SCREENING DIFFERENT MORPHOTYPES OF COLOCASIA [*Colocasia esculenta* L.Schott] FOR SHADE TOLERANCE

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture
Kerala Agricultural University

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COLLEGE OF HORTICULTURE
Vellanikkara - Thrissur
Kerala - India
1990

DECLARATION

I hereby declare that this thesis entitled 'Screening of different morphotypes of colocasia for shade tolerance' is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
3.11.1990.

PRAMEELA .P.

CERTIFICATE

Certified that this thesis entitled 'Screening of different morphotypes of colocasia for shade tolerance' is a record of research work done independently by **Miss. Prameela, P.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Professor of Agronomy,
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CERTIFICATE

We, the undersigned members of the Advisory Committee of **Miss. Prameela, P.,** a candidate for the degree of Master of Science in Agriculture agree that the thesis entitled 'Screening of different morphotypes of colocasia for shade tolerance' may be submitted by Miss. Prameela, P., in partial fulfilment of the requirement for the degree.

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ACKNOWLEDGEMENT

With immense pleasure I take this opportunity to express heartfelt gratitude and unforgettable indebtness to **Dr. R. Vikraman Nair,** Professor of Agronomy and Chairman of my advisory committee for his expert guidance, constant encouragement and patience that he has bestowed on me during the course of my research and preparation of this manuscript.

I gratefully acknowledge Dr. E. Tajuddin, Professor and Head, Department of Agronomy, for his valuable suggestions and guidance in the preparation of this thesis. It gives me very great pleasure to place on record my sincere thanks to Dr. P.V. Balachandran, Associate Professor, Department of Agronomy for his valuable suggestions and timely support. I thankfully acknowledge the guidance and valuable suggestions rendered by Sri. V.K.G. Unnithan, Associate Professor, Department of Agricultural Statistics.

I wish to express my deep felt gratitude and sincere thanks to Dr. A.V.R. Kesava Rao, Associate Professor, Dept. of Agricultural Meteorology for the keen interest, critical suggestions and the timely help I received from him in radiation measurement.

My sincere thanks are also due to Dr. V.K. Venugopal, Associate Professor, Dept. of Soil Science and Agrl. Chemistry for his expert guidance in chemical analysis. It is with deep gratitude that I remember the help rendered by Dr. K.C. Velayudhan, Scientist, NBPGR, Regional Station, Vellanikkara in identification of Colocasia morphotypes.

The supply of seed materials from CTCRI, Sreekariyam and NBPGR, Regional Station, Vellanikkara is thankfully acknowledged.

I avail myself of this opportunity to thank Sri. K.N. Natarajan, Farm Assistant, for his timely help and cooperation throughout the study. I further express my deep sense of gratitude to all the staff members of the Dept. of Agronomy for their unfailing helps offered during the course of my research, and to KAU Computer Centre for the statistical analysis of the data. I express my heartfelt thanks to all my friends for their cooperation and to Shri. O.K. Ravindran for his neat typing.

It is with deep gratitude that I remember the constant encouragement and cooperation of my parents, sister and brother. Thanks are also due to the financial assistance and the permission granted for taking this problem as a part of the ICAR Project on Shade studies on Coconut based Intercropping Situations. My posting in the above ICAR Adhoc scheme as Junior Research Fellow is duly acknowledged.

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Introduction

INTRODUCTION

Light is the primary factor in photosynthesis. The amount of light energy intercepted by a crop is a major discriminant of crop production (Watson, 1952). Since the capacity to utilize light efficiently in photosynthesis is the basis of agricultural production, the adaptations or modifications in plants for better light use efficiency may be of importance for attaining greater yields especially from inter and mixed cropping situations. It has frequently been stressed that identification of suitable crops is likely to be one of the major ways of improving intercropping performance.

Colocasia is one of the important tropical edible aroid and is usually recommended for intercropping in coconut gardens. They are adapted to a wide range of ecological conditions that exist in the tropics. The ability of cocoyams to tolerate shady conditions makes them suitable for intercropping between taller plantation crops, so that light filtering through the plantation canopy is not wasted.

Taro has usually been studied in monoculture. The ability of the crop to do well is crucially dependent on its ability to tolerate shade where it is grown beneath the canopy of tree crops. Very little work has so far been done on the shade tolerance of colocasia, but it seems clear that colocasia can grow and yield reasonably in light intensities that would cause complete crop failure in many other crops.

Studies on crop performance at graded shade levels of a few common intercrops of coconut belt were taken up at the College of Horticulture, Vellanikkara, Thrissur, during 1981 to 1983. Based on the yield trend, colocasia was classed as shade tolerant.

It has often been reported that there can be substantial inter-varietal differences in shade affinity/tolerance of crops and that it should be possible to exploit this aspect profitably in intercropping situations. The present study has such a varietal assessment under different shade levels as one of the major objectives.

A probable consequence of raising crops under shade is the variation in quality of crop produce especially in the case of economic products whose accumulation is directly linked with photosynthesis. A general assessment of changes in quality of product is yet another objective of the study.

The major objectives of the field study may be summarised as follows:

(i) To screen varieties of colocasia for shade tolerance and to select varieties suitable for varying shade situations.

(ii) To study changes in quality of crop produce induced by shading.

Review of Literature

REVIEW OF LITERATURE

Solar radiation is considered as an essential component in biosphere activity via the photosynthetic performance of plants. Productivity of a plant depends on its capacity to efficiently harvest solar energy for the metabolic production and also the partitioning efficiency of the same for higher productivity. This character of a plant is controlled by the genetic make up of it to a certain extent. However, the environmental conditions under which it grows also control the above to a great extent. The influence of shade on various aspects such as photosynthesis, vegetative characters, drymatter accumulation, yield, flowering, fruiting etc. has been studied in many crops of commercial importance. However, published literature on such studies in colocasia is scanty. Hence literature available on the subject, irrespective of the crop is reviewed.

2.1 Genotypic response to light intensity

The varietal ability to shade tolerance has been studied in several crops, including tuber crops. Martin (1985) studied the effect of mild and heavy shade on 18 sweet potato cultivars selected for shade tolerance and found that cultivars differed significantly in response to shade. Selections for shade tolerance outyielded standard cultivar under mild shade, but were equally inhibited from producing in strong shade. The effect of 0 and 50 per cent shade on three Colocasia esculenta cultivars was studied by Caiger (1986). In full sun, yields were 21.7, 16.3 and 16.9 kg fresh weight/plot compared with 12.6, 12.4 and 11.6 kg fresh weight/plot in 50 per cent shade for cultivars Dalokena, Manua and Manua Kula respectively. Yield differences between shaded and unshaded plants were significant for all the three cultivars, but yield differences between cultivars were not significant.

Among the different rice varieties tried at Coimbatore, the variety Ponni performed better even in 25 per cent of normal light where as IR-20 was found as the most susceptible one to low light intensity (Vijayalakshmi et al., 1987). Jadhav (1987) studied the effect of partial shading on the yield of rice. Twenty five rice varieties were tested under natural sunlight and 45-50 per cent of available sunlight. Pankaj, IET 5852 and IET 5854 gave the highest grain yields under normal light while IET 3257, IET 4697 and IET 5633 did so under reduced light. In an experiment to study the response of Amaranthus spp. to various light intensities, all the seven species tried responded in a similar way to light intensity (Simbolon and Sutarno, 1986).

The growth, development and yield of seven potato cultivars were evaluated under field conditions with photoperiods ranging from 11.5 to 16 hours and light intensities from full light to 42 per cent light in three experiments at Philippines (Demagante and Zaag, 1988). Among the cultivars, DTO-33 was found least affected by shading, followed by Desiree, LT-2 and Red Pontiac. LT-5 and P-3 suffered the greatest tuber yield reduction through shading. Sreekumari et al. (1988) identified seven cassava genotypes as shade tolerant in respect of tuber yield.

Brian et al. (1988) in their studies on modelling the effect of light, CO_2 and temperature on the growth of two potato varieties found that tuber yield was the highest with high light (550 μmol m^{-2} s^{-2} PPF) for 'Norland' and with medium light (455 μ mol m^{-2} s^{-2} PPF) for 'Russet Burbank'.

Varughese (1989) noticed appreciable varietal differences in shade response of ginger and turmeric in her trials at Vellanikkara.

2.2 Growth and growth attributes

2.2.1 Plant height

Increase in plant height due to shading is reported in several crops like ginger, turmeric (Bai and Nair, 1982, Varughese, 1989), groundnut (George, 1982), tomato (Kamaruddin, 1983), winged bean (Sorenson, 1984), Cassava (Ramanujam et al., 1984 and Sreekumari et al., 1988), sweet red pepper (Rylski and Spigelman, 1986), Amaranthus spp. (Simbolon and Sutarno, 1986), broadbean (Xia, 1987), rice (Singh et al., 1988) and potato (Demagante and Zaag, 1988).

Negative influence of shading on plant height was noticed in redgram (George, 1982), bird'sfoot trefoil and alfalfa (Cooper, 1966) whereas George (1982) and Bai and Nair (1982) reported that plant height is unaffected by shading in cowpea, blackgram and colocasia.

2.2.2 Leaf area development and number of leaves

As in the case of plant height, contradictory findings are reported in the case of leaf area development under shaded conditions. Martin (1985) noticed increase in foliage growth of sweet potato under lower light intensities. The leaf number and leaf size of *Amaranthus* spp. were found greater at the intermediate than at high light level (Simbolon and Sutarno, 1986). Venkataramanan and Govindappa (1987) also observed that clove seedling kept under shade produced more number of leaves than seedlings exposed to sun. Gratani *et al*. (1987) found that leaf area of sun leaves (upper layer) was lower than that of shade ones within a beech crown.

However in rice leaf area development and photosynthetic efficiency were reduced due to low light intensity (Venkateswaralu, 1977). Xia (1987) found that in *Vicia faba* plants subjected to 50 and 25 per cent shade, the number of leaves per plant decreased.

2.2.3 Drymatter production

Caesar (1980) observed the highest drymatter yield of *Colocasia esculenta* under full sunlight whereas *Xanthosoma saggittifolium* produced highest drymatter under shade. Increased drymatter production at reduced light is also reported in ginger (Ravisankar and Muthuswamy, 1986). Venkataramanan and Govindappa (1987) reported that coffee seedlings kept under shade produced more total drymatter compared to those exposed to sun.

A drastic decrease in drymatter accumulation was noticed in all the rice varieties raised under shade (Vijayalakshmi *et al.*, 1987).

2.2.4 Growth analysis

Ramadasan and Satheesan (1980) recorded the highest leaf area index, crop growth rate and net assimilation rate with three turmeric cultivars grown in open condition compared to the same under shade. Low radiation (78 per cent and 32 per cent of full solar radiation) led to production of leaves with high specific leaf area in cassava while leaf area index under full sun increased (Fukai *et al.*, 1984). A reduction in harvest index under shaded condition is reported in rice by Vijayalakshmi *et al.* (1987).

According to Ono and Iwagaki (1987) satsuma mandarin trees subjected to reduced light intensities increased SLA and LAI while there was a reduction in leaf area density with increasing shade. Venkataramanan and Govindappa (1987) observed that the increased total drymatter production of coffee seedlings grown under shade was due to increase in NAR and this parameter showed a significant positive correlation with total drymatter. Jadhav (1987) reported that in field pea, CGR, LA and NAR are positively correlated with PAR while RGR, LAR, LWR and SLA are negatively correlated.

2.3 Chlorophyll content

It has been established by several workers that shaded plants have a higher chlorophyll content compared to plants exposed to sun. Gratani et al. (1987) observed that even within a tree canopy, the lower layer of leaves had the maximum chlorophyll content. Singh (1988) recorded an increased leaf chlorophyll content in potato under 25 per cent of normal sunlight.

Nii and Kurowia (1988) studied the anatomical changes including chloroplast structure in peech leaves under different light conditions and found that chlorophyll content per unit leaf area and per dry weight increased with shading. Shade-leaf chloroplasts (10 and 25 per cent of full sun) were larger and rich in thylakoids, while sun-leaf chloroplasts (50 and 100 per cent of full sun) showed poorly stacked grana. Starch accumulation in the chloroplasts of sun-leaves was markedly higher than in shade-leaf chloroplasts.

Increased chlorophyll content under shaded condition is also reported in colocasia (Bai, 1981).

Contradictory to the above findings Pandey et al. (1980) in chickpea and Grant and Ryug (1984) in leaves of Kiwifruit observed the same chlorophyll content at varying shade levels whereas Rao and Mittra (1988) found that in peanut shading reduced the chlorophyll content.

2.4 Physiological activities

Considerable differences between varieties in their photosynthetic rate per unit leaf area had been found in many crop plants. Shading greatly reduced photosynthetic rate in crops like alfalfa (Wolf and Blaser, 1972), bean (Crookston et al., 1975), grapes (Vasundara, 1981 and Mathai, 1987), cotton (Singh, 1986), citrus (Ono and Iwagaki, 1987), groundnut (Senagupta and Jadhav, 1988) and potato (Singh, 1988).

A positive influence of shade on photosynthesis and drymatter accumulation had been reported in the case of ginger and turmeric (Bai and Nair, 1982).

Reduced translocation of assimilates under shaded condition is reported in brinjal (Krishnankutty, 1983), potato (Singh, 1988) and groundnut (Sengupta and Jadhav, 1988).

A progressive increase in cuticular resistance to transpiration because of shading was reported in tea (Harikrishnan and Sharma, 1980 and Handique and Manivel, 1987). Ono and Iwagaki (1987) found that in satsuma mandarin trees, photosynthesis and respiration diminished with increasing shade intensity, respiration being the more affected.

2.5 Yield

The environmental conditions under which a plant grows control the productivity of the plant to a great extent. Out of the various physical environmental factors, the light regime is one which has much influence on the growth and productivity of a plant (Bindra and Brar, 1977).

Severe yield reduction due to shading is reported in many crops like maize (Earley et al., 1966), sorghum (Pepper and Prine, 1972), rice (Rai and Murthy 1977 and Vijayalakshmi et al., 1987), soybean (Wahua and Miller, 1978) etc.

Gracy and Holmer (1970) found that in potato, shading at the beginning of tuber initiation reduced the rate of tuber formation and growth while shading during the early stages had no effect on the number of tubers though it reduced the final yield.

Xanthosoma saggittifolium and Colocasia esculenta var. antiquorum were tested in a pot trial for shade tolerance (Caesar, 1980). Xanthosoma produced only the corm under shade and the growth of cormels was negligible. Colocasia had the highest yield with full light. Higher yield of taro in full sun is also reported by Bai (1981) and Caiger (1986). Ramadasan and Satheesan (1980) and Varughese (1989) observed highest yield of turmeric in the open. George (1982) observed a drastic reduction in yield of pulse crops due to shading. The average fruit yields for tomatoes, cucumbers, bean, capsicum, melons and okras grown under shade tended to be higher than in the open but such a tendency was reduced with increase in the amount of shade (El. Aidy, 1984). Ravisankar and Muthuswamy (1986, 1987) recorded the highest yield of ginger with a low light intensity of 15.3 klx. Highest yield of ginger under low light intensity of about 25 per cent shade was also reported by Bai and Nair (1982) and Varughese (1989). Ramanujam et al. (1984) and Okoli and Wilson (1986) found that cassava will respond to reduced light with a significant reduction in tuber yield. In groundnut yield was most affected by shading during flowering, pegging and filling but shading at maturity did not reduce yield (Rao and Mittra, 1988).

2.6 Quality of the produce

Light regimes of a plant determine the productivity and quality of its produce (Tikhomirov et al., 1976). Comparing between sun adapted and shade adapted species of higher plants, Bjorkman (1968) observed comparatively lower content of soluble protein in shade plants.

Partial shade during the stage of fruit development was found to improve the quality of pineapple (Nayar et al., 1979). In another study on the same crop, total soluble solids showed an increase from 15.3 per cent to 16.05 per cent from 0 per cent shade to 75 per cent shade. The results of some shading experiments showed that growing *Camellia sinensis* var. *assamica*, *Coffea arabica*, *Cinchona ledgeriana* and *Rauvolfia yunnanensis* under the shade improved the quality of their respective products and made better use of available sunlight (Feng, 1982).

Ravisankar and Muthuswamy (1987) reported that ginger crop grown in shade provided quality rhizomes. While volatile oil, nonvolatile acetone extract, starch and protein showed a slow increase with increasing shade, the crude fibre content was unaffected by shading. Singh and Randhawa (1988) observed that the oil and curcumin contents in turmeric were not affected by intercropping. Contradictory to the above findings Varughese (1989) recorded a reduction in oleoresin content in ginger and curcumin content in turmeric grown under shade.

Rao and Mittra (1988) noticed that shading did not affect the seed oil content of peanut. No differences in starch or total sugar contents were found between shaded and unshaded kiwifruit (Snelgar and Hopkirk, 1988).

