ICAR Ad-hoc Scheme

On

Shade Studies On Coconut-based Intercropping Situations

FINAL RESEARCH REPORT

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PREFACE

The ICAR Ad-hoc Scheme 'Shade studies on coconut-based intercropping situations' was started on 1.4.1988 to compare the performance of the available varieties of ginger, turmeric, colocasia and soybean under varying levels of shade and to select the promising ones for varying shade situations. The other objectives were to predict the performance of varieties of these crops at different shade intensities, to asses quality changes of crop produces induced by shading and to quantify the age-population relationships with light infiltration through coconut canopies.

During the first and second year, field trials were conducted under artificial shade only and during the third year, six varieties of each of the crops were raised under coconut plantations also to ascertain their performance under natural conditions. The present report pertains to the experimental period from April 1988 to September, 1991 and it embodies the results and recommendations based on the experiments conducted for 3½ years.

FINAL RESEARCH REPORT

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FINAL REPORT OF RESEARCH SCHEME

1. Project title : Shade studies on coconut based intercropping situation

2. Sanction Number : F 8(9)/85/AFC dated 8.10.1987

3. Date of start : 1.4.1988

4. Date of termination : 30.9.1991

5. (a) Name of institute : College of Horticulture
Vellanikkara - 680 654
Thrissur, Kerala, India

   (b) Division/Department/ Section : Department of Agronomy

   (c) Location of work : Vellanikkara

6. Technical personnel employed:

Name with designation	Date of joining	Date of leaving	Total number of man months spent
1. Geetha, S. Research Associate	30.12.1988	10.1.1989	--
2. Pandidurai, V. Research Associate	7.2.1989	12.12.1990 (Resigned)	22
3. Sindhu, K. Research Associate	20.2.1991	13.8.1991 (Resigned)	6
4. Susan Varghese Junior Research Fellow	1.4.1988	20.4.1989	12
5. Prameela, P. Junior Research Fellow	21.4.1989	3.4.1990	12
6. Hemalatha, S. Junior Research Fellow	2.5.1990	31.3.1991	11
7. Natarajan, K.V. Farm Assistant (Agri) Senior Grade	11.5.1988	31.5.1989	12
8. Rajendra Babu Farm Assistant (Agri) Grade I	1.6.1989	30.9.1991	28

7. Total outlay

Share of ICAR — 4,46,000

Share of participating agency — NIL

8. Total amount spent

Share of ICAR — 4,51,783

Share of participating agency — NIL

9. Objectives:

1. To compare the performance of the available varieties of ginger, turmeric, colocasia and soybean under varying levels of shade and to select the promising ones for varying shade situations.

2. To predict the performance of varieties of the above crops at different shade intensities.

3. To assess quality changes, if any, of crop produce induced by shading.

4. To quantify the age population relationships with light infiltration through coconut canopies.

10. Approved technical programme

(a) Remarks of scientific panel on earlier Annual report

(i) First annual report - The report is accepted

(ii) Second annual report - The work and this system was appreciated by the panel. The annual report was accepted.

(i) For the first year

About 20 promising varieties each of four crops viz., colocasia, ginger, turmeric and soybean are to be raised in small plots at shade levels of 0 (open), 25, 50 and 75 per cent and their general performance will be assessed. For providing shade 'Pandals' will be erected on wooden/metallic frames and covered with coconut fronds or mats of suitable mesh to provide the required levels of shade. These will be covered on all sides also (to prevent entry of slant rays) leaving a clearance of 1 m from the ground level (to facilitate air movement). The experiment will be conducted in a split plot design with shade levels as whole plot treatments and varieties as sub-plots.

Number of replications	-	4
Whole plot treatments	-	Four shade levels of 0, 25, 50 and 75 per cent
Sub-plot treatments	-	About 20 varieties

Observations

A. Growth and yield observations

1. Plant height - Height of 10 randomly selected plants in each of the crops to be measured from the base to the tip of the longest tiller or branch.

2. Girth at collar - This is to be recorded in colocasia only, where circumference at the collar of the most vigorous tiller of 10 randomly selected plants will be recorded.

3. Number of branches/tillers - Number of aerial shoots arising around a single plant to be noted in 10 randomly selected plants.

4. Yield - (Yield of grain/rhizome/tuber) and yield components.

B. Chemical studies

1. General fertility level of experimental field prior to planting.

(ii) For the second year

1. Repeating experiment of first year
2. Survey of shade levels in coconut gardens

This item of work which is to be taken up concurrently envisages measurements of shade intensities in coconut interspaces of different age and plant population levels. The observations are to be taken up in farmers' fields using suitable sampling techniques.

(iii) For the third year

1. Comparison of varieties screened in, in larger plots and under coconut canopy.

2. Survey of shade

3. Statistical analysis and preparation of final report

Based on the yield trends, a selection of 5 to 6 varieties of each crop will be made for testing as a replicated trial in larger plots under artificial shade. Comparison again, will be made at shade levels of 0, 25, 50 and 75 per cent. Observations on growth and growth analysis parameters will be taken to explain the yield trends. Prediction equations will be developed based on yields of last year.

These initially screened varieties will also be grown under an existing coconut plantation of uniform age. In addition to observations on the growth and yield of these crops, the growth and yield measurements of the main crop, coconut, also will be taken to find out the possible adverse/allelopathic effects. The plot size will be the area occupied by a coconut tree (7.5 m x 7.5 m) excluding an area of 2 m radius around each tree (basin area). Measurement of the mean light infiltration through the existing coconut canopy will be made. There will be two types of control plots. One with coconut alone without intercrops and another with sole crops in the open. Comparison of the extent of yield decline under coconut canopy will be made with the yield at identical artificial shade.

Detailed field trial

Whole plot treatments - Four shade levels of 0, 25, 50 and 75 per cent.

Sub plot treatments - 5 to 6 varieties

Observations

In addition to the growth and yield observations included in the initial screening trial the following are also included in this experiment.

A. Growth and yield observations

1. Leaf area index - To be recorded using measurements of length and width and from the number of leaves.

2. Total dry weight and dry weight of plant parts - To be recorded using four sample plants at grand growth stage.

3. Harvest index - To be recorded at harvest from data on economic yield and total dry weight corrected to moisture free values.

4. Stomatal size - To be recorded at monthly intervals to arrive at illumination thresholds for stomatal closure and opening.

B. Meteorological observations

Weekly observations of PAR at hourly intervals and of soil temperature and relative humidity twice daily.

C. Chemical studies

Estimation of quality parameters of crop produce, curcumin in turmeric, oleoresin in ginger, starch and oxalic acid in colocasia and protein in soybean.

Field trial under coconut

Design	-	Randomised block
Replications	-	4
Treatments (varieties)	-	6
Plot size	-	Area around a coconut tree excluding the basin area.

There will be separate experiments for all the crops included.

Observations

1. Same observations as for the initial screening trial.
2. Leaf production and number of functional leaves of coconut.
3. Yield of coconut

Detailed report

All the soybean varieties tested during the first year completely failed under 50 and 75 per cent shade level and had a poor performance under the low shade of 25 per cent indicating that it is shade sensitive. So, only three crops proposed for the study were raised during the subsequent years. The report therefore covers ginger, turmeric and colocasia only. Hundred and thirty days after planting, colocasia under existing coconut plantation was completely damaged by wild boar. All control measures taken proved ineffective. Hence observations of colocasia under existing coconut plantation beyond 30DAP could not be collected.

(a) Materials and methods

1. Artificial shade

(i) Shade

Pandals of size 27 m x 11 m were erected on wooden frames 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 which was done to avoid direct entry of slant rays. An ordinary lux meter was used for measurement of radiation for adjustment during first year and LI-190 SA Quantum Sensor and LI-191 SA Line Quantum Sensor were used for adjusting shade intensities to the desired levels from second year onwards. The structures were erected by June 1988 and experimental planting was done by May-June of 1988, 89 and 90.

(ii) Planting material

During the first year thirteen varieties of ginger, twelve varieties of turmeric and sixteen varieties of soybean were raised. Disease free, healthy rhizome bits of ginger each weighing 20 to 25 g were planted on raised beds of width 1 m at a spacing of 25 cm x 25 cm leaving 30 cm between varieties. Finger rhizomes of turmeric each weighing 15 g were raised on beds of width 90 cm at a spacing of 15 cm x 30 cm, leaving sufficient space (30 cm) between varieties. Soybean seeds were sown on raised beds of width 90 cm at a spacing of 45 cm x 5 cm. Plot size for ginger was 1 m x 1 m, that of turmeric was 0.9 x 0.6 m^2 and that of soybean was 4.5 x 0.9 m^2.

During the second year, ten varieties of turmeric raised during the first year, eleven morphotypes of colocasia and twenty soybean varieties were raised. Turmeric was planted on beds of width 90 cm at a spacing of 15 cm x 30 cm. Colocasia was raised on ridges formed 60 cm apart with a plant-to-plant distance of 45 cm. Soybean was sown on raised beds of 90 cm width with a spacing of 45 cm x 5 cm. Plot size of turmeric was 0.9 m^2, that of colocasia was 3.24 m^2 and that of soybean was 0.9 m^2.

During the third year, six varieties each of ginger, turmeric and colocasia were raised. Rhizomes of turmeric and cormels of colocasia harvested during the previous year were stored and used as seed material for third year's experiment. Rhizomes of ginger were collected from various sources including research stations. Ginger was planted on beds of width 100 cm at a spacing of 25 cm x 25 cm. Turmeric was planted on raised beds of 90 cm width with a spacing of 15 cm x 30 cm. Colocasia was raised on ridges formed 1 m apart with a plant-to-plant distance of 1 m. Plot size of ginger was 4 m^2, that of colocasia was 20 m^2 and that of turmeric, 3.51 m^2.

(iii) Manures and fertilisers

Manures and fertilisers were applied as per the package of practices recommendations of the Kerala Agricultural University (1989). Urea, super phosphate and muriate of potash were the fertilisers used. Mulching was done using green leaves for retension of soil moisture and to control weeds.

(iv) After cultivation

Weeding and earthing up were done one month and two months after planting. Paraquat was sprayed to control the weeds growing in between the main plots.

(v) Plant protection

One spraying with Ekalux was given for soybean, ginger and turmeric against shoot borer. Phorate was applied to ginger to control the attack of rhizome weevil. Cheshunt compound was applied for the control of soft rot of ginger. Periodical sprayings with Dithane were given to colocasia against leaf blight during the rainy season.

Methods

Layout of the field - The experiment was laid out in a split plot design with four replications. The treatments included factorial combinations of four shade levels and varieties. The shade levels were assigned to main plots and varieties to sub plots. The number of sub-plot treatments varied over the years.

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

Sub plot treatments during the first year

Ginger varieties

Jorhat, Nadiya, Jamaica, Pottangi Selection 667, Rio-de-jeneiro, Pottangi Selection 17, Kuruppampadi, Jugijan, Valluvanad, PGS-35, Amballoor local, PGS-10 and Nedumangad.

Turmeric varieties

Myduckur, Armoor, PCT-2, PTS-9, Ethamukulam, PCT-8, PTS-10, PTS-24, PCT-5, CO-1, BSR-1 and PTS-38.

Soybean varieties

PLSO-18, Monetta, Davis, KB-74, Hardee, Himso-1531, EC-63298, PK-471, KHS b-2, EC-39824, DS-79-277, EC-26691, MACS-124, DS-76-1-37-1, KB-38 A and DS-83-20.

Sub plot treatments during the second year

Colocasia morphotypes

M_1, M_2, M_7, M_8, M_9, M_{10}, M_{12}, M_{15}, M_{16}, M_{17} and Sree Rashmi (Details of the morphotypes are given in Appendix I).

Turmeric varieties

PCT-5, PCT-8, BSR-1, PTS-9, Ethamukulam, PCT-2, CO-1, PTS-24, PTS-10, PTS-38.

Soybean varieties

EC 63298, Hardee, PK 471, Bragg 88, KB 74, Ankur, KB-38-A, Improved pelican, KHS b 2, DS-79-227, Monetta, EC-29824, DS-76-1-37-1, EC 39824, PLSO-18, MACS-124, Himso, DS-83-20, EC-26691 and Davis.

Subplot treatments during the third year

Ginger varieties

Maran	Rio de jeneiro
Kuruppumpadi	Nedumangadu
Himachal	Amballoor local

Turmeric varieties

PCT-5	PCT-8
PTS-9	PTS-38
BSR-1	Ethamukulam

Colocasia morphotypes

M_1, M_2, M_9 M_{10}, M_{16} and M_{17}.

Natural shade under coconut plantation

Planting material

Healthy rhizomes of ginger and turmeric and cormels of colocasia stored for planting under artificial shade were used.

Manures and fertilisers

Cultural and manurial practices followed for the crops under artificial shade were repeated.

Plant protection

Soil drenching with cheshunt compound was done for controlling soft rot of ginger and Dithane spraying was given to colocasia to control leaf blight.

Methods

Layout - The six varieties of ginger, turmeric and colocasia were planted in randomised block design with four replications. Each variety was planted around one coconut palm leaving a basin area of 12.56 m^2. Net area around one palm planted with each crop variety was 30 m^2.

Treatments

Six varieties of ginger, turmeric and colocasia planted under artificial shade were used for this trial also.

Survey of shade

The light infiltration under coconut canopy was measured during second and third years. LI-190 SA Quantum Sensor and LI-191 SA Line Quantum Sensor were used for light measurement. The average of hourly values from 9 am to 5 pm was taken as the mean light infiltration percentage. Such measurements were made from different coconut situations.

Additional observations

In addition to the observations included in the technical programme, the following observations were also taken.

(i) First year

Ginger and turmeric

1. Dry matter production - Component parts of sample plants were dried to constant weight at 70 to 80°C in hot air oven and average dry weight per plant was worked out and expressed as g $plant^{-1}$.
2. Chlorophyll content - Chlorophyll fractions 'a', 'b', total and ratio of a to b were estimated 150 DAP by the spectrophotometric method as described by Starnes and Hadley (1965).
3. Harvest index - Harvest index was calculated as $HI = \frac{Y\ econ}{Y\ biol}$ where Y econ and Y biol are dry weight of rhizome and total dry weight of plants, respectively.
4. Quality of the produce - Curcumin content in turmeric (ASTA, 1964) and oleoresin content in ginger (ISI, 1974) were estimated.

(ii) Second year

Colocasia and turmeric

1. Dry matter production
2. Chlorophyll content
3. Harvest index
4. Quality of produce - Curcumin content in turmeric (ASTA, 1964) and starch (AOAC, 1960) and oxalic acid content (CTCRI, 1983) in colocasia were estimated.

(iii) Third year

Ginger, turmeric and colocasia

1. Chlorophyll content - Chlorophyll a, b and total chlorophyll content were estimated 170 DAP by the spectrophotometric method as described by Starmes and Hadley (1965).

2. Net assimilation rate - NAR was calculated as follows:

$$NAR = \frac{w_2-w_1}{t_2-t_1} \quad \frac{\log e\ LA_2-\log e\ LA_1}{LA_2-LA_1}$$ where

w_2 and w_1 are total dry weights of plants at time t_2 and t_1, t_2-t_1 is time interval in days and LA_2 and LA_1 are leaf area indices at time t_2 and t_1.

Statistical analysis

The data were subjected to analysis of variance following the methodcof Panse and Sukhatme (1978). During the first year since all the soybean varieties failed under shade, analysis was made as RBD for open only. Due to lack of sufficient seeds, two varieties were not sown in one replication, hence missing plot technique was adopted for the analyses. Besides this, there were differences in the plant population in various plots, because of some germination problem. For this, yield data were analysed following the method of analysis of covariance, taking plant population as x and yield as y.

Since a few ginger varieties were lost in the open due to severe disease incidence, the data were analysed in two ways - one excluding the main plot in which there was damage (Analysis 2) and the other excluding the missing sub plots (Analysis 1). One of the missing varieties in the open (V_{13}) was found to be the best in all shade levels and hence to have a comparison of this variety with other varieties in the open, yield data were also analysed by deleting one replication (Analysis 3).

During the second year, since all the soybean varieties failed in 50 and 75 per cent shade and as the yields were drastically reduced in 25 per cent shade, the data were analysed for open and 25 per cent shade separately treating the design as randomised block. Since all the varieties of turmeric and colocasia were not planted in all the four replications due to lack of sufficient planting material, the data were analysed in two ways, one deleting the missing sub plots (M_{12}, M_{15} and M_{16} in the case of colocasia and V_4, V_5, V_6, V_9 and V_{11} in the case of turmeric) and the other by deleting the two replications having missing sub plots.

During the third year, the data from all the three crops viz., ginger, turmeric and colocasia planted under artificial shade and natural shade were subjected to analysis of variance.

Results and discussion

A. GINGER

I Trials under artificial shade

As had been indicated elsewhere, experiments on ginger were conducted only for the first and third years. Results obtained are given below and discussed.

1. Plant height (Tables 1 and 2)

Between shade levels, the trend was one of increase in plant height with increasing levels of shade during both the seasons. Among the varieties, Nedumangad (V_2) recorded the highest height values during the first year and these values were significantly different from the mean of other varieties at 120 and 180 days after planting. Eventhough this shade response was apparent during the third year at the last stage 180 days after planting, it was not so at the earlier stages of 60 and 120 days. The interaction between shade levels and varieties was also significant. Over the seasons, the mean height values of varieties that were common for both seasons were distinctly higher during the first year than the third year. The effects of season and dates of planting were probably responsible for these. Such a better growth during the first year was however, not reflected in final yield and in fact the yield was better during the third year.

Table 1. Effect of shade on plant height (cm) of ginger cultivars

Treatments	1988				1990		
	60 DAP	120 DAP (1)	120 DAP (2)	180 DAP	60 DAP	120 DAP	180 DAP
Levels of shade (per cent)							
T_1 (0)	48.3	66.2	--	--	41.9	48.2	51.2
T_2 (25)	58.5	82.5	82.3	81.6	39.7	55.8	69.7
T_3 (50)	58.6	79.7	79.7	79.1	36.3	57.3	81.5
T_4 (75)	62.6	79.0	78.8	77.2	47.5	60.1	82.7
SEm ±	1.37	1.44	1.76	1.24	2.47	1.45	3.95
C.D (0.05)	4.39	4.60	NS	NS	5.59	3.29	8.93
Varieties							
V_1 Amballoor local	54.2	77.4	81.5	79.4	40.5	56.6	71.3
V_2 Nedumangad	62.8	89.4	94.0	89.8	37.3	54.4	74.8
V_3 Rio-de-jeneiro	52.5	--	79.0	81.9	37.1	55.1	70.5
V_4 Kuruppampadi	60.6	80.6	84.3	79.8	47.0	61.0	72.9
V_5 Maran	--	--	--	--	43.0	51.5	69.0
V_6 Himachal	--	--	--	--	43.3	53.5	69.0
V_7 Jorhat	62.0	73.2	75.8	71.7	--	--	--
V_8 Nadiya	58.4	73.7	76.3	73.9	--	--	--
V_9 Jamaica	65.4	77.4	80.2	77.4	--	--	--
V_{10} Pottangi selection-667	62.6	82.0	85.9	82.9	--	--	--
V_{11} Pottangi selection-17	60.4	82.6	87.6	85.9	--	--	--
V_{12} Jugijan	55.9	79.1	83.3	83.5	--	--	--
V_{13} Valluvanad	65.0	77.9	80.1	78.2	--	--	--
V_{14} PGS-35	39.2	63.0	66.7	73.7	--	--	--
V_{15} PGS-10	41.9	65.6	68.8	72.9	--	--	--
SEm ±	1.42	1.50	1.90	1.90	1.45	2.63	2.06
C.D (0.05)	3.94	4.14	5.30	5.30	2.90	5.27	4.13

DAP - Days after planting

(1) Data analysed by deleting one sub plot (V_3)

(2) Data analysed by deleting one main plot (T_1)

Table 2. Interaction effect of shade levels and ginger cultivars on plant height (cm)

Varieties	1990									
	60 DAP					180 DAP				
	Shade levels (per cent)					Shade levels (per cent)				
	0	25	50	75	Mean	0	25	50	75	Mean
V_1 Amballoor local	34.2	39.0	44.1	44.5	40.5	45.3	72.3	83.6	84.2	71.3
V_2 Nedumangad	39.9	36.1	32.1	41.0	37.3	50.0	78.3	81.6	89.1	74.8
V_3 Rio-de-jeneiro	35.9	39.4	27.1	46.2	37.1	51.1	61.9	83.1	86.0	70.5
V_4 Kuruppampadi	45.4	42.7	44.6	55.6	47.0	57.0	70.8	85.7	78.3	72.9
V_5 Maran	46.9	37.4	35.2	52.2	43.0	52.2	61.9	80.8	81.3	69.0
V_6 Himachal	49.4	43.6	34.6	45.6	43.3	51.6	72.7	74.5	77.0	69.0
Mean	41.9	39.7	36.3	47.5		51.2	70.1	81.5	82.7	

For 60 DAP
SEm ± difference between 2 sub plot means at the same level of main plot = 2.90
C.D for the above at 5 per cent level = 5.81
S.E of difference between 2 main plot means at the same level of sub plot = 3.63
C.D for the above at 5 per cent level = 7.69

For 180 DAP
S.E of difference between 2 sub plot means at the same level of main plot = 4.13
C.D for the above at 5 per cent level = 8.25
S.E of difference between 2 main plot means at the same level of sub plot = 5.46
C.D for the above at 5 per cent level = 11.66

2. Number of tillers (Tables 3, 4 and 5)

During 1988, there was a steady decrease in mean tiller number with increasing levels of shade, the lowest number being at the highest shade intensity. This was so at all the three stages of observation, 60, 120 and 180 days after planting. During 1990, on the contrary, such a trend was not apparent and the differences in mean values were not statistically significant. Between varieties, there were significant differences and the variety, Pottangi Selection 17 gave the highest tiller number at most of the stages during 1988. During 1990, Rio-de-jeneiro had the highest tiller number among the six varieties tested. The interaction between shade levels and varieties was significant at 60 and 180 days after planting during 1988 and at 180 days during 1990. A comparison of the mean values of the two seasons would indicate that there was more profuse tillering during 1990. It is to be noted that unlike in plant height, yields were higher during 1990.

3. Number of leaves (Table 6)

This observation was recorded during 1988 only. The trend of results was one of decrease in leaf number with increasing shade levels. This trend was noted at all the three stages of 60, 120 and 180 days after planting. As expected, varieties showed significant differences. Over the stages, there was a substantial increase in tiller number from 60 to 120 days and a decrease from 120 to 180 days. In this extent of decline, there were substantial inter-varietal differences and in two varieties, PGS-35 and PGS-10, there was increase instead of a decrease over this period.

Table 3. Effect of shade on number of tillers of ginger cultivars

Treatment	1988				1990		
	60 DAP	120 DAP (1)	120 DAP (2)	180 DAP	60 DAP	120 DAP	180 DAP
Levels of shade (per cent)							
T_1 (0)	4.7	14.0	--	--	2.5	10.9	14.3
T_2 (25)	3.6	10.6	10.6	11.0	2.1	10.6	15.6
T_3 (50)	3.2	8.6	8.4	10.0	2.5	12.2	14.0
T_4 (75)	2.9	7.3	7.3	8.0	1.8	9.2	12.3
SEm ±	0.21	0.51	0.54	0.28	0.43	0.9	0.75
C.D (0.05)	0.68	1.65	1.9	0.98	NS	NS	NS
Varieties							
V_1 Amballoor local	3.2	8.6	7.4	7.4	1.8	9.0	13.3
V_2 Nedumangad	3.6	10.0	8.7	9.4	1.5	9.1	12.4
V_3 Rio-de-jeneiro	3.2	--	7.7	8.9	3.3	15.0	20.4
V_4 Kuruppampadi	3.2	9.2	7.9	7.5	1.5	9.0	12.3
V_5 Maran	--	--	--	--	2.2	10.3	12.6
V_6 Himachal	--	--	--	--	3.1	11.8	11.8
V_7 Jorhat	3.1	9.2	8.4	7.7	--	--	--
V_8 Nadiya	3.6	9.6	9.0	8.6	--	--	--
V_9 Jamaica	3.7	10.4	9.8	9.8	--	--	--
V_{10} Pottangi Selection 667	3.1	9.0	7.7	7.9	--	--	--
V_{11} Pottangi Selection 17	4.2	12.3	10.8	12.5	--	--	--
V_{12} Jugijan	3.9	9.8	7.8	9.5	--	--	--
V_{13} Valluvanad	3.9	11.5	10.1	10.0	--	--	--
V_{14} PGS-35	4.0	11.2	8.9	13.4	--	--	--
V_{15} PGS-10	4.0	10.9	9.8	13.2	--	--	--
SEm ±	0.20	0.52	0.45	0.54	0.21	0.99	1.19
C.D (0.05)	0.54	1.45	1.27	1.52	0.43	1.97	9.38

DAP - Days after planting

(1) Data analysed by deleting one sub plot (V_3)

(2) Data analysed by deleting one main plot (T_1)

Table 4. Interaction effects of shade levels and ginger cultivars on number of tillers at 60 DAP

Varieties	1988				
	Shade levels (per cent)				
	0	25	50	75	Mean
V_1 Amballoor local	4.8	3.2	2.4	2.5	3.2
V_2 Nedumangad	4.8	3.4	3.5	2.8	3.6
V_3 Rio-de-jeneiro	3.8	3.3	2.9	2.7	3.2
V_4 Kuruppampadi	4.4	3.0	3.0	2.7	3.2
V_7 Jorhat	3.4	3.4	3.3	2.4	3.1
V_8 Nadiya	3.9	3.8	3.1	3.8	3.6
V_9 Jamaica	4.0	3.9	3.5	3.6	3.7
V_{10} Pottangi selection 667	4.3	2.9	2.8	2.6	3.1
V_{11} Pottangi selection 17	5.3	4.3	3.8	3.6	4.2
V_{12} Jugijan	5.7	4.5	2.8	2.8	3.9
V_{13} Valluvanad	5.5	3.9	3.3	3.1	3.9
V_{14} PGS-35	6.1	4.3	3.4	2.4	4.0
V_{15} PGS-10	5.3	3.7	3.7	3.3	4.0
Mean	4.7	3.6	3.2	2.9	

DAP - Days after planting

Table 5. Interaction effects of shade levels and ginger cultivars on number of tillers

Varieties		1988				1990				
		180 DAP				180 DAP				
		Shade levels (per cent)				Shade levels (per cent)				
		25	50	75	Mean	0	25	50	75	Mean
V_1	Amballoor local	8.0	7.2	7.0	7.4	14.3	14.0	13.8	11.2	13.3
V_2	Nedumangad	8.9	11.2	8.1	9.4	8.3	15.9	10.1	15.2	12.4
V_3	Rio-de-jeneiro	11.1	8.9	6.8	8.9	25.1	16.6	10.0	15.8	20.4
V_4	Kuruppampadi	7.2	7.9	7.2	7.5	10.8	19.4	10.2	8.6	12.3
V_5	Maran	--	--	--	--	11.8	11.2	14.6	12.9	12.6
V_6	Himachal	--	--	--	--	15.5	10.5	11.1	10.0	11.8
V_7	Jorhat	8.8	8.7	5.8	7.7	--	--	--	--	--
V_8	Nadiya	9.2	8.8	7.9	8.6	--	--	--	--	--
V_9	Jamaica	11.1	10.0	8.4	9.8	--	--	--	--	--
V_{10}	Pottangi selection-667	8.9	7.9	6.8	7.9	--	--	--	--	--
V_{11}	Pottangi selection-17	13.4	13.2	11.1	12.5	--	--	--	--	--
V_{12}	Jugijan	11.8	8.7	8.1	9.5	--	--	--	--	--
V_{13}	Valluvanad	10.8	10.6	8.8	10.0	--	--	--	--	--
V_{14}	PGS-35	18.2	13.8	8.3	13.4	--	--	--	--	--
V_{15}	PGS-10	15.5	13.9	10.2	13.2	--	--	--	--	--
Mean		11.0	10.0	8.0		14.3	14.6	14.0	12.3	

DAP - Days after planting

Table 6. Effect of shade on number of leaves and net assimilation rate of ginger cultivars

Treatment	1988 Number of leaves 60DAP	120 DAP (1)	120 DAP (2)	180 DAP	1990 Net assimilation rate g m^{-2} day^{-1} 60-120DAP	120-180DAP
Levels of shade (per cent)						
T_1 (0)	29.5	142.5	--	--	--	1.88
T_2 (25)	24.7	115.1	114.4	80.0	2.76	2.05
T_3 (50)	22.7	90.0	88.8	74.2	2.52	2.58
T_4 (75)	22.1	74.8	74.0	62.4	3.06	2.26
SEm ±	1.45	5.8	6.56	4.9	0.44	0.19
C.D (0.05)	4.66	18.6	22.71	NS	0.99	0.43
Varieties						
V_1 Amballoor local	22.5	91.4	80.0	45.6	3.20	0.85
V_2 Nedumangad	25.7	113.0	100.5	69.4	3.35	2.21
V_3 Rio-de-jeneiro	20.2	--	81.8	79.5	2.98	1.70
V_4 Kuruppampadi	23.2	95.4	82.9	54.7	3.22	3.33
V_5 Maran	--	--	--	--	2.29	2.59
V_6 Himachal	--	--	--	--	3.65	2.46
V_7 Jorhat	23.6	96.8	87.9	48.1	--	--
V_8 Nadiya	24.8	100.9	93.7	60.2	--	--
V_9 Jamaica	28.3	108.3	100.0	68.6	--	--
V_{10} Pottangi selection 667	23.0	95.6	83.3	49.3	--	--
V_{11} Pottangi selection 17	30.0	130.9	120.4	103.6	--	--
V_{12} Jugijan	25.5	105.7	86.2	71.8	--	--
V_{13} Valluvanad	30.3	121.5	107.0	70.3	--	--
V_{14} PGS-35	22.8	103.6	85.0	106.4	--	--
V_{15} PGS-10	22.3	103.9	92.8	115.6	--	--
SEm ±	1.30	4.99	4.78	6.63	0.38	0.31
C.D. (0.05)	3.60	13.83	13.40	18.6	0.76	0.62

DAP - Days after planting

(1) Data analysed by deleting one sub plot (V_3)

(2) Data analysed by deleting one main plot (T_1)

Table 7. Interaction effect of shade levels and ginger cultivars on net assimilation rate

Varieties	1990									
	60-120 DAP					120-180 DAP				
	Shade levels (per cent)					Shade levels (per cent)				
	0	25	50	75	Mean	0	25	50	75	Mean
V_1 Amballoor local	2.8	4.1	2.2	3.7	3.2	1.0	0.8	1.8	1.8	0.9
V_2 Nedumangad	4.3	3.3	3.2	2.6	3.4	1.7	1.4	4.0	1.9	2.2
V_3 Rio-de-jeneiro	2.4	2.0	1.9	5.7	3.0	1.1	2.4	2.5	0.9	1.7
V_4 Kuruppampadi	6.4	2.1	2.9	1.6	3.2	2.0	2.5	4.9	3.9	3.3
V_5 Maran	3.7	2.3	1.0	1.3	2.3	4.8	2.6	0.8	2.2	2.6
V_6 Himachal	5.2	2.9	3.0	3.5	3.7	2.7	2.7	1.5	2.9	2.5
Mean	4.1	2.8	2.5	3.1		1.9	2.1	2.6	2.3	

DAP - Days after planting

60 DAP S.E of difference between two sub plot means at the same level of main plot = 0.76
C.D for the above at 5 per cent level = 1.52
S.E of difference between 2 main plot means at the same level of sub plot = 0.82
C.D for the above at 5 per cent level = 1.70

120 DAP S.E of difference between two sub plot means at the same level of main plot = 0.62
C.D for the above at 5 per cent level = 1.24
S.E of difference between two main plot means at the same level of sub plot = 0.60
C.D for the above at 5 per cent level = 1.21

4. Dry matter production (Tables 8 and 10)

During 1988, dry matter production was the highest at the low shade level of 25 per cent. The trend was one of increase in dry weight upto this level of shade followed by a progressive decrease with further increase in shade intensity, the lowest values being at the highest shade of 75 per cent. During 1990, on the contrary, there was increase upto 25 per cent shade and with further increase in shade level, dry weight remained statistically at par. It is to be noted that yield response to shade was also similar. Among the varieties, Valluvanad had the highest mean dry weight in 1988. During 1990, Himachal was the variety with the highest dry matter yield. The interaction between the shade levels and varieties was significant during 1990 and in most of the varieties, dry weight values were the lowest in the open, all the shade levels recording higher mean dry weight figures.

5. Net assimilation rate (Tables 6 and 7)

This observation was recorded only during 1990. The stages of observation were between 60 and 120 days after planting and between 120 and 180 days. The values showed a general increase with increasing shade levels. Between varieties, there were variations from 2.29 to 3.65 $g\ m^{-2}\ day^{-1}$ during the first stage and from 1.88 to 2.58 $g\ m^{-2}\ day^{-1}$ during the period from 120 to 180 days. The interactions were also significant at the two stages. Over the stages, the values tended to decrease with advancing age.

