AGRONOMIC AND PHYSIOLOGICAL RESPONSES OF RECENTLY DEVELOPED CORCHORUS CAPSULARIS L. AND C. OLITORIUS L. LINES TO VARIOUS CULTURAL PRACTICES

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A DISSERTATION PRESENTED TO

THE UNIVERSITY OF DHAKA

IN FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

IN BOTANY

UNIVERSITY OF DHAKA

1990

CERTIFICATE

This is to certify that the research work embodying the results reported in this thesis has been carried out under our guidance in the experimental field and glass houses of Bangladesh Jute Research Institute,Dhaka. It is further certified that the work presented here is original and suitable for submission for the award of Doctor of Philosophy.

19/2/90

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INTRODUCTION

Since demographic pressure warrants more land under food crops, the farmers are more inclined to grow food crops to meet the needs of their families. This necessitates planting of both Corchorus capsularis L. and C. olitorius L. within March and harvest within July to fit in transplanted 'aman' in the cropping pattern.

Rao and Prasad (1978) and Mandal et al. (1976-77) suggested that newly evolved C. olitorius cultivar such as JRO 878, JRO 7835 and JRO 524 could be grown during the same time as C. capsularis because of their less photosensitivity. Sanyal (1963) further suggested that before 'aman' season jute could be grown profitably if a minimum period of 90-100 days is available for planting it. Mahanta and Barthakur (1968) reported that for economic yield the plants on March 17 sowings should be 120 days old; however to obtain any substantial quantity of fibre the crop must be at least 90 days old.

In a coordinated jute-rice rotational trial Pandey et al. (1969) and Dargan et al. (1970) planted jute on March 20 and April 5. From each sowing 120, 135 and 150 days old plants were harvested. After each harvest aman rice was planted.

All the above mentioned results were reported from India. Because of the changed circumstances in which jute is gradually being pushed to the marginal land, it is keenly felt that similar experiments on agronomic manipulations as reported in India should be carried out here also. These agronomic manipulations would determine the a) effects of harvest of crops at different field durations on fibre yield of C.capsularis and C.olitorius cultivars, and b) effects of interaction between dates of sowing X field duration on fibre yield of C.capsularis cultivars.

The assessment of yield advantage involves the comparison of the yield of component crops in an intercropping situation vis-a-vis sole crops. It must take into account the competitive relationships among the component crops which compete with each other.

Therefore, the assessment of yield involves the evaluation of competitive relationships of pure stand versus intercrop situations.

Since fibre yield has always been of primary interest, many experiments have been conducted for improving yield, but practically no experiments were conducted to study the growth phases or phenology of jute.

As jute is a rainfed crop, an understanding of the phenology and relationship of growth phases at different sowing dates at a particular location is an essential step towards developing appropriate jute varieties suitable for planting over a longer period i.e., from middle of February to end of April.

Seed yield per unit area is the dry matter accumulation in the seeds during their filling period. Currently the agronomists are using the concept of 'Physiological maturity' to measure precise duration of the seed filling period. However, agronomists have identified visible indicators with physiological maturity. For instance in maize (Daynard and Duncan, 1969) and sorghum (Eastin et al. 1973) formation of black layer in the placental region of the kernels signals physiological maturity. In soybean physiological maturity is indicated by the first sign of seed shrinkage (Crookston and Hill, 1978).

Since 1959, several workers (PCJC, 1959-60, 1960-61, 1961-62; Wahhab and Ali, 1976; Talukder and Ali, 1979) studied jute seeds collected from the fruits of various maturity stages to determine their suitability for using them in the following season. Neither of those studies gave any indication of physiological maturity or visual indicators to determine their stage of physiological maturity.

Progress from selection for quantitative traits, such as yield is often reduced due to the effect of a large genotype x environment interaction (GxE). The estimate of GxE interactions proposed by Comstock and Robinson (1952), Hanson et al. (1956) and Comstock and Moll (1963) gave no indication of the response of individual genotypes to the environment without giving an opportunity to measure the stability of individual genotypes tested. However, Eberhart and Russell (1966), Finley and Wilkinson (1963) and Perkins and Jinks (1968) considered GxE interactions as linear functions of environment. Regression on the yield of a genotype over the mean yield of all genotypes in each environment was considered for evaluating performance of the genotypes for their stable yield. This was originally proposed by Yates and Cochran (1938) and was later modified by Finley and Wilkinson (1963) and further elaborated and modified by Eberhart and Russell (1966).

Regression techniques permit the GxE interaction to be partitioned into two stability parameters, namely the linear regression coefficient and deviation from regression mean square. Eberhart and Russell's method has been widely used in comparing and measuring genotypic performance of different annual crop species; however, little information is available on *Corchorus* species. So far two reports are available on the yield stability of *Corchorus* species -- namely on varieties of *C.olitorius* reported by Dastidar and Das (1981) and the other on varieties of both *C.capsularis* and *C.olitorius* by Khandakar *et al*.(1988).

However, Khandakar *et al*. (1988) did not report partitioning of GxE interaction into linear regression coefficient and deviation from regression mean square.

In the light of the consideration of the above facts experiments were designed to determine the

1. Effect of dates of sowing and stage of harvest on yield i.e.;

1.1. Whether the duration of the crop in the field could be reduced from the normal practice without substantial reduction in yield by manipulation of stage of harvest.

1.2. Fibre yield obtained from different harvest dates from crops sown at four different timings.

2. Quantum of growth and yield of the crops planted with jute in an intercropping. This necessitated the study of

2.1 Competitive abilities of the component crops

2.2. Response of the yield contributing characters of the component crops.

2.3. Response of growth parameters under the influence of intercropping.

3. Phenology and correlation of growth phases of jute planted on different dates

3.1. Growth stages at different dates of planting.

3.2. Taking into consideration the time of the beginning and the end of flowering stage and the appearance of first and last pod as observed per potted plant.

4. Physiological maturity of *C. capsularis* seeds for obtaining specific information on

4.1. Identification of visual indicators at different stages of physiological maturity;

4.2. Evaluation of relationship between maturity of seeds and different seed attributes.

5. Genotype x environment interactions and their influence on maintaining yield stability of *C.capsularis* genotypes. Determination of this parameter necessitated the further study of

5.1. Partitioning GxE interaction into two components, namely regression coefficient and deviation from regression,

5.2. Regression on individual genotypes.

MATERIALS AND METHODS

Expt. 1. Effect of dates of sowing and stage of harvest on yield.

1.1. Stage of harvest:

The genotypes used were CVE-3, CC-45 and Dhabdhabey of Corchorus capsularis and OVT-3, Chaitali and 0-9897 of C.olitorius. These genotypes were sown on 15 March in 1984, 1985 in Agricultural Research Farm at Manikganj and at Central Station, Dhaka in 1986. The experiment was laid out in 6 replications in a split plot design assigning genotypes in the main plots and harvests in the sub-plots. The sub-plot size was 4.57m x 4.57m. Each row was 4.57m long with a row spacing of 30 cm and plant to plant spacing of 7.5 to 10 cm. Data were analysed yearwise for three years and subjected thereafter to a combined analysis.

The plants were harvested at field duration (harvest stage) of 90 (H1), 105(H2), 120(H3), 135(H4) and 150(H5) days after sowing at an interval of fifteen days. Leaving the guard rows alternate single rows were harvested. Flowering data were recorded at each harvest by counting the harvested plants with and without flower.

1.2. Dates of sowing x stage of harvest:

Five genotypes of C.capsularis, such as CVE-3, CVL-1, Dhabdhabey, D-154 and CC-45 were sown at four different dates on 15 March (D1), 30 March (D2), 14 April (D3) and 29 April

(D4). Plants were harvested on four different field durations at 90 (H1), 105(H2), 120(H3) and 135(H4) days after sowing. The experiment was conducted in Agricultural Research Farm at Manikganj, in 1984 and 1985 and in 1986 at Central Station, Dhaka. A split split plot design was followed with three replications. The genotypes were placed in the main plots, dates of sowing in the sub plots and harvest stage in sub-sub-plots. The sub-plot size was 6.09m x 4.57m and sub-sub plot was 4.57m x 1.52m having row length of 4.57m. In all the planting dates, seeds were sown in lines with a row spacing of 30 cm and plant to plant spacing of 7.5 to 10 cm. Innermost rows were harvested from the sub-sub plots. Three years' data were analyzed separately.

Expt. 2. Quantum of growth and yield of the crops planted with jute in an intercropping.

C.capsularis cultivar D-154 and C.olitorius cultivar O-4 of jute were intercropped with Setaria italica (foxtail millet), and also Oryza sativa cv. Kalamanik, aus rice (upland rice). These crops were grown in 1982 and 1983 in Agriculture Research Farm at Manikganj. The proportion of the crops in intercropping was 50:50. The inter-row and intra-row spacing for sole jute, millet and aus were 30 cm x 15 cm. For intercropping the inter-row and intra-row spacing was 15 cm x 15 cm for the component crops and the crops were sown in alternate single row.

The experimental designs were randomized complete block design with six replications. D-154+aus and D-154+millet, with sole crops constituted one experiment and O-4+aus and O-4+millet with sole crops were the other experiment. The plot size was 3.05 meter x 3.05 meter. Space between the block, plot and around the field was 0.50 meter. The seeds of all the crops were sown on 22 March in both years.

