Dedicated to

my

Parents

ECONOMISING PLANTING MATERIAL IN GINGER (*Zingiber officinale* R.) USING MINI-SEED RHIZOME

BY

NIZAM S A

THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1995

DECLARATION

I hereby declare that this thesis entitled "**Economising planting material in ginger (*Zingiber officinale* R) using mini seed rhizome** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship or other similar title of any other University or Society

S A Nizam

Vellayani
30th oct 1995

NIZAM S A

CERTIFICATE

Certified that this thesis entitled **“Economising planting material in ginger** (*Zingiber officinale* **R**) **using mini seed rhizome** is a record of research work done independently by **Sri NIZAM S A** 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

Vellayani
30th Oct 1995

Dr B K JAYACHANDRAN
Chairman
Advisory Committee
Associate Professor
Department of Horticulture

APPROVED BY

CHAIRMAN

Dr B K JAYACHANDRAN,
Associate Professor,
Department of Horticulture

MEMBERS

1 **Dr G SREEKANTAN NAIR,**
Professor & Head,
Department of Horticulture

2 **Dr K RAJMOHAN,**
Associate Professor,
Department of Horticulture

3 **Dr (Mrs) S T MERCY,**
Professor,
Department of Agricultural Botany

EXTERNAL EXAMINER

Dr Md Abdul Khader
Head, Hort College, TNAU CBE
Rtd

ACKNOWLEDGMENTS

With great pleasure I wish to express and place on record my sincere and deep sense of gratitude to Dr B K Jayachandran Associate Professor Department of Horticulture College of Agriculture Vellayani and Chairman of my Advisory Committee for his versatile and gracious guidance timely and valuable suggestions constant and inspiring encouragement affectionate advice and constructive criticism throughout the course of investigation and preparation of the manuscript His sustained interest co operation timely help sympathy and generosity have been very much beyond his formal obligation as chairman of the Advisory Committee for which I am immensely indebted to him

I am extremely thankful to Dr G Sreekantan Nair Professor and Head of Department of Horticulture for his valuable guidance constructive criticism and timely help extended to me during the course of my research work and in the preparation of the thesis

I wish to express my sincere thanks to Dr S Ramachandran Nair (General Co ordinator K H D P) for his active assistance and immense help extended to me during the initial stages of my research work

I am greatly obliged to Dr K Rajmohan Associate Professor Department of Horticulture for his inspiring guidance worthy suggestions and timely help throughout the course of research critical evaluation of the thesis and keen interest shown in the study

My sincere thanks are due to Dr (Mrs) S T Mercy Professor Department of Agricultural Botany for her valuable suggestions critical evaluation of the thesis and keen intrest shown in the study

I am extremely thankful to Dr (Mrs) P Saraswathy Professor of Agrl Statistics for her sincere and timely help in the execution of the thesis and to Sri Ajith Kumar Programmer for the generous help in the computer analysis of the data

My thanks are also due to Sri Abdul Hameed Professor Department of Soil Science and Agricultural Chemistry for his sincere help in the instrumental and chemical analysis

I wish to express my sincere thanks to all other members of the Department of Horticulture for their help throughout the period

I wish to express my deep sense of gratitude to Anitha S and Geetha Roy for their friendly co operation enthusiastic encouragement and manifold assistance at various stages of this work

I am extremely thankful to the timely help and co operation I have received from my friends of whom I wish to make special mention to M/s Ajith lal C S Moossa P P Naveen Leno Santhosh Kumar S Bindu C P Bindu C S and Geetha S

I wish to express my sincere thanks to M/s Athira Computers Kesavadasapuram Thiruvananthapuram for the sincere and careful computer work including data processing

With deep sense of gratitude and pleasure I wish to thank my brothers Nazeem and Shaji for their enthusiastic encouragement and manifold assistance

I am also thankful to the Kerala Agricultural University for providing the facilities required for the conduct of the research work and for awarding a fellowship for the PG programme

Above all to God the Almighty for making me optimistic giving good health and for his unspeakable help rendered through various hands which helped to complete this work successfully

S A Nizam

NIZAM S A

CONTENTS

LIST OF ABBREVATIONS

A O A C	Association of Official Agricultural Chemists
BR	Bulking Rate
CGR	Crop Growth Rate
DAP	Days After Planting
DMP	Dry Matter Production
HI	Harvest Index
LAI	Leaf Area Index
NAR	Net Assimilation Rate
NVEE	Non Volatile Ether Extract
UI	Utilisation Index

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

INTRODUCTION

Ginger is one of the most important spice crops of the world In India it is cultivated in an area of 52 460 ha and produces around 1 27 000 tonnes of dried ginger annually The main producing states are Kerala Meghalaya and Orissa (Pruthi 1993) Botanically ginger is a herbaceous perennial plant with underground rhizomes but cultivated as an annual The high cost of production of ginger is a major constraint for capturing international markets Jayachandran (1993) reported that in Kerala the cost of seed ginger is the single largest item of expenditure accounting for as much as 40 per cent

Trials conducted at various parts of the country demonstrated the superiority of bigger seed ginger rhizome as planting material Considering the cost benefit aspects rhizome weighing 15g (Kerala Agricultural University 1993) and 20 25g (National Research Centre for Spices 1989) are recommended for planting Thus the quantity of seed rhizome required varies from 1500 to 2500 kg per hectare Accordingly the cost of planting material in ginger ranges from Rs 27 000 to 45 000 per hectare depending upon the spacing adopted at an average cost of Rs 18 per kg of seed rhizome This initial high cost acts as a limiting factor in ginger cultivation

Mother rhizome can be detached from the growing ginger plant at 3 4 months maturity without adverse effect to the plant (Jayachandran *et al* 1982) Srivastava *et al* (1992) pointed out that recovery of mother rhizome is a common practice in Sikkim and according to him the practice is beneficial to the plant as it provides more space for rhizome development Nair (1977) reported that even sprouts detached from mother rhizomes gave good results

The principal function of mother rhizome thus appears to initiate and produce first daughter rhizome which in turn produces the remaining part of rhizomes Though rhizomes with multiple buds are planted usually only one bud develops In other words a small rhizome with one viable bud seems to be sufficient as seed material

The size of the seed ginger can be reduced if we could easily identify viable healthy buds at the time of preparing rhizomes for planting

Seed standardisation study at Solan in Himachal Pradesh for three years showed no significant difference in yield for rhizomes in a range of 10 20g (Korla *et al* 1989) Studies in Kerala (Jayachandran 1989) for three seasons showed that mini seed ginger rhizome with one healthy viable bud and weighing 5 7 g produced normal plants with an average of 17 tillers per plant and rhizome yield of 180 g per plant Thus it would be possible to reduce the seed size further to 10 g or less and considerable saving can be brought in the requirements of seed ginger

Another important factor limiting ginger production is the unavailability of cultivable area Studies conducted in India and elsewhere revealed that ginger is a shade loving/tolerant crop (Aclan and Quisumbing 1976 Bai 1981 Ravisankar and Muthuswamy 1987 Jayachandran *et al* 1991 and George 1992) Kerala is the largest ginger producing state accounting for about 40 50 per cent of the total production in India In Kerala the area under the crop is 15 490 ha with an annual production of 43 600 tonnes (Pruthi 1993) But it is well understood that ginger under partial shade as an intercrop and as a crop component of the homestead cultivation occupies a substantial area in Kerala However a major proportion of land under perennial monocrop such as coconut is still unexploited or underexploited

The present investigation Economising planting material in ginger (*Zingiber officinale* R) using mini seed rhizome was taken up with the following objectives

To standardise the size of tne mini seed ginger rhizome and to assess the comparative performance of the same under open and intercropped conditions

To standardise a pre treatment for the mini seed rhizome for better performance

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Ginger one of the important spice crops is propagated vegetatively Rhizomes are used as planting material This is the common method of propagation as there is no seed set in ginger It is estimated that seed ginger alone accounts to about 40 per cent of the over all production cost If the size of planting material could be reduced considerable saving can be brought to the requirement of planting material and the cost of production can be reduced

This review is classified under two sections The first part deals with the response of crops to varying sizes of planting materials In the second part the effect of natural and artificial shade on the growth and development are reviewed

I RESPONSE OF CROPS TO SIZE OF PLANTING MATERIAL

a Sprouting

Hussain and Said (1967) reported that in turmeric the use of larger size rhizomes resulted in significantly higher sprouting and fresh yield than smaller size rhizomes or from whole or divided central rhizomes

In an experiment to economise the planting material in elephant foot yam four sizes of planting bits (250 500 750 and 1000 g) were used It was shown that the sprouting was delayed when the planting material was too small (Kerala Agricultural University 1983)

Banana suckers weighing more than 390 220 390 and 30 100g were planted in nursery beds Sprouting percentage after 45 days plant height from 30 to 150 days and size after removal from nursery beds were recorded for each grade In all the cases best results were obtained with suckers weighing 220 390g or more than 390g (Hernandez *et al* 1988)

b Vegetative growth of the plant

In *Colocasia* Bourke and Perry (1976) observed that longer seed setts showed larger leaf areas Such plants produced more suckers per plant during the early growth itself

Lyonga (1979) reported that in tannia the optimum weight of planting sett and plant density were 400 500g and 10 000 plant per ha Trials conducted in Kerala Agricultural University (1983) showed that in Amorphopahllus plant height and canopy size were less when smaller planting bits were used

Experiment using banana cv Palayankodan the treatments were three different weight groups of suckers The weight groups used were 1 1 5 2 2 5 and 3 3 5 kg Plants from suckers weighing 3 3 5 kg group recorded the maximum girth The number of functional leaves were influenced by sucker weight in a positive manner Suckers weighing 1 1 5 kg showed significantly lower leaf number Peteole length was maximum (36 cm) for the weight group of 3 3 5 kg Duration of the crop was the shortest for the longest weight group (322 days for 3 3 5 kg) But any of the bunch characters like weight of bunch length of bunch number of hands weight of hands number of fingers etc were not influenced by the treatments (Kerala Agricultural University 1984 b)

Kohli and Saini (1986) suggested that in ginger the seed rhizome should have 2 4 buds and should weigh 25 40 g This should be planted 5 cm deep with eyes facing upwards

A two year old field trial with ginger cultivar Gorubathan revealed that the use of longest rhizome (40g) at planting gave the greatest plant height number of leaves per clump and rhizome yield (Sengupta *et al* 1986)

In another study Patel *et al* (1988) observed that in banana the use of large fresh suckers induced early and vigorous vegetative growth which resulted in early and concentrated harvests

The seed rate recommendation of Kerala Agricultural University (1993) is 1500 kg of ginger rhizomes per ha The seed size recommended is 15g with at least one viable healthy bud

Studies in Kerala (Jayachandran 1989) for three seasons showed that mini seed ginger rhizome possessing one healthy viable bud and weighing 5 7g produced normal plants with an average of 17 tillers per plant and an average yield of 180g per plant

Korla *et al* (1989) used four sizes of rhizomes for planting They compared the rhizome bits weighing 5 10 10 15 15 20 and 20 25g in a three year trial with *Zingiber officinale* cv Local Dharja under Solan conditions He observed no significant difference in responses between 10 15g and 15 20g for number of tillers leaf breadth rhizome length and breadth yield per plant and yield per plot

Comparative yield trials of 15 ginger varieties (13 indigenous) in North Eastern India showed that Nadia and China to produce the highest yields Yield was correlated with the shoot height leaves per clump of shoots and tillers per clump (Roy and Wamanan 1990)

c Yield

In ginger Aiyadurai (1966) recommended as seed rate of 540 to 630 kg per acre for obtaining maximum yield

In a study with colocasia Bourke and Perry (1976) observed that seed setts measuring 5 1 9 0 cm yielded more compared to setts measuring 4 5 cm in diameter

In Southern Nigeria Enyi (1967) found that increasing the seed sett size of tannia from small (43 71g) to large size (156 185 g) lead to an increase in yield It is reported that in ginger larger rhizomes weighing 150g with 4 6 buds gave higher yield compared to smaller ones of 60g with two buds (Randhawa *et al* 1972)

Scott and Younger (1972) observed a positive correlation between the seed tuber weight and the number of tuber per plant in potato

Nair (1977) reported good results in ginger with sprouts detached from mother rhizomes The average yield of green ginger was around 1 16 kg per plant

Many experimental results show that in potato total yield and yield over small riddle sizes increase with increase in seed tuber size As the riddle size over which yield in considered increases there is a tendency for yield to increase with seed size to a maximum and then declines (Harris 1978)

Experiments showed that in tapioca both the tuber size and number of tuber per plant were maximum when 30 cm long setts were used Longer setts (25 30 cm) compared to cuttings of 8 10 cm gave higher yields Studies in Brazil revealed close correlation between cutting length and early maturity Using full length stem has some advantages such as ease of planting early harvest good yield and good quality (Thampan 1979)

Trials conducted in turmeric revealed that whole rhizomes were the best planting material for realising the maximum yield of green turmeric (Kerala Agricultural University 1981)

Studies at Vellayani revealed that mother rhizome can be detached from the growing ginger plant at 3 4 months maturity without adverse effects to the plant (Jayachandran *et al* 1982)

Timpo (1982) conducted trials with different sizes of rhizome in two local varieties of ginger namely Pale Yellow and Red The rhizome size used were 5 cm (20 1 g) 7 cm (30 2 g) and 9 cm (44 3 g) The yield rose with rhizome size from 36 1 41 6 t ha^{1} in the Pale Yellow variety and from 26 7 32 6 t ha^{1} in the Red variety

In amorphophallus experiments (Kerala Agricultural University 1983) showed that the highest yield of 40 121t ha^{1} was obtained with planting bits of size 1 kg This was on par with the bit of 750g combined with farm yard manure and urea application Bits weighing 250g produced the lowest yield at all manurial levels

Yield of green and cured turmeric rhizome was significantly influenced by the weight of planting material used Rhizome weighing 60g at 10 x 20 cm spacing planted in mid May gave maximum yield (Kerala Agricultural University 1984 a)

Experiments with *Costus* showed that the yield of rhizome was proportionally higher when heavier planting material was used (Kerala Agricultural University 1984 c)

Maximum yield of 94 7 t ha^{1} with a corm weight of 5 28 kg was obtained in amorphophallus when seed corm of 1 kg size was used as planting material (Ashokan *et al* 1984 and Sen *et al* 1984)

Trials in *Dioscorea alata* showed that tuber yield increased with increasing size of middle setts but did not increase for head setts which seem to be more efficient than middle setts The greater yield of large setts seems to be related to a longer duration of rapid tuber bulking (Furguson *et al* 1984)

A two year old field trial with ginger cultivar Gorubathan revealed that the use of longest rhizome (40g) at planting gave the greatest plant height number of leaves per clump and rhizome yield (Sengupta *et al* 1986)

Variation in seed size caused significant differences in yield of *Dioscorea esculenta* (Kerala Agricultural University 1989 c) Seed material weighing 130g produced an yield of 28 6 t ha^{1} while 50g seed material produced only 10 43 t ha^{1}

In banana large corms were significantly superior to small corms But there was no significant variation between medium and large corms (Baghel *et al* 1987)

An experiment was conducted (Ahmed *et al* 1988) to study the effect of seed size and spacing on the yield of ginger Rhizomes weighing 10 11 20 and 21 30g were planted at 15 20 or 25 cm in row spacing in rows of 45 cm apart The highest yield of 13 42 t ha^{1} was obtained with the largest rhizomes planted at the closest spacing The smallest rhizome planted at 25cm spacing gave only 5 41 t ha^{1}

In a fertilizer variety yield trial in ginger planting rates ranging from 15 21 q ha ^{1} were used (Mohanty *et al* 1988) The highest yield of fresh rhizomes (6 61 12 78 t ha ^{1}) in the different clones were obtained with the highest planting and fertilizer rates

Okwuowulu (1988 a) used seed rhizomes ranging from 5 40g Seed harvest multiplication ratio was inversely affected at higher seed weights Large ginger setts were preferred for flowering and hybridisation work but smaller setts gave rapid seed ginger multiplication

Okwuowulu (1988 b) reported that mother rhizomes remain undercomposed even at crop maturity and can be detached during crop growth without significantly affecting the yield A mean of 58 per cent of seed ginger from smaller setts and 86 per cent from longer setts can be recovered in fully plantable condition This provides means for achieving rapid multiplication and for obtaining higher aggregate yield from a given quantity of rhizomes

A seed corm size cum spacing trial in amorphophallus four seed corm sizes (250 500 750 and 1000 g) and three spacings (50x50 75x75 and 100x100 cm) were the treatments Results showed that 1000g seed corm was significantly superior Effect of seed size was evident only at lower spacing (50x50 cm) The highest yield of 77 2 t ha ^{1} was recorded by 750g corm with 50 x 50 cm spacing (Kerala Agricultural University 1989 b)

In *Acorus calamus* the yield of fresh rhizome was always higher (Philip *et al* 1992) for a larger planting material (6 cm with top) compared to smaller planting material (3 cm with top)

Studies in Kerala (Jayachandran 1989) for three seasons showed that mini seed ginger rhizome possessing one healthy viable bud and weighing 5 7g produced normal plants with an average of 17 tillers per plant and an average yield of 180g per plant

Korla *et al* (1989) used four sizes of rhizomes for planting They compared the rhizome bits weighing 5 10 10 15 15 20 and 20 25g in a three year trial with *Zingiber officinale* cv Local Dharja under Solan conditions He observed no significant difference in responses between 10 15g and 15 20g for number of tillers leaf breadth rhizome length and breadth yield per plant and yield per plot

Roy and Wamanan (1989) reported that yield of fresh ginger cv Nadia increased with planting piece weight They used rhizomes weighing from 5 to 35 g

Four different mini sett sizes (15 30 45 and 60 g) were tried in *Dioscorea alata* and *D rotundata* Mini setts weighing 60g was found to be superior However the performance of mini setts weighing 30g was found to be on par with 45g mini sett (George 1990)

Okwuowulu (1992) studied the influence of varying mini sett weights intra row spacing sites and weather condition on yield of ginger cv Taffin giwa He observed that small seed rhizomes weighing 3g can give potential setts Using mini setts stimulated complete harnessing of food reserve in mother rhizomes

Srivasthava *et al* (1992) point out that recovery of mother rhizome is a common practice in Sikkim and they suggest that the practice will be beneficial to the growing plant because it provides more space for rhizome development

d Quality of the product

In Argentina experiments showed the advantage of using longer setts (25 30 cm) compared to cuttings of 8 10 cm long in tapioca The yield of tubers and starch content were distinctly more when larger cuttings were used (Thampan 1979)

Studies conducted in Kerala Agricultural University (1984 c) with *Costus* showed that the yield of rhizome and diosgenin content were proportionately higher when heavier planting material were used

In turmeric it was found that for cultivation mother rhizomes of size 25 30g is the best But the driage was not different compared to other treatments (Kerala Agricultural University 1989 a)

Variation in seed size caused significant difference in yield of *Dioscorea esculenta* Seed size had no influence on any of the quality characters such as protein starch and crude fibre (Kerala Agricultural University 1989 c)

