MORPHOLOGICAL STUDIES
AND
QUALITY EVALUATION
OF GINGER (*Zingiber officinale Rosco.*) TYPES

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Morphological studies and quality evaluation of ginger (*Zingiber officinale* Rosco.) types" is a bonafide record of research work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

NYBE, E.V.

Vellanikkara,
15th September, 1978.

CERTIFICATE

Certified that this thesis entitled "Morphological studies and quality evaluation of ginger (*Zingiber officinale* Rosco.) types" is a record of research work done independently by Shri Nybe, E.V. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of Shri Nybe, E.V. a candidate for the degree of Master of Science in Horticulture with major in Horticulture agree that the thesis entitled "Morphological studies and quality evaluation of ginger (*Zingiber officinale* Rosoo.) types" may be submitted by Shri Nybe, E.V. in partial fulfilment of the requirements for the degree.

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INTRODUCTION

INTRODUCTION

The ginger of commerce is the dried underground rhizome of ginger (*Zingiber officinale* Rosco.). This has a refreshing odour and pleasing taste and is used mainly as a spice and medicine since 5000 B.C. In the present day, the uses of ginger is increased in different forms which naturally increases the demand of the same all over the world.

India still continues to be the largest producer and supplier of ginger and ginger products. Kerala contributes 50 per cent of the production of ginger (43500 tonne) and 73 per cent of the area in India (26800 ha). Utter Pradesh, West Bengal, Himachal Pradesh and Andhra Pradesh are the other major producing states in India.

India accounts for about 50 per cent of the world export of ginger which is 40 per cent of the annual production. Next to pepper, ginger is the most important spice exported from India, accounting for 12.88 per cent (9464.50 mt) of the spice export from India (73478.98 mt) during the year 1977-78. Apart from dry ginger we are also exporting ginger oil (977 kg worth Rs. 5.2 lakhs) and oleoresin (715 kg worth Rs. 1.2 lakhs). Ginger and its products contribute 9.89 per cent of total export earnings from spices (Rs.138 crores). Exports of ginger from India have shown increase both in terms of quantity and earnings from 6050.48 metric tonnes valued at Rs. 2.10 crores

in 1972-73 to 9464.50 metric tonnes valued at Rs.13.64 crores in 1977-78. We are not in a position to meet the world demand. The price of ginger is presently ruling abnormally high (Rs.18/- per kg of dry ginger) which was only Rs.5.22 per kg in 1968-69 and Rs.8.57 per kg during 1975-76 and if sufficient quantities are made available, India can substantially increase the foreign exchange earning from this crop. Hence there is urgent need for increasing the production to cope up with the increased demand for export as well as for internal requirements.

Although the importance of ginger as a spice and medicinal crop is well known in India from time immemorial, research information on this crop is meagre. While considering the importance of this crop in the economy of our country, the production of marketable quality ginger is inadequate. Indian ginger is regarded as next in quality to Jamaican ginger because of its high fibre content. The production and productivity of ginger in India is also low. There was not much attention on the quality of ginger till recently.

The introduction of gingerin (ginger oleoresin) which contain all the flavouring and pungent principles present in the original spice has increased the possibilities of exp anding its export. The use of oleoresin, a sterile product provides a solution to the unhygienic nature of spice utilisation. The pungency or flavour of oleoresin can be adjusted to the required strength and thereby provide uniformity of flavour and avoid

hot-spots resulting by the use of ground spice. It also facilitates export by reducing tonnage during transport and provides potential employment in the centre of production. This necessitated varietal screening with due emphasis on yield and quality.

Many of the types cultivated have acquired different regional or local names although the type or variety is often the same. This confusion can be avoided only by fixing up specific morphological criteria for identifying specific types or varieties.

The use of ginger in different forms are increasing. The quality requirement for different products such as dry ginger, gingerin, ginger oil, ginger beer, vitaminised effervescent ginger-powder, gingerale, pickles, ginger candy, ginger essences, etc. are quite different. Therefore it is also essential to find out the content of important chemical constituents at different stages of maturity.

No work has been done on the morphological description of different ginger types to classify them. Though quality evaluation has been undertaken in respect of few types, quality evaluation based on morphological and yield characteristics has not been made. Similarly the variations in chemical constituents at different stages of maturity also require detailed study. Therefore the present investigation was undertaken

with the following objectives:

1. To find out the feasibility of fixing up specific morphological criteria to identify different types.
2. To evaluate the comparative yield and relative tolerance to important pests and diseases.
3. To evaluate the quality in terms of dryage, oleoresin, oil and crude fibre content in different types.
4. To study the quality variations at different periods of maturity.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

A number of workers have studied the varietal, cultural and other economic characters of this important spice crop in India as well as other producing countries. An attempt is made to provide a comprehensive review on different aspects taken up for the present investigation. They are presented below.

1. Germination.

The germplasm collection and screening studies in ginger including 31 types, conducted at the Central Plantation Crops Research Institute, Kasargode (Anon, 1972) showed that maximum germination was in type Maran (91%) followed by Nadia (90.6%), Karakal (88.9%) and Bajpai (88%). Thankamma Pillai (1975) observed maximum germination percentage in the type Utter Pradesh (98.0%) followed by the types Bajpai (97.5%), Burdwan (93.8%), Vengara (91.3%) and Assam (91.3%). According to Nair (1975) the types Maran and Thinladium recorded significantly higher percentage of germination over Rio-de-Janeiro, China and Sieraleon. Thankamma Pillai *et al.* (1976) noticed maximum germination in Maran and Mohitnagar, followed by Valluvanad, Wynad Local, Bahreica and Jamaica.

Evenson (1978) found that when ginger was germinated at constant soil temperatures of 20, 25, 30 and 35°C, a significant quadratic relationship existed with an optimum of 25 and 26°C. In another experiment involving three constant

(22.5, 27.5 and 32.5°C) and nine fluctuating temperature regimes, corresponding with mean soil temperatures varying from 24.2 to 30.8°C, a marked effect of temperature was again found in constant temperature treatments, the optimum being at 27.5°C. However, with fluctuating temperatures, growth appeared to be somewhat less dependent on temperature and the optimum was slightly higher (29°C).

2. Morphological studies.

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. Miller (1938) stated that the rhizome was the region of food storage and the great bulk of food materials which accumulated in plants were carbohydrates, fats and proteins.

Purewal (1957) showed that there was highly significant and positive correlation between plant height and yield in tuberous plants like colocasia. Ihra (1959) reported that the development of rhizome was closely associated with that of shoot. Curtis (1959) observed that the development of storage organs was greatly influenced by day length, temperature and available nutrient supply. Harry (1962) studied the morphological characters of four different commercial types of ginger - African, Jamaican, Cochin and Japanese ginger.

Thomas and Kannan (1969) reported that Rio-de-Janeiro was a vigorous growing type with bigger sized and well formed rhizomes, free and well set fingers. Thankamma Pillai (1973a) pointed out that the 31 types tested, showed significant differences in their vegetative characters such as number of tillers, height of plants and number of leaves. She also reported that plant height and leaf number were found to be associated with rhizome yield.

Nair (1975) observed no significant difference among the five types selected for the trial on linear growth in the early stages. There was no difference among the types in the case of number of tillers per clump at the initial stage of development but at successive stages of growth, pronounced differences were obtained. Among the types, Rio-de-Janeiro and Sieraleon were significantly superior in tiller production. Those two types were at the top in leaf production also. However, there was no significant difference in leaf area among the five types of ginger.

3. Cultural practices.

Lokanath and Dash (1964) opined that a spacing of 6 x 6 inches was best to give higher yield than 9 x 9 inches or 12 x 12 inches irrespective of the planting method adopted. Planting on flat beds subsequently converted to ridge beds gave significantly higher yield than either flat or ridge planting alone. Kannan and Nair (1965) reported that planting

during the first week of April instead of May or June produced highest yield. The application of leaf mulch immediately after planting and about six weeks later using a total of 20 tonnes of leaves per hectare resulted in a 200 per cent increase in yield over the non-mulched crop.

Aiyadurai (1966) on reviewing the Scheme for research on ginger in Wynad (Kerala) found that there was no added advantage in ploughing the land more than the minimum required (4 to 6 times). The seed rate of 1200 lb to 1400 lb per acre was found to be optimum and spacing of 9" x 6" and 9" x 9" were necessary for getting the maximum yield in ginger. Mulching the crop with 15000 lb of green leaf per acre was sufficient. At Thodupuzha the planting of large-sized seed rhizomes (i.e. 1½" to 2½") gave significantly increased yield than planting of small-sized seed material (i.e. ½" to 1"). Closer spacing of 6" x 6" was found to give substantially higher yields. He also found that sandy loam to loam soil was best for ginger cultivation in Himachal Pradesh. Planting the seed rhizomes at a depth of 1.5 inches had given better yields.

Nair and Varma (1970) noted that the yield of ginger was not increased by increase in number of ploughings before planting, the maximum required was found to be four to six. The yield was to a great extent influenced by the date of planting. Early planting by the first week of April was found to be the best. Among the different spacings tried, the results had shown that closer spacings of 22.9 x 15.2 cm and 22.9x22.9 cm

were the best for maximum yield. They also found that the yield and size of seed bit were correlated, the optimum size being one ounce.

Randhawa and Nandpuri (1970) studied the various cultural operations for ginger and found that optimum spacing was 25 cm between rows and 15-20 cm between plants. Mulching with green leaf was found to be an essential operation for high yield and the optimum being three applications at the rate of 12.5, 5 and 5 tonnes per hectare for the first, second and third mulching respectively. Optimum seed rate was found to be 1250 kg per hectare, each seed bit being about one ounce in weight.

Randhawa et al. (1972) revealed that highest yields resulted from 20 x 20 and 20 x 30 cm spacings. Large rhizomes (150 g with 4-6 buds) gave higher yields than small ones (60 g with 2 buds).

Thankamma Pillai (1973b) observed that a seed rate of 1800 kg per hectare produced significantly superior effect on number of tillers, height of plants, breadth of leaves and yield of rhizome. Muralidharan (1973) pointed out that a heavy mulch could change the physical and chemical environment of the soil underneath, resulting in increased availability of phosphorus and potassium.

4. Fertilizer studies.

Ashby (1948) observed that increased dose 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.

A very high response of ginger to nitrogen has been recorded by the Department of Agriculture, Jamaica (Anon, 1953). Grosman (1954) recommended a top dressing of fertilizer mixture (10:8:7) at the rate of 5 cwt per acre for higher yield of ginger.

Sayed (1960) recommended the application of 10000 lb of powdered cattle manure to supply 50 lb of nitrogen or the application of 10000 lb of green leaf at the time of planting and a second application of 5000 lb per acre, about 45 days after planting to get the same effect. He also recommended the application of 25 lb of nitrogen in the form of ammonium sulphate for maximum production of ginger and stressed the importance of application of both organic and inorganic forms.

Abraham (1960) found that turmeric and ginger were supposed to be similar in their plant food requirements as they belong to the same family zingiberaceae. Application of 50 lb N, 50 lb P_2O_5 and 100 lb K_2O per acre was found to give maximum yield of ginger (Anon, 1960).

Russel (1955) investigated the effect of nitrogen on plant growth and concluded that it was needed for the rhizome development of long duration crops whereas in short duration crops the effect of nitrogen was only on the top.

Kannan and Nair (1965) reported that ginger was an exhaustive crop and required heavy manuring with 25-30 tonnes of cattle manure per hectare as basal dose and fertilizer mixture of NPK (3:8:16) at the rate of 450 kg per hectare for increased production.

Thomas (1965) observed that for raising economic crops of ginger in virgin soils in Wynad, application of N and P_2O_5 was not necessary, provided the crop was supplied with 10 tonnes of organic matter and 15000 lb of green leaf mulch per hectare.

Aiyadurai (1966) found that the application of organic manure at 150 lb nitrogen per acre in two or three instalments in the form of cow-dung over a basal dressing of five cart loads of cattle manure per acre gave high yields. He also observed an increased yield of 1600 lb of green ginger per acre by the application of mustard oil cake in addition to basal dressing of cattle manure in Assam. Work done at Himachal Pradesh showed that nitrogen fertilization of the crop with 50 to 100 lb nitrogen per acre had significantly increased the yield by 18 to 32 per cent and also improved the dry matter content of rhizome.

Randhawa and Nandpuri (1969) reported that the application of 100 kg nitrogen, 50 kg P_2O_5 and 50 kg K_2O increased the plant height, number of branches and the yield of rhizomes in Himachal Pradesh.

It has been found that ginger responded even to a higher dose of fertilizers. The maximum yield of 43,000 kg green ginger per hectare was recorded in case of Rio-de-Janeiro when 100 kg N, 100 kg P_2O_5 and 200 kg K_2O per hectare were applied (Nair and Varma, 1970).

Dasaradhi et al. (1971) stressed the importance of nitrogen at the active growth and tillering stages i.e., between 120 to 135 days and 200 to 210 days from planting. At that time, the nitrogen consumption was high which went up to three per cent in leaves. But it was normal at other times. They further concluded that readily available form of nitrogen should be applied during that stages.

Bajan and Singh (1972) showed that though saw-dust when used alone was harmful, the application of urea along with saw-dust to soil resulted in a significant increase in yield in ginger. Increase in growth characters such as tillers, leaves per plant and height of plants were also noted.

Saraswat (1972) found that application of phosphorus at 20 and 40 kg per hectare increased the yield of ginger by 21.5 and 11.5 per cent respectively, whereas nitrogen and

potash were ineffective. The oil content was adversely affected by nitrogen applications. Thankamma Pillai (1973b) found that higher level of nitrogen produced significant effect on the number of leaves, breadth of leaves and number of tillers.

Muralidharan et al. (1974) revealed that 70 kg nitrogen per hectare significantly increased the number of tillers and yield of rhizome, but the application of phosphorus had no effect while potash at the rate of 140 kg per hectare significantly reduced the yield of rhizome, other plant characters remained unaffected.

Muralidharan and Ramankutty (1977) noted the effect of potash and boron on the growth and yield of ginger and concluded that boron at 15 kg per hectare increased the number of tillers per clump, number of leaves per clump and reduced the incidence of soft-rot disease. But further increase in boron level reduced the yield. The treatment combination of 120 kg K_2O and 10 kg boron per hectare produced the maximum number of leaves and tillers per clump.

5. Yield of rhizome.

Khan (1959) reported that the type Burdwan, an introduction from West Bengal recorded the maximum yield of thirteen times the quantity of seed used while the type Rio-de-Janeiro from Brazil excelled all other types in rhizome size, but its total yield amounted to only eight times the seed rate.

Kannan and Nair (1965) recorded a high yield of 25000 to 30000 kg of green ginger per hectare in the case of Rio-de-Janeiro and 18000 to 20000 kg (green) per hectare in the type China. The results achieved by the scheme for research on ginger at Assam (Aiyadurai, 1966) showed that the type Nadia consistently recorded the highest yield. Rio-de-Janeiro and Ernad also appeared as promissing types. According to him the ginger types Rio-de-Janeiro and China recorded 25 to 30 per cent more yield than the local types. Thomas (1966) reported that in a trial of 18 types in Kerala, Rio-de-Janeiro yielded 32550 lb per acre as compared with the type China (16758 lb per acre). Nair (1969) reported that the experiments conducted at Ambalavayal had shown that Maran gave an equally good yield as that of Rio-de-Janeiro.

Thomas and Kannan (1969) observed that in a five year trial of 14 strains of ginger the type Rio-de-Janeiro was significantly superior in yield to all other strains except China and gave an average yield of 25000 lb per acre.

Muralidharan (1972) from the studies on the comparative performance of 12 types of ginger found that the type Rio-de-Janeiro was significantly superior to all other types except the type Assam for the yield of green ginger.

Thankamma Pillai (1973a) reported that the ginger types Wynad Kunnamangalam, Wynad Local, Tura and China were high yielding while Peechi and Utter Pradesh were low yielding.

Sankaranarayana (1974) recorded an yield of 12000 to 23000 kg per hectare of green ginger in general. The percentage of dry ginger to green ginger varied from 16.25 to 22 per cent.

Thankamma Pillai (1974) analysed the yield data from 35 ginger types and showed that maximum yield was recorded in types such as Nadia, Poona, Thinladium, Burdwan, Juggijan and Taiwan respectively.

Nair (1975) reported that of the four types studied, the type Rio-de-Janeiro recorded the maximum yield followed by China, Maran, Sieraleon and Thinladium.

Thankamma Pillai (1975) found that among the 32 cultivars of ginger, yield was maximum in Wynad Manantody followed by Wynad Manjeri and Jorhat.

Nair *et al.* (1976) observed that of the eleven cultivars of ginger studied, Nadia gave the highest yield of green ginger (4933.5 kg/ha) and dry ginger (1021 kg/ha) followed by Himachal Pradesh with 4400 kg per hectare and 819 kg per hectare respectively.

Thankamma Pillai and Nambiar (1976) reported that the yield was maximum in Valluvanad (11.5 kg/3m^2) followed by Assam (11.07 kg/3m^2) and Maran (9.73 kg/3m^2). Exotic types, Bangkok and Jamaica, planted in pots and types China and Tafingiva raised in the field yielded large and thick rhizomes.

6. Quality evaluation.

According to Kannan and Nair (1965) the drying percentage of the type Rio-de-Janeiro was 16-18 with a fibre content of 5.19 per cent whereas in the case of China the recovery of dry ginger to green ginger varied from 13-15 per cent, with a low fibre content of 3.43 per cent.

The review of Aiyadurai (1966) on the scheme for research on ginger in Wynad (Kerala) recorded that the recovery of dry ginger was highest in Vengara, Ernad, Sieraleon, Himachal Pradesh and Karakal while it was low in China and Rio-de-Janeiro. He also reported that the types Karakal, Burdwan, Ernad and China had the least fibre content and Himachal Pradesh, Mysore and Bajpai had the highest fibre content.

Trials conducted by Thomas (1966) revealed that Rio-de-Janeiro was the best type. He recorded a drying percentage of 16.25 and crude fibre content of 5.19 per cent in Rio-de-Janeiro. The next best was China which yielded 15 per cent of dry to green ginger and 3.43 per cent fibre.

Nair (1969) felt that Maran was a superior one as that type gave a higher percentage of dry ginger to green ginger and was comparatively less susceptible to soft-rot disease.

Gulati (1969) obtained essential oil from the rhizomes of Zingiber elatum (wild ginger) with a yield of 0.59 per cent based on fresh weight. It was found to contain borneol and

formic and acetic acid. Oil (0.17 per cent) was also obtained from Zingiber chrysanthum. Connell and Sutherland (1969) opined that the pungency of ginger was due to its conversion products shogaol and zingerone.

A three-directional TLC analysis of the essential oils and oleoresins from five different samples of ginger showing odour differences (Arctander, 1969) showed clearly distinguishable patterns and the significance of a group of oxygenated compounds in the odour of ginger more than the differences in terpene hydrocarbons.

Krishnamoorthy et al. (1970) reported that the peelings of ginger contained some amount of oil which could be used for distillation. So also the leaves just before the time of harvest contained some oil which could be distilled at the time of harvest. The flavour quality of the oil obtained from green ginger was much superior to that from dry ginger. They also reported high oil content in types such as Manantody (Kerala) and Mysore (2.7) followed by Assam (2), Jorhat and Utter Pradesh (2). Maximum oleoresin content was recorded in the type Assam (9.3) followed by Manantody (9.2), Utter Pradesh (8.8) and Jorhat (8.3).

Nair and Varma (1970) found that the optimum time of harvest was 260 days after planting. The crop was harvested 215 days after planting and subsequently at 15 days interval upto 275 days. A steady increase in the percentage of volatile

oil was noted upto 260 days of planting and further delay in harvest decreased the percentage of oil and increased the fibre content.

Natarajan et al. (1970) reported that the chemical analysis of various raw ginger samples done at CFTRI, Mysore, showed that the volatile oil varied from 1.25 to 2.81 per cent, crude fibre 1.4 to 9.5 per cent, cold alcohol extract 1.12 to 3.9 per cent and acetone extract 5.11 to 11.71 per cent. They also stressed the importance of evolving and popularising proper varieties of ginger for use in specialized products. Connell and Jordan (1971) had claimed that higher citral was a characteristic of Australian type ginger.

Muralidharan (1972) observed that the percentage recovery of dry ginger from green ginger was the lowest in Rio-de-Janeiro while the type Tura recorded the highest value (25.09%) which was on par with Nadia and Himachal Pradesh. The lowest fibre content was noticed in types Himachal Pradesh (4.23%) and Tura (4.53%) but those were poor yielders. The highest oleoresin content of 7.1 per cent was observed in Kuruppampady followed by Wynad Local, Assam, Mysore, Valluvanad and Narasapattom. He recommended the types like Kuruppampady, Wynad Local, Assam and Valluvanad for large scale cultivation to feed the processing industry, since they possessed both the qualities of higher yield and higher content of oleoresin.

Govindarajan (1972) conducted studies to find out the difference between the essential oil and oleoresin obtained from green and dry ginger and concluded that the concentrates from green ginger were superior in odour. His work also suggested that higher citral was a characteristic of green ginger odour and careful handling to preserve that component could give a superior oil or oleoresin.