In easter lilly Miller and Langhans (1989) observed that irradiance reduction of 50 to 85 per cent significantly reduced carbohydrate concentration in leaves and floral buds and induced export from the daughter bulb, as indicated by increased levels of daughter bulb soluble carbohydrate and reduction in starch concentration. Dark grown plants exhibited similar daughter bulb carbohydrate metabolism as full sun grown plants. These results indicated that there is a minimum irradiance requirement for carbohydrate export process from the daughter bulb.

The above literature review clearly indicates that considerable differences exists between crops and varieties in their response to shade. The effect of low light intensity on plant height was positive in crops like ginger, groundnut, sweet potato, tomato, turmeric etc. while it was negative in the case of red gram. An increase in chlorophyll content with increase in shading is reported in most of the plants. Though shading reduced yield considerably in cereals and pulses, it had also been indicated that crops like ginger, pineapple, tea, melons etc. can be grown safely under shade. Deviations in shade response had also been recorded in the same crop in some cases, presumably as a result of variations in the level of shade provided for the experimental set up and the varieties used which were not reported in most of the cases.

Materials and Methods

MATERIALS AND METHODS

A field experiment was conducted with a view to screen out morphotypes of colocasia (Colocasia esculenta L.. Schott.) for shade tolerance during the year 1989-'90.

The experiment was carried out at the College of Horticulture, Vellanikkara, Thrissur, Kerala, India, situated at 10° 32' N latitude and 76° 10' E longitude and at an altitude of 22.25 m above mean sea level.

3.1 Cropping history of the field

The area was under a similar experiment with ginger and turmeric during the previous year.

3.2 Soil

The soil of the experimental site was deep well drained sandy clayloam. The data on physical and chemical properties of the soil are given in Table 1.

3.3 Season and climate

The experiment was conducted during the period, May 1989 to December 1989. Colocasia morphotypes were planted in 12th and 13th

May, 1989. The crop was harvested 207 to 230 days after planting depending on duration of morphotypes.

Table 1 Physico-chemical properties of the soil

1. Mechanical composition (Hydrometer Method, Bouyoucos, 1962)

Sand	–	77.5 per cent
Silt	–	5.0 per cent
Clay	–	17.5 per cent
Texture	–	Sandy clay loam

2. Chemical properties

Constituent	Content	Rating	Method used for estimation
Total nitrogen	0.2 per cent	High	Microkjeldhal (Jackson, 1958)
Available phosphorus (Bray-I extract)	19 ppm	High	Chlrostannous reduced molybdo phosphoric blue colour method (Jackson, 1958)
Available potassium (Neutral normal ammonium acetate extract)	93.75 ppm	Medium	Flame photometry (Jackson, 1958)
PH (1:2.5, soil:water ratio)	5.4	Strongly acidic	pH meter (Jackson, 1958)

The meteorological data for the crop period (May to December 1989) are presented in Appendix-I.

The crop received a total of 2298.3 mm of rainfall during the period from 12th May 1989 to 30th December 1989. The relative humidity ranged from 53 to 91 per cent. There was 101 rainy days during the crop period. In general the weather conditions as a whole were conducive for the normal growth of colocasia.

3.4 Shading

Unplaited coconut leaves were used for providing shade to the desired level.

3.5 Seeds

Eleven morphotypes of colocasia were used for the experiment. Healthy cormels weighing 25-35 g, free from pest and disease were selected. Ridges were made 60 cm apart and tubers were planted at the spacing of 45 cm on the ridges. Mulching was done soon after planting.

3.6 Fertilizers

The crop received recommended cultural and manurial practices as per the Package of Practices Recommendations of the Kerala Agricultural University (KAU, 1986). Nitrogen, phosphorus and potassium were supplied through urea, superphosphate and muriate of potash, respectively.

3.7 Plant protection measures

The crop was sprayed with Bordeaux mixture (1%) against colocasia blight at periodical intervals during the heavy rainfall months. A spray of Ekalux was also given against leaf eating caterpillars sixty days after planting.

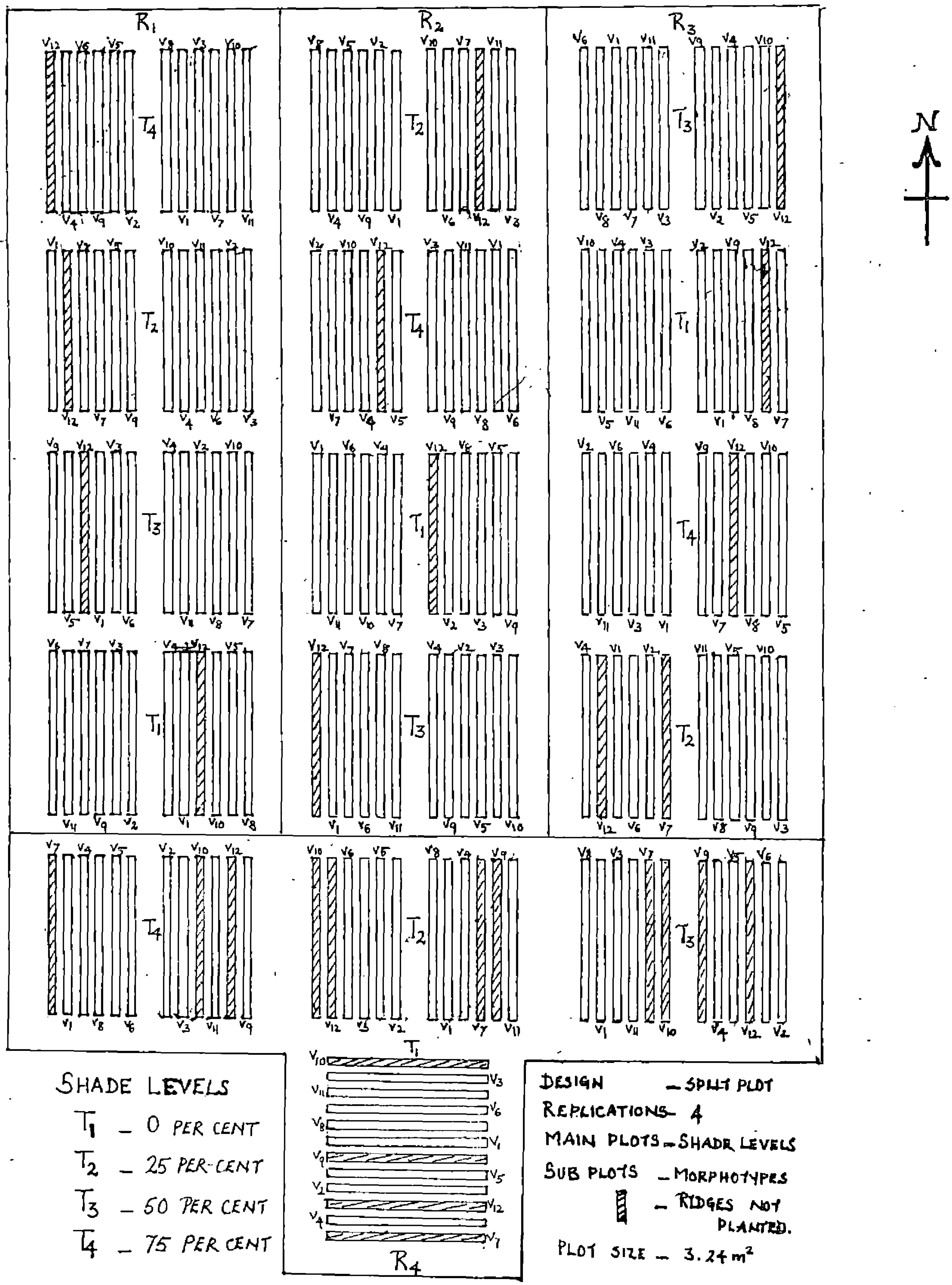
3.8 Lay out of the experiment

The experiment was laid out in a split plot design with four replications. The lay out plan is given in Fig. 1. Shade levels were assigned to main plots and morphotypes to subplots.

3.9 Details of treatments

Main plot treatments

Notation		Shade level
T_1	–	0 per cent shade (open)
T_2	–	25 per cent shade
T_3	–	50 per cent shade
T_4	–	75 per cent shade



R1
R2
R3
R4
N
SHADE LEVELS
T1 _ 0 PER CENT
T2 _ 25 PER-CENT
T3 _ 50 PER CENT
T4 _ 75 PER CENT
DESIGN _ SPLIT PLOT
REPLICATIONS _ 4
MAIN PLOTS _ SHADE LEVELS
SUB PLOTS _ MORPHOTYPES
_ RIDGES NOT PLANTED.
PLOT SIZE _ 3.24 m²

Subplot treatments consisted of 11 morphotypes of colocasia

Morphotypes

M_1

M_2

M_7

M_8

M_9

M_{10}

M_{12}

M_{17}.

M_{15}

M_{16}

Sree Rashmi

The prominent characters of these morphotypes are given below:

Morphotype 1

Plant semierect, medium tall, leaves drooping, petioles light green, margins of leaf medium wavy, tuberisation very high, corm small to medium, cormels oblong, spherical to thickly spatulate, tubers non acrid. North Indian type cultivated both under rainfed and irrigated conditions. Medium thick leaves.

Fig.1 Layout of the experimental field

Symbols used

V_1	-	M_1	V_6	-	M_{10}
V_2	-	M_2	V_7	-	M_{12}
V_3	-	M_7	V_8	-	M_{17}
V_4	-	M_8	V_9	-	M_{15}
V_5	-	M_9	V_{10}	-	M_{16}
			V_{11}	-	Sree Rashmi

Morphotype 2

Plant type same as the above, leaves similar but petiole with purple pigmentation, tuberisation very high. Mother corm small to medium, tubers oblong, spherical to thickly spatulate, non acrid. Leaf margin purple and similarly wavy as above. Distributed all over upto Northern Kerala and Tamilnadu. No flowering has been noticed under Trichur conditions. Medium thick leaves.

Morphotype 7

Plant type is semierect and almost like morphotype 12 but leaf shape is different. Tubers are almost similar to broad 'Kannan group'. It is from Bihar.

Morphotype 8

Dwarf to medium tall, semierect plant, leaves semi drooping or horizontal, margin medium wavy, purple margin, small to medium leaves with purple spot at the centre. Petiole green, tuberisation high, corm small, spherical, cormels small to medium, oblong, spatulate, dirty and scaley. This belongs to 'Kannan group' of varieties and is from Kerala, Karnataka and Maharashtra.

Morphotype 9

Dwarf to medium tall plants, semierect, leaves cup shaped in the early stages, semidrooping later on, margin highly wavy, purple coloured, petiole green, purple spot (spreading) present at the centre of leaf. Tuberisation high, corm and cormels similar to morphotype 8. Also belongs to 'Kannan group' and is from Kerala.

Morphotype 12

Medium to tall erect plants, semierect to drooping leaves, leaf margin undulate, thin leaves, leaf centre with fading light purple brown spot, leaves are elongated and boat shaped. Tuberisation high, mother corm spherical, small to medium in size, tubers spherical to oblong, thickly spatulate. Very common cultivated type in central Kerala and belongs to 'Kannan group'.

Morphotype 10

Medium high to tall plants, similar to plants in broad 'Kannan group' shaped drooping leaves with dark purple petiole tip tubers are similar to that of 'Kannan group'. It is also a cultivated type from Kerala.

Morphotype 15

This morphotype is very drastically different from all other by whitish green petiole, leaf margin and leaf centre. Semierect large plant type, leaves drooping and large compared to above described morphotypes. Tuberisation is less but mother corms are very large, spherical with a light rose pigmentation at the growing region, cormels oblong. This is found in North East India and in Kerala. This has edible, cormels. Corms are also sometimes used for edible purposes. No purple pigmentation is noticed anywhere on the plant. It does not flower. .

Morphotype 16

This is the largest plant type and is known as 'Kuda chembu' or 'Malaraman' in Kerala. Found also in Thamilnadu. It is characterised by purple petioles, very large drooping leaves, light purple leaf centre, purple and less wavy leaf margin. Tuberisation is less but corms are very large and edible. Has light rose pigmentation on growing parts.

Morphotype 17

This is characterised by semierect small to medium plant type, very dark purple petioles, dark green leaves, purple leaf centre and dark purple leaf margin. This morphotype hails from Kerala. It is highly productive and highly tuberising. Mother corm small to medium, cormels oblong, spatulate. Known as 'Karutha chembu' in Kerala. It is susceptible to blight.

3.10 Provision of shade

Pandals of size 27 m x 11 m were erected on wooden poles to provide artificial shade to the desired level. Unplaited coconut leaves were used for providing shade. All the sides were also covered with unplaited coconut leaves except for 1 m from the ground level. This was done to prevent the direct entry of slant rays. Ridges were taken leaving a border area of 1 m within the plots to avoid the border effect.

3.11 Observations

Sampling technique

Random sampling technique was adopted to select the sample plants for studying the various growth characters. Five plants were selected at random as observation plants from each subplot for recording biometric observations. Observations were recorded at 60 days after planting (DAP) and 120 DAP. At 180 DAP, no growth observations were taken as drying up of the above ground parts had already started.

The observations recorded were the following.

A. Biometric observations

1. Plant height

The height of the selected plants was measured from the collar region to the tip of the top most petiole and the average worked out.

2. Number of tillers per plant

The number of tillers was determined by counting the number of aerial shoots arising around a single plant and the average of the five sample plants worked out for each subplot.

3. Girth of the collar

Girth of the collar region of the most vigorous tiller was measured and average worked out.

4. Number of leaves per clump

The number of leaves per clump was determined by counting the number of leaves of all the tillers of five sample plants. The average number per plant was then worked out.

5. Chlorophyll content of the leaves

Chlorophyll a, chlorophyll b and total chlorophyll content of leaves were estimated at 150 DAP by spectrophotometric method as described by Starnes and Hadley (1965). The second terminal leaf of a few plants selected at random constituted the samples.

6. Total dry weight

Pseudoshoot and underground portions of the uprooted plants were separated and dried to constant weight at 70°C to 80°C in hot air oven. From the dry weight of component parts for five plants, average dry weight per plant for these parts was worked out. The sum of dry weight of components gave the total drymatter yield and it was expressed as g $plant^{-1}$.

7. Tuber yield

Yield of mother corm as well as cormels was recorded separately from each subplot, and was expressed as t ha^{-1} of fresh produce. The sum of corm and cormel yield was worked out to get total yield in t ha^{-1}.

8. Harvest index

Harvest index was calculated as follows:

Harvest index = $\frac{Y\ econ}{Y\ biol}$ where Y econ and Y biol were dry weight of tuber and total dry weight of plant, respectively.

9. Haulm yield

The yield of aerial part in five observation plants was recorded and expressed as t ha^{-1} of dry weight

B. Chemical studies

1. Content of fertilizer nutrients

Samples of plant components collected for recording the dry weight were used for chemical analysis. The nitrogen and phosphorus contents of tuber and haulm were determined colorimetrically using Nessler's reagent (AOAC, 1960) and by Vanado molybdo phosphoric yellow colour method (Jackson, 1958), respectively. The potassium content was determined flame photometrically (Jackson, 1958). Digestion of plant samples for estimating phosphorus and potassium was done using the diacid digestion mixture of nitric and perchloric acids.

2. Uptake of fertilizer nutrients

The total uptake values of nitrogen, phosphorus and potassium by the plant were calculated from the nutrient contents and dry weights and expressed as kg ha^{-1}.

3. Quality analysis

The samples collected for quality analysis were peeled, sliced and then dried. The dried samples were ground to pass through a 60 mesh sieve.

1. Starch content in the tuber

Starch content in tubers of different colocasia morphotypes were found out following the standard procedure as stated in A.O.A.C. (1960).

The reducing sugar content was not estimated as the content of this ingredient was negligibly low.

2. Oxalic acid content in the tuber

The total oxalic acid content was determined following the method suggested by CTCRI (CTCRI, 1983). Details of the procedure is given below.

Ten grams of the sample was weighed and about 75 ml of 0.25 N Hcl was added. It was extracted around 60°C in a water bath. It was centrifuged and supernatant was collected. The extraction was repeated and the supernatant was pooled. 25 ml of tungstophosphoric acid was added as a clarifying agent and left overnight. It was centrifuged and the pH of the collected supernatant was adjusted to 4.5 with dilute ammonia solution. 25 ml of calcium chloride reagent (acetate buffer) was added to it and was kept overnight. The solution was centrifuged and the precipitate was collected. The precipitate was washed with 25 ml of wash solution, stirring with a glass rod to break the precipitate. It was centrifuged and the precipitate was collected. The precipitate was dissolved in 50 ml of hot 2N H_2SO_4. The solution was heated around 80°C and was titrated against standard $KMnO_4$.

C. Cooking quality

Cooked samples were used for assessing the acridity. The acridity was assessed organoleptically.

D. Disease intensity

Incidence of colocasia blight was noticed after about 110 days of planting. The extent of incidence was generally more under shaded condition. However the disease was kept under check by periodic sprays of Bordeaux mixture.

E. Statistical analysis

The experimental data were subjected to analysis of variance. As some morphotypes were not planted in all replications, data were analysed in two ways, one by deleting the missing subplots from all the four replications and second by deleting the two replications having missing subplots.