II RESPONSE OF CROPS TO SHADE

a Sprouting

Increasing percentage of sprouting was observed with increasing levels of shade in ginger (Babu 1993) He observed significant differences between open and shaded conditions with respect to the sprouting percentage and suggested that the conducive condition provided by low soil temperature high relative humidity and soil moisture under shaded condition enhanced the sprouting

b Vegetative growth

Panicker *et al* (1969) reported that in tobacco plant height increased by 35 2 per cent under shade as compared to planting in the open Studies in ginger revealed that plants grown under full sunlight were found to be shorter compared to shaded plants (Aclan and Quisumbing 1976) Experiments with maize showed that plant height increased with increasing levels of shade (Moss and Stinson 1961)

Susan Varghese (1989) observed a decrease in the number of tillers with increasing levels of shade at all growth stages both in ginger and turmeric According to Attridge (1990) a limitation in energy supply resulting from the decreased proportion of incident radiation available per tiller may also be partly responsible for the decrease in tiller formation

A positive correlation has been reported between net assimilation rate and irradiance (Black man and Wilson 1951 Newton 1963 and Coombe 1966) Ramadasan and Satheesan (1980) recorded the highest LAI CGR and NAR with three turmeric cultivars grown in open condition compared to the crop grown under shade

c Yield

Positive influence of shade on yield was reported in many crops In Chinese cabbage lettuce and spinach the highest fresh weight was recorded at 35 per cent shade beyond which the performance was poor than those in full sunlight (Moon and Pyo 1981) Pushpa Kumari (1989) reported that tannia (*Xanthosoma sagittifolium*) recorded highest yield under 25 per cent shade with an almost equal yield at 50 per cent shade

In turmeric the highest yield was recorded under 25 per cent shade (Susan Varghese 1989)

Ravisankar and Muthuswamy (1988) observed that fresh rhizomes yield increased when ginger was grown as an intercrop in arecanut plantation According to Jayachandran *et al* (1991) ginger Rio de Janeiro is a shade loving plant producing higher yield under low shade intensity (25%) and comparable yield with that of open under medium shade intensity (50%) However shade intensity beyond 50 per cent decreased the yield Ancy Joseph (1992) recorded the highest green ginger yield under 25 per cent shade followed by 50 zero and 75 per cent shade

MATERIALS AND METHODS

MATERIALS AND METHODS

A pot culture experiment was conducted to standardise the procedure of the preparation of the mini seed rhizome in ginger This was followed by field experiments in the open as well as in the intercropped (coconut garden) conditions to standardize the size of mini seed ginger rhizome as planting material

Experimental site

The experiment was conducted at the Instructional farm Vellayani Thiruvananthapuram located at 8°5 North latitude 17°1 East longitude and at an altitude of 29m above mean sea level

The soil of the experimental location was red loam belonging to the Vellayani series and texturally classed as sandy clay loam The physical and chemical characteristics of the soil are given in Table 1

Table 1 Soil characteristics of experimental field

1 1 Open	
A Mechanical composition	
Coarse sand (%)	63 2
Fine sand (%)	13 5
Silt (%)	2 5
Clay (%)	20 4
B Chemical properties	
Available nitrogen (kg ha^{1})	184 4
Available P_2O_5 (kg ha^{1})	33 7
Available K_2O (kg ha^{1})	103 8
pH	5 2
1 2 Intercrop	
A Mechanical composition	
Coarse sand (%)	61 1
Fine sand (%)	14 2
Silt (%)	2 7
Clay (%)	21 4
B Chemical properties	
Available nitrogen (kg ha^{1})	178 9
Available P_2O_5 (kg ha^{1})	31 7
Available K_2O (kg ha^{1})	105 0
pH	5 4

The light intensity in the coconut garden was found to be 65 per cent of that in the open condition in a bright sunny day

Cropping history of the field

In the open condition the field was under ginger cultivation for the last two years In the coconut garden the field was kept fallow in the past

Season

The pot culture study was done in March to May 1993 The field experiments were conducted during June 1993 to February 1994

MATERIALS

Planting materials

Ginger cultivars namely Kuruppampady Maran Nedumangadu and Rio de Janeiro were used for the experiment Healthy and disease free rhizomes weighing 5 10 and 15 g were used for planting

Fertilizers

The following fertilizers were used for the experiment

Urea
Superphosphate
Muriate of potash

METHODS

The experiment consisted of pot culture and field trials The field trial was conducted both under open and intercropped conditions

Part I

Standardisation of the procedure for the preparation of mini seed rhizome (Pot culture)

The experiment was done as a pot culture to standardise the best soaking treatment prior to planting It is observed that a developing bud suppresses the growth of other buds around them in a stem Inorder to assess this effect a cutting treatment (before soaking and after soaking) was also included in the pot culture experiment

Preparation of rhizomes

Healthy rhizomes were selected and cut into weight groups of 5 10 and 15 g in each variety The rhizome bits were accurately weighed in a balance

a Cutting and soaking

The rhizomes were cut into weight groups of 5 10 and 15g in each variety Then they were separately kept immersed in distilled water for 24 hours After this period water was completely drained and the rhizomes were kept in perforated polythene covers for a period depending on the treatment b Soakıng and cuttıng

The healthy rhızomes were soaked as such for 24 hours Then the water was completely draıned and the whole rhızomes were kept ın perferated polythene covers for a perıod dependıng upon the treatment After thıs perıod the rhızomes were cut ınto weıght groups of 5 10 and 15 g just before plantıng

Layout of the experıment

The experıment was done as a factorıal CRD wıth 120 treatment combınatıons

Soakıng treatment (5)

A Soakıng ın water (24 hours) 15 days prıor to plantıng
B Soakıng ın water (24 hours) 10 days prıor to plantıng
C Soakıng ın water (24 hours) 5 days prıor to plantıng
D Soakıng ın water (24 hours) 1 day prıor to plantıng
E No soakıng (control)

Method of soakıng (2)

1 Cuttıng and soakıng
2 Soakıng and cuttıng

Varıetıes (4)

K Kuruppampady
M Maran
N Nedumangadu
R Rıo de Janeıro

Seed rhizome sizes (3)

X	5g
Y	10g
Z	15g

Preparation of potting mixture

Potting mixture was made by mixing one part fertile soil 2 parts coarse sand and one part dried and powdered cowdung Mud pots of 30 x 30 cm size were selected and were uniformly filled with the potting mixture

Seed treatment

All the rhizome bits were treated with a combination of Mancozeb and Malathion for 30 minutes to give a terminal concentration of 0 3% for the former and 0 1% for the latter After the treatment the rhizome bits were dried in shade by spreading them on a clean floor

Planting

Planting was done based on treatment combinations In each pot 10 healthy rhizomes bits were planted with buds facing upwards Planting depth was around 3 cm Then they were thoroughly irrigated and kept under uniform shade

Aftercare

The pots were irrigated once in 5 days and the weeds were removed as and when necessary

Observations

Sprouting

The number of rhizomes germinated were counted and expressed as percentage The observations were taken at 15 and 60 days after planting to study the immediate as well as long lasting effects of soaking treatments

Plant height

The height of the plant was measured from the base of the plant to the base of the youngest fully opened leaf and expressed in cm 60 DAP

Root growth

The plants were uprooted on 60 days after planting and length of roots were measured It was measured from the base of the plant to the tip of the longest root and expressed in cm

Part II

Field trials

Field experiments were done in the open condition as well as in the coconut garden to standardise the size of mini seed rhizome

These experiments were laid out in split plot design with four replications each (Fig 1 & Fig 2) The plot size was 3x1 m The varieties were assigned to the main plot and seed sizes to the subplots

Fig 1 LAY OUT OF MAIN FIELD EXPERIMENT
(SPLIT PLOT DESIGN OPEN CONDITION)

I

KX	MY	NZ	RX
KY	MZ	NX	RZ
KZ	MX	NY	RY

III

NY	RX	KZ	MX
NX	RZ	KY	MY
NZ	RY	KX	MZ

II

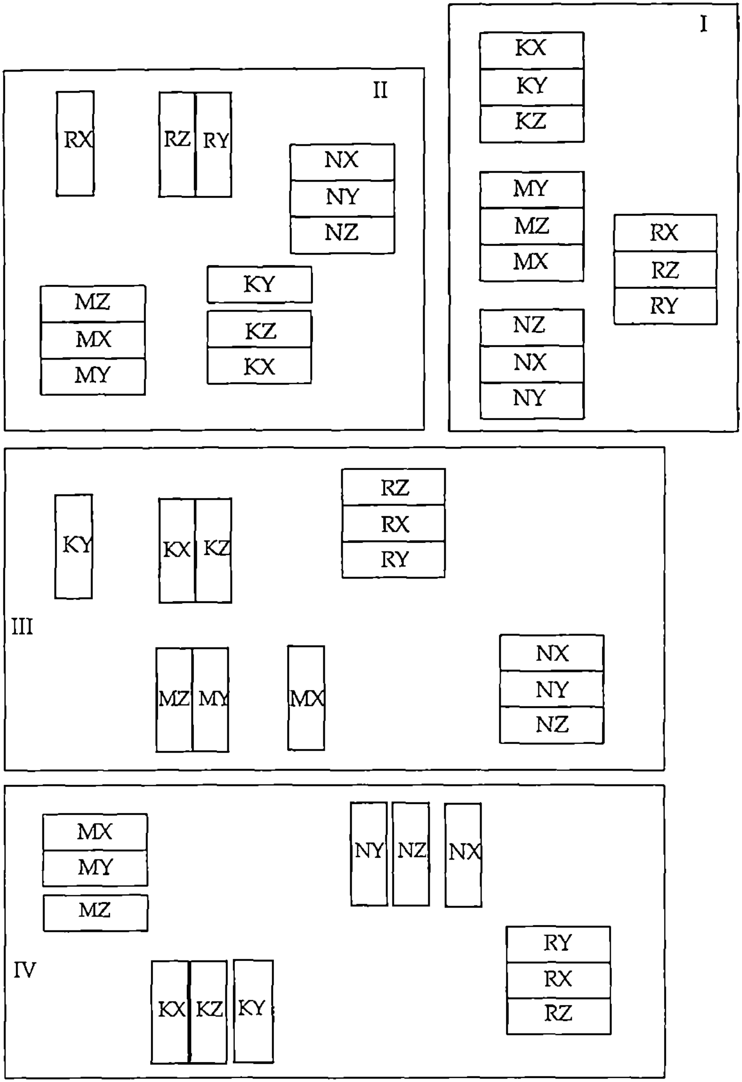
MY	NZ	RZ	KX
MX	NY	RX	KZ
MZ	NX	RY	KY

IV

RY	KX	MZ	NZ
RZ	KY	MX	NY
RX	KZ	MY	NX

Varieties		Rhizome sizes	
K	Kuruppampady	X	5g
M	Maran	Y	10g
N	Nedumamgadu	Z	15g
R	Rio de Janeiro		

Fig 2 LAYOUT OF MAIN FIELD EXPERIMENT
SPLIT PLOT DESIGN
INTERCROPPING IN COCONUT GARDEN



Varieties		Rhizome sizes	
K	Kuruppampady	X	5g
M	Maran	Y	10g
N	Nedumamgadu	Z	15g

Treatments

A Varieties (4)

K Kuruppampady
M Maran
N Nedumangadu
R Rio de Janeiro

B Seed sizes (3)

X 5 g
Y 10 g
Z 15 g

Treatment combinations (12)

KX	MX	NX	RX
KY	MY	NY	RY
KZ	MZ	NZ	RZ

Preparation of the rhizome bits

The best treatment in part I of the experiment (cutting and soaking rhizomes in water 10 days prior to planting) was used for the preparation of mini seed rhizomes for field trials

Seed treatment

Seed treatment for protection from pest and diseases was done as in Part I of the experiment

Land preparation and planting

Beds of size 3 x 1 m and 30 cm in height were made on previously prepared soil with 40 cm spacing between beds Farm yard manure was applied to each bed at the rate of 30 t ha^{-1} by placing in small pits taken at a spacing of 25x25 cm Seed rhizomes were planted in the pits at a depth of 3 5 cm with the buds facing upwards The pits were then covered with soil

Fertilizer application

The fertilizer dose of 75 50 50 kg N P_2O_5 and K_2O ha^{-1} as per the package of practices recommendations (Kerala Agricultural University 1993) was followed Full dose of phosphorus and 50 per cent K_2O were applied as basal dose

Half the quantity of nitrogen was applied 60 days after planting The remaining quantity of nitrogen and K_2O were applied 120 days after planting

Mulching

Mulching was done immediately after planting with green leaves at the rate of 15 t ha^{-1} and repeated twice at the rate of 7 5 t ha^{-1} first two months and second four months after planting

After cultivation

Hand weeding was done before each mulching and was repeated according to weed growth during the 5th and 6th months after planting Earthing up was also done along with first mulching

Plant protection

The crop was almost free from pest attack both under open and intercropped conditions However prophylatic spraying was done with Nuvacron Leaf spot disease was noticed under open condition But in shade only very limited leaf spot disease symptom appeared Leaf spot attack in open condition was managed by spraying Fytolan

OBSERVATIONS

Random sampling technique was adopted to select sample plants for studying various growth characters Five plants were selected at random as observational plants for recording observations and the mean was worked out Observations on plant height number of tillers per plant and number of leaves per plant were taken on 90 120 150 and 180 days after planting (DAP) Observations on dry matter production were taken on 90 135 and 180 DAP After 180 days growth observation were not recorded since the above ground parts started drying up in the open condition

The following observations were recorded

Sprouting

The number of plants germinated was counted 30 DAP and 60 DAP and expressed as percentage

Plant height

The height of the plant was measured from the base of the plant to the base of the youngest fully opened leaf and expressed in cm

Number of tillers per plant

The number of tillers was recorded by counting the number of aerial shoots arising around a single plant

Number of leaves per plant

The number of fully opened leaves were taken

Leaf area index

Leaf area index was calculated on 90 135 and 180 days after planting Sample plants were randomly selected for each treatment Those plants were uprooted and brought to the laboratory and the leaf area was determined using a leaf area meter Thereafter the leaf area index was calculated using the following equation

$$\text{Leaf area index} = \frac{\text{Leaf area of sample plant (cm}^2\text{)}}{\text{Area occupied by the sample plant (cm}^2\text{)}}$$

Dry matter production

Pseudostem leaves and rhizomes of the uprooted plants were separated and dried to constant weight at 70 80°C in a hot air oven

The sum of the dry weight of the components gave the dry matter yield and was expressed as grams per plant

Net assimilation rate

The procedure given by Watson (1958) modified by Buttery (1970) was followed The following formula was used to derive NAR and expressed as g m ^{2} day ^{1}

$$NAR = \frac{(W2 - W1)}{\frac{(t2\ t1)\ (A1 + A2)}{2}} \quad \text{where}$$

W_2	total dry weight of plant g m ^{2} at time t2
W_1	total dry weight of plant g m ^{2} at time t1
(t2 t1)	time interval in days
A2	leaf area index at t2
A1	leaf area index at t1

Crop growth rate

It was calculated using the formula of Watson (1958)

$$CGR = NAR \times LAI$$

expressed as g m ^{2} day ^{1}

Bulking rate

The rate of bulking in rhizome was worked out on the basis of increase in dry weight of rhizome and expressed in gram per plant per day

$$\text{Bulking rate} = \frac{W2 \quad W1}{t2 \quad t1} \qquad \text{where}$$

W2 Dry weight of rhizome at a time t2

W1 Dry weight of rhizome at a time t1

Top yield

The yield of top in individual treatments were recorded from the net area and expressed on kg ha ^{1} on dry weight basis

Rhizome spread

The length of the rhizome was measured and the mean value was expressed in cm

Harvest index

Harvest index (HI) was calculated as follows

$$HI = \frac{Y\ econ}{Y\ biol} \qquad \text{where}$$

Y econ total dry weight of rhizome

Y biol total dry weight of plant

Utilization index

Utilization index (UI) is the ratio of the rhizome weight to the top weight This is calculated from the dry weight of rhizomes and dry weight of top parts

Green ginger yield

The yield of green ginger rhizome from each treatment was recorded from the net area and expressed in kg ha ^{1} on fresh weight basis

Recovery of dry ginger

Immediately after harvest rhizome samples were taken from each treatment The skin of rhizome was scraped off and cleaned thoroughly They were chopped into small pieces for easy drying and were dried in sun for a week After this the rhizomes were dried to constant weight in a hot air oven The weight of dry ginger was recorded and expressed as kg ha ^{1}

Volatile oil

The content of volatile oil was estimated by Clevenger distillation method (A O A C 1975) and expressed as percentage (v/w) on dry weight basis

Non volatile ether extract

Non volatile ether extract (NVEE) was estimated by Soxhlet distillation method (A 0 A C 1975) and expressed as percentage on dry weight basis

Crude fibre content

The crude fibre content was estimated by the A O A C method (1975) and expressed as percentage on dry weight basis

Starch

Starch content was analysed using copper reduction method suggested by A O A C (1975) and expressed as percentage on dry weight basis

RESULTS

RESULTS

I Pot culture

Effect of soakıng treatments sıze of seed rhızomes and varıetıes on sproutıng

The data recorded 15 days after plantıng (Table 2) suggest that pretreatments were sıgnıfıcantly dıfferent Soakıng rhızomes 15 days prıor to plantıng recorded the hıghest sproutıng (16 03%) The effect of soakıng rhızomes 10 days and fıve days prıor to plantıng were on par Among treatments soakıng the rhızomes one day prıor to plantıng gave the lowest sproutıng (1 84%) The effect of control was on par wıth soakıng rhızome fıve days and one day prıor to plantıng

Among varıetıes Nedumangadu recorded the hıghest sproutıng (49 89%) followed by Rıo de Janeıro The performance of Maran and Kuruppampady was less and remaıned on par

Among rhızome sızes plants raısed from 5g recorded the lowest sproutıng (3 41%) whıle plants from 15g recorded the hıghest (6 24%) But the effects of plants obtaıned from 10 and 15g were on par

Table 2 Effect of soaking treatments size of seed rhizome and varieties on the germination (%) of ginger (15 Days after planting, pot culture)

Soaking Treatments	Methods of soaking		Varieties				Seed rhizome Size			Means soaking Treatment
	1	2	K	M	N	R	X	Y	Z	
A	18 20 (25 26)	13 96 (21 94)	2 24 (8 61)	0 00 (0 00)	83 75 (66 23)	11 22 (19 57)	6 95 (15 29)	22 20 (28 11)	21 16 (27 39)	16 03 (23 60)
B	5 80 (13 94)	4 54 (12 30)	0 00 (0 00)	0 00 (0 00)	57 66 (49 41)	0 003 (3 07)	8 42 (16 87)	3 33 (10 52)	4 30 (11 97)	5 15 (13 12)
C	4 13 (11 73)	2 57 (9 23)	0 00 (0 00)	0 00 (0 00)	39 33 (38 84)	0 003 (3 07)	2 04 (8 22)	4 30 (11 97)	3 81 (11 25)	3 31 (10 48)
D	2 20 (8 53)	1 51 (7 07)	0 00 (0 00)	0 00 (0 00)	26 84 (31 20)	0 00 (0 00)	0 006 (4 61)	2 08 (8 30)	3 31 (10 49)	1 84 (7 80)
E	2 57 (9 23)	3 19 (0 29)	0 00 (0 00)	0 00 (0 00)	39 66 (39 03)	0 00 (0 00)	2 04 (8 22)	2 89 (9 80)	3 81 (11 25)	2 87 (9 76)
Means	5 63 (13 73)	4 44 (12 16)	0 0009 (1 72)	0 00 (0 00)	49 89 (44 94)	0 008 (5 142)	3 41 (10 64)	5 64 (13 74)	6 24 (4 47)	