2.1. Land equivalent ratio (LER) analogous (in part) to the calculation of Willey and Osiru (1972) was used. Usually LER is applied to combined intercrop yields but can also be applied usefully to the intercrop yield of each crop. This may be denoted by L. Lj, Lm and La thus indicate the LERs for the intercrop yields of jute, millet and aus, respectively. The term Lj, Lm, etc. have been most commonly termed relative yields and LER the relative yield total (RYT-De Wit and van Den Bergh, 1965).

For jute in a 50 : 50 mixture with millet it can be written:

$$LER = \frac{Yjm}{Yjj} + \frac{Ymj}{Ymm}$$

In addition to the LER concept, aggressivity (McGilchrist, 1965) was used to describe competitive relationships. The aggressivity (A) gives a simple measure of the extent of the relative yield increase in jute when it is greater than that of millet or that of aus as intercrop yields.

The following symbols were used to express the functions of intercrop competitions :

Yjj = Pure stand yield of jute

Ymm = Pure stand yield of millet

Yaa = Pure stand yield of aus

Yjm = Intercrop yield of jute (in combination with millet)

Ymj = Intercrop yield of millet (in combination with jute)

Yja = Intercrop yield of jute (in combination with aus)

Yaj = Intercrop yield of aus (in combination with jute)

Zjm = Proportion of jute (in combination with millet)

Zmj = Proportion of millet (in combination with jute)

Zaj = Proportion of aus (in combination with jute)

Aggressivity of jute intercropped with millet (Ajm) in 50 : 50 ratio can be written :

$$Ajm = \frac{Yjm}{Yjj \times Zjm} - \frac{Ymj}{Ymm \times Zmj}$$

An aggressivity value of zero indicates that the component crops are equally competitive.Higher the value,higher is the aggressivity. For both the components same numerical value is used but negative sign is assigned to the dominated and positive to the dominant crop of the intercrop. The terms dominant and dominated used by Huxley and Maingu (1978) were used.

2.2. Plant height, panicle length, panicle weight, grain weight, dry fibre weight were measured to get the impact of intercropping on yield contributing characters of the sole and component crops. Leaving the border rows, four plants from each replication was sampled for the estimation of the above characters.

Fibre content percentage (ICAR,1970), per cent of ripened grain (Abedin & Chowdhury, 1982) and caryopsis weight were measured by using the following formulae :

$$\text{Fibre content \%} = \frac{\text{Dry fibre wt.}}{\text{Dry fibre wt. x dry stick wt.}} \times 100$$

$$\text{Ripened grain \%} = \frac{\text{Number of filled grains/Panicle}}{\text{Number of grains/Panicle}} \times 100$$

$$\text{Caryopsis wt.} = \frac{\text{Total grain wt./Panicle}}{\text{Number of caryopsis/Panicle}}$$

2.3. The growth parameters, such as Relative growth rate (RGR), Net assimilation rate (NAR) and Leaf area ratio (LAR) were computed following the formulae (Radford, 1967) as shown below :

$$RGR = \frac{\log_e W2 - \log_e W1}{t2 - t1}$$

$$NAR = \frac{W2 - W1}{A2 - A1} \times \frac{(\log_e A2 - \log_e A1)}{t2 - t1}$$

$$LAR = \frac{A2 - A1}{W2 - W1} \times \frac{(\log_e W2 - \log_e W1)}{(\log_e A2 - \log_e A1)}$$

where, W is the dry weight, t the time interval and A is the leaf area.

Two plants from each replication were collected for growth analysis from the crop combinations of D-154 + millet and were taken from the central line of each plot for growth analysis. Sequential harvests of jute were made starting from 30 days upto 120 days with an interval of 30 days. Millet and aus were harvested from 30 days upto 90 days with an interval of 30 days.

The plant materials of millet and aus were separated into leaves, culm and panicle, and that of jute into leaves, bark and stick. The plant materials were dried in an airforced drier at 80 Celsius (C) for 7 days to a constant wt. and the dry wt. was taken by a digital electric balance. Millet and aus were harvested for final yield at 90 days and jute at 120 days after sowing. This gave difference in spatial arrangement and temporal difference to jute of 30 days.

Expt. 3. Phenology and correlation of growth phases of jute planted on different dates.

3.1. In both 1984 and 1985 nine taxa of C.capsularis, namely D-154, CVL-1, CVE-3, Dhabdhabey, Halmaheira, Akashu, Kajla, CH-2 and BZ-1 were planted at Manikganj on 15 March through 29 April at an interval of 15 days. Seeds were sown in lines 30 cm apart with plant to plant spacing of 7.5 to 10 cm. The row length was seven meters in both years. Each row was considered as a replication. There were four replications for each genotype.

i) The stages of development were recorded three times namely a) at 50% floral bud, b) at 50% flowering and c) at the end of life cycle. These stages were determined by visual observation at two to three days interval. Planting to flowering and life cycle measured by calendar days (CD) was subjected to correlation analysis.

ii) Temperature records were obtained daily from 8 March 1980 to 30 November 1986 from nearby Tobacco Leaf Depot at Manikganj.

From the temperature records of 1984 and 1985 the growing degree days (GDD) were calculated according to Martin and Leonard (1967) taking 20 C as base temperature (Rao, 1980; Johansen, 1981 and Khandakar and Begum,1987), i.e.

GDD = (Maximum temperature C + minimum temp. C)/2-Base Temperature. The daily GDDs were summed up for planting to flowering and life cycle and was subjected to correlation analysis.

3.2. In 1984 and 1985 CVL-1 and CVE-3 were sown in pots on 30 April at Central Station in Dhaka. Dates were recorded at the beginning and the end of flowering period as well as of first and last pod formation. The statement "first fruit formation" means the development of ovary into a small pod on the 5th day following fertilization. The number of flowers and pods were recorded every alternate day. The whole flowering period and the period of healthy pod formation was divided into an equal number of four-day long periods. The average number of flowers and pods during each four-day period was subjected to polynomial regression analysis.

Expt. 4. Physiological maturity of *C.capsularis* seeds.

The study was conducted at the Central Station, Dhaka in 1984 and 1985 with CVL-1 and CVE-3 of *C.capsularis*. Seeds were sown in pots on 30 March in both years. Measurements of seed dry weight began 30 days after anthesis and continued with an interval of 10 days until the pods were removed from the plant on each sampling date and dried in the sun. Seeds were collected from the dried pods and dry weight of seeds were recorded.

The date of physiological maturity or attainment of maximum seed dry weight, was determined following the method applied by Crookston and Hill (1978). First, the mature seed weight (Plateau) was determined. This value was the mean of all weights which did not differ significantly (5% level of probability) from the most mature samples. Next, by means of least squares regression analysis, a slope was obtained from the values which differed from the mean of the most mature group. The point at which the calculated regression line intercepted the plateau value was defined as the date of physiological maturity.

4.1. Changes were observed at the following stages of pod and seed development:

a) first sign of mature seed coat colour

b) attainment of semi-dry condition of fruit while the stem is still green

c) when stem started showing signs of drying

d) when both stem and pod were physiologically dry.

4.2. Seeds of different maturity were subjected to the following tests:

a) **Seed weight (wt.):** Seeds of different maturity groups were weighed in a sensitive balance.

b) **Germination test:** Standard procedure (Talukder and Rahman, 1977) was followed.

c) **Vigour value:** Method used by Jain and Saha (1971) was followed. The rate of germination was recorded both in petridish and in the seed pan for 5 days begining after 24 hours from the time of sowing.

d) **Seedling dry weight:** Seedlings of 72 hours old were dried at 70 C for 24 hours and weighed in sensitive balance.

For all the tests replicated samples were used. Analysis of variance of the pooled data of 1984 and 1985 was employed to analyse dry wt. of seed, germination percentage, vigour and dry wt. of seedling of cultivar CVL-1.

Expt. 5. Genotype x environment interactions and their influence on maintaining stability of *C.capsularis* genotypes.

Five genotypes of *C.capsularis* namely, CVE-3, CC-45, Dhabdhabey, D-154 and CVL-1 were sown on six different dates as shown below :

March 15, 30

April 14, 29

May 14, 29.

The experiment was conducted at Manikganj in three consecutive years from 1984 to 1986 in three replications. In the split plot design, dates of sowing were placed in the main plots and genotypes in the sub-plots. The sub-plot size was 3.05 x 3.05 meter with 3.05 meter row length. Two innermost rows were harvested from each sub-plot for each genotype allowing a field duration of 105 days after sowing for all the plantings. Each date of sowing in a given year was considered an individual environment. Thus there were 18 environments.

5.1. Variance components were estimated from the combined analysis of the data on fibre yield collected in the three consecutive years. The regression analysis of variance was worked out following Eberhart and Russell (1966). In this analysis, pooled errors were derived from the residuals of the combined analysis. Using the pooled error mean square from the combined analysis of variance regression mean square was tested for significance. Regression mean square was also tested against deviation mean square for regression.

5.2. Stability parameters were calculated according to Eberhart and Russell (1966). The stability parameters measured were:

a) Linear regression coefficient (bi) of individual genotypes mean yield on the average of all genotypes in each environment, and

b) Mean squares of deviation from regression (s2di) for each genotype.

As suggested by Eberhart and Russell (1966) for the above two parameters F test was applied.