RESULTS

Observations on various plant characters were recorded to assess the performance of colocasia morphotypes and also to assess the effect of shade on growth and yield of these morphotypes. The results of the experiment are presented in this chapter.

Since some of the morphotypes were not planted in all replications, data were analysed in two ways. One excluding the missing subplots (M_{12}, M_{15} and M_{16}) from all the four replications and the other excluding the two incomplete replications. Both are presented in the Tables. No growth observation had been taken at 180th day after planting, as there was total drying of many morphotypes by that time.

4.1 Biometric observations

4.1.1 Plant height (Table 2, Appendix II)

Plant height went on increasing with increasing levels of shade at 60 and 120 DAP. At both the growth stages plants at 0 per cent shade differed significantly from all other treatments and recorded the lowest plant height. Plant height values at all other shade levels were on par.

Among the morphotypes, M_{10} and M_2 recorded the highest plant height at 60 and 120 DAP, respectively. Data analysed in both ways showed similar result with respect to shade levels as well as morphotypes, there being statistically significant differences at both the stages and in both the methods of analysis. Morphotype x shade level interaction was not significant at any stage.

4.1.2 Number of tillers (Table 2,3; Appendix III)

There was no significant difference between shade levels with respect to number of tillers at both the stages except at 120 DAP (Analysis 1). Highest tiller number was recorded by plants in the open condition (T_1) at 120 DAP. Treatment of the highest shade level (T_4) gave the lowest tiller number at both the stages.

Varietal differences were significant. At 60 DAP, the morphotype M_{17} recorded the highest tiller number and was superior compared to all others whereas at 120 DAP all of the morphotypes except M_{15}, M_{16} and Sree Rashmi had comparable tiller numbers.

Significant interaction between morphotypes and shade levels was observed at 120 DAP (Analysis 1). Trends in tiller number with increasing shade levels were different in different morphotypes. A steady decline in tiller number with shading was noticed in M_1, M_{10} and M_{17} in which the plants at full illumination had significantly higher tiller number. In morphotypes M_7 and M_8 maximum number of tillers was at 25 and 50 per cent shade respectively. With further

Table 2 Effect of shade on plant height and tiller number of colocasia morphotypes

Treatments	Plant height (cm)				Number of tillers			
	60 DAP		120 DAP		60 DAP		120 DAP	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Shade levels (%)								
T_1 (0)	32.9	33.8	54.3	56.3	1.2	1.1	4.4	4.5
T_2 (25)	52.5	57.1	92.2	99.0	1.9	1.8	4.2	4.1
T_3 (50)	57.2	56.3	102.9	103.7	1.3	1.1	3.8	3.8
T_4 (75)	62.8	68.2	104.6	114.9	1.2	0.8	3.3	2.9
SEm ±	3.1	4.2	4.4	5.3	0.3	0.3	0.3	0.7
CD (0.05)	7.0	13.3	10.0	17.0	NS	NS	0.7	NS
Morphotypes								
M_1	50.1	54.4	71.1	73.5	1.0	1.0	4.8	4.9
M_2	55.3	58.8	105.7	111.9	2.0	1.8	3.9	3.9
M_7	44.3	45.2	92.0	96.5	0.6	0.7	4.4	4.8
M_8	47.8	48.7	79.5	75.8	0.8	0.6	3.6	3.8
M_9	54.9	59.4	92.8	99.3	0.5	0.8	3.3	3.8
M_{10}	56.5	62.7	89.6	92.2	1.8	1.8	4.6	4.7
M_{12}	–	53.6	–	92.8	–	1.3	–	4.8
M_{17}	53.6	56.3	78.8	80.6	3.6	3.0	4.5	4.0
M_{15}	–	44.9	–	93.6	–	0.7	–	2.6
M_{16}	–	56.4	–	106.0	–	0.7	–	2.5
Shree Rashmi	48.5	52.0	98.5	104.3	1.0	1.1	2.5	2.4
SEm ±	2.5	3.7	3.6	4.8	0.3	0.5	0.4	0.6
CD (0.05)	5.1	7.6	7.2	9.7	0.6	1.0	0.8	1.2

(1) Data analysed by deleting three subplots M_{12}, M_{15} and M_{16}

(2) Data analysed by deleting two replications

Table 3 Mean number of tillers of colocasia morphotypes at different shade levels at 120 DAP (Analysis 1)

Morphotypes	Shade levels (per cent)				
	0	25	50	75	Mean
M_1	5.9	5.2	4.8	3.2	4.8
M_2	5.2	3.5	3.6	3.4	3.9
M_7	4.1	5.2	4.5	4.0	4.4
M_8	2.5	4.4	5.2	2.5	3.6
M_9	3.3	2.8	3.7	3.4	3.3
M_{10}	5.5	4.7	4.4	4.1	4.6
M_{12}	-	-	-	-	-
M_{17}	5.9	4.9	3.9	3.3	4.5
M_{15}	-	-	-	-	-
M_{16}	-	-	-	-	-
Sree Rashmi	3.1	2.8	1.9	2.3	2.5
Mean	4.4	4.2	4.0	3.3	

SE of difference between two subplot means at the same level of main plot = 0.79

CD for the above at 5 per cent level = 1.60

SE of difference between two main plot means at the same level of subplot =0.33

CD for the above at 5 per cent level = 0.67

increase in shading tillering decreased. Morphotypes M_{17}, M_1, M_8 and M_{10} recorded the highest tiller number at 0, 25, 50 and 75 per cent shade, respectively.

4.1.3 Number of leaves (Table 4; Appendix III)

No significant effect of shade on number of leaves was noticed at either 60th or 120th day after planting. Among the morphotypes M_{17} had the maximum number of leaves at both 60 and 120 DAP (Analysis 1). Variety x shade interaction was not significant at any stage.

4.1.4 Chlorophyll content (Table 6)

Total chlorophyll and its fractions, chlorophyll a and chlorophyll b increased progressively with increasing levels of shade, at 150th day after planting. The ratio of chlorophyll a to b was found to be decreasing with shading.

Morphotype M_9 had the highest total chlorophyll content and M_{16} had the lowest. The range in total chlorophyll content was from 2.30 to 3.08 mg g^{-1} fresh weight in the different morphotypes.

4.1.5 Girth at the collar (Tables 4, 5; Appendix III)

In general there was an increase in girth at the collar under shaded condition. The treatment T_1 (open) differed significantly from

Table 4 Effect of shade on number of leaves and girth at the collar of colocasia morphotypes

Treatments	Number of leaves				Girth at the collar (cm)			
	60 DAP		120 DAP		60 DAP		120 DAP	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Shade levels (%)								
T_1 (0)	5.5	4.9	12.7	14.0	10.6	11.1	14.1	15.0
T_2 (25)	6.2	6.1	12.7	13.3	13.5	13.9	17.3	18.2
T_3 (50)	5.8	5.3	12.4	11.7	13.1	13.1	18.1	18.3
T_4 (75)	5.9	5.4	11.6	10.6	13.1	13.8	18.5	19.5
SEm ±	0.3	0.3	0.9	0.9	0.5	0.7	0.7	1.4
CD (0.05)	NS	NS	NS	NS	1.0	NS	1.6	NS
Morphotypes								
M_1	4.4	4.6	11.3	12.0	11.6	11.9	13.0	12.9
M_2	6.0	5.7	12.1	12.4	12.4	12.6	19.6	19.5
M_7	5.2	4.9	13.2	13.8	10.2	10.2	18.2	18.6
M_8	5.5	5.3	12.3	12.5	12.0	12.2	15.4	14.7
M_9	5.6	5.9	10.5	12.5	14.3	15.2	16.8	17.3
M_{10}	5.8	5.7	14.2	15.2	14.3	15.4	18.1	18.5
M_{12}	-	5.8	-	17.0	-	13.2	-	17.1
M_{17}	8.7	7.9	15.9	13.8	14.0	14.6	14.9	14.5
M_{15}	-	4.4	-	8.6	-	11.6	-	18.2
M_{16}	-	3.7	-	9.6	-	14.0	-	23.9
Sree Rashmi	5.5	5.5	9.5	9.2	11.8	12.1	20.0	20.1
SEm ±	0.5	0.6	1.2	1.5	0.6	0.9	0.7	1.0
CD (0.05)	0.9	1.2	2.3	3.0	1.2	1.9	1.4	2.1

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

Table 5 Mean girth at the collar at 120 DAP of colocasia morphotypes at different shade levels (Analysis 1)

Morphotypes	Shade levels (per cent)				
	0	25	50	75	Mean
M_1	12.7	12.6	13.6	12.9	13.0
M_2	15.9	19.6	20.8	22.2	19.6
M_7	13.7	19.7	19.5	20.0	18.2
M_8	12.4	16.0	16.5	16.9	15.4
M_9	12.2	17.2	19.3	18.7	16.8
M_{10}	14.8	16.5	20.3	20.8	18.1
M_{12}	-	-	-	-	-
M_{17}	14.9	15.4	14.8	14.4	14.9
M_{15}	-	-	-	-	-
M_{16}	-	-	-	-	-
Sree Rashmi	16.4	21.2	20.4	21.8	20.0
Mean	14.1	17.3	18.1	18.5	

SE of difference between two subplot means at the same level of main plot = 1.4

CD for the above at 5 per cent level = 2.7

SE of difference between two main plot means at the same level of subplot = 0.73

CD for the above at 5 per cent level = 1.5

Table 6 Effect of shade on contents of chlorophyll fractions of colocasia leaves at 150 DAP

Treatments	Chlorophyll 'a' mg g^{-1} fresh weight	Chlorophyll 'b' mg g^{-1} fresh weight	Total (a+b) mg g^{-1} fresh weight	Chlorophyll a/b
Levels of shade (%)				
T_1 (0)	1.30	0.88	2.18	1.48
T_2 (25)	1.40	1.05	2.45	1.33
T_3 (50)	1.56	1.21	2.77	1.29
T_4 (75)	1.63	1.35	2.98	1.21
Varieties				
M_1	1.80	1.04	2.42	1.33
M_2	1.44	1.10	2.54	1.31
M_7	1.65	1.22	2.87	1.35
M_8	1.51	1.10	2.61	1.37
M_9	1.71	1.37	3.08	1.25
M_{10}	1.58	1.28	2.86	1.23
M_{12}	1.48	1.11	2.59	1.33
M_{17}	1.36	0.99	2.35	1.37
M_{15}	1.35	1.01	2.36	1.34
M_{16}	1.32	0.98	2.30	1.35
Sree Rashmi	1.53	1.17	2.70	1.31

all other shade levels at both 60 and 120 DAP. Treatments 25, 50 and 75 per cent shade levels were on par at 60 DAP (Analysis 1) and 120 DAP (Analysis 2).

Significant interaction between shade levels and morphotypes was noticed at 120th day after planting (Analysis 1). At 0 and 25 per cent shade Sree Rashmi recorded the maximum girth where as M_2 had the maximum girth at 50 and 75 per cent shade. About the trend of different morphotypes at various shade levels, there was the common trend of increase with increasing shade. The only exception to this was in M_{17} which showed little variation.

4.1.6 Haulm yield (Tables 7, 8; Appendix IV)

There was no significant variation between shade levels in haulm yield. Plants grown at 0 per cent shade recorded the highest mean haulm yield which was on par with all other shade levels in Analysis 2 whereas in Analysis 1, 50 per cent shade recorded the highest haulm yield which was on par with 25 and 75 per cent shade levels.

Varietal differences were significant and the morphotype M_{16} recorded the highest haulm yield and M_8 the lowest (Analysis 2).

Main plot x subplot interaction was found significant when analysed by deleting three subplots. The morphotypes M_2, M_{17}, M_7 and Sree Rashmi recorded the highest values at 0, 25, 50 and 75 per cent shade levels, respectively.

4.1.7 Drymatter production (Tables 7, 9; Appendix IV)

Significant variation was noticed among shade levels with respect to total drymatter production in both the analyses. Drymatter production was the highest at 25 per cent shade level when analysed by deleting three subplots. Though in analysis 2, the treatment T_1 (open) recorded the highest value, there was only a marginal difference from drymatter production at 25 per cent shade. There was a drastic reduction in drymatter production at 50 and 75 per cent shade, the extent of decrease being 22 and 27 per cent respectively (Analysis 2) of the drymatter production at 0 per cent shade.

Among the morphotypes M_{10} had the highest drymatter production when analysed by deleting two replications. The morphotype was replaced by M_2 in Analysis 1, though M_{10} was on par with M_2.

Significant interaction between shade levels and morphotypes was noticed when the data were analysed by deleting three subplots. Morphotypes M_2 and M_8 recorded the highest values in the open and at 25 per cent shade, whereas M_{10} recorded the highest values at both 50 and 75 per cent shade.

4.1.8 Harvest index (Table 7, Appendix IV)

No significant difference in harvest index values could be noticed among shade levels when the data were analysed by deleting two

Table 7 Effect of shade on haulm yield, drymatter production and harvest index of colocasia morphotypes

Treatments	Haulm yield t ha^{-1}		Drymatter g $plant^{-1}$		Harvest index	
	(1)	(2)	(1)	(2)	(1)	(2)
Shade levels (%)						
T_1 (0)	1.1	1.2	206.6	221.2	0.85	0.84
T_2 (25)	1.0	1.1	222.9	220.3	0.87	0.87
T_3 (50)	1.2	1.2	179.5	173.6	0.81	0.82
T_4 (75)	0.9	1.2	154.3	160.9	0.82	0.78
SEm $\pm$	0.1	0.1	8.9	4.0	0.02	0.02
CD (0.05)	NS	NS	20.1	12.7	0.04	NS
Morphotypes						
M_1	0.8	0.9	177.4	196.8	0.88	0.88
M_2	1.3	1.3	248.1	246.4	0.86	0.86
M_7	1.3	1.2	137.8	129.5	0.76	0.77
M_8	1.0	0.9	176.4	144.8	0.83	0.82
M_9	0.8	0.9	169.8	168.6	0.86	0.86
M_{10}	1.0	1.1	241.8	250.4	0.88	0.88
M_{12}	–	1.0	–	148.7	–	0.81
M_{17}	1.1	1.0	198.5	188.2	0.82	0.82
M_{15}	–	1.4	–	235.7	–	0.83
M_{16}	–	2.1	–	249.7	–	0.77
Sree Rashmi	1.1	1.4	176.6	175.1	0.81	0.77
SEm $\pm$	0.1	0.2	14.7	26.9	0.02	0.02
CD (0.05)	0.2	0.4	29.2	54.4	0.04	0.05

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

Table 8 Mean haulm yield (t ha^{-1}) of colocasia morphotypes at different shade levels (Analysis 1)

Morphotypes	Shade levels (per cent)				Mean
	0	25	50	75	
M_1	0.95	0.87	0.68	0.78	0.82
M_2	1.66	0.92	1.34	1.10	1.25
M_7	1.07	1.22	1.89	1.02	1.30
M_8	0.73	1.11	1.36	0.76	0.99
M_9	0.67	0.68	1.04	0.75	0.78
M_{10}	0.85	0.95	1.10	1.07	1.00
M_{12}	-	-	-	-	-
M_{17}	1.41	1.31	1.10	0.51	1.08
M_{15}	-	-	-	-	-
M_{16}	-	-	-	-	-
Sree Rashmi	1.09	0.98	1.00	1.40	1.11
Mean	1.05	1.01	1.19	0.92	

SE of difference between two subplot means at the same level of main plot =0.23

CD for the above at 5 per cent level = 0.46

SE of difference between two main plot means at the same level of subplot = 0.11

CD for the above at 5 per cent level = 0.24

Table 9 Mean drymatter production (g $plant^{-1}$) of colocasia morphotypes at different shade levels (Analysis 1)

Morphotypes	Shade levels (per cent)				Mean
	0	25	50	75	
M_1	194.3	219.1	175.8	120.5	177.4
M_2	339.4	240.8	192.3	219.9	248.1
M_7	123.1	153.5	166.3	108.2	137.8
M_8	126.1	254.6	183.3	141.8	176.4
M_9	166.1	173.6	185.1	155.1	169.8
M_{10}	232.0	253.4	262.6	220.2	241.8
M_{12}	-	-	-	-	-
M_{17}	271.4	254.4	141.3	128.1	198.5
M_{15}	-	-	-	-	-
M_{16}	-	-	-	-	-
Sree Rashmi	201.4	234.4	130.3	141.5	176.6
Mean	206.6	222.9	179.5	154.3	

SE of difference between two subplot means at the same level of main plot =29.3

CD for the above at 5 per cent level = 58.3

SE of difference between two main plot means at the same level of subplot = 8.9

CD for the above at 5 per cent level = 17.9

replications. However in Analysis 1 significant difference in harvest index was found and the highest value was recorded at 25 per cent shade level though it was on par with that of 0 per cent shade. With increasing shade beyond 25 percent, harvest index decreased.

No significant interaction was noticed among shade levels and morphotypes.

Morphotypes M_1 and M_{10} recorded the highest harvest index of 0.88 when analysed in two ways and M_7, the lowest.