F Test	Soaking Treatment (S*)	Methods of soaking (NS)	Varieties (s*)	Seed rhizome size (s*)
CD (0 05)	2 841		2 341	2 201

Method of soaking	Varieties				Seed rhizome size		
	K	M	N	R	X	Y	Z
1	0 0005 (1 23)	0 00 (0 00)	57 05 (49 05)	0 007 (4 67)	3 46 (10 73)	5 71 (3 83)	8 21 (6 65)
2	0 001 (2 21)	0 00 (0 00)	42 75 (40 83)	0 009 (5 60)	3 35 (10 55)	5 58 (3 66)	4 52 (12 28)

Var	Rhizome size		
	X	Y	Z
K	0 00 (0 00)	0 008 (5 16)	0 00 (0 00)
M	0 00 (0 00)	0 00 (0 00)	0 00 (0 00)
N	42 55 (40 72	50 54 (45 31)	56 60 (48 79)
R	0 001 (1 84)	0 006 (4 50)	0 025 (9 08)

F Test	Soaking treatments x Varieties (S *)	Method of soaking x Varieties (S *)	Variety x Size (S *)	Others
CD (0 05)	5 682	3 593	4 402	—

(Transformed values in brackets)

Interaction of soaking treatments method of soaking and seed rhizome sizes with varieties were also found significant

Observations recorded 60 days after planting (Table 3) revealed that the effect of pretreatments were not significant in sprouting Only varieties and size of seed rhizomes were found significant The highest sprouting was recorded by Nedumangadu (100%) followed by Maran (99 8%) and were on par The effects of Kuruppampady and Rio de Janeiro on sprouting were comparitively low Sprouting increased with increasing size of seed rhizomes However the performance of 10 and 15g was on par

Effect of soaking treatments size of seed rhizomes and varieties on the plant height (cm) 60 days after planting

The data presented in Table 4 revealed that soaking treatments were significantly different with respect to plant height Better performance was recorded in rhizomes soaked one day prior to planting and was on par with 10 days prior to planting The effect of other soaking treatments were on par Among varieties Rio de Janeiro recorded the lowest plant height (24 09 cm) The effect of other varieties were comparitively high and remained on par Size of rhizome was found significant with respect to plant height Plants obtained from rhizome weighing 5g recorded the lowest height (29 2 cm) The influence of plants raised from 10 and 15g was high and on par in plant height

Table 3 Effect of soaking treatments, size of seed rhizome and varieties on the germination (%) of ginger (60 Days after planting, pot culture)

Soaking Treat ments	Methods of soaking		Varieties				Seed rhizome Size			Means soaking Treatment
	1	2	K	M	N	R	X	Y	Z	
A	97 11 (80 21)	96 29 (78 90)	97 75 (81 39)	100 00 (90 00)	100 00 (90 00)	70 13 (56 87)	92 82 (74 46)	97 90 (81 66)	98 29 (82 49)	96 72 (79 56)
B	91 06 (72 60)	97 15 (80 28)	94 42 (76 34)	99 71 (86 92)	100 00 (90 00)	62 91 (52 48)	93 41 (75 13)	94 25 (76 12)	95 68 (78 00)	94 50 (76 44)
C	94 19 (76 05)	92 87 (74 51)	98 29 (82 49)	99 40 (85 57)	100 00 (90 00)	46 63 (43 07)	93 28 (74 97)	93 02 (74 68)	94 25 (76 12)	93 54 (75 28)
D	95 68 (78 00)	96 05 (78 54)	92 94 (74 60)	100 00 (90 00)	100 00 (90 00)	72 67 (58 48)	89 64 (71 22)	96 48 (79 18)	99 03 (84 34)	95 87 (78 27)
E	93 07 (74 74)	97 11 (80 21)	97 63 (81 14)	98 85 (83 85)	100 00 (90 00)	66 95 (54 91)	93 65 (75 40)	94 42 (76 04)	97 50 (80 91)	95 30 (77 48)
Means	94 41 (76 32)	96 01 (78 48)	96 48 (79 19)	99 77 (87 27)	100 00 (90 00)	64 05 (53 16)	92 62 (74 24)	95 34 (77 54)	97 20 (80 37)	

F Test Soaking Treatment (S*) Methods of soaking (NS) Varities (s*) Seed rhizome size (s*) Others (NS)

CD (0 05) — — 4 340 3 755

(Transformed values in brackets)

Table 4 Effect of soaking treatments size of seed rhizome and varieties on the plant height (cm) of ginger (60 DAP, pot culture)

Soaking Treat ments	Methods of soaking		Varieties				Seed rhizome S ze			Means soak ng Trea ment
	1	2	K	M	N	R	X	Y	Z	
A	33 13	32 53	34 93	34 60	37 57	24 21	27 40	35 85	35 23	32 83
B	34 33	36 83	38 70	38 17	40 50	24 95	28 31	39 60	38 82	35 58
C	35 23	31 95	38 30	37 00	36 46	22 58	30 16	35 15	35 45	33 59
D	35 68	37 03	36 93	41 03	40 07	27 41	31 36	37 88	39 85	36 36
E	33 20	32 63	37 83	37 17	35 40	21 28	28 86	33 38	36 52	32 92
Means	34 31	34 19	37 34	37 59	38 00	24 09	29 22	36 37	37 18	

F Test	Soaking Treatment (S*)	Methods of soaking (NS)	Varit es (s*)	Seed rh zome s ze (s*)
CD (0 05)	1 673		1 497	1 296

Method of soaking	Variet es				Seed rh zome s ze		
	K	M	N	R	X	Y	Z
1	37 53	38 29	38 74	22 68	28 44	37 59	36 91
2	37 15	36 89	37 25	25 49	30 00	35 15	37 44

Var	Rh zome s ze		
	X	Y	Z
K	30 40	40 14	41 48
M	31 76	39 74	41 28
N	34 14	39 96	39 90
R	20 58	25 64	26 04

F Test	Soak ng treatments x Var et es (S *)	Method of soak ng x Var et es (S *)	Variety x S ze (S *)	Others
CD (0 05)	2 366	2 117	2 592	—

(Transformed values n bracke s)

Table 5 Effect of soaking treatments, size of seed rhizome and varieties on the root growth (cm) of ginger (60 DAP, pot culture)

Soaking Treatments	Methods of soaking		Varieties				Seed rhizome Size			Means soaking Treatment
	1	2	K	M	N	R	X	Y	Z	
A	35.84	33.57	35.07	31.83	41.27	30.66	30.93	37.03	36.17	34.71
B	35.38	38.68	37.33	31.10	47.37	32.33	31.93	39.13	40.05	37.03
C	35.16	35.28	36.07	33.00	44.13	27.67	32.60	35.33	37.73	35.22
D	34.50	39.88	37.55	34.90	42.20	34.12	31.73	40.48	39.38	37.19
E	35.37	36.77	36.20	35.23	44.70	28.54	32.64	37.98	37.88	36.17
Means	35.29	36.84	36.44	33.21	43.93	30.66	31.96	37.98	38.24	

F Test	Varieties (s*)	Seed rhizome size (s*)	Others (NS)
CD (0.05)	2.474	2.143	

Effect of soaking treatments, varieties and size of seed rhizomes on the root growth (cm) 60 days after planting

The results presented in Table 5 show that root growth was not influenced by soaking treatments However the influence of varieties and seed sizes were significant The influence of varieties were distinctly different from one another with respect to root length The effect of plants derived from 5g was the least However the effects of plants obtained from 10 and 15g were superior and were on par

II Field experiments (Open and intercropped condition)

Sprouting

a Open

Sprouting showed an increasing trend with increasing seed rhizome sizes (Table 6) Under both the stages (30 and 60 DAP) plants raised from 5g bit recorded only lesser sprouting and was distinctly inferior Plants obtained from rhizome weighing 15g gave the highest sprouting in both the stages and was distinct from plants raised from 10 and 5g On 30 DAP Nedumangadu gave distinctly higher effect (88 76%) followed by Maran (77 29%) These two varieties were distinctly different and also distinctly different from Kuruppampady and Rio de Janeiro The effect of Kuruppampady and Rio de Janeiro were on par The lowest sprouting was recorded by Kuruppampady

(68 83%) In the second stage of observation (60 DAP) the lowest sprouting was recorded by Rio de Janeiro (77 95%) and was on par with Kuruppampady (78 32%) The effect of seed rhizome size remained same as in the first stage

Interaction was significant only at 30 and 60 DAP Nedumangadu at 15g produced the highest sprouting at both the stages followed by 10g of the same and were on par Lowest sprouting was recorded by Rio de Janeiro at 5g (53 17%)

b Intercrop

The data (Table 7) revealed that sprouting increased with increasing size of seed rhizome in both the stages (30 and 60 DAP) The effects of the size of rhizomes were distinctly different from one another Plant from rhizome bits weighing 5g recorded the lowest sprouting (80 99%) while 15g produced the highest (92 36%) The effects of varieties were significant Kuruppampady recorded the lowest sprouting (71 45%) and was on par with Rio de Janeiro Nedumangadu recorded the highest sprouting (89 93%) and was followed by Maran At 60 DAP varieties showed a similar pattern However the sprouting percentage increased 60 DAP

The interaction was found significant under both the stages of observation

Table 6 Effect of size of seed rhizome and variety on the sprouting (%) of ginger under open condition

6 1 30 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	64 61 (53 47)	67 75 (55 38)	74 03 (59 34)	68 83 (56 06)
M	65 15 (53 80)	79 74 (63 22)	85 50 (67 59)	77 29 (61 54)
N	84 94 (67 14)	89 28 (70 86)	91 73 (73 25)	88 76 (70 42)
R	53 17 (46 80)	71 40 (57 65)	80 78 (63 97)	68 96 (56 14)
Mean size	67 59 (55 30)	77 64 (61 78)	83 51 (66 04)	
F Test	Variety (S *)	Size (S *)		Variety Size (S *)
CD (0 05)	2 654	1 857		3 713

6 2 60 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	70 97 (57 38)	79 27 (62 89)	84 12 (66 48)	78 32 (62 25)
M	73 49 (58 99)	87 54 (69 30)	92 83 (74 44)	85 45 (67 58)
N	93 79 (75 54)	97 08 (80 12)	99 48 (85 83)	97 28 (80 50)
R	61 13 (51 41)	81 31 (64 36)	88 56 (70 20)	77 95 (61 99)
Mean size	70 24 (60 83)	87 35 (69 17)	92 62 (74 24)	
F Test	Variety (S *)	Size (S *)		Variety Size (S *)
CD (0 05)	4 055	2 437		4 875

(Transformed values in brackets)

Table 7 Effect of size of seed rhizome and variety on the sprouting (%) of ginger as intercrop in coconut garden

7 1 30 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	67 83 (55 43)	70 91 (57 33)	75 53 (60 33)	71 45 (57 70)
M	70 84 (57 30)	81 34 (64 38)	85 08 (67 25)	79 36 (62 98)
N	86 48 (68 40)	89 63 (71 19)	93 26 (74 92)	89 93 (71 50)
R	62 27 (52 10)	76 59 (61 04)	80 78 (63 97)	73 52 (59 03)
Mean size	72 39 (58 30)	80 06 (63 48)	84 25 (66 62)	
F Test	Variety (S *)	Size (S *)		Variety Size (S *)
CD (0 05)	2 278	2 011		4 022

7 2 60 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	73 10 (58 73)	80 78 (63 97)	85 45 (67 55)	79 98 (63 42)
M	80 78 (63 97)	89 13 (70 72)	93 83 (75 59)	88 40 (70 09)
N	93 40 (75 08)	95 97 (78 39)	98 83 (83 75)	96 40 (79 07)
R	73 20 (58 80)	84 41 (66 72)	87 10 (68 89)	81 87 (64 80)
Mean size	80 99 (64 15)	88 25 (69 95)	92 36 (73 75)	
F Test	Variety (S *)	Size (S *)		Variety Size (S *)
CD (0 05)	2 798	1 909		3 818

(Transformed values in brackets)

Plant height

a Open

In all the four stages of observation (90 120 150 and 180 DAP) the size of seed rhizome significantly influenced plant height (Table 8) This ranged from 16 38 cm to 44 08 cm under the influence of rhizome size The performance of plant from 5g was the least in all the stages and was found to be significantly inferior to 10 and 15g The difference in height recorded by plants raised from 10 and 15g were found to be low and was insignificant The effect of varieties on plant height became insignificant in the later stages

b Intercrop

At 90 DAP the response of plants from 5g rhizome significantly differed from 10 and 15g (Table 9) But the influence of plants from 10 and 15g were on par Plant height showed significant difference at 120 DAP with respect to variety and seed rhizome size However at 150 DAP and thereafter height recorded no significant difference with respect to varieties and size of seed rhizomes The performance of plants derived from 15g was comparitively high Among varieties Maran recorded the highest value (62 27 cm)

The data suggest that only in the initial two stages (90 and 120 DAP) variety and size of rhizomes produced significant influences In the later stages (150 and 180 DAP) these factors were found to produce insignificant results

Table 8 Effect of sıze of seed rhızome and varıety on the mean heıght of gınger plants (cm) under open condıtıon

8 1 90 DAP

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	18 73	20 00	19 67	19 47
M	14 60	19 87	22 27	18 91
N	16 07	22 93	22 87	20 56
R	16 13	19 33	19 40	18 29
Mean sıze	16 38	20 48	21 05	
F Test	Varıety (NS)	Sıze (S *)	Varıety S ze (NS)	
CD (0 05)	1 858	1 961	3 921	

8 2 120 DAP

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	30 87	30 80	31 73	31 13
M	22 93	31 60	31 60	28 71
N	26 47	32 13	29 67	29 42
R	22 53	30 73	28 27	27 18
Mean sıze	25 70	31 32	30 32	
F Test	Varıety (S)	Sıze (S *)	Varıety S ze (NS)	
CD (0 05)	2 590	2 866	5 732	

Table 8 (Contd)

8 3 150 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	38 07	37 13	40 20	38 47
M	33 80	39 80	40 53	38 04
N	32 80	37 47	36 33	35 53
R	31 33	39 27	36 73	35 78
Mean size	34 00	38 42	38 45	
F Test	Variety (NS)	Size (S)		Variety S ze (NS)
CD (0 05)	3 630	3 305		6 610

8-4 180 DAP

Varieties	Rh zome s ze			Mean variety
	X	Y	Z	
K	44 80	43 00	43 20	43 67
M	37 13	46 40	46 47	43 33
N	36 73	42 53	38 87	39 38
R	38 27	44 40	41 53	41 40
Mean s ze	39 23	44 08	42 52	
F Test	Variety (NS)	Size (S)		Variety S ze (NS)
CD (0 05)	6 178	3 271		6 542

Table 9 Effect of size of seed rhizome and variety on the mean height of ginger plants (cm) as intercrop in coconut gardens

9 1 90 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	21 60	28 93	30 13	26 89
M	28 27	33 07	35 60	32 31
N	29 73	37 60	38 07	35 13
R	19 13	25 53	26 47	23 71
Mean size	24 68	31 28	32 57	
F Test	Variety (S *)	Size (S *)	Variety Size (NS)	
CD (0 05)	2 679	2 367	4 733	

9 2 120 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	38 40	43 47	48 80	43 56
M	48 47	50 67	52 27	50 47
N	46 27	51 07	51 93	49 76
R	34 27	40 73	45 07	40 02
Mean size	41 85	46 48	49 52	
F Test	Variety (S)	Size (S *)	Variety Size (NS)	
CD (0 05)	8 554	3 438	6 876	

Table 9 (Contd)

9 3 150 DAP

Var eties	Rhizome s ze			Mean variety
	X	Y	Z	
K	51 73	51 40	58 53	53 89
M	60 33	61 20	59 40	60 31
N	58 27	59 87	59 47	59 20
R	49 27	52 93	56 53	52 91
Mean size	54 90	56 35	58 48	
F Test	Variety (NS)	S ze (NS)		Variety S ze (NS)
CD (0 05)	10 752	4 062		8 123

9 4 180 DAP

Variet es	Rh zome size			Mean var ety
	X	Y	Z	
K	58 27	53 87	59 60	57 24
M	62 73	62 07	62 00	62 27
N	59 13	58 40	59 40	58 98
R	54 93	57 33	62 13	58 13
Mean s ze	58 77	57 92	60 78	
F Test	Var e y (NS)	S ze (NS)		Varie y S ze (NS)
CD (0 05)	9 976	4 188		8 376

Number of tillers

a Open

The size of seed rhizomes resulted in significant differences in number of tillers per plant (Table 10) The influence of plants raised from 10 and 15g were on par till 150 DAP In the last stage of observation (180 DAP) plants obtained from 10g resulted in significant difference in number of tillers per plant recording the highest number of tillers (18 62)

On 90 DAP Nedumangadu produced the highest number of tillers (3 96) and was distinctly superior to other varieties This superiority in tiller production was maintained throughout the growth period However the influence of Rio de Janeiro and Kuruppampady were similar to Nedumangadu on 150 DAP The influence of Maran was distinctly inferior in tiller production

The interaction of seed rhizome sizes and varieties became significant after 120 DAP Nedumangadu and Rio de Janeiro at 10g were the superior treatments Maran at 5g recorded the lowest performance (11 67 at 180 DAP) The effect remained as such throughout the growth period

b Intercrop

The data showed that (Table 11) size of seed rhizome influenced tillering under shade The effect of plants raised from 5g was the lowest on 90 DAP (2 03) But the performance of plants from 10 and 15g were on par In the later stages (120 150 and 180 DAP) the influence of size was insignificant

Table 10 Effect of sıze of seed rhızome and varıety on the mean number of tıllersper plant under open condıtıon

10 1 90 DAP

Varıetıes	Rh zome sıze			Mean var ety
	X	Y	Z	
K	2 33	2 40	2 67	2 47
M	1 27	2 07	2 53	1 96
N	3 13	4 93	3 80	3 96
R	2 20	3 20	2 93	2 78
Mean sıze	2 23	3 15	2 98	

F Test	Varıety (S*)	S ze (S*)	Varıety Sıze (NS)
CD (0 05)	0 786	0 400	0 800

10 2 120 DAP

Varıetıes	Rh zome s ze			Mean varıety
	X	Y	Z	
K	6 93	6 40	7 27	6 87
M	3 80	6 07	6 67	5 51
N	8 00	10 53	8 87	9 13
R	4 87	7 80	7 33	6 67
Mean s ze	5 90	7 70	7 53	

F Test	Var ety (S*)	S ze (S*)	Var ety S ze (NS)
CD (0 05)	1 250	1 046	2 091

Table 10 (Contd)

10 3 150 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	14 27	13 40	13 60	13 76
M	8 60	12 67	13 00	11 42
N	14 27	19 20	15 33	16 29
R	10 13	16 20	15 73	14 02
Mean size	11 82	15 38	14 42	
F Test	Variety (S*)	Size (S*)	Variety Size (S)	
CD (0 05)	2 651	1 696	3 392	

10-4 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	17 33	15 33	16 20	16 29
M	11 67	16 07	14 80	14 18
N	16 53	21 47	16 07	18 02
R	15 00	21 60	16 80	17 80
Mean size	15 13	18 62	15 97	
F Test	Variety (S)	Size (S*)	Variety Size (S*)	
CD (0 05)	2 838	1 490	2 981	