Table 8. Effect of shade on dry matter production and harvest index of ginger cultivars

Treatments	Total dry weight (g $plant^{-1}$) 1988 (1)	Total dry weight 1988 (2)	Total dry weight 1990	Harvest index 1988 (1)	Harvest index 1988 (2)	Harvest index 1990
Levels of shade (per cent)						
T_1 (0)	35.1	--	17.9	0.33	--	0.50
T_2 (25)	40.5	42.8	28.7	0.39	0.39	0.64
T_3 (50)	30.3	33.0	31.6	0.36	0.37	0.61
T_4 (75)	22.2	22.9	29.4	0.36	0.37	0.61
SEm ±	0.92	0.96	2.32	--	--	0.03
C.D. (0.05)	2.93	3.31	5.24	--	--	0.11
Varieties						
V_1 Amballoor local	28.7	28.6	25.9	0.43	0.47	0.54
V_2 Nedumangad	39.0	37.8	25.5	0.32	0.30	0.55
V_3 Rio-de-jeneiro	--	34.6	21.1	--	0.28	0.40
V_4 Kuruppampadi	34.9	33.4	27.1	0.48	0.50	0.68
V_5 Maran	--	--	26.6	--	--	0.63
V_6 Himachal	--	--	35.2	--	--	0.71
V_7 Jorhat	--	33.1	--	--	0.50	--
V_8 Nadiya	31.9	30.8	--	0.49	0.50	--
V_9 Jamaica	35.0	33.9	--	0.45	0.48	--
V_{10} Pottangi selection-667	31.3	30.1	--	0.40	0.40	--
V_{11} Pottangi selection-17	--	41.9	--	--	0.25	--
V_{12} Jugijan	29.8	28.4	--	0.29	0.31	--
V_{13} Valluvanad	---	39.2	--	--	0.47	--
V_{14} PGS-35	27.6	27.2	--	0.18	0.18	--
V_{15} PGS-10	30.0	28.9	--	0.25	0.25	--
SEm ±	2.00	2.63	--	--	--	0.03
C.D. (0.05)	5.58	7.40	--	--	--	0.07

(1) Data analysed by deleting sub plots (V_3, V_7, V_{11}, V_{13})

(2) Data analysed by deleting one main plot (T_1)

Table 9. Interaction effect of shade levels and ginger cultivars on harvest index

Varieties	1988								
	(1)					(2)			
	Shade levels (per cent)								
	0	25	50	75	Mean	25	50	75	Mean
V_1 Amballoor local	0.29	0.50	0.47	0.45	0.43	0.50	0.47	0.45	0.47
V_2 Nedumangad	0.39	0.33	0.27	0.28	0.32	0.33	0.27	0.28	0.30
V_3 Rio-de-jeneiro	--	--	--	--	--	0.30	0.24	0.31	0.28
V_4 Kuruppampadi	0.41	0.54	0.44	0.53	0.48	0.54	0.44	0.53	0.50
V_7 Jorhat	--	--	--	--	--	0.44	0.57	0.51	0.51
V_8 Nadiya	0.45	0.51	0.48	0.50	0.49	0.51	0.48	0.50	0.50
V_9 Jamaica	0.37	0.47	0.52	0.45	0.45	0.47	0.52	0.45	0.48
V_{10} Pottangi selection-667	0.40	0.44	0.42	0.34	0.40	0.44	0.42	0.34	0.40
V_{11} Pottangi selection-17	--	--	--	--	--	0.24	0.26	0.25	0.25
V_{12} Jugijan	0.23	0.29	0.36	0.28	0.29	0.29	0.36	0.28	0.31
V_{13} Valluvanad	--	--	--	--	--	0.48	0.48	0.46	0.47
V_{14} PGS-35	0.15	0.20	0.15	0.22	0.18	0.20	0.15	0.22	0.19
V_{15} PGS-10	0.24	0.29	0.19	0.29	0.25	0.29	0.19	0.29	0.25

Table 10. Interaction effect of shade levels and ginger cultivars on harvest index and total dry weight (1990)

Varieties	Harvest index					Total dry weight				
	Shade levels (per cent)									
	0	25	50	75	Mean	0	25	50	75	Mean
V_1 Amballoor local	0.50	0.56	0.54	0.57	0.54	16.8	26.6	33.5	26.8	25.9
V_2 Nedumangad	0.38	0.48	0.69	0.56	0.55	10.3	41.3	25.8	24.4	25.5
V_3 Rio-de-jeneiro	0.27	0.52	0.42	0.41	0.40	14.6	19.4	25.0	25.6	21.1
V_4 Kuruppampadi	0.65	0.66	0.69	0.74	0.68	25.1	23.7	30.4	29.0	27.1
V_5 Maran	0.59	0.71	0.54	0.67	0.63	12.7	29.1	40.1	24.1	26.6
V_6 Himachal	0.59	0.82	0.76	0.69	0.71	28.0	31.9	34.2	46.6	35.2
Mean	0.50	0.65	0.61	0.61		17.9	28.7	31.6	29.4	

Harvest index

SE of difference between 2 sub plot means at the same level of main plot = 0.07

CD for the above at 5 per cent level = 0.13

SE of difference between 2 main plot means at the same level of sub plot = 0.07

CD for the above at 5 per cent level = 0.14

Total dry weight

SE of difference between 2 sub plot means at the same level of main plot = 2.85

CD for the above at 5 per cent level = 5.71

SE of difference between two main plot means at the same level of sub plot = 3.49

CD for the above at 5 per cent level = 7.38

6. Chlorophyll content (Table 11)

Chlorophyll fractions a and b and total chlorophyll content estimated in leaves 150 days after planting showed a trend of increase with increasing levels of shade during 1988. The range in total chlorophyll content was from 0.63 mg g^{-1} fresh weight in the open to 1.43 at 75 per cent shade. In the case of ratio between the fractions of chlorophyll, there was no consistent trend with varying shade levels. Between varieties, there were some differences though these were relatively small.

7. Yield (Tables 12, 13 and 14, Fig. a and B)

In the case of yield of rhizome, there was a trend of increase in yield upto the low shade level of 25 per cent followed by a decrease with further increase in shade intensity during 1988. During 1990 when only six varieties were included and when the plot sizes were bigger, the trend was again one of increase in yield upto 25 per cent shade, this yield level being maintained at the higher shade levels also. Clearly, errors were to be larger during the first season as the plot sizes were small. Yet it is difficult to neglect the clear trend shown by most of the varieties. Apparently, a reason for the differences in responses is seasonal in nature. In as much as the yields are higher under shade than in the open, this crop will qualify itself to be classed as 'shade-loving'. Expressed as percentages of that in the open, the rhizome yields at 25, 50 and 75 per cent shade were 115, 68 and 48 respectively, during 1988

Table 11. Effect of shade on contents of chlorophyll fractions of ginger cultivars

Treatments	Chlorophyll a mg g^{-1} fresh weight	Chlorophyll b mg g^{-1} fresh weight	Chlorophyll a+b mg g^{-1} fresh weight	Chlorophyll a/b
	1988	1988	1988	1988
Levels of shade (per cent)				
T_1 (0)	0.42	0.21	0.63	2.00
T_2 (25)	0.80	0.54	1.34	1.48
T_3 (50)	0.87	0.56	1.43	1.55
T_4 (75)	0.93	0.56	1.43	1.66
Varieties				
V_1 Amballoor local	0.66	0.50	1.16	1.32
V_2 Nedumangad	0.78	0.56	1.34	1.39
V_3 Rio-de-jeneiro	0.98	0.56	1.54	1.75
V_4 Kuruppampadi	0.71	0.45	1.16	1.57
V_5 Maran	--	--	--	--
V_6 Himachal	--	--	--	--
V_7 Jorhat	0.67	0.40	1.07	1.67
V_8 Nadiya	0.80	0.49	1.29	1.63
V_9 Jamaica	0.82	0.42	1.24	1.95
V_{10} Pottangi selection-667	0.69	0.43	1.12	1.60
V_{11} Pottangi selection-17	0.81	0.42	1.23	1.92
V_{12} Jugijan	0.73	0.41	1.14	1.78
V_{13} Valluvanad	0.71	0.38	1.09	1.86
V_{14} PGS-35	0.74	0.44	1.18	1.68
V_{15} PGS-10	0.80	0.59	1.39	1.35

Data collected 150 days after planting

Table 12. Effect of shade on rhizome yield of ginger cultivars (t ha^{-1})

Treatments	Fresh weight basis				Dry weight basis			
	1988			1990	1988			1990
	(1)	(2)	(3)		(1)	(2)	(3)	
Levels of shade (Per cent)								
T_1 (0)	11.7	--	14.1	8.8	1.6	--	1.7	1.5
T_2 (25)	13.6	14.6	15.3	17.9	2.1	2.1	2.2	3.0
T_3 (50)	8.0	9.0	9.0	17.7	1.3	1.4	1.5	3.0
T_4 (75)	5.5	6.2	6.0	16.6	1.0	1.0	1.0	2.8
SEm ±	0.66	0.64	0.52	1.77	0.12	0.09	0.13	0.31
C.D (0.05)	2.1	2.21	1.80	5.50	0.39	0.31	0.45	0.70
Varieties								
V_1 Amballoor local	7.2	6.9	7.6	11.5	1.4	1.4	1.3	2.1
V_2 Nedumangad	10.8	9.1	11.4	15.3	1.6	1.4	1.7	2.4
V_3 Rio-de-jeneiro	--	8.6	--	11.4	--	1.0	--	1.4
V_4 Kuruppampadi	13.1	12.0	13.9	17.2	2.2	2.1	2.2	3.0
V_5 Maran	--	--	--	14.7	--	--	--	3.0
V_6 Himachal	--	--	--	21.6	--	--	--	4.0
V_7 Jorhat	--	13.1	14.6	--	--	2.2	2.1	--
V_8 Nadiya	12.5	11.7	12.6	--	1.9	2.0	1.9	--
V_9 Jamaica	15.5	13.8	16.1	--	2.1	2.1	2.2	--
V_{10} Pottangi selection-667	10.9	10.8	11.5	--	1.6	1.7	1.7	--
V_{11} Pottangi selection-17	--	10.0	10.5	--	--	1.2	1.1	--
V_{12} Jugijan	10.3	9.9	11.6	--	1.3	1.1	1.2	--
V_{13} Valluvanad	--	15.9	17.4	--	--	2.5	2.6	--
V_{14} PGS-35	2.8	2.9	3.1	--	0.6	0.6	0.7	--
V_{15} PGS-10	4.0	4.0	4.4	--	0.5	0.5	0.6	--
SEm ±	0.63	0.68	0.75	--	0.12	0.12	0.13	--
C.D (0.05)	1.77	1.90	2.12	--	0.34	0.34	0.37	--

(1) Data analysed by deleting sub plots (V_3, V_7, V_{11}, V_{13})

(2) Data analysed by deleting one main plot (T_1)

(3) Data analysed by deleting one replication (R_1) and one sub plot (V_3)

Table 13. Interaction effect of shade levels and ginger cultivars on rhizome yield (t ha^{-1})

Varieties	1988													
	(1)					(2)				(3)				
	Shade levels (per cent)													
	0	25	50	75	Mean	25	50	75	Mean	0	25	50	75	Mean
V_1 Amballoor local	8.1	10.4	6.1	4.3	7.2	10.4	6.1	4.3	6.9	7.9	10.7	10.3	4.5	7.6
V_2 Nedumangad	16.1	13.9	7.6	5.8	10.8	13.9	7.6	5.8	9.1	17.4	14.6	7.6	5.9	11.4
V_3 Rio-de-janeiro	--	--	--	--	--	13.0	8.0	4.9	8.6	--	--	--	--	--
V_4 Kuruppampadi	16.5	16.1	10.5	9.3	13.1	16.1	10.5	9.3	12.0	19.3	16.5	10.4	9.4	13.9
V_7 Jorhat	--	--	--	--	--	18.2	13.6	7.4	13.1	18.5	18.0	14.9	7.2	14.6
V_8 Nadiya	14.8	16.4	10.6	8.1	12.5	16.4	10.6	8.1	11.7	15.2	17.0	11.8	6.6	12.6
V_9 Jamaica	20.6	19.3	13.2	9.0	15.5	19.3	13.2	9.0	13.8	22.8	19.0	13.6	8.9	16.1
V_{10} Pottangi selection-667	11.4	18.4	8.2	5.7	10.9	18.4	8.2	5.7	10.8	11.8	19.9	8.5	6.0	11.5
V_{11} Pottangi selection-17	--	--	--	--	--	14.9	9.3	6.0	10.0	12.9	14.4	9.5	5.2	10.5
V_{12} Jugijan	11.3	16.5	9.4	3.8	10.3	16.5	9.4	3.8	9.9	13.7	17.3	10.6	4.6	11.6
V_{13} Valluvanad	--	--	--	--	--	21.3	14.4	12.1	15.9	21.7	23.2	14.3	10.6	17.4
V_{14} PGS-35	2.6	5.0	2.9	0.95	2.8	5.0	2.9	0.95	2.9	2.9	5.2	3.1	1.2	3.1
V_{15} PGS-10	4.5	6.0	3.0	2.8	4.1	6.0	3.0	2.8	4.0	4.6	7.4	3.6	2.2	4.4
Mean	11.7	13.6	8.0	5.5	--	14.6	9.0	6.2	--	14.1	15.3	9.6	6.0	--

SEm ± 1.78 — SEm ± 1.7 — SEm ± 2.13

C.D (0.05) — C.D (0.05) 3.3 — C.D (0.05) 4.24

(1) Data analysed by deleting 3 sub plots (V_3, V_7 and V_{11})

(2) Data analysed by deleting one main plot (T_1)

(3) Data analysed by deleting one replication (R_1) and one sub plot (V_3)

Table 14. Interaction effect of shade levels and ginger cultivars on rhizome yield (t ha^{-1})

Varieties	1990									
	Fresh weight basis					Dry weight basis				
	Shade levels (per cent)									
	0	25	50	75	Mean	0	25	50	75	Mean
V_1 Amballoor local	7.14	12.34	14.56	12.07	11.53	1.37	2.41	2.87	1.92	2.14
V_2 Nedumangad	4.09	25.06	18.08	14.06	15.32	0.62	3.84	2.80	2.21	2.37
V_3 Rio-de-jeneiro	4.98	13.40	13.50	13.50	11.35	0.59	1.63	1.66	1.69	1.39
V_4 Kuruppampadi	15.53	14.88	19.18	19.01	17.16	2.66	2.58	3.38	3.43	3.01
V_5 Maran	6.72	18.62	19.01	14.26	14.65	1.19	3.33	3.42	2.61	2.64
V_6 Himachal	14.57	22.91	22.13	26.62	21.56	2.62	4.19	4.11	5.06	4.00
Mean	8.84	17.87	17.74	16.6		1.51	2.99	3.04	2.82	

Fresh weight basis

SE of difference between two sub plot means at the same level of main plot = 2.08

C.D for the above at 5 per cent level = 4.16

SE of the difference between two main plot means at the same level of sub plot = 2.59

CD for the above at 5 per cent level = 5.5

Dry weight basis

SE of difference between two sub plot means at the same level of main plot = 0.35

CD for the above at 5 per cent level = 0.71

SE of difference between two main plot means at the same level of sub plot = 0.45

CD for the above at 5 per cent level = 0.96

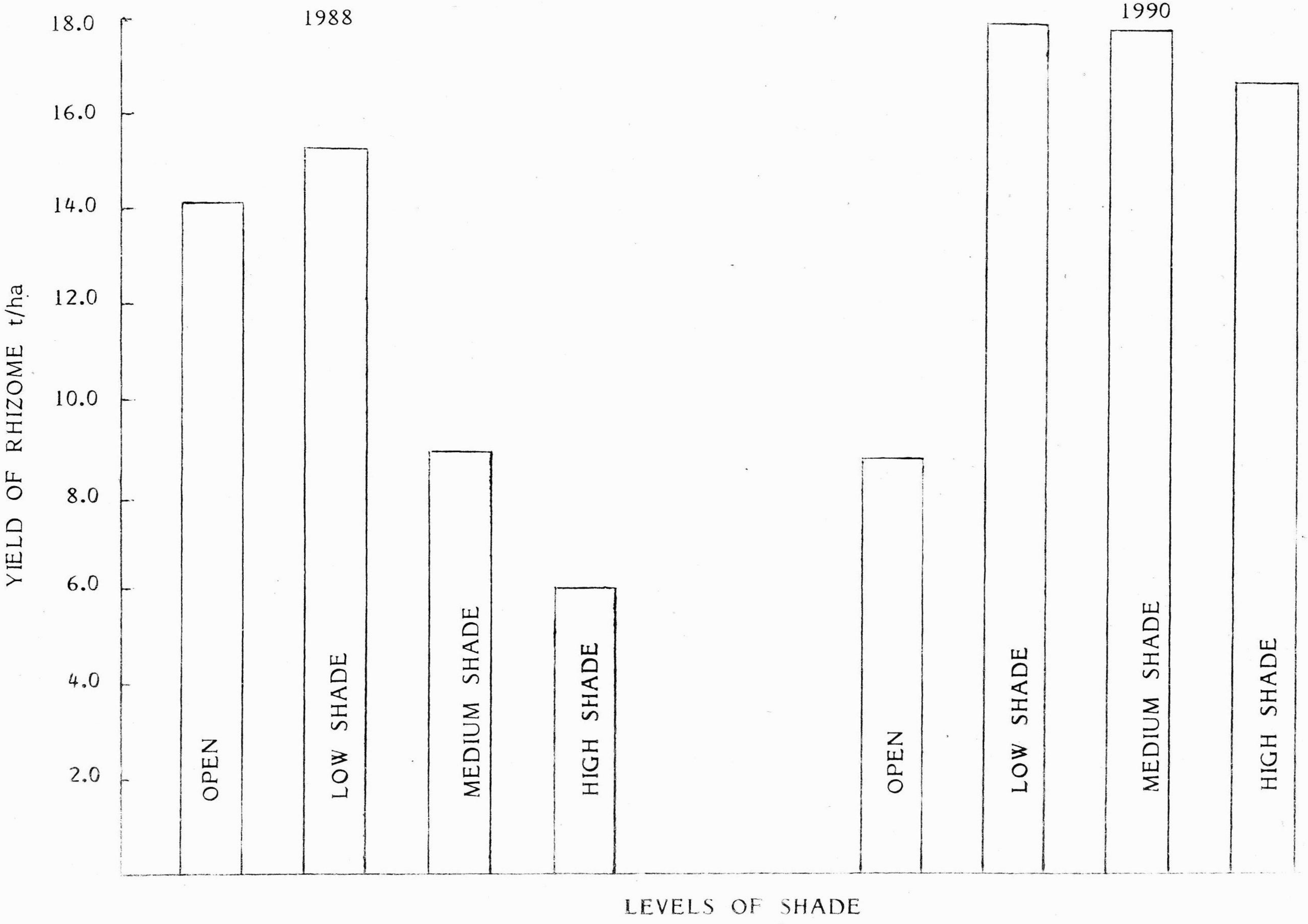


Fig.a EFFECT OF SHADE ON THE YIELD OF GINGER

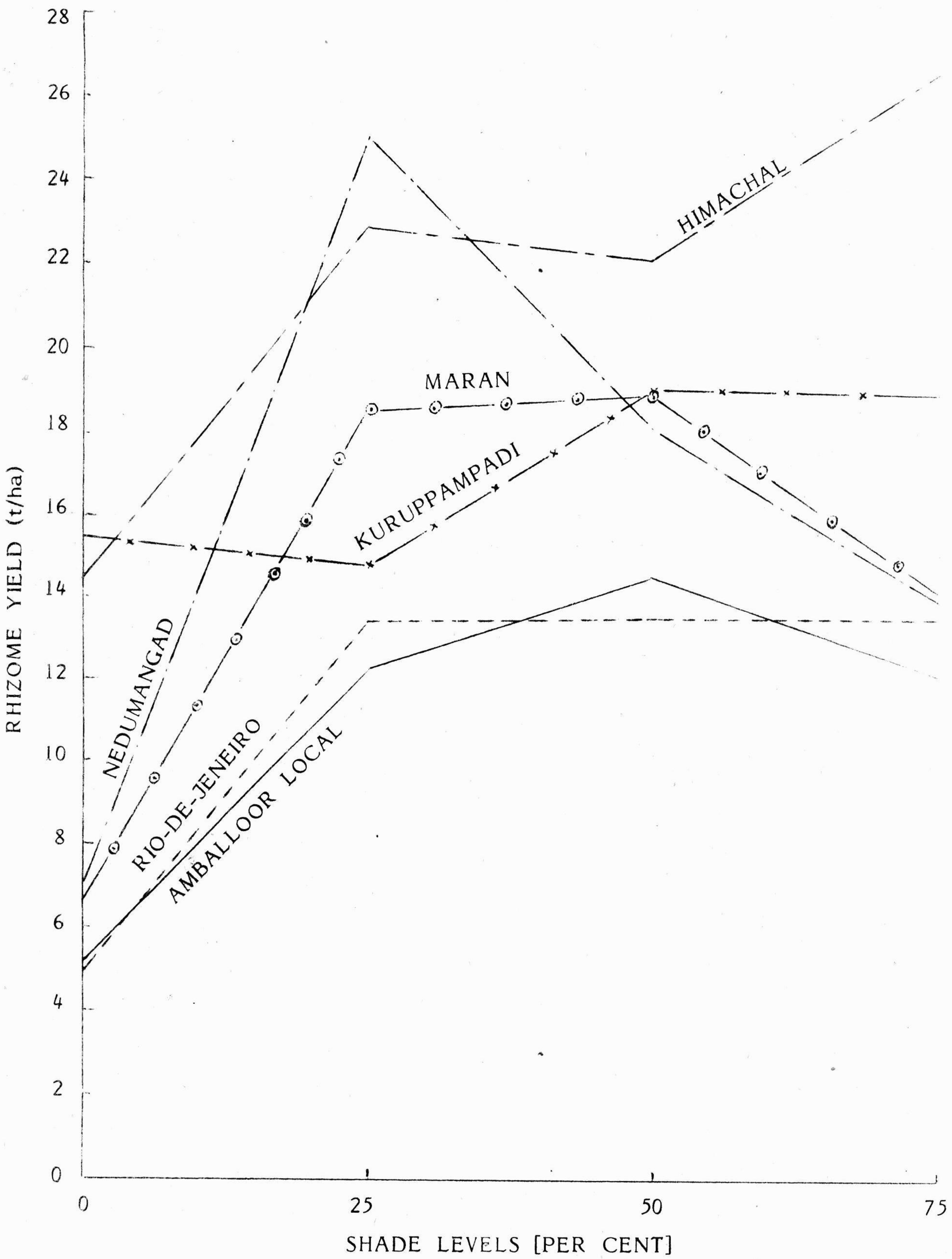


Fig.b EFFECT OF SHADE ON THE YIELD OF GINGER VARIETIES (1990)

on fresh weight basis when analysed by deleting a few sub plots. The corresponding figures for 1990 were 203, 201 and 189. The trends remained the same in the case of yield on dry weight basis also.

Among the varieties, the highest yielding variety was Valluvanad during 1988. This variety, however, could not be included in the trial during 1990. Among the varieties tested during 1990, Himachal was the best followed by Kuruppampadi. The best variety of 1990, Himachal was, however, not included during 1988 thus making strict comparison and selection of varieties difficult.

The interaction effects were significant during 1988 and '90. During 1988, nearly all the varieties showed a trend of increase upto 25 per cent shade followed by a decrease at higher shade levels. During 1990, on the contrary, there was substantial yield increase upto the low level of shade in five out of six varieties. The trend beyond this was one of statistical parity in all these five varieties excepting Nedumangad which showed a significant yield decline beyond 25 per cent shade. The variety which registered no increase in yield by shading was Kuruppampadi which gave statistically comparable yield figures at all shade levels including the open. The highest yielding variety in the open during 1988 was Jamaica, Valluvanad giving the second highest yield. At 25 and 75 per cent shade, it was Valluvanad that recorded the highest yield. This variety also yielded high at 50 per cent and was very close to the highest yielding variety, viz. Jorhat. Based on these results, the variety, Valluvanad may be indicated as generally the best for all shade situations. During 1990, the highest yielder was Kuruppampadi in the open, Nedumangad at the low shade and Himachal at the other two shade levels. If one variety among the six tested during 1990 is to be selected as generally the best for all the shade situations, it will be Himachal.

Data on yield on dry weight basis also showed nearly an identical trend as fresh weight.

8. Harvest index (Tables 8, 9 and 10)

The pattern of variation in harvest index was nearly the same as that of yield in the case of shade levels during both the seasons and in the case of varieties during 1990. During 1988, there was, thus, increase upto 25 per cent shade followed by a decline beyond that level of shade. During 1990, the trend was one of increase upto the low level followed by a near stability beyond this level. Such a close relation with final yield was not apparent in the case of mean harvest index of varieties during 1988 when the varieties Nadiya, Kuruppampadi and Jamaica gave relatively high values. In 1990, the variety with the highest value was Himachal which was also the highest yielder. The interaction was significant during both the seasons. A comparison between the values of the two seasons would indicate that these were substantially higher during 1990.

It is to be noted that the yields also were higher during this season. While better growth of the plant and higher total dry matter production were definitely important factors responsible for the higher yield of the second season, higher translocation of carbohydrates as is indicated by higher harvest index must also be recognised as important.

9. Oleoresin content (Table 15)

This estimation was done only during 1988. Content of oleoresin was more in the open and shading tended to decrease the content in rhizome though only slightly. There were quite some differences between varieties and some of the varieties which were superior in terms of quality were Rio-de-jeneiro, Jugijan and Pottangi selection 17.

10. Uptake of nutrients (Table 15)

Estimations of the uptake of the fertiliser nutrients N, P and K were made at harvest during 1988. The values followed nearly the same trend as that of rhizome yield in the case of mean values of shade levels and varieties. The only exception was in the case of phosphorus whose uptake values steadily decreased with increasing levels of shade, the highest values being in the open even though the yield increased upto 25 per cent shade.

II Trial under natural shade

This trial was taken up only during the last season and the objective was to confirm the results on varietal performance under natural shade of coconut. The

Table 15. Effect of shade on uptake of nutrients and oleoresin content of ginger cultivars

Treatment	1988			
	Nutrient uptake (Kg ha^{-1})			Oleoresin
	N	P	K	(%)
Levels of shade (per cent)				
T_1 (0)	90.8	25.3	277.5	8.82
T_2 (25)	99.1	18.7	329.7	7.95
T_3 (50)	68.8	11.7	264.1	6.49
T_4 (75)	46.6	6.7	183.0	7.06
Varieties				
V_1 Amballoor local	50.3	12.3	173.2	5.94
V_2 Nedumangad	84.8	17.4	246.1	7.48
V_3 Rio-de-jeneiro	82.2	14.7	250.8	9.23
V_4 Kuruppampadi	79.0	18.2	291.1	6.38
V_5 Maran	--	--	--	--
V_6 Himachal	--	--	--	--
V_7 Jorhat	64.4	10.5	236.7	5.82
V_8 Nadiya	60.4	16.2	261.0	5.62
V_9 Jamaica	84.4	15.4	278.0	5.88
V_{10} Pottangi selection-667	72.5	13.1	236.4	7.26
V_{11} Pottangi selection-17	105.5	20.4	372.8	8.76
V_{12} Jugijan	65.8	13.1	236.8	9.36
V_{13} Valluvanad	111.8	17.1	308.9	5.96
V_{14} PGS-35	58.8	16.0	278.3	11.92
V_{15} PGS-10	72.2	18.5	256.3	9.69

coconut palms were about 10 years old and an area of 6.5mx 6.5m around each coconut palm excluding the basin area of 2.5 m radius constituted the plot size. All the six varieties included in the experiment of the final year under artificial shade were included in this trial also. Measurements of the light intensity below the coconut canopy indicated it to be about 50 per cent. This experimental crop could be planted only about a month after the crop under artificial shade was planted. Also, only five out of the six varieties included in the trial under artificial shade could be included in this.

Data collected included growth characters like plant height, number of tillers, net assimilation rate, total dry weight and yield of rhizome and yield components. Uptake of nutrients N, P and K and assessment of quality parameters were also included (Tables 16, 17 and 18). An overall assessment of these data would indicate that the varietal differences in most of the characters including rhizome yield were not significant. A comparison with the data of the crop under artificial shade during the same season would also show that in plant height, harvest index and oleoresin content, the values were comparable. In net assimilation rate the values under natural shade were less and in tiller number, total dry weight, rhizome yield and nutrient uptake, substantially less. Clearly, the performance of the crop was much better under artificial shade. The only two possible reasons for this are the delay in

Table 16. Plant height, number of tillers and net assimilation rate of ginger varieties under natural shade

Varieties	Plant height (cm)			No. of tillers			NAR	
	60DAP	120DAP	180DAP	60DAP	120DAP	180DAP	60-120 DAP	120-180 DAP
V_1 Amballoor local	41.8	59.9	74.9	0.5	4.2	6.9	0.4	3.4
V_2 Nedumangad	45.8	65.8	83.7	0.4	3.5	7.3	1.5	1.8
V_4 Kuruppampadi	44.8	68.7	80.8	0.3	3.0	8.0	4.2	1.0
V_5 Maran	42.8	55.5	79.4	1.4	5.4	9.7	3.4	1.2
V_6 Himachal	44.9	58.2	72.1	0.9	5.5	7.4	3.5	1.6
SEm ±	4.9	3.5	4.4	0.3	1.0	1.1	0.6	0.1
C.D (0.05)	NS	7.6	NS	0.7	NS	NS	0.1	0.2

DAP - Days after planting

Table 17. Haulm yield, rhizome yield, harvest index, percentage dryage and total dry matter production of ginger varieties under natural shade

Varieties	Haulm yield (t ha^{-1})	Rhizome yield (t ha^{-1})	Harvest index	Percentage dryage	Total dry weight (g $plant^{-1}$)
V_1 Amballoor local	0.97	5.20	0.52	19.8	12.5
V_2 Nedumangad	1.36	3.51	0.29	15.6	11.9
V_4 Kuruppampadi	1.11	3.84	0.39	17.7	11.2
V_5 Maran	3.42	3.42	0.36	18.1	10.9
V_6 Himachal	1.05	3.47	0.36	18.8	10.6
SEm ±	0.21	1.07	0.08	0.10	2.0
C.D (0.05)	NS	NS	NS	0.2	NS

Table 18. Uptake of nutrients, oleoresin content and oil content of ginger varieties under natural shade

Varieties	Total uptake (kg ha^{-1}) N	P	K	Oleoresin (per cent)	Oil (per cent)
V_1 Amballoor local	40.9	10.1	37.8	8.6	3.0
V_2 Nedumangad	15.6	10.0	34.3	6.3	3.5
V_4 Kuruppampadi	28.7	9.2	26.8	7.2	3.0
V_5 Maran	16.2	8.6	40.9	7.0	--
V_6 Himachal	22.9	8.5	30.9	6.0	2.5
SEm ±	2.8	1.4	3.2	--	--
C.D (0.05)	6.1	NS	7.0	--	--

planting of the experimental crop under natural shade and the soil differences. The site of the trial under artificial shade was under undisturbed natural vegetation immediately before whereas the area for the trial under natural shade was cleared much earlier and brought under coconut. A variety of crops were also raised in the interspaces.

The general lack of significant differences between varieties under natural shade alone is perhaps due to the above two restrictions on the growth of the crop.

B. TURMERIC

I Trials under artificial shade

A total of 12 varieties were included in the case of turmeric for the initial screening trial during 1988 and only 10 when this trial was repeated during 1989. The two varieties which could not be included during the second year were Myduckur and Armoor. Again, out of the 10 varieties included during the second year, five could not be planted in two out of four replications for want of adequate seed material. These five varieties were PCT-2, PTS-10, DTS-24, Co-1 and PTS-38. The data of this season were analysed by two methods, viz; one by deleting the missing subplots and another by deleting the two replications having missing subplots. Based on the results of these two seasons, six varieties were selected as superior for different shade levels to be carried forward for further testing in larger plots. These six varieties were PCT-5, PTS-9, BSR-1, Ethamukulam, PCT-8 and PTS-38. The results of the three seasons are given below and discussed.

1. Plant height (Table 19)

During 1988, height of plants increased with increasing levels of shade upto 50 per cent after which it tended to decrease. Among the varieties, BSR-1 and Co-1 recorded higher height values at later stages eventhough the values were higher for other varieties at the earlier stages. Variety x shade interaction was significant at 120 and 180 days. Data on these appear in the First Annual Report and are not reproduced here. During 1989, the trend was again one of increasing height with

Table 19. Effect of shade on plant height (cm) of turmeric varieties

Treatments	1988			1989						1990		
	60 DAP	120 DAP	180 DAP	60 DAP		120 DAP		180 DAP		60 DAP	120 DAP	180 DAP
				(1)	(2)	(1)	(2)	(1)	(2)			
Shade levels (per cent)												
T_1 (0)	60.4	93.8	91.7	39.5	32.3	74.0	65.4	93.9	88.3	46.1	86.0	93.5
T_2 (25)	74.2	117.0	113.9	45.6	42.8	86.3	83.1	98.9	101.2	52.8	99.8	105.6
T_3 (50)	74.5	116.6	115.0	49.3	44.5	89.2	93.2	101.2	112.4	52.8	107.8	114.3
T_4 (75)	71.2	98.0	95.6	56.3	54.8	98.9	107.4	109.8	123.1	55.1	102.3	113.5
SEm ±	2.78	2.68	3.00	3.7	5.0	6.1	9.5	7.9	10.8	3.0	3.8	4.3
CD (0.05)	8.89	8.56	9.63	8.5	NS	13.7	NS	NS	NS	NS	NS	NS
Varieties												
V_1 Myduckur	76.4	109.7	106.2	--	--	--	--	--	--	--	--	--
V_2 Armoor	72.1	97.6	93.5	--	--	--	--	--	--	--	--	--
V_3 PCT-2	71.7	106.9	104.6	--	38.8	--	81.9	--	103.6	--	--	--
V_4 PTS-9	65.2	105.3	106.9	39.5	41.0	80.3	83.1	105.1	105.9	52.0	98.7	106.5

Contd.

Table 19 (Contd.)

Treatments	1988			1989						1990		
	60 DAP	120 DAP	180 DAP	60 DAP		120 DAP		180 DAP		60 DAP	120 DAP	180 DAP
				(1)	(2)	(1)	(2)	(1)	(2)			
V_5 Ethamu-kulam	67.8	108.0	107.3	47.7	46.1	88.5	90.8	108.8	107.6	54.3	99.8	104.6
V_6 PCT-8	65.7	88.3	81.8	45.5	48.6	84.7	89.4	86.1	90.3	51.6	102.5	107.6
V_7 PTS-10	66.9	107.2	107.7	--	44.5	--	104.5	--	126.9	--	--	--
V_8 PTS-24	68.9	110.3	108.4	--	37.8	--	79.3	--	108.1	--	--	--
V_9 PCT-5	77.0	101.4	94.0	55.2	55.8	92.9	90.2	91.8	88.9	55.6	101.7	109.7
V_{10} Co 1	71.8	115.2	112.8	--	37.6	--	74.7	--	105.4	--	--	--
V_{11} BSR-1	71.2	116.8	118.1	47.2	48.7	89.8	93.5	112.9	109.8	51.0	97.4	106.8
V_{12} PTS-38	66.5	109.6	105.5	--	37.3	--	85.3	--	115.9	51.3	93.7	105.3
SEm $\pm$	2.16	2.55	2.59	3.0	3.6	4.7	7.3	4.3	4.3	1.9	2.1	3.4
CD (0.05)	6.00	7.08	7.19	6.0	7.3	9.5	14.8	8.6	13.1	NS	NS	NS

DAP - Days after planting

(1) Data analysed by deleting five subplots (V_3, V_7, V_8, V_{10} and V_{12})

(2) Data analysed by deleting two replications

increasing shade levels. The treatment differences were, however, statistically significant only at two stages and that too when analysed deleting five subplots. Varietal differences were significant eventhough varieties that recorded higher height were different at the three stages. Interaction was not significant. During 1990 when only six varieties were used, neither shade effects nor varietal effects assumed statistical significance. Mean values were, however, higher under the shaded situations. Interaction between these two factors also was not significant.