Lewis et al. (1972a) opined that Jamaican ginger was valued most because of its fine lemon-like odour. African ginger was considered inferior while the Indian ginger known in the world market as Cochin ginger was regarded as next to Jamaican but superior to ginger from Africa.

Experiments conducted by Natarajan et al. (1972) to study the chemical composition of different ginger types revealed that the types such as Mysore (2.7%), Manantody (2.7%) and Ernad Manjeri (2.5%) were rich in volatile oil content whereas it was minimum in Nadia (1.0%) followed by Ernad Chermad, Poona, Thingpuri and China (1.4%). Maximum acetone extract was recorded in types like Assam and Manantody (9.3% and 9.2% respectively). The types Kunnamangalam and Nadia were found to be low in fibre content (4.79% and 5.67%). The results on maturity studies revealed that most of the constituents like volatile oil, acetone extract and crude fibre content increased during the course of maturity (from September to December).

Lewis et al. (1972b) studied the various constituents of ginger (commercial types) and found that Cochin ginger was bold, light brown, partly peeled having lemon-like odour and flavour. The yield of volatile oil was 2.2 per cent and non-volatile extract (E.D.C.) 4.25 per cent. Sieraleon ginger was plump, dark, partly peeled from sides; pungent and slightly camphoraceous yielding 1.6 per cent oil and 7.2 per cent oleo-resin. Nigerian ginger was bold, light, partly peeled, fibrous, very pungent and camphoraceous in flavour. They yielded 2.5 per cent oil and 6.5 per cent non-volatile extract. Jamaican ginger was very bold, very light, buff coloured, clearly peeled, delicate in aroma and flavour, volatile oil one per cent and non-volatile extract 4.4 per cent.

They also presented the chemical analysis data for the various ginger types grown in India. According to them high volatile oil content was recorded in Mysore (2.1%), Wynad Manantody (2%), Assam (1.9%) and Utter Pradesh (1.8%) types. Ethylene dichloride extract was highest in Wynad Manantody (5.25%) followed by Karakal (3.95%), Utter Pradesh (3.9%), Wynad Local (3.8%) and Rio-de-Janeiro (3.67%). But Rio-de-Janeiro excelled all other types in alcohol extract (8.34%) followed by Wynad Manantody (7.17%), Vengara (5.89%), Wynad Local (5.81%) and Valluvanad (5.76%).

Jogi et al. (1972) studied the changes in crude fibre, fat and protein content of ginger at different stages of maturity (5, 5.5, 6, 6.5 and 7 months after planting) of some

important types. They showed that moisture, crude protein and fat content decreased with advanced maturity whereas, the crude fibre showed an increasing trend. Harvesting after 198 days of planting (6.5 months) was recommended when the level of lipid was lowest and fibre content highest.

Mathai and Prakash (1972) found that the type Rio-de-Janeiro gave the maximum yield of oleoresin followed by the types Manantody and Karakal. They also revealed that Rio-de-Janeiro and Wynad Manantody gave the maximum total ash and possessed the highest fibre content.

Mathew et al. (1972) reported that the type Rio-de-Janeiro excelled all other types in the yield of essential oil (2.5). The next best type was Mysore (2.1) followed by Wynad Manantody (2) and Assam (1.9). He also studied the odour characteristics of the oil of 27 cultivars. Most of the cultivars were normal in odour but Maran was more lemon scented than normal, Assam and Sieraleon more pungent whereas Wynad Kunnamangalam, Burdwan and Juggijan were milder. Gas chromatographic studies revealed that fresh ginger oil obtained from distillation of whole ginger had a higher curcumene content and lower zingiberene content than that from peeled and dried ginger. It was interesting to note that ginger peel oil contained higher amount of curcumene than zingiberene when compared with commercial dry ginger oil.

Mathai (1973) in his quality studies on spices, analysed

20 types of ginger for their dry matter and oleoresin content. He reported that dry matter varied from 11.1 per cent in Rio-de-Janeiro to 28.4 per cent in Ernad Chernad but it was 16.1 per cent in Maran and 21.4 per cent in Sieraleon. The acetone extract was maximum in Jorhat (10.1) followed by Thinladium, Sieraleon (6.8), Rio-de-Janeiro (6.6) and Maran (5). He also pointed out that the yield of oleoresin was higher when alcohol was used as the solvent and the dry matter increased with maturity of rhizome while the crude fibre content decreased with age.

Lewis (1973) stressed the importance of selecting proper variety of spice for oil and oleoresin extraction. He opined that the main considerations of the varieties grown for drying were the physical appearance of the dried rhizomes and the yield of dry ginger per hectare. He recommended the following four types for the extraction of oil and oleoresin. Rio-de-Janeiro (oil - 3.5 ; NVE - 6), Manantody (oil - 2 ; NVE - 5.3), Maran (oil - 2 ; NVE - 4.3) and Wynad Local (oil - 1.5 ; NVE - 3.8). Gingerol content of the ginger oleoresin was found to be 25-30 per cent.

Muralidharan (1974) recommended Rio-de-Janeiro, Assam, Utter Pradesh, Vengara and Wynad Local for green ginger production. He further explained that the maximum recovery (25.09) of dry ginger was noticed in the type Tura on par with Nadia and Himachal Pradesh. He pointed out that the

types Wynad Local, Vengara, Rio-de-Janeiro, Assam, Kuruppampady, Valluvanad and Ernad Manjeri were able to give more than 200 kg oleoresin per hectare which were suitable for processing industry.

Mathai (1974) conducted quality studies in spices and concluded that in ginger, oleoresin content was higher in early stages of growth. It was 10.1 to 16.1 per cent in the third month and 4.8 to 9 per cent in the seventh month.

Nair (1975) observed that when oleoresin content decreased, crude fibre content increased. He also worked out the correlation of yield with the important morphological characters and found positive correlation in all cases.

He further recorded the highest drying percentage in types Sieraleon and Maran. Maximum oleoresin content was in Rio-de-Janeiro and lowest in Thinladium. Rio-de-Janeiro accounted the maximum crude fibre content whereas it was minimum in Maran.

Helmi et al. (1975) observed that oil and oleoresin yields of ginger increased with tuber age. Refrigerated storage for upto four weeks did not affect quality but storage at room temperature had adverse effects.

Nambudiri et al. (1975) concluded that the gingerol content in oleoresin was maximum in Narasapattom (36.8%) followed by Thingpuri (31.3%), Sieraleon (27.9%) and Thinladium (16.5%).

Guenther (1975) considered Jamaican ginger as the finest grade, possessing the most delicate aroma and flavour. The Cochin quality ranked second. It exhibited a characteristic lemon-like by-note which was responsible for the preference of Cochin ginger by some people even to that of Jamaican ginger. West African ginger was usually considered to rank third. Of all ginger grades, it possessed the greatest pungency and gave the highest yield of essential oil.

Mathai (1976) studied the seasonal variations in the chemical constituents of spice cultivars and found that oleoresin, starch and essential oil content increased with increase in maturity whereas the crude fibre content decreased with maturity in the case of pepper.

7. Pests and diseases.

Trujillo (1963) isolated Fusarium oxysporum from diseased ginger which was pathogenic to healthy rhizomes. Hot-water treatment at temperatures and times below the thermal death point of the rhizome failed to kill the fungus. Temperature at 50°C for ten minutes controlled root knot nematodes in ginger rhizomes.

Kannan and Nair (1965) reported that losses due to the attack of rhizome-rot caused by Pythium aphanidermatum to the crop even ranged from 80-90 per cent in serious cases.

Aiyadurai (1966) reported that treating the seeds and soil at the time of planting with Cheshunt compound (one ounce in two gallons of water) at 0.25 pint per pit or wettable Ceresan 0.1 per cent at 0.25 pint per pit was found to be effective in the control of soft-rot disease. He also found that spraying the crop with Bordeaux mixture (4:4:50) could control the leaf-spot disease of ginger. Nair (1969) expressed that the type Maran was comparatively tolerant to soft-rot disease while Rio-de-Janeiro was quite susceptible.

Sarma and Nambiar (1974) found that the incidence of soft-rot was 22.78 per cent in plots treated with Aureofungin at 200 ppm and 28.34 per cent in those treated with 0.1 per cent Captafol as against 68.88 per cent in control. They also reported that the leaf-spot incidence was least in plots treated with Thiram 0.1 per cent followed by Carbendazin (0.1).

Sarma et al. (1975) showed that the incidence of soft-rot disease was the least in ginger types Jorhat and Sieraleon (11.25) as against 82 per cent in Kuruppampady. Nair (1975) concluded that the type Maran was significantly superior with regard to the tolerance to rhizome-rot. China was the most susceptible to the above disease.

Sarma et al. (1976) reported that methoxyethyl mercuric chloride treated plots recorded significantly less incidence of soft-rot (10.8) in ginger. Brahma and Nambiar (1976)

recorded least incidence (4%) of leaf-spot in plots treated with Maneb plus zinc and Bordeaux mixture one per cent.

Kumar (1977) observed wilting and rhizome-rot characterised by premature drooping, wilting, yellowing and drying of plants in patches or in whole bed. The basal portions were discoloured, shrunken and sometimes watery. The causal organism was identified as Fusarium solani Mart.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was undertaken from April 1977 to June 1978 at the Research Station and Instructional Farm, College of Horticulture, Vellanikkara with a view to screen out the ginger types based on quantity, quality and relative tolerance to pests and diseases. An attempt was also made to verify the quality variations at different maturity levels.

The field trial was undertaken in loamy laterite soil of moderate fertility. The topography of the land was fairly level and quite uniform with good drainage facilities.

1. Design and layout.

Design	5 x 5 lattice
Number of types	25
Number of replications	4
Total number of plots	100
Net plot size	3m x 1m
Gross plot size	3.6m x 1.6m = 5.76 sq.m. inclusive of 30 cm channel all round.
Total experimental area	688 sq.m.
Spacing	25cm x 25cm
Total number of plants per plot	48

2. Types.

The following are the 25 ginger types selected for the study:

T1 - Valluvanad

T2 - Vengara

T3 - Ernad Chernad

T4 - Ernad Manjeri

T5 - Wynad Local

T6 - Wynad Kunnamangalam

T7 - Bajpai

T8 - Karakal

T9 - Taiwan

T10 - Tafingiva

T11 - Sieraleon

T12 - Thodupuzha

T13 - Maran

T14 - Rio-de-Janeiro

T15 - Wynad Manantody

T16 - Kuruppampady

T17 - Arippa

T18 - Thingpuri

T19 - Utter Pradesh

T20 - Himachal Pradesh

T21 - Jorhat

T22 - Narasapattom

T23 - Nadia

T24 - China

T25 - Assam

A total of four blocks accommodating four replications having 25 plots in each replication were laid out. Boundaries, both outer and in between replications were also provided.

3. Cultivation.

The land was ploughed four times and beds of 3m x 1m with 20cm height and 30cm channel around each bed were formed.

Ginger rhizomes of 25 selected types from the germplasm collection of the college were utilized as planting material. The rhizomes were soaked for 30 minutes in 0.25 per cent Agallol-3 solution to which was added Ekalux at the rate of 1 ml for 2 l of solution and spread under shade to drain the water. Those treated seed rhizomes were used for planting. The selected seed rhizomes were cut into bits of 15 g weight each bit having one or two viable, healthy buds. They were spaced at 25cm x 25cm. Planting was done on 3rd May 1977. The four types i.e., Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local which were selected for studying the quality variations at different periods of maturity were planted in separate plots.

Mulching was undertaken twice at the rate of 15 tonnes and 7.5 tonnes of green leaves per hectare; first at the time

of planting and the second 45th day after planting. Earthing up was done twice.

Organic manure in the form of cattle manure was applied as basal dressing at the rate of 5 tonnes per hectare. The dose of fertilizer applied was 100, 100 and 200 kg of N, P_2O_5 and K_2O per hectare respectively.

Weeding was done four times during the cropping season.

As a precaution against soft-rot disease, soil drenching was done with Agallol-3 (1 ml/l) 60 days after planting followed by prophylatic spraying with Dimecron (1 ml/l) and Cuman (3 ml/l) against shoot-borer attack and leaf-spot disease respectively. The crop was again sprayed with Dimecron and Dithane-Z-78 (2 g/l) on 120th day after planting as the borer attack and leaf-spot disease were noticed. Along with second spraying soil drenching was also done with Thiride (1 g/l) as a prophylatic measure against soft-rot disease. Drenching with Cheshunt compound was done on 18th August 1977 when rhizome-rot was observed. It was repeated on 16th September and 28th October 1977 followed by spraying with Dimecron and Dithane-Z-78.

The crop was harvested on 13th January 1978 (i.e. on 255th day after planting) when most of the tillers had dried up. Ten labelled plants were lifted individually for detailed studies and the rest of the plants per bed were harvested for

recording the total yield. In the case of types selected for evaluating quality variations at different periods of maturity, harvesting was done at 15 days interval starting from 154th day of planting.

4. Sampling technique.

The entire population was considered for recording the germination and flowering percentage and rhizome-rot, leaf-spot, and shoot-borer incidence. Random sampling technique was adopted to select the sample plants for studying the various morphological characters such as height, number of tillers and number of leaves per plant, length of petiole, number and length of roots, number, length, girth, number of nodes per finger and internodal length of primary and secondary fingers for recording yield per plant and to study the chemical aspects such as oleoresin, oil, and crude fibre. Ten plants were selected at random from each plot eliminating the border rows for recording the above data. In the case of ginger types selected for studying quality variations at different periods of maturity, four plants were harvested at random from each type to constitute one sample. Four such samples were collected at each time of harvest to find out the yield, oleoresin, oil and crude fibre.

5. Pre-harvest studies.

5.1 Germination.

The number of plants germinated out of the 48 rhizome

bits planted in the individual plots were recorded to work out the germination percentage.

5.2 Height of the plant.

The height of the main pseudostem of the selected ten plants from each plot was recorded. Measurement was taken from the base of the main pseudostem up to the tip of the topmost leaf.

5.3 Number of tillers per plant.

The number of tillers were determined by counting the number of aerial shoots that had arisen from the rhizome.

5.4 Number of leaves per tiller.

Ten tillers were randomly selected from each of the plant and the number of leaves of those tillers were recorded separately. The number of leaves per tiller was then determined by calculating their mean.

5.5 Number of leaves per plant.

The number of leaves per clump was determined by multiplying the mean number of leaves per tiller with the number of tillers per clump.

5.6 Length, width and leaf area index of last fully opened leaf.

The length of the leaf from the base to the tip of the last fully opened leaf of the main tiller was measured. The breadth of the leaf was also measured at the centre similarly.

The leaf area index calculated was the product of length and breadth obtained as detailed above.

5.7 Length of petiole.

The petiole length of bottom most leaf was measured from the top of the rhizome up to the base of that leaf.

5.8 Percentage of flowering.

The number of plants flowered per plot was recorded and the percentage was calculated based on the total number of plants in that plot.

5.9 Length of inflorescence stalk.

From each plot, ten inflorescences were selected at random for measuring the length.

5.10 Length of inflorescence.

The length was measured from the base of the first bract to the tip of the inflorescence.

5.11 Number of developed flowers per inflorescence.

The number of developed flowers were determined by counting the number of flowers that were opening in each inflorescence. All the flowers were not developed and opened.

5.12 Soft-rot incidence.

The incidence of rhizome-rot caused by Pythium aphanidermatum was recorded, four times during the growth period. The percentage of infection was worked out, noting the number of plants infected, out of the total number of plant population in each plot.

5.13 Leaf-spot incidence.

The leaf-spot caused by Phyllosticta zingiberi was catagorized into four stages based on the number of spots on the leaf, i.e., light - 0ito 5 spots, medium - 6 to 15 spots, severe - 16 to 40 spots and very severe - more than 40 spots. They were given numericals for statistical analysis (light - 0, medium - 1, severe - 2 and very severe - 3). From each observation plant, ten leaves were randomly selected for taking observation.

5.14 Incidence of shoot-borer attack.

The number of shoot-borer (Dichochrosis punctiferalis) attacked tillers per clump was counted and the percentage of shoot-borer attacked tillers per plant was worked out.

6. Post-harvest studies.

6.1 Number and length of roots per plant.

The total number of roots produced from the rhizomes of each observation plant was recorded separately and their mean was calculated. Five roots were selected at random from each plant for measuring their length.

6.2 Primary and secondary fingers.

(i) Number of primary and secondary fingers. The number of rhizomes originating from the seed rhizome were counted and recorded as the number of primary fingers per plant. The rhizomes originating from the primary fingers were considered as the secondary fingers.

(ii) Number of nodes per finger, length, breadth and internodal length of primary and secondary fingers.

Five primaries and five secondaries were selected at random from each plant for recording the finger characteristics. The number of nodes on each primary and secondary finger was counted and recorded separately. The length was measured and the internodal length calculated. The girth at bottom, middle and top portions were measured similarly and the mean was found out.

6.3 Yield of rhizome.

The individual plant yield was recorded by taking the average weight of rhizome obtained from the ten selected plants. The plot yield was recorded by taking the weight of the entire rhizome harvested from individual plots of size 3 sq.m. and expressed as net yield per plot. Yield per hectare was calculated by converting the gross yield per plot (5.76 sq. m.) into hectare basis and expressed as gross yield per hectare.

6.4 Dry ginger production.

(1) Percentage of dry ginger recovery. Immediately after harvest, 10 kg of fresh rhizome was taken from each type and dried in the sun. Drying was continued to get a constant weight and from the final weight, the percentage of dry ginger was worked out. But in the case of types selected for quality evaluation at different periods of maturity, the percentage of dry ginger recovery was worked out by drying the complete rhizomes (each sample constituting rhizomes from four plants) harvested at different stages.

(ii) Dry ginger production per hectare. It was calculated on the basis of the percentage of dry ginger obtained by drying 10 kg samples of green ginger and multiplying the gross yield of green ginger by the ratio and expressed as gross yield of dry ginger.

6.5 Chemical analyses.

(i) Sample preparation. Samples of 150 g of dried rhizome were taken and ground in a grinding mill to obtain particles of about 500 micron size. Undue heating of the mill was avoided during grinding. It was mixed carefully to avoid stratification and transferred to the previously dried sample container and immediately closed. Grinding was done on the same day of analysis.

(ii) Moisture content of samples. The moisture content was determined by adopting the method given in the Indian Standard Methods of Sampling and Test for Spices and Condiments (1974) using toluene as the extractant.

(iii) Oleoresin. Four samples per type representing four replications were taken for the test. The oleoresin percentage was determined as per the Official Analytical Methods of the American Spice Trade Association (1960) using the Soxhlet method of extraction. The oleoresin production per hectare was calculated based on the dry ginger production per hectare and the percentage recovery of oleoresin.

(iv) Essential oil. Essential oil was extracted by water distillation adopting Clevenger trap method as per ASTA (American Spice Trade Association, 1960) and expressed as percentage. The yield per hectare of oil was calculated by multiplying the dry ginger production per hectare with the percentage recovery of oil.

(v) Crude fibre content. The crude fibre content was estimated using the defatted ginger powder left after the extraction of oleoresin. For crude fibre analysis also the Official Analytical Methods of the American Spice Trade Association (1960) was followed.

7. Statistical analysis.

Analysis of variance and correlation coefficients were worked out as per the techniques suggested by Cochran and Cox (1950).

RESULTS

RESULTS

A detailed study of the growth characters and quality aspects of twenty five ginger types was carried out and the results of the investigation are presented below. The analysis of variance tables for different characters are given in appendix.

1. Morphological characters.

Ginger belongs to the order scitaminae and family zingiberaceae. The plants are perennial herbs, persisting for a longer or shorter period by means of a rhizome which is a creeping, thick-jointed, branched, sympodial one. The branches grow obliquely upwards and develop leafy aerial shoots from their terminal bud.

The roots are long (9 to 14 cm) and each plant produces on an average 50 to 70 roots which are fleshy. The height of the plant varies depending upon the types and agroclimatic conditions. Generally the height varies between 53 to 72 cm. The aerial stem is oblique, invested by the smooth sheaths of the leaves.

The leaves are two-rowed, 12 to 30 cm long and 1.65 to 2.5 cm broad, bifarious, ovate-lanceolate, oblong-lanceolate or linear-lanceolate, very smooth above, glabrous underneath, gradually tapering to a point, the mid-rib prominent, laterals

parallel. The long sheath is produced upward into a bifid ligule.

The inflorescence develops from the rhizome along with a scale leaf. It forms a bracteate spike or raceme, each bract subtending a single flower with a lateral or obliquely posterior bracteole. The bracts are spirally arranged. The length of the stalk varies from 15 to 30 cm.

The details of the flower are given in Fig. 1.

The flowers are rather small, when compared to those of the other genera, yellowish green, zygomorphic, bisexual, epigynous, trimerous. The calyx is tubular or bell shaped, dividing above into three short teeth, and split on one side. The corolla is tubular below, but separates above into three subequal oblong to lanceolate connate segments less than 2.5 cm long.