Table 11 Effect of sıze of seed rhızome and varıety on the mean number of tıllers per plant as ıntercrop ın coconut garden

11 1 90 DAP

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	1 67	2 07	2 27	2 00
M	1 60	2 00	1 93	1 84
N	3 07	3 87	3 93	3 62
R	1 80	2 07	2 27	2 04
Mean sıze	2 03	2 50	2 60	
F Test	Varıety (S*)		S ze (S)	Varıety Sıze (NS)
CD (0 05)	0 519		0 392	0 784

11 2 120 DAP

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	4 80	6 13	5 87	5 60
M	4 80	5 00	4 67	4 82
N	7 73	8 87	8 80	8 47
R	5 13	5 60	6 40	5 71
Mean sıze	5 62	6 40	6 43	
F Test	Var ety (S*)		Sıze (NS)	Varıety Sıze (NS)
CD (0 05)	1 013		1 238	2 476

Table 11 (Contd)

11 3 150 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	8 60	11 53	12 13	10 76
M	11 33	10 53	11 33	11 07
N	13 53	16 20	14 27	14 67
R	10 00	11 87	14 07	11 98
Mean size	10 87	12 53	12 95	

F Test	Variety (S*)	Size (NS)	Variety Size (NS)
CD (0 05)	2 405	2 475	4 950

11 4 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	11 93	14 27	15 80	14 00
M	14 20	12 00	14 67	16 62
N	15 67	17 33	15 93	16 31
R	13 60	14 27	18 80	15 56
Mean size	13 85	14 47	16 30	

F Test	Variety (NS)	Size (NS)	Variety Size (NS)
CD (0 05)	3 114	2 367	4 735

The influence of varieties were seen in the first three stages of observation (90 120 and 150 DAP) As an intercrop the influence of Nedumangadu with respect to tillering was the highest The effects of other varieties (Maran Rio de Janeiro and Kuruppampady) were comparatively low and were on par

Number of leaves per plant

a Open

Under open condition the effect of size of seed rhizome was significant with respect to leaf production (Table 12) The performance of plants obtained from 10g and 15g rhizomes were insignificant in the initial stages (90 120 and 150 DAP) After 150 DAP plants raised from 10g bit recorded the highest number of leaves (192 65) and was distinctly superior

Among varieties Nedumangadu recorded the highest number of leaves till 150 DAP (180 98 at 150 DAP) The influence of varieties were insignificant in the last stage (180 DAP) The effect of Maran was the least with respect to leaf production

Significant interactions were observed after 150 DAP Nedumangadu at 10g and Rio de Janeiro at 10g were the superior treatments The least performance was noticed in Maran at 5g (124 93)

Table 12 Effect of size of seed rhizome and variety on the mean number of leaves per plant under open condition

12 1 90 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	15 67	14 87	17 73	16 09
M	8 60	14 60	15 67	12 96
N	22 00	31 67	24 47	26 04
R	15 27	29 00	18 27	20 84
Mean size	15 38	22 53	19 03	
F Test	Variety (S*)	Size (S)	Variety Size (NS)	
CD (0 05)	6 871	4 694	9 388	

12 2 120 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	61 60	59 07	64 33	61 67
M	32 53	52 27	57 13	47 31
N	74 80	99 07	76 07	83 31
R	40 60	75 20	65 40	60 40
Mean size	52 38	71 40	65 73	
F Test	Variety (S*)	Size (S*)	Variety Size (NS)	
CD (0 05)	7 984	10 646	21 292	

Table 12 (Contd)

12 3 150 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	152 67	136 00	149 67	146 11
M	84 87	126 67	138 33	116 62
N	155 87	224 87	162 20	180 98
R	105 60	172 07	166 00	147 89
Mean size	124 75	164 90	154 05	
F Test	Variety (S*)		Size (S*)	Variety S ze (S)
CD (0 05)	33 790		19 203	38 407

12-4 180 DAP

Varieties	Rh zome size			Mean variety
	X	Y	Z	
K	197 27	171 60	184 13	184 33
M	124 93	166 40	161 07	150 80
N	168 27	198 00	146 87	171 04
R	152 60	234 60	175 13	187 44
Mean s ze	160 77	192 65	166 80	
F Test	Var ety (NS)		S ze (S*)	Var ety S ze (S *)
CD (0 05)	38 202		17 746	35 492

b Intercrop

The size of seed rhizome was found to be significant with respect to leaf production under intercropped condition (Table 13) The effect of plants from 5g was the lowest and was inferior to plants obtained from 10 and 15g The influence of plants from 10 and 15g were on par At 180 DAP the influence of size of seed rhizome became insignificant with respect to leaf production

Among varieties Nedumangadu produced the highest number of leaves at 90 120 and 150 DAP and was distinctly superior At these sages the effect of other varieties were low and remained on par But on 180 DAP the effects of seed rhizome size and variety became insignificant

Leaf area index (LAI)

a Open

Size of seed rhizome influenced the leaf area index throughout the growth period (Table 14) The data suggest that leaf area index increased with increasing seed rhizome size In the first growth phase (90 DAP) the performance of plants from 10g was on par with plants from 5 and 15g But the effect of plants raised from 5g and 15g rhizomes were different In the last two stages (135 and 180 DAP) LAI recorded by plants from 10 and 15g were on par At 180 DAP plants obtained from 5g bits recorded the lowest LAI of 5 139 while 15g recorded the highest of 6 854

Table 13 Effect of sıze of seed rhızome and varıety on the mean number of leaves per plant as ıntercrop ın coconut garden

13 1 90 DAP

Varıetıes	Rhızome s ze			Mean varıety
	X	Y	Z	
K	12 00	15 07	16 40	14 49
M	11 33	14 27	14 00	13 20
N	23 53	30 73	30 87	28 38
R	12 40	13 93	15 53	13 96
Mean sıze	14 82	18 50	19 20	
F Test	Varıety (S*)	Sıze (S*)		Var ety Sıze (NS)
CD (0 05)	2 580	2 620		5 240

13 2 120 DAP

Var etıes	Rhızome s ze			Mean var ety
	X	Y	Z	
K	42 00	54 07	65 40	53 82
M	50 87	50 87	47 60	49 78
N	80 93	94 00	91 87	88 93
R	44 40	50 93	62 93	52 76
Mean s ze	54 55	62 47	66 95	
F Test	Varıety (S*)	Sıze (NS)		Var ety S ze (NS)
CD (0 05)	14 976	10 967		21 935

Table 13 (Contd)

13 3 150 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	92 20	114 40	144 07	116 89
M	142 00	128 13	135 67	135 27
N	166 73	190 27	190 80	182 60
R	102 80	120 27	171 47	131 51
Mean size	125 93	138 27	160 50	
F Test	Variety (S*)	Size (S)	Variety Size (NS)	
CD (0 05)	34 996	26 655	53 310	

13-4 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	145 80	154 73	177 40	159 31
M	185 33	152 07	141 67	159 68
N	183 40	195 47	160 00	179 62
R	151 73	157 40	214 80	174 64
Mean size	166 57	164 92	173 47	
F Test	Variety (NS)	Size (NS)	Variety Size (NS)	
CD (0 05)	51 595	25 833	51 665	

Table 14 Effect of sιze of seed rhιzome and varιety on the Leaf area ιndex of gιnger under open condιtιon

14 1 90 DAP

Varιetιes	Rhιzome sιze			Mean varιety
	X	Y	Z	
K	0 682	0 947	1 078	0 902
M	0 643	0 755	0 875	0 757
N	1 071	1 214	1 313	1 200
R	0 350	0 648	0 825	0 608
Mean sιze	0 686	0 891	1 023	
F Test	Varιety (S*)	S ze (S)	Varιety S ze (NS)	
CD (0 05)	0 2251	0 2322	0 4644	

14 2 135 DAP

Varιetιes	Rh zome sιze			Mean varιety
	X	Y	Z	
K	1 622	3 431	3 562	2 872
M	1 215	2 335	2 534	2 028
N	3 327	3 597	3 797	3 574
R	0 958	2 262	2 611	1 944
Mean sιze	1 780	2 906	3 126	
F Test	Var ety (S*)	S ze (S*)	Var ety S ze (NS)	
CD (0 05)	0 5806	0 6138	1 227	

Table 14 (Contd)

14 3 180 DAP

Varieties	Rh zome size			Mean variety
	X	Y	Z	
K	5 240	7 487	7 952	6 893
M	3 931	4 708	5 169	4 603
N	5 579	6 279	6 513	6 124
R	5 805	6 704	7 782	6 764
Mean size	5 139	6 294	6 854	

F Test	Variety (NS)	Size (S)	Variety Size (NS)
CD (0 05)	1 916	1 077	2 194

The ınfluence of varıetıes were sıgnıfıcant ın the fırst two growth stages (90 and 135 DAP) Rıo de Janeıro recorded the lowest LAI (0 608 and 1 944) and was followed by Maran Nedumangadu produced the hıghest leaf area ındex followed by Kuruppampady The ınfluence of varıety was not sıgnıfıcant ın the last stage (180 DAP)

b Intercrop

The data presented ın Table 15 ındıcated that at 90 DAP plants derıved from rhızome bıts weıghıng 15g resulted ın the hıghest LAI (1 014) and was on par wıth plants from 10g (0 904) But they were dıstınctly dıfferent from plants from 5g bıts In the second stage of observatıon (135 DAP) the effect of plants obtaıned from 10g was sımılar to 5 and 15g but ınfluence of plants raısed from 5g was dıstınctly dıfferent from 15g In the last stage (180 DAP) the ınfluence of the seed rhızome sıze was not sıgnıfıcant

Nedumangadu recorded the hıghest LAI at 90 DAP (1 479) Kuruppampady recorded the lowest leaf area ındex (0 483) and was followed by Rıo de Janeıro and Maran In the second stage (135 DAP) Nedumangadu produced the hıghest leaf area ındex (2 743) The effect of Maran was on par wıth Kuruppampady and Rıo de Janeıro In the thırd stage (180 DAP) Kuruppampady recorded the lowest LAI (1 750) and was on par wıth Maran At thıs stage Rıo de Janeıro recorded the hıghest LAI (7 287) and was on par wıth Nedumangadu

Table 15 Effect of sıze of seed rhızome and varıety on the Leaf area ındex of gınger as ıntercrop ın coconut garden

15 1 90 DAP

Varıetıes	Rhızome s ze			Mean varıety
	X	Y	Z	
K	0 265	0 544	0 639	0 483
M	0 640	0 864	0 854	0 786
N	1 369	1 430	1 637	1 479
R	0 511	0 778	0 926	0 738
Mean sıze	0 696	0 904	1 014	
F Test	Varıety (S*)	Sıze (S)		Varıety S ze (NS)
CD (0 05)	0 1263	0 2054		0 4108

15 2 135 DAP

Var et es	Rhızome sıze			Mean varıety
	X	Y	Z	
K	1 021	1 039	1 355	1 138
M	1 463	1 414	1 631	1 503
N	2 138	3 092	3 000	2 743
R	1 029	2 426	2 489	1 981
Mean sıze	1 413	1 993	2 118	
F Test	Varıety (S*)	Sıze (S)		Var ety S ze (NS)
CD (0 05)	0 7119	0 5807		1 1614

Table 15 (Contd)

15 3 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	1 445	1 672	2 133	1 750
M	2 961	2 584	2 714	2 753
N	5 006	7 515	7 871	6 798
R	5 328	7 426	9 106	7 287
Mean size	3 685	4 800	5 456	

F Test	Variety (S*)	Size (NS)	Variety S ze (NS)
CD (0 05)	1 7603	1 7870	3 5740

Dry matter production

a Open

Seed rhizome size and variety influenced the drymatter production in ginger (Table 16) Plants raised from 15g showed the highest dry matter production throughout the growth period and was on par with plants from 10g The performance of plants obtained from 5g was the lowest The drymatter content ranged from 5 01 to 54 88g for 5g bits and from 7 99 to 86 23g for 15g bits in the growth period

Nedumangadu was found superior at 90 and 135 days after planting and was on par with Kuruppampady Rio de Janeiro recorded the lowest drymatter production except in the last stage The influence of varieties became insignificant at 180 DAP

b Intercrop

The data indicate that (Table 17) size of seed rhizomes resulted in significant difference in drymatter production The effect plants from 5g were the lowest However plants derived from 10 and 15g produced comparatively high DMP and was on par in the last stages (135 and 180 DAP) At 180 DAP the effect of plants from 5g was the least (28 73 g) while plants from 15g recorded the highest DMP (41 84g)

Nedumangadu recorded higher DMP in the initial stages (90 and 135 DAP) Later Rio de Janeiro showed the highest performance (45 61g) and was on par with Nedumangadu (42 76 g) Kuruppampady and Maran recorded low DMP under intercropped condition

Table 16 Effect of sıze of seed rhızome and varıety on the mean dry matter production of gınger (g plant ¹) under open condıtıon

16 1 90 DAP

Varıetıes	Rhızome sıze			Mean var ety
	X	Y	Z	
K	5 56	7 27	8 79	7 21
M	4 77	6 43	6 69	5 96
N	7 06	8 25	9 29	8 20
R	2 65	5 54	7 22	5 14
Mean s ze	5 01	6 87	7 99	
F Test	Varıety (S*)	Sıze (S*)		Varıety S ze (NS)
CD (0 05)	1 360	1 615		3 229

16 2 135 DAP

Var etıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	12 80	27 06	27 49	22 45
M	11 41	17 93	25 64	18 33
N	22 50	27 41	29 95	26 62
R	5 85	15 96	16 90	12 90
Mean s ze	13 14	22 09	24 99	
F Test	Varıety (S*)	S ze (S*)		Var ety Sıze (NS)
CD (0 05)	4 421	3 803		7 607

Table 16 (Contd)

16 3 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	57 12	96 29	99 95	84 45
M	48 85	73 63	78 53	67 04
N	63 55	63 70	72 29	66 51
R	49 98	73 45	94 14	72 52
Mean size	54 88	76 77	86 23	

F Test	Variety (NS)	Size (S*)	Variety Size (NS)
CD (0 05)	22 601	12 386	24 773

Table 17 Effect of size of seed rhizome and variety on the mean dry matter production of ginger (g plant $^{-1}$) as intercrop in coconut garden

17 1 90 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	2 12	4 59	5 31	4 00
M	4 34	5 73	6 51	5 53
N	8 06	7 93	8 61	8 20
R	2 77	5 11	5 72	4 54
Mean size	4 32	5 84	6 54	

F Test	Variety (S*)	Size (S*)	Variety Size (NS)
CD (0 05)	0 567	0 907	1 813

17 2 135 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	9 63	6 67	12 01	9 44
M	12 25	8 79	13 30	11 51
N	13 46	21 17	19 23	17 95
R	6 20	11 80	14 45	10 82
Mean size	10 38	12 16	14 75	

F Test	Variety (S*)	Size (S*)	Variety Size (S)
CD (0 05)	3 256	2 563	5 126

Table 17 (Contd)

17 3 180 DAP

Varieties	Rhizome s ze			Mean variety
	X	Y	Z	
K	17 94	17 87	39 48	25 10
M	25 93	29 73	25 70	27 12
N	33 05	47 26	47 96	42 76
R	38 00	44 61	54 22	45 61
Mean size	28 73	34 87	41 84	
F Test	Variety (S*)	Size (S*)	Variety S ze (NS)	
CD (0 05)	7 163	7 028	14 055	

Interaction was found significant only at 135 DAP Nedumangadu at 10 and 15g recorded superior performance and was on par

Net assimilation rate (NAR)

a Open

The data revealed that net assimilation rate is not influenced by the size of seed rhizome under open conditions (Table 18) But it showed an increasing trend with increasing seed rhizome size

NAR was significantly influenced by varieties during the initial stage (90 to 135 DAP) Kuruppampady Maran and Nedumangadu gave better results and were on par Rio de Janeiro gave lesser NAR At this stage NAR ranged from 0 102 0 159 g m ^{2} day ^{1} In the second phase (135 to 180 DAP) Nedumangadu recorded a low NAR compared to other varieties Here the range of NAR was from 0 104 to 0 221 g m ^{2} day ^{1} The interaction of rhizome size and variety was not significant

b Intercrop

Net assimilation rate was not influenced by size of rhizome and varieties in the first stage of observation (90 135 DAP) But in the second stage (135 180 DAP) these factors along with their interaction were found significant (Table 19) Plants obtained from 10g recorded a higher NAR compared to plants from 5 and 15g bits at this stage

Table 18 Effect of size of seed rhizome and variety on the net assimilation rate (NAR) of ginger under open conditions (g m 2 day 1)

18 1 Between 90 135 DAP

Varieties	Rhizome size X	Rhizome size Y	Rhizome size Z	Mean variety
K	0 135	0 223	0 182	0 180
M	0 129	0 166	0 230	0 175
N	0 152	0 163	0 154	0 156
R	0 122	0 138	0 119	0 126
Mean size	0 134	0 172	0 171	

F Test	Variety (S)	Size (NS)	Variety Size (NS)
CD (0 05)	0 0370	4 326	8 652

18 2 Between 135 180 DAP

Varieties	Rhizome size X	Rhizome size Y	Rhizome size Z	Mean variety
K	0 292	0 272	0 256	0 273
M	0 304	0 331	0 276	0 304
N	0 162	0 156	0 146	0 155
R	0 287	0 269	0 321	0 292
Mean size	0 261	0 257	0 250	

F Test	Variety (S*)	Size (NS)	Variety Size (NS)
CD (0 05)	0 0753	5 585	0 1117

Table 19 Effect of size of seed rhizome and variety on the net assimilation rate (NAR) of ginger as intercrop in coconut gardens (g m ^{2} day ^{1})

19 1 Between 90 135 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	0 222	0 096	0 160	0 159
M	0 117	0 067	0 139	0 108
N	0 086	0 127	0 100	0 105
R	0 089	0 093	0 123	0 102
Mean size	0 129	0 096	0 131	
F Test	Variety (NS)		Size (NS)	Variety Size (NS)
CD (0 05)	0 0547		0 0533	0 1066

19 2 Between 135 180 DAP

Varieties	Rhizome size			Mean var ety
	X	Y	Z	
K	0 120	0 278	0 264	0 221
M	0 117	0 332	0 141	0 196
N	0 115	0 104	0 094	0 104
R	0 236	0 207	0 124	0 189
Mean size	0 147	0 230	0 156	
F Test	Variety (S)		S ze (S*)	Variety Size (S*)
CD (0 05)	0 0811		0 0504	0 1008

Nedumangad recorded a low NAR and the influence of other varieties were comparatively high and on par

Maran at 10g recorded the highest NAR (0 332g m ^{2} day ^{1}) and was on par with Kuruppampady at 10g and 15g Nedumangadu at 15g gave the lowest NAR (0 094g m ^{2} day ^{1})

Crop growth rate (CGR)

a Open

The data presented in Table 20 revealed that crop growth rate was influenced by size of seed rhizome and varieties in the initial phase (90 to 135 DAP) The influence of plants raised from 5g was the lowest (0 181 g m ^{2} day ^{1}) The influence of plants obtained from 10 and 15g were superior and were on par In the second phase (135 to 180 DAP) also size of seed rhizome gave similar results Highest CGR was recorded by plants from 15g (1 361g m ^{2} day ^{1})

Varieties were significant only in the first phase (90 to 135 DAP) Nedumangad recorded the highest CGR (0 409 g m ^{2} day ^{1}) and was on par with Kuruppampady Rio de Janeiro recorded the lowest rate (0 173 g m ^{2} day ^{1}) In the second phase (135 to 180 DAP) the effect of variety and interaction were not significant

