of tillers with more leaves might be the yield contributing factors. The yield contributing characters of variety V_4 (Thinladium) may be the height, number of tillers and lesser leaf numbers with higher leaf where, in variety V_5 (Sierra Leone), the optimum height conditions with more number of leaves, tillers and bigger leaf area might be the yield contributing characters.

Yoshida (1972) in his review on the physiological aspects of grain yield, has correlated yield with some of the morphological characters of some of the grain crops, which principles may be true in the case of ginger crop which is a monocotyledon plant. He expressed the view that an optimum plant height having short, and small leaves which are more evenly distributed than long and large leaves in a canopy are better yielder than otherwise. Tanner et al. (1966) expressed the importance of leaf angle and leaf width for selection of high yielding types. Tanaka et al. (1966) opined the benefit of open tillering type. Medium tillering has been recommended for rice varieties by Beachell et al. (1964). That faster growth, excessively large leaf area beyond the optimum, which in turn are closely related to high tillering capacity may lead to low yield were expressed by Takeda et. al (1959), Tanaka et al. (1964), Tsunoda (1964). Friend (1966) further expressed that the varietal differences in the leaf photosynthetic rate may be caused by the variety/environment interaction since the temperature and light regimes affects the morphological characters of leaf and since varieties differ in their response to changes in the environment. Watson (1947 and 1951) expressed the view that the area of the surface that intercepts solar radiation is the most important factor than the photosynthetic efficiency of leaf per unit. Thus the various factors discussed above might have influenced the yield due to the differences in their morphological characters of the various ginger varieties.

The present investigation also revealed that the Urea and Planofix combination gave significant yield closely followed by Planofix alone or Urea alone though all the treatments were significantly superior to the control (T_1).

The importance of Nitrogen in improving the growth and finally yield has been reported by various workers. Randhawa and Nandpuri (1966) expressed that N 100 Kg. also have improved the growth and yield of ginger. Muralidharan et al. (1974) opined that 70 Kg. N per hectare increased the number of tillers and yield of rhizomes significantly with some varieties. However, from their further studies on the application even of 50 Kg./ha of nitrogen particularly to the variety Rio-de-Janeiro started decreasing the yield. Dasaradhi (1971) stressed the importance of the application of easily available nitrogen upto 200 to 210 days after planting. The beneficial effect of Urea as soil application has been recommended by Rajan and Singh(1972) for improvement in growth and yield of rhizome. The effect of Urea sprays for improvement of yield in potato have been reported by Mehrotra et al. (1969). Das and Sahoo(1973). The improvement of yield by applying Urea 2% spray has been reported by Shanmugam and Thamburaj (1974) in the case of sweet potato and Tapioca. The improvement in yield of potato by Urea 2% and its combinations with Planofix had been reported by Das and Padhi (1974). Freeland(1949) reported that NAA 100 ppm stimulated photosynthesis by 10 percent.

From the above it is evident that Urea and Planofix and their combinations were capable of improving the yeild of ginger. It is further observed that these chemicals which have stimulated the vegetative growth of the varieties concerned are responsible for manufacturing more elaborate food, by efficient photosynthetic activity. The excess food thus manufactured, after meeting the requirements for plant growth and maintainance was made available for the development of rhizome and stored in them, thus in turn elevating the yield. Urea alone or in combination might have delayed the senescence of the leaves giving rise to more number of effective leaves per plant thus increased the photosynthetic activity of the plants and increased the manufacture of corbohydrate materials and finally resulting in an increased yield of rhizome. The Planofix alongwith Urea might have helped in this way since it containt NAA as the active incredient.

Quality Studies

Volume of fresh ginger: No significant difference existed between varieties, sub-plot treatments or their interaction (Table 13). But among the varieties V_1 has the maximum volume followed by V_3, V_2, V_5 and V_4. Among the sub-plot treatments T_6 (Urea 2% and Planofix 400 ppm) recorded the maximum volume and T_1 (Control) the least volume.

Thus it is observed that China (V_1) has the bigger sized rhizome and when treated with Urea 2% + Planofix 400 ppm (T_6) the volume was still improved.

Specific gravity of Rhizome: In this case also no significant difference was noted among the varieties, sub-plot treatment and their interactions (Table 14). However, the maximum specific gravity was recorded by V_4 followed by V_5, V_2, V_3 and V_1 in the order of merit. Among the chemical treatments, control (T_1) recorded the maximum specific gravity and T_6 (Urea 2% + Planofix 400 ppm) had the minimum.

Thus it is seen that varieties which produced rhizomes having more volume showed the minimum specific gravity. It is also observed that Planofix 200 ppm, Urea 2% and Urea 2% + Planofix 200 ppm showed an apparent increase of specific gravity over Planofix 400 ppm and Urea 2% + Planofix 400 ppm.

The effect of Urea 2% and Planofix 200 ppm and their combination produced an apparent increase in specific gravity in the case of potato has been reported by Das and Padhi (1974).

Recovery of Dry Ginger

A close examination of recovery of dry ginger from green ginger (Table 15) showed that these varieties and sub-plot treatments were highly significant. Sierra Leone (V_5) variety recorded the maximum recovery, followed by Maran (V_2), Thinladium (V_4), China (V_1) and Rio-de-Janeiro (V_3), respectively. Among the sub-plot treatments, control had the maximum recovery of dry ginger followed by Urea 2% + Planofix 200 ppm (T_4), Urea 2%(T_2). Planofix 200 ppm (T_3) recorded more recovery than Planofix 400 ppm (T_5) and Urea 2% + Planofix 400 ppm (T_6). However, the variety and treatment combination V_5 T_1 recorded the maximum recovery whereas, V_3 T_5 had the minimum value.

The percentage recovery of Rio-de-Janeiro was in agreement with the findings of Kannan and Nair(1965), but in the case of China they reported lower value (13.15%).

However, Thomas(1966)has reported 16.25% of recovery with the variety Rio-de-Janeiro.