The stamens are in two whorls of three each. The outer whorl is represented by three lateral staminodes. The inner staminal whorl is complete, the median (posterior) stamen is fertile, while the other two unite to form the labellum which forms the most conspicuous member in the flower because of its pink colour with yellow markings. Anther is two celled, the cells being contiguous, crowned with a long narrow curved tapering grooved crest.

Ovary is inferior, tricarpellary, syncarpous, ovules arranged on axile placenta. Style filiform and lies in a

channel along the fertile stamen, the stigma (funnel shaped, ciliate) projecting beyond the crest of the anther. Stigmatic hairs are present in groups.

Morphological and yield characters of 25 types of ginger are given in Table 1. Though there are differences in morphological characters such as height, number of tillers, number of leaves, length and breadth of leaves, leaf area index, number and length of roots and number, length, girth and internodal length of primary and secondary fingers among the types, it is difficult to classify them based on these characters. However, by constant observation of the rhizomes, the types can be identified to certain extent.

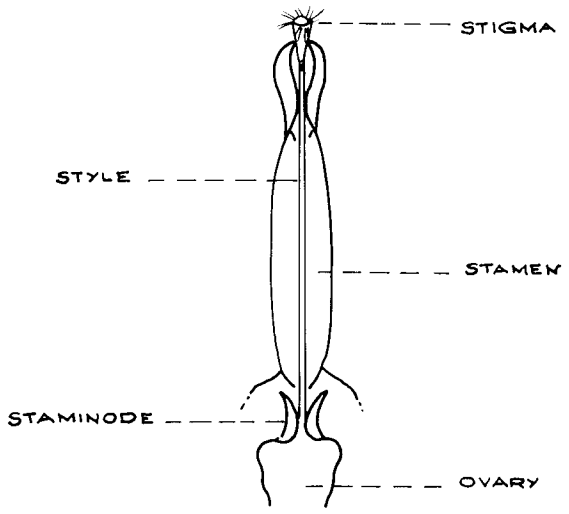
PLATE-I Inflorescence development of ginger.

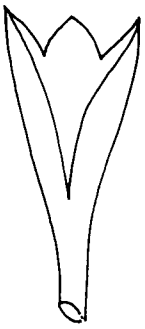
PLATE-II Stages of development of inflorescence in ginger.

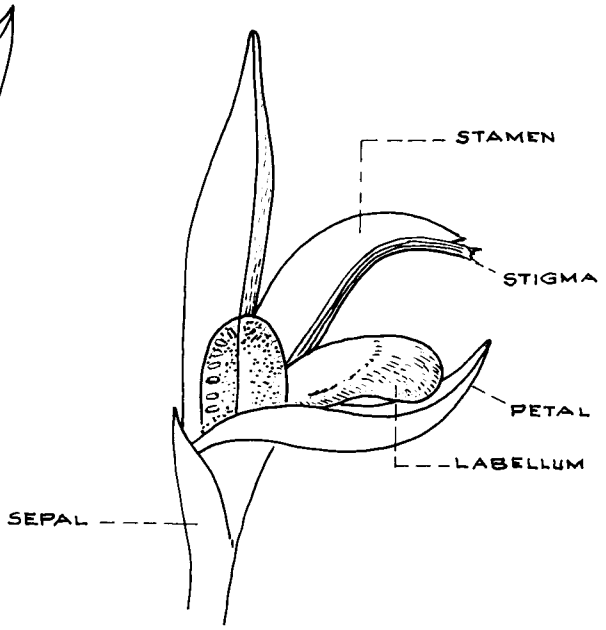
PLATE-III Opened flowers of ginger.


1
2
3
4

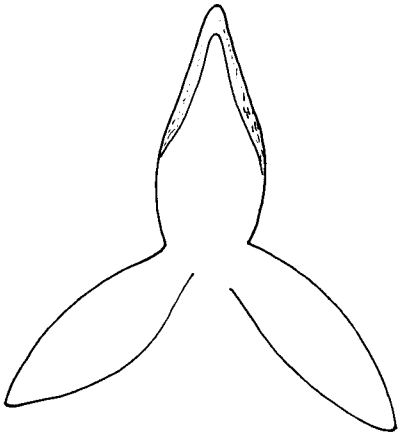
FIG. 1 . FLOWER STRUCTURE OF GINGER

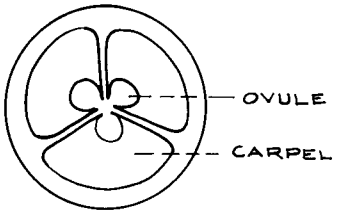



CALYX

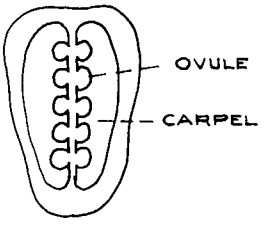


A FLOWER

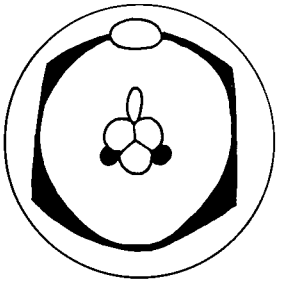

COROLLA



T.S. OF OVARY



L.S. OF OVARY



$\oplus, \varphi, K_{(3)}, C_{(3)} A_{1+5}, \bar{G}_{(3)}$

FLORAL DIAGRAM

Table 1a. Morphological and yield characters of ginger types.

Type/Characters	Ht. of plant		No. of tillers/plant		No. of leaves/tiller	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	71.55	67.3-74.0	23.99	19.6-27.0	20.28	19.5-21.5
Vengara	59.56	54.2-63.6	19.36	12.2-24.8	16.48	15.1-17.8
Ernad Chernad	69.96	56.0-81.8	21.21	19.8-22.1	15.13	10.7-17.9
Ernad Manjeri	64.75	54.4-69.2	20.48	17.1-24.9	14.31	12.4-17.6
Wynad Local	64.77	57.1-71.3	21.12	19.3-22.9	16.84	15.1-19.1
Wynad Kunnamangalam	60.09	55.6-66.2	25.06	20.3-35.1	16.78	13.2-19.1
Bajpai	68.07	54.7-79.2	22.91	18.9-24.9	16.93	15.5-17.5
Karakal	61.26	54.4-67.4	23.13	22.3-23.9	15.54	14.5-18.4
Taiwan	59.43	49.2-72.0	21.97	28.9-26.8	16.74	16.6-17.8
Tafingiva	66.05	59.2-72.5	16.24	13.3-17.4	13.81	12.8-15.3
Sieraleon	66.44	60.7-77.67	22.32	19.0-25.1	16.32	15.0-18.2
Thodupuzha	63.27	58.0-69.5	24.32	20.0-29.0	15.90	14.7-17.6
Maran	63.08	59.6-66.4	18.21	17.7-18.9	15.21	12.8-16.8
Rio-de-Janeiro	59.69	55.3-62.4	23.08	20.0-25.8	16.38	14.9-18.4
Wynad Manantody	63.72	59.6-66.1	24.67	19.5-29.2	16.13	14.0-17.4
Kuruppampady	62.33	57.9-66.8	23.00	21.3-26.2	15.63	14.9-16.7
Arippa	59.82	52.6-65.1	17.43	9.8-21.0	14.57	12.7-17.1
Thingpuri	53.05	49.8-55.5	18.24	16.2-21.7	16.05	14.1-17.9
Utter Pradesh	60.44	49.4-71.0	21.61	18.4-24.3	16.50	15.3-19.3
Himachal Pradesh	57.17	51.3-69.6	14.96	11.8-18.8	15.62	13.8-17.0
Jorhat	63.29	53.4-76.4	22.94	19.5-25.6	15.09	13.6-16.7
Narasapattom	62.33	55.0-67.3	22.74	20.6-24.5	16.02	15.3-16.9
Nadia	61.42	54.2-65.5	17.44	13.2-22.2	14.94	13.9-15.6
China	64.80	60.6-69.2	18.63	15.9-20.8	15.72	13.6-17.7
Assam	61.43	49.7-75.4	24.77	20.2-34.4	15.45	14.3-16.5

Table 1b. Morphological and yield characters of ginger types.

Types/Characters	Leaf area index		No. of roots/plant		Length of roots(cm	
	Mean	Range	Mean	Range	Mean	Range
Vabluvanad	35.45	31.5-39.2	103.11	89.1-113.5	13.90	13.3-15.0
Vengara	40.83	37.0-45.8	72.50	62.5- 85.1	12.23	11.7-12.9
Ernad Chernad	37.40	34.2-45.5	50.49	42.9- 65.4	13.35	12.3-16.0
Ernad Manjeri	52.95	38.9-63.5	43.03	29.0- 57.0	9.80	9.0-10.4
Wynad Local	34.68	30.7-36.9	52.02	37.1-72.7	8.65	8.2- 9.8
Wynad Kunnamangalam	38.40	29.0-44.6	46.58	26.3- 76.4	10.73	9.8-11.2
Bajpai	39.18	36.6-37.5	66.28	57.0- 75.1	10.85	10.4-11.8
Karakal	41.98	31.9-56.0	65.57	44.1- 95.6	9.23	8.0-10.2
Taiwan	37.55	35.8-39.0	72.51	56.7- 90.0	12.65	11.7-14.0
Tafingiva	41.20	36.8-46.2	48.27	33.5- 59.4	11.60	11.2-12.4
Sieraleon	39.10	36.2-41.6	100.11	83.7-117.6	12.98	11.2-15.1
Thodupuzha	40.75	30.0-45.5	78.90	29.6-121.3	12.05	10.9-13.0
Maran	41.23	32.6-53.3	63.02	53.5- 71.9	13.78	12.0-15.3
Rio-de-Janeiro	37.33	28.1-54.3	69.39	60.5- 84.4	12.58	12.1-13.2
Wynad Manantody	38.35	34.8-41.1	63.07	37.8- 81.3	14.58	12.9-18.1
Kuruppampady	33.73	28.4-36.6	71.07	65.3- 79.5	12.53	12.6-13.0
Arippa	43.60	35.9-51.7	54.89	45.[illegible]- 65.4	12.80	12.5-13.3
Thingpuri	28.45	26.6-29.9	22.38	20.6- 27.4	11.68	10.7-13.2
Utter Pradesh	38.35	31.6-41.6	46.05	30.1- 65.8	11.90	10.5-13.0
Himachal Pradesh	37.08	30.3-40.3	44.36	35.6- 59.5	12.58	10.9-13.8
Jorhat	36.25	32.4-43.1	55.64	36.1- 78.4	13.55	12.7-14.4
Narasapattom	40.80	34.8-48.0	44.56	33.5- 51.9	13.45	12.3-14.5
Nadia	43.28	37.6-48.2	36.95	27.2- 43.2	14.75	13.0-16.0
China	39.93	34.8-45.9	54.91	42.9-68.6	14.23	14.5-16.0
Assam	31.55	25.1-38.1	28.95	23.9- 33.4	12.23	11.8-12.8

Table 1c. Morphological and yield characters of ginger types.

Types/Characters	No. of primary fingers/plant		No. of nodes per primary finger		Length of primary fingers (cm)	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	8.55	7.2-10.0	5.44	5.30-5.68	6.19	5.81-6.60
Vengara	7.28	5.9- 8.1	5.69	5.60-5.90	6.05	5.91-6.15
Ernad Chernad	6.85	5.9- 8.1	5.87	5.18-6.47	5.87	5.51-6.29
Ernad Manjeri	7.68	7.0- 8.2	8.02	7.85-8.31	7.38	7.17-7.57
Wynad Local	9.08	7.9-10.9	6.77	6.36-7.08	7.16	6.94-7.43
Wynad Kunnamangalam	7.70	6.4- 8.9	6.70	6.40-7.04	7.35	6.89-7.96
Bajpai	8.30	6.8- 9.2	6.42	6.23-6.54	7.81	7.49-8.49
Karakal	5.98	5.1- 7.2	7.01	6.41-7.82	6.62	6.03-6.92
Taiwan	5.95	5.8- 6.1	6.43	6.24-6.78	6.58	6.24-7.38
Tafingiva	5.33	4.7- 6.5	5.90	5.73-5.98	5.90	5.73-6.14
Sieraleon	6.33	5.4- 7.0	6.45	5.91-6.87	6.55	6.05-7.25
Thodupuzha	4.78	2.9- 6.5	5.50	4.76-5.90	5.43	4.52-6.20
Maran	5.25	5.0- 5.8	5.63	5.42-5.94	5.88	5.73-6.17
Rio-de-Janeiro	5.50	5.1- 6.1	5.71	5.30-5.91	6.17	5.80-6.57
Wynad Manantody	5.00	3.8- 5.7	5.68	4.81-6.13	5.95	5.36-6.33
Kuruppampady	4.80	3.9- 5.6	6.05	5.73-6.60	6.15	6.02-6.22
Arippa	3.88	3.6- 4.2	5.69	5.28-5.94	5.84	5.69-5.99
Thingpuri	3.78	3.0- 4.6	5.93	5.50-6.40	5.85	5.40-6.70
Utter Pradesh	3.78	3.5- 4.1	5.51	4.98-6.00	5.47	5.02-5.93
Himachal Pradesh	4.40	3.4- 5.4	6.10	5.91-6.27	5.79	5.37-6.04
Jorhat	5.50	3.8- 7.6	6.18	5.86-6.71	5.70	5.57-5.87
Narasapattom	5.28	4.6- 6.2	5.90	5.80-6.17	5.83	5.29-6.37
Nadia	4.95	5.0- 5.4	6.33	6.15-6.69	6.24	6.14-6.42
China	4.68	3.4- 5.5	5.79	4.72-5.51	6.29	5.76-6.74
Assam	4.73	4.1- 5.3	6.15	6.05-6.22	6.14	6.04-6.20

Table 1d. Morphological and yield characters of ginger types.

Types/Characters	Internodal length of primary finger (cm)		Girth of primary finger (cm)		No. of secondary fingers/plant	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	1.18	1.12-1.26	6.73	6.60-6.90	23.75	18.6-27.4
Vengara	1.14	1.01-1.28	6.20	6.07-6.48	17.30	13.5-20.1
Ernad Chernad	0.96	0.05-1.05	6.50	6.28-6.73	19.00	15.0-21.7
Ernad Manjeri	0.96	0.88-0.99	6.96	6.82-7.12	18.33	16.4-19.5
Wynad Local	1.04	1.01-1.11	6.58	6.38-6.74	22.60	20.5-27.8
Wynad Kunnamangalam	1.10	1.05-1.18	6.71	6.07-7.19	21.33	15.0-28.0
Bajpai	1.10	1.07-1.16	7.32	6.81-7.82	28.45	25.4-35.1
Karakal	1.28	1.03-1.97	6.78	6.38-7.35	26.50	19.8-40.0
Taiwan	1.04	1.00-1.09	6.36	5.96-7.08	18.03	16.5-19.9
Tafingiva	1.07	1.03-1.14	8.21	7.97-8.40	21.33	18.4-25.5
Sieraleon	1.02	0.97-1.06	6.37	5.76-6.99	30.18	28.1-32.5
Thodupuzha	0.99	0.93-1.06	6.77	6.06-7.44	19.75	11.0-26.9
Maran	1.04	1.00-1.07	6.96	6.53-7.54	22.85	20.4-25.0
Rio-de-Janeiro	1.06	0.98-1.12	6.82	6.54-7.22	20.73	17.7-23.7
Wynad Manantody	1.05	1.02-1.09	6.55	5.68-6.99	18.98	13.2-22.1
Kuruppampady	1.07	1.04-1.09	6.76	6.47-7.27	22.38	16.5-29.9
Arippa	1.03	0.99-1.11	6.95	6.56-7.39	15.78	13.1-17.5
Thingpuri	0.98	0.98-1.05	5.96	4.60-6.55	11.85	9.0-15.9
Utter Pradesh	1.00	0.99-1.01	7.57	7.09-8.13	14.40	12.4-15.7
Himachal Pradesh	0.95	0.86-1.01	6.83	6.50-7.05	12.75	10.7-15.3
Jorhat	0.97	0.95-0.99	6.96	6.63-7.28	16.90	13.3-21.6
Narasapattom	0.99	0.95-1.03	6.94	6.30-7.21	21.63	18.6-24.1
Nadia	0.99	0.96-1.00	7.15	6.87-7.41	15.25	12.1-17.9
China	1.07	0.96-1.28	7.05	6.60-7.34	18.20	11.3-26.7
Assam	0.99	0.97-1.02	6.32	6.28-6.87	18.03	16.0-21.9

Table 1e. Morphological and yield characters of ginger.

Types/Characters	No. of nodes per secondary finger		Length of secondary fingers (cm)		Internodal length of secondary fingers (cm)	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	4.76	4.50-4.98	5.15	5.08-5.23	1.10	1.04-1.16
Vengara	5.19	4.64-5.80	5.49	5.21-5.80	1.21	1.15-1.29
Ernad Chernad	4.80	4.54-5.24	5.71	4.89-6.72	1.12	1.08-1.18
Ernad Manjeri	6.26	6.10-6.48	6.05	5.85-6.31	0.99	0.93-1.03
Wynad Local	6.13	5.74-6.48	6.31	5.89-6.76	1.01	0.94-1.06
Wynad Kunnamangalam	6.19	5.82-6.66	6.69	6.24-7.21	1.09	1.06-1.12
Bajpai	6.47	6.32-6.69	6.65	7.32-7.54	1.10	1.08-1.12
Karakal	6.46	6.34-6.54	6.67	6.47-6.82	1.03	0.98-1.06
Taiwan	6.26	6.04-6.86	6.05	5.86-6.79	0.99	0.97-1.02
Tafingiva	5.85	5.66-6.00	6.40	6.16-6.54	1.10	1.07-1.13
Sieraleon	5.96	5.78-6.34	5.97	5.78-6.34	0.99	0.93-1.01
Thodupuzha	5.49	5.20-5.76	5.66	4.57-5.91	0.96	0.84-1.03
Maran	6.58	6.40-6.98	6.87	6.23-7.79	1.04	0.97-1.19
Rio-de-Janeiro	6.28	5.96-6.52	6.36	6.11-6.66	1.04	1.03-1.06
Wynad Manantody	6.24	5.66-6.84	6.55	5.72-7.12	1.05	1.01-1.09
Kuruppampady	6.07	5.79-6.42	6.34	5.99-6.93	1.04	1.02-1.08
Arippa	5.65	5.31-6.01	5.76	5.31-6.01	1.01	0.98-1.03
Thingpuri	6.08	5.70-6.70	6.32	6.10-7.50	1.05	0.96-1.12
Utter Pradesh	5.89	5.64-6.40	5.62	5.35-6.19	0.96	0.92-0.99
Himachal Pradesh	5.83	5.70-6.00	5.54	5.35-5.76	0.95	0.94-0.96
Jorhat	5.87	5.76-5.98	5.83	5.55-6.12	0.99	0.95-1.02
Narasapattom	5.94	5.72-6.06	6.15	5.82-6.68	1.00	1.00-1.02
Nadia	6.04	5.78-6.36	6.23	5.98-6.68	1.03	1.02-1.05
China	5.62	5.50-6.10	5.88	5.40-6.54	1.04	1.01-1.07
Assam	6.41	6.36-6.50	6.62	6.34-6.78	1.03	0.99-1.05

Table 1f. Morphological and yield characters of ginger types.

Types/Characters	Girth of secondary fingers (cm)		Incidence of soft-rot (%)		Incidence of shoot-borer (%)	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	6.68	6.40-6.90	11.90	7.61-15.38	43.53	31.48-54.71
Vengara	6.47	6.05-6.70	3.40	1.41- 5.29	36.36	29.03-41.30
Ernad Chernad	6.36	6.07-6.88	6.53	3.54- 8.69	33.38	20.81-47.79
Ernad Manjeri	5.84	5.48-6.00	6.41	4.31- 9.36	30.38	23.39-42.97
Wynad Local	5.76	5.46-6.22	3.50	1.49- 5.73	32.90	28.78-37.31
Wynad Kunnamangalam	6.05	5.86-6.41	10.60	3.91-15.18	24.71	17.73-35.00
Bajpai	6.50	6.23-6.86	5.32	2.34- 7.30	35.48	16.40-50.20
Karakal	5.90	5.77-5.99	5.10	1.81- 9.01	29.63	24.66-37.23
Taiwan	5.00	4.85-5.18	23.40	12.96-36.08	28.64	23.32-32.80
Tafingiva	7.01	6.80-7.28	26.40	15.61-42.91	31.34	27.07-38.18
Sieraleon	5.48	5.15-6.17	4 .20	3 .71-6 .89	30.08	19.81-54.21
Thodupuzha	5.17	4.70-5.38	11.60	10.01-13.12	26.05	16.07-33.46
Maran	5.76	5.45-5.91	3.20	0.00- 7.19	26.93	22.53-36.50
Rio-de-Janeiro	6.43	5.71-8.36	27.50	18.28-36.37	21.33	17.00-24.03
Wynad Manantody	6.07	5.83-6.23	3.60	0.56- 8.29	31.56	13.49-57.43
Kuruppampady	5.60	5.00-6.41	3.60	1.50- 5.26	27.47	23.85-31.45
Arippa	5.24	4.19-5.75	4.81	3.21- 6.10	20.87	17.43-28.57
Thingpuri	5.33	5.01-5.81	6.93	2.43-11.45	27.72	22.89-33.33
Utter Pradesh	6.18	5.69-6.48	5.27	3.99-19.08	31.09	24.43-39.48
Himachal Pradesh	6.31	6.22-6.43	16.30	10.00-21.41	30.38	22.03-38.19
Jorhat	5.73	5.53-5.93	7.41	2.35-17.50	40.26	31.22-45.64
Narasapattom	5.73	5.78-6.15	4.01	3.00- 7.20	32.57	16.96-43.20
Nadia	6.28	6.08-6.53	7.50	3.57-10.81	39.11	28.22-68.63
China	6.28	5.54-7.36	10.70	7.64-19.38	37.70	30.20-50.90
Assam	5.52	5.24-5.68	7.20	6.43-12.35	37.12	19.80-69.43

Table 1g. Morphological and yield characters of ginger types.