Table 20 Effect of sıze of seed rhızome and varıety on the crop growth rate (CGR) of gınger under open condıtıon (g m 2 day 1)

20 1 Between 90 135 DAP

Varıetıes	Rhızome s ze			Mean varıety
	X	Y	Z	
K	0 161	0 439	0 415	0 339
M	0 147	0 256	0 421	0 275
N	0 343	0 426	0 459	0 409
R	0 071	0 232	0 215	0 173
Mean sıze	0 181	0 338	0 378	

F Test	Varıety (S*)	S ze (S*)	Varıety S ze (NS)
CD (0 05)	0 1040	0 0971	0 1941

20 2 Between 135 180 DAP

Var et es	Rh zome sıze			Mean var ety
	X	Y	Z	
K	0 985	1 538	1 610	1 378
M	0 832	1 238	1 175	1 082
N	0 912	0 807	0 941	0 887
R	0 981	1 278	1 716	1 325
Mean s ze	0 927	1 215	1 361	

F Test	Var ety (NS)	S ze (S)	Var ety S ze (NS)
CD (0 05)	0 5334	0 2765	0 5530

b Inter crop

The data (Table 21) revealed that the size of seed rhizome was not significant with respect to crop growth rate under intercropped condition In the initial stage (90 to 135 DAP) Nedumangadu recorded the highest CGR (0 217g m^{2} day^{1}) In the second stage (135 180 DAP) superior performance was recorded by Rio de Janeiro (0 773g m^{2} day^{1}) followed by Nedumangadu (0 551 g m^{2} day^{1}

Interaction was significant only in the initial stage (90 to 135 DAP) Nedumangadu at 10 and 15g gave superior performance and were on par The lowest performance was recorded by Kuruppampady at 10g (0 046g m^{2} day^{1}) and was on par with Maran at 10g and 5g of Rio de Janeiro and Nedumangadu

Bulking rate (BR)

a Open

The data indicated that (Table 22) the influence of plants obtained from 15g was the highest (0 790g day^{1}) and was not significantly different in plants from 10g at 135 to 180 DAP Plants raised from 5g recorded the lowest BR (0 505g day^{1}) Varieties were found significant only in the initial phase (90 to 135 DAP) Nedumangadu recorded the highest bulking rate (0 135g day^{1}) while Rio de janeiro resulted in the lowest BR (0 036g day^{1}) Varieties were insignificant with respect to BR in the second stage (135 to 180 DAP) of observation

Table 21 Effect of size of seed rhizome and variety on crop growth rate of ginger as intercrop in coconut garden (g m 2 days 1)

21 1 Between 90 135 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	0 167	0 046	0 149	0 121
M	0 176	0 073	0 151	0 133
N	0 120	0 294	0 236	0 217
R	0 076	0 149	0 194	0 140
Mean size	0 135	0 140	0 182	
F Test	Variety (S)	Size (NS)	Variety Size (S*)	
CD (0 05)	0 0736	0 0463	0 0926	

21 2 Between 135 180 DAP

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	0 185	0 249	0 611	0 348
M	0 304	0 461	0 276	0 347
N	0 435	0 580	0 638	0 551
R	0 707	0 729	0 884	0 773
Mean size	0 408	0 505	0 602	
F Test	Variety (S*)	Size (NS)	Variety Size (NS)	
CD (0 05)	0 2066	0 1686	0 3371	

Table 22 Effect of sıze of seed rhızome and varıety on the bulkıng rate of gınger under open condıtıon (g day 1)

22 1 Between 90 135 DAP

Varıet es	Rh zome s ze			Mean var ety
	X	Y	Z	
K	0 065	0 190	0 131	0 129
M	0 053	0 116	0 208	0 121
N	0 111	0 154	0 140	0 135
R	0 007	0 061	0 041	0 036
Mean sıze	0 059	0 130	0 130	
F Test	Varıety (S*)		Sıze (S*)	Varıety Sıze (S)
CD (0 05)	0 0395		0 03329	0 0660

22 2 Between 135 180 DAP

Varıet es	Rh zome s ze			Mean var ety
	X	Y	Z	
K	0 587	0 799	0 866	0 817
M	0 450	0 750	0 688	0 629
N	0 559	0 441	0 520	0 507
R	0 423	0 685	1 084	0 731
Mean s ze	0 505	0 719	0 790	
F Test	Varıety (NS)		Sıze (S*)	Varıety S ze (S*)
CD (0 05)	0 3004		0 1066	0 2131

Interaction was found significant in the growth period with respect to BR In the second phase (135 to 180 DAP) Rio de Janeiro at 15g recorded the highest BR (1 084g day ^{1}) and was on par with Kuruppampady at 10g The performance of Rio de Janeiro at 5g was the lowest in the growth periods

b Intercrop

Bulking rate was not influenced by size of seed rhizome in the initial phase (135 to 180 DAP) But it became significant (Table 23) in the second phase (135 to 180 DAP) Plants raised from rhizomes weighing 15g recorded the highest BR (0 337g day ^{1}) followed by plants from 10g (0 269g day ^{1}) and were on par Plants obtained from 5g gave the lowest BR (0 180g day ^{1}) and was distinctly inferior

Varieties were significant in the first phase of growth (90 135 DAP) Nedumangadu recorded the highest BR (0 083g day ^{1}) and was on par with Maran and Kuruppampady The effect of Rio de Janeiro was the lowest (0 032g day ^{1})

Nedumangadu at 15g gave the highest BR and was on par with Kuruppampady at 5g and Nedumangadu at 10g Rio de Janeiro at 5g recorded the lowest BR in the first phase In the second phase (135 to 180 DAP) Kuruppampady at 15g recorded the highest bulking rate (0 556g day ^{1})

Table 23 Effect of size of seed rhizome and variety on the bulking rate of ginger as intercrop in coconut garden (g day [1])

23 1 Between 90 135 DAP

Variet es	Rh zome s ze			Mean variety
	X	Y	Z	
K	0 109	0 033	0 600	0 067
M	0 042	0 051	0 047	0 047
N	0 043	0 084	0 122	0 083
R	0 016	0 028	0 053	0 032
Mean size	0 053	0 049	0 070	

F Test	Var ety (S)	S ze (NS)	Variety Size (S*)
CD (0 05)	0 0379	0 0217	0 0434

23 2 Between 135 180 DAP

Var et es	Rh zome s ze			Mean var ety
	X	Y	Z	
K	0 104	0 118	0 556	0 259
M	0 165	0 453	0 244	0 287
N	0 126	0 218	0 222	0 188
R	0 325	0 285	0 325	0 312
Mean s ze	0 180	0 269	0 337	

F Tes	Var ety (NS)	S ze (S)	Var ety S ze (S)
CD (0 05)	0 1027	0 1095	0 2190

Top yield

a Open

Top yield was found to be the highest in plants obtained from rhizomes weighing 15g (2211 20 kg ha ^{1}) and was on par with plants from 10g (Table 24) The influence of plants from 5g bit was the lowest and was distinctly different in plants derived from 10 and 15g bits

Top yield was found to be the highest in Nedumangadu (2204 80 kg ha ^{1}) and Maran recorded the lowest (1476 26 kg ha ^{1}) The influence of Nedumangadu was found to be on par with Kuruppampady but was distinctly different from Maran and Rio de Janeiro The interaction was not significant

b Intercrop

The data (Table 25) revealed that plants raised from 15 g produced the highest top yield (2232 62 kg ha ^{1}) under intercropped conditions The effect of plants from 15g was comparable to plants from 10g The influence of plants derived from 5g was the lowest (1558 26 kg ha ^{1}) and was distinctly inferior to plants from 10 and 15g

Nedumangadu produced the highest top yield (3180 98 kg ha ^{1}) and was distinctly superior The performance of other varieties (Kuruppampady Maran and Rio de Janeiro) were inferior but were on par

Table 24 Effect of sıze of seed rhızome and varıety on the top yıeld of gınger (kgha ^{1}) under open condıtıon

Varıet es	Rhızome sıze			Mean varıety
	X	Y	Z	
K	1683 20	2019 19	2464 00	2055 47
M	1001 60	1347 20	2080 00	1476 26
N	1788 802	2579 20	2246 40	2204 80
R	1049 60	1900 80	2054 40	1668 26
Mean sıze	1380 80	1961 60	2211 20	
F Test	Varıety (S*)	S ze (S*)		Varıety S ze (NS)
CD (0 05)	416 81	421 17		842 33

Table 25 Effect of sıze seed rhızome and varıety on the top yıeld of gınger (kg ha ^{1}) as ıntercrop ın coconut garden

Var etıes	Rhızome s ze			Mean varıety
	X	Y	Z	
K	1026 98	1283 74	1323 94	1211 55
M	1849 81	1602 31	1599 26	1683 81
N	2165 34	3761 49	3616 10	3180 98
R	1190 93	2159 14	2391 14	1913 74
Mean s ze	1558 26	2201 68	2232 62	
F Test	Var ety (S*)	S ze (S*)		Varıety Sıze (S *)
CD (0 05)	728 21	282 62		565 25

Nedumangadu at 10 and 15g produced the hıghest top yıelds and was on par Kuruppampady at 5g recorded the lowest top yıeld (1026 98 kg ha $^{-1}$)

Rhızome spread

a Open

The effect of the sıze of seed rhızome was sıgnıficant ın rhızome spread (Table 26) Plants derıved from 15g seed materıal resulted ın the hıghest rhızome spread (24 65 cm) and was on par wıth the effect of plants from 10g (23 90 cm) The performance of plants from seed rhızome weıghıng 5g was the lowest (20 19 cm) and was dıstınctly ınferıor

The data revealed that rhızome spread was ınfluenced by varıetıes too Maran showed the hıghest rhızome spread (24 26 cm) and was on par wıth Kuruppampady (23 98 cm) Rıo de Janeıro recorded the lowest rhızome spread (21 60 cm) and was on par wıth Nedumangadu

b Intercrop

The data presented ın Table 27 revealed sıgnıficant dıfferences between plants obtaıned from 5 and 15g wıth respect to rhızome spread Rhızome spread ıncreased wıth ıncreasıng seed rhızome sıze The effect of plants raısed from 15g was the hıghest (20 26 cm) and was on par wıth that of plants from 10g (18 48 cm)

Table 26 Effect of size of seed rhizome and variety on the mean rhizome spread of ginger under open condition (cm)

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	22 03	24 07	25 83	23 98
M	20 73	26 00	26 03	24 26
N	19 20	23 23	23 03	21 82
R	18 80	22 30	23 70	21 60
Mean size	20 19	23 90	24 65	
F Test	Variety (S)		Size (S*)	Variety Size (NS)
CD (0 05)	2 155		1 459	2 918

Table 27 Effect of size of seed rhizome and variety on the mean rhizome spread of ginger as intercrop in coconut garden (cm)

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	14 27	14 57	17 90	15 58
M	15 26	18 07	16 73	16 69
N	18 03	21 03	21 23	20 10
R	18 77	20 23	25 23	21 41
Mean size	16 58	18 48	20 26	
F Test	Variety (S*)		Size (S*)	Variety Size (NS)
CD (0 05)	2 342		2 722	5 443

As intercrop Rio de Janeiro recorded the highest rhizome spread (21 41cm) followed by Nedumangadu and were on par Kuruppampady and Maran recorded comparitively lesser effects Kuruppampady recorded the lowest spread (15 58 cm)

Harvest index (HI) of ginger

a Open

Harvest index showed a decreasing trend with increasing size of rhizomes under open condition (Table 28) Plants raised from 5g recorded the highest HI (0 655) The effect of plants from 10 and 15g were less

Among varieties Kuruppampady (0 673) and Maran (0 670) recorded higher HI Nedumangadu recorded the lowest HI (0 537)

Interaction of size of rhizomes with varieties were found significant Maran and Kuruppampady at 5g recorded higher HI while Nedumangadu at 10 and 15g recorded a lower HI

b Intercrop

As intercrop size of rhizomes influenced HI (Table 29) The effect of plants obtained from 5g was the lowest (0 581) while that of plants raised from 10 and 15g were higher and on par

Table 28 Effect of size of seed rhizome and variety on the harvest index of (HI) ginger under open condition

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	0 6873	0 6710	0 6600	0 673
M	0 6980	0 6767	0 6350	0 670
N	0 5613	0 5250	0 5233	0 537
R	0 6730	0 6420	0 6360	0 650
Mean size	0 655	0 629	0 614	

F Test	Variety (S*)	Size (S*)	Variety Size (S*)
CD (0 05)	0 00734	0 00411	0 00823

Table 29 Effect of size of seed rhizome and variety on the harvest index of (HI) ginger as intercrop in coconut garden

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	0 6897	0 7277	0 7160	0 711
M	0 6817	0 7577	0 7460	0 728
N	0 4713	0 4773	0 4900	0 480
R	0 4827	0 4633	0 4733	0 473
Mean size	0 581	0 607	0 606	

F Test	Variety (S*)	Size (S*)	Variety Size (S*)
CD (0 05)	0 01601	0 009271	0 01854

Among varieties Maran (0 728) and Kuruppampady (0 711) recorded the higher HI Rio de Janeiro recorded the lowest HI (0 473)

Maran at 10 and 15g recorded comparatively higher HI while Rio de Janeiro at 10 and 15g and Nedumangadu at 5g recorded lesser HI

Utilization index (UI) of ginger

a Open

The data revealed that (Table 30) the utilization index decreased with increasing size of seed rhizomes Plants raised from 5g recorded the highest UI (1 962) and plants from 15g recorded the lowest (1 631)

Among varieties Kuruppampady recorded the highest UI (2 058) and was on par with Maran (2 049) Nedumangadu recorded the lowest UI (1 161)

The interaction of size of rhizomes with varieties were found significant Maran and Kuruppampady at 5g recorded the highest UI while Nedumangadu at 10 and 15g recorded the lowest

b Intercrop

Under shade plants obtained from 5g bits recorded the lowest utilization index (1 548) while the effect of plants from 10 and 15g were higher and on par (Table 31)

Table 30 **Effect of size of seed rhizome and variety on the utilisation index (UI) of ginger under open condition**

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	2 197	2 039	1 939	2 058
M	2 313	2 093	1 741	2 049
N	1 280	1 105	1 099	1 161
R	2 058	1 793	1 745	1 865
Mean size	1 962	1 758	1 631	
F Test	Vane y (S*)	S ze (S*)		Variety Size (S*)
CD (0 05)	0 0614	0 0356		0 0712

Table 31 **Effect of size of seed rhizome and variety on the utilisation index (UI) of ginger as intercrop in coconut garden**

Vane ies	Rhizome s ze			Mean var e y
	X	Y	Z	
K	2 226	2 682	2 528	2 479
M	2 140	3 145	2 956	2 747
N	0 892	0 913	0 963	0 923
R	0 934	0 863	0 898	0 898
Mean size	1 548	1 901	1 836	
F Test	Var ety (S*)	S ze (S*)		Variety S ze (S*)
CD (0 05)	0 2286	0 1212		0 2425

Among varieties Maran (2 747) and Kuruppampady (2 479) recorded the highest UI Under shade Rio de Janeiro recorded the lowest UI (0 898)

Interaction was found significant with respect to UI Maran at 10 and 15g recorded the highest UI while Nedumangadu and Rio de Janeiro recorded the lowest UI at all rhizome sizes

Green ginger yield

a Open

Size of seed rhizome resulted in significant differences in green ginger yield Table 32 and Fig 3 indicated that plants raised from 5g recorded the lowest green ginger yield (13688 kg ha ^{1}) and was distinctly inferior to plants obtained from 10 and 15 g The influence of plants raised from 15g was the highest (18480 kg ha ^{1}) and was on par with plants from 10g which recorded 16632 kg ha ^{1}

Green ginger yield was found to be the highest in Kuruppampady (22360 kg ha ^{1}) under open condition and was distinctly superior The influence of other three varieties (Maran Nedumangadu and Rio de Janeiro) were on par

Table 32 **Effect of size of seed rhizome and variety on the green ginger yield (kg ha^{-1}) under open condition**

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	20400	21488	25200	22360
M	11584	13128	19488	14736
N	11360	16000	13328	13560
R	11416	15896	15912	14408
Mean size	13688	16632	18480	
F Test	Variety (S*)	Size (S)	Variety Size (NS)	
CD (0.05)	3422.4	2800.0	—	

Table 33 **Effect of size of seed rhizome and variety on the green ginger yield (kg ha^{-1}) as intercrop in coconut garden**

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	11476	16317	17354	15049
M	19024	22999	22875	21633
N	15745	27546	26448	23246
R	7656	13812	15405	12291
Mean size	13475	20169	20520	
F Test	Variety (S*)	Size (S*)	Variety Size (NS)	
CD (0.05)	6716.09	2563.52	5127.03	

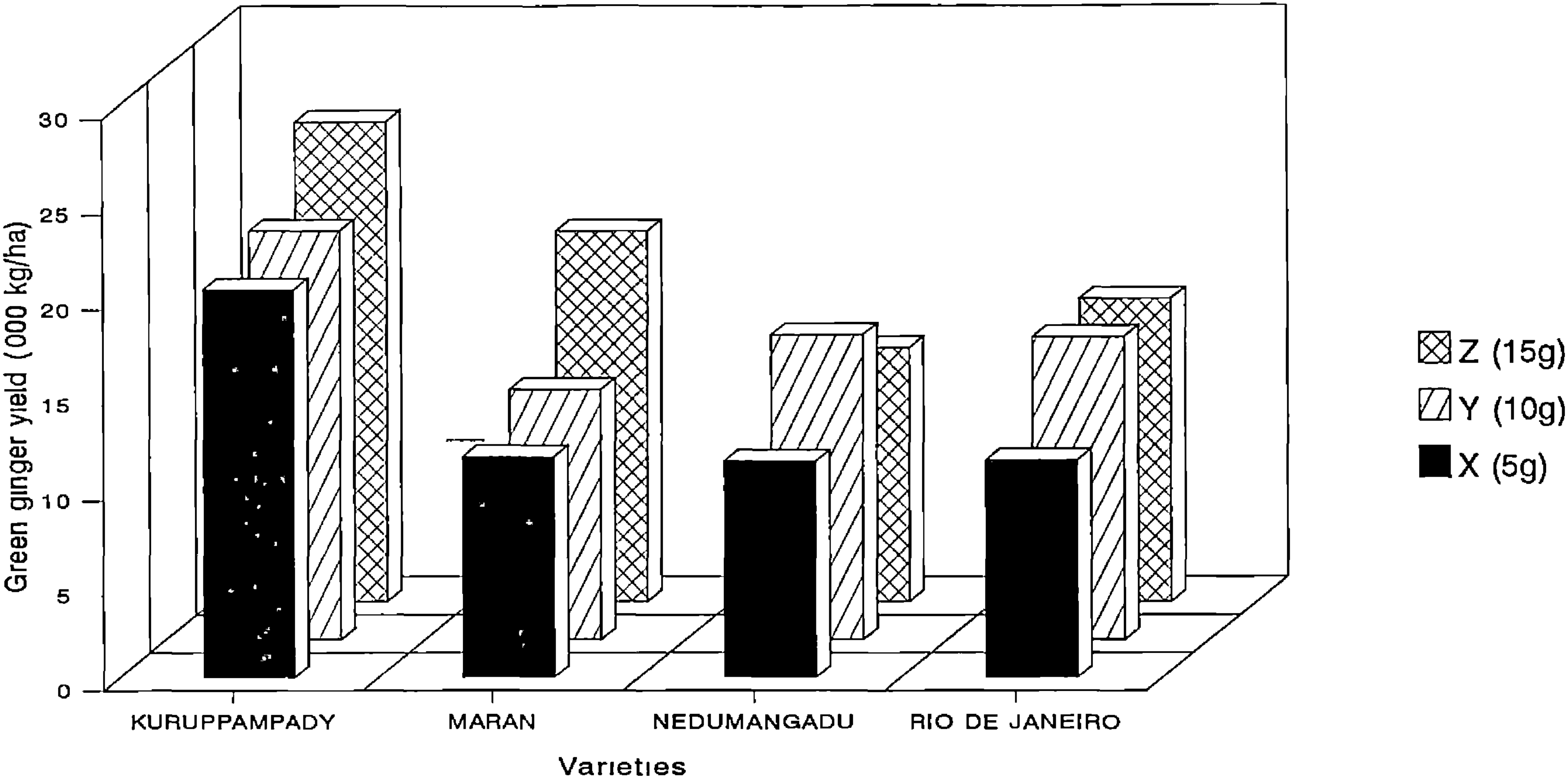


Fig. 3. Effect of seed rhizome size and variety on the green ginger yield (kg/ha) under open condition