Aiyadurai (1966) in his review on the Research Scheme on ginger taken up at Wynad showed higher dry ginger recovery for Sierra Leone and low value for China and Rio-de-Janeiro. Nair(1969) recommended the variety Maran for its higher dry ginger production. While Muralidharan (1972) reported the lowest percentage of recovery in the case of Rio-de-Janeiro but he found no significant increase in the case of Maran and Nadia, Tingpuri varieties. He has further reported the percentage of recovery for Rio-de-Janeiro as 14.99%,Maran as 19.83%, Thinladium as 21.03% and Sierra Leone as 19.23%.

Thus from the above it is understood that in the present study also the varieties have produced better value in case of percentage of recovery of dry ginger.

Das and Sahoo(1973) failed to get any significant difference in the case of 1000 ppm Planofix on the moisture content of Potato tubers while Das and Padhi (1974)reported that Urea 2% and combination of Urea 2% and Planofix 250ppm increased the moisture content of Potato tubers i.e. decreased the percentage of dry matter content which is also true in the case of ginger.

From the variety with sub-plot treatment interaction it is clearly noticed that the varieties with control gave comparately more recovery of dry ginger, than with chemical treatments.

Dry Ginger Production per Hectare

From Table 16 it was noted that the variety Maran (V_3) had the maximum dry ginger per hectare followed by V_5, V_1, V_4 and V_3 however, they did not significantly differed among themselves. Among the sub-plot treatments T_4 (Urea 2% + Planofix 200 ppm) produced the maximum dry ginger per hectare and T_1 (control) the minimum. The ultimate plot levels V_2 T_4 gave the maximum dry ginger whereas, V_3 T_1 the minimum while V_2 T_2, V_2 T_3, V_2 T_5, V_2 T_6, V_3 T_3, V_3 T_4, V_3 T_5, V_3 T_6, V_4T_2 and V_5T_6 were significantly superior to V_3 T_1.

The variation between the various varieties, sub-plot treatments is attributed to the percentage recovery of dry ginger with the total yield of fresh ginger.

Storage Studies

Weight loss during storage : The studies on the weight loss of ginger rhizomes were studied (Table 17) and there were significant effect. Thus weight loss was maximum with the variety V_3 (Rio-de-Janeiro) and the minimum was with V_2 (Maran) and was near to V_2 was with V_1 (China). However, V_3 (Rio-de-Janeiro), V_4 Thinladium and V_5 (Sierra Leone) did not show any significant difference. Among the sub-plot treatments i.e. between the chemicals no significant difference was noticed.

However, T_2 (Urea 2%) recorded the maximum weight loss and T_6 (Urea 2% + Planofix 400 ppm) the minimum. The interaction of varieties and sub-plot treatments were significant and there by it indicated the differential response of the varieties to the chemical treatments. Thus among all the variety with chemical combinations V_3 T_3 recorded the maximum weight loss and V_2 T_5 the minimum. However, V_4 T_3 combination had significantly lower value as compared to V_4 T_1.

It is concluded that those varieties which had the minimum percentage recovery of dry ginger invariably produced maximum weight loss i.e. more moisture content might have lost during storage. Almost a same trend of effect is noticed by the specific gravity. Further Urea and Planofix alone resulted more pronounced results of weight loss. The interaction between the varieties with the above characters might have influenced in the weight loss difference in the varieties.

Volume loss during storage: The studies on volume loss of ginger rhizome during the storage revealed that there were significant difference among the five varieties and between the variety and the chemicals interaction (Table 18). Thus V_3 (Rio-de-Janeiro) recorded maximum volume loss followed by V_1 (China). The minimum volume loss however, was recorded with the variety Maran. Among the sub-plot treatments Urea 2% (T_2) recorded the maximum volume loss and T_4 (Urea 2% + Planofix 200 ppm) recorded the minimum. Considerable variation is noticed in the case of variety and chemical interaction. It is interesting to note that variety Thinladium with Planofix 200 ppm (V_4 T_3) had significantly lower value than the control showing thereby that the shrinkage in the volume of the tuber was the least compared with the control. It is also further observed that in this particular combination(V_4 T_3) the weight loss, damage (Rot and driage) and insect attack were also low as compared to others.

It is interesting tonote that there may be an existence of a close relationship between volume loss with the weight loss, thereby it is attributed that the factors which caused the weight loss might also have helped to the volume loss. Thus the moisture percent, specific variety, incidence of diseases and pests etc. hold good here also.

<u>Damage during storage</u> : In this regard the varieties have shown significant differences and the interaction between variety and the chemical are also significant(Table 19).V_4 (Thinladium) recorded the maximum damage closely followed by V_5 (Sierra Leone). Hoever, the minimum damage was recorded by V_2 (Maran). In the case of sub-plot treatments the T_2 (Urea 2%) recorded the maximum loss and T_6 (Urea 2% + Planofix 400 ppm) have the least damage though not significantly. Considerable variation within the interaction is noted. Thus V_1 T_4 had the minimum damage than the control. Thus it may be due to the production of helthier and sound rhizomes due

to the treatment of Urea and Planofix as a result the rhizomes could resist the attack of the rot disease and scale insects.

Chemical Analysis

<u>Recovery of Oleoresin</u> : A high degree of difference was noticed (Table 20) among the varieties, sub-plot treatments and their interaction. With regards to the Oleoresin content of the rhizome V_3 (Rio-de-Janeiro) accounted the maximum oleoresin percentage followed by V_1 (China) V_2 (Maran) V_5 (Sierra Leone), V_4 (Thinladium) respectively. With regards to the chemical treatment (sub-plot) T_6 (Urea 2% + Planofix 400 ppm) recorded the maximum oleoresin followed by T_5, T_4, T_3 which were significantly superior to T_1 (Control) which had the minimum value, T_2 though gave apparently higher value was not significantly so. A high degree of variation existed in the behaviour of ultimate plots (Interaction between variety with chemical). However, the combinations of Urea 2% with Planofix have shown superiority over others. T_6 having combination with V_1, V_2 and V_3 produced significantly higher oleoresin content. Further, V_4 T_4 and V_5 T_4 also produced significantly higher values as compared to the control. Natarajan et al. (1972) having their study on Chemical composition of ginger varieties recorded the acetone extract (Oleoresin) as 7.2% with the variety Rio-de-Janeiro, Maran 6.7%, Thinladium 5.9% and China 5.8%. Lewis et al (1972)

have observed that the alchohol extract (oleoresin) for varieties Rio-de-Janeiro was 8.34%, Maran 4.77%, China 4.74% Thinladium 3.3% and Sierra Leone 5.47%. However, for Rio-de-Janeiro they recorded acetone extract as 10.3%. Mathai and Prakash (1972) reported the maximum yield of oleoresin in the variety Rio-de-Janeiro. They failed to get any significant difference between Maran and Sierra Leone in this regard Mathai(1973)found higher percent of oleoresin (8.6%) for Thinladium, Sierra Leone(6.8%), Rio-de-Janeiro (6.6%) and Maran(5%). Again Muralidharan(1974a)recommended Rio-de-Janeiro for oleoresin content.