4.1.9 Cormel yield (Tables 10, 11; Appendix V; Fig 2, 3, 4 and 5)

Highly significant variation was noticed among shade levels with respect to cormel yield. Data analysed by deleting three subplots showed an increasing trend in yield upto 25 per cent shade and a decrease thereafter. The yield in 25, 50 and 75 per cent shade expressed as percentage yield in the open were 109, 94 and 77 per cent, respectively. The yields at 0 and 25 per cent shade levels were statistically on par whereas that at 75 per cent shade was significantly lower compared to other shade levels.

Data analysed by deleting two replications showed a slightly different trend. The yield decreased gradually with increase in level of shade, the percentage yield at 25, 50 and 75 per cent shade being 93, 83 and 66 per cent, respectively, of the yield at full illumination. However, as in Analysis 1, the yields at 0 and 25 per cent shade were on par.

Among the morphotypes, M_2 recorded the highest yield and was significantly superior to all other treatments in both analyses. The next best yielders common in both analyses and which were on par were Sree Rashmi, M_{10}, M_{17} and M_1. M_{16} and M_9 were also found to be on par with these four morphotypes in Analysis 2.

Significant interaction between morphotypes and shade levels was found only when the data were analysed by deleting three subplots. The morphotype Sree Rashmi recorded the highest yield at 50 per cent shade whereas M_2 was the best yielder at all other shade levels. These morphotypes differed significantly from all other morphotypes. At 50 per cent shade the cormel yield of morphotypes M_2, M_{10} and Sree Rashmi were on par. The trend in yields were different for the various morphotypes. The highest cormel yield was recorded at 25 per cent shade level for the morphotypes M_1, M_7, M_8 and Sree Rashmi. There was a gradual decrease in cormel yield with further increase in intensity of shading in these. The morphotypes M_2 and M_{17} had the highest yield in the open whereas M_9 and M_{10} recorded the highest yield at 50 per cent shade. Regarding the trend in cormel yield of the three morphotypes; viz., M_{12}, M_{15} and M_{16} which were not included in Analysis 1, the morphotype M_{12} recorded the highest yield at 25 per cent shade level whereas M_{15} and M_{16} at full illumination.

4.1.10 Corm yield (Table 10; Appendix V; Fig 6, 7, 8 and 9)

Corm yield was the lowest in the open and was significantly low compared to all other shade levels (Analysis 1). With decrease in

Table 10 Effect of shade on total tuber yield, cormel yield and corm yield of colocasia morphotypes

Treatments	Cormel yield t ha^{-1}		Corm yield t ha^{-1}		Total tuber yield t ha^{-1}	
	(1)	(2)	(1)	(2)	(1)	(2)
Shade levels (%)						
T_1 (0)	22.9	23.5	3.4	5.0	27.0	28.5
T_2 (25)	24.9	22.6	5.0	6.6	30.0	29.1
T_3 (50)	21.5	19.4	5.1	6.6	26.2	25.3
T_4 (75)	17.7	15.5	5.1	6.7	22.5	22.1
SEm $\pm$	1.3	1.3	0.4	0.9	1.4	0.7
CD (0.05)	2.9	4.0	0.9	NS	3.2	2.1
Morphotypes						
M_1	21.3	24.0	2.7	2.8	24.1	26.8
M_2	33.8	32.6	6.0	6.3	39.6	38.8
M_7	14.9	14.7	3.3	3.2	18.2	17.9
M_8	18.5	16.3	4.1	3.4	21.7	17.9
M_9	16.1	17.4	2.5	2.7	20.7	20.5
M_{10}	22.4	22.6	8.1	8.4	30.7	31.0
M_{12}	-	14.6	-	6.0	-	20.3
M_{17}	22.2	21.1	4.7	4.4	26.8	25.8
M_{15}	-	16.4	-	12.7	-	29.1
M_{16}	-	18.4	-	13.2	-	31.6
Sree Rashmi	24.6	24.6	5.9	5.3	29.6	29.2
SEm $\pm$	2.2	3.7	0.6	1.5	2.4	4.5
CD (0.05)	4.4	7.4	1.2	3.1	4.8	9.0

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

Table 11 Mean cormel yield (t ha^{-1}) of colocasia morphotypes at different shade levels (Analysis 1)

Morphotypes	Shade levels (per cent)				Mean
	0	25	50	75	
M_1	22.3	24.8	22.4	15.9	21.3
M_2	46.2	33.7	26.1	29.3	33.8
M_7	13.0	18.4	16.0	12.4	14.9
M_8	11.9	26.1	20.6	15.5	18.5
M_9	11.2	17.1	19.1	17.2	16.1
M_{10}	20.7	19.8	25.4	23.8	22.4
M_{12}	(15.3)	(18.8)	(15.8)	(8.4)	(14.6)
M_{17}	32.69	27.8	15.6	12.7	22.2
M_{15}	(21.9)	(18.4)	(9.9)	(15.6)	(16.4)
M_{16}	(25.8)	(16.1)	(19.7)	(12.1)	(18.4)
Sree Rashmi	25.5	31.9	26.8	14.4	24.6
Mean	22.9	24.9	21.5	17.7	

SE of difference between two subplot means at the same level of main plot =4.4

CD for the above at 5 per cent level = 8.8

SE of difference between two main plot means at the same level of subplot = 1.3

CD for the above at 5 per cent level = 2.6

(The figures in brackets indicate the mean yields of M_{12}, M_{15} and M_{16} in Analysis - 2) light intensity there was a progressive increase in yield. Though the highest yield was recorded at 75 per cent shade level, there was no significant difference between corm yield at different shade levels from 25 to 75 per cent. The morphotype M_{16} recorded the highest yield (13.16 t ha^{-1}) followed by M_{15} (12.67 t ha^{-1}).

No interaction between morphotypes and shade levels was noticed when analysed in two ways.

4.1.11 Total tuber yield (Tables 10, 12; Appendix V; Fig 10, 11, 12, 13 and 14)

Total tuber yield followed the same pattern as that of cormel yield with the highest value recorded at 25 per cent shade. With further decrease in light intensity tuber yield decreased. The percentage yield at 25, 50 and 75 per cent shade levels were 111, 97 and 83 (Analysis 1) and 102, 89 and 78 (Analysis 2) of the yield at full illuminations. The share of cormel and corm yield to the total tuber yield was on an average 82 and 18 per cent (Analysis 1) and 77 and 23 per cent (Analysis 2) respectively.

Subplot treatments differed significantly. The morphotype M_2 recorded the highest yield of 39.59 t ha^{-1} and was significantly superior to all others in both the analyses. M_{16}, M_{10}, Sree Rashmi, M_{15} were the next best morphotypes.

Significant interaction between shade levels and morphotypes was noticed when the data were analysed by deleting three subplots.

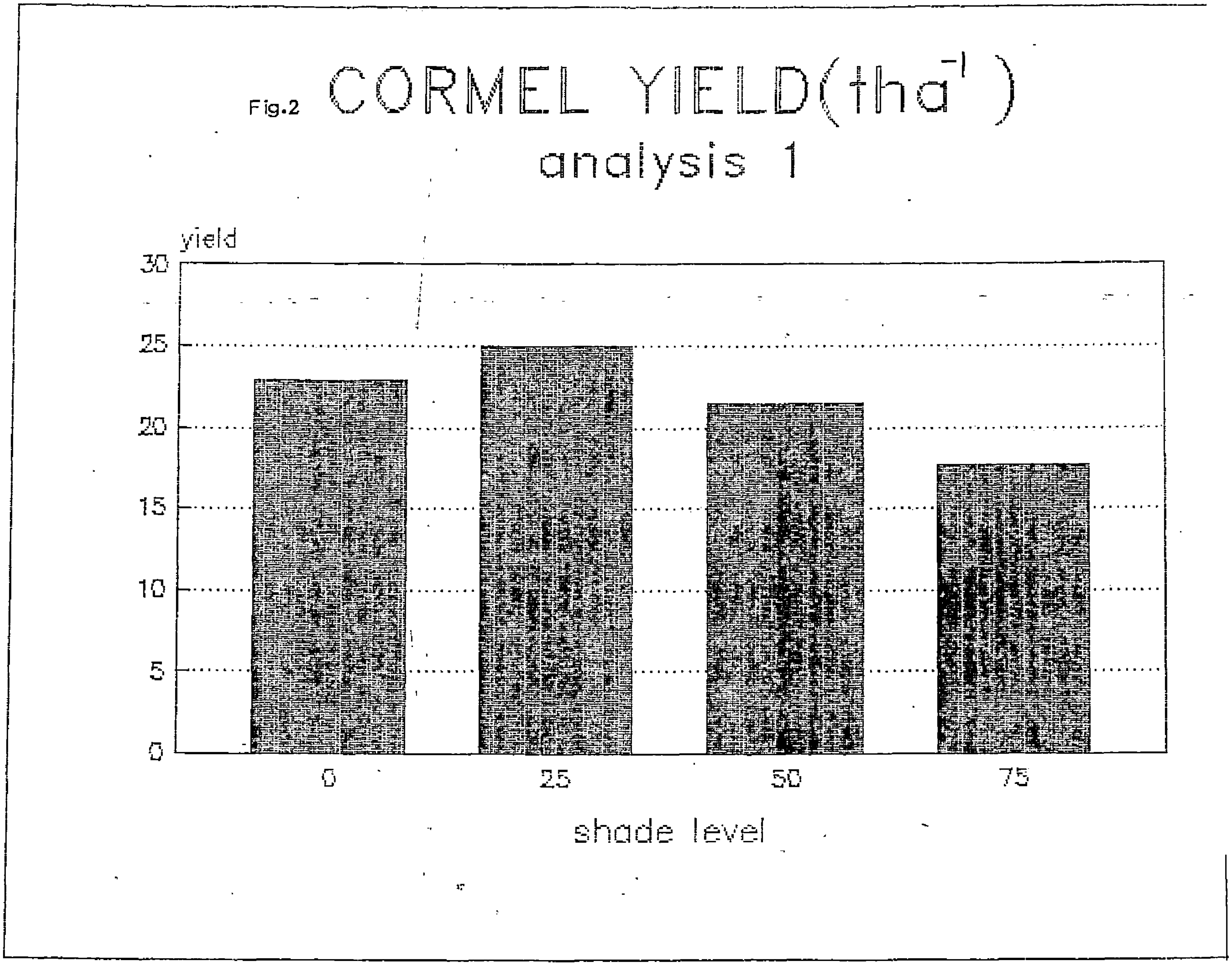


Fig.2 CORMEL YIELD(tha^{-1})
analysis 1
yield
30
25
20
15
10
5
0
0
25
50
75
shade level

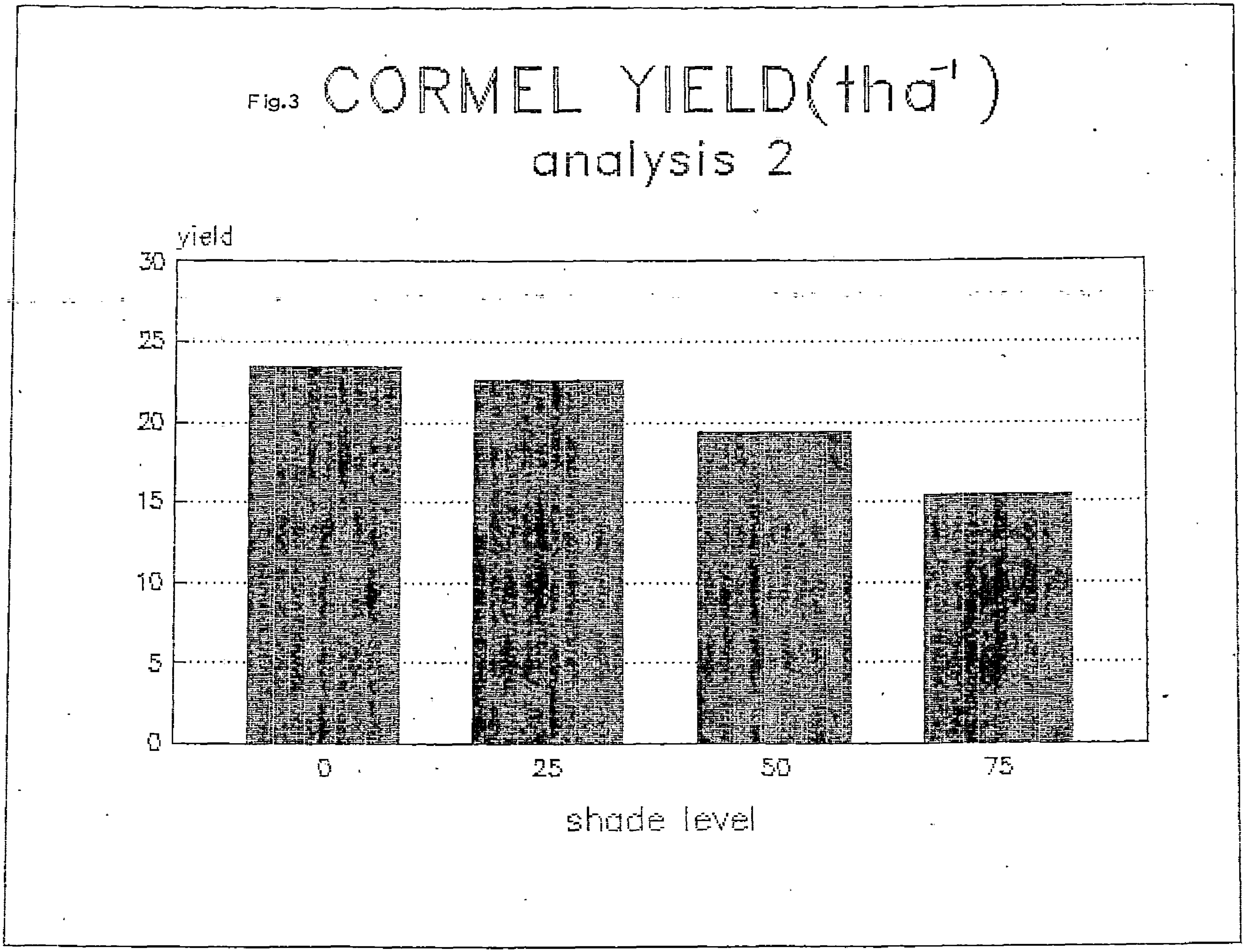


Fig.3 CORMEL YIELD(tha⁻¹)
analysis 2
yield
30
25
20
15
10
5
0
0
25
50
75
shade level

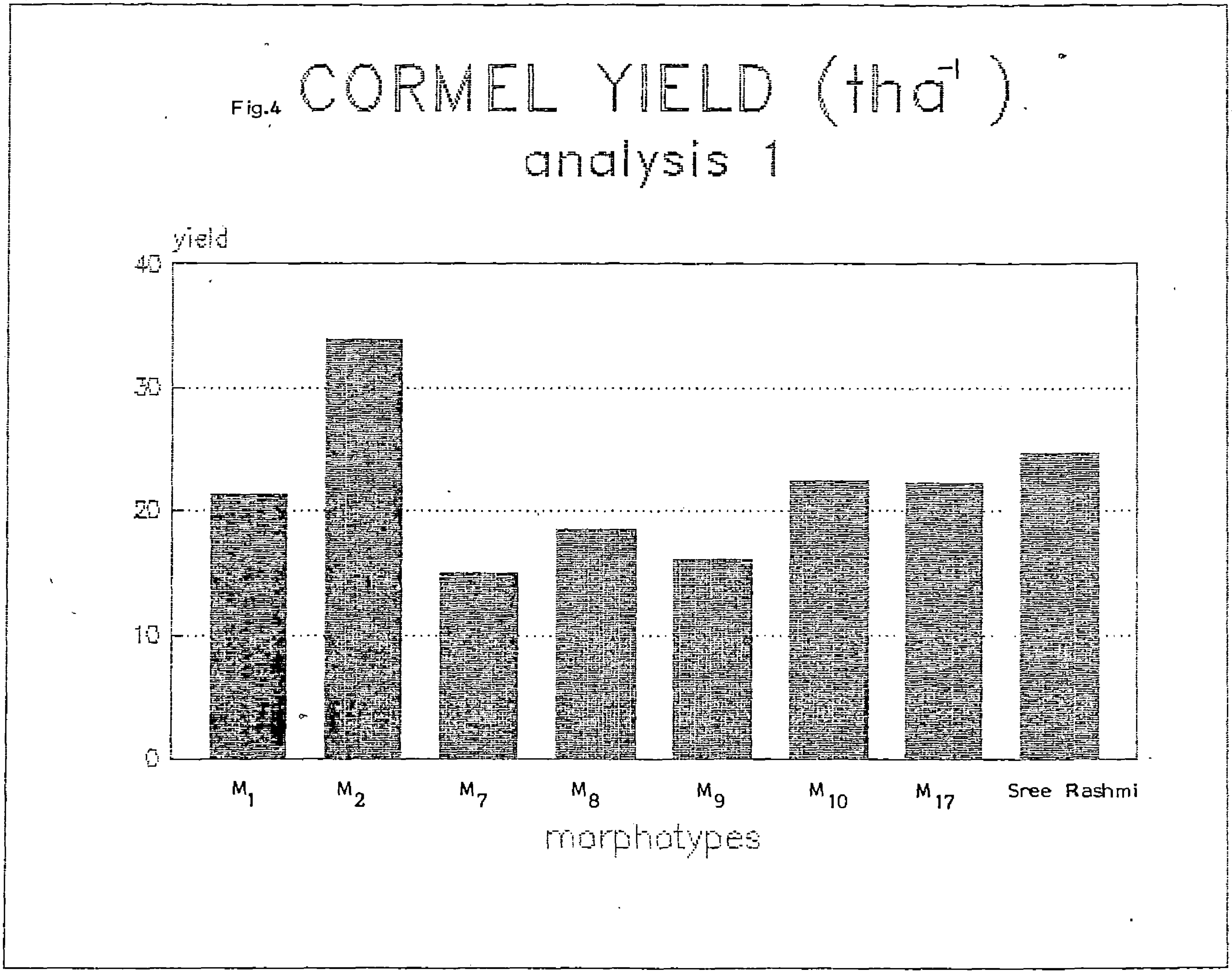


Fig.4 CORMEL YIELD (tha^{-1})
analysis 1
yield
40
30
20
10
0
M_1
M_2
M_7
M_8
M_9
M_{10}
M_{17}
Sree Rashmi
morphotypes