An overall assessment of the results should indicate that there were indications of the plants being taller under shade at least upto the intermediate shade level of 50 per cent. This shade effect was not conspicuous enough to attain consistent statistical significance.

2. Number of tillers (Table 20)

The general trend of variation in tiller number with increase in shade level was one of decrease during 1988 and '89. During the second year, however, differences were significant only when the number of replications was taken as four after deleting five subplots. There was no such consistent trend noticed during 1990 and the differences were not statistically significant. Varietal differences were significant during the first two years of initial screening, varieties, Ethamukulam, Co-1 and BSR-1 being three of the most profusely tillering. During 1990 also, Ethamukulam and BSR-1 recorded generally higher values, but the varietal differences were not

Table 20. Effect of shade on number of tillers of turmeric varieties

Treatment	1988			1989				1990		
	60 DAP	120 DAP	180 DAP	120 DAP		180 DAP		60 DAP	120 DAP	180 DAP
				(1)	(2)	(1)	(2)			
Shade levels (per cent)										
T_1 (0)	1.6	3.8	3.3	1.9	1.5	3.2	3.0	1.7	2.7	2.8
T_2 (25)	1.2	1.7	1.7	1.2	1.0	2.2	2.3	1.4	1.9	1.9
T_3 (50)	1.3	1.6	1.5	1.2	1.3	2.3	2.3	1.6	2.7	2.8
T_4 (75)	1.2	1.3	1.4	1.2	0.7	2.0	1.9	1.5	2.3	2.4
SEm ±	0.08	0.12	0.12	0.2	0.2	0.2	0.3	0.1	0.3	1.1
CD (0.05)	0.26	0.40	0.39	0.4	NS	0.6	NS	NS	NS	NS
Varieties										
V_1 Myduckur	1.3	1.7	1.6	--	--	--	--	--	--	--
V_2 Armoor	1.2	1.9	1.9	--	--	--	--	--	--	--
V_3 PCT-2	1.5	2.4	2.4	--	0.8	--	2.8	--	--	--
V_4 PTS-9	1.3	1.9	1.9	1.1	1.3	2.2	2.2	1.6	2.0	2.4

Contd.

Table 20 (Contd.)

Treatment	1988			1989				1990		
	60 DAP	120 DAP	180 DAP	120 DAP (1)	120 DAP (2)	180 DAP (1)	180 DAP (2)	60 DAP	120 DAP	180 DAP
V_5 Ethamukulam	1.5	2.6	2.3	2.2	1.8	3.5	3.4	1.5	2.0	2.5
V_6 PCT-8	1.5	1.9	1.6	0.8	0.6	1.6	1.0	1.7	2.6	2.6
V_7 PTS-10	1.2	2.4	2.3	--	1.0	--	2.3	--	--	--
V_8 PTS-24	1.2	2.1	2.1	--	1.2	--	2.5	--	--	--
V_9 PCT-5	1.4	1.9	1.6	0.7	0.5	1.5	1.5	1.3	1.8	1.9
V_{10} Co 1	1.3	2.2	2.2	--	1.4	--	3.1	--	--	--
V_{11} BSR-1	1.2	2.1	2.1	2.0	1.7	3.2	2.9	1.6	2.7	2.8
V_{12} PTS-38	1.1	2.1	1.8	--	1.1	--	2.0	1.4	2.1	2.2
SEm ±	0.09	0.14	0.15	0.3	0.3	0.3	0.4	0.04	0.2	1.0
CD (0.05)	0.27	0.39	0.42	0.5	0.6	0.6	0.9	NS	NS	NS

DAP - Days after planting

(1) Data analysed by deleting five subplots (V_3, V_7, V_8, V_{10} and V_{12})

(2) Data analysed by deleting two replications

significant. Among the interaction effects, the only stage at which it was found significant was at 120 days during 1988. (Data on this are not presented).

Eventhough it is not very much conspicuous and not always statistically significant, it is to be reckoned that there is at least some depressing effect of shade on tillering in turmeric.

3. Number of leaves (Table 21)

This observation was recorded in 1988 and 1990 only. Barring the exception of 120 days after sowing both in 1988 and '90, there was no significant effect of shading. At this stage which was also the stage of highest number of leaves on the plant, there was a near steady decrease in leaf number with increasing levels of shade, the highest number being in the open. Between varieties, the differences were significant excepting at 60 and 180 days in 1990. Ethamukulam was the variety with the highest leaf number at nearly all the stages during both the seasons. This variety also retained a substantial number of leaves for a longer period as indicated by a relatively large leaf number at the last stage of observation 180 days after planting. Over the stages, there was increase upto 120 days followed by a decline afterwards. Comparing between the seasons, the values were generally comparable excepting at the last stage, 180 days after planting. The values were very much lower in 1988 presumably as a result of delayed planting and the consequent earlier occurrence of dry season.

4. Dry matter production (Table 22)

The trend of dry matter production with shading varied between seasons. During 1988 and '89, the highest mean values

Table 21. Effect of shade on leaf number of turmeric varieties

Treatments	1988			1990		
	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP	180 DAP
Shade levels (per cent)						
T_1 (0)	8.9	16.5	3.1	6.8	16.6	10.1
T_2 (25)	7.5	10.6	3.4	6.5	12.1	10.9
T_3 (50)	7.7	11.0	2.8	6.1	11.8	9.1
T_4 (75)	7.0	9.6	2.7	6.2	10.9	12.2
SEm ±	0.5	0.7	0.3	0.2	0.8	3.8
CD (0.05)	NS	2.3	NS	NS	2.3	NS
Varieties						
V_1 Myduckur	8.0	10.3	2.0	--	--	--
V_2 Armoor	6.8	9.2	3.1	--	--	--
V_3 PCT-2	8.6	13.3	3.6	--	--	--
V_4 PTS-9	7.9	11.7	2.8	6.3	12.6	9.0
V_5 Ethamukulam	9.3	15.2	3.4	6.6	15.7	11.9
V_6 PCT-8	8.6	10.9	0.2	6.4	10.5	9.2
V_7 PTS-10	7.4	12.2	3.5	--	--	--
V_8 PTS-24	7.2	12.1	0.0	--	--	--
V_9 PCT-5	8.2	11.1	0.0	6.4	10.6	9.0
V_{10} Co-1	6.9	13.0	0.0	--	--	--
V_{11} BSR-1	7.3	12.0	0.0	6.4	15.6	12.4
V_{12} PTS-38	7.1	11.4	3.6	6.2	12.2	11.4
SEm ±	0.4	0.6	0.4	0.1	0.7	4.7
CD (0.05)	1.1	1.6	1.0	NS	2.8	NS

DAP - Days after planting

Table 22. Effect of shade on dry matter production of turmeric varieties

Treatments	1988 Dry matter production (g plant^{-1})	1989 Dry matter production (g plant^{-1}) (1)	1989 Dry matter production (g plant^{-1}) (2)	1990 Dry matter production (g plant^{-1})
Shade levels (per cent)				
T_1 (0)	45.9	74.2	65.0	36.6
T_2 (25)	34.3	60.4	54.3	39.5
T_3 (50)	28.8	52.6	51.0	43.5
T_4 (75)	20.8	55.2	51.6	41.6
SEm ±	1.84	8.1	13.0	2.0
CD (0.05)	2.24	NS	NS	NS
Varieties				
V_1 (Myduckur)	27.6	--	--	--
V_2 (Armoor)	26.4	--	--	--
V_3 (PCT-2)	35.4	--	44.7	--
V_4 (PTS-9)	32.6	59.0	61.6	40.4
V_5 (Ethamukulam)	35.0	59.6	57.2	39.4
V_6 PCT-8	27.6	51.9	51.6	44.4
V_7 PTS-10	32.0	--	48.4	--
V_8 PTS-24	34.9	--	44.2	--
V_9 PCT-5	38.2	68.2	59.1	37.8
V_{10} Co-1	32.1	--	44.2	--
V_{11} BSR-1	37.1	64.3	57.5	39.0
V_{12} PTS-38	30.6	--	48.1	42.6
SEm ±	2.24	3.5	2.01	1.8
CD (0.05)	6.23	7.0	4.1	NS

(1) Data analysed by deleting five subplots (V_3, V_7, V_8, V_{10} and V_{12})

(2) Data analysed by deleting two replications

were noted in the open, there being a progressive decrease with increasing shade levels. The differences were significant during 1988 but not in 1989. During 1990 neither the trend nor statistical significance was noted. Between varieties, there were significant differences during the first two seasons when the values were generally higher for the higher yielding varieties. The interaction was significant only during 1989 (Data not presented).

Eventhough there are seasonal differences, a clear indication is that turmeric has the ability to grow under shade. Its growth under shade is to be reckoned as comparable to the shade-free, open condition if not better. There are varietal differences also but these are either not consistent or are being masked by high error variation.

5. Chlorophyll content of leaves (Table 23)

There was a very consistent and conspicuous trend of increase in contents of chlorophyll fractions, a and b and of total chlorophyll with increasing shade levels. During all the three seasons, this effect was noticed. In the case of varietal variations, on the contrary, the differences in percentages were not very high and even in exceptional cases where these were, the effects did not persist over the seasons. The consistent trend of increase in chlorophyll content with increasing shade levels was reported in several other crops and it is often attributed to faster photodestruction of this pigment at higher levels of illumination. The higher leaf content of chlorophyll was also apparent in the visual appearance of the crop and it looked distinctly darker green under shade than in the open.

Table 23. Effect of shade on chlorophyll content of turmeric leaves at 150 DAP

Treatment	1988				1989				1990*			
	Chlorophyll (mg g^{-1} fresh tissue)											
	a	b	a+b	a/b	a	b	a+b	a/b	a	b	a+b	a/b
Shade levels (Per cent)												
T_1 (0)	0.38	0.26	0.64	1.46	0.77	0.54	1.31	1.43	0.47	0.36	0.82	1.25
T_2 (25)	0.71	0.45	1.17	1.57	0.85	0.64	1.49	1.33	0.73	0.58	1.30	1.31
T_3 (50)	0.87	0.54	1.42	1.61	1.14	0.82	1.96	1.39	0.93	0.77	1.69	1.18
T_4 (75)	1.12	0.60	1.72	1.86	1.28	0.97	2.25	1.32	1.10	0.81	1.88	1.31
Varieties												
V_1 Myduckur	0.74	0.60	1.24	1.49	--	--	--	--	--	--	--	--
V_2 Armoor	0.77	0.52	1.29	1.44	--	--	--	--	--	--	--	--
V_3 PCT-2	0.90	0.50	1.40	1.82	1.05	0.75	1.80	1.40	--	--	--	--
V_4 PTS-9	0.82	0.49	1.31	1.59	1.08	0.78	1.86	1.38	--	--	--	--
V_5 Ethamukulam	0.74	0.36	1.10	1.97	0.99	0.75	1.74	1.32	0.78	0.62	1.40	1.23
V_6 PCT-8	0.92	0.63	1.55	1.42	0.98	0.71	1.69	1.38	0.80	0.63	1.43	1.30
V_7 PTS-10	0.83	0.46	1.29	1.83	0.89	0.66	1.55	1.35	0.81	0.66	1.47	1.30
V_8 PTS-24	0.81	0.40	1.21	2.01	1.05	0.78	1.83	1.35	--	--	--	--
V_9 PCT-5	0.83	0.43	1.26	1.90	1.05	0.74	1.79	1.42	--	--	--	--
V_{10} Co -1	0.64	0.48	1.12	1.54	1.02	0.72	1.74	1.42	0.78	0.62	1.34	1.24
V_{11} BSR-1	0.54	0.35	0.90	1.53	1.15	0.82	1.97	1.40	--	--	--	--
V_{12} PTS-38	0.73	0.42	1.15	1.68	0.99	0.72	1.71	1.38	0.81	0.64	1.45	1.25
									0.79	0.62	1.41	1.26

* Data of 1990 relate to [illegible] days after planting.

6. Leaf area index and net assimilation rate (Table 24)

These observations were recorded only during 1990 when sufficient number of plants were available for destructive sampling. The data collected showed lack of significant differences between shade levels and varieties. Over the stages, there was a substantial increase in leaf area index from around 1.0 at 60 days to about 3.0 at 120 days and 8.0 at 180 days after planting. In net assimilation rate, the change over the stages was not substantial.

7. Yield (Table 25, Fig.c)

The rhizome yield data followed slightly different patterns during the three seasons. While the pattern of the first two seasons was one of decrease with increasing shade level, it was one of parity at all shade levels during the third year. On dry weight basis, there was even increase in yield with increasing shade levels during this third season. It is difficult to explain these differences as there were no major climatic variants between three seasons. Neither were there attributable factors other than climate. The only conclusion that can be drawn from the results is that turmeric can come up well under shade at least upto the intermediate level of about 50 per cent and give reasonable yields. It is also to be noted that many growth characters showed similarity in variation with yield. During the first two seasons when yield declined with shade, tiller number, leaf number and dry matter production also showed a similar trend. During 1990,

Table 24. Effect of shade on leaf area index and net assimilation rate of turmeric varieties

Treatments	Leaf area index			Net assimilation rate	
	60 DAP	120 DAP	180 DAP	60-120 DAP	120-180 DAP
Shade levels (per cent)					
T_1 (0)	0.92	2.94	8.42	1.47	2.53
T_2 (25)	1.23	3.70	8.12	1.65	2.28
T_3 (50)	1.22	3.40	7.38	2.00	2.04
T_4 (75)	1.07	2.80	7.07	2.09	2.44
SEm ±	0.14	0.27	0.51	0.19	0.16
CD (0.05)	NS	NS	NS	NS	NS
Varieties					
V_1 PCT-5	1.20	2.95	7.80	1.61	2.14
V_2 PTS -9	1,31	3.34	7.95	1.73	2.05
V_3 BSR-1	1.05	3.18	8.26	1.60	2.60
V_4 Ethamukulam	0.91	3.30	7.28	2.05	2.29
V_5 PCT-8	1.18	3.40	7.30	1.83	2.91
V_6 PTS-38	1.05	3.02	7.82	1.96	1.99
SEm ±	0.14	0.27	0.52	0.19	0.18
CD (0.05)	NS	NS	NS	NS	NS

DAP - Days after planting

Table 25. Effect of shade on rhizome yield of turmeric varieties

Treatments	1988 Rhizome yield (t ha^{-1}) Fresh wt basis	1988 Rhizome yield (t ha^{-1}) Dry wt basis	1989 Rhizome yield (t ha^{-1}) Fresh wt basis(1)	1989 Rhizome yield (t ha^{-1}) Fresh wt basis (2)	1990 Rhizome yield (t ha^{-1}) Fresh wt basis	1990 Rhizome yield (t ha^{-1}) Dry wt basis
Shade levels (per cent)						
T_1 (0)	19.3	3.3			21.0	3.2
T_2 (25)	14.2	2.6			21.8	4.1
T_3 (50)	10.7	2.1			25.7	4.9
T_4 (75)	5.8	1.2			20.7	5.1
SEm ±	0.9	0.1			1.5	0.2
CD (0.05)	2.8	0.4			NS	0.7
Varieties						
V_1 Myduckur	12.2	2.2			--	--
V_2 Armoor	9.0	1.6			--	--
V_3 PCT-2	13.4	2.8			--	--
V_4 PTS-9	13.0	2.2			22.4	4.3
V_5 Ethamukulam	13.1	2.6			21.9	4.3
V_6 PCT-8	11.5	2.7			24.8	5.3
V_7 PTS-10	11.7	1.9			--	--
V_8 PTS-24	12.7	2.0			--	--
V_9 PCT-5	15.9	3.5			21.9	4.0
V_{10} Co-1	13.4	2.1			--	--
V_{11} BSR-1	13.5	2.1			22.0	4.2
V_{12} PTS-38	10.7	1.7			20.7	4.0
SEm ±	1.1	0.2			1.4	0.3
CD (0.05)	3.1	0.6			NS	0.7

(1) Data analysed by deleting five subplots (V_3, V_7, V_8, V_{10} & V_{12})

(2) Data analysed by deleting two replications

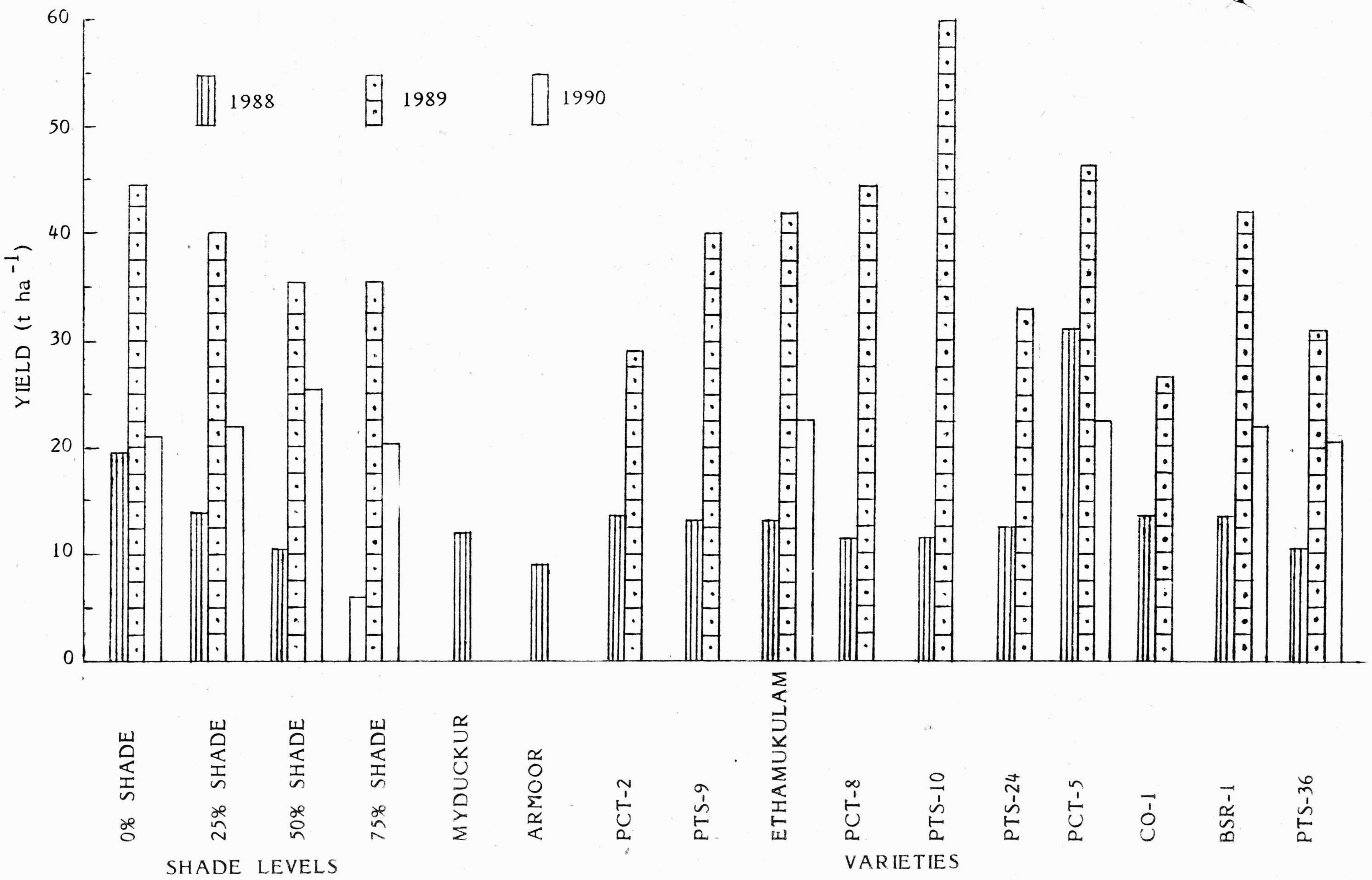


Fig.c EFFECT OF SHADE ON THE YIELD OF TURMERIC VARIETIES

on the contrary all these parameters showed parity at all shade levels. In the case of leaf area index and net assimilation rate also, the mean values were comparable at all shade levels during 1990.

Between varieties, there were significant differences during all the three seasons but the trends were far from consistent. Again the differences between varieties which were significant during 1988 and '89 fell short of significance during 1990. The interactions were also significant during the first two seasons but not in 1990. During the two seasons when the interaction was significant, the trends were not consistent. Data on these are, therefore, not presented. It is concluded from the results on varietal differences that eventhough there are, perhaps, differences in yielding abilities, these are not high enough to offset the experimental errors. Similarly, it is to be concluded that varietal differences in shade responses in the tested varieties were not high enough to be consistent.

8. Haulm yield (Table 26)

Data on this were collected during 1989 and 1990 only. During both the seasons, shade effect was not significant. Varietal differences were significant in 1988 but not in 1990. Comparing between seasons, the values were higher in 1988.

9. Harvest index (Table 26)

Between shade levels, differences in harvest index were not significant during any of the three seasons.

Table 26. Effect of shade on haulm yield and harvest index of turmeric varieties

Treatments	Percentage dryage 1990	Haulm yield ($t\ ha^{-1}$) 1989 (1)	Haulm yield 1989 (2)	Haulm yield 1990	Harvest index 1988	Harvest index 1989 (1)	Harvest index 1989 (2)	Harvest index 1990
Shade levels (per cent)								
T_1 (0)	15.5	5.3	4.8	2.1	0.40	0.67	0.62	0.53
T_2 (25)	18.6	4.2	3.8	2.9	0.41	0.64	0.65	0.51
T_3 (50)	19.4	4.3	4.4	3.1	0.38	0.63	0.61	0.55
T_4 (75)	24.5	4.6	5.0	2.5	0.39	0.63	0.56	0.65
SEm ±	0.5	0.6	0.8	0.2	0.01	0.03	0.02	0.03
CD (0.05)	1.4	NS	NS	NS	NS	NS	NS	NS
Varieties								
V_1 Myduckur	--	--	--	--	0.34	--	--	--
V_2 Armoor	--	--	--	--	0.32	--	--	--
V_3 PCT-2	--	--	3.8	--	0.46	--	0.61	--
V_4 PTS-9	19.1	5.2	5.6	2.9	0.42	0.57	0.54	0.55
V_5 Ethamukulam	19.4	4.4	4.5	2.8	0.44	0.65	0.65	0.58
V_6 PCT-8	22.4	3.9	4.1	2.4	0.54	0.65	0.62	0.66
V_7 PTS-10	--	--	5.8	--	0.37	--	0.63	--
V_8 PTS-24	--	--	4.2	--	0.35	--	0.59	--
V_9 PCT-5	18.8	4.6	3.8	2.5	0.66	0.69	0.69	0.55
V_{10} Co-1	--	--	4.3	--	0.33	--	0.55	--
V_{11} BSR-1	18.8	4.9	4.2	3.2	0.30	0.64	0.66	0.56
V_{12} PTS-38	18.4	--	4.8	3.1	0.36	--	0.55	0.52
SEm ±	0.9	0.4	0.6	0.2	0.01	0.05	0.05	0.22
CD (0.05)	2.3	0.8	1.3	NS	0.05	0.10	0.10	NS

(1) Data analysed by deleting five subplots (V_3, V_7, V_8, V_{10} & V_{12})

(2) Data analysed by deleting two replications.

Differences between varieties were significant during the first two seasons when PCT-5 gave the highest values. During the third year, differences were not significant. It is to be noted that this variety was not included in the final testing during 1990.

10. Quality of produce (Tables 26 and 27)

Quality of turmeric was assessed during 1990 through estimation of percentage dryage and curcumin content and during 1988 and '89 using curcumin content. In percentage dryage of 1990, there were significant shade effects, there being a progressive increase from 15.5 to 24.5 with increasing shade levels. Among the varieties, the mean value was the highest in PCR-8 (22.4 per cent) and lowest in PTS-38 (18.4 per cent). In curcumin content, the shade effects were not consistent. Varieties also showed some differences but the only consistent effect is the low value recorded in PCT-5.

11. Uptake of nutrients (Table 27)

Uptake of the three fertiliser nutrients was estimated during 1988 and 1990 only. Here again, pooled plant samples were used for estimation of contents of nutrients and the data could not, therefore, be subject to statistical analysis. The available data indicate that the uptake generally showed the same pattern as that of dry matter production and hence of rhizome yield. Thus, during 1988, there was a steady decrease in nutrient uptake with increasing shade levels whereas during 1990, there was steady increase.

Table 27. Effect of shade on uptake of nutrients N, P and K and curcumin content of turmeric varieties

Treatments	1988				1989	1990			
	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	Curcumin (percent)	Curcumin (percent)	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	Curcumin (per cent)
Shade levels (per cent)									
T_1 (0)	81.3	19.9	245.8	5.9	4.15	76.9	14.2	158.4	1.7
T_2 (25)	73.0	12.5	249.1	5.6	3.78	114.6	16.0	215.9	2.1
T_3 (50)	67.9	12.4	259.8	4.2	3.76	137.4	20.3	304.1	3.1
T_4 (75)	65.5	10.2	210.8	3.9	3.26	132.6	17.5	314.0	2.4
Varieties									
V_1 Myduckur	66.7	12.3	215.8	4.05	--	--	--	--	--
V_2 Armoor	63.2	11.3	262.5	5.61	--	--	--	--	--
V_3 PCT-2	81.4	14.2	238.9	5.06	3.79	--	--	--	--
V_4 PTS-9	93.7	9.1	178.3	5.20	3.33	119.1	22.4	225.1	2.8
V_5 Ethamukulam	87.9	23.2	364.2	5.00	3.83	107.5	20.5	252.3	3.2
V_6 PCT-8	69.5	17.6	180.2	2.30	3.43	129.0	23.3	285.0	2.4
V_7 PTS-10	64.0	10.9	267.0	5.90	3.62	--	--	--	--
V_8 PTS-24	58.3	13.7	220.4	6.00	3.63	--	--	--	--
V_9 PCT-5	75.6	17.6	195.1	2.90	3.26	96.4	13.0	227.3	1.8
V_{10} Co 1	62.3	11.6	269.6	5.60	3.63	--	--	--	--
V_{11} BSR-1	63.3	12.5	288.5	5.50	3.66	127.8	22.4	250.6	2.6
V_{12} PTS-38	60.0	10.9	262.2	5.50	4.22	110.5	19.3	284.4	1.4

The only exception to this was in the case of potassium which registered an increase with increase in shade level even in 1988 and which showed a very much more than proportionate increase in 1990. This came about as a result of a large increase in content of this nutrient because of shading (data not presented). This was the pattern reported in many other crops and actually noted in the other crops included in this trial. Between varieties, the pattern was nearly the same as that of dry matter production.

II Trial under natural shade

The area used for planting ginger under natural conditions was also used for turmeric. Nearly all the growth and yield observations taken for the crop under artificial shade were included in this trial also. Unlike what it was under artificial shade, the number of varieties included was only five, the one excluded being PTS-38. Data collected are presented in Tables 28-32. As the results show, growth and yield of the crop were much poorer under natural shade. Such a poor performance was also reflected on the uptake of nutrients. In characters like chlorophyll content, harvest index and percentage of dryage, the values were comparable to those under artificial shade. In none of the characters, there was significnat difference between varieties. The only attributable reason for the poorer performance of the experimental crop under natural conditions is the delay in planting which also resulted in a shorter crop duration and the probable inferiority of the soil.

Tables 28. Plant height, number of tillers and net assimilation rate of turmeric varieties under natural shade

Varieties	Plant height			Number of tillers	
	60 DAP	120 DAP	180 DAP	60 DAP	120 DAP
V_1 PCT-5	32.5	100.1	104.5	0.7	2.9
V_2 PTS-9	32.8	83.3	111.7	1.1	3.2
V_3 BSR-1	35.35	103.4	109.2	1.1	3.3
V_4 Ethamukulam	38.2	101.3	104.9	0.6	3.0
V_5 PCT-8	34.3	94.4	97.7	0.6	3.0
SEm $\pm$	4.0	5.2	5.5	0.97	1.04
CD (0.05)	NS	NS	NS	NS	NS

DAP - Days after planting

Table 29. Number of leaves, net assimilation rate and dry matter production of turmeric varieties under natural shade

Varieties	Number of leaves			Net assimilation rate		Dry matter production (g plant^{-1})
	60 DAP	120 DAP	180 DAP	60-120 DAP	120-180 DAP	
V_1 PCT-5	7.9	11.9	14.1	2.3	2.1	25.8
V_2 PTS-9	5.75	11.7	14.1	2.9	2.0	28.3
V_3 BSR-1	7.1	12.8	14.4	2.2	1.6	27.0
V_4 Ethamukulam	8.2	12.9	14.0	3.1	2.0	27.4
V_5 PCT-8	5.9	10.2	15.7	2.4	1.3	31.2
CD (0.05)	NS	NS	NS	NS	NS	NS

DAP - Days after planting

Table 30. Contents of chlorophyll fractions of turmeric varieties at 135 days after planting under natural shade

Varieties	Chlorophyll a (mg g^{-1} fresh weight)	Chlorophyll b (mg g^{-1} fresh weight)	Chlorophyll a+b (mg g^{-1} fresh weight)	Chlorophyll a/b
V_1 PCT-5	0.81	0.60	1.41	1.35
V_2 PTS-9	0.87	0.72	1.59	1.20
V_3 BSR-1	0.90	0.70	1.70	1.28
V_4 Ethamukulam	0.88	0.70	1.58	1.25
V_5 PCT-8	0.83	0.68	1.51	1.22

Table 31. Rhyzome yield (fresh and dry weight) haulm yield, percentage dryage, and harvest index of turmeric varieties under natural shade

Treatments	Yield (fresh weight) (t ha^{-1})	Yield (dry weight) (t ha^{-1})	Haulm yield (t ha^{-1})	Harvest index	Percentage dryage
V_1 PCT-5	12.0	2.4	2.33	0.51	20.5
V_2 PTS-9	10.2	2.09	2.43	0.46	20.0
V_3 BSR-1	12.8	2.53	2.19	0.53	19.8
V_4 Ethamukulam	12.0	2.46	2.30	0.51	21.5
V_5 PCT-8	9.3	1.93	2.25	0.46	20.5
CD (0.05)	NS	NS	NS	NS	NS

Table 32. Content and uptake of nutrients N, P and K by turmeric varieties under natural shade

Treatment	Nitrogen (per cent)		Phosphorus (per cent)		Potassium (per cent)		Uptake (kg ha^{-1})		
	Haulm	Rhizome	Haulm	Rhizome	Haulm	Rhizome	N	P	K
PCT-5	1.25	2.4	0.20	0.26	3.4	3.5	60.8	12.2	125.9
PTS-9	1.23	1.90	0.16	0.18	3.4	3.4	52.3	8.3	117.5
BSR-1	1.19	1.8	0.13	0.14	3.9	3.9	59.9	10.6	165.3
Ethamukulam	1.19	2.2	0.23	0.27	4.4	4.5	42.3	8.2	160.4
PCT-8	1.24	1.7	0.16	0.19	2.4	2.9	46.1	7.7	81.3

C. COLOCASIA

Experiments on colocasia were conducted only for two seasons, 1989 and 1990. A total of 10 morphotypes received from the National Bureau of Plant Genetic Resources, Regional Station, Trichur along with 'Sree Rashmi', a released variety from the Central Tuber Crops Research Institute, Trivandrum were used for the initial screening trial of 1989. These 10 morphotypes were selected from a large number of types assembled from all over the country and this collection represented a fair assembly of variability available in the country. The morphotypes included and their prominent characters are given in Appendix I. During 1989, seed tubers of three morphotypes, M12, M15 and M16 were not enough to plant all the four replications and as such, these three were planted only in two replications. Data collected were statistically analysed by two methods, one by deleting the three subplots (morphotypes) and another by deleting two replications with missing subplots. From the data of the first year, six morphotypes were selected for the trial of 1990 in larger plots. The same morphotypes were also grown under natural shade of coconut with a light infiltration of about 50 per cent in the interspaces. These could not, however, be taken to the stage of harvest because of damage of the crop by wild boar. Data collected from this trial therefore included some early growth observations only. These are not included in this report. Results of the experiments on colocasia are presented and discussed below.

1. Plant height (Table 33)

Barring a few exceptions, plant height went on increasing with increasing levels of shade, plants grown in the open being the shortest during nearly all the stages of observation and during both the seasons. Among the morphotypes, M_2 recorded higher height values at nearly all the stages during both the seasons. The varietal responses to shade were not different as indicated by lack of statistically significant interaction.

2. Number of tillers (Table 34)

There was no consistent trend of variation in tiller number with increasing shade levels though the treatment differences were significant at 120 days after planting in 1989 and at 60 days in 1990. On the contrary, differences between morphotypes were significant at all the stages during both the seasons. At the first stage of observation 60 days after planting, the types with highest tiller number were M_2 and M_{17}. At later stages, it was M_1 and M_{10} that were having highest number of tillers. The interactions were generally not significant. The only exception was at 120 days during 1989 by analysis (1). Data on this are not presented and discussed.

3. Number of leaves (Table 35)

This observation was taken during 1989 only when it was recorded at 60 and 120 days after planting. No significant effect of shade on this character was noticed at any of the stages of observation and in any of the methods of analysis. Among the morphotypes, M_{17} had the maximum number of leaves at both 60 and 120 days. Interaction was not significant at any stage.