Types/Characters	Yield/hectare of green ginger (kg)		Drying percentage		Yield/hectare of dry ginger (kg)	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	19134	17199-21097	18.60	16.96-20.69	3559	3199-3924
Vengara	11380	5602-16000	19.60	17.93-21.48	2231	1098-3136
Ernad Chernad	18267	13900-26000	20.00	18.64-21.89	3653	2780-5200
Ernad Manjeri	19531	13102-23199	21.60	18.86-23.77	3669	2830-5011
Wynad Local	19943	13902-25402	18.40	17.63-19.59	4219	2558-4674
Wynad Kunnamangalam	18057	13701-27000	22.40	20.84-23.54	4045	3069-6048
Bajpai	23585	17500-33199	21.60	20.60-22.02	5094	3780-7171
Karakal	20182	15599-26401	15.20	13.64-16.28	3068	2371-4013
Taiwan	10915	6802-13500	21.20	19.83-23.46	2314	1442-2862
Tafingiva	7517	4000-19698	17.60	15.60-18.84	1323	704-3502
Sieraleon	10750	6000-14500	21.60	20.80-22.43	2322	1296-3132
Thodupuzha	8479	2802-13698	25.20	23.97-25.31	2120	706-3452
Maran	25210	18700-28800	20.00	17.69-22.80	5042	3740-5760
Rio-de-Janeiro	17656	16602-18801	18.60	15.93-19.66	3284	3088-3497
Wynad Manantody	12250	7799-15500	19.40	17.61-21.55	2377	1513-3007
Kuruppampady	9571	8600-13300	23.00	21.54-24.83	2201	1978-3059
Arippa	7743	4000-12101	22.80	20.15-24.42	1765	912-2759
Thingpuri	8523	3799-14402	19.40	18.17-21.03	1653	737-2212
Utter Pradesh	5297	3902- 6701	21.40	20.16-22.29	1134	835-1434
Himachal Pradesh	7278	4801- 9199	22.10	20.63-23.74	1608	1061-2033
Jorhat	17049	12902-19701	21.40	20.01-22.81	3648	2761-4216
Narasapattom	23536	20902-25618	20.40	19.53-21.36	4801	4264-5226
Nadia	28544	22602-31801	22.60	20.84-23.92	6453	5108-7187
China	9549	5100-19200	21.00	18.80-22.31	2005	1071-4032
Assam	11786	3900 -23300	18.00	16.94-19.07	2122	702-4194

Table 1h. Morphological and yield characters of ginger types.

Types/Characters	Oleoresin percentage		Yield/hectare of oleoresin (kg)		Ginger oil percentage	
	Mean	Range	Mean	Range	Mean	Range
Valluvanad	8.78	8.21-9.00	312	292-320	2.20	1.90-2.43
Vengara	5.85	5.42-6.24	130	121-139	2.30	1.53-3.42
Ernad Chernad	5.98	4.93-7.04	218	180-257	1.72	1.01-2.43
Ernad Manjeri	8.09	6.81-9.53	342	250-350	1.75	1.64-1.91
Wynad Local	9.14	7.54-10.91	335	318-460	1.60	1.23-2.41
Wynad Kunnamangalam	6.52	5.84-6.90	264	236-279	1.49	1.04-2.62
Bajpai	9.22	7.82-10.63	470	398-541	1.48	1.03-1.96
Karakal	6.23	5.61-6.72	191	172-206	2.40	2.24-2.64
Taiwan	5.98	5.51-6.82	138	128-156	1.66	1.43-1.90
Rafingiva	7.92	6.51-10.40	105	86-138	0.74	0.61-1.04
Sieraleon	5.83	5.13-6.84	135	125-160	1.70	1.04-2.41
Thodupuzha	6.38	5.82-6.90	135	123-146	1.62	1.23-2.43
Maran	10.05	9.43-10.91	504	475-550	1.94	1.70-2.23
Rio-de-Janeiro	10.53	7.81-13.84	346	256-455	2.30	0.33-2.71
Wynad Manantody	4.91	3.51-6.13	167	83-146	1.94	1.70-2.24
Kuruppampady	8.00	6.03-10.71	176	133-236	1.79	1.42-1.90
Aripps	5.42	4.92-6.00	96	87-106	1.70	1.43-1.90
Thingpuri	7.42	7.22-7.64	123	119-126	2.20	1.90-2.42
Utter Pradesh	6.05	5.23-6.54	69	59-74	1.25	0.80-1.71
Himachal Pradesh	5.39	5.02-5.73	87	81-92	0.57	0.10-1.70
Jorhat	6.26	5.80-6.61	228	212-241	1.72	1.53-1.90
Narasapattom	6.79	6.61-6.92	326	317-332	1.25	0.84-1.70
Nadia	5.41	4.01-7.24	349	259-467	1.48	1.11-1.90
China	7.00	5.54-9.63	140	111-193	1.90	1.90-1.90
Assam	7.29	6.30-7.91	155	134-168	2.20	1.70-2.72

Table 11. Morphological and yield characters of ginger types.

Types/Characters	Yield per hectare of ginger oil (kg)		Crude fibre percentage	
	Mean	Range	Mean	Range
Valluvanad	78.30	68-86	4.21	3.74-4.43
Vengara	51.75	34-76	4.45	4.31-4.82
Ernad Chernad	62.84	37-88	5.60	5.24-5.82
Ernad Manjeri	73.83	60-76	4.74	4.43-5.11
Wynad Local	62.38	52-102	5.75	5.64-5.90
Wynad Kunnamangalam	60.27	42-106	6.00	5.82-6.31
Bajpai	75.40	52-100	4.52	4.11-5.23
Karakal	71.78	69-81	5.70	5.64-5.91
Taiwan	39.11	33-44	4.65	4.42-5.11
Tafingiva	11.11	8-14	5.72	5.60-5.82
Sieraleon	39.94	24-56	4.87	4.61-5.50
Thodupuzha	36.46	26-52	4.46	4.33-4.81
Maran	97.82	86-112	6.17	5.74-7.13
Rio-de-Janeiro	62.72	11-89	5.60	5.23-5.84
Wynad Manantody	46.10	40-53	4.28	4.13-4.51
Kuruppampady	37.20	31-42	6.47	5.12-7.31
Arippa	30.01	25-34	4.07	3.80-4.51
Thingpuri	36.37	31-40	5.59	5.20-6.04
Utter Pradesh	14.17	9-19	3.79	3.32-4.31
Himachal Pradesh	12.71	2-28	3.89	3.50-4.21
Jorhat	62.75	56-69	4.45	3.93-4.61
Narasapattom	60.02	40-82	5.38	4.82-5.90
Nadia	95.51	72-123	3.90	3.54-4.40
China	38.10	38-38	3.47	3.32-3.50
Assam	47.10	36-58	5.82	5.21-6.33

Germination percentage, height, number of tillers, number and length of roots per plant of different ginger types are furnished in Table 2.

1.1 Germination.

It may be seen from the table that the types differ significantly at five per cent level in respect of germination percentage. The type Nadia recorded the maximum germination (98.43%) followed by Bajpai (97.39%), Kuruppampady (97.39%), Jorhat (96.35%) and Thingpuri (96.35%). But no significant difference was noticed among the above types. The lowest germination percentage of 82.81 was observed in China. The other types which were comparatively poor in germination are Arippa (86.97%), Himachal Pradesh (88.02%), Wynad Manantody (88.54%) and Rio-de-Janeiro (89.58%).

1.2 Height of the plant.

The statistical analysis of the data showed that the height of the plants varied significantly at five per cent level. There existed no significant difference among the types Valluvanad (71.55 cm), Ernad Chernad (69.96 cm), Bajpai (68.07 cm), Sieraleon (66.44 cm), Tafingiva (66.05cm), China (64.80 cm), Wynad Local (64.77 cm) and Ernad Manjeri (64.75 cm). The above types were significantly taller than the rest of the types. The type Thingpuri recorded the minimum height (53.05 cm) followed by Taiwan (59.43 cm),

Table 2. Growth characters of ginger types.
(Mean values)

Types	Germination per cent (45 days after planting)	Height of the plant (cm)	No. of tillers per plant	No. of roots per plant	Length of roots (cm)
Valluvanad	90.80	71.55	23.99	103.11	13.90
Vengara	93.25	59.56	19.36	72.50	12.23
Ernad Chernad	95.87	69.96	21.21	50.49	13.35
Ernad Manjeri	90.34	64.75	20.48	43.03	9.80
Wynad Local	92.70	64.77	21.12	52.02	8.65
Wynad Kunnamangalam	95.83	60.09	25.86	46.58	10.73
Bajpai	97.39	68.07	22.91	66.28	10.85
Karakal	91.66	61.26	23.13	65.57	9.23
Taiwan	95.83	59.43	21.97	72.51	12.65
Tafingiva	93.22	66.05	16.24	48.27	11.60
Sieraleon	94.27	66.44	22.32	100.11	12.98
Thodupuzha	92.18	63.27	24.32	78.90	12.05
Maran	91.14	63.08	18.21	63.02	13.78
Rio-de-Janeiro	89.58	59.69	23.08	69.39	12.58
Wynad Manantody	88.54	63.72	24.67	63.07	14.58
Kuruppampady	97.39	62.33	23.00	71.07	12.53
Arippa	86.97	59.82	17.43	54.89	12.80
Thingpuri	96.35	53.05	18.24	22.38	11.68
Utter Pradesh	95.31	60.44	21.61	46.05	11.90
Himachal Pradesh	88.02	57.17	14.96	44.36	12.58
Jorhat	96.35	63.29	22.94	55.64	13.55
Narasapattom	93.22	62.33	22.74	44.56	13.45
Nadia	98.43	61.42	17.44	36.95	14.75
China	82.81	64.80	18.63	54.91	14.23
Assam	94.79	61.43	24.77	28.95	12.23
F - value	1.68*	2.04*	3.02**	7.33**	7.17**
CD- (P = 0.05)	7.84	7.85	4.86	19.98	1.66

* Significant at 5% level.
** Significant at 1% level.

Vengara (59.56 cm) and Arippa (59.82 cm). The type Maran recorded 63.08 cm and Nadia 61.42 cm height which were on par with other tall types except Valluvanad and Ernad Chernad.

1.3 Number of tillers per plant.

The data show that the types vary significantly at one per cent level. The number of tillers per plant varied from 25.86 to 14.96. The type Wynad Kunnamangalam produced maximum number of tillers per plant (25.86) followed by Assam (24.77), Wynad Manantody (24.67), Thodupuzha (24.32) and Valluvanad (23.99). However, they did not show any significant difference among themselves. The lowest tiller production was in the type Himachal Pradesh (14.96); closely followed by Tafingiva (16.24), Arippa (17.43), Nadia (17.44) and Maran (18.21). They were not significantly different from one another.

1.4 Number of roots per plant.

Valluvanad produced the maximum number of roots per plant (103.11) closely followed by Sieraleon (100.11) which were significantly higher than the other types at one per cent level. Minimum number of roots were produced by the type Thingpuri (22.38) followed by Assam (28.95) and Nadia (36.95) which were statistically not significant.

1.5 Length of roots.

In respect of root length, Nadia ranked first with a measurement of 14.75 cm which showed no significant difference

from the types Wynad Manantody (14.58 cm), China (14.23 cm), Valluvanad (13.90 cm), Maran (13.78 cm), Jorhat (13.55 cm), Narasapattom (13.55 cm) and Ernad Chernad (13.35 cm). But they were significantly longer than the remaining types at one per cent level. Shortest roots were produced by the type Tafingiva (11.60 cm) closely followed by Thingpuri (11.68 cm)and Utter Pradesh (11.90 cm).

1.6 Leaf characters.

The average number of leaves per tiller per plant, the length of the petiole ofbottom-most leaf and the length, breadth and leaf area index of the last fully opened leaf of ginger types, recorded on 155th day after planting are presented in Table 3.

1.61 Number of leaves per tiller.

It was observed that Valluvanad tops the list with an average of 20.23 leaves per tiller which was significantly higher from the rest of the types at one per cent level. The number of leaves was minimum in Tafingiva (13.81) followed by Ernad Manjeri (14.31), Arippa (14.57) and Nadia (14.94). Statistical analysis showed that there was no significant difference among the remaining 21 types.

1.6.2 Number of leaves per plant.

The data indicated that there existed highly significant variation among the types with respect to the number of

Table 3. Leaf characters of ginger types.
(Mean values)

Types	No. of leaves/ tiller	No. of leaves/ plant	Length of petiole (lowest leaf) (cm)	Length (cm)	Breadth (cm)	Leaf area index (lxb)
Valluvanad	20.28	471.19	13.79	18.63	1.91	28.35
Vengara	16.48	331.48	11.90	19.26	2.12	32.66
Ernad Chernad	15.13	321.64	12.15	18.48	2.02	29.90
Ernad Manjeri	14.31	289.96	11.75	21.88	2.41	42.34
Wynad Local	16.84	360.17	11.43	17.33	2.00	27.72
Wynad Kunnamangalam	16.76	452.97	11.98	18.06	2.12	30.72
Bajpai	16.93	398.02	9.98	18.76	2.09	31.34
Karakal	15.54	438.02	12.06	18.51	2.25	33.55
Taiwan	16.74	369.68	10.95	18.15	2.05	30.03
Tafingiva	13.81	221.69	11.77	18.44	2.23	32.96
Sieraleon	16.32	362.80	11.25	19.78	2.04	31.28
Thodupuzha	15.90	388.91	12.54	18.78	2.17	32.60
Maran	15.21	273.37	12.95	19.50	2.10	32.98
Rio-de-Janeiro	16.38	376.22	12.73	17.78	2.29	29.85
Wynad Manantody	16.13	394.57	11.27	18.04	2.13	30.68
Kuruppampady	15.63	354.90	11.46	17.41	1.95	26.99
Arippa	14.57	258.63	11.58	18.95	2.35	34.89
Thingpuri	16.05	287.13	10.40	16.25	1.81	22.76
Utter Pradesh	16.50	357.52	10.67	17.85	2.18	30.69
Himachal Pradesh	15.62	232.83	11.48	18.42	2.01	29.64
Jorhat	15.09	345.98	10.54	18.41	2.01	28.99
Narasapattom	16.02	361.47	12.00	19.41	2.15	32.62
Nadia	14.94	254.63	12.64	20.15	2.19	34.64
China	15.72	288.89	11.39	18.96	2.14	31.95
Assam	15.45	379.04	11.16	16.71	1.92	25.26
F - value	2.64**	3.98**	0.88^{NS}	2.35**	1.60^{NS}	0.74^{NS}
CD - (P = 0.05)	2.12	95.86	2.57	2.10	0.30	10.51

NS Not significant.
** Significant at 1 level.

leaves per plant. Maximum number of leaves per plant was produced by the type Valluvanad (471.19) followed by Wynad Kunnamangalam (452.97) and Karakal (438.02) whereas Tafingiva recorded the least number of 221.69 leaves per plant followed by Himachal Pradesh (232.83), Nadia (254.63), Arippa (258.63) and Maran (273.37).

1.6.3 Length of petiole.

There was practically no difference in petiole length among the 25 types of ginger studied. But the length was comparatively high in Valluvanad (13.79 cm), Maran (12.95 cm), Rio-de-Janeiro (12.73 cm), Nadia (12.64 cm) and Thodupuzha (12.54 cm). It was minimum in Bajpai (9.98 cm) followed by Thingpuri (10.40 cm), Jorhat (10.54 cm) and Utter Pradesh (10.67 cm).

1.6.4 Length of leaf.

With regards to the length of leaf, the types differed significantly at one per cent level. Ernad Manjeri with a length of 21.88 cm ranked first followed by Nadia (20.15 cm), Sieraleon (19.78 cm), Maran (19.50 cm) and Narasapattom (19.41 cm). But the latter two have significantly short leaves as compared to the former three types. Minimum length of 16.25 cm was recorded in the type Thingpuri followed by Assam (16.71 cm) and Wynad Local (17.33 cm) which did not differ significantly among themselves but are highly significant from the other types.

1.6.5 Breadth of leaf.

The data showed that there was no significant difference among types in respect of the breadth of leaf. Maximum breadth was observed in Ernad Chernad (2.41 cm) followed by Arippa (2.35 cm), Rio-de-Janeiro (2.29 cm), Tafingiva (2.23 cm) and Nadia (2.19 cm). Minimum breadth was recorded in Thingpuri (1.81 cm) followed by Valluvanad (1.91 cm), Assam (1.92 cm) and Kuruppampady (1.95 cm).

1.6.6 Leaf area index.

The leaf area index varied from 22.76 to 42.34. But the variation was statistically not significant. The types Ernad Manjeri, Arippa, Nadia and Karakal showed higher leaf area index while it was less in Thingpuri, Assam, Kuruppampady and Valluvanad.

1.7 Flowering characteristics.

Flowering characteristics such as flowering percentage, number of inflorescence per plant, number of flowers per inflorescence, length of inflorescence and length of inflorescence stalk are given in Table 4. They were not statistically analysed because, some of the types have not flowered which resulted in incomplete data.

The type Wynad Local had the highest flowering percentage of 11.71 followed by Assam (10.94%) and Rio-de-Janeiro (10.14%). Stray flowering was noticed in Nadia (0.52%),

Table 4. Flowering characters of ginger types.
(Mean values)

Types	Flowering per cent	No. of inflores-cence per plant	No. of flowers per inflo-rescence	Length of inflo-rescence (cm)	Length of inflo-rescence stalk (cm)
Valluvanad	6.57	1.15	12.56	4.79	11.46
Vengara	2.49	0.50	6.00	4.40	14.15
Ernad Chernad	4.94	1.42	16.12	4.83	11.85
Ernad Manjeri	1.11	0.50	10.00	5.45	19.55
Wynad Local	11.71	1.95	14.06	4.69	11.68
Wynad Kunna-mangalam	1.60	0.35	16.20	4.84	19.64
Bajpai	7.43	2.93	14.80	4.82	10.20
Karakal	6.03	1.50	13.13	3.25	12.69
Taiwan	0.53	0.25	7.00	3.75	12.70
Tafingiva	0.63	0.50	14.50	5.30	17.20
Sieraleon	2.92	1.00	11.83	4.98	10.18
Thodupuzha	NF	NF	NF	NF	NF
Maran	1.19	0.50	12.50	4.50	15.00
Rio-de-Janeiro	10.14	1.40	12.57	4.61	13.05
Wynad Manantody	6.06	1.93	15.27	5.00	10.46
Kuruppampady	5.30	1.91	15.47	4.85	10.67
Arippa	0.61	0.25	9.00	4.10	17.15
Thingpuri	NF	NF	NF	NF	NF
Utter Pradesh	1.14	0.83	11.63	4.19	13.85
Himachal Pradesh	NF	NF	NF	NF	NF
Jorhat	8.15	1.50	15.00	5.09	12.28
Narasapattom	1.14	0.50	9.50	4.35	10.25
Nadia	0.52	2.00	15.25	4.37	10.66
China	0.74	0.25	15.00	5.30	16.10
Assam	10.94	0.65	12.85	4.63	10.51

NF Not flowered.

NB Observations recorded on 155th and 200 th day after planting.

Taiwan (0.53), Arippa (0.61), Tafingiva (0.63) and China (0.74) whereas the types Thodupuzha, Thingpuri and Himachal Pradesh had not flowered.

1.7.1 Number of inflorescence per plant.

The number of inflorescence per plant ranged from 2.93 to 0.25, the maximum number being recorded in Bajpai followed by Nadia (2) and the least in China, Arippa and Taiwan (0.25).

1.7.2 Number of flowers per inflorescence.

With regards to the number of flowers per inflorescence, the type Wynad Kunnamangalam ranked first with an average number of 16.20 which was closely followed by Ernad Chernad (16.12). Minimum number of flowers was produced by the type Vengara (6) followed by Taiwan (7) and Arippa (7).

1.7.3 Length of inflorescence.

It may be seen from the table that the longest inflorescence was produced by Ernad Manjeri (5.45 cm). The other types with comparatively long inflorescence were China (5.30cm), Tafingiva (5.30 cm), Jorhat (5.09 cm) and Wynad Manantody (5cm). The minimum length of 3.25 cm was recorded in Karakal followed by Taiwan (3.75 cm), Arippa (4.10 cm), Utter Pradesh (4.19 cm) and Naracapattom (4.35 cm).