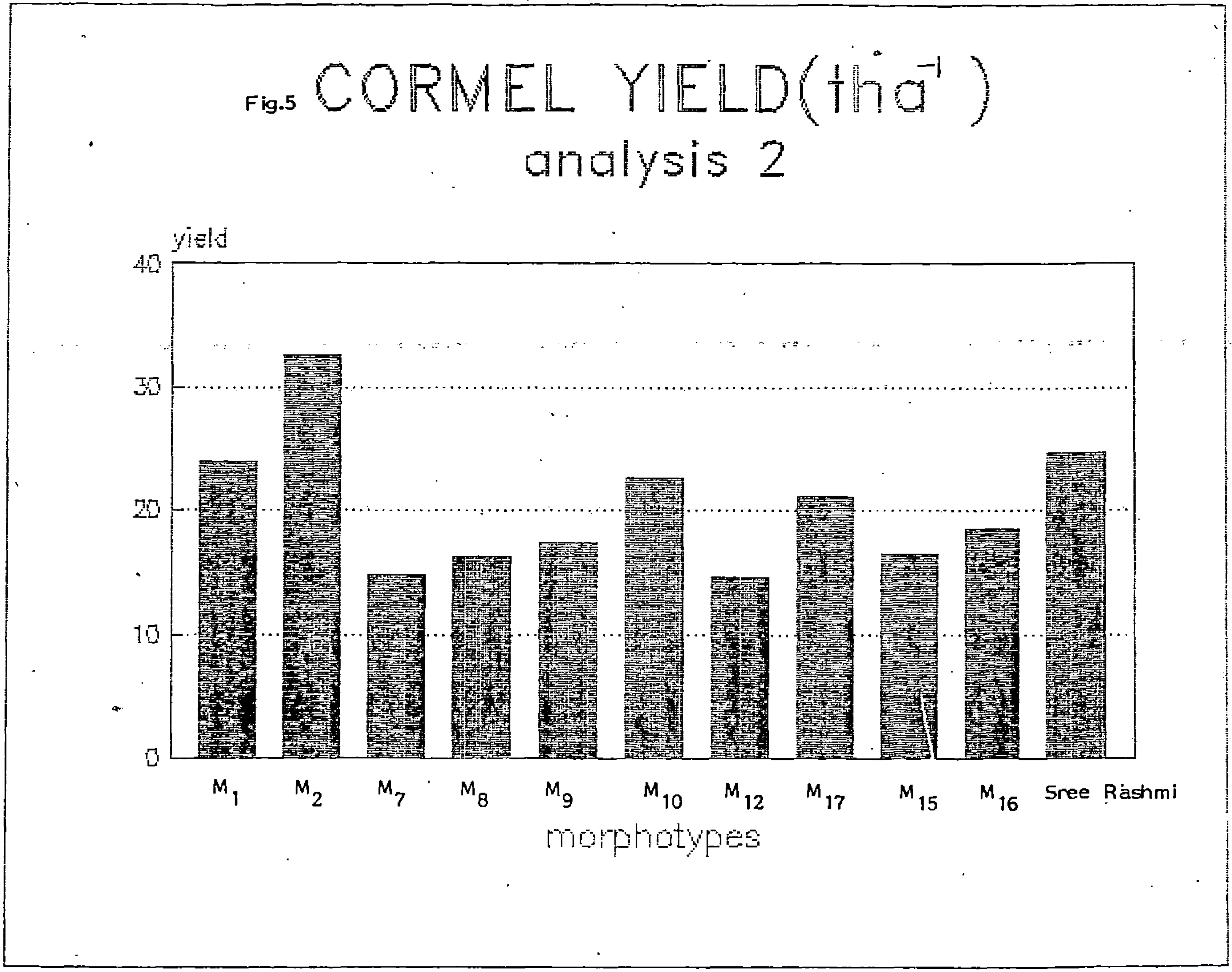


Fig.5 CORMEL YIELD(t ha⁻¹)
analysis 2
yield
40
30
20
10
0
M1
M2
M7
M8
M9
M10
M12
M17
M15
M16
Sree Rashmi
morphotypes

Fig.6

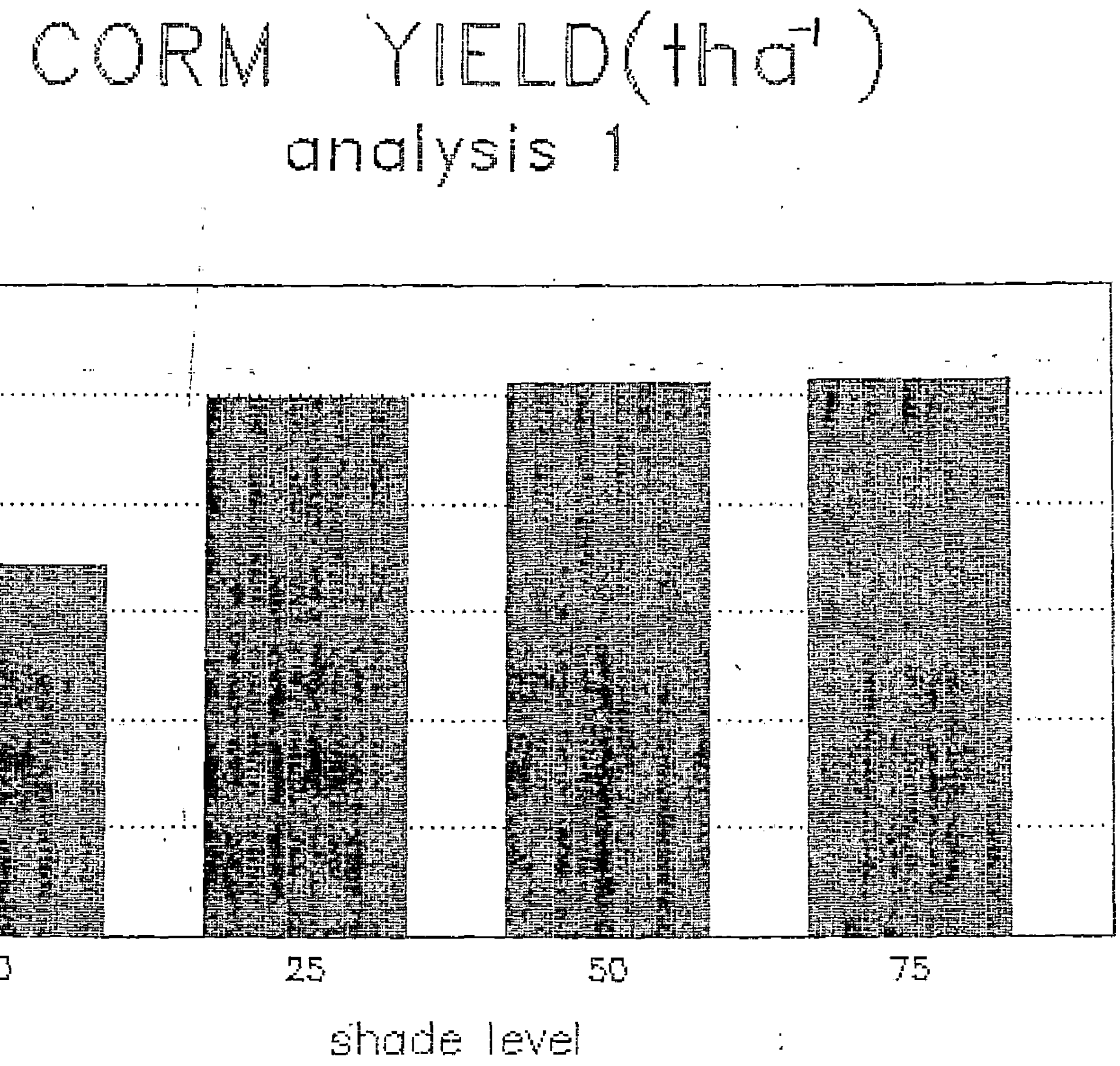
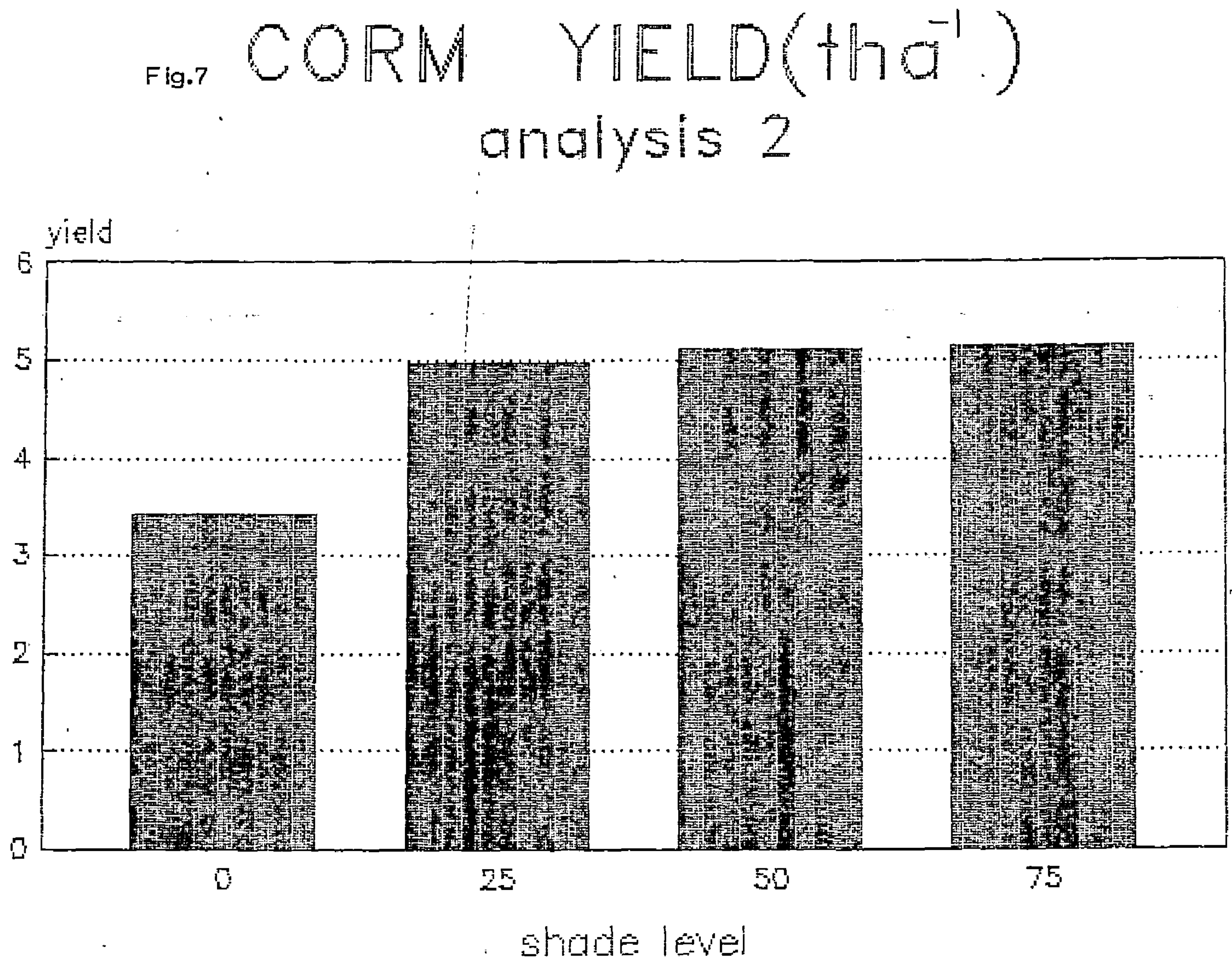