RESULTS

1. Effect of dates of sowing and stage of harvest on yield.

1.1. Stage of harvest:

In both 1984 and 1985 the variance components for genotypes were significant at one per cent level. However in 1986 it was significant (5%) at 5 and 25 df (Table 1). Combined analysis also showed highly significant genotype component at 5 and 375 df (Table 1).

Among the *C.capsularis* genotypes CVE-3 and CC-45 gave highest yield in all the years. Unlike CVE-3 and CC-45, the *C.olitorius* genotypes were not significantly different in their contribution towards yield for both 1984 and 1985. In 1986 the yield of OVT-3 was about the same as CVE-3 and CC-45 (Table-2). The average yield of CVE-3 over a period of three years was highest regardless of the duration of the crop in the field (Table-3).

It was observed that among the *C.olitorius* genotypes, Chaitali and OVT-3 had 50 per cent plants with flower at 120 days from the date of their planting. As against this,among the *C.capsularis* genotypes 55 per cent plants of both CVE-3 and Dhabdhabey were at the flowering stage at 120 days. During the same period only 1 per cent of the population of CC-45 and O-9897 were in blossom (Table 5).

Table 1: Partitioned sum of squares and variance components of individual and combined years' analysis for fibre yield in jute

	SS Harvest partitioned(ss=ms)					Mean sum of squares	
Year	HL	HQ	HC	HQ		genotype	harvest
1984	46.0***	0.141	0.319	0.008		1.15**	11.6***
1985	52.0***	0.400	0.009	0.030		0.512**	13.1***
1986	16.6***	0.464	0.179	0.004		0.222*	4.31***
Combined	109***	0.951	0.265	0.034		1.62***	27.5***
					Y	2.88***	
					YxH	0.762***	
					GxH	0.130	
					YxGxH	0.0319	

***, **, * significant at 0.1%, 1% and 5% levels respectively.

Table 2: Effect of different dates of harvest on fibre yield (ton/ha) of <u>C</u>.<u>capsularis</u> and <u>C</u>.<u>olitorius</u>

Year	genotype	No. of days between sowing and harvest					Mean genotype
		90	105	120	135	150	
1984	CVE-3	1.15	1.63	2.12	2.32	2.55	1.95a
	CC-45	0.94	1.43	1.98	2.29	2.66	1.86a
	Dhabdhabey	0.84	1.34	1.64	1.99	2.05	1.57b
	OVT-3	1.11	1.46	1.83	2.24	2.77	1.88a
	Chaitali	0.95	1.34	1.90	2.36	2.57	1.82a
	0-9897	1.13	1.51	1.93	2.17	2.57	1.86a
Mean harvest		1.02e	1.45d	1.90c	2.23b	2.53a	
1985	CVE-3	1.39	1.83	2.08	2.34	2.97	2.12a
	CC-45	1.05	1.60	2.18	2.37	2.57	1.96a
	Dhabdhabey	0.83	1.38	1.54	1.71	2.17	1.53b
	OVT-3	1.04	1.44	1.84	2.19	2.69	1.84ab
	Chaitali	0.98	1.48	1.91	2.35	2.65	1.87ab
	0-9897	1.23	1.72	1.90	2.07	2.43	1.87ab
Mean harvest		1.09e	1.58d	1.91c	2.17b	2.58a	
1986	CVE-3	1.20	1.56	1.83	1.92	2.15	1.73a
	CC-45	1.16	1.53	1.74	1.94	2.15	1.70a
	Dhabdhabey	0.99	1.41	1.58	1.68	1.81	1.49bc
	OVT-3	1.14	1.44	1.63	1.82	2.16	1.64a
	Chaitali	1.08	1.43	1.66	1.83	2.01	1.60b
	0-9897	1.12	1.50	1.72	1.74	1.83	1.58b
Mean harvest		1.11d	1.48c	1.69ab	1.82a	2.02a	

Numericals followed by common letters do not differ significantly at 1% level in 1984, 1985 and 5% level in 1986.

Table 3: Three years' average yield (ton/ha) of crop harvested at 15 days' interval

Genotype	Duration of the crop in the field (days)					Mean
	90	105	120	135	150	genotype
CVE-3	1.24	1.67	2.01	2.19	2.55	1.93
CC-45	1.05	1.52	1.96	2.20	2.46	1.84
Dhabdhabey	0.88	1.37	1.58	1.79	1.90	1.50
OVT-3	1.09	1.44	1.76	2.08	2.54	1.78
Chaitali	1.00	1.41	1.82	2.18	2.41	1.76
0-9897	1.16	1.57	1.85	1.99	2.27	1.77
Mean harvest	1.07	1.50	1.83	2.07	2.36	

LSD 5% level 0.1537

Table 4: Effect of year x harvest stage interaction for yield

Harvest	1984	1985	1986	Mean harvest
H1	1.01	1.08	1.11	1.07e
H2	1.45	1.57	1.48	1.50d
H3	1.90	1.91	1.69	1.83c
H4	2.23	2.17	1.82	2.07b
H5	2.52	2.57	2.02	2.37a
Mean year	1.82a	1.86a	1.62b	

Numericals followed by common letters do not differ significantly at 1% level.

H1= 90-day, H2=105-day, H3= 120-day, H4=135-day and H5=150-day.

Table 5: Flowering percentage among the genotypes in different field duration at 15 March sowing (Three years' average, 1984, 1985, 1986)

Genotype	Duration of the crop in the field (days)				
	90	105	120	135	150
	Flowering percentage				
Chatali	20	37	51	67	88
OVT-3	23	39	52	100	100
O-9897	0	<1	<1	2	4
Dhabdhabey	30	40	55	100	100
CVE-3	28	39	57	97	100
CC-45	0	0	1	2	5

The harvest component was found to be highly significant individually in each of the three years as well as when the data for 3 years were combined (Table 1). On partitioning the sum of squares for harvest, linear component was found highly significant for all the three years and in combined analysis (Table 1). The correlation coefficients on yield for field duration were highly significant (Fig 1).

In combined analysis year component and year x harvest interactions were highly significant (Table 1 and 4). Genotype x harvest interaction was not significant in all the three years as well as in combined analysis. Year x genotype x harvest interaction was also not significant in combined analysis.

1.2. Dates of sowing x stage of harvest:

In 1984, 1985 and 1986 the genotypes performance was highly significant (F=51.34, 27.05 and 9.71) at 4 and 8 df. Highly significant difference was observed in all the three years (F=3.46, 5.00 and 23.56) in fibre yield of crops sown on different dates at 3 and 30 df (Table 6).

On partitioning the sum of squares for dates, quadratic component was found significant at 5, 1 and 0.1 per cent level in 1984, 1985 and 1986 (Table 7). However,about 31, 91 and 81 per cent of the total variation in yield can be explained by the equations given in table 8. Data compiled over three years' average showed best fit to quadratic response curve (Fig 2).

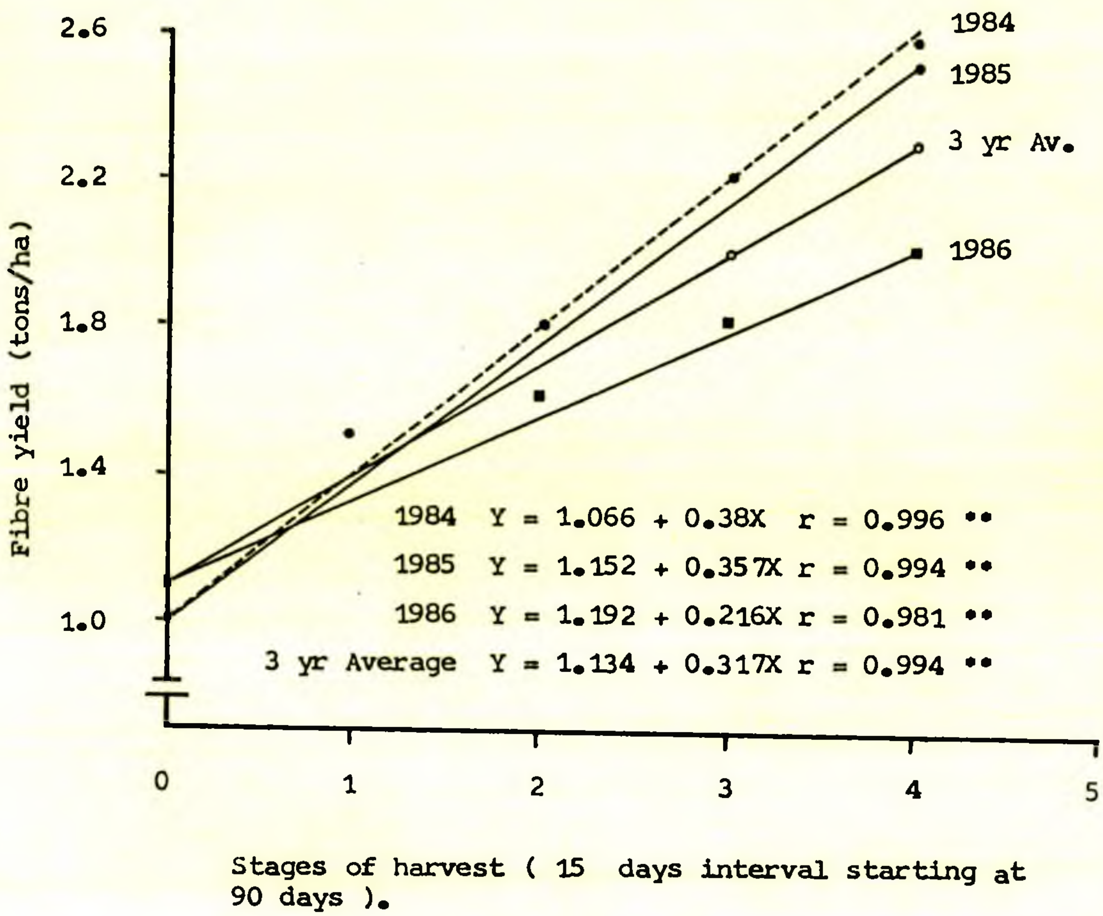


Figure 1 : Influence of different stages of harvest on yield

Table 6:Significant variance components for fibre yield in jute

Year	G	D	GxD	H	DxH
1984	0.087***	0.159*	0.012*	0.384***	0.016**
1985	0.113***	0.030**	0.013*	0.341***	0.019**
1986	0.085***	0.033***	0.011***	0.389***	0.026***