From the above it is clear that a high degree of variation were noticed by various workers in the oleoresin recovery. Variation in this character is also noticed due to the various solvents used for extraction. In the present investigation a higher percentage of oleoresin from Rio-de-Janeiro, Maran, China and Sierra Leone were recovered respectively. The higher percent in the case of Rio-de-Janeiro may be its varietal character .

Among the sub-plot treatments Urea and Planofix combinations as well as Planofix along produced better percentage of oleoresin. The chemicals might have stimulated the production of oleoresin by entering into the oleoresin biosynthesis mechanism of the plant. But T_2 (Urea 2%) alone failed to produce any significant results. This is almost in agreement with the findings of Saraswat (1974) who found adverse effect of nitrogen application on the oil content of ginger. It can be attributed that N(Urea) might have improved the other constituents such as starch, protein etc. thereby the reduction in the oleoresin content was caused, whereas, Planofix might have stimulated the production of oleoresin. This stimulation may show differential response in different varieties and further it can be presumed that the attack of scale insects and the rhizome rot might have adversely affected the oleoresin content in the case of Thinladium (V_4).

<u>Oleoresin Production on Hectare basis</u>: Variety V_2 (Maran) recorded the maximum oleoresin production and V_4 (Thinladium) the minimum. In the case of sub-plot treatments the oleoresin production was maximum for treatment T_6 (Urea 2% + Planofix 400 ppm). T_1 invariably had lower oleoresin content on hectare basis also. Variation existed also in the oleoresin production with the ultimate plot levels.

These observations (Table No. 21) showed that the oleoresin production on hectare basis was more than that reported by Muralidharan (1974), who recorded oleoresin production of the variety Rio-de-Janeiro as 205.8 Kg./ha. Maran 194.3 Kg./ha, China 173.2 Kg./ha, Sierra Leone 172.2Kg./ha and Thinladium 134.0 Kg./ha. In this present study the varieties except Rio-de-Janeiro produced more than double oleoresin. However, variety Maran was the best to produce more oleoresin followed by Rio-de-Janeiro and the application of Urea 2% + Planofix have further influenced the oleoresin production also.

Crude fibre content of Rhizome: The variety V_3 (Rio-de-Janeiro) accounted the maximum crude fibre content while V_2 (Maran) was having the least value and other varieties remained in between the two. T_6 (Urea 2% + Planofix 400 ppm) accounted the minimum, while T_3 and T_4 had the maximum crude fibre content.

The data showed that (Table 22) there was difference among the varieties and the application of chemicals have also had some effect on the fibre content.

The difference on crude fibre content between varieties have been reported by various workers. Thus Kannan and Nair (1965) reported the fibre content of Rio-de-Janeiro as 5.19% and China as 3.43%. Thomas (1966) recorded the same quantity of fibre content for these varieties, whereas, Natarajan et al. (1972) recorded higher percentage of crude fibre content with China (8.00%), Rio-de-Janeiro (7.14%), Thinladium (9.60%) and Maran (6.16%) and found that crude fibre content increases with maturity. Lewis et al. (1972) reported a still higher crude fibre content of 9.1% with Rio-de-Janeiro.

Increased crude fibre content in the advanced maturity stage was recorded by Jogi et al (1972) while Mathai and Prakash (1972) reported that varieties pøroducing higher yield possessed the maximum fibre content. Muralidharan (1974) reported the crude fibre content of the various varieties like, Rio-de-Janeiro 6.77%, China 6.52%, Sierra Leone 5.16%, Thinladium 6.73 and Maran 5.67%.

The application of Planofix at 400 ppm or Planofix 200 ppm + Urea 2% seemed to have reduced the fibre content of the rhizome in general.

Correlation Studies

Yield and growth characters: Correlation coefficient worked on yield and various growth characters showed no significant relationship. And the yield and leaf area in the final stage of growth showed a negative correlation(Table 23).

Pillai (1973) reported that plant height and leaf number were associated with yield. Assoication of quantitative characters on yiled has been reported in elephant yarn as stated by Shanmugam and Thamburaj(1974). They found the correlation of number of leaves and grith of tubers with the total yield of yarm.

The non-significant association of growth charactors might be due to the following. For each variety there might be the optimum height, tiller number, thickness of pseudostem leaf number and leaf area for the optimum or maximum yield.

The variation in these characters may lead to the variation in the yield also. About the tillering, the type of tillering about leaf characters, position (leaf angle), length of leaf etc. are more important factors which affect the photosynthetic efficiency and there by more influence on the final yield. In the present study as the chemicals are applied at a later stage of development their effect is more prnounced on the yield than on growth. That might also lead to show the non-significant association of yield and growth characters.

Oleoresin and Crude fibre: The correlation studies between these characters revealed that they are negatively correlated.

This is in agreement with the opinion of Muralidharan (1972), who felt that these characters cannot be considered as correlated because varieties which produced high percentage of oleoresin also have high as well as low percentages of crude fibre. Whereas, Mathai and Prakash (1972) have observed that the correlation of these characters are ture.

CHAPTER V

SUMMARY & CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "Studies on the effect of foliar application of Urea and Planofix on the growth, yield and quality of ginger varieties (*Zingiber officinale* Roscoe)" was undertaken at the Horticultural Research Station, Department of Horticulture, Orissa University of Agriculture and Technology, Bhubaneswar, Orissa, during 1974-75.