1.7.4 Length of inflorescence stalk.

It was observed that there existed considerable variation between types in respect of the above character. Maximum

stalk length was observed in Wynad Kunnamangalam (19.64 cm) followed by Ernad Manjeri (19.55 cm), Bajpai (10.20 cm) and Narasapattom (10.25 cm).

1.8 Primary finger characters.

Number of fingers per plant, length of fingers, number of nodes per finger, internodal length and girth are presented in Table 5.

1.8.1 Number of fingers per plant.

The mean values presented in the table show that the number of primary fingers per plant was maximum in Wynad Local (9.11) followed by Valluvanad (8.62), Bajpai (8.29) and Wynad Kunnamangalam (7.72). The number was less in Thingpuri (3.75), Utter Pradesh (3.76) and Arippa (3.91). But the difference in number of fingers was statistically not significant. Nadia had 4.89 number of primary fingers and Maran 5.21.

1.8.2 Length of fingers.

The variation in length of fingers was significant at one per cent level. As regards the length, Bajpai tops the list with an average of 7.81 cm, but not significantly different from the types Ernad Manjeri, Wynad Kunnamangalam and Wynad Local. There was no significant difference among the remaining types except the type Thingpuri (5.47 cm) which was significantly inferior to the other 24 types. The length was 6.24 cm in Nadia and 5.85 cm in Maran which were not significantly different from Bajpai.

Table 5. Primary finger characters of ginger types.
(Mean values)

Types	No. of fingers per plant	Length (cm)	No. of nodes per finger	Internodal length (cm)	Girth (cm)
Valluvanad	8.62	6.19	7.94	1.18	6.73
Vengara	7.31	6.05	5.68	1.14	6.20
Ernad Chernad	6.83	5.87	5.86	0.96	6.50
Ernad Manjeri	7.67	7.38	7.84	0.96	6.96
Wynad Local	9.11	7.16	6.75	1.04	6.59
Wynad Kunnamangalam	7.72	7.35	6.71	1.10	6.71
Rajpai	9.29	7.81	6.42	1.10	7.32
Karakal	5.91	6.62	7.01	1.28	6.77
Taiwan	5.89	6.58	6.68	1.04	6.36
Tafingiva	5.31	5.90	5.90	1.07	8.11
Sieraleon	6.37	6.55	6.46	1.02	6.37
Thodupuzha	4.79	5.43	5.50	0.99	6.77
Maran	5.21	5.88	5.63	1.04	7.00
Rio-de-Janeiro	6.47	6.17	5.70	1.06	6.81
Wynad Manantody	5.01	5.95	5.65	1.05	6.54
Kuruppampady	4.86	6.15	6.06	1.07	6.76
Arippa	3.91	5.84	5.69	1.03	6.95
Thingpuri	3.75	5.85	5.93	0.98	5.96
Utter Pradesh	3.76	5.47	5.51	1.00	7.57
Himachal Pradesh	4.43	5.79	6.10	0.95	6.83
Jorhat	5.53	5.70	6.19	0.97	6.97
Narasapattom	5.27	5.83	5.90	0.99	6.94
Nadia	4.89	6.24	6.40	0.99	7.40
China	4.63	6.29	5.78	1.07	7.05
Assam	4.72	6.12	6.14	0.99	6.53
F - value	1.46^{NS}	11.46**	12.96**	2.00*	4.76**
CD - (α = 0.05)	1.22	0.52	1.54	0.20	0.59

NS Not significant.
* Significant at 5 level.
** Significant at 1 level.

1.8.3 Number of nodes per finger.

It was observed that the types differed significantly at one per cent level in this respect. Though the type Valluvanad with an average of 7.94 nodes ranked first, there was no significant difference from the types Ernad Manjeri (7.83), Karakal (7.01), Wynad Local (6.75), Wynad Kunnamangalam (6.71), Taiwan (6.68), Sieraleon (6.46) and Bajpai (6.42) and Nadia (6.40). Minimum number of nodes was produced by Thodupuzha (5.50) followed by Utter Pradesh (5.51) and Maran (5.63).

1.8.4 Internodal length.

Statistical analysis of the data revealed that the variation among types with regard to internodal length was significant only at five per cent level. The maximum length of 1.28 cm was recorded by the type Karakal followed by Valluvanad (1.18 cm), Vengara (1.14 cm), Wynad Kunnamangalam (1.10cm) and Bajpai (1.10 cm). They were significantly longer than the rest of the types, but the difference among them was not significant. The internodes were short in Himachal Pradesh (0.95 cm), Ernad Chernad (0.96 cm), Ernad Manjeri (0.96 cm), Jorhat (0.97 cm), Thingpuri (0.98 cm) and Nadia (0.99 cm).

1.8.5 Girth of fingers.

It may be seen from the table that there existed highly significant variation in girth of rhizomes among types. Maximum

girth was observed in the type Tafingiva (8.11 cm) followed by Utter Pradesh (7.57 cm), Nadia (7.40 cm) and Bajpai (7.32cm). The type Thingpuri (5.96 cm) recorded the minimum girth followed by Vengara (6.20 cm) and Sieraleon (6.37 cm).

1.9 Secondary finger characters.

Characters of secondary finger such as number of fingers per plant, length of finger, number of nodes per finger, internodal length and girth are furnished in Table 6.

1.9.1 Number of fingers per plant.

The data showed that the number of secondary fingers per plant varied significantly at one per cent level. The type Sieraleon produced the maximum number (30.4) of secondary fingers followed by Bajpai (28.38), Karakal (26.41) and Maran (24.81). But there was no significant difference among them. The least number of 11.87 fingers was produced by Thingpuri followed by Himachal Pradesh (12.84). Nadia produced only 15.24 fingers which was low.

1.9.2 Length of fingers.

As regards the length of secondary fingers there was significant variation among types at one per cent level. The type Bajpai had the longest finger (7.40 cm) followed by Maran (6.87 cm), Wynad Kunnamangalam (6.69 cm) and Karakal (6.67 cm). There was no significant difference between Bajpai and Maran but Bajpai differ significantly from the rest of the types.

Table 6. Secondary finger characters of ginger type.
(Mean values)

Types	No. of fingers per plant	Length (cm)	No. of nodes per finger	Inter-nodal length (cm)	Girth (cm)
Valluvanad	23.84	5.16	4.76	1.10	6.72
Vengara	17.32	5.49	5.19	1.21	6.54
Ernad Chernad	19.00	5.71	4.80	1.12	6.35
Ernad Manjeri	18.24	6.05	6.26	0.99	5.85
Wynad Local	22.67	6.31	6.13	1.01	5.78
Wynad Kunna-mangalam	21.32	6.69	6.19	1.09	6.06
Bajpai	28.38	7.40	6.47	1.10	6.54
Karakal	26.41	6.67	6.46	1.03	5.86
Thaiwan	17.86	6.23	6.26	0.99	4.98
Tafingiva	21.31	6.40	5.85	1.10	6.99
Sieraleon	30.34	5.97	5.96	0.99	5.50
Thodupuzha	19.75	5.21	5.49	0.96	5.21
Maran	24.81	6.87	6.58	1.04	5.73
Rio-de-Janeiro	20.62	6.36	6.28	1.04	5.66
Wynad Manantody	19.03	6.55	6.24	1.05	6.06
Kuruppampady	22.48	6.33	6.07	1.04	5.58
Arippa	15.81	5.67	5.65	1.01	5.25
Thingpuri	11.87	6.32	6.08	1.05	5.26
Utter Pradesh	14.34	5.62	5.89	0.96	6.13
Himachal Pradesh	12.84	5.54	5.83	0.95	6.26
Jorhat	16.98	5.83	5.87	0.99	5.76
Narasapattom	21.64	6.15	5.94	1.00	5.79
Nadia	15.24	6.23	6.04	1.03	6.26
China	18.12	5.88	5.62	1.04	6.27
Assam	18.09	6.62	6.41	1.03	5.53
F - value	5.38**	7.06**	11.25**	7.00**	9.00**
CD - (P = 0.05)	5.53	0.56	0.40	0.06	0.48

** Significant at 1% level.

The type Valluvanad produced the shortest fingers with an average length of 5.16 cm followed by Thodupuzha (5.21 cm) and Vengara (5.49 cm). Nadia had a length of 6.33 cm which was significantly shorter than Bajpai and Maran and on par with other types.

1.9.3 Number of nodes per finger.

The types which produced comparatively more number of nodes per secondary finger were Maran (6.58), Bajpai (6.47), Karakal (6.46) and Assam (6.41). The difference among them was not significant. Nadia recorded 6.04 nodes which was comparatively high but was significantly lesser than Maran. The number of nodes was less in Valluvanad (4.76), Ernad Chernad (4.80) and Vengara (5.19). The data showed that the types differed significantly at one per cent level.

1.9.4 Internodal length.

With regard to the internodal length, the type Vengara (1.21 cm) produced secondary fingers with longest internodes followed by Ernad Chernad (1.12 cm), Valluvanad (1.10 cm), Bajpai (1.10 cm) and Tafingiva (1.10 cm). The type Himachal Pradesh produced the shortest internodes which had a mean length of 0.95 cm followed by Thodupuzha (0.96 cm) and Utter Pradesh (0.96 cm). Statistical analysis showed highly significant difference among types. The internodes of Maran (1.04 cm) and Nadia (1.03 cm) were also comparatively long.

1.9.5 Girth of fingers.

The mean girth of the secondary finger which varied from 5.21 cm to 6.99 cm showed significant difference among types at one per cent level. Maximum girth was recorded in the case of Tafingiva (6.99 cm) followed by Valluvanad (6.72cm), Vengara (6.54 cm) and Bajpai (6.54 cm) which were statistically not different. The type Nadia recorded a mean girth of 6.26 cm which did not differ significantly from the other types except Tafingiva and Valluvanad. The types such as Thodupuzha (5.21 cm), Arippa (5.25 cm), Thingpuri (5.26 cm) and Sieraleon (5.50 cm) produced fingers with comparatively small girth.

2. Incidence of pests and diseases.

Percentage of soft-rot infection, percentage of shoot-borer infected tillers per plant and incidence of leaf-spot disease are presented in Table 7.

2.1 Percentage of soft-rot infection.

Among the 25 cultivars, the type Rio-de-Janeiro showed maximum susceptibility (27.50%) to soft-rot disease followed by Tafingiva (26.40%), Taiwan (23.40%) and Himachal Pradesh (16.30%). The infection was very mild in the types Maran (3.20%), Vengara (3.40%), Wynad Local (3.50%), Wynad Manantody (3.60%) and Kuruppampady (3.60%). The incidence was medium in Bajpai (5.32%) and Nadia (7.50%).

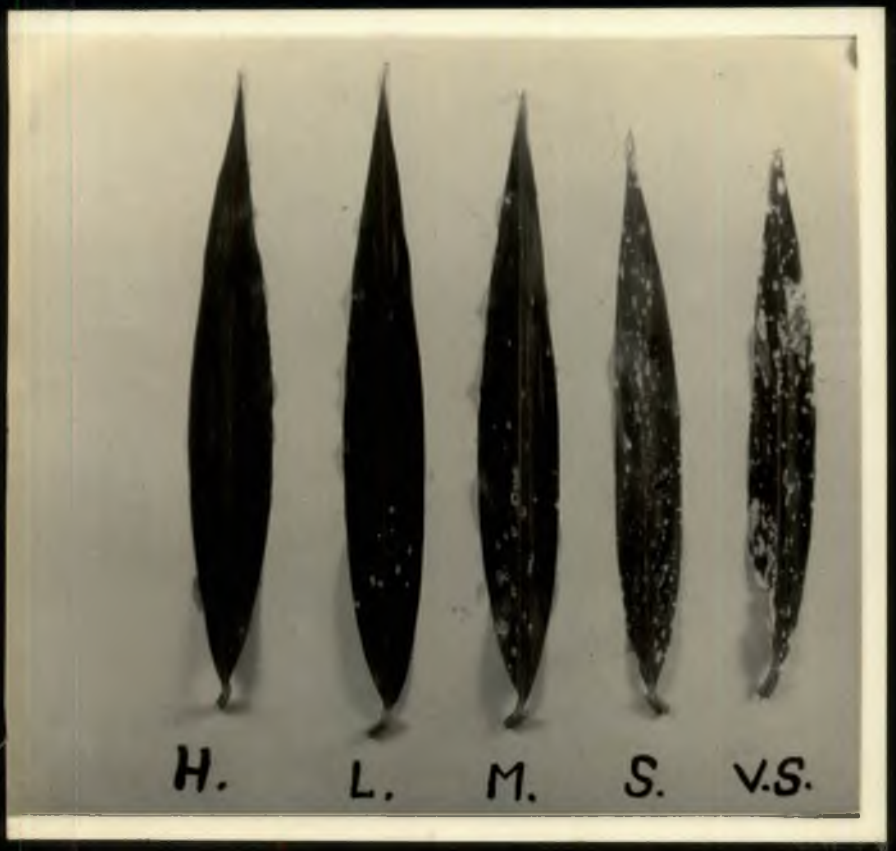
Table 7. Incidence of pests and diseases.
(Mean values)

Types	Percentage of soft-rot infection	Percentage of shoot-borer infected tillers per plant	Incidence of leaf-spot
Valluvanad	11.90	43.40 (41.22)	1.69 (1.64)
Vengara	3.40	36.30 (37.03)	1.34 (1.53)
Ernad Chernad	6.53	32.90 (35.04)	1.37 (1.54)
Ernad Manjeri	6.41	30.20 (33.32)	1.04 (1.43)
Wynad Local	3.50	32.80 (34.97)	1.04 (1.43)
Wynad Kunnamangalam	10.60	24.30 (29.54)	1.28 (1.51)
Bajpai	5.32	34.80 (36.14)	1.07)(1.44)
Karakal	5.10	29.50 (32.92)	0.96 (1.40)
Taiwan	23.40	28.50 (32.29)	1.86 (1.69)
Tafingiva	26.40	31.20 (33.99)	0.80 (1.34)
Sieraleon	4 .20	29.40 (32.82)	1.19 (1.48)
Thodupuzha	11.60	25.80 (30.50)	1.50 (1.58)
Maran	3.20	26.90 (31.22)	1.19 (1.48)
Rio-de-Janeiro	27.50	21.30 (27.46)	1.43 (1.56)
Wynad Manantody	3.60	30.50 (33.52)	0.90 (1.38)
Kuruppampady	3.60	27.50 (31.60)	0.96 (1.40)
Arippa	4.81	24.70 (29.82)	1.72 (1.65)
Thingpuri	6.93	27.70 (31.72)	1.69 (1.64)
Utter Pradesh	5.27	31.00 (33.81)	1.37 (1.54)
Himachal Pradesh	16.30	30.20 (33.34)	1.13 (1.46)
Jorhat	7.41	40.20 (39.34)	1.22 (1.49)
Narasapattom	4.01	32.13 (34.49)	1.76 (1.66)
Nadia	7.50	38.80 (38.54)	1.34 (1.53)
China	10.70	37.60 (37.80)	1.19 (1.48)
Assam	7.20	36.50 (37.16)	1.22 (1.49)
F - value		1.59^{NS}	4.00^{**}
CD- (F = 0.05)		7.38	0.14

NS Not significant.
** Significant at 1% level.
Values within brackets are angular transformed ones.
Values within brackets are expressed as $\sqrt{x+1}$

PLATE-IV Incidence of leaf-spot disease (*Phyllosticta zingiberi*).

H - Healthy (no spots)
L - Light (1 to 5 spots)
M - Medium (6 to 15 spots)
S - Severe (16 to 40 spots)
VS - Very severe (more than 40 spots)


H.
L.
M.
S.
V.S.

2.2 Percentage of shoot-borer infected tillers per plant.

No significant difference was found among the types for the shoot-borer infection. The types Valluvanad (43.40%), Jorhat (40.20%), Nadia (38.80%), China (37.60%), Assam (36.50%) and Vengara (36.30%) were more susceptible to shoot-borer attack. It was also noticed that the types Rio-de-Janeiro (21.30%), Wynad Kunnamangalam (24.30%), Arippa (24.70%) and Thodupuzha (25.80%) were comparatively more tolerant than other types.

2.3 Incidence of leaf-spot disease.

The data on the incidence of leaf-spot was statistically analysed and highly significant variation among types was observed. Taiwan (1.69) was found to be the most susceptible type to leaf-spot followed by Narasapattom (1.66), Arippa (1.65), Valluvanad (1.64), Thingpuri (1.64), Thodupuzha (1.58) and Rio-de-Janeiro (1.56). No significant difference existed among themselves. The type Tafingiva (0.80) recorded the least incidence of leaf-spot which was on par with Karakal (0.96), Kuruppampady (0.96), Ernad Manjeri (1.43), Wynad Local (1.43), Bajpai (1.44) and Himachal Pradesh (1.46).

3. Yield characters.

The data on yield per plant, net yield per bed, dryage, projected yield per hectare of green ginger and dry ginger are furnished in Table 8.

Table 8. Yield characters of ginger types.
(Mean values)

Types	Yield/ plant (g)	Net yield per bed (3 sq. m) (kg)	Drying percentage	Projected gross yield per hectare	
				Green ginger (kg)	Dry ginger (kg)
Valluvanad	498.63	11.02	18.60 (25.55)	19133.68	3558.86
Vengara	364.00	6.56	19.60 (26.28)	11380.21	2230.52
Ernad Chernad	423.25	10.52	20.00 (26.56)	18267.36	3653.47
Ernad Manjeri	469.00	11.49	21.60 (27.69)	19942.78	3669.47
Wynad Local	411.88	11.25	18.40 (25.40)	19531.25	4218.75
Wynad Kunnamangalam	369.13	10.40	22.40 (28.25)	18057.29	4044.83
Bajpai	417.25	13.59	21.60 (27.69)	23585.07	5094.38
Karakal	426.13	11.63	15.20 (22.95)	20182.29	3067.71
Taiwan	296.00	6.29	21.20 (27.42)	10914.93	2313.97
Tafingiva	440.75	4.33	17.60 (24.80)	7517.36	1323.06
Sieraleon	361.25	6.19	21.60 (27.69)	10750.00	2322.00
Thodupuzha	267.63	4.88	25.20 (30.13)	8479.17	2119.79
Maran	402.13	14.52	20.00 (26.56)	25210.07	5042.01
Rio-de-Janeiro	376.08	10.17	18.60 (25.55)	17656.25	3284.06
Wynad Manantody	381.98	7.06	19.40 (26.13)	12250.00	2376.50
Kuruppampady	351.53	5.51	23.00 (28.66)	9571.18	2201.37
Arippa	251.88	4.46	22.80 (28.52)	2743.06	1765.42
Thingpuri	260.80	4.91	19.40 (26.13)	8522.57	1653.38
Utter Pradesh	317.53	3.05	21.40 (27.56)	5296 .88	1133.53
Himachal Pradesh	276.93	4.19	22.10 (28.04)	7277.78	1608.39
Jorhat	365.83	9.82	21.40 (27.56)	17048.61	3648.40
Narasapattom	415.68	13.56	20.40 (26.85)	23536.46	4801.44
Nadia	465.55	16.45	22.60 (28.38)	28553.82	6453.16
China	422.00	5.50	21.00 (27.28)	9548.61	2005.21
Assam	349.15	6.79	18.00 (25.10)	11786.46	2121.56
F - value	3.75**	9.78**	3.61**		
CD - (P = 0.05)	98.37	3.59	4.60		

** Significant at 1 level.
NB Values within brackets are angular transformed ones.
Net yield was calculated on the basis of the actual area occupied by the plants whereas for the calculation of gross yield, the entire area including boundaries, drainage channels, foot path etc. were taken into consideration.

3.1 Yield per plant.

Observations on yield per plant showed marked differences among the types. The type Valluvanad with 498.63 g of green ginger per plant ranked first which was not superior from the types Ernad Manjeri (469.00 g), Nadia (465.55 g), Tafingiva (440.75 g), Karakal (426.13 g) and Ernad Chernad (423.25 g). Maran had an yield of 402.13 g per bed which was significantly lower from the above types. The type Arippa (251.88 g) was the least in the list followed by Thingpuri (260.80 g), Utter Pradesh (317.53 g) and Assam (349.15 g). No significant variation was recorded among them.

3.2 Net yield per bed.

The analysis of the data on yield per bed showed significant variation at one per cent level. Maximum yield per bed of 16.45 kg was recorded in the type Nadia followed by Maran (14.52 kg), Bajpai (13.59 kg) and Narasapattom (13.56kg) which were not significantly different. The type Utter Pradesh (3.05 kg) was found to be the poorest in yield which was on par with Himachal Pradesh (4.19 kg), Tafingiva (4.33 kg), Arippa (4.46 kg), Thodupuzha (4.88 kg) and Thingpuri (4.91kg).