***, **, * Significant at 0.1%, 1% and 5% levels.

Table 7: Partitioned sum of squares and significant variance components for dates of sowing and harvest stages

Year	DL	DQ	DC	HL	HQ	HC
1984	0.0075	0.0298*	0.0105	1.1512***	0.0002	0.0012
1985	0.0152	0.0667**	0.0073	1.0310***	0.0014	0.0001
1986	0.0302***	0.0499***	0.0185***	1.1638***	0.0016	0.005

***, **, * significant at 0.1%, 1% and 5% levels.

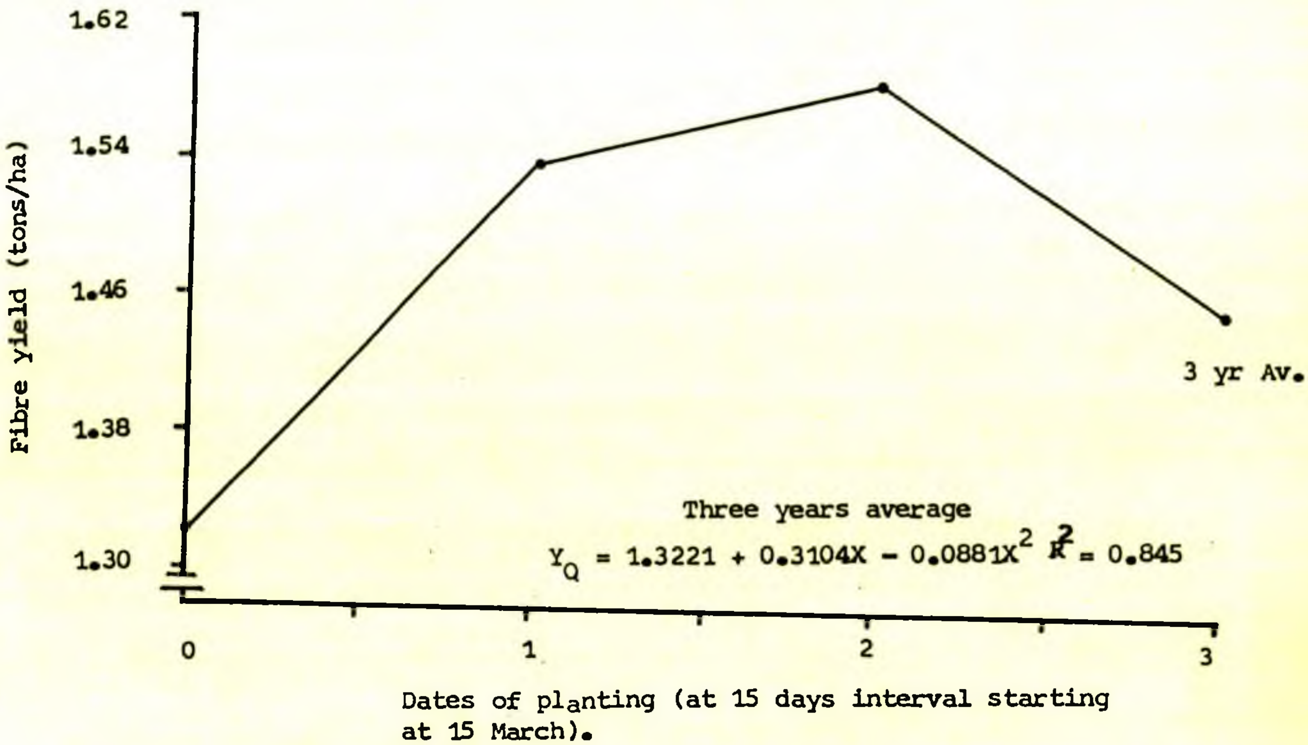


Figure 2 : Effect of dates of sowing on yield.

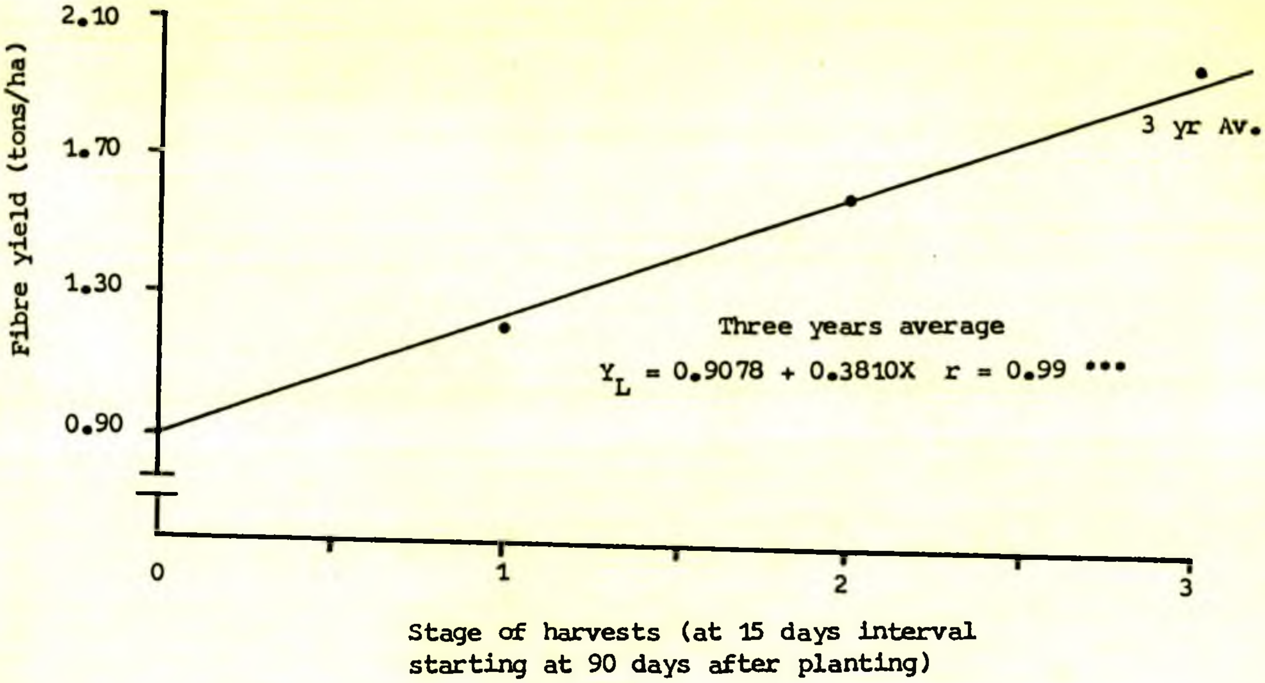


Figure 3 : Effect of stages of harvest on yield.

Table 8: Equations for dates of planting and stages of harvest

Dates of Planting		R^2
1984	$Y=1.4161 + 0.0845x - 0.0178x^2$	0.315
1985	$Y=1.3226 + 0.3581x - 0.1045x^2$	0.918*
1986	$Y=1.2794 + 0.3334x - 0.0902x^2$	0.812
Stages of harvest		**r**
1984	$Y=0.8997 + 0.3872x$	0.999**
1985	$Y=1.1020 + 0.2614x$	0.712
1986	$Y=0.8794 + 0.3894x$	0.999**

**, * significant at 1% and 5% level.

Harvest stage showed significant difference (F=66.69, 51.07 and 63.48; respectively) in 1984, 1985 and 1986 at 0.1 per cent level with 3 and 120 df (Table 6). On partitioning sum of squares for harvest stage, linear component was found significant at 0.1 per cent level (Table 7). The correlation coefficients for harvest stage on yield were significant at 1 per cent level in two (1984 and 1986) out of three years (Table 8). The average of three years' data indicated best fit to linear relationship (Fig 3).

The interaction between genotype and date showed significant difference (F=2.61, 2.12 and 7.81 respectively) in 1984, 1985 and 1986. In 1984 and 1985 it was significant at 5 per cent and in 1986 at 0.1 per cent level at 12 and 30 df (Table 6).