Table 33. Effect of shade on plant height (cm) of colocasia morphotypes

Treatment	1989 60 DAP (1)	1989 60 DAP (2)	1989 120 DAP (1)	1989 120 DAP (2)	1990 60 DAP	1990 120 DAP	1990 180 DAP
Shade levels (per cent)							
T_1 (0)	32.9	33.8	54.3	56.3	60.3	69.7	81.0
T_2 (25)	52.5	57.1	92.2	99.0	74.7	86.4	93.5
T_3 (50)	57.2	56.3	102.9	103.7	78.2	86.0	93.9
T_4 (75)	62.8	68.2	104.6	114.9	73.7	94.3	95.0
SEm±	3.1	4.2	4.4	5.3	3.27	6.98	9.42
CD (0.05)	7.0	13.3	10.0	17.0	7.39	15.79	NS
Morphotypes							
M_1	50.1	54.4	71.1	73.5	69.4	62.6	74.7
M_2	55.3	58.8	105.7	111.9	78.4	100.3	105.3
M_7	44.3	45.2	92.0	96.5	--	--	--
M_8	47.8	48.7	79.5	75.8	--	--	--
M_9	54.9	59.4	92.8	99.3	77.6	102.7	106.1
M_{10}	56.5	62.7	89.6	92.2	72.5	83.9	89.6
M_{12}	--	53.6	--	92.8	--	--	--
M_{15}	--	44.9	--	93.6	--	--	--
M_{16}	--	56.4	--	106.0	67.4	88.2	94.1
M_{17}	53.6	56.3	78.8	80.6	65.1	66.9	75.3
Sree Rashmi	48.5	52.0	98.5	104.3	--	--	--
SEm±	2.5	3.7	3.6	4.8	2.39	2.84	2.96
CD (0.05)	5.1	7.6	7.2	9.7	5.10	6.06	6.32

DAP - Days after planting

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

(2) Data analysed by deleting two replications

Table 34. Effect of shade on tiller number of colocasia morphotypes

Treatment	1989				1990		
	60 DAP		120 DAP		60 DAP	120 DAP	180 DAP
	(1)	(2)	(1)	(2)			
Shade levels (per cent)							
T_1 (0)	1.2	1.1	4.4	4.5	2.8	5.8	6.2
T_2 (25)	1.9	1.8	4.2	4.1	3.3	6.0	6.3
T_3 (50)	1.3	1.1	3.8	3.8	2.9	6.0	6.2
T_4 (75)	1.2	0.8	3.3	2.9	2.1	4.6	4.8
SEm±	0.3	0.3	0.3	0.7	0.3	0.6	0.6
CD (0.05)	NS	NS	0.7	NS	0.6	NS	NS
Morphotypes							
M_1	1.0	1.0	4.8	4.9	3.3	7.6	9.0
M_2	2.0	1.8	3.9	3.9	4.0	5.7	6.3
M_7	0.6	0.7	4.4	4.8	--	--	--
M_8	0.8	0.6	3.6	3.8	--	--	--
M_9	0.5	0.8	3.3	3.8	1.3	6.2	6.3
M_{10}	1.8	1.8	4.6	4.7	2.9	6.1	6.2
M_{12}	--	1.3	--	4.8	--	--	--
M_{15}	--	0.7	--	2.6	--	--	--
M_{16}	--	0.7	--	2.5	1.1	2.8	3.1
M_{17}	3.6	3.0	4.5	4.0	4.0	5.2	5.3
Sree Rashmi	1.0	1.1	2.5	2.4	--	--	--
SEm±	0.3	0.5	0.4	0.6	0.26	0.49	0.55
CD (0.05)	0.6	1.0	0.8	1.2	0.56	1.04	1.17

DAP - Days after planting

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

(2) Data analysed by deleting two replications

Table 35. Effect of shade on number of leaves and girth at the collar of colocasia morphotypes (1989)

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 (per cent)								
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_{15}	--	4.4	--	8.6	--	11.6	--	18.2
M_{16}	--	3.7	--	9.6	--	14.0	--	23.9
M_{17}	8.7	7.9	15.9	13.8	14.0	14.6	14.9	14.5
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

DAP - Days after planting

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

(2) Data analysed by deleting two replications

4. Girth at collar (Table 35)

This observation also was recorded during 1989 only. In general, there was increase in girth at collar under shaded condition. The values in the open differed significantly from all other shade levels both at 60 and 120 days after planting. Between the three shade situations of 25, 50 and 75 per cent, the differences were not significant. The morphotypes with higher girth at the first stage of 60 days were M_9 and M_{10} and that with highest values at the second stage 120 days after planting was M_{16}. Interaction between morphotypes and shade levels was significant in the case of the observation at 120 days. Data on this are not presented.

5. Chlorophyll content of leaves (Table 36)

Samples of leaves for estimation of chlorophyll content were collected 150 days after planting during 1989 and 130 days after during 1990. While it was pooled samples that were used for estimation in 1989, samples were drawn from all the plots during 1990. As such, statistical analysis of data could be done in 1990 but not in 1989. The components estimated were chlorophyll a, chlorophyll b, chlorophyll a+b and chlorophyll a/b. Results showed a near consistent effect of increase in chlorophyll a, b and a+b with increasing levels of shade. During 1990, the treatment differences were also statistically significant. In the case of ratio between the chlorophyll fractions, the results were not consistent. Such an increase in chlorophyll content by shading was noted in the other crops tested and the trend was apparent visually also in that the

Table 36. Effect of shade on contents of chlorophyll fractions of colocasia leaves

Treatments	1989 (150 DAP)				1990 (130 DAP)			
	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	Chlorophyll 'a' mg g^{-1} fresh weight	Chlorophyll 'b' mg g^{-1} freshweight	Total (a+b) mg g^{-1} freshweight	Chlorophyll a/b
Shade levels (per cent)								
T_1 (0)	1.30	0.88	2.18	1.48	0.94	1.32	2.27	0.72
T_2 (25)	1.40	1.05	2.45	1.33	1.03	1.34	2.37	0.77
T_3 (50)	1.56	1.21	2.77	1.29	1.18	1.54	2.72	0.77
T_4 (75)	1.63	1.35	2.98	1.21	1.20	1.52	2.71	0.79
SEm±	--	--	--	--	0.01	0.01	0.02	0.02
Morphotypes								
M_1	1.80	1.04	2.42	1.33	1.04	1.38	2.42	0.76
M_2	1.44	1.10	2.54	1.31	0.99	1.30	2.29	0.77
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	1.32	1.66	2.98	0.79
M_{10}	1.58	1.28	2.86	1.23	1.23	1.58	2.81	0.77
M_{12}	1.48	1.11	2.59	1.33	--	--	--	--
M_{15}	1.35	1.01	2.36	1.34	--	--	--	--
M_{16}	1.32	0.98	2.30	1.35	0.96	1.33	2.29	0.72
M_{17}	1.36	0.99	2.35	1.37	0.99	1.32	2.32	0.74
Sree Rashmi	1.53	1.17	2.70	1.31	--	--	--	--
SEm ±	--	--	--	--	0.02	0.03	0.03	0.02
CD (0.05)	--	--	--	--	0.04	0.05	0.06	0.05

DAP - Days after planting

shaded crop looked darker green. Between varieties, there were some differences and the type with highest total chlorophyll content during both the seasons was M_9.

6. Dry matter production (Table 37)

Total dry matter production using sample plants was estimated at harvest during 1989 and at 60, 120 and 180 days after planting and at harvest during 1990. The general trend was one of parity between 25 per cent shade and the open and a general decline towards the highest shade level of 75 per cent. Between varieties also, there were differences which attained levels of statistical significance but the results were not always consistent. During 1989, the morphotypes, M_2, M_{10}, M_{15} and M_{16} gave relatively high values whereas in 1990, M_2 was generally better at most of the stages. The interaction was significant in the data of 1989 only and that too only when analysed by deleting three subplots. These data are therefore, not reproduced and discussed.

7. Yield of tuber (Tables 38, 39 and 40, Fig. d)

As was indicated earlier, trials with colocasia were taken up during 1989 and 1990 only. The former was the initial screening trial with 11 morphotypes/varieties and the latter, the final test with selected six varieties in larger plots. The crop of the first season was very good and there were no serious problems of pests and diseases. During the second season, on the contrary, there was serious incidence of Photophthora blight and even with all the possible fungicidal methods of control, damage continued to be high and for the

Table 37. Effect of shade on dry matter production (g plant^{-1}) of colocasia morphotypes

Treatments	1989 At harvest (1)	1989 At harvest (2)	1990 60 DAP	1990 120 DAP	1990 180 DAP	1990 At harvest
Shade levels (per cent)						
T_1 (0)	206.6	221.2	28.7	56.4	67.0	129.5
T_2 (25)	222.9	220.3	36.4	54.6	72.6	145.0
T_3 (50)	179.5	173.6	33.3	58.2	70.8	124.6
T_4 (75)	154.3	160.9	27.4	57.8	71.5	115.3
SEm ±	8.9	4.0	5.6	5.4	5.3	0.8
CD (0.05)	20.1	12.7	NS	NS	NS	1.8
Morphotypes						
M_1	177.4	196.8	24.3	36.1	51.1	107.3
M_2	248.1	246.4	37.5	62.6	92.8	169.8
M_7	137.8	129.5	--	--	--	--
M_8	176.4	144.8	--	--	--	--
M_9	169.8	168.6	38.9	64.3	61.7	116.6
M_{10}	241.8	250.4	29.0	59.9	68.4	123.7
M_{12}	--	148.7	--	--	--	--
M_{15}	--	235.7	--	--	--	--
M_{16}	--	249.7	27.3	70.6	85.9	151.1
M_{17}	198.5	188.2	31.6	47.0	62.9	103.3
Sree Rashmi	176.6	175.1	--	--	--	--
SEm ±	14.7	26.9	4.14	6.13	4.94	1.04
CD (0.05)	29.2	54.4	8.82	13.07	10.53	2.21

DAP - Days after planting

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

(2) Data analysed by deleting two replications

Table 38. Effect of shade on total tuber yield, cormel yield and corm yield of colocasia morphotypes

Treatments	1989 Cormel yield ($t\ ha^{-1}$) (1)	1989 Cormel yield ($t\ ha^{-1}$) (2)	1989 Corm yield ($t\ ha^{-1}$) (1)	1989 Corm yield ($t\ ha^{-1}$) (2)	1989 Total yield ($t\ ha^{-1}$) (1)	1989 Total yield ($t\ ha^{-1}$) (2)	1990 Corm yield ($t\ ha^{-1}$)	1990 Cormel yield ($t\ ha^{-1}$)	1990 Total yield ($t\ ha^{-1}$)
Shade levels (per cent)									
T_1 (0)	22.9	23.5	3.4	5.0	27.0	28.5	1.54	2.11	3.65
T_2 (25)	24.9	22.6	5.0	6.6	30.0	29.1	1.72	2.49	4.13
T_3 (50)	21.5	19.4	5.1	6.6	26.2	25.3	1.44	2.39	3.83
T_4 (75)	17.7	15.5	5.1	6.7	22.5	22.1	1.47	2.49	3.96
SEm ±	1.3	1.3	0.4	0.9	1.4	0.7	0.10	0.19	0.22
CD (0.05)	2.9	4.0	0.9	NS	3.2	2.1	NS	NS	NS
Morphotypes									
M_1	21.3	24.0	2.7	2.8	24.1	26.8	0.98	1.88	2.86
M_2	33.8	32.6	6.0	6.3	39.6	38.8	2.02	3.29	5.31
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	1.22	2.98	4.10
M_{10}	22.4	22.6	8.1	8.4	30.7	31.0	1.57	2.28	3.85
M_{12}	--	14.6	--	6.0	--	20.3	--	--	--
M_{15}	--	16.4	--	12.7	--	29.1	--	--	--
M_{16}	--	18.4	--	13.2	--	31.6	2.31	1.91	4.22
M_{17}	22.2	21.1	4.7	4.4	26.8	25.8	1.15	1.89	3.04
Sree Rashmi	24.6	24.6	5.9	5.3	29.6	29.2	--	--	--
SEm ±	2.2	3.7	0.6	1.5	2.4	4.5	0.10	0.20	0.24
CD (0.05)	4.4	7.4	1.2	3.1	4.8	9.0	0.20	0.43	0.51

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

(2) Data analysed by deleting two replications

Table 39. Mean cormel yield (t ha^{-1}) of colocasia morphotypes at different shade levels (1989)

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_{15}	(21.9)	(18.4)	(9.9)	(15.6)	(16.4)
M_{16}	(25.8)	(16.1)	(19.7)	(12.1)	(18.4)
M_{17}	32.7	27.8	15.6	12.7	22.2
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 done by deleting two replications)

Table 40. Total tuber yield (t ha^{-1}) of colocasia morphotypes at different shade levels

Morphotypes	Shade levels (per cent) 0	25	50	75	Mean
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_{15}	(33.2)	(30.7)	(20.5)	(31.8)	(29.1)
M_{16}	(39.1)	(26.9)	(35.8)	(31.6)	
M_{17}	36.0	33.7	20.0	17.6	26.8
Sree Rashmi	28.9	38.5	30.9	20.0	29.6
Mean	27.0	20.0	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 done by deleting two replications)

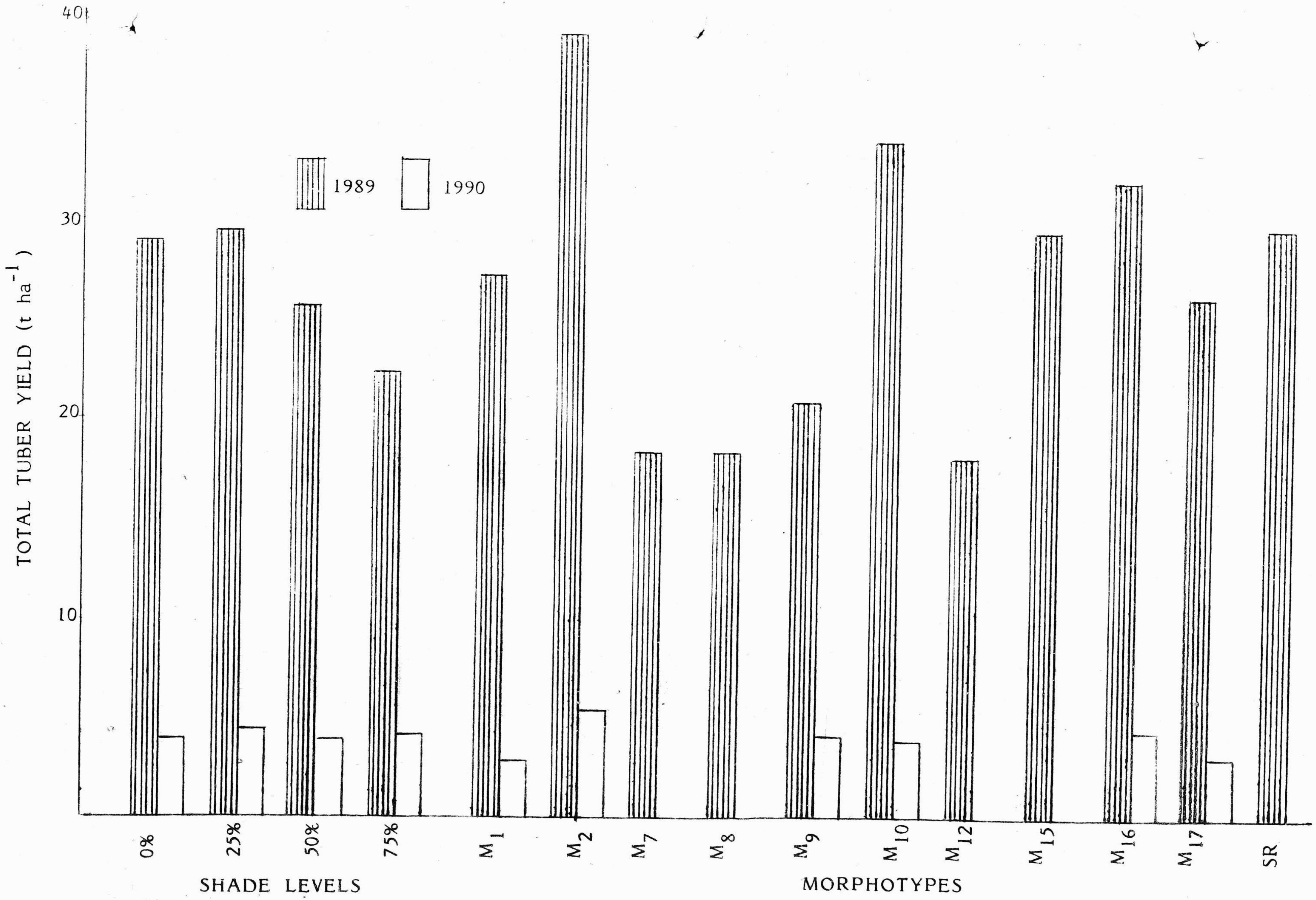


Fig.d EFFECT OF SHADE ON TOTAL TUBER YIELD OF COLOCASIA MORPHOTYPES

major part of the season, leaves continued to be damaged. This was reflected in all the growth characters and yield and in the latter, the extent of difference between the two seasons was as much as 5 to 8 times. Though plot sizes were larger during the second season, data of this season, therefore, are to be conceived with caution and reliance has to be primarily on the data of the first season, 1989. Again, the experiment of 1989 was also handicapped by the inadequacy of seed materials of three morphotypes which were enough for planting only two replications. Details of statistical treatment given to counter this were given earlier. As the results show, there was highly significant variation among shade levels with respect to cornel yield. Data analysed by deleting three subplots showed an increasing trend in yield upto 25 per cent shade and a decrease thereafter. The yields at 25, 50 and 75 per cent shade expressed as percentage of the yield in the open were 109, 94 and 77 per cent, respectively. The values at 0 and 25 per cent shade levels were statistically at par whereas that at 75 per cent was significantly lower than the other two shaded situations (25 and 50 per cent). Data analysed by deleting two replications showed a slightly different trend. The yield values here decreased gradually with increase in level of shade, the percentages of yield at 25, 50 and 75 per cent shade being 93, 83 and 66 per cent, respectively of the yield at full illumination. 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 types in both the methods of analysis. The next best yielders common in both the methods of analysis and which were on par were Sree Rashmi, M_{10}, M_{17} and M_1. Significant interaction between morphotypes and shade levels was noted when the data were analysed by deleting three subplots. The variety, Sree Rashmi gave the highest yield at 50 per cent shade whereas M_2 was the best yielder at all other shade levels. Also, at 50 per cent, the cormel yields of M_2, M_{10} and Sree Rashmi were on par. Regarding the trends in yield of the types at the four shade levels, there were large differences between the tested morphotypes. The types M_1, M_7 and M_8 recorded an increase in yield upto 25 per cent shade and there was a gradual decrease in yield with further increase in shade intensity. The types M_2 and M_{17} had the highest yield in the open whereas M_9 and M_{10} recorded the highest values at 50 per cent shade. Among the morphotypes, M_{12}, M_{15} and M_{16} which were not included in analysis 1, M_{12} gave the highest yield at 25 per cent shade and M_{15} and M_{16} at full illumination.

In corm yield (Table 38), the values were significantly lower in the open than at all other shade levels (analysis 1). With decrease in light intensity, there was progressive increase in corm yield. Eventhough the highest yield was at 75 per cent shade level, there was no significant difference in the values at 25, 50 and 75. Among the morphotypes, M_{16} recorded the highest corm yield of 13.2 tonnes followed by M_{15} with 12.7 tonnes. No interaction between shade levels and morphotypes was noticed.

Total tuber yield trend followed the same pattern as that of cormel yield with the highest value recorded at 25 per cent shade. With further increase in shade intensity, tuber yield decreased. The percentages of yield at 25, 50 and 75 per cent shade were 111, 97 and 83 (analysis 1) and 102, 89 and 78 (analysis 2), respectively, of the yield at full illumination. The shares of cormel yield and corm yield to the total tuber yield were, on an average, 82 and 18 per cent (analysis 1) and 77 and 33 per cent (analysis 2), respectively. Subplot treatments differed significantly. The morphotype, M_2 recorded the highest yield of 39.6 tonnes and this type was superior to all others in both the methods of analysis. M_{16}, M_{10}, Sree Rashmi and M_{15} were the next best. Significant interaction between shade levels and morphotypes was noticed when the data were analysed by deleting three subplots. M_2 recorded the highest yield at all shade levels except at 50 per cent shade where M_{10} gave the highest yield. The trend in the total tuber yield of the different morphotypes at varying shade levels was exactly the same as that of cormel yield.

During 1990, when crop growth and yield were abnormally low, differences between shade levels were not significant in terms of corm yield, cormel yield and total tuber yield. Between varieties, there were some differences, M_{16} recording the highest corm yield and M_2 giving the highest cormel yield and total tuber yield. Interactions were not significant.

As the yields were very low during 1990, as crop growth was extremely abnormal because of disease damage and as it is to be concluded that conditions were not at all favourable for full yield expression, all the discussion is made and conclusions drawn based on the data of 1989. It is, however, to be recognised that the plot sizes were small. The mean yield of 1989 at the low shade of 25 per cent was the highest, higher than even the open, shade free situation. Eventhough there was decrease in yield with further increase in shade intensity, the crop gave an yield of 78 to 83 per cent even at the intense shade level of 75 per cent. As the yield was higher at a certain level of shade than in the open, colocasia appears to fall in the category of shade-loving plants. The responses of the different morphotypes to varying levels of shade were, however, different as indicated by the significant interaction. The morphotypes M_1, M_7, M_8, M_9, M_{10} and M_{12} and the variety Sree Rashmi had the highest yield under shaded condition and are, hence, to be classed 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 percentages of light intensity. Following this classification, these four morphotypes will 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 higher rate of photosynthesis as indicated by the higher rate of dry matter accumulation coupled with the highest harvest index recorded at this level of shading. Though better performance of colocasia under shade than in the open is not reported elsewhere, Bai and Nair (1982) 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 as 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 shade. Besides this, cholorophyll content and leaf area of colocasia were also higher under shaded condition which are some adaptive mechanisms of plants for shaded environments.

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 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 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.

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 the replications, statistical analysis including all the replications and subplots was not possible. Based on the available data on total tuber yield, the best morphotypes for each of the shade levels are selected as follows.

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}, M_2, Sree Rashmi and M_1
75 per cent shade - M_2, M_{10}, Sree Rashmi and M_9

Of the above selected types, M_2 and Sree Rashmi are to be reckoned as the same morphotype, Sree Rashmi being a selection from the morphotype, M_2 released by the Central Tuber Crops Research Institute. As M_2 outyielded Sree Rashmi in all cases, Sree Rashmi is to be excluded from the list of superior types, thus leaving the types M_1, M_2, M_8, M_9, M_{10} and M_{17} as the superior ones through analysis 1. This list is incomplete as three morphotypes, M_{12}, M_{15} and M_{16} were not included in analysis 1. Study of the yield data by analysis 2 would indicate that the highest yielders are M_1, M_2, M_{10}, M_{15}, M_{16} and M_{17}. 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 yields of M_{15} and M_{16} were very much higher than those of 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 list of types that are superior may, thus, include M_1, M_2, M_{10}, M_{15}, M_{16} and M_{17}. The best type of all these may be taken to be M_2 which gave the highest yield at 0, 25 and 75 per cent shade and second highest at 50 per cent. It is also to be noted that this morphotype has given the highest yield during 1990 also when restrictions on yield were high.

8. Haulm yield (Table 41)

Differences between shade levels were not significant in both the seasons. Between morphotypes, on the contrary, differences were significant. During 1989, M_{16} gave the highest yield and M_2 came next best. During 1990, M_2 gave the higher mean haulm yield. In the first season, the interaction assumed statistical significance. Data on this are not presented. Comparing between the two seasons, the values were higher during 1989 though the extent of difference was much less than in tuber yield. This observation is not to be given much of importance as it more often reflects the retention of above-ground plant parts rather than their total weight as a substantial portion of these plant parts dry much earlier than harvest and is lost.

9. Harvest index (Table 41)

During 1989, there was no significant difference in harvest index between shade levels in analysis 2. In analysis 1 where three subplots were deleted, these assumed significance. The trend was one of increase upto 25 per cent shade followed by a decrease. Even here, treatment differences were narrow and were in the range from 0.81 to 0.87. It may, perhaps, be safer to conclude that there are no consistent treatment differences. Even such a conclusion is very remarkable because the trend in most of the shade - intolerant and shade - sensitive plants is a sharp decline in harvest index because of shading. The fact that such a decline is not there in colocasia and that the proportion of photosynthates that is

Table 41. Effect of shade on haulm yield and harvest index of colocasia morphotypes

Treatments	1989 Haulm yield (t ha^{-1}) (1)	1989 Haulm yield (t ha^{-1}) (2)	1989 Harvest index (1)	1989 Harvest index (2)	1990 Haulm yield (t ha^{-1})	1990 Harvest index
Shade levels (per cent)						
T_1 (0)	1.1	1.2	0.85	0.84	0.5	0.64
T_2 (25)	1.0	1.1	0.87	0.87	0.5	0.62
T_3 (50)	1.2	1.2	0.81	0.82	0.5	0.59
T_4 (75)	0.9	1.2	0.82	0.78	0.5	0.56
SEm ±	0.1	0.1	0.02	0.02	0.02	0.03
CD (0.05)	NS	NS	0.04	NS	NS	NS
Morphotypes						
M_1	0.8	0.9	0.88	0.88	0.5	0.5
M_2	1.3	1.3	0.86	0.86	0.6	0.7
M_7	1.3	1.2	0.76	0.77	--	--
M_8	1.0	0.9	0.83	0.82	--	--
M_9	0.8	0.9	0.86	0.86	0.4	0.6
M_{10}	1.0	1.1	0.88	0.88	0.4	0.6
M_{12}	--	1.0	--	0.81	--	--
M_{15}	--	1.4	--	0.83	--	--
M_{16}	--	2.1	--	0.77	0.5	0.6
M_{17}	1.1	1.0	0.82	0.82	0.4	0.6
Sree Rashmi	1.1	1.4	0.81	0.77	--	--
SEm ±	0.1	0.2	0.02	0.02	0.03	0.02
CD (0.05)	0.2	0.4	0.04	0.05	0.07	0.05

(1) Data analysed by deleting 3 sub plots (M_{12}, M_{15} and M_{17})

(2) Data analysed by deleting two replications

translocated to the tuber remains unaltered by shading is, perhaps, one of the important reasons for the ability of this crop to perform well under shade.

Between morphotypes, there were significant differences noted in both the methods of analysis and M_1 and M_{10} recorded the highest harvest index of 0.88 and M_7, the lowest values of 0.76 and 0.77 in analyses 1 and 2, respectively. No significant interaction was noted. During 1990 also, shade levels were statistically at par and morphotypes significantly different.

10. Content and uptake of nutrients (Tables 42 and 43)

Data on these were collected only during 1989. Nitrogen contents in both haulm and tubers were more under shaded conditions than in the open. Between the three shaded situations, the differences either were small or there was a tendency for the content to decrease with increasing shade levels beyond 25 per cent. In the case of phosphorus, there was no consistent trend. In potassium, there was a very consistent trend of increase in content of this nutrient with increase in shade in both haulm and tuber. Varieties showed some difference in the content of nutrients in tuber and large differences in haulm.

Uptake of nitrogen increased from 0 to 25 per cent shade and then showed a progressive and drastic decrease. Uptake values at 25, 50 and 75 per cent shade levels were 110, 90 and 79 per cent, respectively of the uptake in the open. Phosphorus uptake also followed a similar pattern, the

Table 42. Effect of shade on nitrogen, phosphorus and potassium contents of colocasia tuber and haulm (1989)

Treatment	N (per cent)		P (per cent)		K (per cent)	
	Haulm	Tuber	Haulm	Tuber	Haulm	Tuber
Shade levels (per cent)						
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_{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
M_{17}	0.75	0.95	0.12	0.29	8.80	4.95
Sree Rashmi	1.90	1.15	0.19	0.25	7.30	6.65

Table 43. Effect of shade on total uptake of nitrogen, phosphorus and potassium and on the contents of starch and oxalic acid

Treatments	1989					1990	
	Uptake (kg ha^{-1})			Starch (%)	Oxalic acid (%)	Starch (%)	Oxalic acid (%)
	N	P	K				
Shade levels (per cent)							
T_1 (0)	87.3	19.8	398.0	28.6	0.39	27.57	0.34
T_2 (25)	96.3	20.3	440.1	26.4	0.34	28.09	0.34
T_3 (50)	78.6	13.5	379.1	27.6	0.28	26.97	0.37
T_4 (75)	69.2	11.6	408.1	21.6	0.31	28.24	0.35
SEm ±	--	--	--	--	--	0.14	0.02
CD (0.05)	--	--	--	--	--	0.32	NS
Morphotypes							
M_1	84.0	18.6	410.1	24.6	0.34	27.84	0.33
M_2	107.2	19.8	749.0	25.2	0.38	28.58	0.39
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	27.75	0.32
M_{10}	90.1	16.9	397.4	29.4	0.30	27.87	0.33
M_{12}	71.6	13.8	308.7	25.4	0.33	--	--
M_{15}	99.2	19.2	435.2	24.8	0.31	--	--
M_{16}	142.9	25.4	673.1	27.9	0.37	26.71	0.37
M_{17}	69.5	18.3	367.6	28.9	0.36	27.54	0.36
Sree Rashmi	71.5	13.0	342.8	22.0	0.34	--	--
SEm ±	--	--	--	--	--	0.23	0.01
CD (0.05)	--	--	--	--	--	0.48	0.02

values at 25, 50 and 75 per cent shade being 103, 68 and 59 per cent, respectively of the uptake at 0 shade. Uptake of potassium also was higher at the low shade as compared to the open, there being a decrease in it with further increase in shade. The corresponding percentage values were 111, 91 and 103, respectively of that in the open at 25, 50 and 75 per cent shade. There was wide variation between morphotypes in the uptake of all the three nutrients. The values ranged from 41.5 to 142.9 kg ha^{-1} for nitrogen, 8.5 to 25.4 kg in phosphorus and 216.3 to 749.0 kg in potassium.

The results on uptake of nutrients generally indicate that there is necessity for supplementing a little of fertiliser nitrogen and phosphorus under low shade and of substantially bringing them down at intense shade. As for potassium, there is need for some supplementation at low shade and of maintenance at the same dose under all other levels of shade.

11. Quality of tuber (Table 44)

This was assessed through contents of starch and oxalic acid in tuber. During 1989, there was a trend of the starch content being lower under shaded situations. However, during 1990, this trend did not persist and the overall conclusion may have to be that this character is not much influenced by shading. Between morphotypes there were some differences but these were not much consistent over the seasons.

In oxalic acid content of tuber, there were no indications of shade effect. Between morphotypes, there were some differences and the range was from 0.28 per cent in M_9 to 0.38 in M_2 in 1989 and from 0.32 in M_9 to 0.39 in M_2. The highest yielding type, thus, is found to have tubers of a little inferiority with respect to oxalate content.

D. SOYBEAN

A total of 18 soybean varieties were included in the trial during 1988 and 20 during 1989. All the varieties failed to come up under shade during 1988 and their growth was abnormal under shade from the beginning. The branches were long and thin and they tended to fall on the ground and after about 30 days, all the plants at 75 per cent shade and by about 40 days, most of the plants at the other two shade levels decayed away. During 1989 when sowing was done before the onset of heavy rains, the crop was better and all the varieties came up at 25 per cent shade. At higher shade levels, they failed. In the open, on the contrary, soybean came up very well. The data collected in the open in 1988 and in the open and at low shade in 1989 were analysed treating the design as randomised block and varieties as the treatments. Data of 1988, thus, had comparison of varieties in the open only and during 1989, both in the open and at 25 per cent shade. Also seeds of two varieties, Monetta and Himzo 1531 were not enough for planting in a replication during 1988 and as such, analysis was done by applying the missing plot technique. Besides this, there were differences in the plant population in various plots because of poor germination arising from delayed sowing. For this, yield data were analysed following the method of covariance taking plant population as the independent variable and yield as the dependent. During 1989, 20 soybean varieties were included and sowing was done by the onset of monsoon. The crop grew and yielded better. The trial with soybean was not continued during the third year as it was not possible to raise the crop under shade.

1. Plant height (Table 44)

During 1988, highly significant variation was noticed among soybean varieties in plant height at all the stages. The mean height values ranged from 8.1 cm to 12.6, 21.4 to 31.9 and 22.8 to 64.7 at 14, 40 and 70 days after planting, respectively. The varieties, DS-83-20 and Himzo 1531 recorded maximum height upto 40 days. The other two varieties that had shown statistical equality with these varieties at 40 days were EC 26691 and DS-1-37-1. At 70 days, varieties, EC 26691 and EC 63298 recorded the maximum height. Variety KB 38 A recorded the lowest mean height at all the stages except at 14 days after sowing. Between stages, there was steady and continued growth upto the last stage, 70 days after sowing. During 1989 also, the differences in plant height of varieties at 60 days after sowing were highly significant both in the open and at the low shade of 25 per cent. In the open, height of different varieties ranged from 37.8 cm in DS-83-20 to 81.4 cm in PLSO 18. The other varieties that maintained statistical parity with PLSO 18 in mean height were EC 26691, Bragg 88, Monetta, Ankur, Improved Pelican and EC 39824. The variety KB 38 A recorded the lowest height of 37.8 cm. The pattern was nearly the same under shade also though nearly all the varieties grew taller under the shaded condition. Comparing between the two seasons, there was better growth during 1989.