3.3 Percentage of dry ginger recovery.

With regard to the percentage of dry ginger recovery, the type Thodupuzha was the first in the list with a dryage of 25.20 per cent which showed no statistical difference from the types Kuruppampady (23.00 %), Arippa (22.80 %), Nadia (22.60 %),

Wynad Kunnamangalam (22.40%), Himachal Pradesh (22.10%), Bajpai (21.60%), Ernad Manjeri (21.60%) and Sieraleon (21.60%). But the type Maran (20.00%) was inferior to Thodupuzha. Drying per cent was minimum in Karakal (15.20%) followed by Tafingiva (17.60%), Assam (18.00%), Wynad Local (18.40%), Rio-de-Janeiro (18.60%) and Valluvanad (18.60%). The above types did not differ significantly.

3.4 Yield of green ginger.

The gross yield of green ginger per hectare followed the same pattern as that of yield per bed. The maximum yield was 28553.82 kg in the type Nadia and minimum in Utter Pradesh (5296.88 kg).

3.5 Yield of dry ginger.

In the case of yield of dry ginger also the type Nadia ranked first with an average yield of 6453.16 kg of dry ginger per hectare followed by Bajpai (5094.36 kg), Maran (5042.01 kg), Narasapattom (4801.44 kg) and Wynad Local (4218.75 kg). The minimum yield of 1133.53 kg was recorded by the type Utter Pradesh closely followed by Tafingiva (1323.06 kg), Himachal Pradesh (1608.39 kg), Thingpuri (1653.38 kg) and Arippa (1765.42 kg). This is illustrated in Fig. 2.

4. The important chemical constituents.

The percentage of oleoresin, essential oil, crude fibre

FIG. 2 . COMPARISON OF GROSS YIELD PER HECTARE OF DRY GINGER OF DIFFERENT GINGER TYPES.

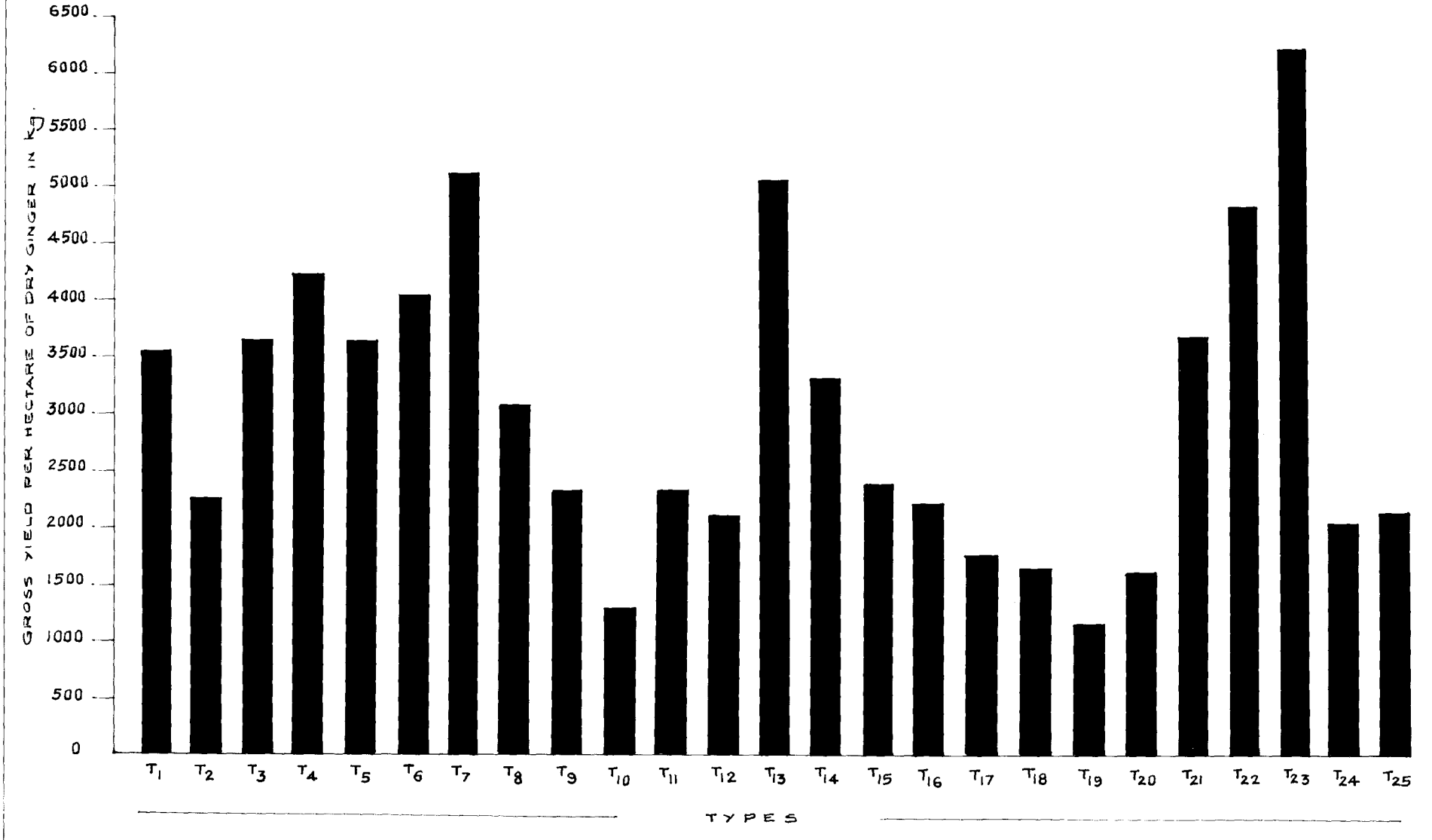


PLATE-V Rhizomes of the ginger type Nadia.

PLATE-VI Rhizomes of the ginger type Bajpai.


Nadiya


Bajpai

PLATE-VII Rhizomes of the ginger type Maran.

PLATE-VIII Rhizomes of the ginger type Narasapattom.


Maran


Narasapattom

and the projected yield per hectare of oleoresin and oil are given in Table 9.

4.1 Oleoresin.

The data on oleoresin percentage revealed that the types differed significantly at one per cent level. Rio-de-Janeiro gave 10.53 per cent oleoresin which was the maximum and on par with Maran (10.05%). But they varied significantly from the remaining types. Bajpai (9.22%), Wynad Local (9.14%) and Valluvanad (8.78%) were the other types high in oleoresin content. Oleoresin recovery was minimum in the type Wynad Manantody (4.91%) followed by Himachal Pradesh (5.39%), Arippa (5.42%), Sieraleon (5.83%), Vengara (5.85%), Ernad Chernad (5.98%) and Taiwan (5.98%). The above types did not differ significantly. The oleoresin content of Nadia was only 5.41 per cent which was comparatively low.

4.2 Yield of oleoresin.

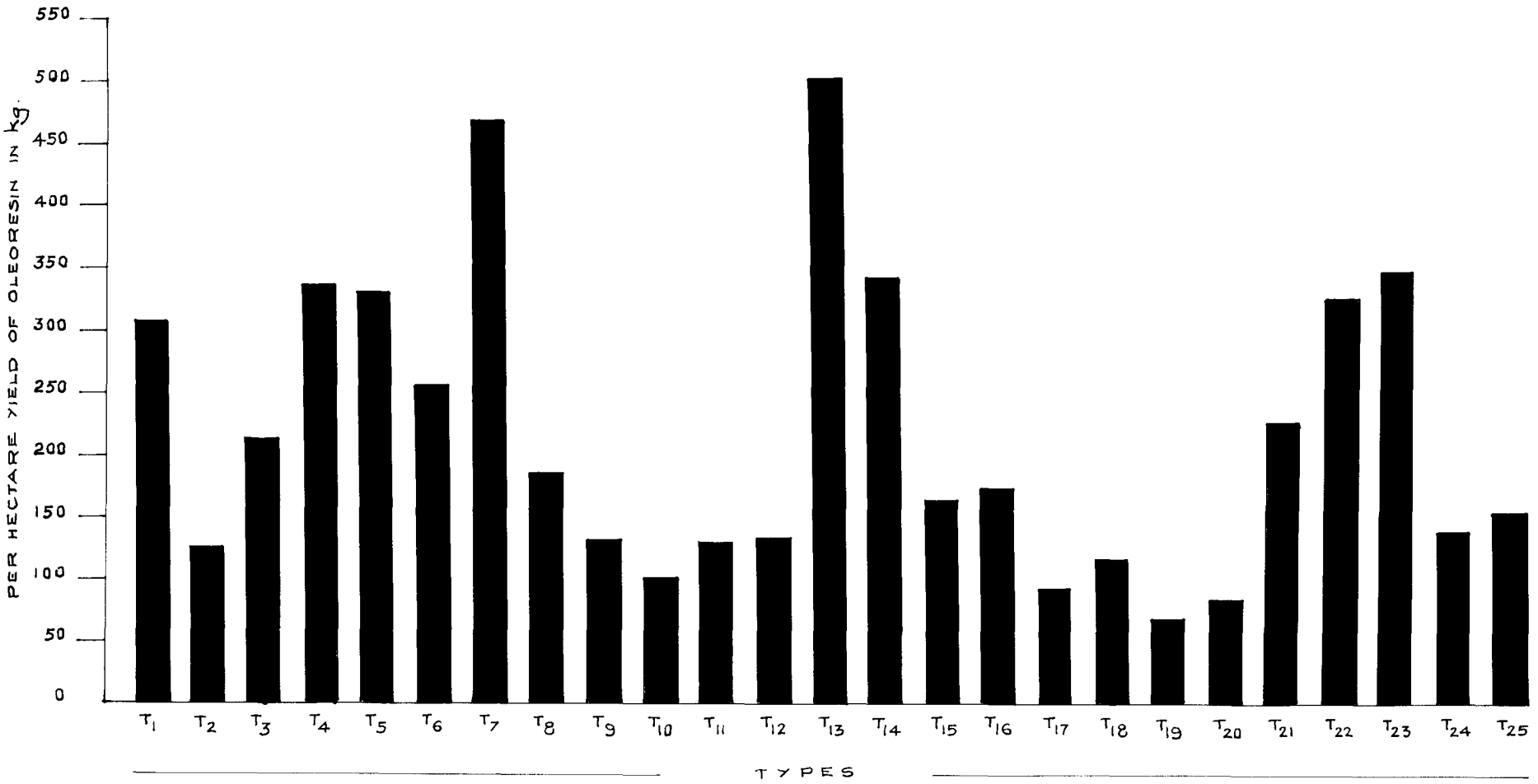
The yield of oleoresin per hectare is illustrated in Fig. 3. Though the percentage recovery of oleoresin was high in Rio-de-Janeiro, it was observed that the type Maran yielded the maximum quantity (504.20 kg) of oleoresin per hectare. It was followed by the types Bajpai (469.70 kg), Nadia (349.12 kg), Rio-de-Janeiro (345.81 kg) and Ernad Manjeri (341.72 kg). Oleoresin production per hectare was least in

Table 9. Oleoresin, oil and crude fibre content of different ginger types and their projected yield per hectare.
(Mean values)

Types	Oleoresin percentage	Yield of oleoresin per ha. (kg)	Ginger oil percentage	Yield of oil per hectare (kg)	Crude fibre percentage
Valluvanad	8.78 (17.23)	312.47	2.20 (8.52)	78.30	4.21 (11.85)
Vengara	5.85 (13.97)	130.49	2.30 (8.72)	51.75	4.45 (12.17)
Ernad Chernad	5.98 (14.08)	218.48	1.72 (7.46)	62.84	5.60 (13.66)
Ernad Manjeri	8.09 (16.46)	341.72	1.75 (7.56)	73.83	4.74 (12.57)
Wynad Local	9.14 (17.55)	335.39	1.60 (7.21)	62.38	5.75 (13.84)
Wynad Kunnamangalam	6.52 (14.77)	263.72	1.49 (6.76)	60.27	6.00 (14.24)
Bajpai	9.22 (17.64)	469.70	1.48 (6.71)	75.40	4.52 (12.15)
Karakal	6.23 (14.41)	191.12	2.40 (8.91)	71.78	5.70 (13.81)
Taiwan	5.98 (14.08)	138.38	1.66 (7.39)	39.11	4.65 (12.45)
Tafingiva	7.92 (16.25)	104.79	0.74 (4.92)	11.11	5.72 (13.83)
Sieraleon	5.83 (13.92)	135.37	1.70 (7.49)	39.94	4.87 (12.76)
Thodupuzha	6.38 (14.59)	135.24	1.62 (7.37)	36.46	4.46 (12.14)
Maran	10.05 (18.45)	504.20	1.94 (8.06)	97.82	6.17 (14.35)
Rio-de-Janeiro	10.53 (18.78)	345.81	2.30 (8.72)	62.72	5.60 (13.71)
Wynad Manantody	4.91 (12.71)	166.69	1.94 (7.85)	46.10	4.28 (11.93)
Kuruppampady	8.00 (16.31)	176.11	1.79 (7.62)	37.20	6.47 (14.71)
Arippa	5.42 (13.43)	95.69	1.70 (7.48)	30.01	4.07 (11.60)
Thingpuri	7.42 (15.79)	122.68	2.20 (8.52)	36.37	5.59 (13.67)
Utter Pradesh	6.05 (14.20)	68.58	1.25 (6.47)	14.17	3.79 (11.16)
Himachal Pradesh	5.39 (13.42)	86.69	0.57 (4.34)	12.71	3.89 (11.30)
Jorhat	6.26 (14.48)	228.39	1.72 (7.53)	62.75	4.45 (12.13)
Narasapattom	6.79 (15.09)	326.02	1.25 (6.47)	60.02	5.38 (13.35)
Nadia	5.41 (13.35)	349.12	1.48 (6.99)	95.51	3.90 (11.39)
China	7.00 (15.22)	140.37	1.90 (7.94)	38.10	3.47 (10.71)
Assam	7.29 (15.63)	154.66	2.22 (8.53)	47.10	5.82 (13.96)
F - value	7.00**		3.62**		23.64**
CD - (P = 0.05)	1.79		1.68		0.66

** Significant at 1 level.
NB Values within brackets are angular transformed ones.

FIG. 3 . COMPARISON OF YIELD PER HECTARE OF OLEORESIN OF DIFFERENT GINGER TYPES.



Utter Pradesh (68.58 kg) followed by Himachal Pradesh (86.69 kg) and Arippa (95.69 kg).

4.3 Essential oil.

Highly significant differences were noticed among the 25 types in essential oil recovery. Highest oleoresin content was recorded in the type Karakal (2.40%) followed by Vengara (2.30%), Rio-de-Janeiro (2.30%), Assam (2.22%), Valluvanad (2.20%) and Thingpuri (2.20%). Statistically, the above types were on par. The types Himachal Pradesh (0.57%), Tafingiva (0.74%), Narasapattom (1.25%) and Utter Pradesh (1.25%) were low in oil recovery but no significant difference was noticed among themselves.

4.4 Yield of oil.

With regard to yield of oil per hectare, the type Maran ranked first with an yield of 97.82 kg per hectare followed by Nadia (95.51 kg), Valluvanad (78.30 kg), Bajpai (75.40 kg) and Ernad Manjeri (73.83 kg). Minimum oil yield per hectare was recorded in Tafingiva (11.11 kg) followed by Himachal Pradesh (12.71 kg) and Utter Pradesh (14.17 kg).

4.5 Crude fibre content.

The data showed that the types differed significantly at one per cent level. The lowest fibre content was in China (3.47%) closely followed by Utter Pradesh (3.79%), Himachal Pradesh (3.89%), Nadia (3.90%), Arippa (4.07%) and Valluvanad

(4.21). The above types did not show any significant variation. Higher fibre content was recorded in the case of types such as Kuruppampady (6.47), Maran (6.17) and Wynad Kunnamangalam (6.00). But there was no statistical difference among themselves.

5. Correlation studies.

The correlation between yield and all other characters studied were worked out and the correlation coefficients for different characters are furnished in Table 10.

No significant correlation was found in the case of yield with the characters such as height of the plant, number of tillers per plant, number of leaves per plant, breadth of last fully opened leaf, number of nodes per primary finger and secondary finger, number of roots per plant and length of roots. Girth of secondary fingers and number of primary fingers showed a highly positive correlation with yield and highly negative correlation in the case of incidence of shoot-borer. Positive correlation at five per cent level was observed in the case of yield per plant with length of last fully opened leaf, leaf area index, length of leaf sheath, length of primary and secondary fingers and number of secondary fingers.

Table 10. Correlation coefficients for different variables.

Variables		Correlation coefficients (r)
X	Y	
Yield per plant	Height of the plant	+0.361^{NS}
"	No. of tillers per plant	+0.357^{NS}
"	No. of leaves per plant	+0.093^{NS}
"	Length of last fully opened leaf	+0.420*
"	Breadth of last fully opened leaf	+0.155^{NS}
"	Leaf area index	+0.386*
"	Length of petiole (lowest leaf)	+0.400*
"	No. of nodes per primary finger	+0.314^{NS}
"	No. of nodes per secondary finger	+0.043^{NS}
"	Length of primary finger	+0.418*
"	Length of secondary finger	+0.383*
"	Girth of primary finger	+0.413*
"	Girth of secondary finger	+0.624**
"	No. of primary fingers	+0.568**
"	No. of secondary fingers	+0.436*
"	No. of roots per plant	+0.095^{NS}
"	Length of roots	+0.010^{NS}
"	Flowering percentage	+0.291^{NS}
"	Intensity of shoot-borer attack	-0.523**

NS Not significant.
* Significant at 5% level.
** Significant at 1% level.

6. Quality difference at various stages of maturity.

Yield per bed of green ginger, dryage, gross yield per hectare of green and dry ginger, oleoresin, oil and fibre content and their projected yield per hectare at different stages of maturity in the case of Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local are estimated and presented in separate tables (Tables 11 to 19).

6.1 Yield of green ginger.

Tables 11 and 12 indicate that yield differ significantly at one per cent level at different maturity stages. In all the four types maximum yield was obtained at 180 days after planting followed by the fourth stage (210 days after planting). There was no significant difference between those two stages. The lowest yield was recorded during the sixth stage (240 days after planting) followed by seventh stage (255 days after planting) and they showed significant variation.

Table 11. Yield of green ginger at different stages of maturity.

Maturity stages in days after planting	Types				Mean
	Mean yield per bed (3 sq.m) in kg				
	Rio-de-Janeiro	Maran	Kuruppampady	Wynad Local	
165	22.80	16.05	16.95	14.40	17.55
180	23.34	22.73	31.35	24.30	25.43
195	21.90	18.53	19.65	18.23	19.58
210	21.59	19.41	27.15	16.47	21.16
225	17.27	15.24	25.62	21.36	19.87
240	8.90	9.50	9.44	6.15	8.50
255	13.68	12.69	17.25	16.08	14.93
270	20.82	11.94	15.84	17.76	16.59
F - value					10.70**
CD (P = 0.05)					4.45

** Significant at 1% level.

Table 12. Yield of green ginger at different stages of maturity.

Maturity stages in days after planting	Types			
	Gross yield/ha in kg (Mean values)			
	Rio-de-Janeiro	Maran	Kuruppampady	Wynad Local
165	39583.33	27864.58	29427.08	25000.00
180	40520.83	39453.13	54427.08	42187.50
195	38020.83	32161.46	34114.58	31640.63
210	37473.96	33697.92	47135.42	28593.75
225	29895.83	26458.33	44479.17	37083.33
240	15442.71	16484.38	16380.21	10677.08
255	23750.00	22031.25	30000.00	27916.67
270	36145.83	20729.17	27500.00	30833.33

6.2 Percentage of dry ginger recovery.

The data presented in Table 13 and Fig. 4 show that there existed highly significant variation in drying percentage at the different stages of maturity. The dry ginger recovery was highest during the last stage in all the cases. The drying percentage continued to increase as the maturity advanced. Although no significant difference was noticed between the last two stages, the differences in dryage among the other types were significant.