The analysis of the results about the main effect of genotype shows that CVL-1 and D-154 were significantly high yielder in all the years (Table 9). As regards the main effect of dates, D3 sowing gave significantly higher yield in all the years. CVE-3 gave highest yield at D1 sowing in all the years as far as numerical values were concerned but these were not statistically significant incomparison to the yield of D-154 and CC-45. D-154 and CVL-1 gave highest yield at D3 compared to CC-45 in all the years. Between themselves D-154 and CVL-1 were significantly different in their yield. However in 1985 the yield between CVL-1 and D-154 was not significantly

Table 9: Effect of genotype x date of planting interaction on fibre yield at different years *

Year	genotype	D1	D2	D3	D4	Mean
	CVE-3	1.482	1.180	1.269	1.265	1.299
	CVL-1	1.157	1.717	2.068	1.720	1.666
1984	Dhab	1.256	1.032	1.232	1.035	1.130
	D-154	1.665	1.928	1.895	1.667	1.788
	CC-45	1.353	1.538	1.642	1.507	1.510
	Date Mean	1.383	1.479	1.621	1.439	
LSD 5% D= 0.025, LSD= 5% GxD= 0.046, LSD= 1% G= 0.028						
	CVE-3	1.334	1.293	1.072	1.180	1.220
	CVL-1	1.095	1.703	2.089	1.701	1.647
1985	Dhab.	1.188	1.073	1.275	1.047	1.146
	D-154	1.642	1.985	2.094	1.753	1.868
	CC-45	1.433	1.594	1.805	1.526	1.589
	Date Mean	1.338	1.530	1.667	1.441	
LSD 1% D = 0.039, LSD 5% GxD= 0.054, LSD 1% G= 0.044						
	CVE-3	1.355	1.147	1.292	1.266	1.265
	CVL-1	1.042	1.635	2.116	1.610	1.601
1986	Dhab.	1.185	1.093	1.264	1.075	1.154
	D-154	1.638	1.848	2.003	1.774	1.816
	CC-45	1.300	1.520	1.620	1.491	1.483
	Date Mean	1.304	1.449	1.659	1.443	
LSD 1% D= 0.019, LSD 1% GxD= 0.053, LSD 1% G= 0.064						

* D1= 15 March, D2= 30 March, D3= 14 April, D4= 29 April.

Table 10: Effect of dates of planting x harvest stages on fibre yield at different years *

Year		H1	H2	H3	H4	Date mean
	D1	0.915	1.264	1.508	1.843	1.383
	D2	0.964	1.387	1.668	1.896	1.479
1984	D3	0.902	1.257	1.727	2.598	1.621
	D4	0.818	1.187	1.893	1.857	1.439
Harvest mean		0.899	1.273	1.699	2.048	
LSD 1% H= 0.027, LSD 1% DxH= 0.160, LSD 5% D= 0.025						
	D1	0.974	1.228	1.391	1.760	1.338
	D2	1.029	1.522	1.701	1.866	1.530
1985	D3	0.977	1:405	1.729	2.556	1.667
	D4	0.729	1.165	1.934	1.936	1.441
Harvest mean		0.928	1.330	1.689	2.030	
LSD 1% H= 0.029, LSD 1% DxH= 0.175, LSD 1% D= 0.039						
	D1	0.910	1.120	1.486	1.700	1.304
	D2	0.966	1.386	1.623	1.820	1.449
1986	D3	0.965	1.277	1.622	2.771	1.659
	D4	0.759	1.179	1.886	1.948	1.443
Harvest mean		0.900	1.240	1.654	2.060	
LSD 1% H= 0.028, LSD 1% DxH= 0.151, LSD 1% D= 0.019						

D1= 15 March, D2= 30 March, D3= 14 April, D4= 29 April.
H1= 90 days, H2= 105 days, H3= 120 days, H4= 135 days.

different in D3 (Table 9). The reasons for this could not be accounted for.

Date x harvest interaction was significant (F=2.86 and 2.77) at 1 per cent level in 1984 and 1985. It was significant (F=4.19) at 0.1 per cent level at 9 and 120 df in 1986 (Table 6). In D4 sowing harvesting at 120 and 135 days did not affect the yield (Table 10).

2. Quantum of growth and yield of the crops planted with jute in an intercropping.

2.1. Competitive abilities of the component crops:

a) Aggressivity: In jute+millet intercropping, the aggressivity values of component crops showed millet as being dominant over jute (Table 11). In jute+aus intercropping, the aggressivity value of component crops shows that the cultivars of jute seriously interfere with the growth of aus (Table 11).

b) Relative yield and LER: In D-154+millet intercropping dominant component crop had higher relative yield and the combined intercrop yield was greater over that of sole crop. In 1982 the combined yield of O-4+millet was found lower (Table 11). The yield increase was 31 and 78 per cent respectively for D-154+millet combination in 1982 and 1983. In the intercropping where O-4 was used the results were inconsistant. In 1982 it was smaller and in the following year the combined yield was found higher as in D-154+millet.

Table 11: Aggressivity and LER values for 50:50 intercrops of two jute cultivars with millet and aus

		Millet Cv.	Sibnagar	Aus Cv.	Kalamanik
		Ajm	Lj	Aja	Lj
		Amj	Lm	Aaj	La
			LER		LER
J	D-154	-0.22	0.60	0.30	0.69
U	1982	0.22	0.71	-0.30	0.54
T			1.31		1.23
E	D-154	-0.04	0.88	0.87	1.20
	1983	0.04	0.90	-0.87	0.77
C			1.78		1.97
U					
L	O-4	-0.53	0.34	0.32	0.50
T	1982	0.53	0.61	-0.32	0.34
I			0.95		0.84
V	O-4	-0.08	0.67	0.63	0.71
A	1983	0.08	0.72	-0.63	0.40
R			1.39		1.11
S					

Ajm and Amj; Aja and Aaj = 'Aggressivity' values for jute and millet; jute and aus, respectively.

Lj, Lm and La = 'Land Equivalent Ratio' for jute, millet and aus, respectively.

LER = Land Equivalent Ratio for combined jute and millet; jute and aus yields.

Jute was the dominant component crop in both D-154+aus and O-4+aus intercrop combination. The dominant component crop gave higher yield and the increase of the combined produce was 23 and 97 per cent in D-154+aus combination in 1982 and 1983 respectively. In O-4+aus combination 11 per cent yield increase was recorded in 1983. The unexpected increase of fibre yield in 1983 as shown in table 11 is due to availability of abundant moisture in the soil consequent on heavy down pour from mid May to mid June i.e., for one month.

2.2. Influence of intercropping on yield contributing characters:

a) Plant height of Cv. D-154 and O-4 decreased in both intercrop combinations i.e.,jute + millet and jute + aus. When grown with aus O-4 grew taller (Table 12). Despite its greater height O-4 gave lower fibre yield than D-154 in intercrop combination with aus.

b) Millet grew taller, and produced more panicle wt. and higher grain yield when grown with D-154 compared to that of O-4 (Table 13).

c) Aus grew taller, produced more panicle wt. and grain yield when this crop was grown with D-154 than with O-4. Ripened grain percentage and caryopsis wt. were more when grown with D-154 than with O-4 (Table 14).

Table 12: Yield contributing characters of jute in sole and intercropping with millet and aus

Year	Cultivar	Plant ht.(cm)	Fibre wt.(gm)	Stick wt.(gm)	Fibre content(%)
		Mean ± S.E.			
1982	D-154 sole	288±10.6	8.85±0.62	21.7±1.95	29.3±0.79
1983		248±13.1	5.55±1.10	13.9±2.60	28.4±0.40
Average		267	7.20	17.8	28.9
1982	D-154(M)	270±12.6	5.37±0.43	13.8±1.15	28.2±0.45
1983		236±11.6	5.02±0.90	13.2±2.27	27.6±0.60
Average		253	5.19	13.5	27.9
1982	D-154(A)	270±7.38	6.16±0.84	18.3±2.51	25.5±0.80
1983		242±13.5	6.71±1.13	17.0±2.99	28.4±0.26
Average		256	6.43	17.6	27.0
1982	O-4 sole	319±4.79	9.89±0.43	20.2±1.15	33.0±0.93
1983		293±11.5	9.09±0.56	21.1±1.44	30.3±0.55
Average		306	9.49	20.7	31.6
1982	O-4(M)	216±17.3	3.33±0.46	7.54±1.02	30.6±0.31
1983		280±6.77	6.16±0.67	13.4±1.16	31.2±0.62
Average		248	4.75	10.5	30.9
1982	O-4(A)	260±12.7	4.96±0.57	11.0±1.53	31.2±0.60
1983		287±10.5	6.49±0.80	14.8±1.69	30.3±0.47
Average		274	5.73	12.9	30.8

D-154(M) and O-4(M)= Jute intercropped with millet

D-154(A) and O-4(A)= Jute intercropped with aus.