2. Number of branches (Table 45)

This observation was taken during 1988 only at 40 and 70 days after sowing. Significant and conspicuous differences

Table 44. Mean plant height (cm) of soybean varieties at different shade levels

Varieties	1988 Open 14 DAS	1988 Open 40 DAS	1988 Open 70 DAS	1989 Open 60 DAS	1989 25% shade 60 DAS
V_1 (PLSO 18)	8.9	23.4	55.8	81.4	97.7
V_2 (Monetta)	8.4	22.3	49.5	71.6	89.7
V_3 (Davis)	9.1	24.7	57.4	61.1	98.2
V_4 (KB 74)	10.3	23.9	24.7	41.8	43.8
V_5 (Hardee)	9.7	27.0	32.4	43.0	47.5
V_6 (Himso 1531)	11.7	31.5	33.8	51.2	57.2
V_7 (EC 63298)	8.9	25.2	58.3	61.9	90.7
V_8 (PK 471)	9.8	21.6	25.3	41.8	48.1
V_9 (KHS b-2)	9.8	27.2	39.9	55.2	56.4
V_{10} (EC 39824)	8.1	23.7	52.4	65.7	77.8
V_{11} (JS-79-277)	9.8	22.1	30.3	46.6	45.7
V_{12} (EC 26691)	9.2	29.6	64.7	78.0	100.4
V_{13} (MACS-124)	10.2	26.7	53.7	63.7	63.3
V_{14} (DS 76-1-37-1)	10.5	29.1	31.5	46.8	47.0
V_{15} (KB-38 A)	9.8	21.4	22.8	37.8	41.1
V_{16} (DS-83-20)	12.6	31.9	48.3	54.6	52.2
V_{17} (Bragg 88)	--	--	--	76.2	90.2
V_{18} (Ankur)	--	--	--	68.1	102.8
V_{19} (Improved pelican)	--	--	--	65.9	90.0
V_{20} (EC 29824)	--	--	--	63.2	84.9
SEm ± (1)	0.46	2.2	4.7	--	--
SEm ± (2)	0.49	2.4	5.1	6.0	5.3
SEm ± (3)	0.42	2.1	4.4	--	--
CD (0.05) (1)	0.92	4.5	9.5	--	--
CD (0.05) (2)	0.98	4.8	10.2	17.0	15.1
CD (0.05) (3)	0.85	4.1	8.8	--	--

(1) Standard error of the difference between a treatment mean that does not contain an estimate of a missing value and one that does.

(2) Standard error of the difference between the means of the treatments containing estimates of the missing value.

(3) Standard error of the difference between treatment means that do not contain an estimate of the missing value.

Table 45. Mean number of branches and protein content of soybean varieties in the open (1988)

Varieties	Number of branches		Protein (%)
	40 DAS	70 DAS	
V_1 (PLSO 18)	7.2	13.3	32.81
V_2 (Monetta)	3.4	13.2	27.18
V_3 (Davis)	7.7	13.2	33.75
V_4 (KB 74)	8.4	8.9	28.12
V_5 (Hardee)	9.1	11.6	33.75
V_6 (Himso 1531)	9.3	10.5	31.87
V_7 (EC 63298)	7.3	12.4	32.81
V_8 (PK 471)	8.6	9.9	31.87
V_9 (KHS b-2)	8.1	9.8	36.56
V_{10} (EC 39824)	7.4	12.9	30.00
V_{11} (JS-79-277)	9.7	11.3	33.75
V_{12} (EC-26691)	8.6	13.9	31.87
V_{13} (MACS-124)	7.9	13.9	23.43
V_{14} (DS-76-1-37-1)	8.9	10.7	27.18
V_{15} (KB-38 A)	7.9	8.7	31.87
V_{16} (DS 83-20)	8.8	10.8	27.18
SEm ± (1)	0.89	1.08	--
SEm ± (2)	0.96	1.16	--
SEm ± (3)	0.82	1.00	--
CD (0.05) (1)	1.80	2.18	--
CD (0.05) (2)	1.94	2.35	--
CD (0.05) (3)	1.66	2.01	--

(1) Standard error of the difference between a treatment mean that does not contain an estimate of a missing value and one that does.

(2) Standard error of the difference between the means of the treatments containing estimates of the missing value.

(3) Standard error of the difference between treatment means that do not contain an estimate of the missing value.

were noticed among varieties in the number of branches. At 40 days, JS-79-277 recorded the maximum number (9.7) and at 70 days, it was EC 26691 that recorded the highest mean number of 13.9. Comparing the two stages of 40 and 70 days, there was increase with advancing age in all the varieties.

3. Days to flowering (Table 46)

Highly significant differences were noticed among varieties in this character. During 1988, PLSO 18 took the maximum number of days (51) and DS-83-20, the minimum (33). During 1989 also, the varietal performance remained nearly the same. Ten out of 20 varieties included during this season flowered in a mean of 48.5 to 51.5 days after sowing. The varieties, Hardee, DS-76-1-37-1, KB-74 and KB 38 A took the minimum number of days in the range from 35.5 to 38.3. At 25 per cent shade also, the trend remained the same eventhough most of the varieties flowered earlier under shade. Comparing between the two seasons, it took a little longer for nearly all the varieties to come to flower during 1989. The timely sowing that was done during 1989 is attributable to this.

4. Days to harvest (Table 46)

The trend in this was nearly the same as in the days to flowering. In 1988, varieties Monetta, PLSO 18, Davis, EC 26691, EC 39824 and EC 63298 had taken maximum number of days. The differences between these six varieties were not statistically significant. KB-74 was the variety which took the shortest period of 85.5 days to come to harvest. During 1989, EC 63298 had the longest growing period of 127 days.

Table 46. Effect of shade on days to flowering, days to harvest and thousand seed weight of soybean varieties

Varieties		1988 Days to flowering	1988 Days to harvest	1988 Thousand seed weight (g)	1989 Days to flowering Open	1989 Days to flowering 25% shade	1989 Days to harvest	1989 Thousand seed weight (g)
V_1 (PLSO 18)		51.3	111.5	73.7	50.3	50.8	121.8	78.6
V_2 (Monetta)		49.4	112.4	74.8	49.8	40.5	120.0	79.4
V_3 (Davis)		49.5	111.0	79.6	51.3	50.5	125.3	76.4
V_4 (KB-74)		33.8	85.5	122.4	36.0	32.0	92.0	121.4
V_5 (Hardee)		35.8	106.5	146.0	38.3	34.5	114.0	129.5
V_6 (Himso 1531)		33.4	107.4	177.6	41.0	32.3	115.0	138.0
V_7 (EC 63298)		49.0	109.5	77.7	50.8	49.3	127.3	71.5
V_8 (PK 471)		36.8	95.8	129.4	39.8	33.3	99.8	131.2
V_9 (KHS b-2)		47.3	102.5	115.5	42.3	39.5	107.0	125.3
V_{10} (EC 39824)		40.0	110.8	72.2	50.5	50.8	123.5	71.7
V_{11} (JS-79-277)		34.5	106.8	131.4	42.0	33.8	111.3	102.1
V_{12} (EC-26691)		48.8	110.8	74.9	50.0	46.3	124.5	80.5
V_{13} (MACS-124)		37.8	104.0	115.7	44.5	36.8	117.3	117.0
V_{14} (DS-76-1-37-1)		34.3	106.0	120.8	36.8	35.5	115.0	112.6
V_{15} (KB-38 A)		34.3	89.8	138.7	35.5	32.3	90.8	118.4
V_{16} (DS-83-20)		33.0	103.0	158.8	39.5	33.3	124.5	80.5
V_{17} (Bragg 88)		--	--	--	51.0	50.0	120.3	77.9
V_{18} (Ankur)		--	--	--	50.8	49.3	123.0	73.5
V_{19} (Improved Pelican)		--	--	--	48.5	44.0	119.5	73.5
V_{20} (EC 29824)		--	--	--	51.5	49.8	123.3	82.3
SEm ±	(1)	0.82	1.80	6.3	--	--	--	--
	(2)	0.89	1.94	6.8	1.4	1.5	1.7	--
	(3)	0.76	1.66	5.8	--	--	--	--
CD (0.05)	(1)	1.66	3.64	12.7	--	--	--	--
	(2)	1.79	3.96	13.7	4.0	4.4	4.8	--
	(3)	1.53	3.35	11.7	--	--	--	--

(1) Standard error of the difference between a treatment mean that does not contain an estimate of a missing value and one that does.

(2) Standard error of the difference between the means of the treatment containing estimates of the missing value.

(3) Standard error of the difference between treatment means that do not contain an estimate of the missing value.

Varieties, Davis, EC 26691, EC 39824, EC 39824 and Ankur also recorded statistically comparable values. Varieties with the shortest periods of growth were KB 74 and KB 38 A (92 and 91 days, respectively). Comparison with the two seasons would indicate that the varietal trends remained nearly the same. It would also indicate that it took much longer during 1989 for the crop to come to harvest. Differences in the dates of sowing are attributable to this seasonal difference.

5. Yield (Table 47, Fig. e)

During 1988, data were analysed in two ways following the analysis of covariance, one excluding the missing varieties, Monetta and Himzo-1531 and the other excluding one replication. When analysis of covariance was done by excluding one replication, the F ratio for regression was found to be non-significant and hence only analysis of variance was done. Data presented as (2), therefore, relate to actual yield values. Also, missing plot technique was not applied in the case of yield data. The results of 1988 showed EC 26691 to be the highest yielder when analysed by both the methods. A number of varieties maintained statistical parity in yield with this highest yielder. Varieties with the lowest yield were PK 471, KB-74 and KB 38 A. During 1989, PLSO 18 recorded the highest yield of 2354 kg/ha in the open and many other varieties including the highest yielder of the first season maintained statistical parity with it. The variety with the lowest yield was DS-8320 whose yield was 770 kg/ha. Shading led to a marked decrease in yield of all the varieties. Under this condition, EC 26691 gave the highest yield of 1067 kg/ha. All the other varieties except KB 38 A and Davis maintained statistical parity with this highest yielder.

Table 47. Mean yield of soybean varieties at different shade levels

Varieties	1988 Yield (kg ha^{-1}) Open (1)	Open (2)	1989 Yield (kg ha^{-1}) Open	25% shade
V_1 (PLSO 18)	1233.4	1177.8	2354.0	949.7
V_2 (Monetta)	--	1263.5	1734.3	1004.7
V_3 (Davis)	1323.6	1574.6	1815.0	407.0
V_4 (KB 74)	729.7	637.0	1415.3	715.0
V_5 (Hardee)	1293.2	1113.1	1114.7	495.0
V_6 (Himso 1531)	--	1139.0	1771.0	557.3
V_7 (EC 63298)	1303.8	1413.3	1404.3	880.0
V_8 (PK 471)	928.5	729.9	1529.0	718.7
V_9 (KHS b-2)	1401.6	1475.1	2196.3	1019.3
V_{10} (EC 39824)	1071.0	1055.3	1510.7	773.7
V_{11} (JS 79-277)	1462.0	876.8	1631.7	872.7
V_{12} (EC 26691)	1592.2	1667.9	1793.0	1067.0
V_{13} (MACS-124)	1507.0	1429.9	1785.7	1026.7
V_{14} (DS-76-1-37-1)	1234.0	1478.2	1408.0	671.0
V_{15} (KB-38 A)	699.9	951.4	1305.3	326.3
V_{16} (DS-83-20)	1211.3	1188.7	770.0	469.3
V_{17} (Bragg 88)	--	--	1837.0	916.7
V_{18} (Ankur)	--	--	1958.0	799.3
V_{19} (Improved Pelican)	--	--	1818.7	597.7
V_{20} (EC 29824)	--	--	1895.7	608.7
SEm ±	68.9	69.1	325.7	228.3
CD (0.05)	215.6	199.8	932.3	653.4

(1) Data analysed by deleting two varieties, Monetta and Himzo 1531.

(2) Data analysed by deleting one replication.

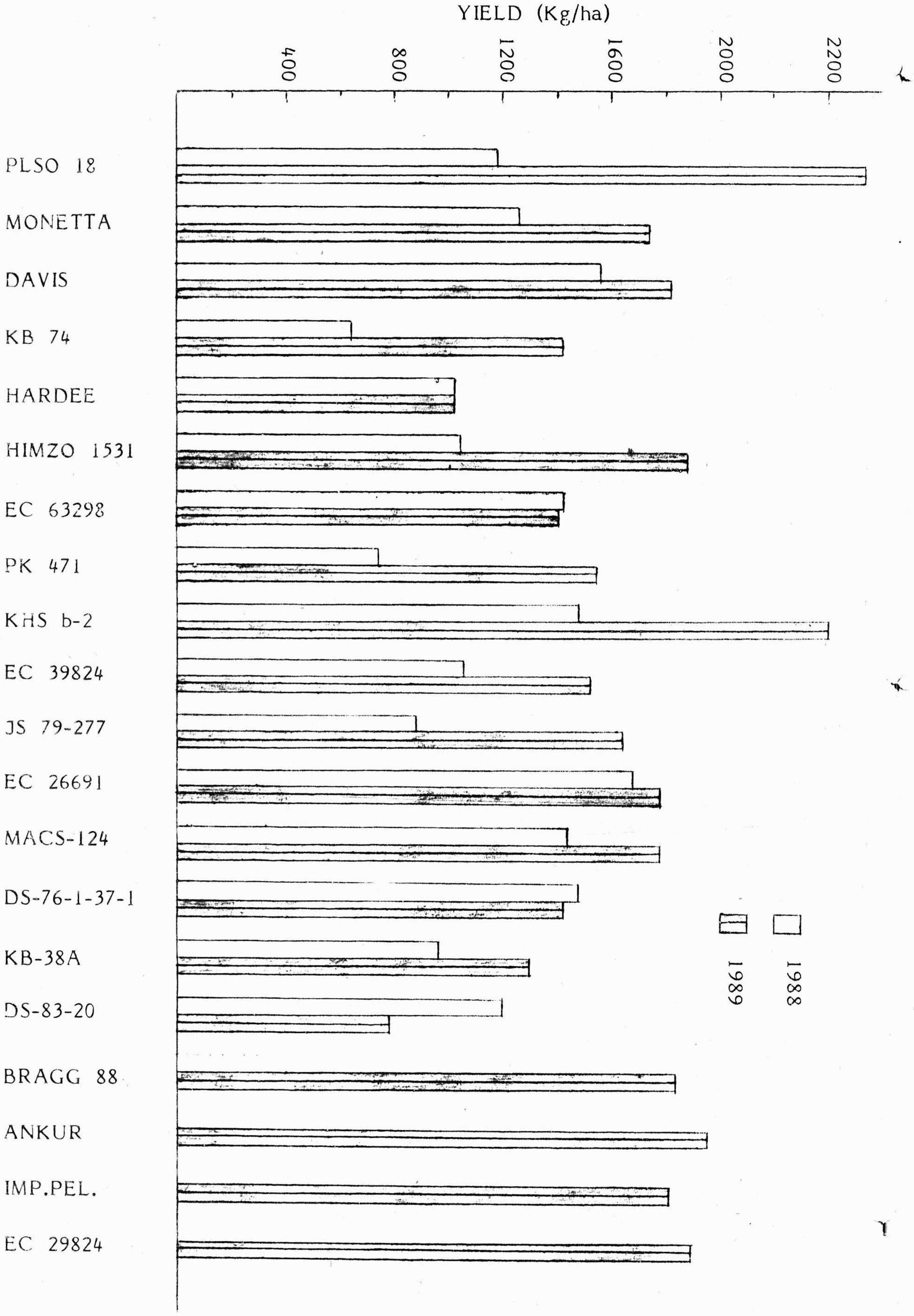


Fig.e YIELD OF SOYBEAN VARIETIES IN THE OPEN

As all the soybean varieties tested failed under 25, 50 and 75 per cent shade levels during 1988, as all of them failed at 50 and 75 per cent shade during 1989 also and as yields were substantially affected even at the low shade of 25 per cent during 1989, soybean is to be classed as shade-sensitive. Such a shade response also will make soybean totally unsuitable for intercropping under shaded conditions. As was pointed out elsewhere, growth of this crop under shade appeared abnormal from the very beginning. During 1988 when sowing was delayed and was done during the period of heavy rains after the onset of monsoon, the long and thin branches produced under shade tended to fall on the ground. These later decayed. There was total crop failure, thus, at all shaded conditions. During 1989 also, the pattern was idential but as sowing could be done earlier, the crop at the low shade level survived and could be taken to maturity. Yield levels were, of course, much lower than in the open. At the higher shade levels of 50 and 75 per cent, the crop failed during 1989 also.

In the open, all the varieties came up very well during both the seasons. The variety with the highest yield was EC 26691 during 1988 and PLSO 18 during 1989. Many other varieties like Monetta, Davis, EC 63298, EC 39824 and EC 26691 were also of comparable performance. All these varieties were already tested earlier for their performance at the location and were all found suitable. They grew luxuriantly and their interspaces were fully covered in about 40 days. Varieties, KB-74, Himzo 1531, PK 471, KHS b-2, JS 79-277, MACS 124, DS 76-1-37-1, KB-38 A and DS 83-20 were subsequent introductions from the University of Agricultural Sciences, Bangalore and all these were shorter in growth and their canopy coverage was poor. Their stand was also poor because of germination problem in 1988. During 1989 when sowing was done in time, when poor germination was compensated by higher seed rate and when the required crop stand could be maintained, at least some of these new varieties gave good, comparable yields eventhough their growth habits were different and canopies poor. The new varieties with good performance were KHS b-2 which came up as the second best, Himzo 1531, PK 471, JS 79-277 and MACS-124.

6. Thousand seed weight (Table 47)

As expected, varieties showed a lot of difference in seed size, the range in thousand seed weight being from 72 g in EC 39824 to 178 g in EC 63298 during 1988 and from 72 g in EC 63298 to 138 g in EC 63298 in 1989.

7. Quality of produce (Table 46)

Quality of soybean was assessed as protein content in grain which ranged from 23.4 per cent in MACS-124 to 36.6 per cent in KHS b-2. Quality assessment of soybean was not done during 1989.

E. LIGHT INFILTRATION THROUGH COCONUT CANOPY

Measurements of light infiltration through coconut canopy were taken since 1989 using line quantum sensor and point quantum sensor simultaneously. The component measured was photosynthetically active radiation (PAR). The line quantum sensor was placed in the coconut interspace and the point quantum sensor outside in an open area. A data logger was attached to the two sensors to record the values at every five or ten seconds to finally work out the hourly mean and store them for subsequent retrieval. It was originally thought that measurements for short periods of about an hour would be taken from a situation and that a very large number of such situations would be covered. Each situation was to represent a given age/height of coconut palm and a spacing. A regression model to arrive at light infiltration as a function of these two factors was expected to be worked out. Observations on light intensity in the interspaces, however, showed that the values varied widely depending on time of day, direction of placement of the sensor and the location. It was also not possible to identify a time interval of the day when infiltration rate would remain steady. As such, measurements were made from morning to evening from three locations of the same situation. The locations were the two sides and the centre and the sensor was always kept in the east-west direction. Centre represented the centre of four coconut palms and the sides, to the two adjacent sides. From each situation, therefore, recording was done at intervals of five seconds from morning till evening and data were collected for three days. The mean radiation for an hour from the values for five second intervals was worked out. These data along with those of point quantum sensor recorded in the open at the same intervals and those of percentage light infiltration are given in Table 48 and are presented graphically in Fig. 1 to 5 for 1990 and Fig. 1 to 14 for 1991. The overall mean percentage infiltration given along with the figures were calculated from all the hourly values whereas those in Tables were from the mean LQ and Q values of each location (The hours given in the **X-axis** of figures stand for the preceding one hour interval). The measurements were also handicapped by defective recording in some cases and leaving aside such values, there were only 19 situations from which dependable figures were available collected from 57 locations on 57 days. Data from five situations were collected in 1990 and 14 situations in 1991.

The results showed wide variations in the overall mean percentage light infiltration from as low as 28 to as much as 82 for the different situations and from 9 to 90 for the different locations. From the available data, attempts were made to work out simple correlation of light infiltration percentage with height of palms and spacing. Within the range of spacing from where measurements were made which was in the range from 6 m x 7 m to 9.8 m x 9.8 m, the simple correlation coefficient was not significant. Similarly, correlation with plant height in the range from 0.7 m to 16.3 m was also not significant. Clearly, the number of situations included in the study was inadequate to work out such a relationship.

However, it is also to be concluded that there are other variables that affect light infiltration, canopy size and canopy density being probably two of them. An important conclusion from these data collected using the best available equipment to measure light under crop canopies and over nearly the whole day at very frequent intervals is that the age - light infiltration relationship is not as simple as was reported earlier. To exclude young coconut plantations of upto 20 years from intercropping on the grounds that light penetration through the canopy will be low as is being now recommended also appears to be wrong.

Table 48. Radiation in the interspaces of coconut and in the open

Situation: Spacing (m^2)	Situation: Height (m)	Location	Date	Measurement	Radiation (micro moles m^{-2} s^{-1}): 9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	Mean
				LQ	232	342	299	1271	881	327	176	84	452
		Side I	16.1.90	Q	1075	1329	1595	1708	1639	1508	1210	783	1356
				Per cent	22	26	19	74	54	22	15	11	33
7.7x7.7	4.6			LQ	288	919	414	218	839	618	76	74	431
		Side II	18.1.90	Q	1112	1467	1553	1305	1630	1484	1126	640	1290
				Per cent	26	63	27	17	51	42	7	12	33
				LQ	182	334	214	920	567	192	162	136	338
		Centre	17.1.90	Q	1127	1439	1637	1773	1741	1513	1227	600	1382
				Per cent	16	23	13	52	33	13	13	23	24
				LQ	634	1071	1732	1246	878	1420	639	--	1089
		Side I	13.3.90	Q	1131	1536	1766	1318	1578	1543	1195	--	1438
				Per cent	56	70	98	95	56	92	53	--	76
9.8x9.8	16.3			LQ	528	1358	1681	1657	1620	492	713	--	1150
		Side II	14.3.90	Q	1079	1488	1736	1735	1711	1587	1210	--	1507
				Per cent	49	91	97	96	95	31	59	--	76
				LQ	--	1149	772	915	1428	1181	844	--	1048
		Centre	12.3.90	Q	--	1234	1148	1138	1492	1340	1174	--	1254
				Per cent	--	93	67	80	96	88	72	--	84

Situation		Location	Date	Measurement	Radiation (micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	--	113	74	174	65	132	274	--	139
		Side I	27.3.90	Q	--	1489	1581	1873	1761	1256	1110	--	1512
				Per cent	--	8	5	9	4	11	25	--	9
5.6x8.8	4.0			LQ	--	1345	1435	1369	1001	419	176	--	958
		Side II	31.3.90	Q	--	1614	1803	1822	1619	1103	894	--	1476
				Per cent	--	83	80	75	62	38	20	--	65
				LQ	222	343	425	624	920	377	154	--	438
		Centre	24.3.90	Q	914	1395	1346	1049	1251	1037	723	--	1102
				Per cent	24	25	32	59	74	36	21	--	40
				LQ	--	267	577	855	640	357	236	--	489
		Side I	11.4.90	Q	--	889	1428	1772	1527	1336	738	--	1282
				Per cent	--	30	40	48	42	27	32	--	38
7.0x7.0				LQ	733	808	856	662	698	1025	661	--	778
		Side II	3.5.90	Q	1256	1318	1619	1272	1399	1471	1087	--	1346
				Per cent	58	61	53	52	50	70	61	--	58
				LQ	720	920	1468	1072	1452	819	564	--	1002
		Side III	2.5.90	Q	1119	1308	1670	1239	1668	1605	1254	--	1409
				Per cent	64	70	88	87	87	51	45	--	71

Situation: Spacing (m^2)	Situation: Height (m)	Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1}): 9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	Mean
				LQ	--	262	947	1589	1494	533	271	--	849
		Side I	15.5.90	Q	--	1307	1664	1934	1850	1583	1205	--	1591
				Per cent	--	20	57	82	81	34	22	--	53
				LQ	744	942	502	781	797	900	456	--	732
7.0x7.0	2.8	Side II	16.5.90	Q	1024	1450	1645	1700	1896	1542	1275	--	1505
				Per cent	73	65	31	46	42	58	36	--	49
				LQ	--	320	331	396	485	815	540	--	481
		Centre	7.5.90	Q	--	660	685	800	998	1441	1092	--	946
				Per cent	--	48	48	50	49	57	49	--	51
				LQ	122	307	1115	394	151	227	267	25	326
		Side I	9.3.91	Q	847	1070	1431	1736	1021	1088	820	105	1015
				Per cent	14	29	78	23	15	21	33	24	32
				LQ	--	158	165	1000	827	328	133	18	376
7.5x7.5	5.4	Side II	11.3.91	Q	--	894	1281	1679	1496	1239	1065	216	1124
				Per cent	--	18	13	60	55	26	12	8	33
				LQ	--	102	329	460	637	224	236	33	289
		Centre	8.3.91	Q	--	251	703	876	1421	1247	994	117	801
				Per cent	--	41	47	53	45	18	24	28	36

Situation		Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	--	244	195	586	1259	543	255	7	441
		Side I	12.3.91	Q	--	1334	1489	1707	1775	1475	745	22	1221
				Per cent	--	18	13	34	71	37	34	32	36
				LQ	--	1126	547	604	305	424	342	16	481
7.5x7.5	5.2	Side II	14.3.91	Q	--	1134	807	1040	1417	1539	1032	86	1008
				Per cent	--	99	68	58	22	28	33	19	48
				LQ	363	630	1330	1055	1272	367	191	20	654
		Centre	13.3.91	Q	899	1159	1555	1681	1544	1524	1128	100	1199
				Per cent	40	54	86	63	82	24	17	20	55
				LQ	--	529	555	1199	1014	644	418	76	634
		Side I	18.3.91	Q	--	1460	1720	1695	1652	1322	987	105	1277
				Per cent	--	36	32	71	61	49	42	72	50
				LQ	345	355	739	671	486	396	204	20	402
7.5x7.5	4.4	Side II	21.3.91	Q	912	985	1133	1297	1527	1247	940	95	1017
				Per cent	38	36	65	52	32	32	22	21	40
				LQ	--	435	1001	1393	1138	986	626	74	808
		Centre	20.3.91	Q	--	1163	1463	1590	1684	1472	1094	104	1224
				Per cent	--	37	68	88	68	67	57	71	66

Situation		Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	250	452	555	674	597	775	513	120	492
		Side I	23.3.91	Q	561	839	862	1269	1070	1053	990	230	859
				Per cent	45	54	64	53	56	74	52	52	57
				LQ	--	--	289	346	206	145	200	18	201
6.0x7.0	2.7	Side II	1.4.91	Q	--	--	1221	1188	1083	1010	863	92	910
				Per cent	--	--	24	29	19	14	23	20	22
				LQ	391	418	1082	958	881	832	387	42	624
		Centre	2.4.91	Q	949	1321	1512	1093	1201	1362	1007	89	1067
				Per cent	41	32	72	88	73	61	38	47	58
				LQ	713	1023	1039	1452	1191	1026	776	74	912
		Side I	4.4.91	Q	968	1356	1355	1694	1472	1334	1043	119	1168
				Per cent	74	75	77	86	81	77	74	62	78
				LQ	350	670	1106	640	623	483	394	48	539
7.0x7.0	1.9	Side II	5.4.91	Q	1246	1190	1567	952	1282	991	965	151	1043
				Per cent	28	56	71	67	49	49	41	32	52
				LQ	709	1305	1721	1426	992	1374	854	54	1054
		Centre	6.4.91	Q	1158	1607	1931	1595	1182	1541	1169	155	1292
				Per cent	61	81	89	89	84	89	73	35	82

Situation: Spacing (m^2)	Situation: Height (m)	Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1}): 9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	Mean
				LQ	515	1171	1121	1218	744	1093	575	51	811
		Side I	9.4.91	Q	923	1474	1428	1509	1006	1303	932	120	1087
				Per cent	56	79	79	81	74	84	62	43	75
				LQ	--	532	686	948	830	396	359	36	541
7.5x7.5	2.6	Side II	10.4.91	Q	--	1358	1790	1185	1125	1349	1048	88	1135
				Per cent	--	39	38	80	74	29	34	41	48
				LQ	834	1065	1270	1243	1166	1051	565	49	905
		Centre	11.4.91	Q	1088	1302	1497	1469	1409	1345	911	100	1140
				Per cent	74	82	85	85	83	78	62	49	79
				LQ	354	787	1223	1380	1097	820	524	20	776
		Side I	19.4.91	Q	931	975	1320	1476	1188	1353	1105	34	1048
				Per cent	38	81	93	93	92	61	47	59	74
				LQ	1025	983	994	904	899	1006	855	83	844
7.5x7.5	1.5	Side II	20.4.91	Q	1224	1152	1140	1020	1018	1216	1119	130	1002
				Per cent	84	85	87	89	88	83	76	64	84
				LQ	--	1245	1337	1324	1256	1203	692	64	1017
		Centre	21.4.91	Q	--	1455	1484	1408	1311	1276	997	66	1142
				Per cent	--	86	90	94	96	94	69	97	89

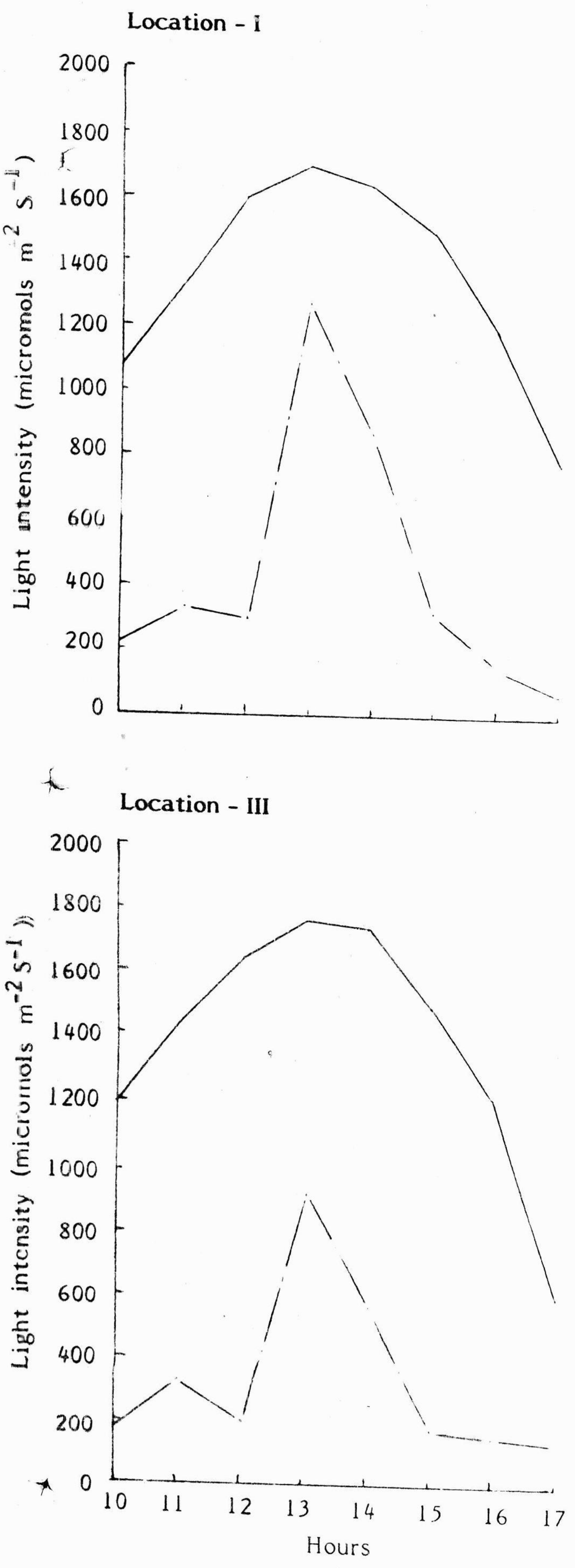
Situation		Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	263	248	223	429	281	252	573	--	324
		Side I	25.4.91	Q	787	1025	611	932	1237	1122	600	--	902
				Per cent	33	24	36	46	23	22	96	--	36
				LQ	195	481	590	207	277	197	120	10	260
8.0x7.0	16.0	Side II	26.4.91	Q	456	826	984	1048	1057	1027	704	35	767
				Per cent	43	58	60	20	26	19	17	29	34
				LQ	218	472	420	833	227	212	129	24	317
		Centre	27.4.91	Q	529	872	1210	1405	1314	965	438	35	846
				Per cent	41	54	35	59	17	22	29	69	37
				LQ	169	252	219	434	434	458	403	13	298
		Side I	29.4.91	Q	898	1149	1031	1171	972	1104	739	39	888
				Per cent	19	22	21	37	45	41	55	33	34
				LQ	226	544	337	227	416	270	142	47	276
8.3x8.3		Side II	30.4.91	Q	828	978	1062	1230	1402	1173	839	188	963
				Per cent	27	56	32	18	30	23	17	25	29
				LQ	93	130	144	94	175	152	103	--	127
		Centre	3.5.91	Q	252	331	367	230	652	527	380	--	391
				Per cent	37	39	39	41	27	29	27		32

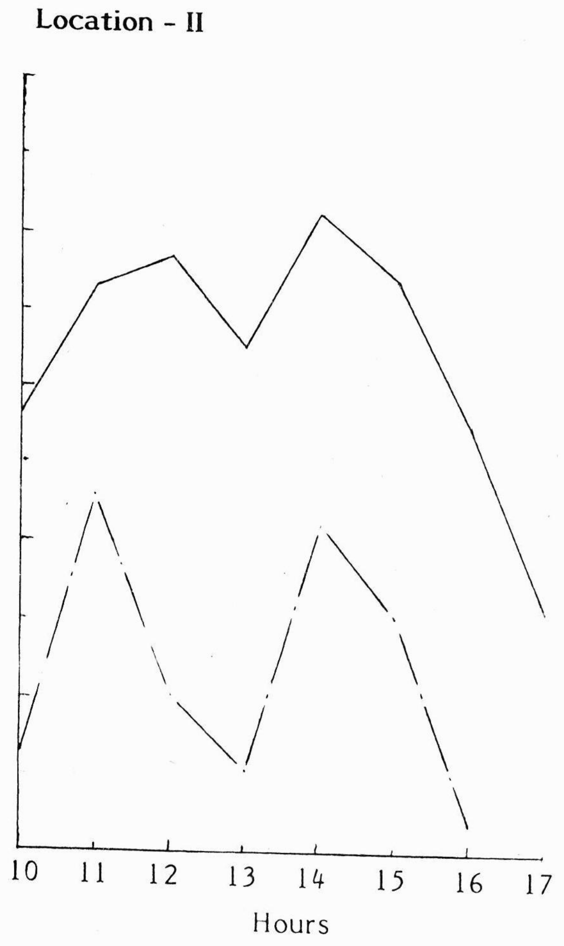
Situation		Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	463	942	436	274	165	140	72	--	356
		Side I	7.5.91	Q	913	1278	1104	1370	1527	1026	703	--	1131
				Per cent	51	74	39	20	11	14	10	--	32
				LQ	117	131	139	460	350	399	305	16	240
8.7x8.8	8.5	Side II	10.5.91	Q	1067	1321	1295	1255	1094	949	937	78	1000
				Per cent	11	10	11	37	32	42	33	21	24
				LQ	288	205	274	266	174	271	146	29	207
		Centre	13.5.91	Q	608	828	1319	901	668	1004	870	160	795
				Per cent	47	25	21	30	26	27	17	18	26
				LQ	629	752	869	1362	781	642	538	36	701
		Side I	17.5.91	Q	915	1002	1364	1557	1095	846	818	66	958
				Per cent	69	75	64	87	71	76	66	55	73
				LQ	225	275	339	224	504	291	270	167	287
8.0x7.0	17.0	Side II	20.5.91	Q	842	1321	1069	809	1097	1252	1007	429	978
				Per cent	27	21	32	28	46	23	27	39	29
				LQ	248	263	272	576	282	334	319	46	293
		Centre	23.5.91	Q	762	1090	1298	1318	1200	1233	925	189	1002
				Per cent	33	24	21	44	24	27	34	24	29