The experiment was laid out in split plot design. The five ginger varieties viz., China (V_1), Maran (V_2), Rio-de-Janeiro (V_3), Thinladium (V_4) and Sierra Leone (V_5) were alloted to the main plots. The chemical treatments T_1 (Control - waterspray), T_2 (Urea 2%), T_3 (Planofix 200 ppm), T_4 (Urea 2% + Planofix 200 ppm), T_5 (Planofix 400 ppm) and T_6 (Urea 2% + Planofix 400 ppm) were alloted to the sub-plots. The sub-plot treatments were applied once as foliar spray, on ginger varieties on the 125th day after planting.

The main object of this experiment was to assess and compare the effect of single as well as mixed application of Urea and Planofix on the growth, yield and quality of the various ginger varieties included in this experiment. The salient findings of the experiment are summarised and presented below.

(1) Germination : The ginger varieties Maran (V_2)

and Thinladium (V_4) recorded significantly higher % of germination over Rio-de-Janeiro (V_3), China (V_1) and Sierra Leone (V_5).

(2) Height of the Plant : In the early stages of growth (upto 120th day) there was no significant difference between the varieties on linear growth, whereas application of the chemicals especially Urea 2% + Planofix 400 ppm (T_6), Planofix 200 ppm (T_3), Planofix 400 ppm (T_5) and Urea 2% + Planofix 200 ppm (T_4) influenced the linear growth than Urea 2% (T_2) alone. Thinaladium (V_4) and Maran (V_2) were significantly more linear than over varieties at the final stages of growth.

(3) Thickness of the main Pseudostem : The varieties expressed their difference from the very early stage of growth. At 180th day of planting the effects were much more pronounced due to the application of the chemicals (sub-plot treatments). Maran (V_2) was significantly superior to all other varieties at the 180th day after planting. All treatments except Urea 2% (T_2) alone recorded significant values. The treatment combinations Urea 2% with Planofix showed more influence than the single applications.

(4) Number of tillers per clump : No significant difference was noticed at the initial stage of development between varieties. But at successive stages of groth , pronounced differences were obtained between the varieties.

The sub-plot treatments did not produce significant differences in tiller production. Among the varieties Rio-de-Janeiro (V_3) and Sierra Leone (V_5) were significantly superior in tiller production.

(5) Number of leaves per clump : The leaf production in varieties Rio-de-Janeiro (V_3) and Sierra Leone (V_5) were significantly superior to all other varieties. The sub-plot treatments failed to produce any significant results in leaf production.

(6) Leaf area : There was no significant difference in leaf area between the five varieties of ginger in the final stage of growth. The treatments with Urea 2% (T_2), Urea 2% + Planofix 200 ppm (T_4) and Urea 2% + Planofix 400 ppm (T_6) however produced significantly more leaf area than control.

(7) Incidence of rhizome rot attack: Variety Maran (V_2) was significantly superior with regards to the tolerance to rhizome rot. China (V_1) was the most effected one than the other varieties. The sub-plot treatments did not produced any significant results.

(8) Incidence of Scale insect attack : Maran (V_2) is the least affected variety while, Thinladium (V_4) is the maximum affected one. The sub-plot treatments did not show any significant difference in this regard.

(9) Yield of rhizome : Though the varieties did not show any significant difference in yield, the variety Rio-de-Janeiro (V_3) recorded the maximum yield followed by China (V_1), Maran (V_2), Sierra Leone (V_5) and Thinladium (V_4). Thus Thinladium (V_4) was the poorest among the varieties. The sub-plot treatments produced significantly better yields than control. But the combinations of Urea and Planofix especially Urea 2% + Planofix 400 ppm (T_6) were better than the single application of the above chemicals.

(10) Volume of fresh ginger : There was no significant influence of varieties and sub-plot treatments on this character. However, the variety China (V_1) had the maximum volume and Thinladium (V_4) the minimum.

(11) Specific gravity : The varieties and sub-plot treatments did not show any significant difference on this character also. However, the control recorded the maximum specific gravity and Urea 2% + Planofix 400 ppm (T_6) recorded the minimum specific gravity.

(12) Recovery of dry ginger : Varieties Sierra Leone (V_5) and Maran (V_2) recorded significantly higher percent of recov-ery of dry ginger than the other varieties and Rio-de-Janeiro (V_3) had the least value. Control recorded the maximum percentage of recovery of dry ginger over all other sub-plot treatments, and the treatment combination with

Urea 2% + Planofix 400 ppm (T_6) recorded the minimum value.

(13) Dry ginger production per hectare : Though the varieties Maran (V_2) recorded the maximum dry ginger and Rio-de-Janeiro (V_3) the minimum dry ginger per hectare, there was no significant difference between the varieties in this regard. Among the sub-plot treatments control recorded the minimum production of dry ginger and Urea 2% (T_2) and its combinations produced maximum dry ginger on hectare basis. Except Planofix 400 ppm (T_5) all other treatments were significantly better than the control in this regard.

(14) Weight loss during storage : The variety Rio-de-Janeiro (V_3) recorded the maximum and Maran (V_2) the minimum weight loss during storage. It is further observed that the Maran (V_2) was significantly superior in storage to Rio-de-Janeiro (V_3) and Sierra Leone (V_5) by recording the least value of weight loss. Among the sub-plot treatments no significant influence were noticed. However, Urea 2% (T_2) recorded the maximum weight loss and Urea 2% + Planofix 400 ppm (T_6) recorded the minimum weight loss thus the combination of Urea and Planofix in the above concentration is superior in reducing the weight loss. There was a differential response among the varieties in this regard.

(15) Volume loss during storage : Among the varieties Maran (V_2) recorded the minimum volume loss whereas,

Rio-de-Janeiro (V_3) had the maximum values which were significantly different. The sub-plot treatments did not indicate any difference among themselves but the interaction between chemicals with the variety were significant. Thus V_4 T_2 recorded the maximum volume loss and V_4 T_3 the minimum among the variety, chemicals interaction.