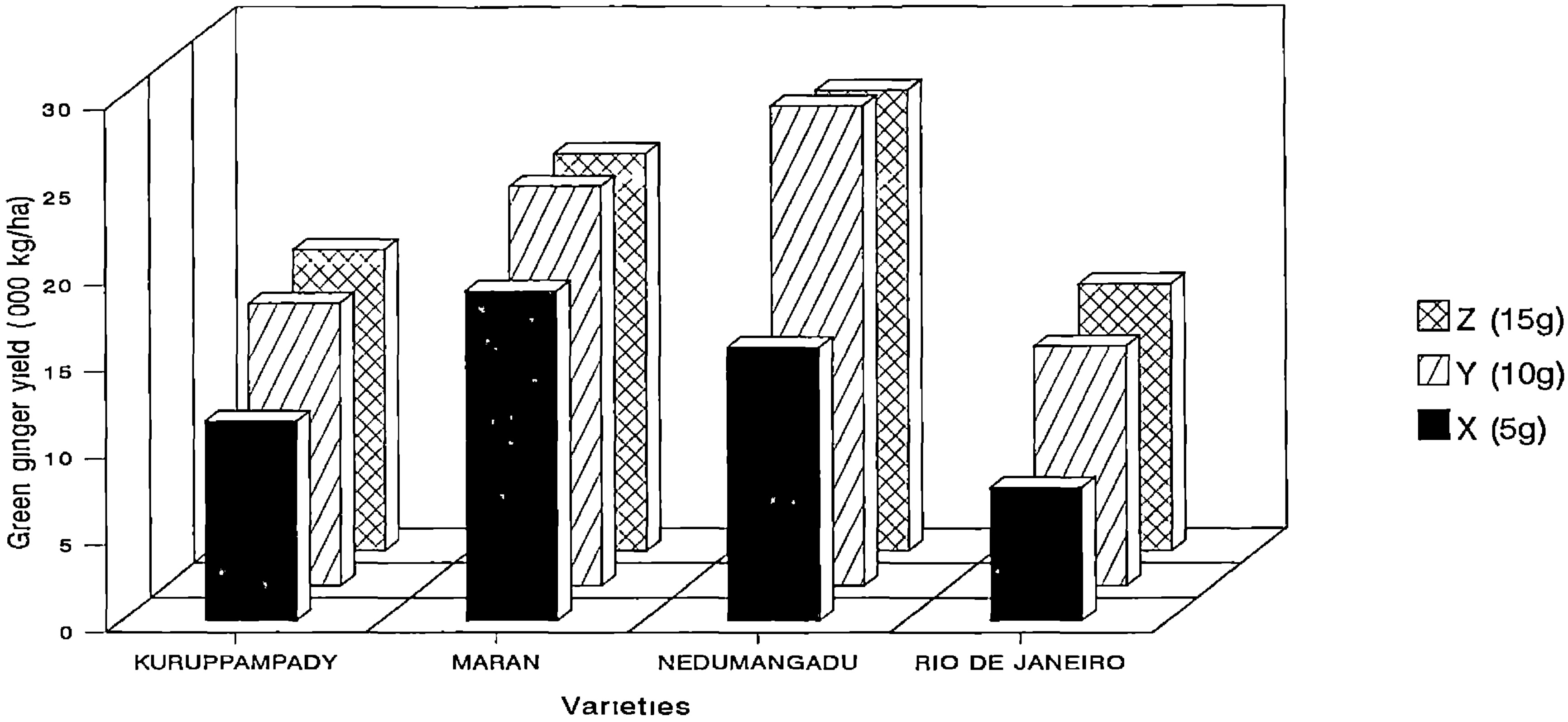


Fig. 4 Effect of seed rhizome size and variety on the green ginger yield (kg/ha) as intercrop in coconut garden

b Intercrop

The data on green ginger yield (Table 33 and Fig 4) yield increased with size of seed rhizome The effect of plants derived from 5g was less (13475 kg ha ^{1}) compared to plants from 10 and 15g and was distinctly inferior The influence of plants obtained from 10 and 15g on yield was on par Plants raised from 15g recorded the highest green ginger yield (20520 kg ha ^{1})

Among varieties Nedumangadu recorded the highest yield (23246 kg ha ^{1} and was on par with Maran (21633 kg ha ^{1}) The yield of Rio de Janeiro was the lowest (12291 kg ha ^{1}) and was on par with Kuruppampady (15049 kg ha ^{1})

Recovery of dry ginger

a Open

The data presented in Table 34 and Fig 5 revealed that the recovery of dry ginger is influenced by the size of seed rhizome The effect of plants from 5g was the lowest (2608 kg ha ^{1}) and was distinctly inferior to plants from 10 and 15g Plants raised from 15g recorded the highest dry ginger yield (3616 kg ha ^{1}) and was on par with plants from 10g (3296 kg ha ^{1})

Among varieties Kuruppampady recorded the highest dry ginger recovery (4184 kg ha ^{1}) and was distinctly superior Other varieties recorded lesser yields and were on par

Table 34 Effect of size of seed rhizome and variety on the recovery of dry ginger (kg ha^{-1}) under open condition

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	3678	4104	4778	4184
M	2314	2814	3616	2912
N	2294	2842	2478	2536
R	2162	3434	3582	3056
Mean size	2608	3296	3616	
F Test	Variety (S*)	Size (S*)	Variety Size (NS)	
CD (0.05)	741.44	596.83	1193.60	

Table 35 Effect of size of seed rhizome and variety on the recovery of dry ginger (kg ha^{-1}) as intercrop in coconut garden

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	2288	3464	3366	3040
M	3942	5064	4774	4592
N	1930	3442	3494	2952
R	1118	1866	2146	1712
Mean size	2320	3456	3448	
F Test	Variety (S*)	Size (S*)	Variety Size (NS)	
CD (0.05)	1235.68	441.27	882.48	

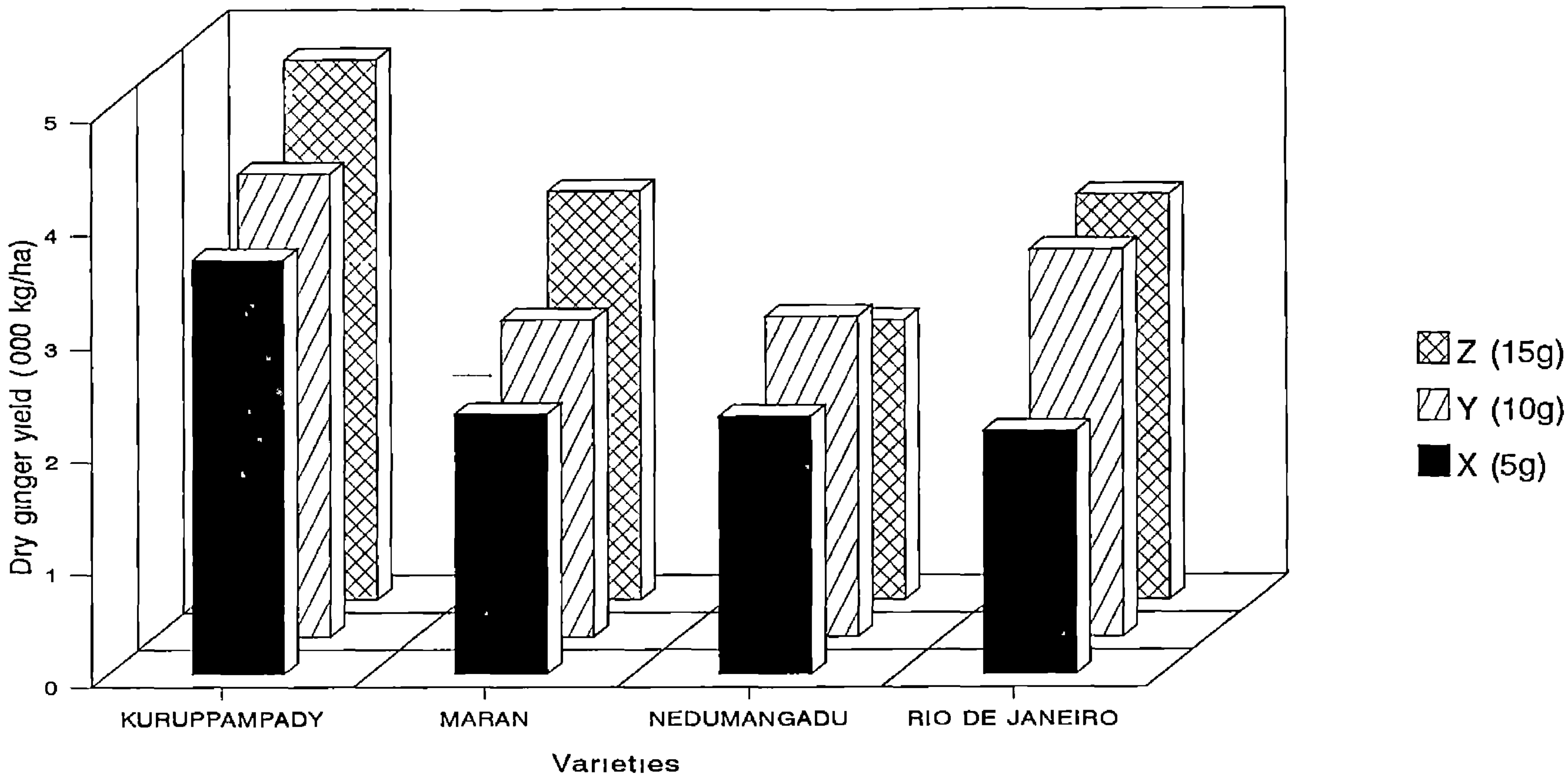


Fig. 5. Effect of seed rhizome size and variety on the recovery of dry ginger (kg/ha) under open condition

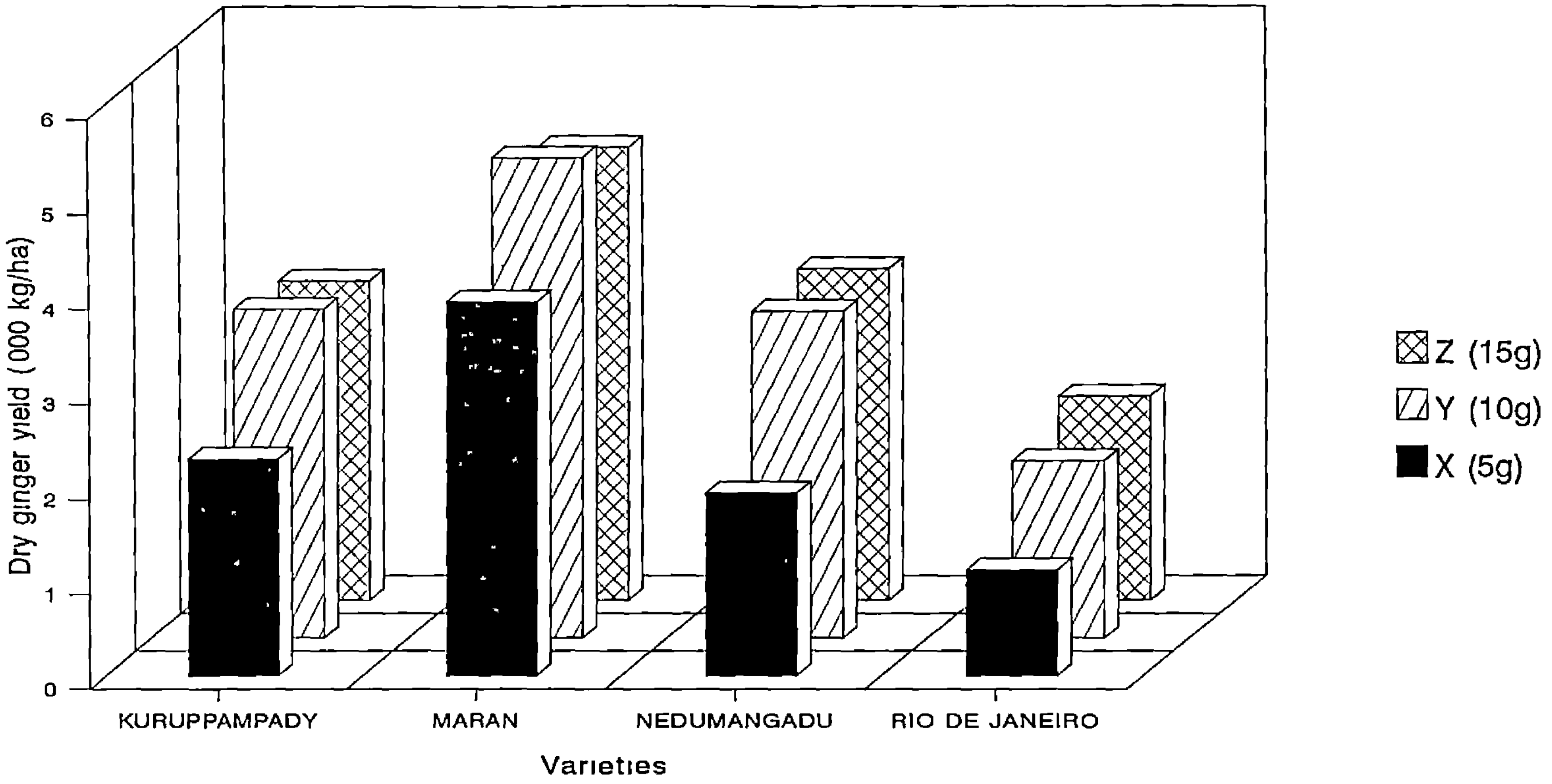


Fig 6. Effect of seed rhizome size and variety on recovery of dry ginger (kg/ha) as intercrop in coconut garden

b Intercrop

Data in Table 35 and Fig 6 showed that dry ginger recovery under shade is influenced by the size of seed rhizome Planting 5g bits recorded the lowest yield (2320 kg ha ^{1}) while the effect of plants from 10 and 15g were higher and were on par

Among varieties Maran recorded the highest yield of dry ginger (4592 kg ha ^{1}) and was distinctly superior The effect of Kuruppampady and Nedumangadu were on par Rio de Janeiro recorded the lowest dry ginger yield (1712 kg ha ^{1})

Volatile oil content

a Open

The data (Table 36) revealed that volatile oil content was not significantly influenced by size of seed rhizome and varieties under open conditions

b Intercrop

Volatile oil content was not significantly influenced (Table 37) by seed rhizome size and varieties used as intercrop in coconut garden However it was observed that rhizomes in intercropped condition possessed a higher volatile oil content than that in open condition

Table 36 Effect of sıze of seed rhızome and varıety on vol atıle oıl content of gınger % (v/w) on dry weıght basıs under open condıtıon

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	2 233	2 150	2 067	2 150
M	2 417	2 350	2 317	2 361
N	2 250	2 233	2 350	2 278
R	2 250	2 250	2 330	2 278
Mean sıze	2 288	2 246	2 267	
F Test	Var ety (NS)	Sıze (NS)	Varıety Sıze (NS)	
CD (0 05)	0 225	0 088	0 176	

Table 37 Effect of sıze of seed rhızome and varıety on vol atıle oıl content of gınger % (v/w) on dry weıght basıs as ıntercrop ın coconut garden

Varıetıes	Rhızome sıze			Mean varıety
	X	Y	Z	
K	2 500	2 583	2 750	2 611
M	2 667	2 667	2 750	2 674
N	2 750	2 583	2 583	2 639
R	2 583	2 750	2 833	2 722
Mean s ze	2 625	2 646	2 729	
F Test	Varıety (NS)	S ze (NS)	Varıety Sıze (NS)	
CD (0 05)	0 111	0 095	0 191	

Table 38 Effect of sıze of seed rhızome and varıety on the non vol atıle ether extract of gınger (%) on dry weıght basıs under open condıtıon

Varıetıes	Rh zome s ze			Mean varıety
	X	Y	Z	
K	3 717	3 733	3 767	3 739
M	3 267	3 200	3 267	3 244
N	3 067	3 200	3 300	3 189
R	3 333	3 433	3 600	3 456
Mean sıze	3 346	3 392	3 483	
F Test	Varıety (S*)	Sıze (S*)	Varıety S ze (NS)	
CD (0 05)	0 150	0 072	0 144	

Table 39 Effect of sıze of seed rhızome and varıety on the non vol atıle ether extract of gınger (%) on dry weıght basıs as ıntercrop ın coconut garden

Varıetıes	Rh zome s ze			Mean var ety
	X	Y	Z	
K	4 800	4 867	4 800	4 822
M	3 367	3 400	3 467	3 411
N	3 333	3 400	3 367	3 367
R	4 200	4 200	4 300	4 233
Mean sıze	3 925	3 967	3 983	
F Test	Var ety (S*)	S ze (NS)	Var ety S ze (NS)	
CD (0 05)	0 203	0 114	0 227	

Maximum fibre content was recorded in Kuruppampady (6 00%) and Rio de Janeiro recorded the lowest content (4 689%)

Among interaction highest fibre content was recorded in Kuruppampady at 10g (6 483%)

b Intercrop

Size of seed rhizome varieties and their interaction was found significant with respect to crude fibre content in intercropped condition (Table 41) Plants obtained from rhizomes weighing 5g recorded the lowest fibre content (5 958%) and was on par with plants from 10g (6 092%) The effect of plants from 15g was the highest (6 367%)

Under shade Rio de Janeiro recorded the highest crude fibre content (6 467%) and was followed by Maran (6 178) The fibre content of Nedumangadu and Kuruppampady were 5 944 and 5 967 respectively

Maran and Rio de Janeiro recorded the highest crude fibre content at 15g rhizome size (6 500%)

Starch

a Open

The data indicated that (Table 42) starch content was not influenced by size of seed rhizome in open condition But the effect of plants derived from 15g was the highest (47 90%)

Table 40 Effect of size of seed rhizome and variety on the crude fibre content of ginger rhizomes (%) on dry weight basis under open condition