CORM YIELD(tha⁻¹)
analysis 1
yield
6
5
4
3
2
1
0
0
25
50
75
shade level

Fig.7



CORM YIELD(tha⁻¹)
analysis 2
yield
6
5
4
3
2
1
0
0
25
50
75
shade level

Fig.8

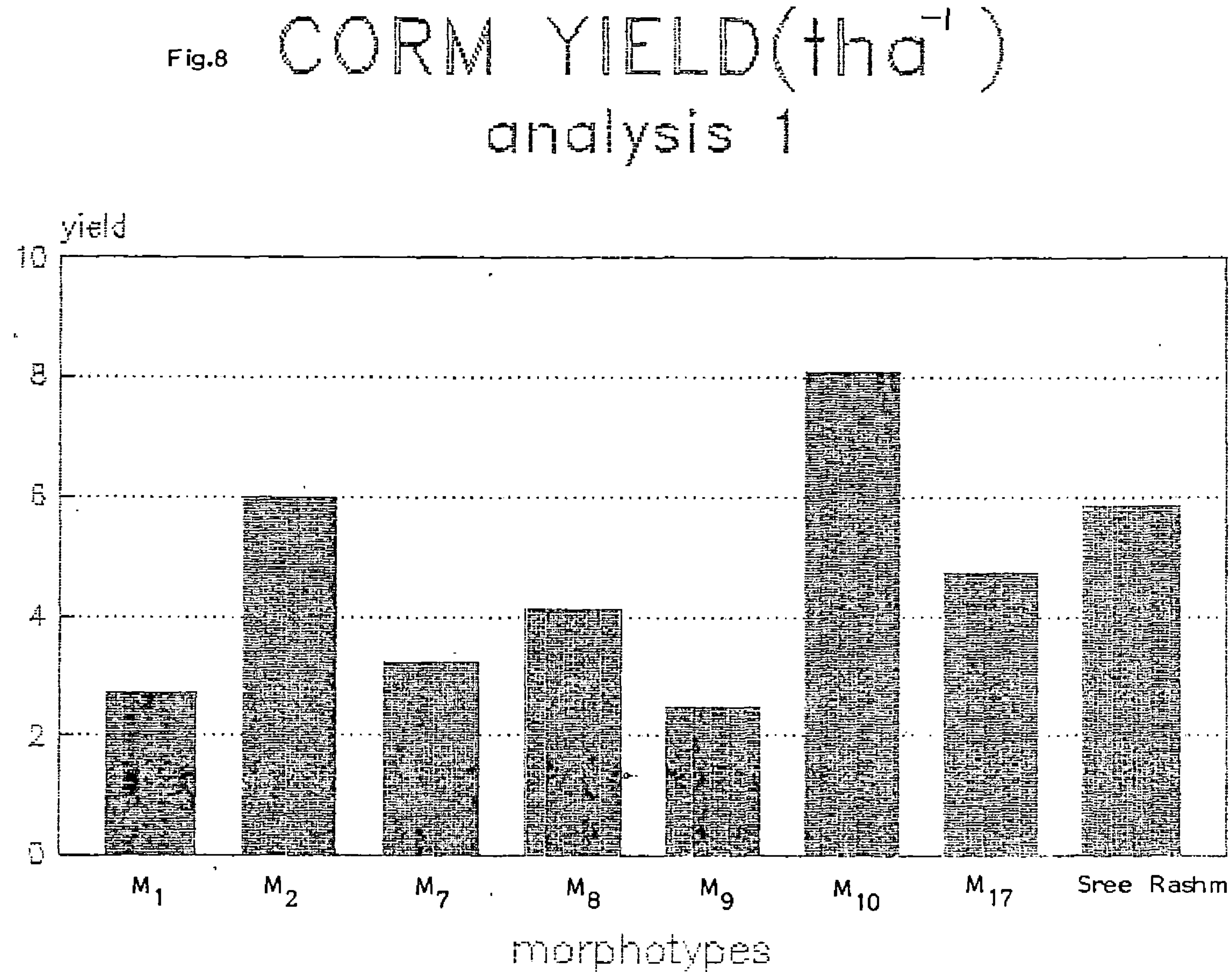
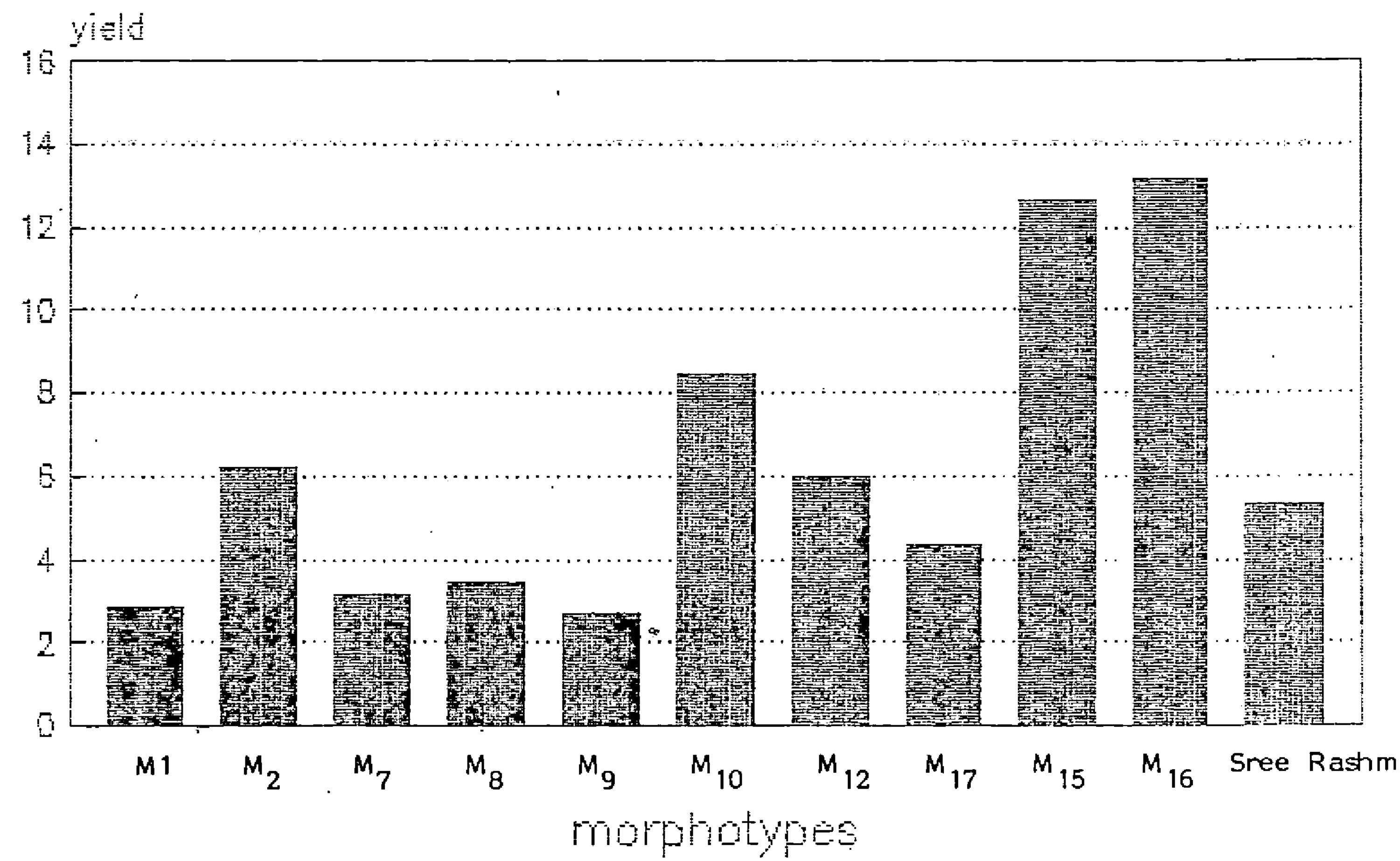

CORM YIELD(tha⁻¹)
analysis 1
yield
10
8
6
4
2
0
M1
M2
M7
M8
M9
M10
M17
Sree Rashmi
morphotypes

Fig.9 CORM YIELD(tha^{-1})
analysis 2



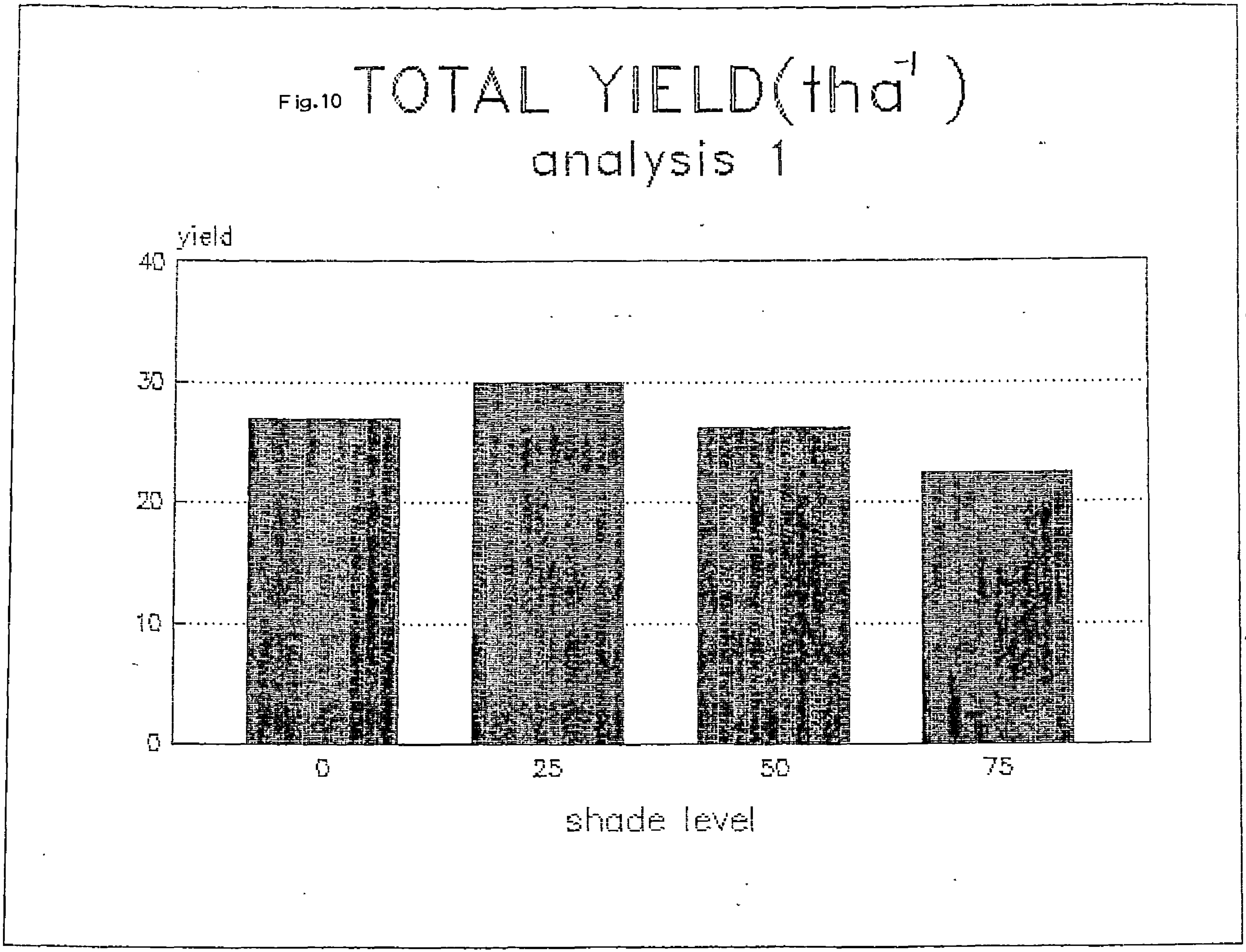


Fig.10 TOTAL YIELD(tha⁻¹)
analysis 1
yield
40
30
20
10
0
0
25
50
75
shade level

Fig.11 TOTAL YIELD($t ha^{-1}$) analysis 2

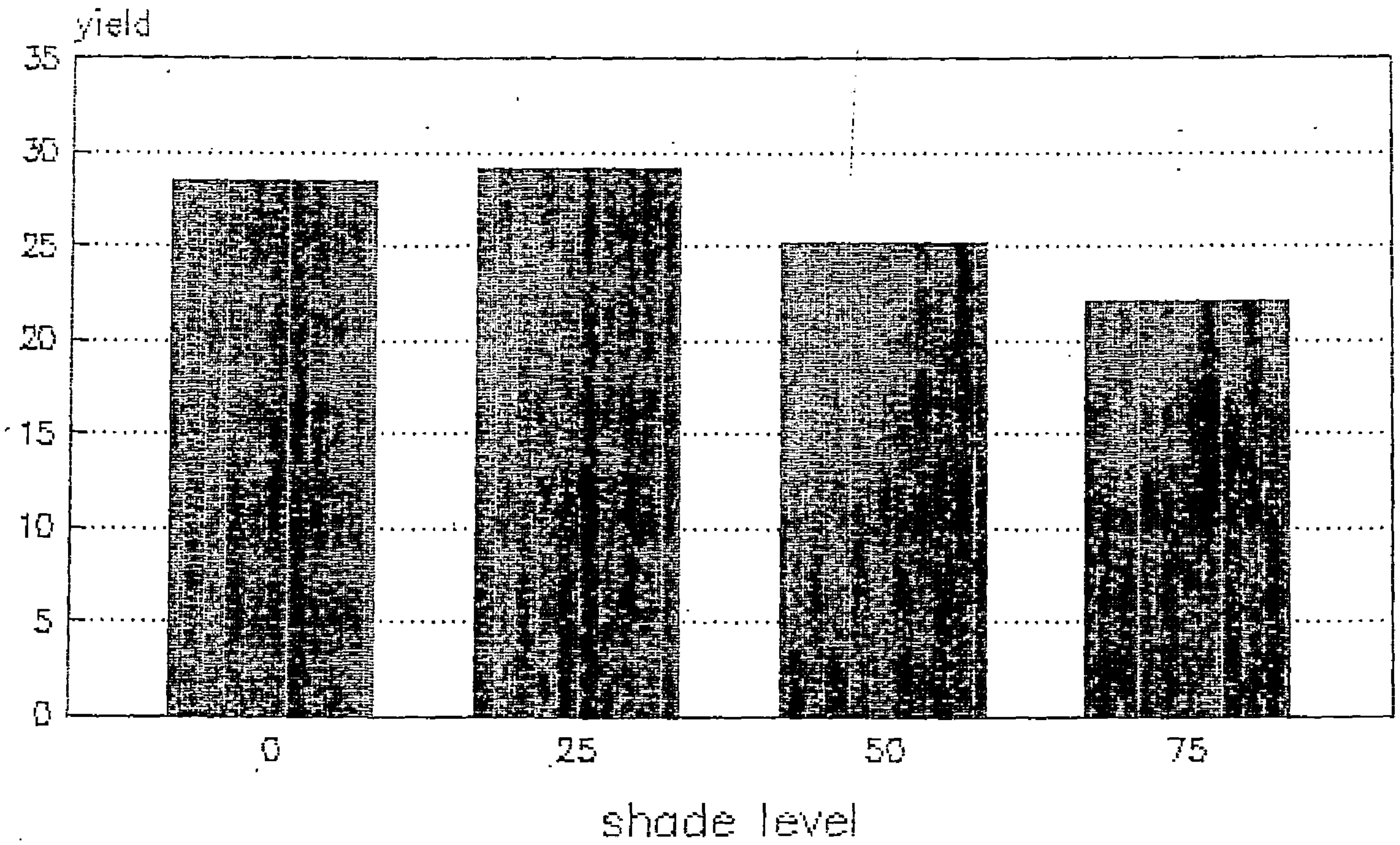


Fig.12

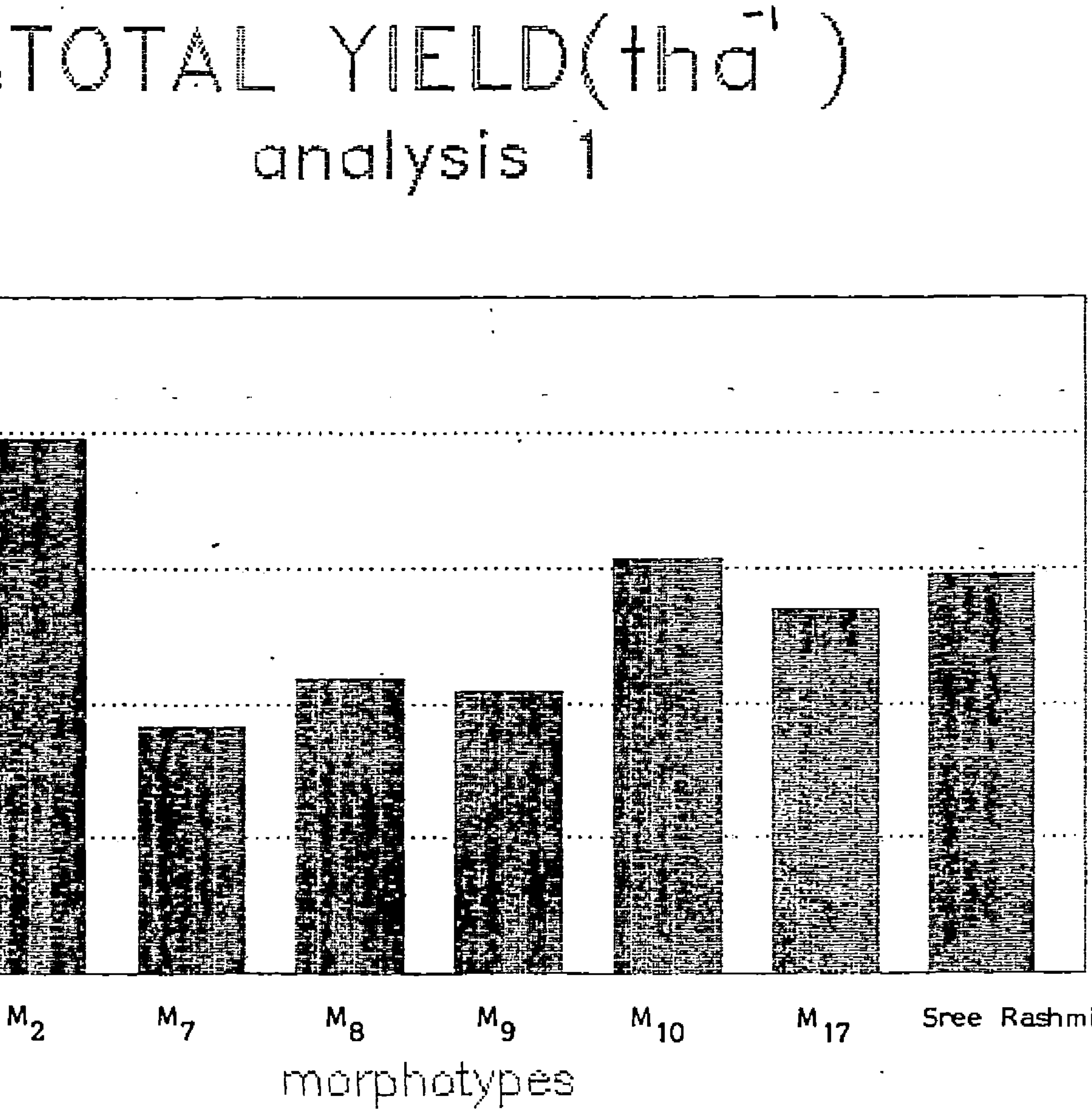

TOTAL YIELD(tha^{-1})
analysis 1
yield
50
40
30
20
10
0
M1
M2
M7
M8
M9
M10
M17
Sree Rashmi
morphotypes