(16) <u>Damage during storage</u> : The varieties Thinladium (V_4) and Sierra Leone (V_5) recorded significantly maximum damage than other varieties. The minimum damage was noticed with the variety Maran (V_2). The damage loss was maximum with the Urea 2% (T_2) and minimum with the mixed applications of Urea 2% + Planofix. The interaction between varieties and sub-plot treatments showed the differential response of different varieties. Thus, V_4 T_5 recorded the maximum damage and V_2 T_5 practically no damage was noticed.

(17) <u>Recovery of Oleoresin</u> : Among the various varieties Rio-de-Janeiro (V_3) recorded significantly higher percent of oleoresin and Thinladium the lowest. The sub-plot treatments except Urea 2% (T_2) significantly increased the recovery of oleoresin over control. However, the Urea 2% + Planofix 400 ppm (T_6) combination produced maximum recovery of oleoresin than other treatments. Among the variety, chemical combinations V_3 T_6 recorded the maximum percentage of oleoresin.

(18) <u>Oleoresin production on hectare basis</u> : The variety Maran (V_2) recorded the maximum oleoresin production per hectare and significantly superior to Thinladium (V_4) which was lowest. Rio-de-Janeiro (V_3) and China (V_1) were also significantly better than Thinladium (V_4). The sub-plot treatments except Urea 2% (T_2) recorded significantly higher oleoresin production over control (T_1) and urea 2% + Planofix 400 ppm (T_6) produced the maximum production of oleoresin on hectare basis. Among the varieties, sub-plot interactions, V_2 T_6 recorded the maximum value and V_4 T_6 recorded the minimum value showing the differential response of the varieties to the sub-plot treatments.

(19) <u>Crude fibre content of rhizome</u> : Variety Rio-de-Janeiro (V_3) accounted the maximum crude fibre % whereas Maran (V_2) recorded the minimum percentage. Among the sub-plot treatments Urea 2% + Planofix 400 ppm (T_6) recorded the minimum value of crude fibre %. Further V_3 T_4 recorded the maximum crude fibre content and V_2 T_5 and V_5 T_4 produced lower percentage of crude fibre.

(20) <u>Correlation studies</u> : The correlation studies with yield and growth characters and oleoresin and crude fibre content did not show any significant inference.

(21) Compatibility of Urea and Planofix on ginger:
No incompatibility symptoms were noted due to the application of Urea and Planofix.

CONCLUSION

From the studies it is evident that the variety Maran (V_2) is superior in most of the characters studied, than varieties Rio-de-Janeiro, China, Thinladium and Sierra Leone. Among the sub-plot treatments Urea 2% + Planofix 400 ppm have shown better effect than others showing its superiority over other chemical treatments. So for commercial cultivation under local conditions are concerned the variety Maran can be recommended with the use of Urea 2% + Planofix 400 ppm foliar spray. However, the experiment may be repeated for confirming the results reported in this investigation.

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* Originals not seen.

APPENDIX

APPENDIX I

ANALYSIS OF VARIANCE TABLE 1. GERMINATION

Source	D.F.	M.S.	Calculated F. Value	Table Value 5%	Table Value 1%
Replication	2	108.02	3.1	4.46	8.65
Variety	4	795.34	22.7**	3.84	7.01
Error	8	34.88			

** indicates significant at 5% and 1% levels.

ANALYSIS OF VARIANCE TABLE 2. LEAF AREA

Source	D.F.	M.S.	Calculated F. Value	Table Value 5%	Table Value 1%
Replication	2	361.15	3.92	4.46	8.65
Main Plots (V)	4	247.51	2.68	3.84	7.01
Error (a)	8	92.03			
Sub-plots (t)	5	65.25	5.36**	2.40	3.41
V x T interaction	20	7.287	0.56	1.78	2.26
Error (b)	50	12.915			
S.E. for treatments			0.9279		
C.D. at 0.05% level			2.63		

** indicates significant at 5% and 1% levels.

ANALYSIS OF VARIANCE TABLE 3. HEIGHT OF PLANTS

Source	D.F.	Days after planting											
		30		60		90		120		150		180	
		M.S.	F Value	M.S.	F Value	M.S.	F Value	M.S.	F Value	M.S.	F Value	M.S.	F Value
Replication	2	54.33	1.56	24.43	0.49	8.39	1.9	63.30	1.17	52.61	1.55	56.54	1.31
Main Plots (V)	4	58.72	1.67	106.30	3.76	203.17	4.82*	198.21	3.67	199.93	4.63*	177.47	4.13*
Error (a)	8	35.17		49.53		42.17		54.04		45.31		42.98	
Sub-plots (t)	5	25.84	2.1	17.24	1.42	26.39	1.26	35.50	1.22	106.91	3.83**	162.61	5.68**
v x t interaction	20	14.10	1.19	17.07	1.41	27.34	1.31	28.35	0.97	41.14	1.47	37.45	1.31
Error (b)	50	[illegible]		12.11		20.94		29.06		27.92		20.67	

* indicates significant at 5% level

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 4. THICKNESS OF MAIN PSEUDOSTEM

Source	D.F.	Days after planting					
		30		60		90	
		M.S.	F. value	M.S.	F. value	M.S.	F. value
Replication	2	0.0020	0.606	0.0167	5.387	0.01	1.69
Main Plots (V)	4	0.0597	18.09**	0.0718	23.16**	0.096	16.27**
Error (b)	8	0.0033		0.0031		0.0059	
Sub-plots (t)	5	0.0018	0.2	0.0016	0.67	0.0024	0.92
v x t interaction	20	0.0024	0.26	0.0024	1	0.0033	1.26
Error (b)	50	0.0090		0.0024		0.0026	
S.E. for Main plots			0.0134		0.01303		0.01733
C.D. at 0.05% level			0.044		0.042		0.056

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 4. THICKNESS OF MAIN FSEUDOSTEM (Contd.)