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	6 050	6 483	5 467	6 000
M	5 967	5 500	5 533	5 667
N	5 033	5 000	4 533	4 856
R	5 000	4 533	4 533	4 689
Mean size	5 513	5 379	5 017	
F Test	Variety (S*)	Size (S*)		Variety Size (S*)
CD (0 05)	0 166	0 180		0 361

Table 41 Effect of size of seed rhizome and variety on the crude fibre content of ginger rhizomes (%) on dry weight basis as intercrop in coconut garden

Varieties	Rhizome size			Mean variety
	X	Y	Z	
K	5 967	5 933	6 000	5 967
M	6 000	6 033	6 500	6 178
N	5 400	5 966	6 467	5 944
R	6 467	6 433	6 500	6 467
Mean size	5 958	6 092	6 367	
F Test	Variety (S*)	Size (S*)		Variety Size (S)
CD (0 05)	0 362	0 190		0 380

Table 42 Effect of size of seed rhizome and variety on the starch content of ginger rhizomes (%) on dry weight basis under open condition

Variet es	Rh zome s ze			Mean variety
	X	Y	Z	
K	51 28	49 78	50 53	50 53
M	43 54	45 03	45 65	44 74
N	46 72	47 51	47 02	47 08
R	47 38	48 65	48 38	48 13
Mean s ze	47 23	47 74	47 90	
F Test	Variety (S*)	Size (NS)	Var ety S ze (NS)	
CD (0 05)	0 8631	0 7305	1 4610	

Table 43 Effect of size of seed rhizome and variety on the starch content of ginger rhizomes (%) on dry weight basis as intercrop in coconut garden

Variet es	Rhizome s ze			Mean variety
	X	Y	Z	
K	43 33	43 47	43 02	43 27
M	44 06	44 47	45 18	44 57
N	43 85	43 57	43 88	43 77
R	40 47	41 70	40 67	40 95
Mean s ze	42 93	43 30	43 19	
F Test	Var ety (S)	S ze (NS)	Variety S ze (NS)	
CD (0 05)	1 025	0 7409	1 482	

Table 44 Cost benefit analysis of using normal and mini seed rhizomes in ginger

44 1 Open

a	b	c	d	e	f	g	h
Size of rhizome (g)	Corresponding seed rate (kg ha^{-1})	Cost of seed ginger @ Rs 18 per kg	Initial saving (Rs)	Mean yield of fresh ginger (kg ha^{-1})	Difference in mean yield (kg)	Difference in profit @ Rs 9/kg of Fresh ginger	Net profit (d - g)
15	1500	27000	—	18480	—	—	—
10	1000	18000	9000	16632	1848	16632	7632
5	500	9000	18000	13688	4792	43128	25128

44 2 Intercrop

a	b	c	d	e	f	g	h
Size of rhizome (g)	Corresponding seed rate (kg ha^{-1})	Cost of seed ginger @ Rs 18 per kg	Initial saving (Rs)	Mean yield of fresh ginger (kg ha^{-1})	Difference in mean yield (kg)	Difference in profit @ Rs 9/kg of Fresh ginger	Net profit (d - g)
15	1500	27000	—	20520	—	—	—
10	1000	18000	9000	20169	351	3159	+5841
5	500	9000	18000	13475	7045	63405	45405

Among varieties Kuruppampady recorded the highest content of starch (50 50%) and was followed by Rio de Janeiro (48 10%) The lowest starch content was observed in Maran (44 71%)

b Intercrop

As observed in open condition the influence of the size of seed rhizome was not significant with respect to starch content in shade too (Table 43) Varieties influenced starch content significantly under shade Maran recorded the highest starch content (44 57%) and was followed by Nedumangadu (43 77%) The performance of these varieties remained on par The influence of Rio de Janeiro was the lowest (40 95%)

DISCUSSION

DISCUSSION

Qualıty of the plantıng materıal ıs the most ımportant factor ın sexual as well as vegetatıve propagatıon and ın successful crop productıon The behavıour of the plantıng materıal lıke sproutıng vıgour and vıabılıty hold a dırect relatıonshıp wıth the sıze of plantıng materıal In vegetatıvely propagated crops larger the sıze of seed materıal hıgher wıll be the quantıty of reserve food present and chances of more vıable buds These factors gıve an ınıtıal boost to the process of sproutıng growth and development However the expressıon of the effects of larger sıze of platıng materıal may be modıfıed by solar radıatıon and varıetıes used

In large scale cultıvatıon ıt ıs not possıble to ıncrease the sıze of plantıng materıal owıng to economıc reasons Thıs ıs more ımportant ın crops lıke gınger where the economıc part and seed materıal are one and the same In gınger ıt ıs estımated that seed materıal alone accounts for about 40 per cent of the overall productıon cost The use of mını seed rhızome can reduce the cost of cultıvatıon and ıncrease profıts

In the present studies the effects of soaking treatments on sprouting and initial growth of ginger are discussed The effect of mini seed rhizome on growth and yield under open and intercropped situations are analysed

I Pot culture

Sprouting

Soaking rhizomes 15 days prior to planting recorded the highest sprouting (16 03%) and one day prior to planting recorded the lowest (1 84%) Moisture is one of the most important factors required for successful sprouting After soaking the seed material requires some duration for sprouting process to start This may be the reason for a higher sprouting recorded from rhizomes soaked in water 15 days prior to planting The reduction in sprouting with the reduction in time gap (between soaking and planting) confirms this fact

Among varieties Nedumangadu recorded a higher sprouting percentage (49 89%) 15 days after planting whereas during the period no sprouting was observed in Maran This may be due to the differences in vigour of the varieties used

The increasing trend of sprouting with increasing weight of planting material was reported in banana (Hernandez *et al* 1988) and in turmeric (Hussain and Said 1967) The significant interaction may be due to the influence of different genotypes and seed rhizome sizes

Sixty days after planting the effect of soaking treatments was insignificant in sprouting (Table 3) This indicates that the influence of soaking treatments exhibited 15 days after planting was not retained as growth period advanced to 60 days after planting Variation in sprouting percentage was observed with respect to size of seed rhizome and varieties This influence was also noticed 15 days after planting

Plant height

The data (Table 4) revealed that superior performance was recorded in rhizomes soaked one day prior to planting and was on par with rhizomes soaked ten days prior to planting The effect of rhizomes soaked 15 days prior to planting was the lowest Soaking treatment might have stimulated the process of sprouting But this initial boost to sprouting might have lost in the absence of moisture and other factors required for continued growth when rhizomes were kept for a longer period of time (15 days) after soaking This might have resulted in slow establishment The root length is observed to be less for rhizomes soaked in water 15 days prior to planting These could be the probable reasons for reduced rate of growth in rhizomes soaked 15 days prior to planting

The effect of varieties may be due to the inherent difference in the vigour Plant height increased with increasing size of rhizomes This may be due to the presence of high amount of reserve food materials This effect was also reported by Korla *et al* (1989) in ginger

Root growth

The soaking treatments were not significant with respect to root growth at 60 days after planting The effect was significant only with different varieties and the size of seed rhizomes Effect of different varieties and variation in the content of reserve food in planting material might have resulted in differences in root length

II Field Experiment

Sprouting

Sprouting percentage was influenced by seed rhizome sizes and varieties used Sprouting percentage increased with increasing seed rhizome size Rhizomes weighing 15g recorded the highest sprouting under both the stages of observation (30 and 60 DAP) The immediate effect of the size of planting material was seen in sprouting exerting maximum influence Similar effect of seed rhizome size on sprouting was reported by Hussain and Said (1967) in turmeric and by Hernandez *et al* (1988) in banana

Among varieties Nedumangadu recorded the highest sprouting (97 28%) Sprouting was comparatively lesser for Kuruppampady and Rio de Janeiro This can be attributed to the difference in vigour of these varieties Nedumangadu possessed more than one viable bud even in rhizomes of 5g size which may be the reason for a good sprouting and establishment

As intercrop the effect of seed rhizome size and varieties remained same as in the open condition The sprouting percentage in intercropped condition was comparatively high This may be due to the low atmospheric and soil temperature high relative humidity and high soil moisture that prevailed in shaded situation producing a congenial condition for better sprouting This result is in agreement with the findings of Babu (1993) under similar agro climatic conditions

Plant height

In the open condition the effect of size of rhizomes was seen throughout the growth period The plant height increased with increasing seed size But the effect of plants obtained from 10g and 15g were not significantly different Studies on amorphophallus also revealed this trend Plant height and canopy size were less when planting bits were smaller (Kerala Agricultural University 1983) This increase in plant height on increasing seed size is also reported in ginger by Korla *et al* (1989) The increase in morphological characters in the present study may be due to the stored food materials in the seed rhizome However the plant height observed in 10g seed material was found to be more than that of plants from 15g at later stages This result is aganist the general trend of producing higher morphological features when large sized seed materials are used This can be due to the overlapping of leaves and competition between plants resulting from increased vegetative growth in plants derived from 15g This condition was observed especially at later stages of growth

In the intercropped situation the effect of seed size was prominent only in the initial stages Varieties created significant difference only in the initial stages Plants grown under shade recorded more height Similar results were reported in crops like tobacco (Panicker *et al* 1969) and maize (Moss and Stinson 1961) Ginger plants grown under full sunlight were found to be shorter compared to shaded plants (Aclan and Quisumbing 1976)

Number of tillers

Number of tillers per plant was significantly influenced by rhizome sizes and varieties used The influence of plants raised from 5g was inferior to 10 and 15 g Similar influence was reported in cardamom (Bose *et al* 1991) They observed that planting of large rhizome (20cm) increased shoot number compared to small rhizomes (2 5cm) The effect of plants raised from 10 and 15g were on par However in later stages the effect of plants from 10g was slightly high This may be due to the higher competition between neighbouring plants observed in plants obtained from 15g at later stages of growth

Nedumangadu recorded higher number of tillers This may be due to the increased vigour of this variety right from sprouting Varietal differences and its combined influence with rhizome size may be the reason for a significant interaction

As intercrop rhizome size was not significant except in the first stage (90 DAP) Reduced light may also masks the effect of rhizome size on tiller production In shade also Nedumangadu exhibited more tillering compared to other varieties

More number of tillers were observed in open condition compared to shade This effect was reported in ginger and turmeric by Susan Varghese (1989) A limitation in energy supply resulting from the decreased proportion of incident radiation available per tiller may be responsible for low tiller formation (Attiridge 1990)

Number of leaves per plant

Under open conditions the size of planting material significantly influence the number of leaves per plant One of the favourable factors like high content of reserve food material in larger seed bits may induce early sprouting higher sprouting percentage and more number of functional leaves Korla *et al* (1989) reported that the number of leaves increases with increasing seed size in ginger Kerala Agricultural University (1984 b) reported that in banana suckers weighing 1 1 5 kg recorded significantly lesser leaf numbers compared to suckers weighing 3 3 5 kg Throughout the growth period the effect of 10g was on par with 15g Nedumangadu produced the highest number of leaves except in the last stage

As intercrop the effect of rhizome sizes and varieties were significant only in the initial stages of growth (90 DAP) At later stages this effect was not observed Nedumangadu recorded a superior performance in the initial stages (90 120 and 150 DAP) This may be due to the higher vigour and tiller production of the variety The effect of varieties became insignificant at 180 DAP

Leaf area index (LAI)

Leaf area index is influenced by the size of planting material and varieties used (Table 14 and 15) Under open condition size of the planting material was found to be significant while under intercropped condition varieties alone were found significant The effect of plants raised from 10 and 15g were found to be superior and was not significantly different The potential of varieties to produce leaves were found varying especially under intercropped conditions The influence on LAI can be attributed to the effect of size and varieties on leaf production

Dry matter production

The effect of size was significant both in the open and intercropped condition Dry matter content increased with seed rhizome size But the effect of plants derived from 10g and 15g were on par Higher seed weight might have resulted in early and vigorous establishment and growth producing more leaves tillers and rhizomes producing higher dry matter content

Under open condition highest dry matter content was recorded by Kuruppampady This indicate the suitability of this genotype to open conditions subsequently Kuruppampady produced the highest green ginger yield in open conditions Similarly Nedumangadu recorded the highest dry matter production and yield of green ginger in the intercropped conditions This makes the variety suitable for intercropping Higher vegetative growth might have resulted in a significant interaction under shade

Net assimilation rate (NAR)

The effect of size of rhizome was not significant with respect to net assimilation rate under open conditions A positive correlation between NAR and irradiance was reported by Blackman and Wilson (1951) Under open conditions the effect of the size of rhizome was masked by the irradiance available in plenty and varieties might have performed according to their genetic potential

Under intercropped condition rhizome size variety and interaction were found significant The effect of plants obtained from 5g was the lowest while the influence of plants from 10 and 15g were higher and were on par on 90 135 DAP Higher growth and development associated with larger rhizome sizes may be the reason for a higher NAR in the initial stage But at later stages of growth (135 180 DAP) neighbouring plants overlap and begin to compete with each other This is more pronounced in plants raised from 15g This may the reason for a reduced NAR observed on 15g under shade In shaded condition the photosynthetic efficiency is low and ginger matures slowly than in open condition The low NAR under shade may be due to this fact coupled with moderately high leaf area index This low photosynthetic rate in shade combined with high leaf area index and competition may be the reason for a low NAR in varieties like Nedumangadu The effect of size of rhizomes and varieties on NAR may be modified by light intensity and competition between plants

Crop growth rate (CGR)

The effect of rhizome size was found significant in crop growth rate under open condition CGR increased with plants raised from 5 to 15g But the effect of plants from 10 and 15g were on par This may be due to the effect of size of rhizome on number of leaves leaf area index and dry matter production under open condition The interaction was not significant

Under shade only varieties were found significant The influence of size of rhizome was less Under open condition the intensity of solar radiation and temperature are comparatively high Hence a larger sized planting material is naturally preferred for better survival under open condition This may be the reason for a significant difference in CGR with respect to seed size under open condition But under intercropped condition even smaller bits will be be protected from intense sunlight because of natural shade provided by coconut leaves This may be the reason for an insignificant result created by rhizomes size under shade

CGR was comparitively low in intercropped condition This condition was reported in turmeric by Ramadasan and Satheesan (1980)

Bulking rate

Size of rhizome influenced the bulking rate throughout the growth period under open condition The effect was positive and the performance of plants derived from 10 and 15g were on par The significant effect of size of rhizome can be attributed to the better sprouting establishment and development of the plant associated with higher seed sizes The significant interaction may be due to the variation created by size of rhizome in different varieties Among varieties Kuruppampady recorded a higher bulking rate under open condition

Under intercropping situation the effect of size and interaction were found significant and the performance of 10 and 15g were on par

Top yield

The effect of size of rhizome on top yield was significant under open and intercropped condition It increased with seed size Plants obtained from 5g was inferior indicating a low vegetative growth The effect of plants raised from 10 and 15g were not significantly different and they exhibited the same effect right from germination

Nedumangadu was found to produce the highest top yield both under open and intercropped conditions This effect can be attributed to the vigorous growth and exhibited by this variety

Interaction effect was found to be significant in intercropped condition This may be due to the superiority of plants raised from 10 and 15g combined with different varieties under shade

Rhizome spread

The effect of size of rhizome on rhizome spread was significantly prominent in open and intercropped conditions Rhizome spread increased with seed size This was also reported by Korla *et al* (1989) in ginger

Under open conditions Maran produced the highest rhizome spread (24 26 cm) followed by Kuruppampady (23 98cm) Under intercropped situation Rio de Janeiro and Nedumangadu were found to possess more rhizome spread

Harvest index and utilization index

Under open condition increasing the size of rhizomes decreased the harvest index and utilization index These indices measure the ability of the plant to translocate the photosynthate to the vegetative and economic parts It is observed that vegetative growth increases with increase in rhizome size But under open conditions higher vegetative growth may be at the expense of rhizome production This may be the reason for a higher index in plants raised from 5g under open condition

As intercrop the harvest index and utilization index varied along with rhizome size Even at larger sizes the available photosynthate may be translocated preferentially to the economic parts and the vegetative growth may be optimum

Among varieties Kuruppampady and Maran recorded higher indies both under open and intercropped conditions This may be attributed to the ability of these varieties to translocate the available photosynthate to the economic parts irrespective of the levels of light intensity

The ability of genotypes to assimilate and translocate photosynthate to economic parts are different This ability is modified by plant growth which in turn is related to the size of planting material This may be the reason for a significant interaction between varieties and rhizome sizes

Green ginger yield

Under open and intercropped conditions the yield of green ginger was found increasing with increasing rhizome size The Plants raised from rhizomes weighing 5g produced the lowest yield while plants from 15g produced the highest under both the conditions This positive response in yield when the weight of seed rhizome increased was reported in ginger by many workers (Aiyadurai 1966 Randhawa *et al* 1972 Timpo 1982 Sengupta *et al* 1986 Mohanthy *et al* 1988 Roy and Wamanan *et al* 1989 and Okwnowulu 1992) The results also showed that the difference in yield created by plants raised from

10 and 15g rhizome bits were not significant Similar result has been reported by Korla *et al* (1989) in ginger

Under open condition the mean difference in yield between 10 and 15g was 1848 kg ha $^{-1}$ and for intercropped condition it was only 351 kg ha $^{-1}$ Therefore decreasing the size of rhizome from 15 to 10g will reduce the cost of cultivation and help to save valuable seed material Considering this the reduction in net profit under open condition is not large The cost benefit analysis (Table 44) indicate that the reduction in size of planting material is more profitable under shade Under intercropped condition even small sized rhizomes will get better establishment and this might have reduced the difference in yield between plants derived from 10 and 15g Therefore it is possible to reduce the size of seed rhizomes from 15 to 10g and still get economic returns for the farmer

The green ginger yield was the highest in Kuruppampady in open condition and Nedumangadu recorded the highest yield in intercropped condition These can be attributed to the combined effect of dry matter production net assimilation rate and leaf area index coupled with other growth parameters exhibited by these varieties under different conditions

Recovery of dry ginger

Rhizome size was found significant with respect to recovery of dry ginger both under open and intercropped conditions Under both the conditions rhizomes weighing plants from 15g recorded the highest dry ginger yield and was on par with that of plants from 10g The effect of plants raised from 5g was the lowest This effect may be due to the influence of size of rhizomes on green ginger yield

Among varieties Kuruppampady and Maran recorded the highest dry ginger yield under open and intercropped conditions respectively This variation can be attributed to the varietal difference in yield driage and the response of varieties under shade

Quality of the produce

Volatile oil content was not significant with respect to rhizome sizes and varieties both under open and intercropped conditions Similar effect of the size of planting material on quality of produce was reported in *Dioscorea esculenta* (Kerala Agricultural University 1989) It is noted that the volatile oil content in shaded condition was high This favourable effect of shade on volatile oil content was reported by George (1992) and Babu (1993) in ginger

Non volatile ether extract (NVEE) was found to be influenced by seed rhizome size NVEE increased with rhizome size This effect of size of planting material on the quality of the produce was reported in *Costus* (Kerala Agricultural University 1984 c)

Kuruppampady recorded the highest NVEE content under open and intercopped condition This effect may be the character of that genotype

NVEE was found to be higher in intercropped conditions Ravi Sankar and Muthuswamy (1987) reported that ginger grown under shade in an intercropped condition produced good quality rhizomes with high NVEE