Fig.13 TOTAL YIELD(tha^{-1})
analysis 2

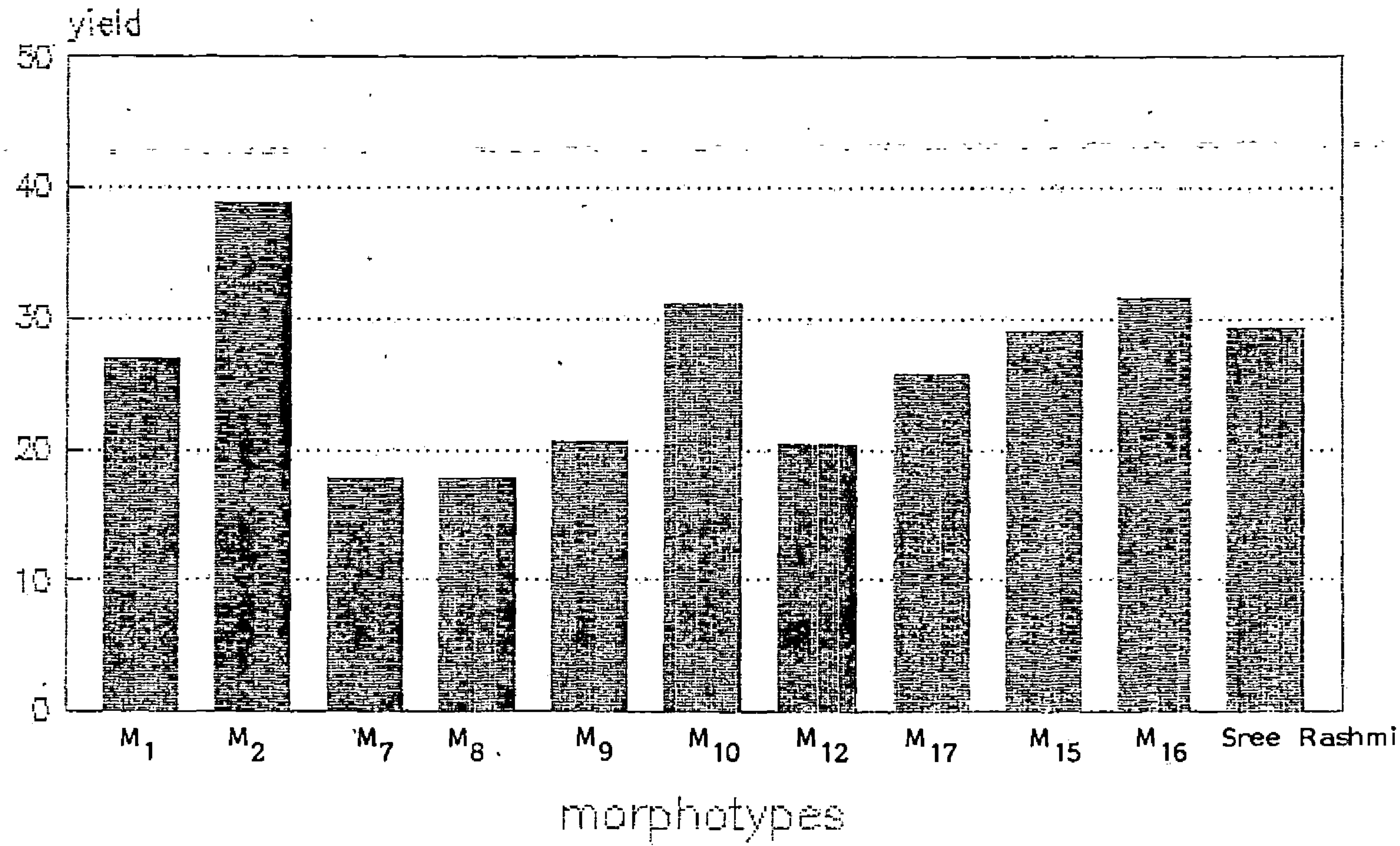


Fig.14 EFFECT OF SHADE ON TOTAL TUBER YIELD OF COLOCASIA MORPHOTYPES

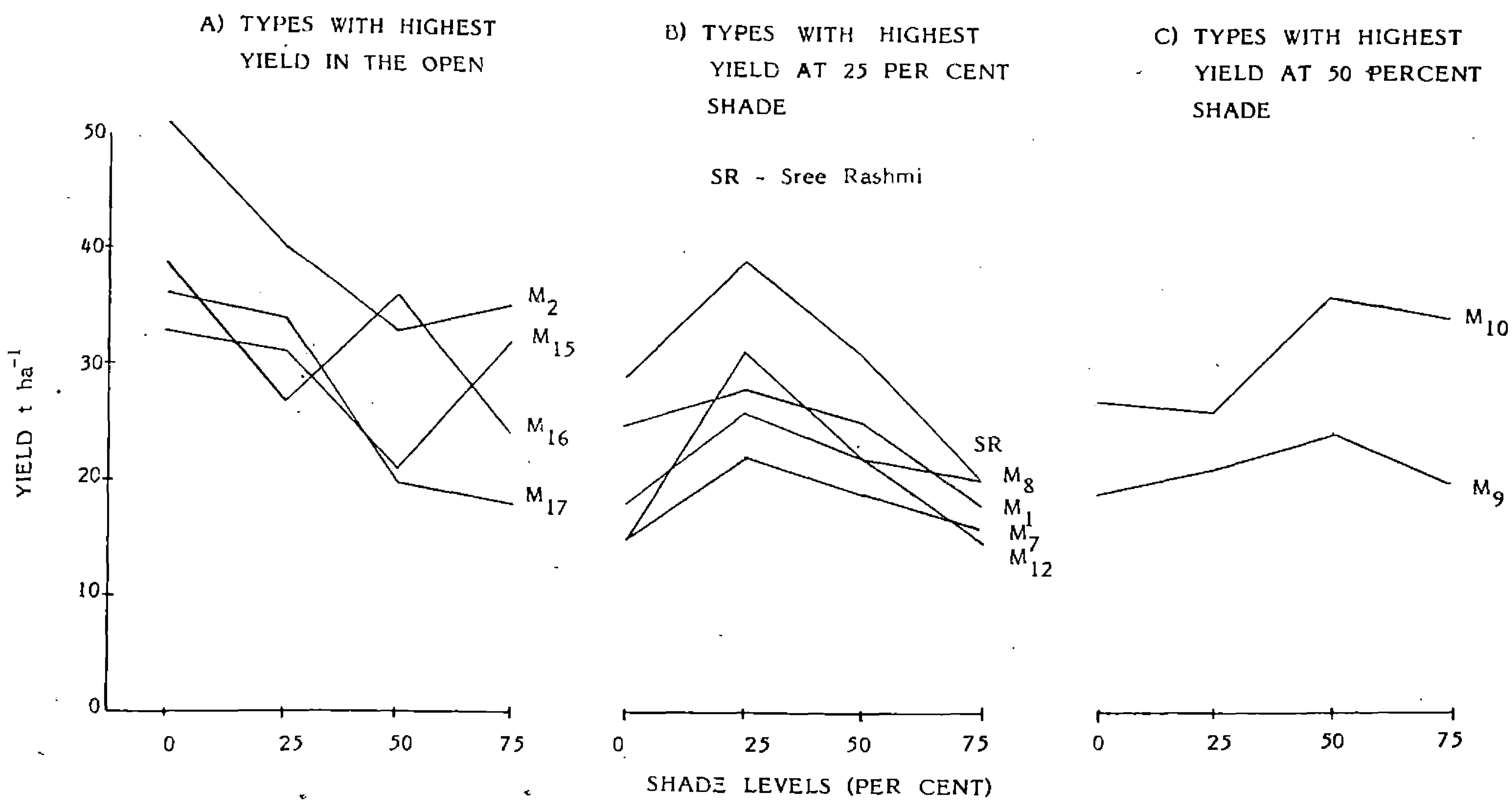


Table 12 Mean total tuber yield (t ha^{-1}) of colocasia morphotypes at different shade levels (Analysis 1)

Morphotypes	Shade levels (per cent)				Mean
	0	25	50	75	
M_1	25.0	27.6	25.4	18.4	24.1
M_2	50.9	39.5	32.8	35.2	39.6
M_7	15.2	22.4	19.4	15.7	18.2
M_8	14.6	30.9	21.9	19.6	21.7
M_9	18.7	21.1	23.9	20.0	20.7
M_{10}	26.7	26.3	36.3	33.7	30.7
M_{12}	(18.2)	(26.3)	(22.0)	(14.7)	(20.3)
M_{17}	36.0	33.7	20.0	17.6	26.8
M_{15}	(33.2)	(30.7)	(20.5)	(31.8)	(29.1)
M_{16}	(39.1)	(26.9)	(35.8)	(24.4)	(31.6)
Sree Rashmi	28.9	38.5	30.9	20.0	29.6
Mean	27.0	30.0	26.2	22.5	

SE of difference between two subplot means at the same level of main plot =4.8

CD for the above at 5 per cent level = 9.6

SE of difference between two main plot means at the same level of subplot =1.4

CD for the above at 5 per cent level = 2.8

(Figures in brackets indicate the mean yields of M_{12}, M_{15} and M_{16} in Analysis 2)

M_2 recorded the highest yield in all shade levels except at 50 per cent shade where M_{10} was the best yielder. The trend in the total tuber yield of different morphotypes was exactly the same as that for cormel yield.

4.2 Chemical studies

4.2.1 Content of fertilizer nutrients (Table 15)

Nitrogen content in both haulm and tubers was more under shaded conditions compared to open. Shade level T_2 recorded the maximum values for both haulm and tubers. With further decrease in light intensity there was a decrease in nitrogen content, though the content was higher than that in the open.

Phosphorus content in haulm and tuber showed a similar pattern as for nitrogen. It increased upto a shade level of 25 per cent and then decreased. However in the case of tuber the values recorded at 50 and 75 per cent shade were lower than that in the open.

In the case of potassium there was a progressive increase in content in haulm and tuber with increase in shading. The mean content in haulm ranged from 6.77 to 10.96 per cent at different shade levels and that in tuber from 4.55 to 5.39 per cent.

The mean contents in tuber and haulm ranged from 0.75 to 1.98 in the case of nitrogen content of haulm and from 0.95 to 1.30 in tuber.

Table 13 Effect of shade on nitrogen, phosphorus and potassium contents of colocasia tuber and haulm

Treatments	N (per cent)		P (per cent)		K (per cent)	
	Haulm	Tuber	Haulm	Tuber	Haulm	Tuber
Shade levels (%)						
T_1 (0)	1.24	1.06	0.12	0.27	6.77	4.55
T_2 (25)	1.67	1.11	0.17	0.28	7.89	5.14
T_3 (50)	1.56	1.07	0.16	0.23	9.21	5.26
T_4 (75)	1.52	1.12	0.15	0.22	10.96	5.39
Morphotypes						
M_1	1.98	1.08	0.20	0.27	8.98	5.23
M_2	1.45	1.15	0.15	0.22	8.68	6.18
M_7	1.03	1.05	0.10	0.24	9.85	4.45
M_8	1.23	1.00	0.12	0.25	10.93	4.63
M_9	1.40	1.30	0.14	0.28	9.68	4.75
M_{10}	1.35	1.05	0.14	0.21	9.23	4.18
M_{12}	1.90	1.05	0.19	0.25	9.23	4.28
M_{17}	0.75	0.95	0.12	0.29	8.80	4.95
M_{15}	1.33	1.15	0.13	0.24	6.40	5.00
M_{16}	1.70	1.18	0.17	0.25	7.65	5.65
Sree Rashmi	1.90	1.15	0.19	0.25	7.30	6.65

The comparable values in the case of phosphorus were 0.10 to 0.20 and 0.21 to 0.29 and in the case of potassium 6.40 to 10.93 and 4.18 to 6.65.

4.2.2 Uptake of nutrients (Table 14)

The uptake of nitrogen increased from 0 per cent shade to 25 per cent shade and then showed a progressive and drastic decrease. The uptake at 25, 50 and 75 per cent shade levels were 110, 90 and 79 per cent, respectively, of the uptake at 0 per cent shade.

The phosphorus uptake was also found to follow a similar pattern as that for nitrogen, the uptake at 25, 50 and 75 per cent shade being 103, 68 and 59 per cent, respectively, of the uptake at 0 per cent shade.

The uptake of potassium was also higher under lower light intensities compared to open. Uptake was the highest under 25 per cent shade and then decreased. However, the uptake was more in 75 per cent shade than in 50 per cent shade.

There was wide variation between morphotypes in the uptake of all the three nutrients. The values ranged from 41.52 kg ha^{-1} to 142.93 kg ha^{-1} for nitrogen, 8.53 kg ha^{-1} to 25.39 kg ha^{-1} for phosphorus and 216.26 kg ha^{-1} to 749 kg ha^{-1} for potassium.

Table 14 Effect of shade on total uptake of nitrogen, phosphorus and potassium and on the contents of starch and oxalic acid

Treatments	Uptake (kg ha^{-1})			Starch	Oxalic acid
	N	P	K	(per cent)	(per cent)
Shade levels (%)					
T_1 (0)	87.3	19.8	398.0	28.6	0.39
T_2 (25)	96.3	20.3	440.1	26.4	0.34
T_3 (50)	78.6	13.5	379.1	27.6	0.28
T_4 (75)	69.2	11.6	408.1	21.6	0.31
Morphotypes					
M_1	84.0	18.6	410.1	24.6	0.34
M_2	107.2	19.8	749.0	25.2	0.38
M_7	41.5	8.5	216.3	26.5	0.37
M_8	57.2	13.2	322.6	21.4	0.29
M_9	76.7	15.1	318.9	30.6	0.28
M_{10}	90.1	16.9	397.4	29.4	0.30
M_{12}	71.6	13.8	308.7	25.4	0.33
M_{17}	69.5	18.3	367.6	28.9	0.36
M_{15}	99.2	19.2	435.2	24.8	0.31
M_{16}	142.9	25.4	673.1	27.9	0.37
Sree Rashmi	71.5	13.0	342.8	22.0	0.34

4.2.3 Starch content of tubers (Table 14)

In general, colocasia grown without shade yielded tubers with high starch content followed by that at 50 and 25 per cent shade levels. The extent of decrease as compared to the open at 25, 50 and 75 per cent shade were 8, 3 and 24 per cent, respectively.

The starch content of different morphotypes ranged from 21.4 (M_7) to 30.6 (M_9) per cent.

4.2.4 Oxalic acid content (Table 14)

A decreasing trend in oxalic acid content was observed with increase in intensity of shading. The highest value was recorded in the open. The extents of decrease as compared to open at 25, 50 and 75 per cent shade were 13, 28 and 21 per cent, respectively. The range of mean oxalic acid content was from 0.28% to 0.38% in the different morphotypes.

4.3 Cooking quality

All the morphotypes tried had edible tubers. Comparing between morphotypes, M_7, M_8, M_9 and M_{12} had slight acridity. Morphotypes M_{10}, M_{15} and M_{16} were of *Colocasia esculenta* var. *esculenta* type and they produced large mother corm. Their mother corms also had good cooking quality.

4.4 Disease intensity

Incidence of colocasia blight was noticed only under shaded condition and it was kept under check by periodic sprays of Bordeaux mixture.

Discussion

DISCUSSION

Results indicated that the total tuber yield as well as cormel yield increased upto the low intensity shade of 25 per cent and then decreased. The total tuber yield at 25, 50 and 75 per cent shade levels expressed as percentage of that in the open were 111, 97 and 83 per cent (Analysis 1) and 102, 89 and 78 per cent (Analysis 2). Though the extent of decline in yield was significant at the intense shade level of 75 per cent the crop still gave a substantial yield of 78-83 per cent at this shade intensity. As yield tends to be higher at certain level of shade than in the open colocasia appears to fall in the category of shade loving plants. But the response of different morphotypes to light intensity was variable. The morphotypes M_1, M_7, M_8, M_9, M_{10}, M_{12} and Sree Rashmi had the highest yield under shaded condition and hence can be classified as shade loving. In the case of M_2, M_{15}, M_{16} and M_{17} the highest yield was recorded in the open. Bai and Nair (1982) categorised colocasia as shade tolerant as the percentage yields were greater than the percentage light intensity received. Following this classification, these four morphotypes will also come under the category of shade tolerant plants.

Most of the morphotypes performed better under 25 per cent shade than in the open. This can be explained as due to the higher rate of photosynthesis, as indicated by the highest drymatter accumulation coupled with the highest harvest index recorded at this level of shading. Though the better performance of colocasia under shade than in the open is not reported elsewhere, Bai (1981) could obtain yield comparable to open at 25 per cent shade level. Hardy (1958) explained the better performance of some crops under shade than in the open due to the reason that there is often a threshold illumination intensity beyond which the stomata of shade loving plants tend to close. This may be one of the reasons for better performance of colocasia under low intensity shade. Besides this the chlorophyll content and leaf area of colocasia were higher under shaded condition, which are some adaptive mechanisms of plants for shaded environments.

The drymatter accumulation by plants followed the same trend as that of total tuber yield and the percentage values at 25, 50 and 75 per cent shade levels were 108, 87 and 75 per cent (Analysis 1) of the drymatter accumlation at full illumination.

The highest value of harvest index was also recorded at light shade of 25 per cent. Hence it appears that the translocation of carbohydrate to economic part was increased by light shading. At medium and high shade levels, harvest index decreased due to decreased tuber yield together with a more or less constant haulm yield. The percentage decrease in tuber yield at these shade levels compared to yield at 25 per cent shade level were 13 and 25 per cent respectively. As the drymatter accumulation also tended to decrease as a result of shading it can be inferred that the photosynthetic mechanism as well as partitioning of photosynthates were affected by shading However, Bai (1981) observed that in colocasia only the photosynthetic mechanism is affected due to shading.

The share of corm yield to the total tuber yield showed a progressive increase with increase in intensity of shading. The values of percentage share of corm yield to the total tuber yield were 13, 17, 19 and 23 per cent (Analysis 1) and 18, 23, 26 and 30 per cent (Analysis 2) at 0, 25, 50 and 75 per cent shade, respectively. The general increase in corm yield in Analysis 2 is due to the inclusion of the two morphotypes M_{15} and M_{16} in which the corm yield contributed about 43 per cent to the total tuber yield. In the rest of the morphotypes, the share of corm yield to the total tuber yield was, on an average, 17 per cent only.