Source	D.F.	Days after planting					
		120		150		180	
		M.S.	F.value	M.S.	F.value	M.S.	F. value
Replication	2	0.0037	0.860	0.0013	0.25	0.0015	0.263
Main plots (v)	4	0.0953	22.15*	0.1013	19.48**	0.1080	18.95**
Error (a)	8	0.0043		0.0052		0.0057	
Sub-plots (t)	5	0.0022	0.815	0.0056	2.07	0.0122	7.62**
v x t interaction	20	0.0039	1.44	0.0035	1.29	0.0072	4.50**
Error (b)	50	0.0027		0.0027		0.0016	

S.E. for main plots 0.1516 0.01673

C.D. at 0.05% level 0.049 0.054

* indicates significant at 5% level

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 5. TILLER NUMBERS/CLUMP

Source	D.F.	Days after planting					
		30		60		90	
		M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	2.585	6.89	0.195	0.29	0.72	0.37
Main Plots (v)	4	0.545	1.45	4.072	6.21*	23.55	12.23**
Error (b)	8	0.375		0.656		1.93	
Sub-plots (t)	5	0.052	0.67	0.320	1.07	3.75	2.19
v x t interaction	20	0.049	0.64	0.330	1.10	2.29	1.33
Error (b)	50	0.077		0.299		1.71	
S.E. for main plots					0.139		0.0327
C.D. at 0.05% level					0.616		1.067

* indicates significant at 5% level

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 5. TILLER NUMBERS/CLUMP (Contd.)

Source	D.F.	Days after planting					
		120		150		180	
		M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	2.72	0.59	2.72	0.69	9.025	1.96
Main plots (v)	4	50.55	7.9**	94.39	24.26	120.267	26.00**
Error (a)	8	6.30		3.39		4.612	
Sub-plots (t)	5	6.70	2.04	8.09	2.22	9.872	2.17
v x t interaction	20	4.52	1.35	5.54	1.52	5.947	1.31
Error (b)	50	3.33		3.64		4.546	
S.E. for main plots			0.591		0.464		0.505
C.D. at 0.05% level			1.93		1.51		1.65

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 6. LEAVES/CLUMP

Source	D.F.	Days after planting					
		30		60		90	
		M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	0.1	0.09	138.19	3.35	5872.15	6.94
Main plots (v)	4	4.595	4.41*	121.79	2.95	9088.12	10.73**
Error (a)	8	1.043		41.22		846.28	
Sub-plots (t)	5	0.586	0.77	17.40	0.69	457.41	0.65
v x t interaction	20	0.781	1	30.84	1.22	845.19	1.20
Error (b)	50	0.762		25.12		703.01	
S.E. for main plots			0.238				0.255
C.D. at 0.05% level			0.77				22.35

* indicates significant at 5% level

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 6. LEAVES/CLUMP (Contd.)

Source	D.F.	Days after planting					
		120		150		180	
		M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	6536.3	5.69	6736.36	5.09	5884.96	3.71
Main plots (v)	4	10524.64	9.02**	11443.70	8.66**	13897.37	8.76**
Error (a)	8	1155.24		1322.0		1585.81	
Sub-plots (t)	5	147.84	0.14	857.86	0.66	1046.98	1.06
v x t interaction	20	909.68	0.95	1392.50	1.07	1373.94	1.30
Error (b)	50	1027.89		1293.60		986.13	
S.E. for main plots			8.04		8.57		9.306
C.D. at 0.05% level			26.22		27.94		30.50

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 7. PESTS AND DISEASES

Source	D.F.	Scale insect attack		At early stage of rhizome development		Total rhizome rot		Final stage of rhizome development		
		M.S.	F.value	M.S.	F.value	M.S.	F.value	D.F.	M.S.	F.value
Replication	2	707.[illegible]	2.35	33.16	0.46	196.98	1.1	2	731.50	1.95
Main plots (v)	4	2014.33	6.68*	709.75	9.7**	1008.91	5.71*	2	337.42	0.90
Error (a)	8	301.36		71.64		176.73		4	372.67	
Sub-plots (t)	5	427.67	1.66	-	-	-	-	5	273.99	2.09
v x t interaction	20	220.33	0.855	-	-	-	-	10	185.31	1.41
Error (b)	50	257.45		-		-		31	130.60	

S.E. for main plots	4.0917	1.99	3.13
C.D. at 0.05% level	13.34	6.50	10.21

* indicates significant at 5% level

** indicates significant at 5% and 1% level

ANALYSIS OF VARIANCE TABLE 8. YIELD OF RHIZOME

Source	D.F.	Plant yield		Net plot yield	
		M.S.	F.value	M.S.	F.value
Replication	2	695.44	0.44	17395.01	0.44
Main plots (v)	4	2832.45	1.81	70809.57	1.8
Error (a)	8	1560.24		39007.08	
Sub-plot (t)	5	1526.51	42.37**	38161.40	42.3**
v x t interaction	20	62.77	1.74	1569.76	1.74
Error (b)	50	35.02		900.66	

** indicates significant at 5% and 1% levels

ANALYSIS OF VARIANCE TABLE 9. QUALITY

Source	D.F.	Volume		Specific gravity		Recovery of dry ginger		Dry ginger production per hectare	
		M.S.	F.Value	M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	9.90	0.67	0.0017	0.29	0.79	0.81	123.62	0.39
Main plots (v)	4	54.79	3.69	0.0590	1.5	59.57	61.41**	250.77	0.80
Error (a)	8	14.857		0.0058		0.97		312.94	
Sub-plots (t)	5	10.276	1.733	0.0014	1.4	4.45	5.94**	87.64	4.71**
v x t interaction	20	4.936	0.84	0.0002	0.2	1.87	2.50**	56.37	3.03**
Error (b)	50	5.927		0.03		0.748		18.58	

** indicates significant at 5% and 1% levels

ANALYSIS OF VARIANCE TABLE 10. STORAGE QUALITY

Source	D.F.	Weight loss		Volume loss		Damage	
		M.S.	F.value	M.S.	F.value	M.S.	F.value
Replication	2	30.375	1.03	4.96	0.24	343.40	2.14
Main plots (v)	4	125.232	4.17*	111.60	5.37*	5431.81	13.791**
Error (a)	8	30.033		20.79		393.84	
Sub-plots (t)	5	25.726	1.49	23.66	1.68	239.61	1.05
v x t interaction	20	30.259	2.23**	44.79	2.62**	1160.79	5.07**
Error (b)	50	17.233		17.06		228.85	