Crude fibre content was influenced by rhizome size and variety In open condition plants from 5g recorded the highest crude fibre content But as intercrop the fibre content varied along with rhizome size Low light intensity and higher vegetative growth may be the reason for this effect Crude fibre content was the highest in Kuruppampady under open condition and in Rio de Janeiro under intercropped conditions

Starch content was not found to be significant with respect to rhizome size under open and intercropped condition However the content increased with rhizome size Similar effect was reported in cassava by Thampan (1979)

Starch content recorded higher values in Kuruppampady and Maran under open and intercropped situation respectively This can be due to the response of these varieties under different light intensities

The study suggested that the size of rhizomes varieties and shade influenced the growth yield and quality of ginger Throughout the crop period the plants raised from 10 and 15g gave similar performance Green ginger and dry ginger yield obtained from 10 and 15g rhizome bits were statistically on par under open and intercropped conditions The study revealed the possibilities of reducing the seed size from 15 to 10g The cost benefit analysis indicated that use of mini seed rhizome weighing 10g is more profitable under shade Using a smaller seed size will also help to contribute more produce to the market

SUMMARY

SUMMARY

An experiment was conducted at the College of Agriculture Vellayani to study the effect of different seed rhizomes sizes (5 10 and 15g) and varieties (Kuruppampady Maran Nedumangadu and Rio de Janeiro) on sprouting growth yield and quality of ginger adopting a split plot design with four replication The experiment was repeated in coconut garden as an intercrop A preliminary pot culture study was also conducted in factorial CRD design to find out a suitable soaking treatment for rhizomes The salient findings are summarised below

Pot culture experiment showed that soaking rhizomes and keeping them for a few days increase sprouting But the effect is not important at later stages of growth Plant height is influenced by soaking treatments Root growth is not affected by the soaking treatment Cutting and soaking rhizomes was found beneficial considering the effect on sprouting and subsequent growth Cutting and soaking rhizomes (24 hours) in water 10 days prior to planting was selected as the best soaking treatment

In the main field experiments the following results were obtained

Size of planting material influenced sprouting The effect of plants raised from 10 and 15g rhizomes bits were higher compared to that of plants from 5g Nedumangadu recorded the highest sprouting under open and intercropped condition Intercropped condition recorded higher sprouting

Plant height increased with increasing seed rhizome sizes The effect of plants obtained from 10 and 15g were not significantly different Under intercropped condition the effect of variety and seed sizes were not seen in the last stages of growth Plants grown under shade recorded more height

Tiller count was influenced by size of rhizomes only under open condition The effect of plants derived from 10 and 15g were on par Tillering was influenced by varieties both under open and intercropped conditions Nedumangadu recorded the highest number of tillers per plant

Under open condition the effect of rhizome size on number of leaves per plant was significant The effect of plants from 10 and 15g were similar

The performance was conparatively less for plants from 5g Nedumangadu recorded the highest number of leaves per plant As intercrop the effect of seed size and variety were not significant at advanced stages of growth

Leaf area index was influenced by rhizome size and variety under open condition The effect of plants obtained from 10 and 15g bits were not very much different Nedumangadu was a superior variety As intercrop variety was found more significant with respect to LAI

The effect of the size of rhizome on dry matter production was significant DMP increased with seed rhizome size The effect of plants raised from 10 and 15g were not significant Kuruppampady and Nedumangadu recorded the highest DMP in open and intercropped condition respectively

The effect of seed rhizomes size was not noticed is net assimilation rate under open condition Maran recorded the highest NAR under open condition As an intercrop plants from 10g recorded a higher NAR Kuruppampady recorded the highest NAR under shade

CGR increased with increasing rhizome sizes under open condition The effect of plants derived from 10 and 15g were on par Under intercropped condition varieties were found significant to CGR Nedumangadu and Rio de Janeiro recorded higher CGR under shade

Bulking rate was influenced by seed rhizome size under open as well as intercropped situations The influence of plants obtained from

10 and 15g bits were similar Among varieties Kuruppampady recorded a higher rate under open condition

Top yield increased with seed rhizome size The lowest top yield was recorded by plants obtained from 5g bits The performance was similar for plants raised from 10 and 15g under both the conditions Nedumangadu recorded the highest top yiled under open and intercropped condition

Harvest index and utilization index were influenced by rhizomes size and variety under open condition Plants derived from rhizome bits of 5g recorded the highest indices while as intercrop plants from 15g recorded the highest indices The effect of plants from 10g was intermediate under both the conditions Among varieties Kuruppampady and Maran recorded the highest indices under open and intercropped conditions

Green ginger yield increased with increasing seed rhizome size It was the lowest for plants derived from 5g and recorded the highest yield for plants from 15g The effect of plants raised from 10 and 15g on green ginger yield were not significantly different Kuruppampady and Nedumangadu recorded the highest green ginger yield under open and intercropped conditions respectively

Recovery of dry ginger was influenced by rhizome size and variety Both under open and intercropped conditions plants raised from 15g recorded the highest dry ginger yield and was on par with that of plants from 10g The effect of plants derived from 5g bits recorded a lesser dry ginger recovery Among varieties Kuruppampady and Maran recorded the highest dry ginger yields under open and intercropped conditions respectively

Volatile oil content was not influenced by rhizome size and variety both under open and shaded conditions However shaded condition recorded higher volatile oil content than in open condition Non volatile ether extract was significantly influenced by rhizome size under open condition NVEE content increased with rhizomes size Under intercropped condition NVEE was not significantly influenced by rhizome size Kuruppampady recorded the highest NVEE content under both the conditions

Crude fibre content was the highest in plants from 5g bits under open while plants raised from 15g bits recorded the highest fibre content in intercropped conditions Kuruppampady and Rio de Janeiro recorded the highest crude fibre content under open and intercropped conditions respectively

Starch content was not found to vary significantly with respect to rhizome sizes under open and intercropped conditions Kuruppampady recorded the highest starch content in open while Maran gave the highest starch content in shade

The study suggested that the size of rhizomes varieties and shade influenced the growth yield and quality of ginger Throughout the crop period the plants raised from 10 and 15g gave similar performance Green ginger and dry ginger yield obtained from 10 and 15g rhizome bits were statistically on par under open and intercropped conditions The study revealed the possibilities of reducing the seed size from 15 to 10g The cost benefit analysis indicated that use of mini seed rhizome weighing 10g is more profitable under shade Using a smaller seed size will also help to contribute more produce to the market

REFERENCES

REFERENCES

Aclan F and Quisumbing E C 1976 Fertilizer requirement mulch and light attenuation on yield and quality of ginger *Phil Agr* **60** 180 191

Ahmed N U Rahman M M Hoque M M and Amzad hossain A K M 1988 Effect of seed size and spacing on the yield of Ginger *Bangladesh Horticulture* **16** (2) 50 52

Aiyadurai S G 1966 *A Review of Research on Spices and Cashewnut in India* Ernakulam ICAR

Ancy Joseph 1992 *Nutrient requirement of ginger (Zingiber offcinale R) under shade* M Sc (Hort) thesis KAU Vellayani Thiruvananthapuram

A O A C 1975 *Official Methods of Analysis* Association of official Agricultural Chemists Washington D C 12th Edn

Ashokan P K Unnithan V K G and Vikraman Nair R 1984 Response of *Amorphophallus* to size of seed corm and manures *J Root Crops* **10** 51 54

Attridge T H 1990 *Light and plant Responses* Edward Arnold A Division of Hodder and Stonghtton Ltd pp 82 101

Babu P 1993 *Effect of shade and mulch on the yield of ginger (Zingiber Officinale R)* M Sc (Hort) thesis KAU Vellayani Thiruvananthapuram

Baghel B S Sarnaik D A and Pathak A C 1987 Study on the size of corms and levels of nitrogen on growth and yield of banana *Research and Development Reporter* **4** (1) 63 66

Bai L E K 1981 *Shade response of common rainfed intercrops of coconut* M Sc (Ag) Thesis KAU Thrissur

*Blackman G E and Wilson G L 1951 The constancy for different species of a logarithmic relationship between net assimilation rate and light intensity and its ecological significance *Ann Bot* (N S) **15** 63 94

Bose T K Mitra, S K and Sadhu M K 1991 Cardamom vegetative propagation In *Propagation of tropical and sub tropical horticultural crops* Naya Prokash Culcutta pp 444

Bourke R M and Perry C H 1976 Influence of settsize on growth and yield of taro (*Colocasia esculenta*) *Papua New Guinea Agric J* **27** 115 120

Buttery B R 1970 Effect of variations in leaf area index on growth of maize and soyabeans *Crop Sci* **10** (1) 9 13

*Coombe D E 1966 The seasonal light climate and plant growth in a Cambridgeshire Wood In light as an Ecological Factor Symp *Brit Ecol Soc* **6** 148 166

*Enyi B A C 1967 Effect of spacing settsize ridging and mulching on the development and yield of coco yam (*Xanthosoma sagittifolium*) *Schott Trop Aqric* **44** 53 60

Ferguson T U Haynes P H and Spence J A 1984 The effect of settsize sett type and spacing on some aspects of growth development and yield in white Lisbon yams (*D alata* L) *Proc of Sixth Symposium of the international Society for tropical root crops* pp 649 655

George B E 1992 *Evaluation of ginger cultivars for shade tolerance* M Sc (Ag) thesis KAU Thrissur

George J 1990 Effect of mini sett sizes and nursery media on the sprouting of yams *J Root Crops* **16** (2) 71 75

Harris P M 1978 Effect of seed size in potato *The potato crop* Chapman and Hall Ltd London pp 291 311

*Hernandez M A Lima M Cartaya G and Gonzalez J 1988 Performance in nursery beds of planting materilas of Zanzibar and MZUZU Green plantains weighing under two pounds *Ciencia y technica en la Agricultura Vindas Tropicales* **11** (1) 49 58

Hussain C and Said M 1967 Effect of size of seed on yield of turmeric (*Curcuma longa*) *W Pakist J Agric Res* **3** (2/3) 122 123

Jayachandran B K Sethumadhavan P and Vijayagopal P D 1982 Perliminary trials on recovery of mother rhizome (seed rhizome) in ginger after establishment of the crop *Proc of National Seminar on Ginger and Turmeric* (pp 93 95) Calicut

Jayachandran B K 1989 *Induced mutation in ginger (Zingiber officinale R)* Ph D Thesis Kerala Agri Univ Thrissur

Jayachandran B K Meera Bai M Abduul Salam M Mammen M K and Kunjamma P Mathew 1991 Performance of ginger under shade and open conditions *Indian Cocoa Arecanut and Spices J* **15** (2) 40 41

Jayachandran B K 1993 Research on mini seed ginger rhizome the need of the day *Spice India* **5** (2) 8 9

Kerala Agricultural University 1981 Effect of different planting materials on yield and quality of turmeric *KAU Research Report 1979 80* pp 180

Kerala Agricultural University 1983 Studies on the economisation of planting material in elephant foot yam *KAU Research Report 1980 81* pp 166 167

Kerala Agricultural University 1984 a Effect of different planting dates weight of rhizomes and spacing on yield and quality of turmeric *KAU Research Report 1982 83* pp 198

Kerala Agricultural University 1984 b Performance of clonal progenies from different yields groups in relation to size of suckers in rainfed banana (*Musa* sp AAB group) Palayamkodan *KAU Research Report 1982 83* pp 298 299

Kerala Agricultural University 1984 c Effect of spacing rhizome weight and time of harvest on the yield and quality constituents in *Costus speciosus* *KAU Research Report* 1982 83 pp 321

Kerala Agricultural University 1989 a The effect of different planting materials on growth yield and quality of turmeric *KAU Research Report 1985 86* pp 225

Kerala Agricultural University 1989 b Seed corm size and spacing trials in amorphophallus *KAU Research Report 1985 86* pp 333

Kerala Agricultural University 1989 c Effect of seed size and fertility levels on the yield and quality of *Discorea esculenta KAU Research Report 1985 86* pp 335

Kerala Agricultural University 1993 Ginger In *Package of Practice recommendations Crops 93* Directorate of Extension Kerala Agricultural University Mannuthy

Kohli U K and Saini S S 1986 Tips on ginger cultivation in the mid hills of Western Himalayas *Indian Horticulture* July Sept **19**

Korla B N Rattan R S and Dohroo N P 1989 Effect of seed rhizome size on growth and yield in ginger *Indian Cocoa Arecanut and Spices J* **13** (2) 47 48

Lyonga S N 1979 Cocoyam production in Camaroon *Proc of fifth Symp Inter Soc Trop Root crops* pp 647 663

Mohanty D C Sharma Y N Naik B S and Panda B S 1988 Influence of fertilizer cum seed rates on yield and performance of the selected ginger clones in the estern ghats highland zone of Orissa *Indian Cocoa Arecanut and Spices J* **12** (1) 1 3

Moon W and Pyo H K 1981 Effect of various shade levels on the growth of some cool season vegetables *J Korean Soc Hort Sci* **22** 153 159

*Moss D N and Stinson H T 1961 Differential response of corn hybrids to shade *Crop Sci* **1** 416 418

Nair G S 1977 A note on the use of detached sprouts as a planting material in ginger *Agricultural Research journal of Kerala* **15** (1) 100 101

National Research Centre for Spices 1989 Ginger *Package of practices* NRCS Calicut

*Newton P 1963 Studies on the expansion of the leaf surface II The influence of light intensity and photo period *J Exp Bot* **14** 458 482

Okwuowulu P A 1988 a Effect of seed ginger weight on the flowering and rhizome yield of fields grown edible ginger (*Zingiber officinale* Rose) in Nigeria *Tropical Science* **28** (3) 171 176

Okwuowulu P A 1988 b Parent sett re cycling in edible ginger (*Zingiber officinale* Rose) production in South eastern Nigeria *Tropical Science* **28** (3) 177 184

Okwuowulu P A 1992 Influence of decreasing mini sett weight and intra row spacing on the coated ginger cv Taffin giwa *J Spices and Aromatic Crops* **1** (1) 59 64

Paniker S N Sajnani B T and Walunjkar W G 1969 Comparitive performance of two varities of cigar wrapper tobacco grown at varying nitrogen and spacing levels under shade and in the open *Indian J Agric Sci* **39** 333 340

Patel N L and Chundrawat B S 1988 Effect of size and testing period of sucker on growth and yield of banana *Indian J Horticulture* **45** (3 4) 189 196

Philip J Nair G S Premalatha and Sudhadevi PK 1992 Effect of planting material and time of harvest on yield and essential oil content of rhizomes in *Acorus calamus Indian Cocoa Arecanut and Spices J* **16** (2) 63 65

Pruthi J S 1993 Ginger In *Major spices of India Crop management and post harvest technology* ICAR New Delhi pp 247 250

Pushpakumari R 1989 *Fertilizer management of minor tuber crops in coconut based cropping system* Ph D thesis Kerala Agric Univ Thrissur Kerala

Ramadasan A and Satheesan K V 1980 *Ann Rep* CPCRI Kasaragode Kerala pp 813

Randhawa K S Nandpuri K S and Bajwa M S 1972 Studies on the comparitive efficiency of different sizes of seed and spacing on the yield of ginger (*Zingiber officinale* Rose) *J of Research India* **9** (2) 239 241

Ravisankar C and Muthuswamy S 1987 Study on the quality of ginger (*Zingiber officinale* R) grown in different light intensities *South Indian Hort* **35** (3) 226 231

Ravisankar C and Muthuswamy S 1988 Influence of light and temperature on leaf area index chlorophyll content and yield of ginger *J Maharashtra Agric Univ* **13** (2) 216 217

Roy A R Wamanan PP 1989 Effect of seed rhizome size on growth and yield or ginger (*Zingiber officinale* R) *Advances in plant Sciences* **2** (1) 62 66

Roy A R and Wamanan P P 1990 Varıetal performance and correlatıons among growth and yıeld attrıbutes of gınger (*Zıngıber offıcınale* R) *Indıan Agrıculturıst* **34** (1) 57 61

Scott R K and Younger A 1972 Relatıonshıp between the number of tubers per plant and sıze of seed tuber ın potato *Outl Agrıc* **7** 3 9

Sen H N Roy Chowdhury and Bose T K 1984 Effect of seed corm weıght and spacıng on the total corm yıeld of amorphophallus *J Rootcrops* **10** 37 39

Sengupta D K Maıty T K Som M G and Bose T K 1986 Effect of dıfferent rhızome sıze on the growth and yıeld of Gınger (*Zıngıber offıcınale* Rose) *Indıan Agrıculturıst* **30** (3) 201 204

Srıvastava L S Upadhaya R C Ray S and Jaınath 1992 Gınger cultıvatıon ın Sıkkım *Spıce Indıa* **5** (7) 21 24

Susan Varughese 1989 *Screenıng of varıetıes of gınger and turmerıc for shade tolerance* M Sc (Ag) thesıs KAU Thrıssur

Thampan P K 1979 *Cassava* Kerala Agrıcultrual Unıversıty Dırectorate of Extensıon Mannuthy pp 73 77

Tımpo G M 1982 Effect of cultıvar and seed sıze on growth and yıeld of gınger (*Zıngıber offıcınale* Rosc) *Kumarsıtech J Agrıcultural Scıence* **1** 14 21

Watson D J 1958 The dependence of net assımılatıon rate on leaf area ındex *Ann Bot* **23** 431 439

* (Orıgınals not seen)

ECONOMISING PLANTING MATERIAL IN GINGER (*Zingiber officinale* R.) USING MINI-SEED RHIZOME

BY

NIZAM S A

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI THIRUVANANTHAPURAM

1995

ABSTRACT

An experiment was conducted at the College of Agriculture Vellayani during the year 1993 1994 to explore the possibility of reducing the size of planting material in ginger using mini seed rhizomes

The field experiments were laid out in a split plot design with four varieties (Kuruppampady Maran Nedumangadu and Rio de Janeiro) and three rhizome sizes (5 10 and 15g) replicated four times both under open and intercropped conditions

The pot culture study to standardise a soaking treatment for ginger rhizomes revealed that soaking rhizomes in water for 24 hours 10 days prior to planting to be the best treatment

Increasing the size of rhizomes resulted in increased sprouting percentage Under open and intercropped conditions rhizomes weighing 15g recorded the highest sprouting Size of seed rhizomes influenced the growth parameters namely plant height number of tillers and number of leaves per plant LAI DMP NAR CGR BR HI UI and top yield It is seen that the performance of plants raised from 10 and 15g with respect to growth parameters were not significantly different

Green ginger yield increased with increasing rhizome size both under open and intercropped condition Plant raised from rhizomes weighing 5g recorded the smallest yield and was inferior to other treatments Plants from rhizomes weighing 15g recorded the highest green ginger yield The difference in yield between plants obtained from 10 and 15g was marginal and statistically insignificant Plants raised from rhizomes weighing 10 and 15g gave higher dry ginger yields in all the four varieties compared to plants from 5g However the difference in yield between plants raised from 10 and 15g rhizome bits were insignificant

The size of rhizomes didnot cause differences in quality components like volatile oil and starch in all varieties but it induced small variations in NVEE and crude fibre

The study suggested that the size of rhizomes varieties and shade influenced the growth yield and quality of ginger Throughout the crop period the plants raised from 10 and 15g gave similar performance Green ginger and dry ginger yield obtained from 10 and 15g rhizome bits were statistically on par under open and intercropped conditions The study revealed the possibilities of reducing the seed size from 15 to 10g The cost benefit analysis indicated that use of mini seed rhizome weighing 10g is more profitable under shade Using a smaller seed size will also help to contribute more produce to the market