Table 13: Yield contributing characters of millet in sole and intercropping with jute

Year	Cultivar	Plant ht.(cm)	Panicle length(cm)	Panicle wt.(gm)	Grain wt.(gm)
1982	millet sole	115±3.07	16.7±0.42	6.24±0.44	4.53±0.25
1983		114±3.70	15.5±0.69	4.70±0.33	3.79±0.23
Average		114.87	16.1	5.47	4.16
1982	millet(D-154)	105±5.12	17.2±0.83	4.97±0.16	3.24±0.17
1983		110±3.94	16.3±0.93	4.01±0.27	3.36±0.18
Average		107	16.7	4.49	3.30
1982	millet sole	114±4.34	14.5±0.95	5.08±0.51	4.28±0.44
1983		114±2.89	16.6±0.85	6.43±0.49	4.36±0.39
Average		114	15.6	5.76	4.32
1982	millet(O-4)	105±4.79	12.1±1.16	3.01±0.72	2.59±0.62
1983		106±2.28	14.1±0.71	4.52±0.46	3.05±0.41
Average		106	13.1	3.77	2.82

millet(D-154)= millet intercropped with jute

millet(O-4)= millet intercropped with jute

Table 14: Yield contributing characters of aus in sole and intercropping with jute

Year	Aus	Plant ht.(cm)	Panicle length(cm)	Grain wt.(gm)	Ripened grain(%)	Caryopsis wt.(mg)
1982	aa	90.1±3.69	19.5±0.45	1.54±0.10	91.9±1.39	24.0±0.68
1983		99.0±2.86	19.6±0.44	1.60±0.08	88.2±1.75	25.2±0.80
Average		94.6	19.6	1.57	90.1	24.6
1982	aj*	81.4±1.94	17.3±0.59	0.84±2.63	73.2±2.63	17.8±0.76
1983		80.0±2.05	18.1±0.33	1.24±0.11	76.0±2.41	18.8±0.62
Average		80.7	17.7	1.04	74.6	18.3
1982	aa	87.4±5.54	17.5±0.33	1.46±0.09	93.1±1.55	23.4±0.30
1983		91.1±3.45	18.3±0.43	1.82±0.16	88.8±1.81	23.7±0.64
Average		89.2	17.9	1.64	91.0	23.6
1982	aj**	73.8±1.34	17.0±0.30	0.50±0.06	63.9±3.14	16.9±1.92
1983		78.1±1.25	16.8±0.31	0.73±0.04	68.1±3.01	17.4±1.22
Average		75.9	16.9	0.62	66.0	17.2

aa= Aus Cv. Kalamanik sole. aj*= Aus intercropped with D-154. aj**= Aus intercropped with O-4.

2.3. Influence of intercropping on the growth parameters of the component crops :

a) Jute: Relative growth rate (RGR) of jute was more in sole crop during the initial 30 days than in the intercrop. When grown with aus and millet, its RGR increased in the third growth period than when jute was the sole crop in the field (Fig 4). This paradox can be explained because by this time harvesting of the component crop is over, extra maturity, more space between the rows etc contributing to the increased growth.

Increase in net assimilation rate (NAR) at third growth period was higher in jute when grown with aus. It was less in the preceding two growth periods (Fig. 5).

Leaf area ratio (LAR): It was more in the first growth period in sole crop but decreased gradually in the following two growth periods. LAR increased in those periods for jute in both the combinations. (Fig. 6).

b) Millet: RGR of millet was more in sole crop at both first and second period of growth compared to that observed in intercropped millet (Fig.7).

NAR too increased in intercropped millet at the second growth period but LAR was higher in millet as sole crop in both the growth periods (Fig. 8,9).

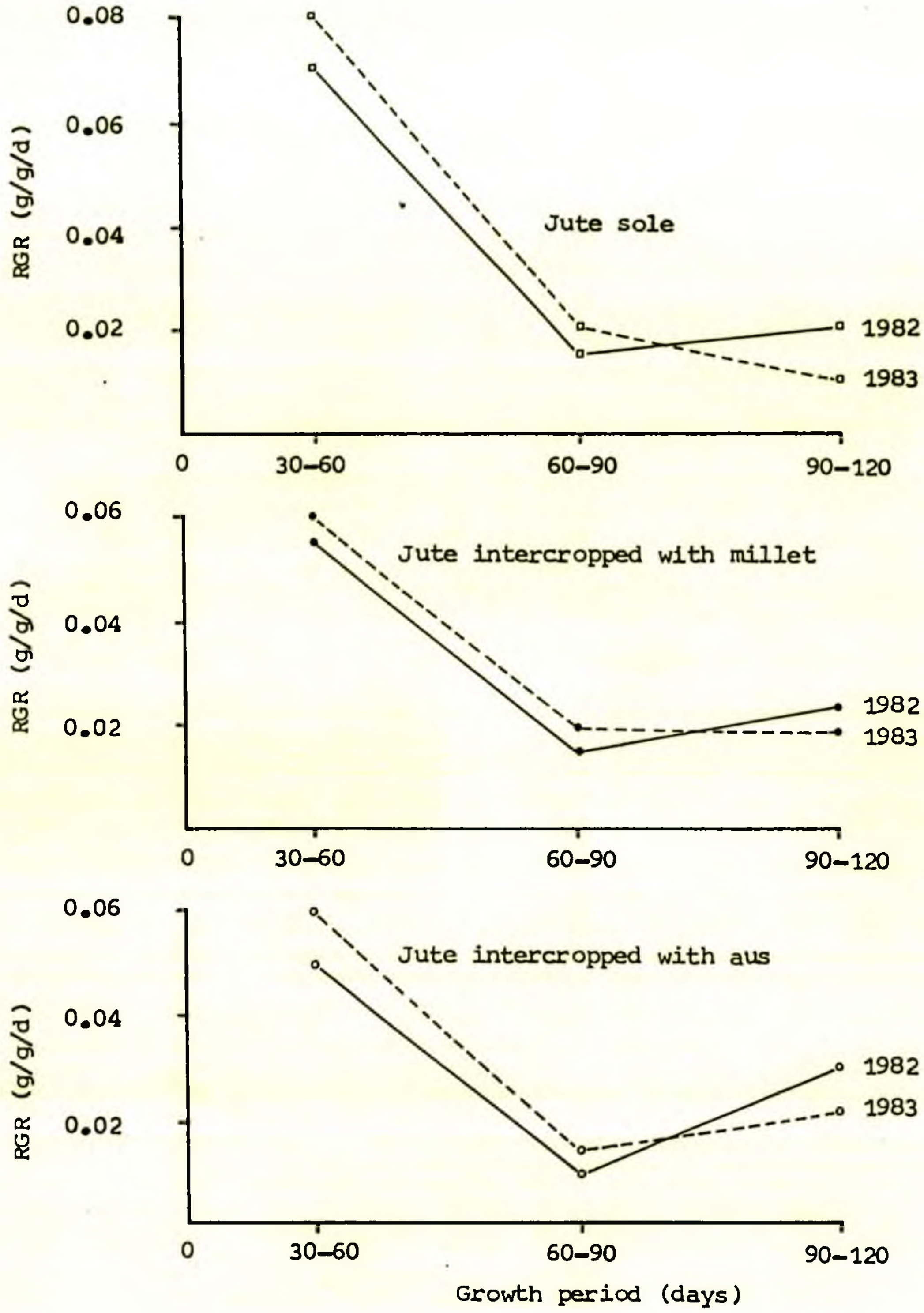


Figure 4 : Relative growth rate (RGR) of jute in sole and in intercroping, note that millet and aus were harvested at 90 days.