* indicates significant at 5% level

** indicates significant at 5% and 1% levels

ANALYSIS OF VARIANCE TABLE 11. OLEORESIN CONTENT

Source	D.F.	Recovery of Oleoresin		Oleoresin production per hectare	
		M.S.	F.value	M.S.	F.value
Replication	2	0.59	1.6	10029.73	0.92
Main plots (v)	4	16.32	45.33**	42544.09	3.98
Error (a)	8	0.36		10608.17	
Sub-plot (t)	5	3.67	14.11**	19437.89	14.30**
v x t interaction	20	0.83	3.19**	3569.10	2.63**
Error (b)	50	0.26		1359.27	

* indicates significant at 5% level

** indicates significant at 5% and 1% levels

APPENDIX II

1. MEAN TABLE FOR THE PLANT HEIGHT OBSERVED AT MONTHLY INTERVALS

(a) Plant height on 30th day after planting (Unit Cms.)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	22.83	23.07	21.17	31.17	20.67	23.90
T_3	25.00	25.00	25.00	30.00	26.67	26.53
T_4	22.67	28.33	23.17	28.00	23.83	25.20
T_5	28.90	26.00	24.00	25.00	24.33	25.46
T_6	26.33	26.50	26.00	25.33	24.17	25.66
T_1 (Control)	23.50	24.67	17.17	24.67	24.33	22.87
Mean	24.88	26.02	22.41	27.36	24.00	

(b) Plant height on 60th day after planting (Unit - Cms)

T_2	34.40	39.07	35.89	46.13	33.73	37.79
T_3	38.20	38.53	37.60	45.20	37.07	39.32
T_4	33.23	39.83	35.87	40.80	36.07	37.12
T_5	38.27	39.67	37.67	39.73	35.07	38.03
T_6	35.80	42.53	37.53	39.27	34.33	37.89
T_1 (Control)	32.27	40.60	29.20	42.27	36.20	36.11
Mean	35.37	40.12	35.61	42.23	35.41	

(c) Plant height on 90th day after planting (Unit-Cms.)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	40.07	48.07	41.87	56.06	42.00	45.77
T_3	47.60	45.80	46.87	55.20	45.60	48.21
T_4	42.27	46.07	45.80	48.87	44.20	45.60
T_5	45.67	47.37	48.47	46.33	43.27	46.20
T_6	45.40	51.40	44.87	48.07	40.80	46.11
T_1 (Control)	40.67	49.93	38.53	49.20	42.13	44.09
Mean	43.51	48.45	44.40	50.62	43.00	

(d) Plant height on 120th day after planting (Unit-Cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	48.93	50.07	45.67	60.27	48.87	50.76
T_3	53.13	52.00	51.40	62.47	54.27	54.65
T_4	50.40	53.53	50.27	57.53	50.87	52.52
T_5	50.53	53.47	54.33	51.07	50.20	51.92
T_6	51.53	58.97	51.40	55.27	48.13	52.88
T_1 (Control)	45.93	55.37	44.20	55.27	50.93	50.44
Mean	48.57	54.33	49.54	56.98	50.54	

(e) Height of plants on 150th day after planting (Unit-cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	50.60	54.03	47.46	63.16	51.56	53.54
T_3	59.30	[illegible]	56.00	66.73	55.83	58.57
T_4	57.40	[illegible]	52.90	59.83	53.67	56.09
T_5	58.10	[illegible]	59.30	54.43	53.93	57.12
T_6	59.90	[illegible]	55.03	62.03	51.67	59.66
T_1 (Control)	48.06	[illegible]	45.83	55.86	52.03	52.16
Mean	55.39	[illegible]	52.75	60.34	53.11	

2. MEAN TABLE [illegible] THICKNESS OF MAIN [illegible] OBSERVED AT MONTHLY [illegible]

(a) Thickness on [illegible] day after planting (Unit-Cms).

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	0.566	0.700	0.566	0.666	0.516	0.603
T_3	0.583	[illegible]	0.550	0.616	0.550	0.586
T_4	0.593	0.650	0.593	0.616	0.533	0.593
T_5	0.583	0.700	0.583	0.633	0.583	0.616
T_6	0.550	[illegible]	0.550	0.616	0.500	0.589
T_1 (Control)	0.550	[illegible]	0.533	0.650	0.600	0.603
Mean	0.569	[illegible]	0.561	0.633	0.547	

(b) Thickness on 60th day after planting (Unit - Cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	0.623	0.776	0.646	0.780	0.650	0.695
T_3	0.686	0.753	0.643	0.756	0.670	0.702
T_4	0.643	0.766	0.683	0.756	0.660	0.702
T_5	0.670	0.803	0.713	0.723	0.670	0.716
T_6	0.636	0.846	0.670	0.723	0.650	0.705
T_1 (Control)	0.616	0.703	0.620	0.760	0.670	0.692
Mean	0.646	0.780	0.662	0.750	0.662	

(c) Thickness on 90th day after planting (Unit - Cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	0.710	0.870	0.713	0.846	0.736	0.775
T_3	0.750	0.870	0.723	0.833	0.763	0.788
T_4	0.760	0.873	0.773	0.790	0.740	0.787
T_5	0.753	0.913	0.793	0.816	0.750	0.804
T_6	0.726	0.906	0.776	0.803	0.723	0.805
T_1 (Control)	0.706	0.916	0.706	0.850	0.770	0.790
Mean	0.724	0.906	0.747	0.823	0.747	

(d) Thickness on 120th day after planting (Unit-Cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	0.740	0.926	0.745	0.893	0.760	0.813
T_3	0.796	0.900	0.786	0.856	0.793	0.826
T_4	0.826	0.930	0.803	0.803	0.786	0.829
T_5	0.790	0.933	0.830	0.836	0.773	0.832
T_6	0.793	1.000	0.810	0.830	0.783	0.851
T_1 (Control)	0.763	0.973	0.733	0.866	0.800	0.826
Mean	0.784	0.950	0.784	0.847	0.782	

(e) Thickness on 150th day after planting (Unit - Cms)

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	0.786	0.900	0.776	0.916	0.790	0.845
T_3	0.836	0.966	0.820	0.893	0.850	0.871
T_4	9.863	1.000	0.843	0.836	0.820	0.872
T_5	0.823	0.973	0.883	0.870	0.826	0.875
T_6	0.846	1.073	0.843	0.866	0.826	0.890
T_1 (Control)	0.780	0.966	0.743	0.870	0.810	0.839
Mean	0.822	0.993	0.818	0.875	0.820	