Situation		Location	Date	Measure-ment	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
				LQ	--	--	438	440	379	332	284	--	375
		Side I	16.7.91	Q	--	--	693	818	713	1008	728	--	792
				Per cent	--	--	63	54	53	33	39	--	47
				LQ	210	291	208	308	593	345	215	--	310
7.5x7.5	6.8	Side II	17.7.91	Q	493	678	531	924	1099	641	686	--	722
				Per cent	43	43	39	33	54	54	31	--	43
				LQ	--	275	85	125	219	169	142	--	169
		Centre	18.7.91	Q	--	518	190	295	631	473	417	--	421
				Per cent	--	53	45	42	35	36	34	--	40
				LQ	--	236	242	311	1081	854	371	--	516
		Side I	24.7.91	Q	--	990	1084	1100	1603	1201	675	--	1109
				Per cent	--	26	22	28	67	71	55	--	47
				LQ	--	326	495	468	439	588	173	--	415
7.5x7.5	6.2	Side II	25.7.91	Q	--	856	1079	1045	949	1071	506	--	918
				Per cent	--	38	46	45	46	55	34	--	45
				LQ	--	159	335	401	258	168	126	--	241
		Centre	26.7.91	Q	--	513	885	1011	883	550	403	--	708
				Per cent	--	31	38	40	29	31	31	--	34

Situation		Location	Date	Measurement	Radiation (Micromoles m^{-2} s^{-1})								Mean
Spacing (m^2)	Height (m)				9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	
		Side I	29.7.91	LQ	--	228	370	749	815	288	249	--	450
				Q	--	759	1334	1272	1110	559	557	--	932
				Per cent	--	30	28	59	73	52	45	--	48
7.5x7.5	6.6	Side II	1.8.91	LQ	--	238	275	276	280	289	234	--	265
				Q	--	459	507	497	525	533	435	--	493
				Per cent	--	52	54	56	53	54	54	--	54
		Centre	2.8.91	LQ	188	268	353	471	308	280	206	--	296
				Q	427	597	741	968	660	626	439	--	637
				Per cent	44	45	48	49	47	45	47	--	46

LQ - Line quantum sensor (shade) Q - Quantum sensor (open)





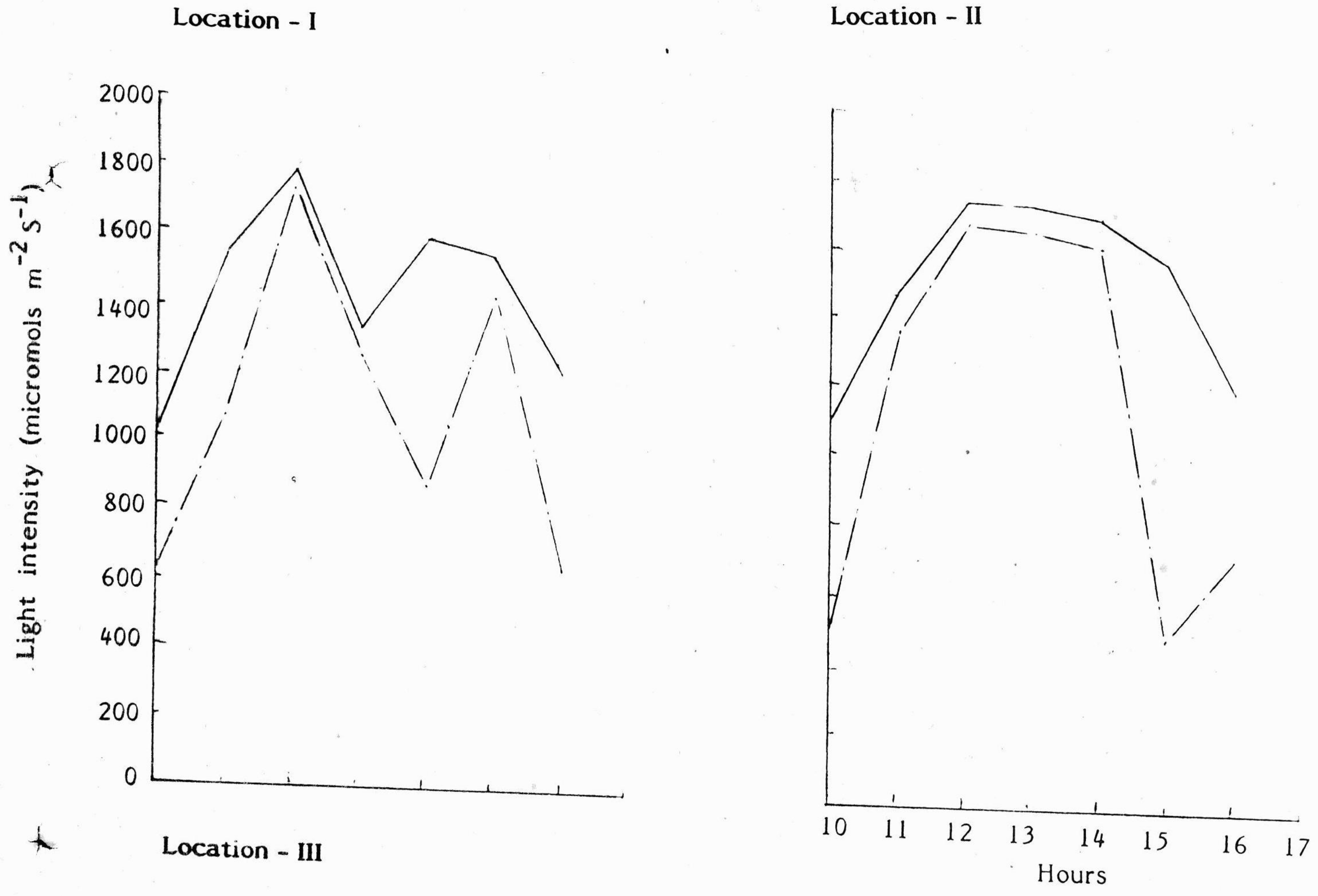
——— Light intensity in the open

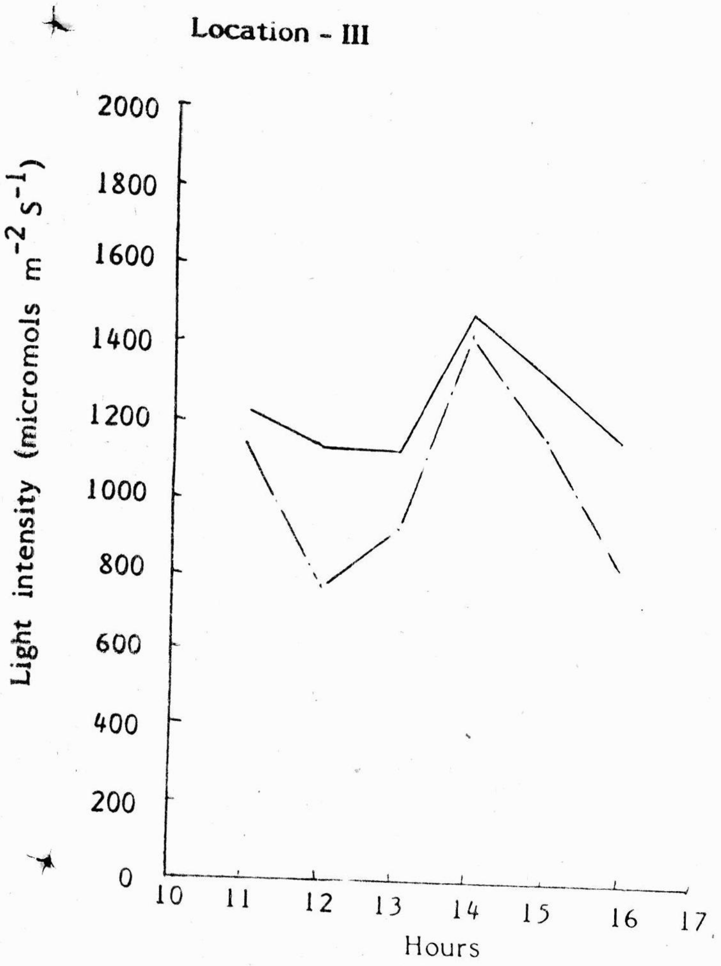
— · — Light intensity under coconut

Average height	4.6 m
Spacing	7.7 m x 7.7 m
Dates	16, 17, 18 January '90

Locations		Light infiltration (per cent)
I	Plant to plant	35
II	Plant to plant	35
III	Centre	25
	Mean	32

FIG.1 LIGHT INFILTRATION THROUGH COCONUT CANOPY



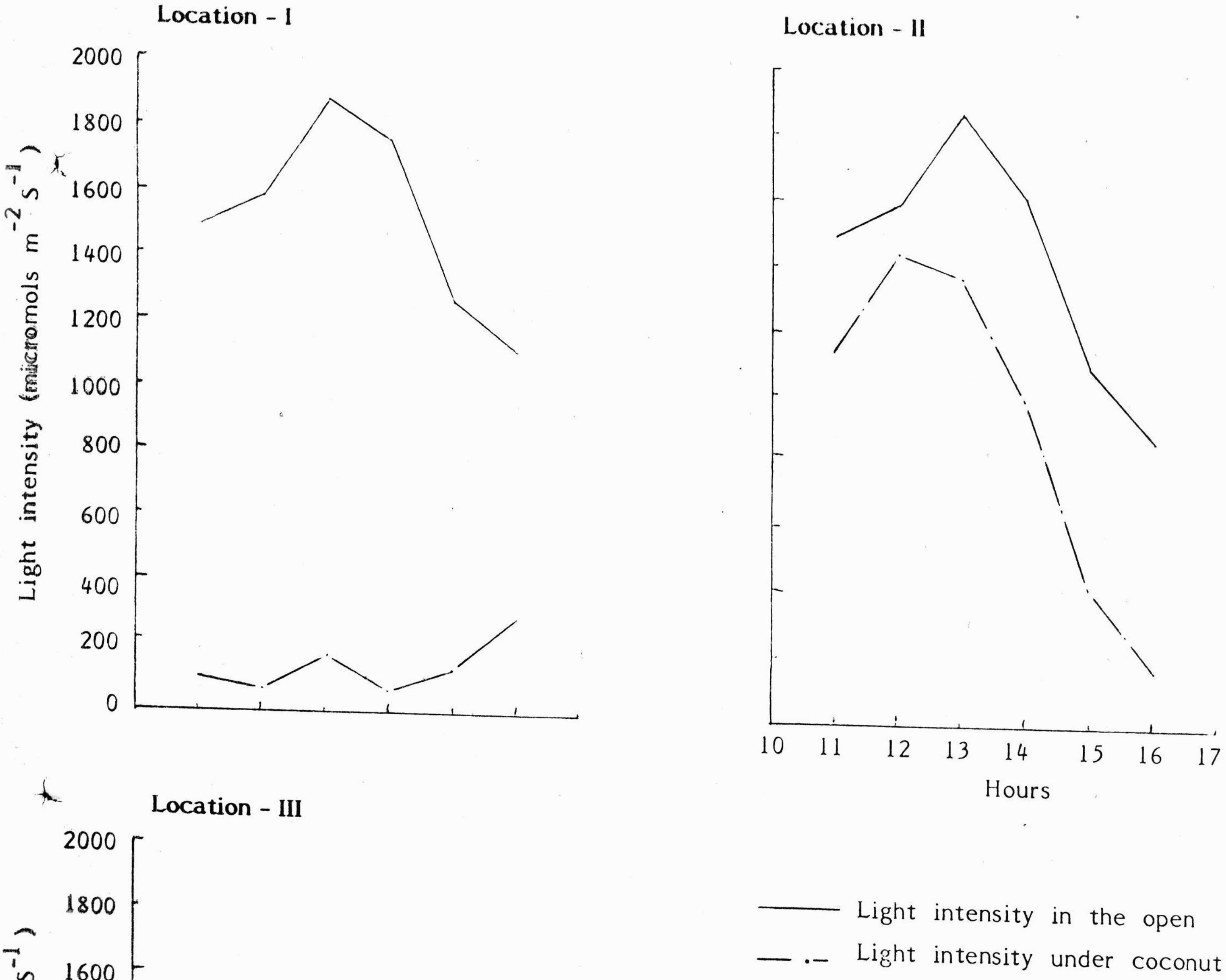


——— Light intensity in the open
—·— Light intensity under coconut

Average height 16.25 m
Spacing 9.8 m x 9.8 m
Dates 12, 13, 14 March '90

	Locations	Light infiltration (per cent)
I	Plant to plant	76
II	Plant to plant	76
III	Centre	84
	Mean	78

FIG.2 LIGHT INFILTRATION THROUGH COCONUT CANOPY



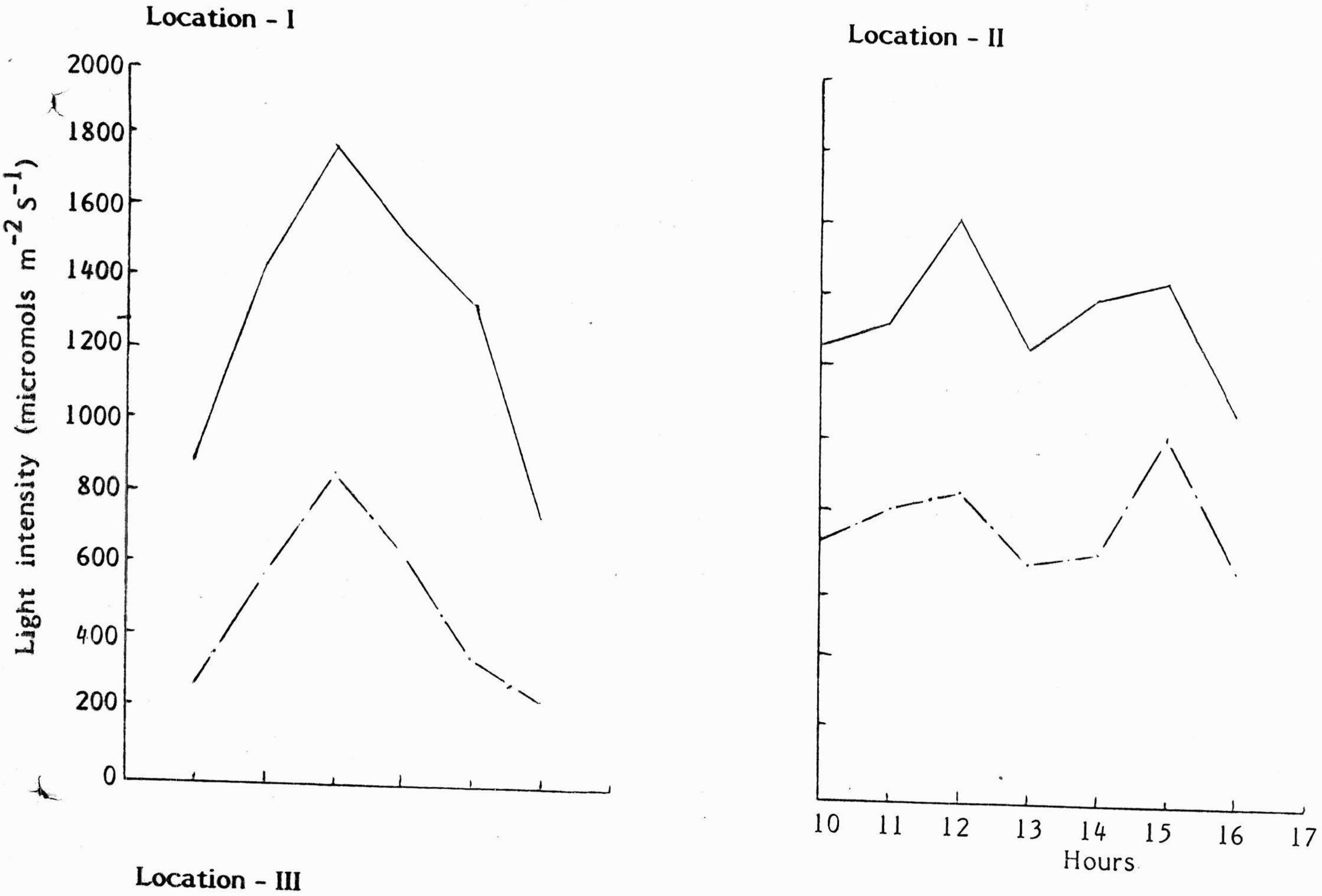
Average height 4 m

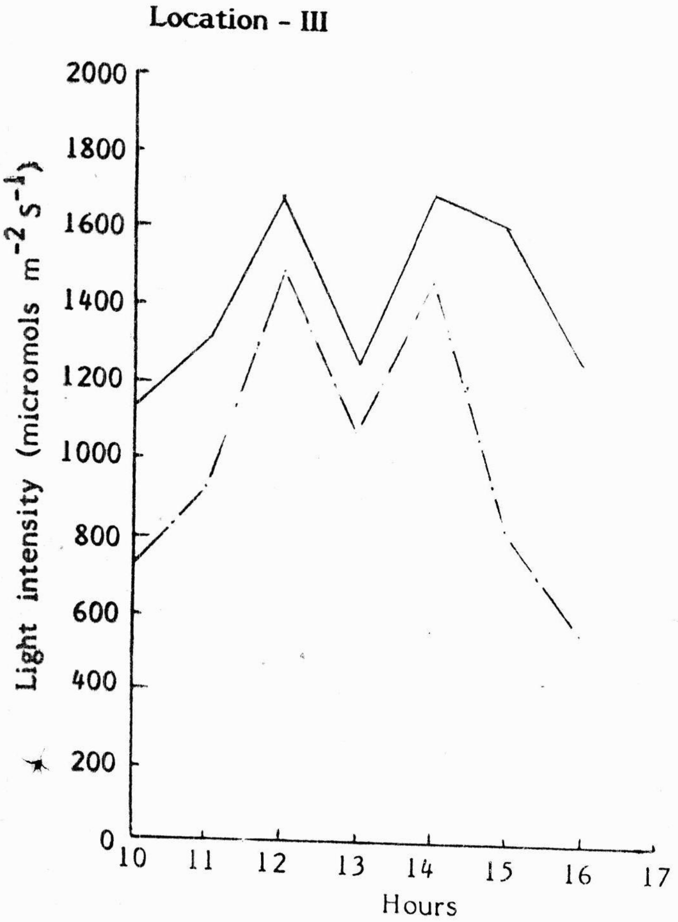
Spacing 5 6 m x 8.8 m

Dates 24, 27, 31 March '90

Locations		Light infiltration (per cent)
I	Plant to plant	9
II	Plant to plant	65
III	Centre	40
	Mean	38

FIG.3 LIGHT INFILTRATION THROUGH COCONUT CANOPY





——— Light intensity in the open

—.— Light intensity under coconut

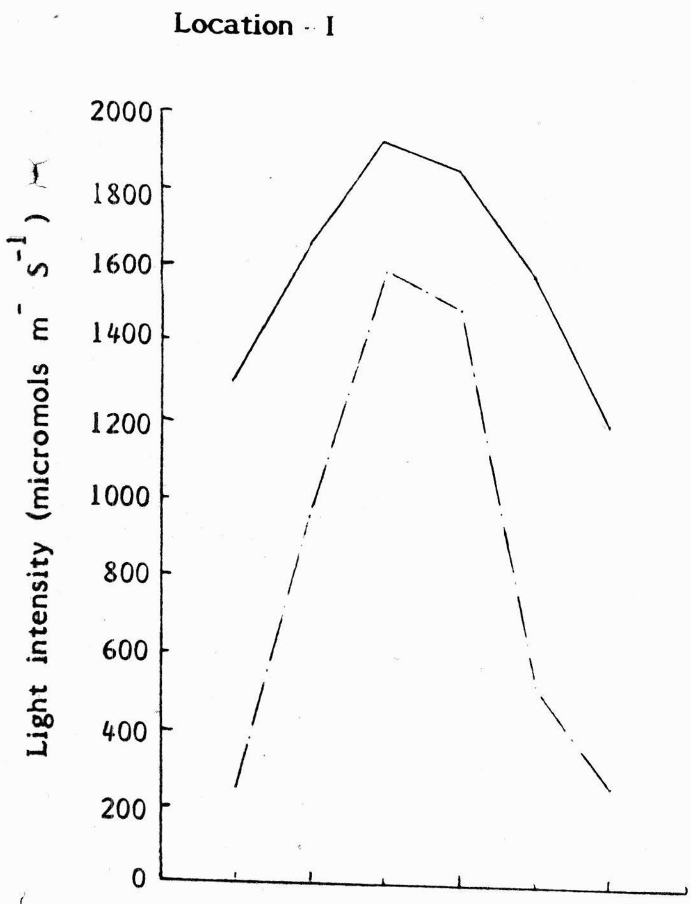
Average height 0.73 m

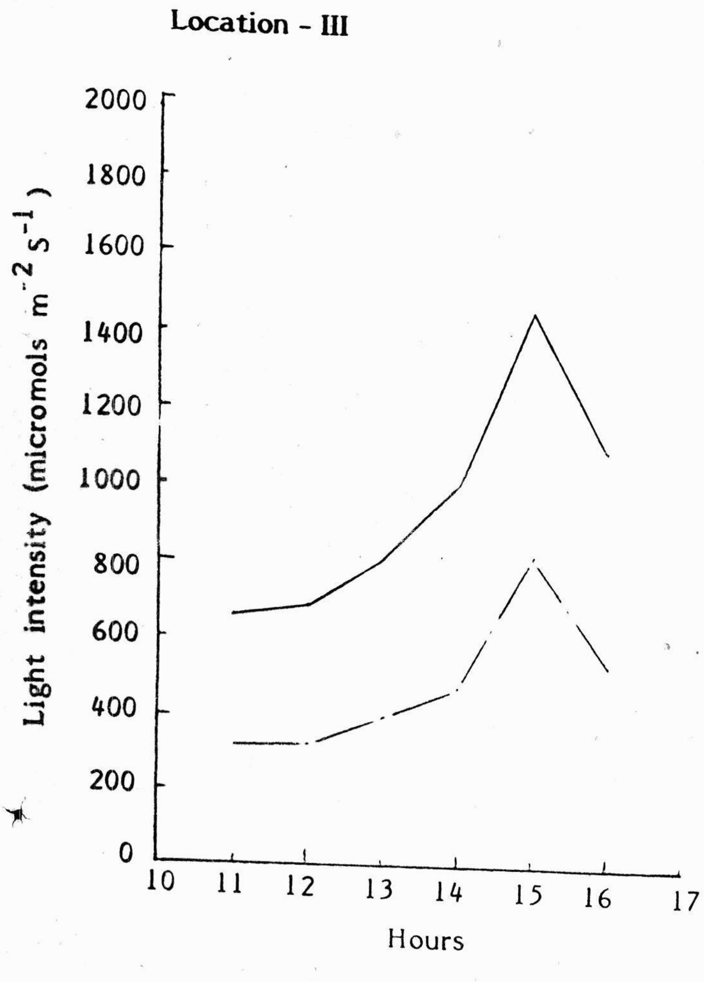
Spacing 7 m x 7 m

Dates 11 April, 2, 3 May '90

	Locations	Light infiltration (per cent)
I	Plant to plant	38
II	Plant to plant	58
III	Centre	71
	Mean	56

FIG.4 LIGHT INFILTRATION THROUGH COCONUT CANOPY





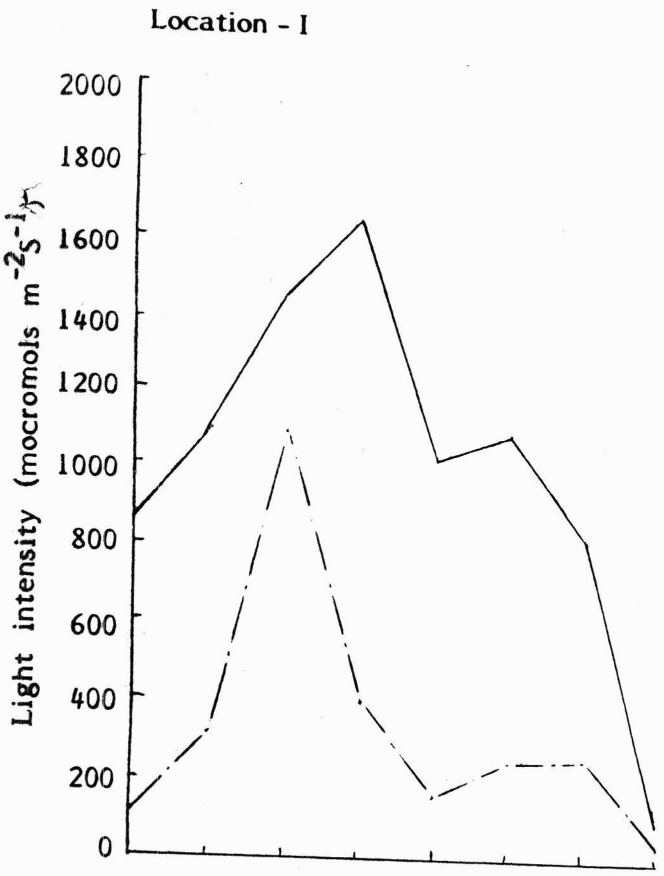
——— Light intensity in the open

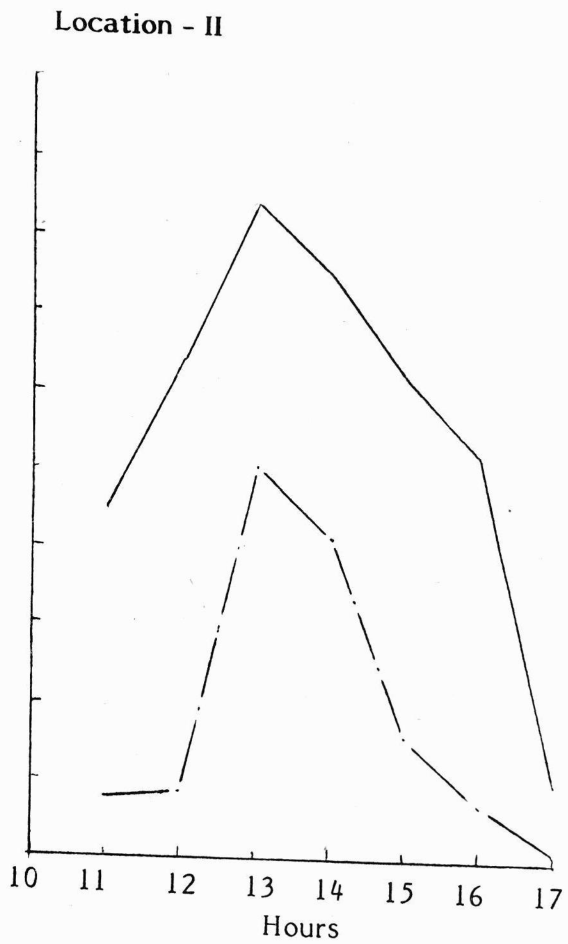
—.— Light intensity under coconut

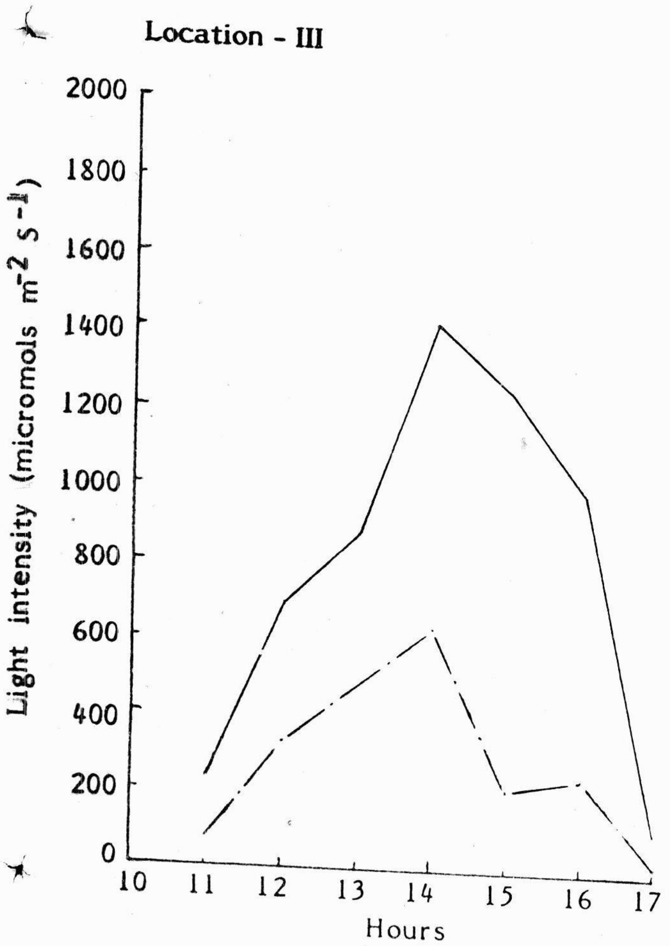
Average height	2.83 m
Spacing	7 m x 7 m
Dates	7, 15, 16 May '90

	Locations	Light infiltration (per cent)
I	Plant to plant	53
II	Plant to plant	49
III	Centre	51
	Mean	51

FIG.5 LIGHT INFILTRATION THROUGH COCONUT CANOPY







——— Light intensity in the open

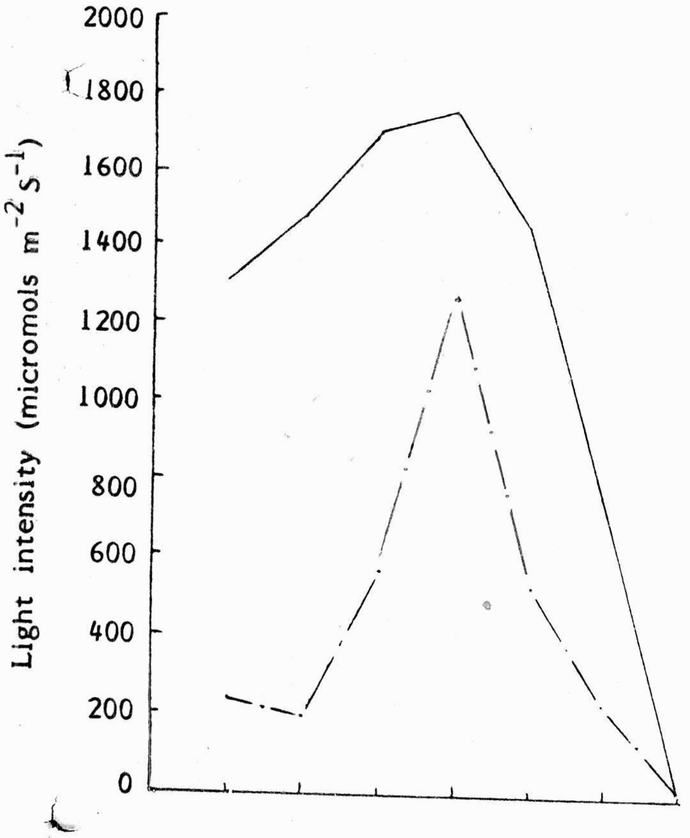
—·— Light intensity under coconut

Age of palms	14 years
Average height	5.4 m
Spacing	7.5 m x 7.5 m
Dates	8, 9, 11 March '91

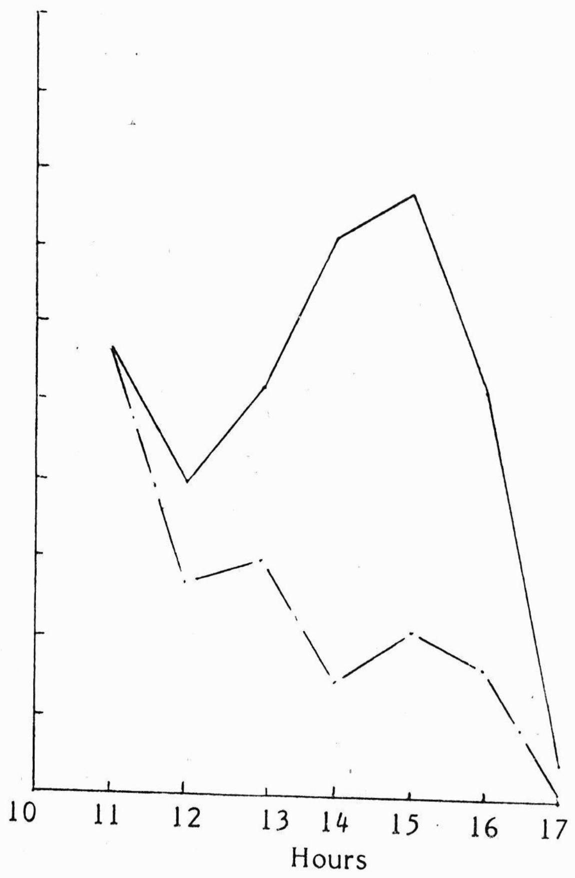
	Locations	Light infiltration (per cent)
I	Plant to plant	32
II	Plant to plant	33
III	Centre	36
	Mean	34