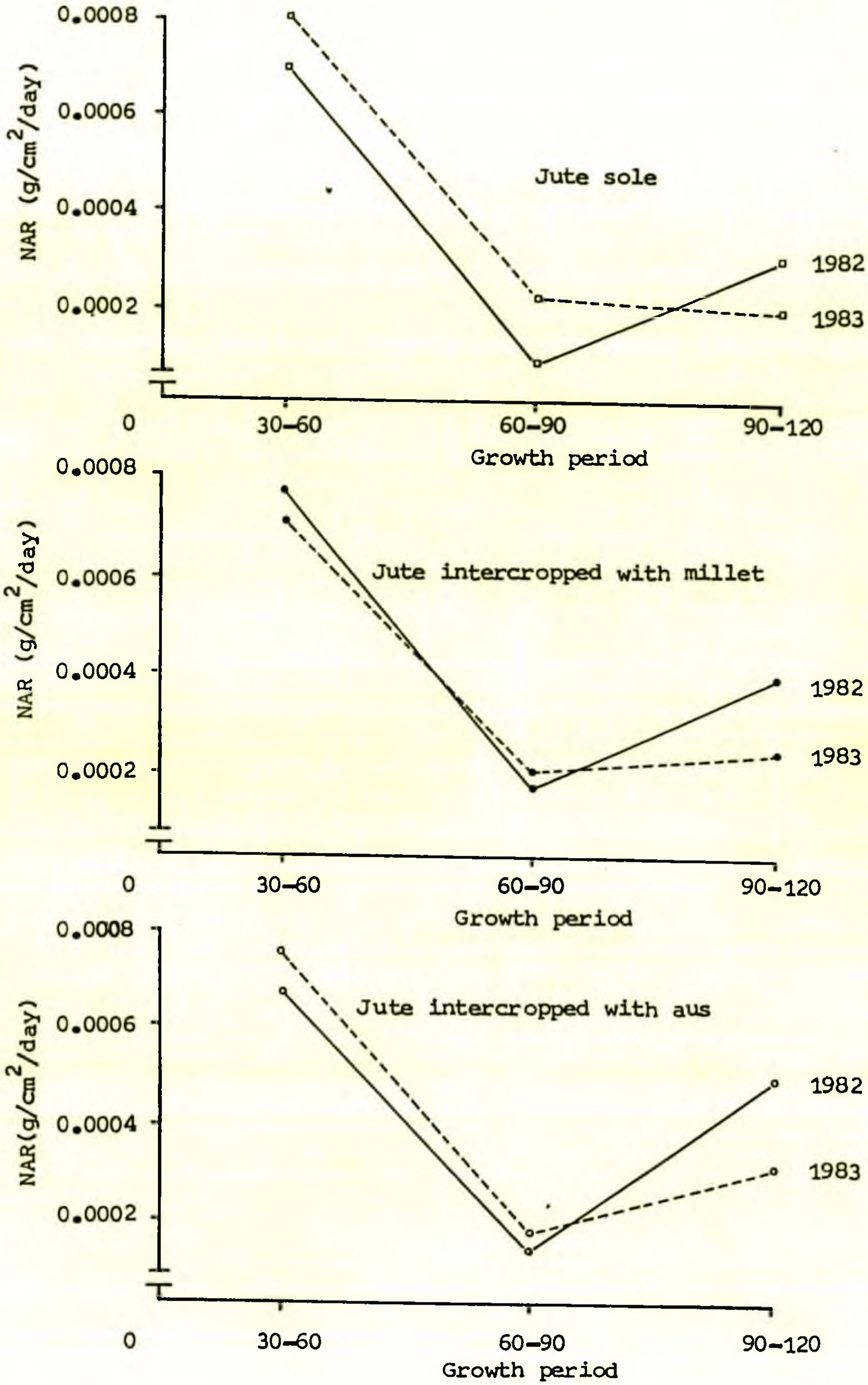


Figure 5 : Net assimilation rate (NAR) of jute in sole and in intercroping, note that millet and aus were harvested at 90 days.

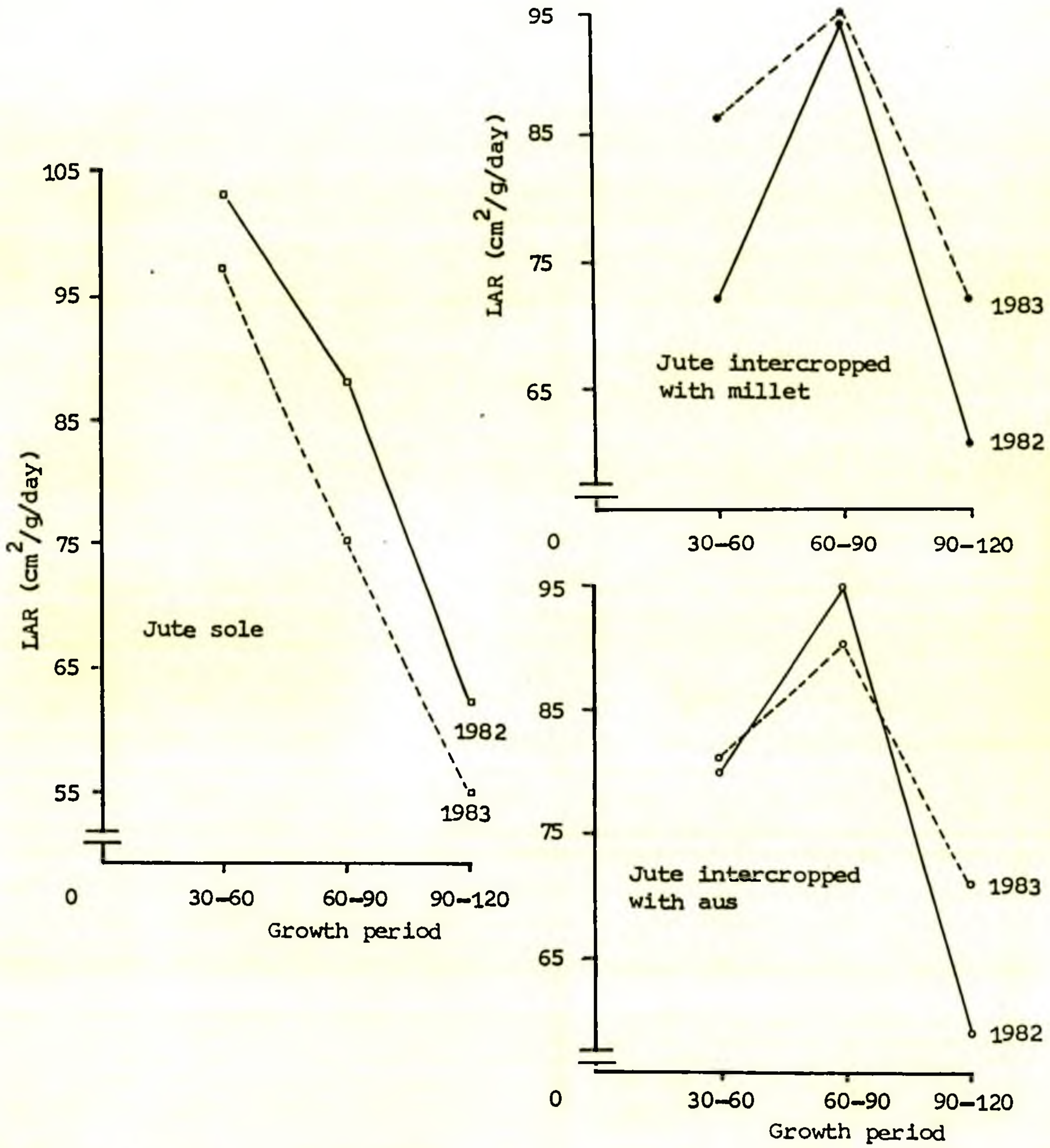


Figure 6 : Leaf area ratio (LAR) of jute in sole and in intercropping, note that millet and aus were harvested at 90 days.

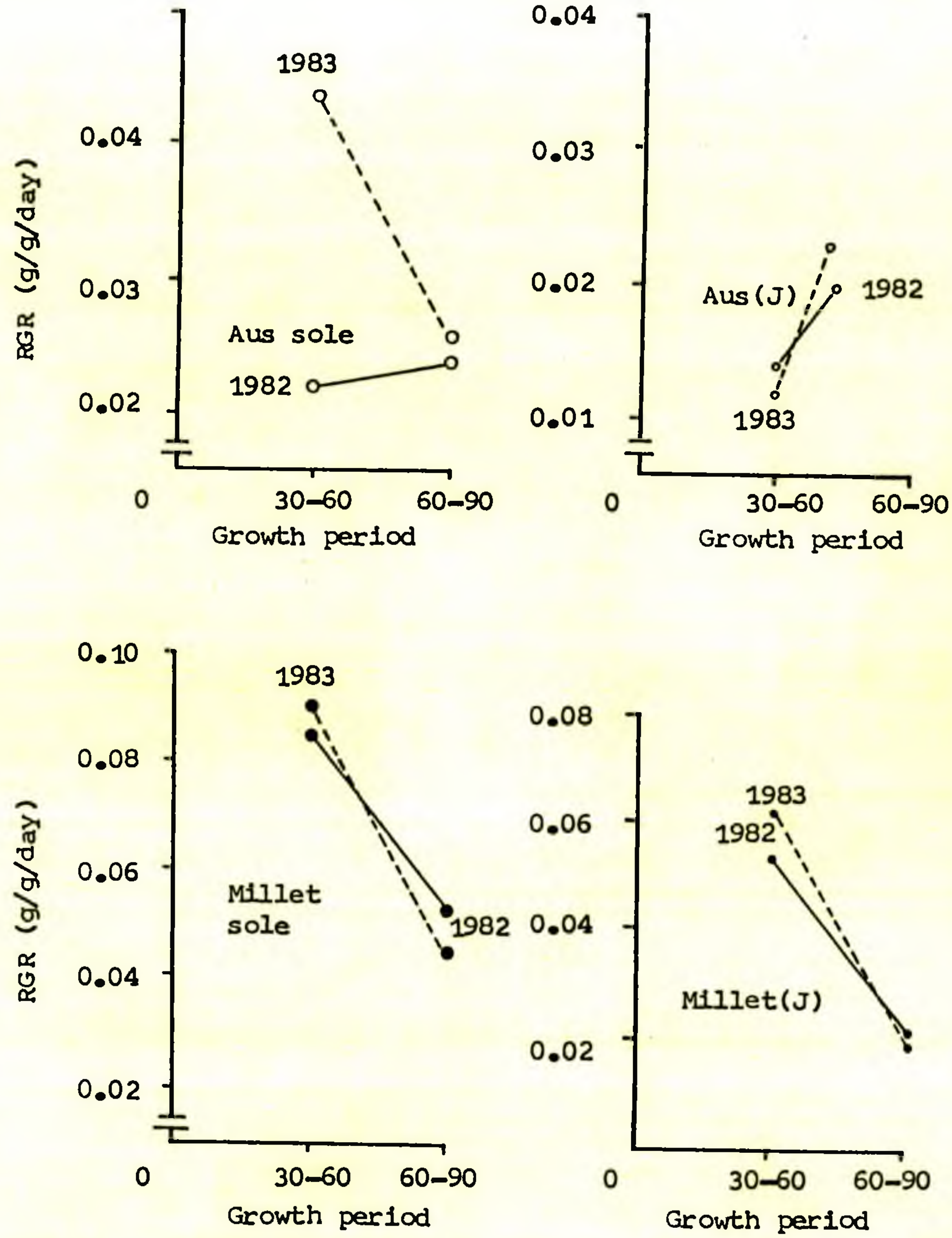


Figure 7 : Relative growth rate (RGR) of sole and intercropped millet and aus.