3. MEAN TABLE FOR TILLER NUMBER/CLUMP AT MONTHLY INTERVALS

(a) Tiller number on 30th day after planting

T_2	1.27	1.79	1.67	1.40	1.73	1.55
T_3	1.27	1.73	1.67	1.27	1.53	1.49
T_4	1.07	1.67	1.53	1.30	1.60	1.41
T_5	1.20	1.70	1.60	1.27	1.60	1.48
T_6	1.07	1.50	1.53	1.47	1.60	1.44
T_1 (Control)	1.47	1.23	1.47	1.33	1.47	1.39
Mean	1.22	1.59	1.58	1.32	1.59	

(b) Tiller number on 60th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	3.93	3.07	4.53	3.67	4.53	4.11
T_3	3.73	3.[illegible]	4.73	2.80	4.07	3.83
T_4	3.27	4.01	4.13	3.13	4.00	3.71
T_5	3.80	3.07	5.40	2.87	4.13	3.97
T_6	3.87	3.[illegible]	4.27	3.60	3.93	3.89
T_1 (Control)	3.53	3.93	3.87	3.27	4.13	3.75
Mean	3.69	3.05	4.49	3.22	4.13	

(c) Tiller number on 90th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	5.93	8.40	9.47	6.73	9.80	8.07
T_3	7.67	7.73	10.33	5.80	9.40	8.19
T_4	6.80	7.67	8.73	6.27	8.60	7.61
T_5	7.73	7.00	12.13	7.13	8.47	8.65
T_6	7.20	8.13	8.07	7.27	7.80	7.69
T_1 (Control)	7.13	7.20	7.60	6.27	7.93	7.23
Mean	7.08	7.33	9.39	6.58	8.67	

(d) Tiller number on 120th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	8.80	11.53	13.07	10.13	13.47	11.40
T_3	10.27	10.33	14.27	8.40	13.13	11.28
T_4	8.67	9.93	12.80	8.93	11.87	10.44
T_5	9.27	10.40	16.80	9.93	11.07	11.49
T_6	9.33	11.40	12.13	10.40	11.67	10.98
T_1 (Control)	9.07	9.80	9.47	9.07	11.47	9.77
Mean	9.23	10.56	13.69	9.48	12.11	

(e) Tiller numbers on 150th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	9.73	12.87	14.27	10.47	15.80	12.51
T_3	11.20	11.67	16.60	9.47	15.53	12.89
T_4	9.60	10.33	14.73	10.47	15.07	12.04
T_5	14.07	10.93	19.40	11.13	13.67	13.84
T_6	10.27	12.07	13.20	11.13	13.53	12.04
T_1 (Control)	9.87	10.67	11.60	9.80	13.40	11.06
Mean	10.79	11.33	14.96	10.41	14.50	

4. MEAN TABLE FOR LEAF NUMBERS/CLUMP AT MONTHLY INTERVALS

(a) Leaf numbers on 30th day after planting

T_2	7.00	8.00	7.67	7.33	7.33	7.46
T_3	7.33	8.00	6.67	6.00	7.33	7.46
T_4	7.33	7.33	8.00	6.67	8.00	7.46
T_5	7.00	7.33	9.00	6.67	7.67	7.53
T_6	7.67	8.33	7.33	6.67	7.33	7.46
T_1 (Control)	7.33	7.33	7.33	6.67	6.33	6.99
Mean	7.27	7.72	8.00	6.66	7.33	

(b) Le[illegible] numbers on 60th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	[illegible].50	30.13	36.63	26.93	29.60	29.16
T_3	[illegible].13	24.93	30.27	27.00	31.00	27.67
T_4	[illegible].70	25.30	32.57	27.20	31.93	28.34
T_5	[illegible].33	25.13	40.47	26.03	29.27	29.65
T_6	[illegible].20	31.57	27.40	24.10	29.53	27.56
T_1 (Control)	[illegible].53	27.93	24.60	29.07	26.67	26.76
Mean	[illegible].56	28.00	31.99	26.72	29.67	

(c) Le[illegible] numbers on 90th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	[illegible].73	91.67	130.06	63.50	111.60	93.31
T_3	[illegible].37	77.93	104.73	67.37	122.83	87.85
T_4	[illegible].13	84.07	125.23	72.33	119.80	92.27
T_5	[illegible].60	91.20	164.93	65.80	86.53	94.61
T_6	[illegible].80	100.60	97.50	71.57	96.67	86.43
T_1 (Control)	[illegible].10	89.53	83.27	77.87	83.53	79.85
Mean	[illegible].62	89.96	117.62	69.74	104.33	

(d) Leaf number [illegible] 120th day after planting

	V_1	[illegible]	V_3	V_4	V_5	Mean
T_2	101.87	[illegible].00	155.33	88.47	138.07	121.31
T_3	94.63	[illegible].40	135.50	92.17	147.67	115.66
T_4	88.13	[illegible].47	160.40	96.33	148.87	121.04
T_5	97.60	[illegible].20	300.00	89.80	142.67	148.85
T_6	77.67	[illegible].77	128.13	97.47	123.33	113.27
T_1 (Control)	92.27	[illegible]10.07	120.03	107.67	114.07	110.62
Mean	92.03	[illegible]19.23	166.56	95.32	135.78	

(e) Leaf n[illegible] on 150th day after planting

	V_1	V_2	V_3	V_4	V_5	Mean
T_2	12[illegible]	137.53	167.87	132.57	175.27	147.73
T_3	1[illegible]	132.67	156.93	103.30	185.90	142.72
T_4	1[illegible]87	127.73	177.76	127.13	176.43	143.98
T_5	[illegible]60	137.73	250.53	126.00	159.03	156.97
T_6	[illegible].20	165.00	146.87	126.80	163.33	144.24
T_1 (Control)	[illegible].07	132.93	143.30	132.30	150.73	133.66
Mean	[illegible]3.32	130.10	173.97	124.68	168.44	