FIG.1 LIGHT INFILTRATION THROUGH COCONUT CANOPY

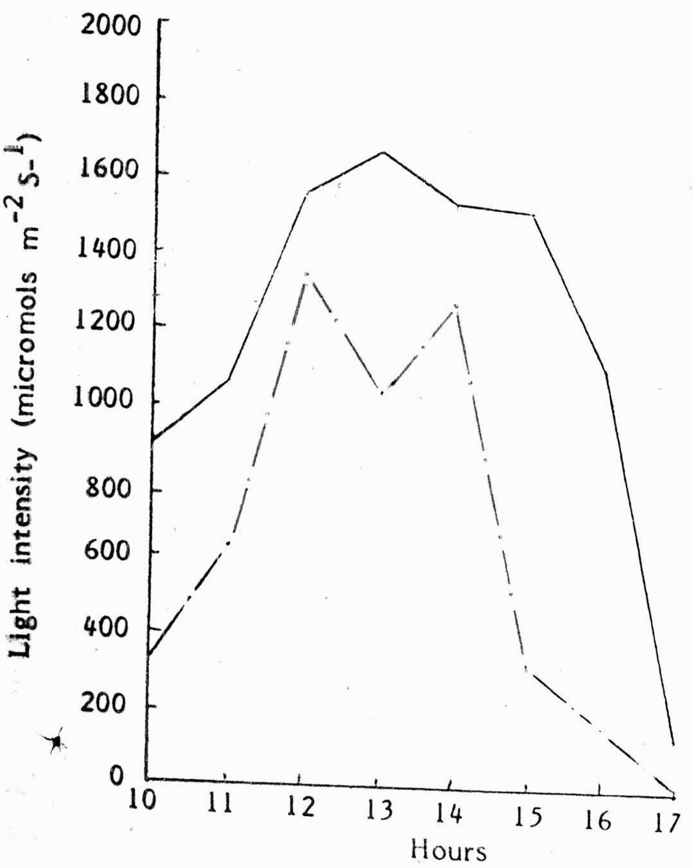
Location - I



Location - II



Location - III



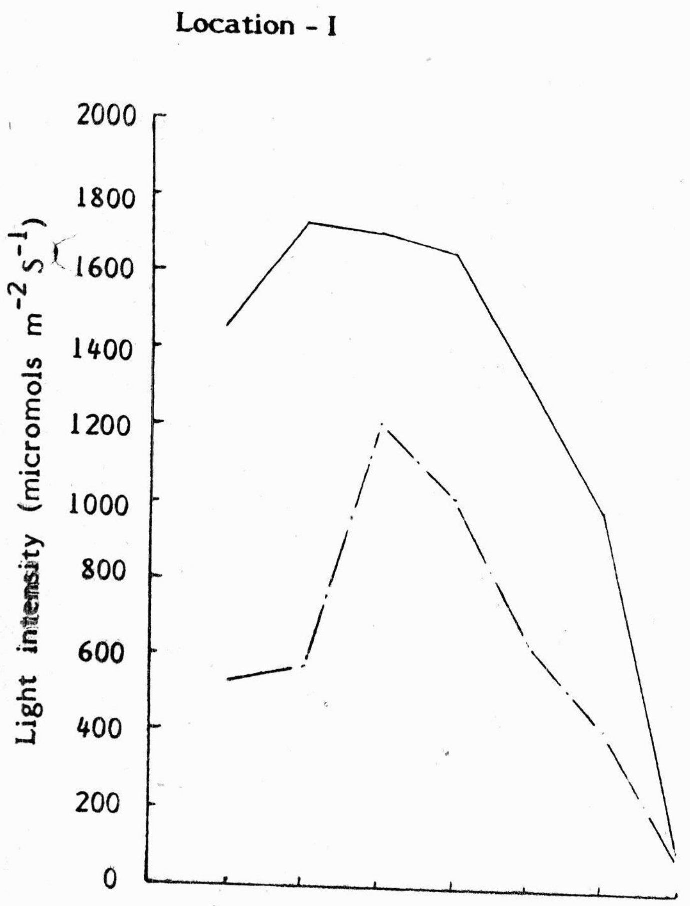
—— Light intensity in the open

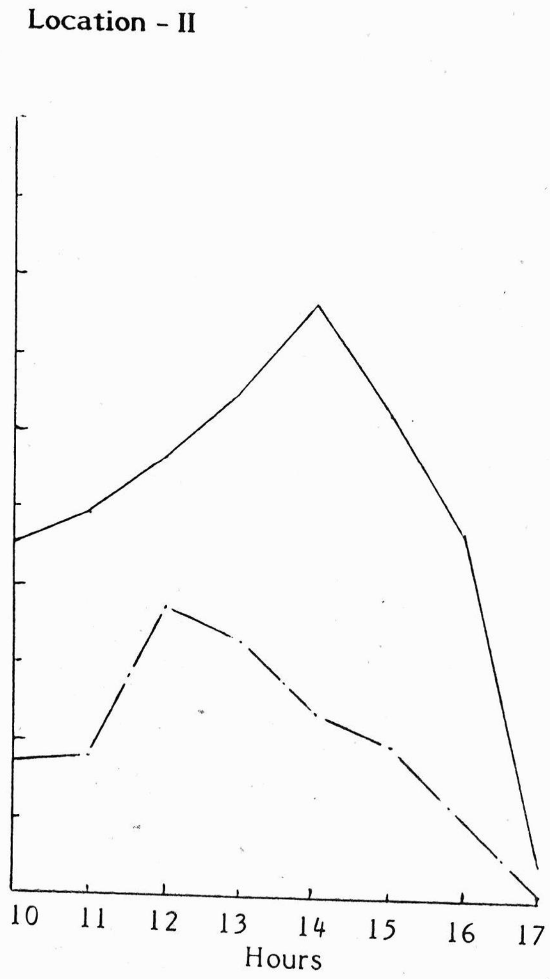
—·— Light intensity under coconut

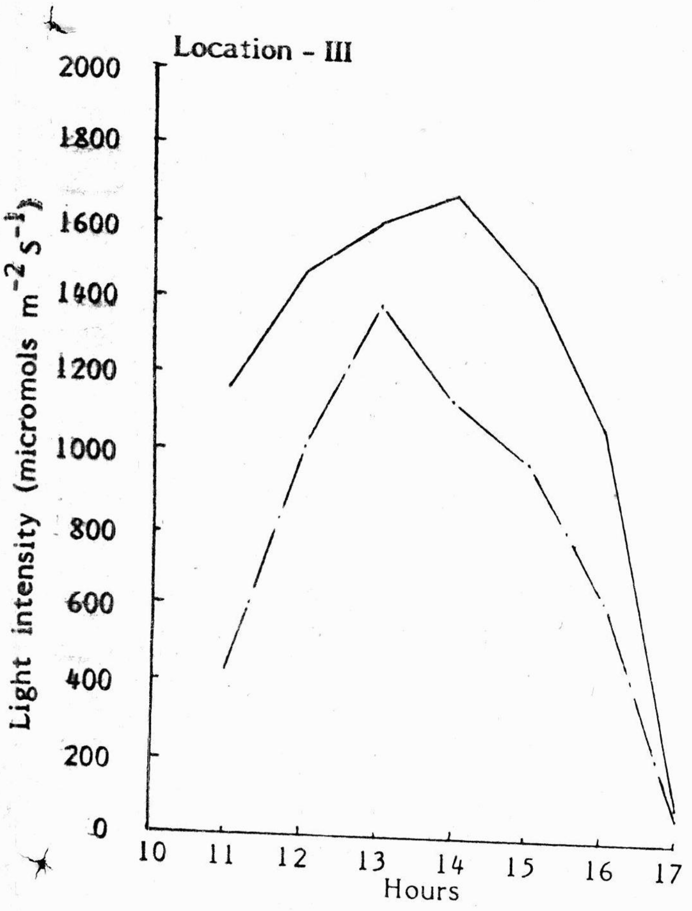
Age of palms	12 years
Average height	5.2 m
Spacing	7.5 mx 7.5 m
Dates	12, 13, 14 March '91

	Locations	Light infiltration (per cent)
I	Plant to plant	36
II	Plant to plant	48
III	Centre	55
	Mean	46

FIG.2 LIGHT INFILTRATION THROUGH COCONUT CANOPY







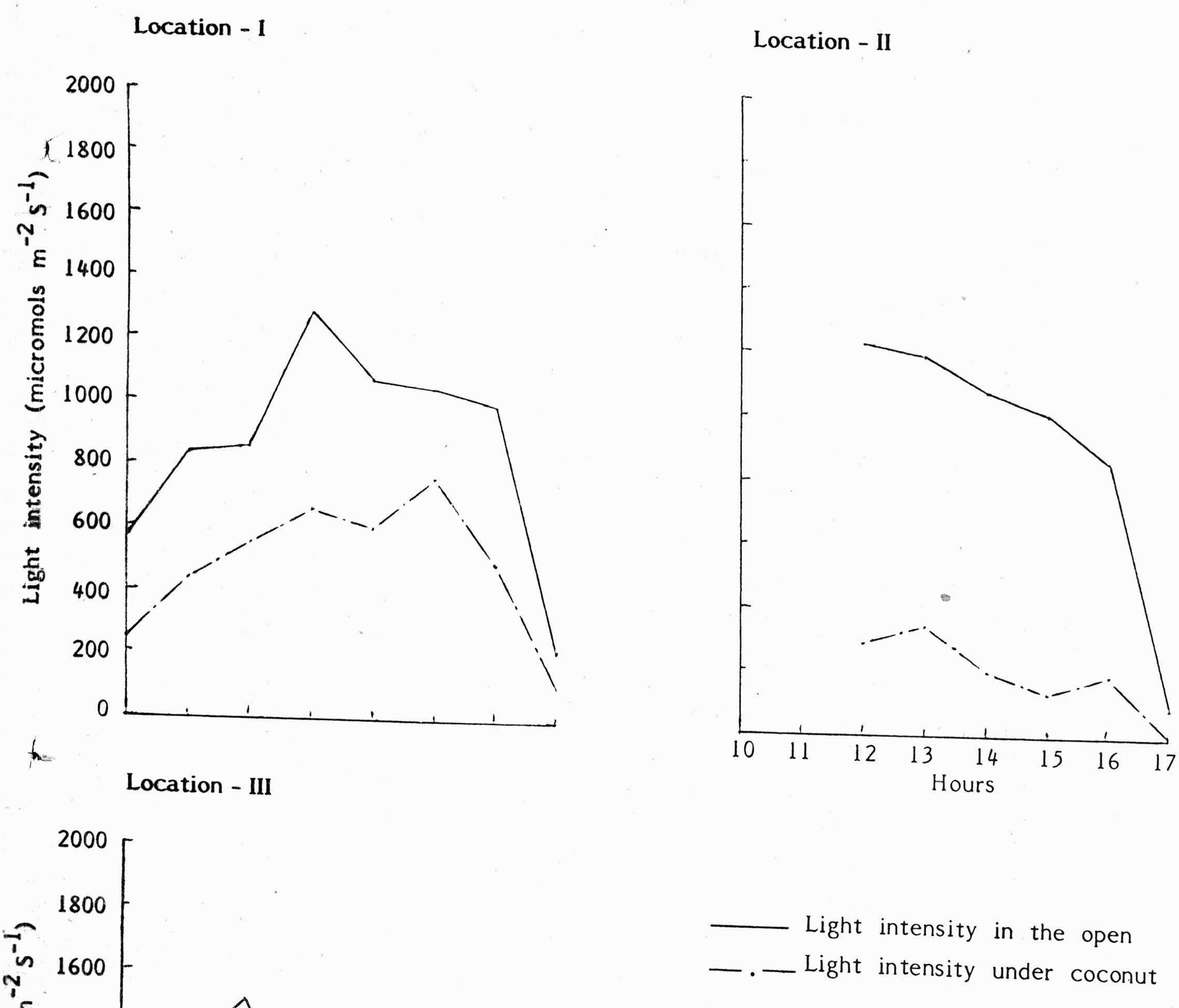
——— Light intensity in the open

—·— Light intensity under coconut

Age of palms	12 years
Average height	4.42 m
Spacing	7.5 m x 7.5 m
Dates	18, 20, 21 March '91

	Locations	Light infiltration (per cent)
I	Plant to plant	50
II	Plant to plant	40
III	Centre	66
	Mean	52

FIG.3 LIGHT INFILTRATION THROUGH COCONUT CANOPY

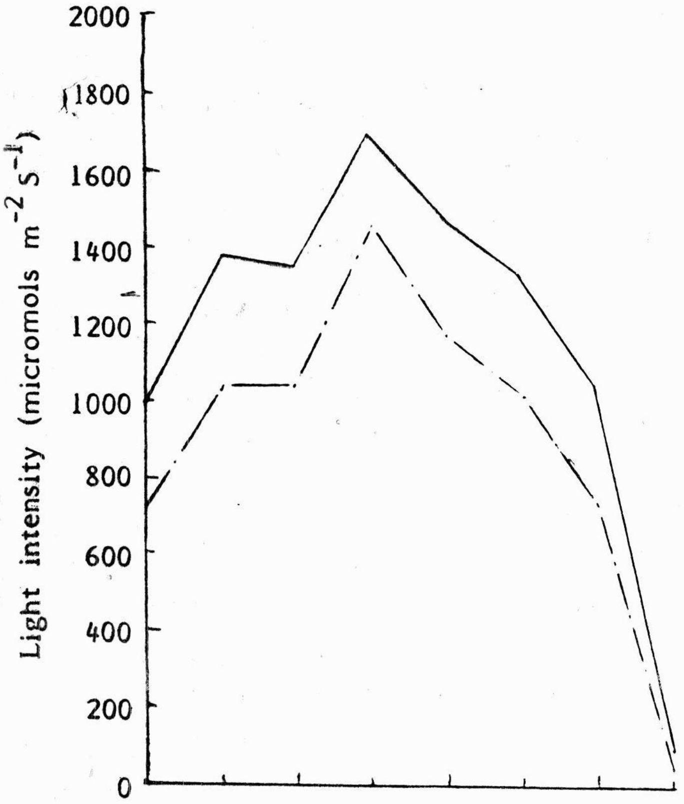


Age of palms	12 years
Average height	2.71 m
Spacing	6 m x 7 m
Dates	23 March, 1, 2 April '91

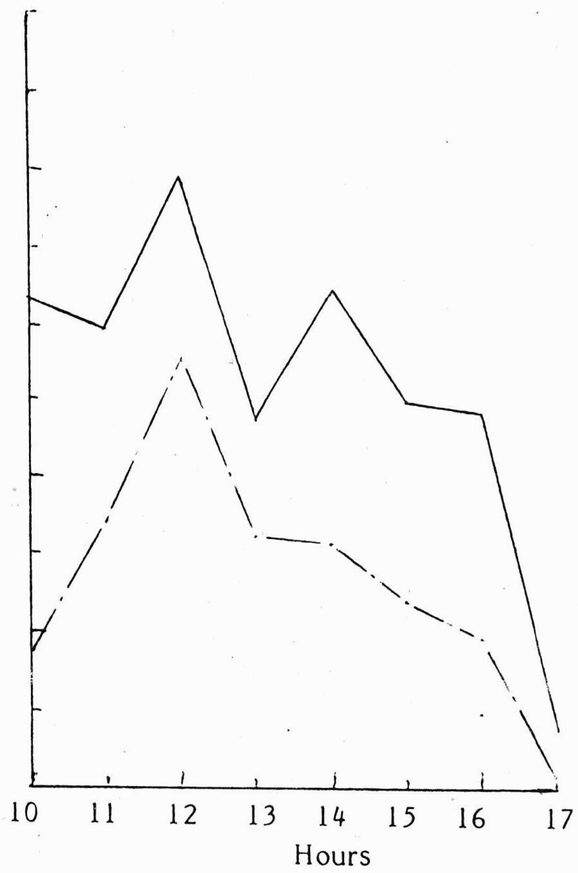
	Locations	Light infiltration (per cent)
I	Plant to plant	60
II	Plant to plant	22
III	Centre	59
	Mean	46

FIG.4 LIGHT INFILTRATION THROUGH COCONUT CANOPY

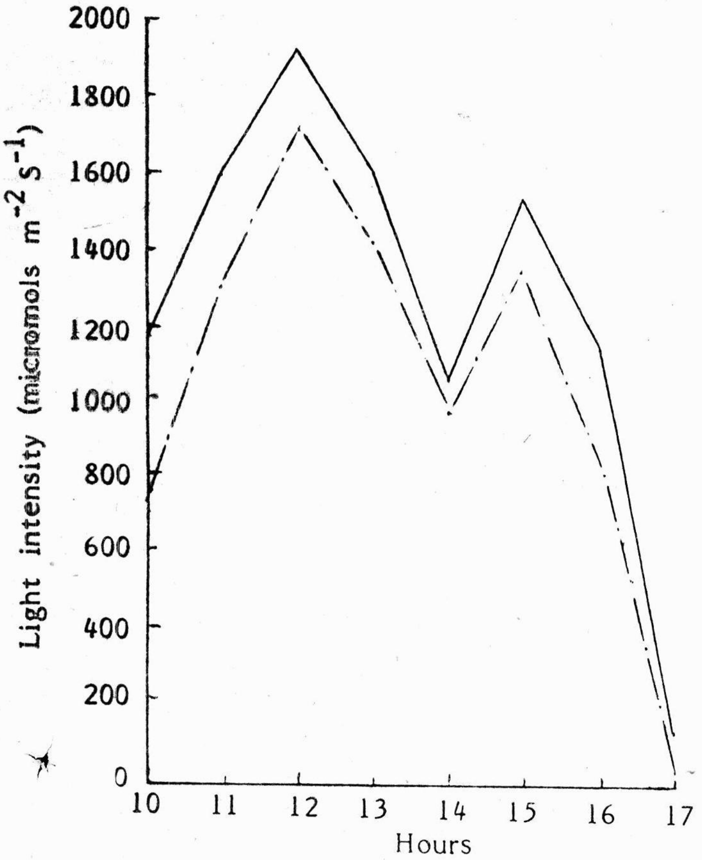
Location - I



Location - II



Location - III



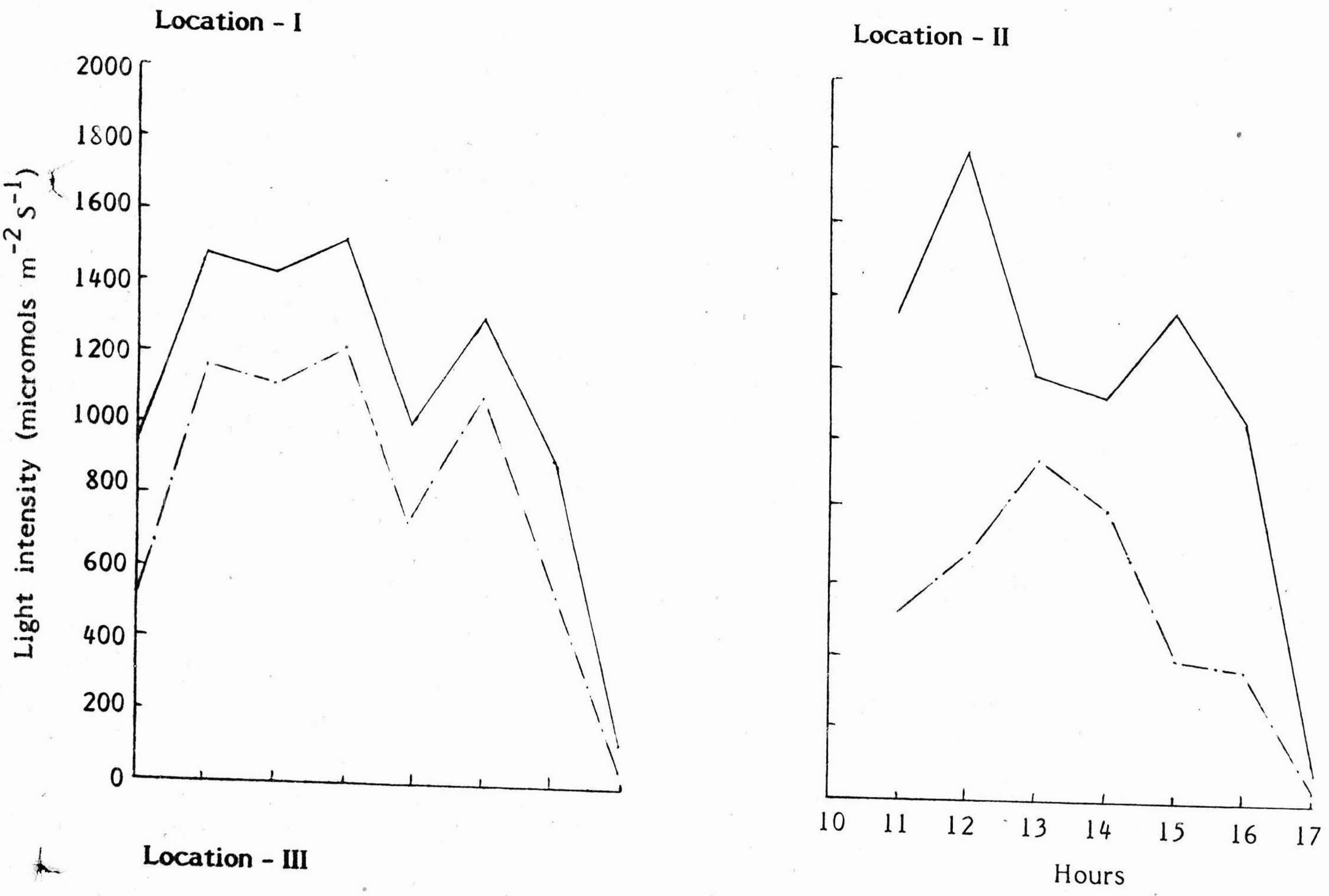
——— Light intensity in the open

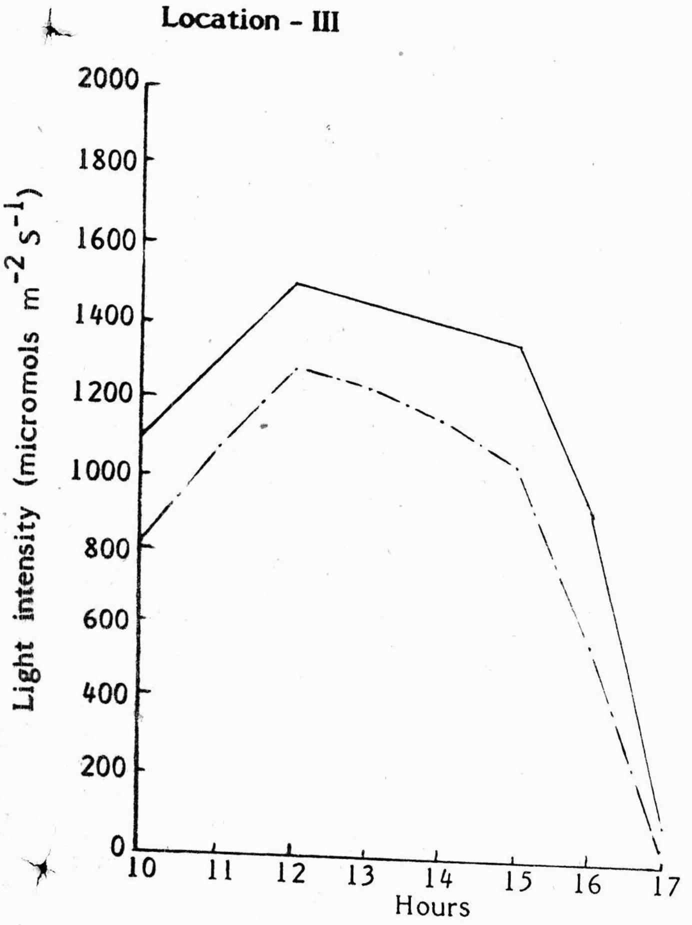
—.— Light intensity under coconut

Age of palms	9 years
Average height	1.9 m
Spacing	7 m x 7 m
Dates	4, 5, 6 April '91

	Locations	Light infiltration (per cent)
I	Plant to plant	78
II	Plant to plant	52
III	Centre	82
	Mean	71

FIG.5 LIGHT INFILTRATION THROUGH COCONUT CANOPY





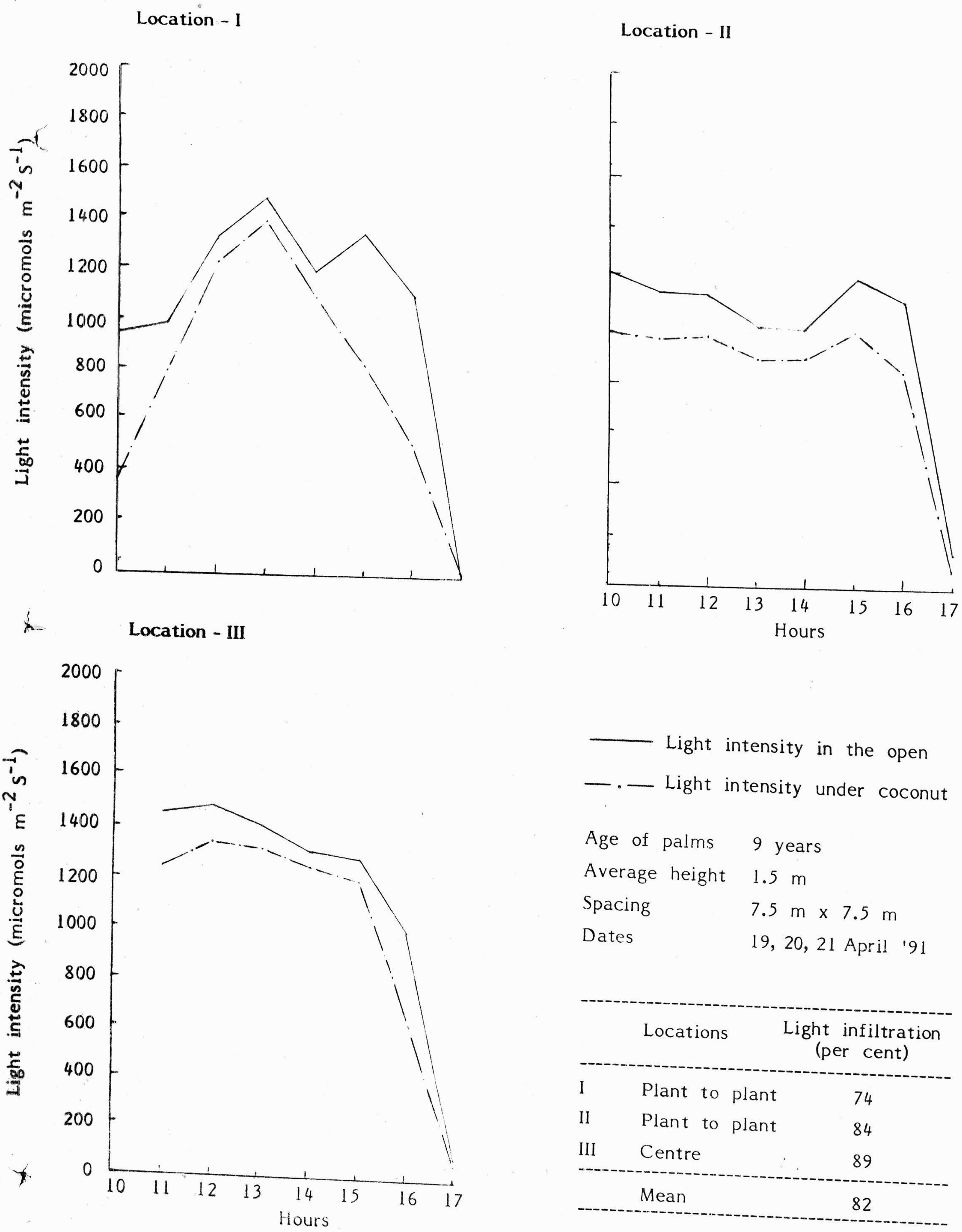
——— Light intensity in the open

—·— Light intensity under coconut

Age of palms	9 years
Average height	2.56 m
Spacing	7.5 m x 7.5 m
Dates	9, 10, 11 April '91

	Locations	Light infiltration (per cent)
I	Plant to plant	75
II	Plant to plant	48
III	Centre	79
	Mean	67

FIG.6 LIGHT INFILTRATION THROUGH COCONUT CANOPY

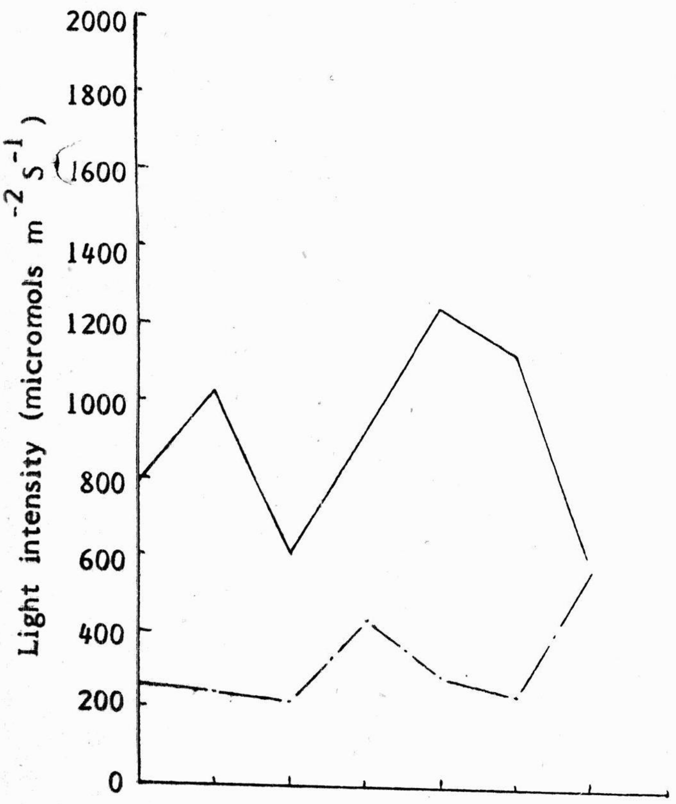


Age of palms	9 years
Average height	1.5 m
Spacing	7.5 m x 7.5 m
Dates	19, 20, 21 April '91

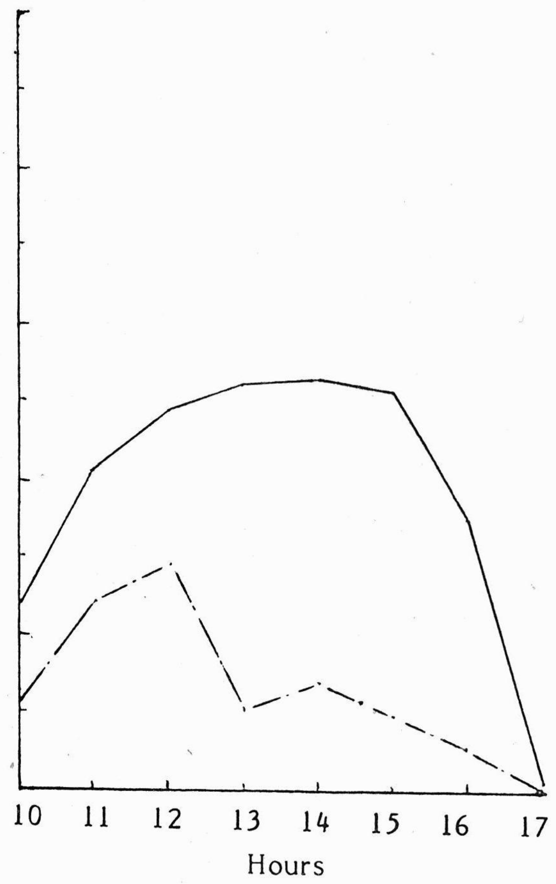
	Locations	Light infiltration (per cent)
I	Plant to plant	74
II	Plant to plant	84
III	Centre	89
	Mean	82

FIG.7 LIGHT INFILTRATION THROUGH COCONUT CANOPY

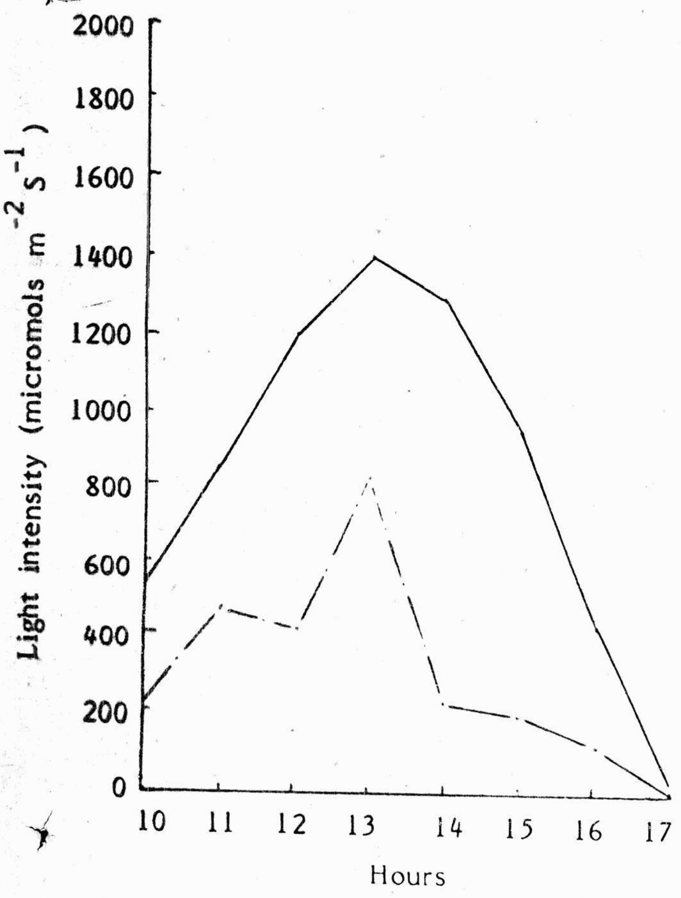
Location - I



Location - II



Location - III



——— Light intensity in the open

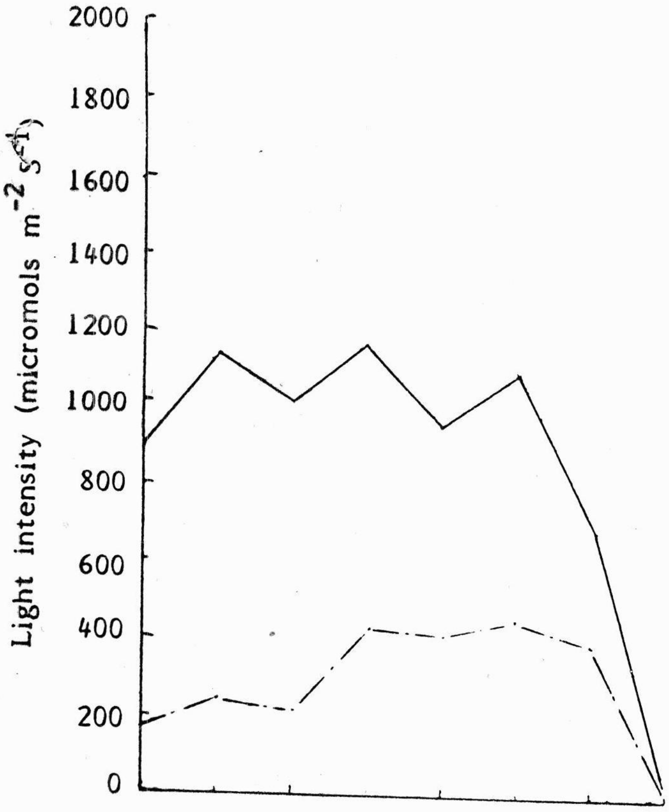
—.— Light intensity under coconut

Age of palms	30 years
Average height	16 m
Spacing	8 m x 7 m
Dates	25, 26, 27 April '91