FIG. 4. DRYING PERCENTAGE AT DIFFERENT STAGES OF MATURITY

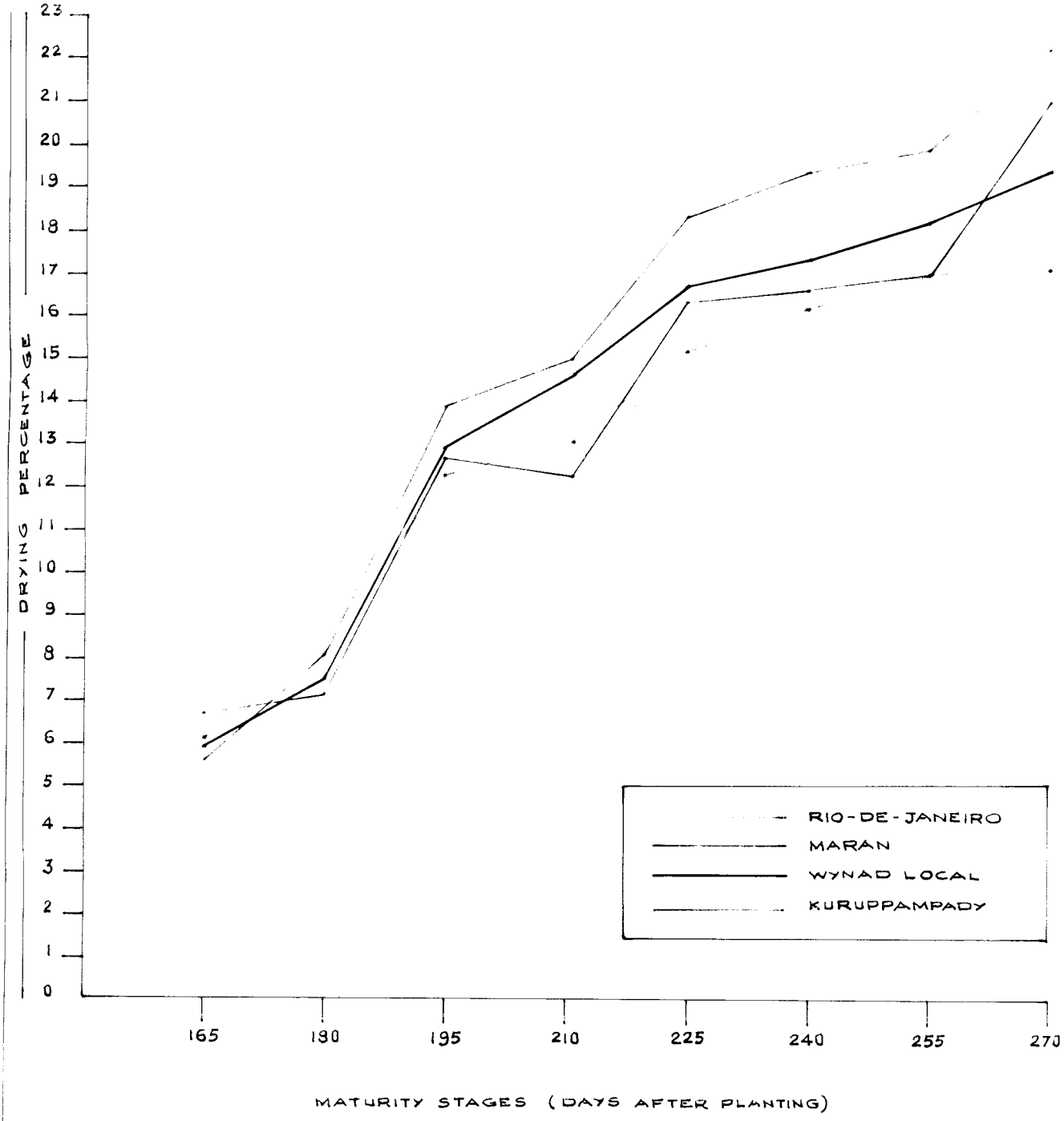


Table 13. Drying percentage at different stages of maturity.

Maturity stages in days after planting	Types — Drying percentage (Mean values)				Mean
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local	
165	6.07 (14.30)	5.65 (13.81)	6.75 (15.12)	5.97 (14.18)	6.11 (14.35)
180	7.98 (16.43)	8.10 (16.54)	7.28 (15.68)	7.54 (15.89)	7.73 (16.14)
195	12.42 (20.62)	14.10 (22.06)	12.14 (20.36)	13.12 (21.22)	12.95 (21.07)
210	13.01 (21.13)	14.88 (22.71)	12.43 (20.62)	14.64 (22.46)	13.74 (21.73)
225	15.31 (23.03)	18.49 (25.48)	16.37 (23.89)	16.78 (24.30)	16.74 (24.18)
240	16.34 (23.81)	19.46 (26.21)	16.67 (24.12)	17.38 (24.65)	17.46 (24.70)
255	16.96 (24.35)	19.95 (26.56)	17.08 (24.43)	18.30 (25.33)	20.00 (25.17)
270	17.23 (24.50)	22.41 (28.25)	21.05 (27.35)	19.58 (26.28)	20.07 (26.60)
F - value					238.09**
CD (P = 0.05)					0.85

** Significant at 1% level.
NB Values within brackets are angular transformed ones.

6.3 Gross yield per hectare of dry ginger.

The yield of dry ginger is given in Table 14. Highest yield of dry ginger was produced during the last stage (270 days

after planting) in the case of Rio-de-Janeiro but it was during the fourth stage (210 days after planting) in Maran and fifth stage (225 days after planting) in Kuruppampady and Wynad Local. The lowest yield was recorded during the first stage (165 days after planting).

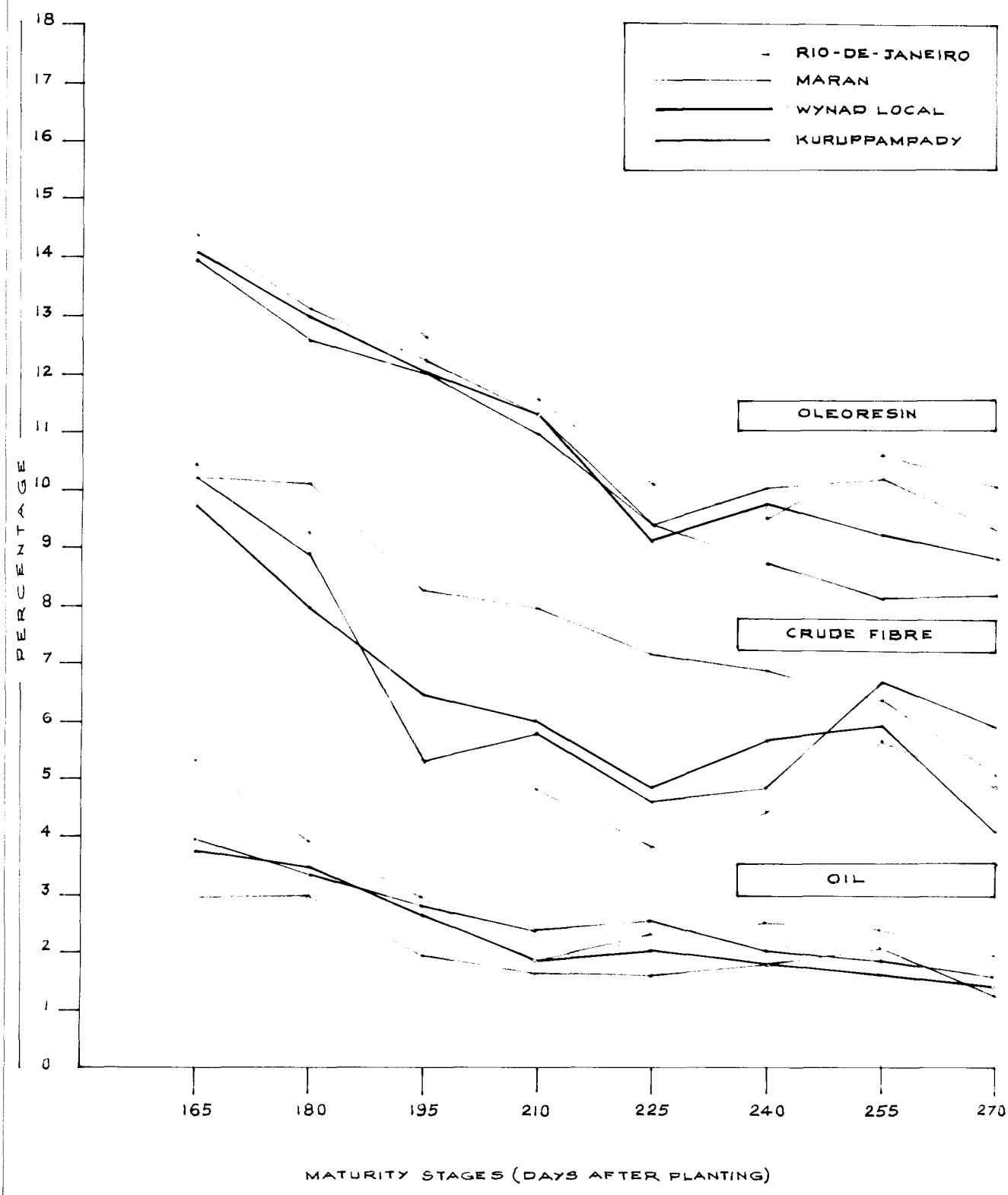
Table 14. Yield of dry ginger at different stages of maturity.

Maturity stages in days after planting	Types			
	Gross yield/ha in kg (Mean values)			
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local
165	2402.71	1574.35	1986.33	1432.50
180	3233.56	3195.70	3962.29	3180.94
195	4722.19	4534.77	4141.51	4151.25
210	4875.36	5014.25	5858.93	4186.13
225	4577.05	4892.15	7281.24	6222.58
240	2523.34	3207.86	2730.58	1855.68
255	4028.00	4395.23	5124.00	5108.75
270	6227.93	4645.93	4645.41	5188.75

6.4 Oleoresin.

The oleoresin percentage varied significantly at one per cent level among the different stages of maturity (Table 15). The percentage of oleoresin was maximum at the first stage in all the types studied and the same was minimum during the last stage (Fig. 5). The differences were highly significant except in the case of last two stages i.e., 255th and 270th day after planting. There was some fluctuation in certain periods in the

FIG. 5 . OLEORESIN, OIL AND CRUDE FIBRE CONTENT AT DIFFERENT STAGES OF MATURITY



decrease of the percentage of oleoresin.

Table 15. Oleoresin content at different stages of maturity.

Maturity stages in days after planting	Types — Oleoresin percentage (Mean values)				Mean
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local	
165	15.64 (23.26)	14.26 (22.22)	13.86 (21.89)	14.00 (21.97)	14.44 (23.30)
180	14.28 (22.22)	13.22 (21.30)	12.46 (20.70)	12.91 (21.05)	13.22 (21.30)
195	12.46 (20.70)	12.18 (20.44)	12.00 (20.27)	11.99 (20.27)	12.16 (20.44)
210	11.37 (19.73)	11.17 (19.55)	10.93 (19.28)	11.25 (19.64)	11.18 (19.55)
225	10.01 (18.44)	9.15 (17.66)	9.21 (17.66)	9.00 (17.46)	9.34 (17.76)
240	9.42 (17.85)	9.85 (18.34)	8.57 (17.05)	9.63 (18.05)	9.37 (17.85)
255	10.53 (18.91)	10.05 (18.53)	8.00 (16.43)	9.14 (17.56)	9.43 (17.89)
270	10.00 (18.44)	9.26 (17.76)	8.13 (16.54)	8.74 (17.16)	8.03 (16.43)
F - value					460.33**
CD (P = 0.05)					0.46

** Significant at 1% level.
NB Values within brackets are angular transformed ones.

6.5 Yield of oleoresin.

The yield of oleoresin is given in Table 16. Though the percentage of oleoresin was maximum during the first stage the total estimated production of oleoresin per hectare was maximum

at different stages in different types i.e., 270th day of harvest in the case of Rio-de-Janeiro (622.79 kg) and 255th day in Wynad Local (560.03 kg) and Kuruppampady (669.87 kg) and 210th day in the case of Maran (551.51 kg). Though there was a tendency to increase the yield of oleoresin as the maturity advanced, it was not even but erratic.

Table 16. Yield of oleoresin at different stages of maturity.

Maturity stages in days after planting	Types			
	Yield per hectare in kg (Mean values)			
	Rio-de-Janeiro	Maran	Kuruppampady	Wynad Local
165	384.43	220.41	278.09	209.05
180	452.70	445.44	515.10	413.52
195	566.66	544.17	496.98	498.15
210	536.29	551.57	644.48	460.47
225	457.71	447.98	669.87	560.03
240	237.19	317.57	230.83	178.15
255	443.08	439.52	409.92	459.79
270	622.79	432.07	376.28	451.42

6.6 Essential oil.

The data presented in Table 17 shows that the percentage of essential oil varied significantly at one per cent level at different stages of maturity. The percentage of essential oil recovery was maximum at 165 days after planting and minimum at 270 days after planting (Fig. 5). Significant differences were

noticed between second and third and third and fourth stages while all other stages were on par.

Table 17. Essential oil content at different stages of maturity.

Maturity stages in days after planting	Types — Essential oil percentage (Mean values)				Mean
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local	
165	5.21 (13.18)	2.80 (9.63)	3.78 (11.24)	3.60 (10.94)	3.85 (11.25)
180	3.78 (11.24)	2.81 (9.63)	3.15 (10.30)	3.26 (10.47)	3.25 (10.41)
195	2.84 (9.63)	1.80 (7.71)	2.70 (9.46)	2.55 (9.28)	2.47 (9.02)
210	1.66 (7.49)	1.46 (7.03)	2.20 (8.53)	1.74 (7.49)	1.77 (7.64)
225	2.15 (8.53)	1.44 (6.80)	2.41 (8.91)	1.93 (7.92)	1.98 (8.04)
240	2.42 (8.91)	1.67 (7.49)	1.92 (7.92)	1.68 (7.49)	1.92 (7.95)
255	2.30 (8.72)	1.94 (7.85)	1.79 (7.62)	1.60 (7.21)	1.68 (7.47)
270	1.92 (7.92)	1.24 (6.29)	1.47 (7.03)	1.25 (6.55)	1.47 (6.95)
F - value					44.24**
CD (P = 0.05)					0.69

** Significant at 1% level.
NB Values within brackets are angular transformed ones.

6.7 Yield of oil.

It was observed from the data in Table 18 that in the types

Kuruppampady and Wynad Local maximum yield of oil was produced during the fifth stage (225 days after planting) whereas it was during the third stage (195 days after planting) in Rio-de-Janeiro and during the second stage in Maran. The lowest yield of oil was during the first stage (165 days after planting) in Maran and in all other types it was during the sixth stage (240 days after planting).

Table 18. Yield of essential oil at different stages of maturity.

Maturity stages in days after planting	Types			
	Yield per hectare in kg (Mean values)			
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local
165	125.18	44.08	75.08	53.70
180	122.23	89.80	124.81	103.70
195	134.11	81.45	111.82	105.86
210	80.93	73.21	128.90	72.84
225	121.29	70.45	175.48	120.10
240	61.07	53.57	52.43	31.18
255	92.64	83.51	92.23	81.74
270	119.58	57.63	85.10	75.47

6.8 Crude fibre.

Analysis of the data presented in Table 19 revealed that the percentage of crude fibre at different stages of maturity differed significantly at one per cent level. It was found that

the fibre content decreased with maturity (Fig. 5). Highly significant variation was noticed between the first and second, and second and third stages.

Table 19. Crude fibre content at different stages of maturity.

Maturity stages in days after planting	Types — Crude fibre percentage (Mean values)				Mean
	Rio-de-Janeiro	Maran	Kuruppam-pady	Wynad Local	
165	10.26 (18.72)	10.08 (18.53)	10.07 (18.53)	9.58 (18.05)	10.00 (18.46)
180	9.08 (17.56)	9.97 (18.43)	8.82 (17.26)	7.94 (12.66)	8.95 (16.48)
195	5.22 (13.18)	8.18 (16.64)	5.18 (13.18)	6.31 (14.54)	6.22 (14.39)
210	4.71 (12.52)	7.83 (16.22)	5.73 (13.81)	5.76 (13.84)	6.01 (14.01)
225	3.73 (11.09)	7.00 (15.34)	4.50 (12.25)	4.73 (12.52)	4.99 (12.80)
240	4.16 (11.83)	6.79 (15.12)	4.65 (12.52)	5.51 (13.56)	5.28 (13.26)
255	5.60 (13.71)	6.17 (14.35)	6.47 (14.71)	5.75 (13.84)	6.00 (14.15)
270	4.84 (12.66)	4.99 (12.92)	5.83 (13.94)	4.04 (11.58)	4.93 (12.78)
F - value					26.29**
CD (P = 0.05)					1.52

** Significant at 1% level.
NB Values within brackets are angular transformed ones.

DISCUSSION

DISCUSSION

In recent years the use of ginger and its products have considerably increased and hence there exist great demand for this valuable spice in the world market. Unfortunately, India, the leading exporter of ginger is unable to produce adequate quantities to cope up with the export demand. Kerala has all the potentialities for increasing the production and productivity of this crop with sufficient stress on quality for which it is valued in the international market. Selection of suitable types with due emphasis on disease resistance and tolerance will be an effective measure to increase the internal production. Results of the present investigation on various aspects of varietal screening and quality evaluation are discussed below.

1. Germination.

The observations on germination percentage revealed that the types differed significantly. The type Nadia ranked first followed by Bajpai (98.43% and 97.39% respectively). Studies conducted at CPCRI (Anon, 1972) showed maximum germination in Maran followed by Nadia whereas Thankamma Pillai (1975) recorded highest germination in the type Utter Pradesh followed by Bajpai. The superiority of Maran in germination has also been reported by Nair (1975) and Thankamma Pillai (1976). The differential performance in germination of the types may be a

specific type character. Perhaps the physiological and storage conditions may affect the germination under uniform soil and cultural conditions.

2. Morphological characters.

2.1 Height and tiller production.

The height of the plant is not found correlated with yield. But Purewal (1957) observed highly significant and positive correlation between yield and plant height in tuberous plants like colocasia. Though Valluvanad recorded maximum height (71.5cm) in yield, it ranked only seventh place (19133 kg per ha) while Nadia and Maran which ranked first and second in yield (28554 and 25210 kg per ha) recorded a height of 61.4 and 63.1cm respectively. The lowest yield of 5296 kg per ha was recorded in the type Utter Pradesh which had a height of 60.4cm. This indicates that height is not the only criteria for high yield. Perhaps an optimum height will be important for higher production rather than the maximum. The types showed significant difference in height which is in conformity with the findings of Thankamma Pillai (1973a) but disagreed with the findings of Nair (1975). Therefore the difference in height may be a genetical character which is naturally affected by soil, nutritional and environmental conditions.

The present study showed highly significant variation

among types in respect of tiller count which agrees with the findings of Thankamma Pillai (1973a). But the tiller production is not correlated with yield. However, the types Nadia, Maran and Bajpai which were high in yield produced only 17.44, 16.21 and 22.91 tillers respectively whereas the maximum was 25.86 tillers per plant in Wynad Kunnamangalam which ranked only nineth in yield. This indicated that the number of tillers alone is not the criteria for higher production.

2.2 Leaf characters.

The number of leaves both per tiller and per plant differed significantly among types. Number of leaves per plant was maximum in Wynad Kunnamangalam (533.08) followed by Valluvanad (462.14) and Karakal (435.75). It is noted that these types were poor in yield as compared to Nadia, Maran, and Bajpai which produced only 262.89, 279.07 and 392.18 leaves per plant respectively. No significant correlation was found between yield and number of leaves. It is quite natural that when the number of tillers and height increase the total number of leaves per plant also increases. Therefore the variation in number of leaves can be explained as the result of the indirect effect of plant height and number of tillers.

The types such as Nadia, Maran, Bajpai and Narasapattom which were at the top in the case of yield have also

recorded higher leaf area index i.e., 43.28, 41.23, 39.18 and 40.80 respectively. The poor yielders such as Thingpuri (28.45), Assam (31.55) and Kuruppampady (33.73) showed lowest leaf area index. Significant and positive correlation was found between yield and leaf area index. Rather than the total number of leaves, the leaf area is found to be more important because of the fact that leaf area is an index of the photosynthetic efficiency of the plant which in turn determines the yield. The orientation of the leaves will also have an effect on photosynthesis. This may be the possible reason for significant and positive correlation between yield and leaf area index while the number of leaves and yield has no significant correlation.

2.3 Root characters.

Root characters such as number and length of roots have got no correlation with yield though these characters showed highly significant variation among types. The type Valluvanad produced the maximum number of roots per plant (103.11) followed by Sieraleon (100.11). The number of roots was least in Thingpuri (22.38) followed by Assam (28.95).

Though there is no correlation between length of roots and yield it was found that the types with longer roots produced higher yield which is evident from the data of the high yielding types like Nadia, Maran and Narasapattom. They produced roots with a mean length of 14.75, 13.78 and 13.55cm

respectively whereas it was only 11.60, 11.68 and 11.90cm in the case of Tafingiwa, Thingpuri and Utter Pradesh in order. The latter three types were found to be low yielders. The higher yield in the case of types with long roots may be due to the possibility of absorbing nutrients from a larger area than the restricted surroundings as in the case of types with shorter roots.

2.4 Rhizome characters.

Rhizome characters are found to have great effect on yield. Highly significant and positive correlation was found between yield and number of primary fingers and girth of secondary fingers. Yield has got no correlation with number of nodes on primary and secondary fingers whereas the number of secondary fingers and length of primary and secondary fingers showed positive correlation with yield at five per cent level.

It is clear from Table 5 that the types differ significantly at one per cent level with respect to number of secondary fingers. The type Sieraleon with a mean of 30.4 secondary fingers was at the top though not significant from Bajpai (28.38) and Maran (24.81). In this case also Thingpuri was the lowest (11.87) followed by Himachal Pradesh (12.84).

The length of primary and secondary fingers showed significant variation among types. It was observed that the type Bajpai produced the longest primary as well as secondary

fingers (7.81cm and 7.40cm respectively) which can be attributed to the high yield of Bajpai. Thingpuri produced the shortest primary fingers (5.47cm) with low number and Valluvanad had the shortest secondary fingers (5.16cm) followed by Thodupuzha (5.21cm) and Vengara (5.49cm). With respect to the length of secondary fingers, Bajpai was on par with Maran (6.87 cm), Wynad Kunnamangalam (6.69cm) and Karakal (6.67cm). Nadia produced medium number of primary fingers with long length and medium secondaries with medium length. But it is on par with Bajpai and Maran in the case of girth of primary and secondary fingers.