The relationship between shade levels and chlorophyll content of colocasia morphotypes was direct and these results were in agreement with general trend of results of such study. In colocasia (Bai, 1981), ginger and turmeric (Bai, 1981 and Varughese, 1989) noticed increased chlorophyll content under shaded conditions.

Plant characters like plant height and girth at the collar showed a steady increase with decrease in light intensity while the number of tillers and number of leaves decreased. The increase in plant height under shade has earlier been reported in crops like ginger, turmeric (Bai and Nair, 1982 and Varughese, 1989), cassava (Ramanujam et al., 1984 and Sreekumari et al., 1988) etc. Bai (1981) observed that in colocasia plant height was unaffected by shading. However, significant increase in plant height due to shading was noted in the present study. The differences in the pattern of the results in these two studies have arisen presumably from the varietal differences. The primary reason for the decrease in the number of leaves under shade appears to be because of shade-induced decrease in tillering. Low tillering under low light intensities is reported also in crops like ginger and turmeric (Bai, 1981 and Varughese, 1989), wheat (Friend, 1965) etc.

One of the main objectives of the present study was to find out whether there exists appreciable inter varietal differences in shade response and if they do, to select varieties for different shade intensities. Significant interaction effects were noticed only when the data were analysed by deleting three subplots. As some of the morphotypes were not planted in all replications statistical analysis including all the replications and subplots was not possible. Based on the total tuber yield, the best morphotypes for each of the shade levels are as follows (Analysis 1).

0 per cent shade	-	M_2, M_{17}, Sree Rashmi and M_{10}
25 per cent shade	-	M_2, Sree Rashmi, M_{17} and M_8
50 per cent shade	-	M_{10}, M2, Sree Rashmi and M_1
75 per cent shade	-	M_2, M_{10}, Sree Rashmi and M_9

Of these, M_2 and Sree Rashmi were reckoned as the same morphotype, Sree Rashmi being a selection from the Morphotype M_2, released by CTCRI, Sreekariyam. As M_2 outyielded Sree Rashmi in all cases Sree Rashmi is to be excluded from the list of superior types, thus leaving the morphotypes M_1, M_2, M_8, M_9, M_{10} and M_{17} as the superior ones through Analysis 1. This list is apparently incomplete as three of the morphotypes were not included in Analysis 1. Selection of superior types for different shade levels is not statistically sound using Analysis 2 as interaction effect was not significant.

Comparison of the overall mean yield values would indicate that M_1, M_2, M_{10}, M_{17}, M_{15} and M_{16} are the superior morphotypes. Out of these, M_1, M_2, M_{10} and M_{17} are common to both selections. Others are M_8, M_9, M_{15} and M_{16}. As the yield of M_{15} and M_{16} were very much higher compared to M_8 and M_9 these two may be included in the list of superior types and M_8 and M_9 excluded. The final selection for further testing may, thus, include M_1, M_2, M_{10}, M_{17}, M_{15} and M_{16}.

The uptake of nutrients followed the same expected trend as that of drymatter accumulation, with the highest uptake values of all the three fertilizer nutrients recorded at the light shade of 25 per cent. The quantities of nitrogen and potassium were more in the haulm compared to tubers whereas phosphorus was more in tubers. In general, the nutrient contents in haulm and tuber were high under shaded condition compared to open. The only exception was in the case of phosphorus content of tuber, where the lowest value was recorded at 75 per cent shade. The highest contents were recorded at 25 per cent shade in the case of nitrogen and phosphorus. The trend in the case of potassium was one of increase with increase in shade intensity. Calculated as percentage of the uptake in the open, the crop removal of nitrogen, phosphorus and potassium at 25, 50 and 75 per cent shade were 110, 90 and 79, 103, 68 and 59 and 111, 95 and 103, respectively. It may therefore be concluded that the requirement of nitrogen and potassium at 25 per cent shade will be around 110 per cent of that in the open condition. Unlike in the case of potassium, a drastic reduction in the uptake of phosphorus and nitrogen was noticed at intense shade level. Hence the requirement of nitrogen supplementation may be around 79 per cent of that in the open at 75 per cent shade. The phosphorus requirement at 50 and 75 per cent shade may be around 68 and 59 per cent of that in the open, respectively.

The results indicate that there is scope for bringing down the nitrogen application rate at intense shade level and phosphorus application rate at both medium and intense shade levels. The fertilizer doses for light shade level should be, however, slightly raised.

The starch content of the tubers showed a progressive decrease with shading from a mean of 28.6 to 21.6 per cent. Decreased carbohydrate level due to shading is reported in leaves and roots of *Ficus benjamina* (Milks *et al.*, 1979). The oxalic acid content was also high in the tubers grown in the open.

The salient features from the above discussion may be summarised as follows.

1. As the overall performance of the crop was better under shade than in the open, this crop may be considered as shade loving. This makes it highly suitable for intercropping in coconut gardens.

2. Six morphotypes M_1, M_2, M_{10}, M_{17}, M_{15} and M_{16} are selected as generally superior for all shade situations.

3. There was a marginal non-significant increase in yield because of ~~light~~ low intensity shading and yield was reasonable even under the intense shade of 75 per cent.

4. The crop requirement of fertilizer nutrients appears to be slightly high under mild shade where yield is the highest. The requirement of potassium does not appear to be very much affected by shading. There is scope for bringing down nitrogen fertilizer at intense shade level and phosphorus at both medium and intense shade levels.

5. A reduction in starch content was observed with shading with appreciable decline under 75 per cent shade.

6. The oxalate content was higher in colocasia grown in open.

Summary

SUMMARY

A field experiment was designed for screening different morphotypes of colocasia for shade tolerance during the year 1989-90 at the College of Horticulture, Vellanikkara, Thrissur, Kerala, India. The objectives of the study were to select morphotypes suitable for varying shade levels and to study the changes in quality of economic produce induced by shading.

Observations on various plant characters were recorded to assess the performance of the crop under shade. Chemical studies were also taken up to assess the content and uptake of fertilizer nutrients and the quality changes.

The results of the experiment are summarised below:

The total tuber yield was the highest under light shade of 25 per cent. Most of the morphotypes also recorded the highest yield at this shade level. As the overall performance of the crop was better under shade than in the open, colocasia was classified as a shade loving crop. The overall mean yields at 25, 50 and 75 per cent shade levels were 111, 97 and 83 per cent respectively of the yield in the open. Based on yield performance the morphotypes M_1, M_7, M_8, M_9, M_{10}, M_{12} and Sree Rashmi were classed as shade loving and M_2, M_{17}, M_{15} and M_{16} as shade tolerant.

The highest values of harvest index and drymatter production were also recorded at 25 per cent shade level. There was no significant difference in haulm yield at different shade levels.

Varietal differences were significant in respect of all the growth and yield parameters.

The effects of shade on plant height, girth at the collar and chlorophyll content were positive whereas those on number of tillers and number of leaves were negative.

The highest content and uptake of all the three fertilizer nutrients were recorded at 25 per cent shade level. The uptake of nitrogen, phosphorus and potassium at this level of shade was 110, 103 and 111 per cent, respectively of the uptake at 0 per cent shade. With further increase in shading, uptake of all the nutrients decreased. This decrease was only marginal in the case of potassium.

Colocasia grown in the open had the highest starch and oxalic acid contents.

Six morphotypes M_1, M_2, M_{10}, M_{15}, M_{16} and M_{17} were selected as generally superior for all shade situations.

The following morphotypes were selected for the varying shade levels.

0 per cent shade	–	M_2, M_{16}, M_{17}, M_{15}
25 per cent shade	–	M_2, Sree Rashmi, M_{17}, M_8
50 per cent shade	–	M_{10}, M_{16}, M_2, Sree Rashmi
75 per cent shade	–	M_2, M_{16}, M_{10}, Sree Rashmi

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* Originals not seen

Appendices

Appendix I   Meteorological data for the crop period (7.5.1989 to 30.12.'89)

Week No.	Month and date	Temperature °C		Soil temperature °C at 5 cm		Rain mm	Humidity %	Sunshine hours
		Max.	Min.	FN	AN			
19	May 7-13	34.5	24.5	27.3	41.4	0.2	72	8.0
20	14-20	34.0	25.1	27.9	40.0	0.8	73	8.1
21	21-27	32.1	23.6	26.7	33.8	0.1	78	4.0
22	May 28-June 3	32.1	24.4	27.2	32.2	0.6	76	4.6
23	4-10	29.2	22.5	25.0	31.2	1.5	87	3.5
24	11-17	29.3	22.9	25.3	31.0	20.4	88	3.1
25	18-24	29.1	22.5	25.0	30.3	26.7	89	2.5
26	June 25-July 1	28.8	22.5	24.8	30.5	171.6	86	3.3
27	2-8	30.9	23.8	26.3	35.0	16.4	81	7.5
28	9-15	29.6	23.8	26.9	33.3	30.5	84	5.6
29	16-22	28.1	22.9	25.9	29.8	162.6	91	0.8
30	23-29	27.1	22.3	24.5	30.1	350.8	90	1.4
31	July 30-Aug.5	30.4	23.5	26.6	33.9	37.3	80	6.9
32	6-12	29.4	23.3	26.5	31.9	56.7	84	5.4
33	13-19	28.3	22.6	25.5	29.3	139.9	89	2.7
34	20-26	29.9	23.1	25.9	31.3	62.9	82	6.4
35	Aug.27-Sept.2	29.3	23.3	25.6	31.7	32.5	83	6.3
36	3-9	30.0	22.9	26.3	33.2	3.4	78	7.2
37	10-16	30.3	22.8	26.4	32.1	63.8	81	8.0
38	17-23	29.3	23.2	26.1	30.4	66.6	86	3.3
39	24-30	29.6	23.3	25.7	33.3	36.0	84	3.5
40	Oct.1-7	31.0	22.6	25.9	37.0	112.0	81	7.8
41	8-14	30.3	22.7	25.6	36.4	114.6	82	5.7
42	15-21	31.4	23.3	25.7	32.1	13.2	78	6.8
43	22-28	31.6	23.3	25.5	34.4	81.3	81	5.8
44	Oct.29-Nov.4	31.2	23.4	25.7	35.9	19.8	74	5.4
45	5-11	32.4	23.1	25.0	41.3	4.1	67	8.3
46	12-18	32.4	24.0	26.0	40.8	4.0	65	7.1
47	19-25	32.8	21.1	24.2	41.0	0	53	9.5
48	Nov.26-Dec.2	32.8	23.0	25.9	41.9	0	61	10.5
49	3-9	32.9	23.9	26.3	41.4	0	57	9.6
50	10-16	32.3	23.0	25.2	40.3	0	60	9.6
51	17-23	32.4	22.6	25.0	40.2	0	61	9.7
52	24-31	33.4	22.7	26.4	43.9	0	62	9.4

Source: Agromet Observatory, College of Horticulture, Vellanikkara.

Appendix II Analysis of variance for plant height and number of tillers of colocasia morphotypes

Source		DF	Mean squares							
			Plant height				Number of tillers			
			60 DAP (1)	60 DAP (2)	120 DAP (1)	120 DAP (2)	60 DAP (1)	60 DAP (2)	120 DAP (1)	120 DAP (2)
Replication	(1)	3	820.1*		792.4		0.5		0.8	
	(2)	1		1013.2		157.8		2.4		0.1
Main plot	(1)	3	5427.4**		1757.4**		3.5		8.1**	
	(2)	3		4575.8*		14283.6**		4.2		9.6
Error (a)	(1)	9	152.8		310.6		1.2		1.7	
	(2)	3		191.3		314.3		1.1		4.9
Subplot	(1)	7	301.7 *		2066.6**		16.9**		9.9**	
	(2)	10		265.3**		1231.7**		4.0**		7.2**
Interaction	(1)	21	77.0		180.8		0.6		2.4*	
	(2)	30		63.8		166.0		1.2		2.00
Error (b)	(1)	84	51.8		104.3		0.7		1.2	
	(2)	40		55.9		92.4		1.0		1.0

* Significant at 5 per cent

** Significant at 1 per cent level

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

Appendix III - Analysis of variance for number of leaves and girth at the collar of colocasia morphotypes

Source		DF	Number of leaves				Girth at the collar			
			60 DAP (1)	60 DAP (2)	120 DAP (1)	120 DAP (2)	60 DAP (1)	60 DAP (2)	120 DAP (1)	120 DAP (2)
Replication	(1)	3	9.5		16.6		16.7		2.10	
	(2)	1		26.4		10.2		18.8		3.3
Main plot	(1)	3	2.4		8.0		55.9**		125.8**	
	(2)	3		5.4		51.00		39.2		83.0
Error (a)	(1)	9	1.6		12.1		3.4		8.5	
	(2)	3		1.4		9.5		4.9		20.6
Subplot	(1)	7	25.4**		67.6**		35.1**		95.2**	
	(2)	10		9.1**		52.3**		21.5**		73.8**
Interaction	(1)	21	1.9		11.8		2.6		8.3**	
	(2)	30		1.7		10.8		2.7		5.8
Error (b)	(1)	84	1.8		10.8		2.8		3.8	
	(2)	40		1.3		9.0		3.5		4.1

* Significant at 5 per cent level

** Significant at 1 per cent level

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

Appendix IV Analysis of variance for drymatter production, haulm yield and harvest index of colocasia morphotypes

Source		DF	Mean squares					
			Drymatter production		Haulm yield		Harvest index	
			(1)	(2)	(1)	(2)	(1)	(2)
Replication	(1)	3	2180.6		0.2		0.002	
	(2)	1		269.2		0.05		0.002
Main plot	(1)	3	29204.6**		0.4		0.025*	
	(2)	3		21531.8**		0.05		0.032
Error (a)	(1)	9	1257.0		0.2		0.006	
	(2)	3		175.0		0.2		0.006
Subplot	(1)	7	22360.3**		0.6**		0.028*	
	(2)	10		16348.4**		1.0**		0.015**
Interaction	(1)	21	6643.9**		0.3**		0.004	
	(2)	30		4135.4		0.1		0.004
Error (b)	(1)	84	1722.8		0.1		0.003	
	(2)	40		2893.6		0.2		0.002

* Significant at 5 per cent level

** Significant at 1 per cent level

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

SCREENING DIFFERENT MORPHOTYPES OF COLOCASIA [*Colocasia esculenta* L Schott] FOR SHADE TOLERANCE

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree

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Appendix V Analysis of variance for cormel yield, corm yield and total tuber yield of colocasia morphotypes

Source		DF	Mean squares					
			Cormel yield		Corm yield		Total yield	
			(1)	(2)	(1)	(2)	(1)	(2)
Replication	(1)	3	69.9		0.9		88.0	
	(2)	1		92.1		8.7		53.6*
Main plot	(1)	3	302.9**		21.7**		304.0**	
	(2)	3		291.8*		14.7		229.1**
Error (a)	(1)	9	25.92		2.5		31.0	
	(2)	3		17.5		8.7		4.9
Subplot	(1)	7	556.1**		58.8**		753.8**	
	(2)	10		236.8**		111.9**		348.8**
Interaction	(1)	21	129.4**		3.7		134.9**	
	(2)	30		71.7		3.7		81.2
Error (b)	(1)	84	39.5		2.9		46.6	
	(2)	40		54.0		9.6		80.0

* Significant at 5 per cent level

** Significant at 1 per cent level

(1) Data analysed by deleting three subplots (M_{12}, M_{15} and M_{16})

(2) Data analysed by deleting two replications

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ABSTRACT

The present study 'Screening of different morphotypes of colocasia for shade tolerance' was conducted during May 1989 to June 1990 at the College of Horticulture, Vellanikkara, Thrissur, Kerala, India. The experiment was laid out in a split plot design with four replications.

Eleven morphotypes of colocasia were raised at shade levels of about 0, 25, 50 and 75 per cent. For providing shade, pandals were erected on wooden frames and covered with unplaited coconut fronds to provide required levels of shade. These were covered on all sides also leaving a clearance of 1 m from ground level. LI-190 SA Quantum Sensor and LI-191 SA Line Quantum Sensor were used for adjusting the shade intensities approximately to the desired levels.

Most of the colocasia morphotypes recorded the highest yield at 25 per cent shade and hence this crop is to be classed as shade loving.

However there were substantial differences in varietal responses to shade and in the morphotypes M_1, M_7, M_8, M_9, M_{10}, M_{12} and Sree Rashmi yields were higher under shaded condition than in the open. In M_2, M_{15}, M_{16} and M_{17} yields were higher in the open and there was steady decline with increasing shade intensity. Harvest index and drymatter accumulation were found to be the highest under 25 per cent

shade level in most of the morphotypes. But the highest starch and oxalic acid contents were in the tubers from the open. Six morphotypes M_1, M_2, M_{10}, M_{15}, M_{16} and M_{17} were selected as generally superior for all shade situations.

Plates


0% SHADE


50% SHADE


75% SHADE