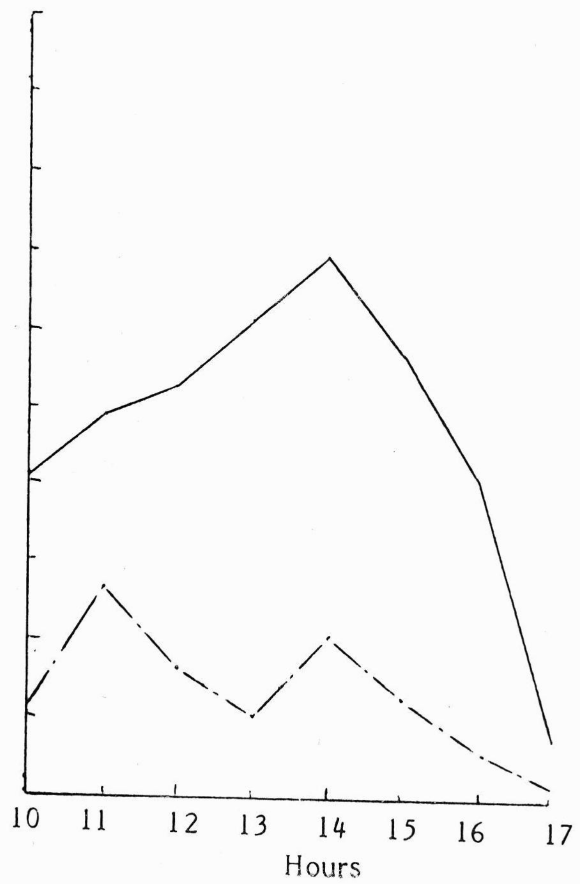
	Locations	Light infiltration (per cent)
I	Plant to plant	36
II	Plant to plant	31
III	Centre	38
	Mean	35

FIG.8 LIGHT INFILTRATION THROUGH COCONUT CANOPY

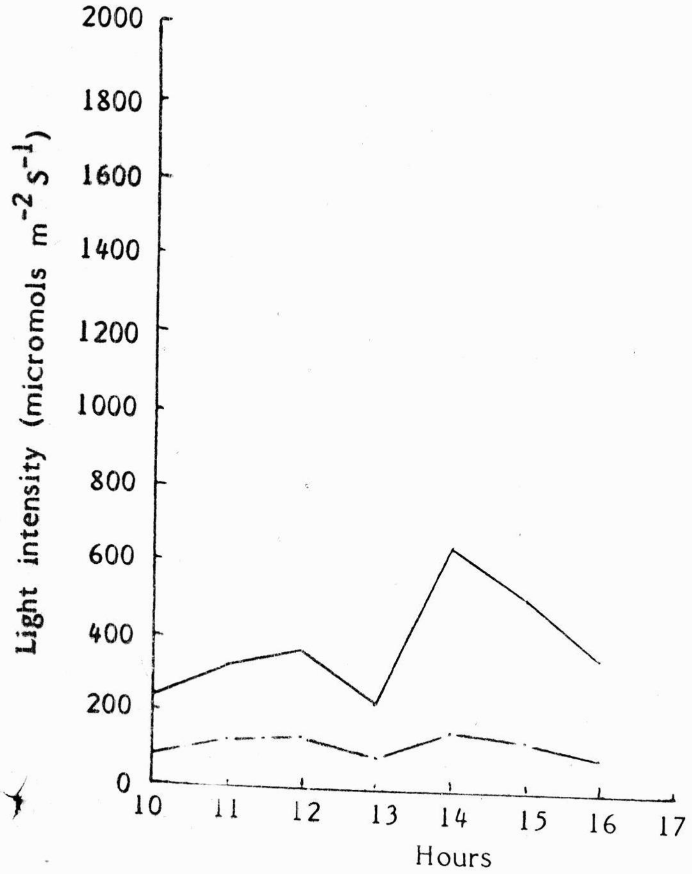
Location - I



Location - II



Location - III



——— Light intensity in the open

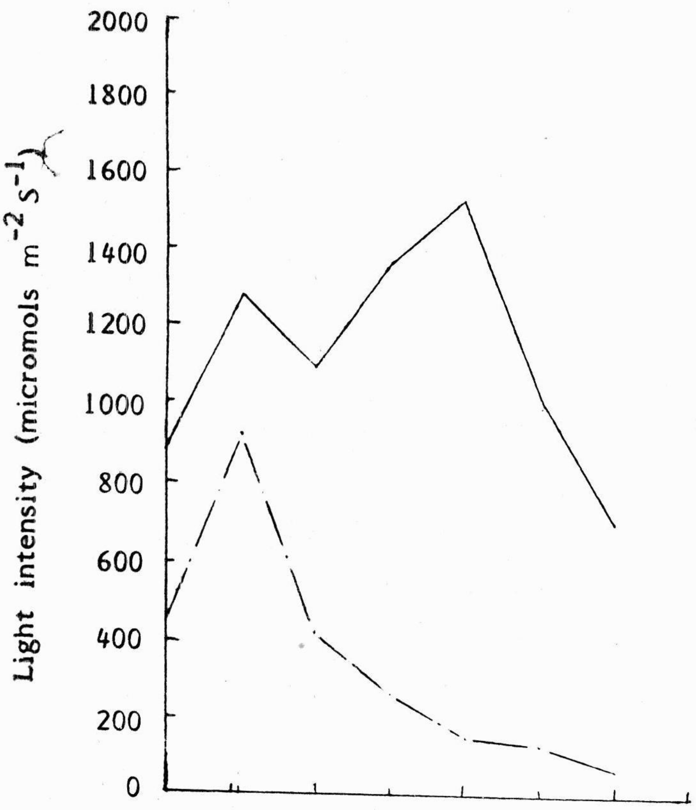
—.— Light intensity under coconut

Age of palms	15 years
Average height	10 m
Spacing	8.3 m x 8.3 m
Dates	29, 30 April, 3 May '91

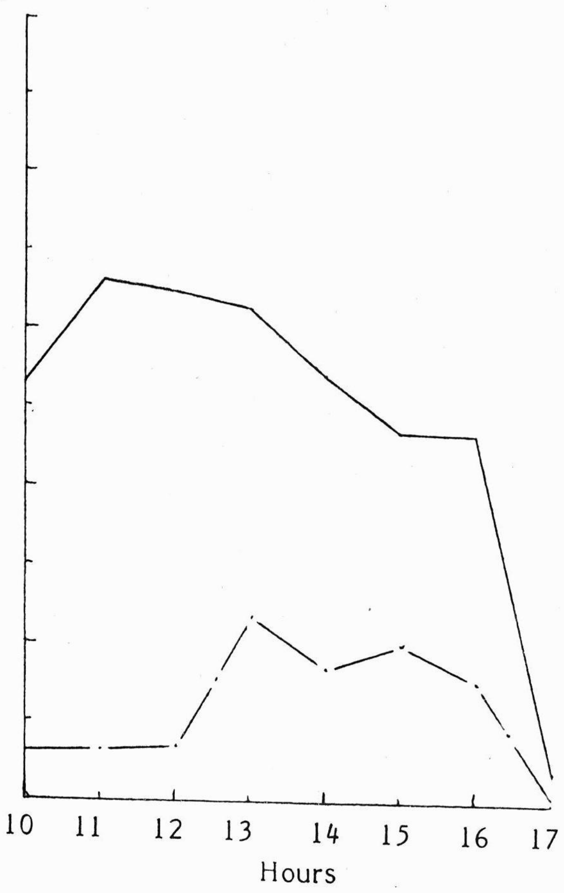
	Locations	Light infiltration (per cent)
I	Plant to plant	34
II	Plant to plant	29
III	Centre	32
	Mean	32

FIG.9 LIGHT INFILTRATION THROUGH COCONUT CANOPY

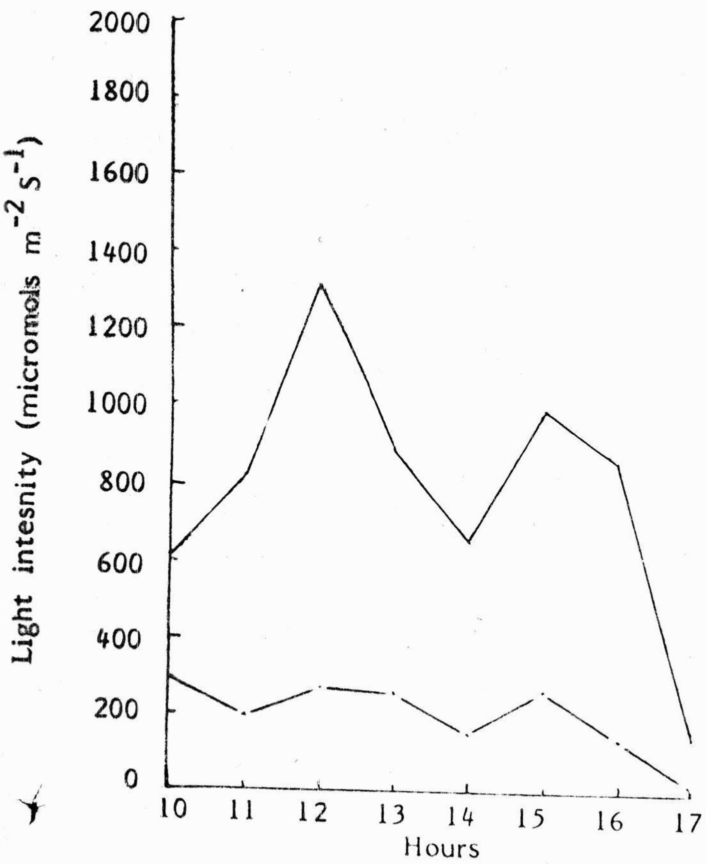
Location - I



Location - II



Location - III



——— Light intensity in the open

—·— Light intensity under coconut

Age of palms 15 years

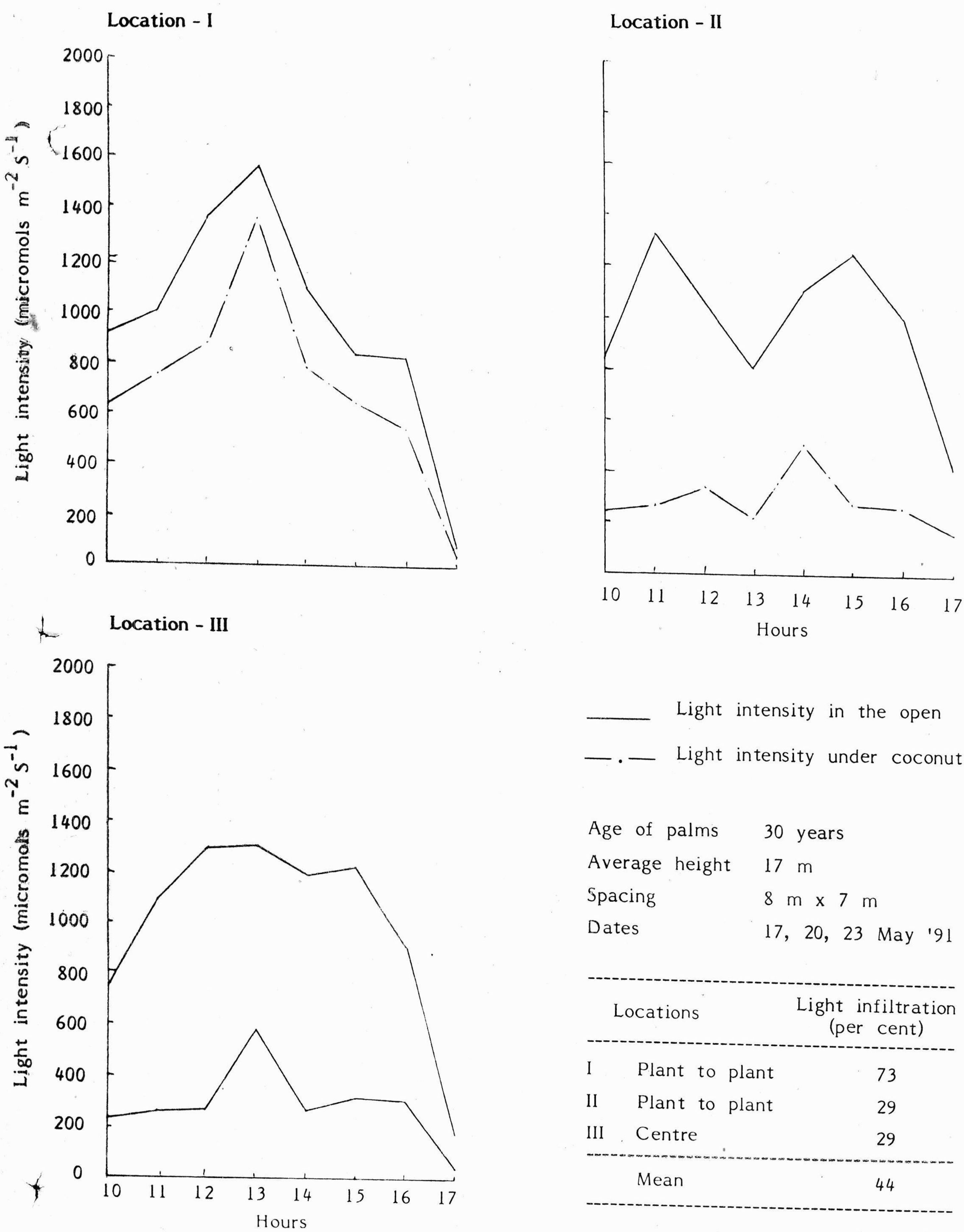
Average height 8.5 m

Spacing 8.7 m x 8.8 m

Dates 7, 10, 13 May '91

	Locations	Light infiltration (per cent)
I	Plant to plant	32
II	Plant to plant	24
III	Centre	26
	Mean	28

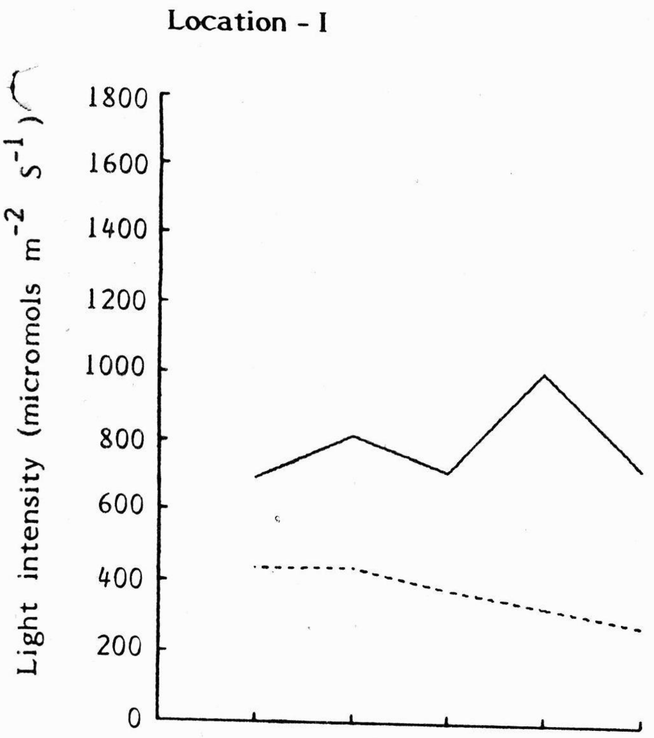
FIG.10 LIGHT INFILTRATION THROUGH COCONUT CANOPY

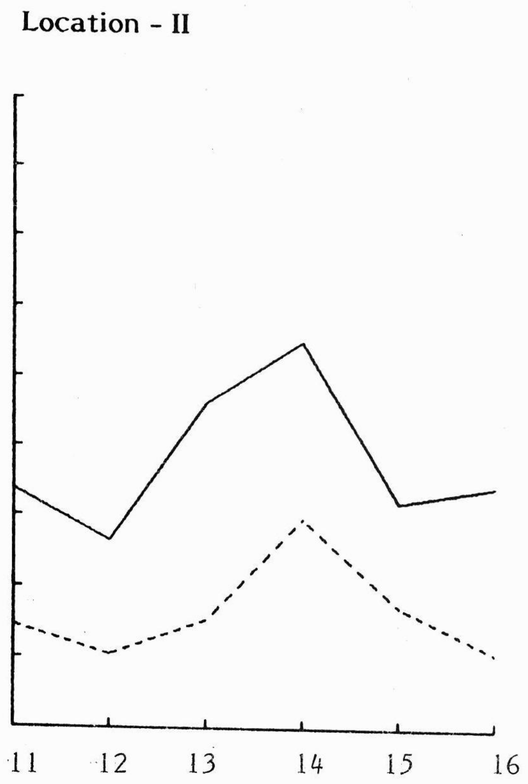


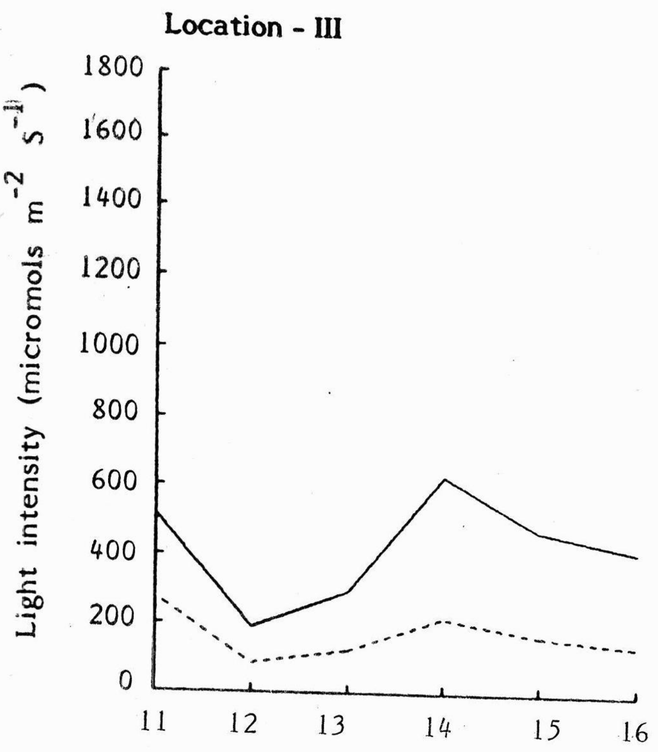
Age of palms	30 years
Average height	17 m
Spacing	8 m x 7 m
Dates	17, 20, 23 May '91

Locations		Light infiltration (per cent)
I	Plant to plant	73
II	Plant to plant	29
III	Centre	29
	Mean	44

FIG.11 LIGHT INFILTRATION THROUGH COCONUT CANOPY







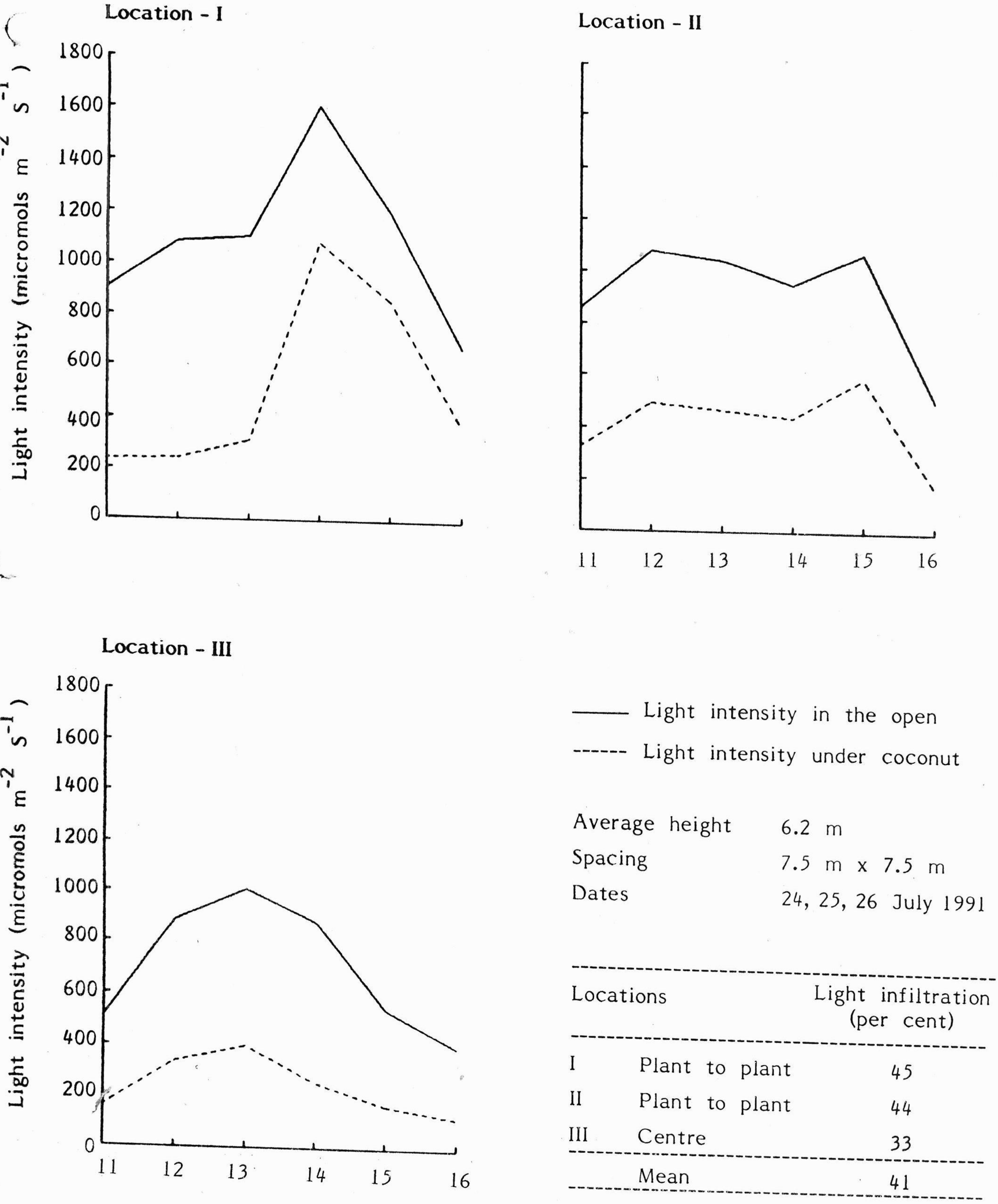
——— Light intensity in the open

------ Light intensity under coconut

Average height	6.75 m
Spacing	7.5 m x 7.5 m
Dates	16, 17, 18 July 1991

Locations		Light infiltration (per cent)
I	Plant to plant	48
II	Plant to plant	42
III	Centre	41
	Mean	44

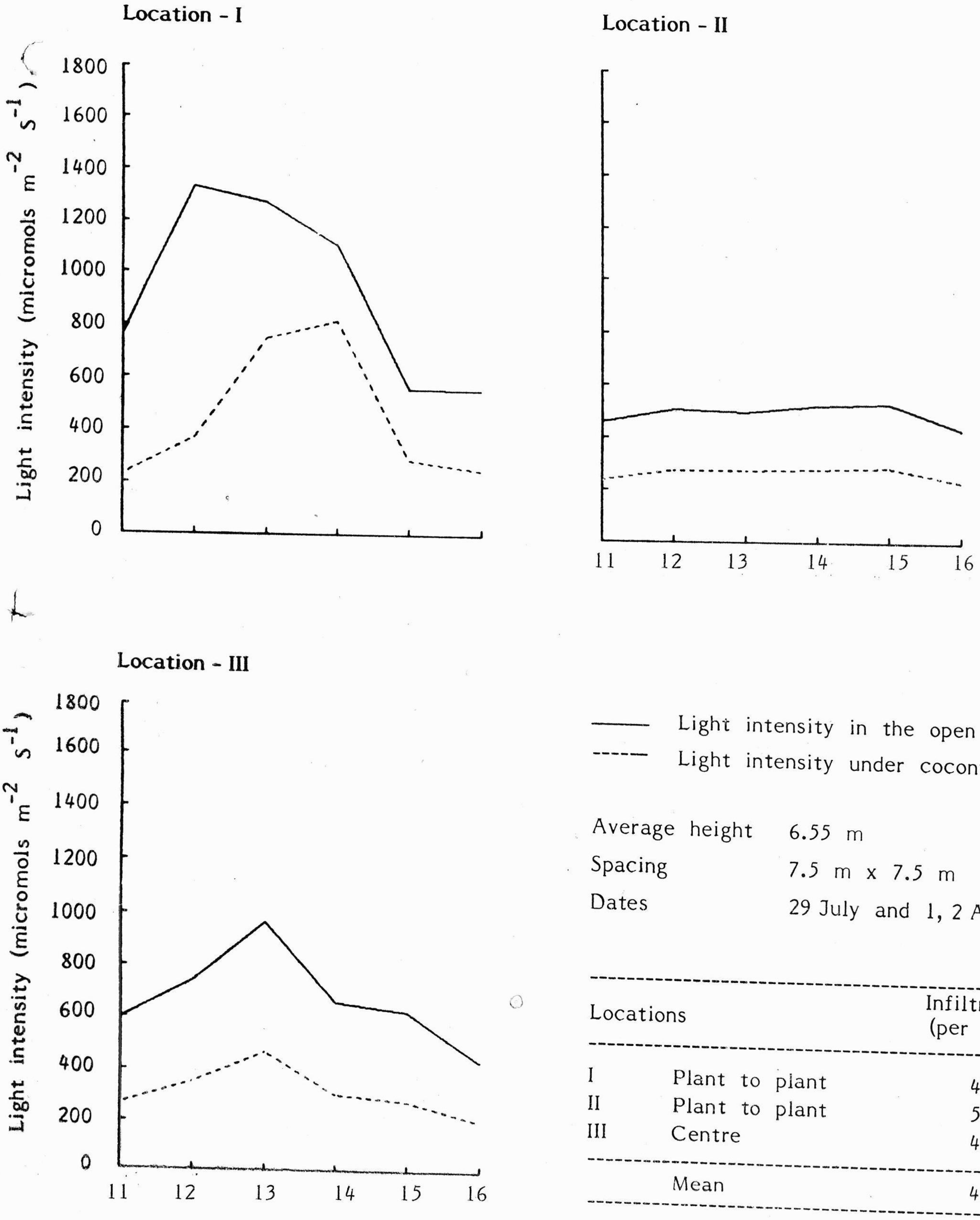
FIG.12 LIGHT INFILTRATION THROUGH COCONUT CANOPY



Average height 6.2 m
Spacing 7.5 m x 7.5 m
Dates 24, 25, 26 July 1991

Locations		Light infiltration (per cent)
I	Plant to plant	45
II	Plant to plant	44
III	Centre	33
	Mean	41

FIG.13 LIGHT INFILTRATION THROUGH COCONUT CANOPY



Average height	6.55 m
Spacing	7.5 m x 7.5 m
Dates	29 July and 1, 2 August 1991

Locations		Infiltration (per cent)
I	Plant to plant	47
II	Plant to plant	54
III	Centre	46
	Mean	49

FIG.14 LIGHT INFILTRATION THROUGH COCONUT CANOPY

12. Summary

A. GINGER

1. Among the growth characters, height of plants and chlorophyll content increased because of shading. The characters that showed a decline by shading were tiller number and number of leaves.

2. The yield of ginger improved by shading. The shade optimum was, however, found to vary with season. As such, ginger is to be classed as 'shade-loving'.

3. The characters that showed nearly identical trend as that of rhizome yield are total dry matter production and harvest index.

4. There were substantial intervarietal differences in shade response of ginger. Based on the available results, Valluvanad and Himachal are to be judged as the best varieties for most of the shade situations.

5. Quality of rhizome as assessed through oleoresin content declined by shading.

B. TURMERIC

1. Plant height and chlorophyll content increased by shading in turmeric and tiller number decreased. Leaf number, dry matter production, leaf area index and net assimilation rate were not affected by shading.

2. Rhizome yield of this crop showed some decline at very intense shade level, but this crop could stand shading

without appreciable decrease in yield. Based on the yield trend, this crop is to be classed either as 'shade-loving' and as 'shade-tolerant'.

3. Nearly all the growth characters including total dry matter production and harvest index showed similarity in shade response to that of rhyzome yield.

4. There were neither very conspicuous and consistent differences in the yield of the tested varieties nor were there such differences in their shade response.

5. Quality of rhizome assessed through percentage of dryage and curcumin content showed improvement due to shading in terms of percentage of dryage. Curcumin content was unaffected by shading.

C. COLOCASIA

1. In this crop, there was increase in plant height, girth and chlorophyll content of leaves by shading. Tiller number and leaf number remained unaffected. Dry matter production followed the same pattern as rhizome yield.

2. As a crop, colocasia is to be classed as shade-loving as the overall mean yield is higher under shade than in the open.

3. Dry matter production at harvest showed nearly the same trend as tuber yield and harvest index was nearly unaffected by shading.

4. The were large inter-varietal differences in shade response, some varieties qualifying themselves to be classed as shade-loving and some others as shade-tolerant. The morphotype, M_2 was the highest yielder at nearly all shade situations.

5. Quality of colocasia tuber is not much affected by shading.

D. SOYBEAN

1. All the varieties of soybean tested failed to come up under shade. When sown early, it came up at very low levels of shade but even here, the growth was abnormal and yield very low. Based on this shade response, soybean is to be classed as shade-sensitive. Such a response also makes soybean totally unsuitable for cultivation under shaded intercropping situations.

2. Varieties showed large differences in their performance at the location. All the varieties that were tested earlier for the location like PLSO 18, Monetta, Davis, Hardee, EC 63298, EC 39824, EC 39821, EC 29824 and Improved Pelican were of good performance in the open. The performance of the newly introduced varieties was variable. KHS b-2, Himzo 1531, PK 471, IS 79-27 and MACS-124 were some of the superior ones of this group.

E. LIGHT INFILTRATION THROUGH COCONUT CANOPY

(i) Light infiltration through coconut canopy varies widely and the range in percentage infiltration values for different situations was from 28 to 82 per cent.

(ii) No significant correlation of percentage light infiltration with height of palms or with spacing was noted. One of the reasons for this appears to be the inadequacy of the number of situations from which observations were recorded.

(iii) The present recommendations that intercropping in coconut plantations which are younger than 20 years is not to be done apparently needs modification.

13. Results which can be exploited in pilot or field scale

(i) The crops ginger, turmeric and colocasia are highly suitable for shaded intercropping situations and soybean, totally unsuitable.

(ii) Ginger varieties and colocasia morphotypes showed large differences in shade response. Among the ginger varieties tested, Valluvanad and Himachal are the best for most of the shade situations and among colocasia morphotypes, M_2 was the best. The turmeric varieties tested showed very little of differences in shade response.

(iii) Light infiltration through coconut canopies varied widely from about 28 to as much as 82 per cent. In the range of coconut spacing from 6m x 7m to 9.8m x 9.8m, there was no consistent relation between spacing and light infiltration. Similarly, no relation between height of coconut palms in the range from 0.7m to 16.3m and light infiltration was found. In as much as these results are based on measurements using line quantum sensor and as there are larger number of observations involved as compared to the earlier results reported by Nelliat _et al_. (1974), it may be concluded that inter/mixed cropping in coconut may be done in any plantation of any age/height and (within reasonable limits) of any spacing.

14. Papers/articles prepared/published

P. Prameela and R. Vikraman Nair. 1990. Screening of different morphotypes of colocasia (_Colocasia esculenta_ L. Schott.) for shade tolerance. National Symposium on Recent Advances in the Production and Utilisation of Tropical Tuber Crops 7-9 Nov. 1990. Indian Society for Roof Crops. (Abstract).

15. Suggestions for future lines of work

(i) In at least a few crops tested, there are found to exist large differences in shade response. There is, therefore, scope for screening varieties of other crops that are usually cultivated under coconut shade.

(ii) Only a few crops that are possible to be cultivated in coconut interspaces have so far been screened for shade response. Other crops also need to be tested.

(iii) There is scope for breeding intercrop varieties suitable for shade situations.

16. Acknowledgement

The Principal Investigator and the staff of the Ad-hoc Project express their sincere gratitude to the following:

1. The Project Co-ordinator (Spices), National Research Centre on Spices, Kozhikode for the help in the procurement of seed materials of ginger and turmeric and for the permission to use the NRC laboratories for chemical analysis for estimation of oleoresin in ginger and curcumin in turmeric and the scientists of the Centre for the help and guidance in chemical analysis.

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5. The Head of the Department of Agronomy, his staff and postgraduate students of the Department for the help rendered and facilities provided

and

6. The Associate Dean of the College for his generous help.

Appendix I

Prominent characters of morphotypes of colocasia

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.

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.

207700

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 Tamilnadu. 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.

[signature]
21/4/92
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Professor of Agronomy & PI