Therefore it can be seen that the number, length and girth of primary and secondary fingers contribute to the higher yield which may be more of a genetical character rather than of environmental because all the types were grown under identical condition.

2.5 Flowering characteristics.

Flowering was very meagre under Vellanikkara condition. The maximum was only 11.71 per cent recorded by the type Wynad Local which was closely followed by Assam (10.94%) and Rio-de-Janeiro (10.14%). The types Thodupuzha, Thingpuri and Himachal Pradesh had not even flowered. Considerable variation was noticed among types in number of inflorescence per plant, number of flowers per inflorescence and length of inflorescence. This variation indicates that flowering is influenced by different agroclimatic conditions in different types.

There are no morphological works to relate with the findings of the present study since it is the first one of that sort. It is rather difficult to classify the different types based on their morphological characters though there exists considerable variation in most of the morphological characters among the types. However, it is a fact that a good number of types can be identified by their rhizome characters such as length, girth, branching habit and colour of sprouts by constant touch and experience.

3. Incidence of pests and diseases.

The incidence of soft-rot (Pythium aphanidermatum) was maximum in Rio-de-Janeiro (27.50) closely followed by Tafingiva (26.40) and Taiwan (23.40) while the type Maran (3.20) had the least incidence. The above findings are in agreement with the findings of Nair (1969) who has reported about the tolerance of the type Maran and susceptibility of Rio-de-Janeiro, under field conditions. Nair (1975) also confirmed the tolerance of Maran. Earlier reports (Anon, 1965) with respect to rhizome-rot are also in conformity with the present findings. Kannan and Nair (1965) recorded the losses due to soft-rot as 80-90 per cent. According to Sarma et al. (1975) Jorhat and Sieraleon were the least affected types (11.25) as against 82 per cent in Kuruppampady. The difference in the degree of incidence among different types may be due to genetical factors.

The type Taiwan (1.69) was the most susceptible to leaf-spot disease (Phyllosticta zingiberi) followed by Narasapattom (1.66), Arippa (1.6), Valluvanad (1.61) and Rio-de-Janeiro (1.56) whereas the type Tafingiva (0.80) recorded the least incidence which was on par with Maran, Bajpai and Nadia. The effect of leaf-spot on yield is indirect due to the reduction in the effective photosynthetic leaf area and consequent decrease in photosynthate.

With respect to shoot-borer (Dichocrosis punctiferalis) incidence, the type Valluvanad was the maximum affected one (43.40%) though not significant. Rio-de-Janeiro was the least affected (21.30%) followed by Wynad Kunnamangalm (24.30%) and Arippa (24.70%). Highly significant and negative correlation was obtained between yield and shoot-borer attack. As a result of the shoot-borer attack the whole vegetative growth is disturbed and the plant became stunted.

4. Yield characters.

There was highly significant variation among the 25 types studied with respect to yield. The type Nadia yielded the maximum green ginger (28554 kg), followed by Maran (25210 kg), Bajpai (23585 kg), Narasapattom (23536 kg), Karakal (20182 kg) and Wynad Local (19943 kg). In the case of dry ginger also the same types were at the top except the type Karakal which was pushed down.

It was observed that the drying percentage varied significantly among types. The type Thodupuzha recorded the maximum drying percentage of 25.2 per cent followed by Kuruppampady (23%), Arippa (22.8%) and Nadia (22.6%). It was minimum in Karakal (15.2%) though not significant from Tafingiva (17.6%), Assam (18%), Wynad Local and Rio-de-Janeiro (18.6%). Poor drying percentage of Rio-de-Janeiro has been expressed by several workers (Kannan and Nair, 1965; Aiyadurai, 1966; Muralidharan, 1972; Mathai, 1973; Muralidharan, 1974 and Nair, 1975). With regards the highest drying percentage it did not conform with the findings of Aiyadurai (1966) who recorded the maximum drying percentage in Vengara followed by Ernad, Sieraleon and Karakal. Muralidharan (1972) and Mathai (1973) also found Tura as the best type with respect to drying percentage. According to Mathai (1973) maximum drying percentage was in Tura. Nair (1969) and Nair (1975) observed higher percentage of dry ginger recovery in Maran. The variation in drying percentage under uniform condition may be attributed to the difference in size of the rhizome. Bigger and stout rhizomes like that of Tafingiva, China, Rio-de-Janeiro etc., may naturally have higher water content. The higher fibre content may also increase the percentage of dryage.

The type Nadia with an yield of 6453 kg of dry ginger topped the list followed by Bajpai (5094 kg), Maran (5042 kg), Narasapattom (4801 kg), Wynad Local (4219 kg) and Wynad Kunnamangalam (4045 kg). Dry ginger yield was minimum in Utter

Pradesh (1134 kg) followed by Tafingiva (1323 kg), Himachal Pradesh (1608 kg) and Thingpuri (1653 kg).

The high yielding capacity of Nadia has already been established by Thankamma Pillai (1974) and Nair et al. (1976). But the findings of Khan (1959), Kannan and Nair (1965), Thomas (1966), Aiyadurai (1966), Thomas and Kannan (1969), Nair (1969), Nair and Varma (1970), Muralidharan (1972) and Nair (1975) disagrees with the findings of the present investigation. They recorded maximum yield in Rio-de-Janeiro. Studies conducted by Nair (1969) at the Horticultural Research Station, Ambalavayal showed that Maran was on par with Rio-de-Janeiro in yield. Works done by Thankamma Pillai (1975) and Thankamma Pillai and Nambiar (1976) did not conform the results in this regard.

Thus it is observed that all the 25 types studied under the Vellanikkara agroclimatic conditions had varying yield which was highly significant also. Yoshida (1972) after studying the various physiological factors affecting yield in grain crops derived the conclusion 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 yielders than otherwise. This may be true in the case of ginger also which is a monocot. Beachell and Jennings (1964) stressed the importance of medium tillering habit for high

yield in paddy. Excessively large leaf area and faster growth which is related with the high tillering capacity may lead to low yield were expressed by Taunoda (1964). Friend (1966) expressed the view that the variation in photosynthetic rate among types may be as a result of variety/environment interaction since the temperature and light regimes affects the morphological characters of leaf. Therefore it is likely that the above factors discussed may be the reason for the differential yield due to the variation in the morphological characters of the different types. It was also observed that the yield has got positive correlation with most of the morphological characters which were highly varying among types.

5. Qualitative characters.

5.1 Oleoresin.

There existed highly significant variation in oleoresin percentage among types. Rio-de-Janeiro contained the maximum oleoresin (10.53%) which was on par with Maran (10.05%) and the same was minimum in Wynad Manantody (4.91%) followed by Himachal Pradesh (5.39%) which was in agreement with the findings of Lewis et al. (1972b), Mathai and Prakash (1972), Mathai (1973), Lewis (1973) and Muralidharan (1974). But it was not in conformity with the work of Muralidharan (1972) who recorded maximum oleoresin in Kuruppampady (7.1%) Krishnamurthy et al. (1970) and Natarajan et al. (1972) who

found the highest oleoresin percentage in Assam (9.3%) followed by Manantody (9.2%).

Maran ranked first in the case of oleoresin production per hectare (504.20 kg) followed by Bajpai (469.70 kg), Nadia (349.12 kg) and Rio-de-Janeiro (345.81 kg) while the type Utter Pradesh (68.58 kg) was the least followed by Himachal Pradesh (86.69 kg). Though the type Rio-de-Janeiro had the highest oleoresin percentage, the yield of dry ginger was poor which contributed to the reduction in yield of oleoresin per hectare. But in the types Utter Pradesh and Himachal Pradesh both oleoresin percentage and dry ginger were low.

The genetic character will definitely have an impact on the yield of oleoresin which may be the reason for the difference in oil yield among types.

5.2 Essential oil.

It may be seen from Table 8 that the types differ significantly for oil recovery, the highest percentage being recorded by Karakal (2.4%) followed by Rio-de-Janeiro (2.3%) which were on par. Himachal Pradesh (0.57%) and Utter Pradesh (1.25%) were poor in oil recovery also. Krishnamurthy et al. (1970) and Lewis et al. (1972b) recorded highest oil percentage in Manantody and Mysore while Natarajan et al. (1972) reported minimum oil content in Nadia (1%). According to Mathew et al. (1972) Rio-de-Janeiro excelled all other types in yield of

oil (2.5%) followed by Mysore (2.1%) and Wynad Menantody (2%).

With regard to per hectare yield of oil also Maran ranked first (97.82 kg) closely followed by Nadia (95.51 kg) and the minimum was in Tafingiva (11.11 kg) followed by Himachal Pradesh and Utter Pradesh. The higher yield in Maran and Nadia may be due to the high dry ginger production. The differential behaviour of types in oil content under uniform conditions can be due to the difference in genetic character. The variation in the percentage of oil content of the same type under different situations may be due to variation in environmental conditions.

5.3 Crude fibre.

Fibre content was low in China (3.47%), Utter Pradesh (3.79%), Himachal Pradesh (3.89%) and Nadia (3.90%) whereas the types Kuruppampady had the highest fibre content (6.47%) followed by Maran (6.17%). The result was in conformity with that of Kannan and Nair (1965), Aiyadurai (1966) and Thomas (1966) but disagreed with the findings of the studies conducted by Lewis et al. (1972a), Mathai and Prakash (1972) and Nair (1975).

6. Quality variations at different stages of maturity.

The maximum yield of green ginger was obtained at 180 days after planting. However, the maximum dry ginger was

during the period between 210 and 225 days after planting though there was slight variation among the types. Nair and Varma (1970) found that under Ambalavayal conditions the optimum time of harvest was 260 days after planting, beyond which the fibre content was found to increase. The variation can be easily explained by the fact that Ambalavayal is around 900 m above sea level and under such conditions the maturity period of all other major crops are found to increase due to low temperature during the growing season when compared to that of plains.

The data presented in Table 13 and Fig. 4 indicate that there exists highly significant variation in the yield of dry ginger at different stages of maturity. Maximum drying percentage was during the last stage (270 days after planting) with a continuous increase from the first to last stage.

The percentage of oleoresin was maximum during the first stage (165 days of planting). But the highest yield per hectare of oleoresin was maximum at different stages in different types. However, the maximum production of oleoresin per hectare was found at 270, 195, 225 and 225 days after planting for Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local respectively. It was also at the same maturity periods that the maximum dry ginger was recorded. Thereafter the yield of dry ginger and oleoresin percentage were found to

decrease. The study also indicated that the optimum maturity period varied among the types, and beyond which, decrease in oleoresin and ginger oil was observed. Mathai (1974) found that oleoresin content was higher in early stages of growth which decreased from 10.1 per cent in the third month to 4.8 per cent during seventh month. But the variation noted during the present study was from 14.44 per cent to 11.18 per cent and 8.03 per cent from 165 to 210 and 270 days respectively after planting. Jogi et al. (1972) found that crude protein and fat content decreased with advanced maturity in ginger.

The essential oil recovery followed the same pattern as that of oleoresin. The maximum percentage of oil recovery was during the first stage and minimum during the last stage. But the maximum oil yield per hectare was recorded at the recommended optimum maturity stages for oleoresin, and varied from type to type. Nair and Varma (1970) noticed a steady increase in the percentage of oil upto 260 days of planting and then decreased at Ambalavayal conditions. The study also revealed that the crude fibre content decreases as the maturity advances which agrees with the findings of Mathai (1973) but disagrees with that of Nair and Varma (1970, Jogi et al. (1972) and Natarajan et al. (1972). A sudden decrease in crude fibre percentage was observed from the second to third stage. It may be due to the rapid growth during that period which resulted in increased rate of dry matter accumulation.

This will naturally result in the reduction of crude fibre percentage though no decrease in the actual quantity of fibre is affected.

SUMMARY

SUMMARY

A detailed study of 25 ginger types was conducted in lattice design during the period from April 1977 to June 1978 at the College of Horticulture, Vellanikkara. The objectives of the investigation were (i) to find out the feasibility of fixing up specific morphological characters to identify different types (ii) to evaluate the comparative yield and relative tolerance to important pests and diseases (iii) to evaluate the quality in terms of drying percentage, oleoresin, oil and crude fibre for different types and (iv) to study the quality variations at different periods of maturity. The results are summarised below:

1. Morphological characters such as height of the plant, number of tillers, number and length of leaf-blade, number and length of roots, number of secondary fingers and number of nodes per finger, length, girth and internodal length of primary and secondary fingers were found to differ significantly among types.

2. There was no significant variation among types for breadth of leaves, length of petiole and number of primary fingers.

3. The germination percentage was also found to differ significantly among types.

4. Length of leaf-blade, length of petiole, leaf area index and number, length and girth of primary and secondary fingers were found to be positively correlated with yield.

5. All the types were not found to flower under Vellanikkara conditions and even among the types flowered, the maximum flowering was only 11.7 per cent.

6. The study revealed that morphological characters are not reliable to classify the types, although some of them can be distinguished by rhizome characters.

7. None of the types studied were found to be resistant to soft-rot (Pythium aphanidermatum) or leaf-spot (Phyllosticta zingiberi) disease. But there was considerable variation in the disease incidence among the types. The maximum incidence of soft-rot was recorded in Rio-de-Janeiro (27.5%) and the minimum in Maran (3.2%). In the other high yielding types like Nadia, Bajpai and Narasapattom the incidence was 7.5, 5.3 and 4.0 per cent respectively. Taiwan showed the highest susceptibility to leaf-spot and the least in Tafingiva.

8. All the types were infected by shoot-borer (Dichocrosis punctiferalis). There was no significant difference among the types. Maximum attack was found in Valluvanad (43.4%) and minimum in Rio-de-Janeiro (21.3%). Nadia, Maran, Bajpai and Narasapattom, the high yielding types recorded 38.8, 26.9, 34.8 and 32.1 per cent incidence respectively.

9. There was highly significant difference in yield among the types studied. The maximum yield of 6453.16 kg per hectare was recorded in Nadia olosely followed by Bajpai (5094.38 kg), Maran (5042.01 kg) and Narasapattom (4801.44 kg).

10. Highly significant variation was noticed among the types with regard to the percentage of dry ginger recovery. Thodupuzha (25.2%) ranked first in this respect. The high yielding types such as Nadia, Bajpai, Maran and Narasapattom recorded 22.6, 21.6, 20.0 and 20.4 per cent of dry ginger respectively.

11. Oleoresin, ginger oil and crude fibre showed highly significant differences among types. The maximum percentage of oleoresin (10.53%) was recorded in Rio-de-Janeiro and it was on par with Maran (10.05%). In Bajpai it was 9.14 per cent and in Nadia only 5.41 per cent. The per hectare yield of oleoresin was maximum in Maran (504.2 kg) followed by Bajpai (469.7 kg), Nadia (349.12 kg) and Rio-de-Janeiro (345.81 kg). Maximum percentage of ginger oil was recorded in Karakal (2.40) followed by Rio-de-Janeiro (2.3%), Maran (1.94), Nadia (1.48) and Bajpai (1.48%). Per hectare yield of oil was maximum in Maran (97.8 kg) followed by Nadia (95.5 kg), Valluvanad (78.30 kg) and Bajpai (75.40 kg). The crude fibre content was minimum in the type China (3.47) and maximum in Kuruppampady (6.47%). Nadia, Maran, Bajpai and Narasapattom recorded 6.17, 3.9, 4.52 and 5.38 per cent respectively.

12. The studies on quality variations at different periods of maturity using four different types (Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local) revealed that the variations in yield, dryage and oleoresin, oil and crude fibre percentage were highly significant among different periods of maturity. The percentage of oleoresin, oil and crude fibre were maximum at 165 days of planting whereas the maximum yield per hectare of oleoresin and oil were found at 270, 195, 225 and 225 days after planting in Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local respectively. It was on the same maturity periods that the dry ginger production was also maximum. Beyond that period, the yield per hectare of dry ginger, oleoresin and ginger oil were reduced. So the above said periods for different types can be taken as the optimum maturity stages for oleoresin and ginger oil yield.

13. Based on the findings of the present investigations we can recommend the cultivation of the types Nadia, Bajpai and Maran for higher total yield of dry ginger, oleoresin and ginger oil for the plains of Kerala.

14. For maximum dry ginger production, Nadia is recommended. Considering the low incidence of soft-rot and higher yield of oleoresin and ginger oil, the type Maran is preferred.

15. The optimum time of harvest will be 270 days after planting in the case of Rio-de-Janeiro, 195 in the case of Maran and 225 days in the case of Kuruppampady and Wynad Local.

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APPENDIX-I

Analysis of variance

Characters	Mean square values			
	Blocks within replication (adj.) df = 16	Replication df = 3	Type (unadj.) df=24	Intrablock error df = 56
Height of the plant	33.47	412.63	61.63	30.14
No. of tillers per plant	15.69	5.19	33.20	11.00
No. of leaves per plant	6369.19	7998.13	16880.76	4239.93
Length of petiole	4.58	15.76	2.68	3.03
Length of last fully opened leaf	2.23	3.59	5.18	2.20
Leaf area index	22.07	265.60	42.65	57.46
No. of roots per plant	200.13	748.26	1462.05	199.37
No. of primary fingers per plant	0.88	2.47	9.33	0.72
No. of secondary fingers per plant	16.56	37.38	80.25	14.93
No. of nodes per primary finger	1.21	2.24	1.71	1.17
No. of nodes per secondary finger	0.09	0.19	0.90	0.08
Internodal length of secondary finger	0.002	0.005	0.014	0.002
Girth of primary finger	0.18	0.31	0.81	0.17
Girth of secondary finger	0.18	0.15	0.99	0.11
Yield per bed	10.65	7.29	56.22	5.75
Ginger oil content	2.13	0.88	4.60	1.27
Crude fibre content	0.39	0.03	5.20	0.22

APPENDIX-II

Analysis of variance

Characters	Mean square values		
	Replication df = 3	Type df = 24	Error df = 72
Germination percentage	23.64	57.81	31.08
No. of leaves per tiller	14.69	5.94	2.25
Breadth of last fully opened leaf	0.14	0.08	0.05
Length of roots	1.66	9.89	1.38
Length of primary fingers	0.48	1.49	0.13
Length of secondary fingers	0.43	1.13	0.16
Internodal length of primary fingers	0.004	0.02	0.01
Yield per plant	12108.96	18157.63	4837.97
Drying percentage	17.05	38.61	10.69
Oleoresin content	0.25	11.27	1.61
Percentage of shoot-borer attacked tillers/plant	387.52	43.26	27.24
Incidence of leaf-spot disease	0.14	0.04	0.01

APPENDIX-III

Analysis of variance

Characters	Mean square values		
	Period df = 7	Type df = 3	Error df = 21
Yield per bed	97.92	34.25	9.15
Drying percentage	78.57	4.22	0.33
Oleoresin content	41.43	6.15	0.09
Ginger oil content	9.29	4.34	0.21
Crude fibre content	27.87	2.21	1.06

MORPHOLOGICAL STUDIES
AND
QUALITY EVALUATION
OF GINGER (*Zingiber officinale Rosco.*) TYPES

By

E. V. NYBE

ABSTRACT OF A THESIS

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ABSTRACT

A detailed study of 25 ginger types was conducted during the period from April 1977 to June 1978 at the College of Horticulture, Vellanikkara with a view to find out the feasibility of fixing up specific morphological characters to identify different types, to screen out ginger types with high yield, high quality and resistant or tolerant to pests and diseases and to study the quality variations at different periods of maturity.

The study revealed that morphological characters are not reliable to classify the ginger types, although some of them can be identified by rhizome characters.

The morphological characters such as length of leaf, leaf area index and number, length and girth of primary and secondary fingers were found to be positively correlated with yield.

All the types studied are susceptible to the incidence of soft-rot, leaf-spot and shoot-borer. The type Maran was relatively tolerant to soft-rot whereas Rio-de-Janeiro was found to be the most susceptible type.

Yield was found to vary significantly among the types studied. Maximum yield was recorded in Nadia followed by Bajpai, Maran and Narasapattom.

Maximum oleoresin percentage was in Rio-de-Janeiro and highest percentage of oil recovery in Karakal. But the maximum yield per hectare of oleoresin and oil was in the type Maran. Fibre content was minimum in China and maximum in Kuruppampady closely followed by Maran.

The yield, dryage and percentage of oleoresin, oil and crude fibre varied significantly among the different maturity periods studied. The percentage of oleoresin, oil and fibre was maximum at 165 days after planting. But the maximum yield per hectare of oleoresin and oil were found at 270, 195, 225 and 225 days after planting in Rio-de-Janeiro, Maran, Kuruppampady and Wynad Local respectively.

Cultivation of the types Nadia, Bajpai and Maran is recommended for higher total yield of dry ginger for the plains of Kerala. Considering the low incidence of soft-rot and higher yield of oleoresin and ginger oil the type Maran is preferred.