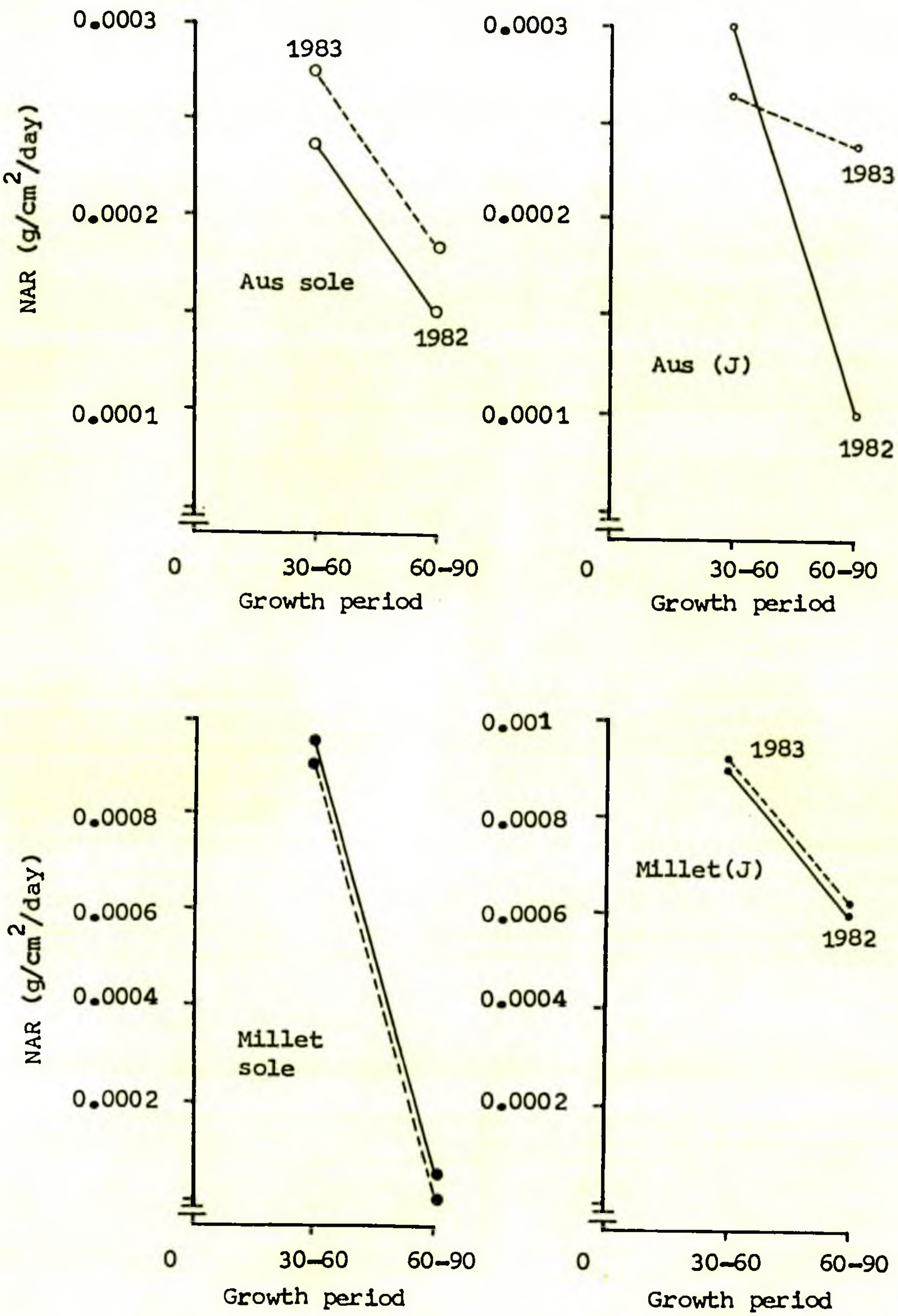


Figure 8 : Net assimilation rate (NAR) of sole and intercropped millet and aus.

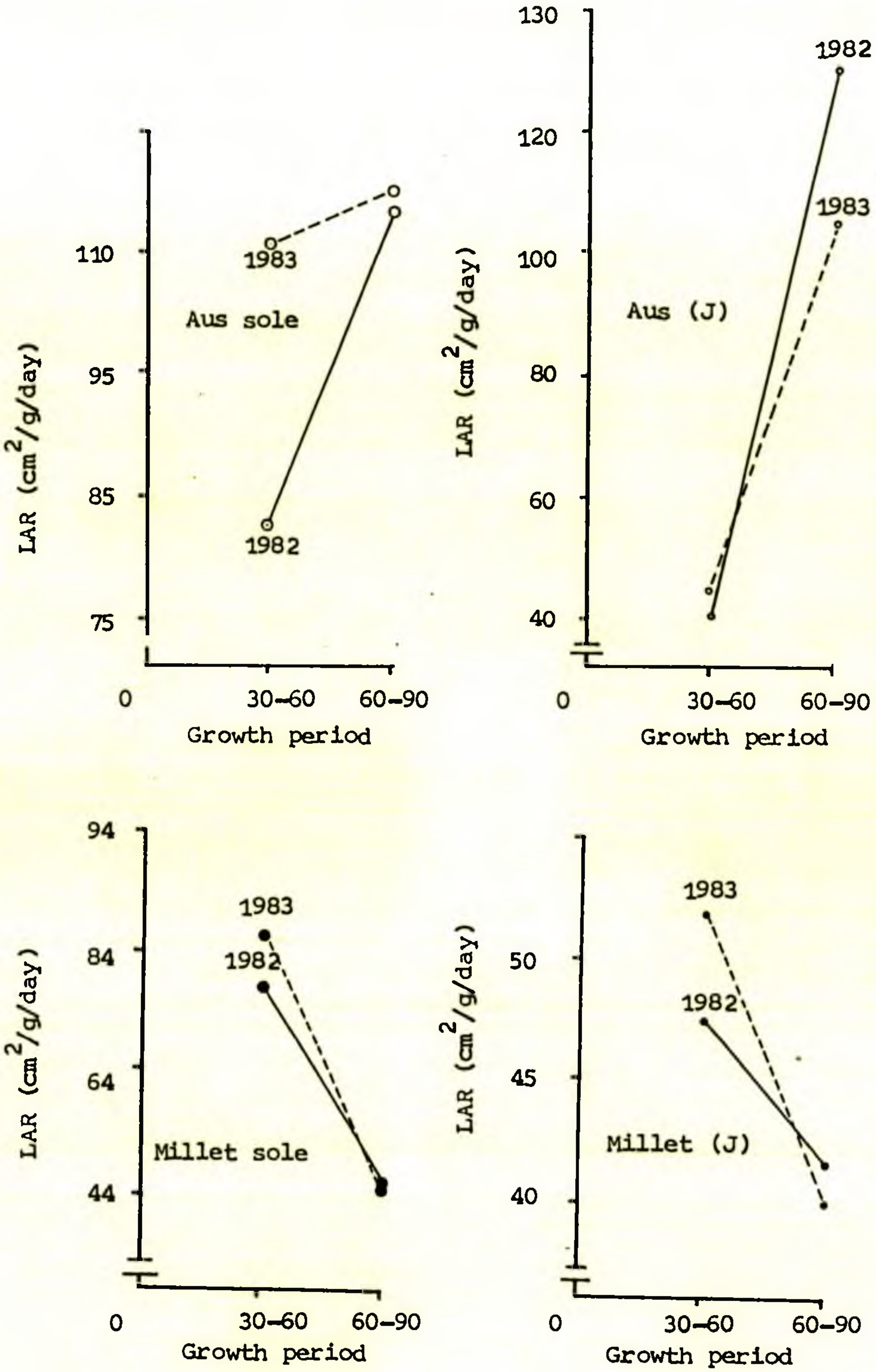


Figure 9 : Leaf area ratio (LAR) of sole and intercropped millet and aus.

c) Aus: Aus as a sole crop had higher RGR in first growth period and similar in second growth period with intercropped aus (Fig. 7). NAR of sole aus was almost same with inter-cropped aus in both periods. LAR was lower in intercropped aus in first growth period but higher in second growth period compared to sole aus (Fig. 8,9).

3. Phenology and correlation of growth phases of jute planted on different dates

3.1. Growth stages at different dates of planting :

Average flowering took higher calendar days (CD) (136 and 134 days, respectively) and growing degree days (GDD) (1029 and 1060, respectively) in 30 March sowing as compared to other sowings in both years (Table 15). Higher CD and GDD were also found for floral bud stage in jute sown in 30 March in both years. Coefficient of variation (CV) among the genotypes for different phenological stages measured by CD and GDD did not vary much (cf. Table 15). The CV in CD and GDD for 50% floral bud stage were higher in 14 April sowing in both years (Table 15).

Delayed sowing by 1.5 months i.e., from 15 March to 29 April shifted the date of flowering by 16 and 21 days in 1984 and 1985 respectively. This shortened total life cycle i.e., if the sowing is delayed from 15 March to 29 April life cycle was shortened by 32 in 1984 and by 54 days in 1985.

Table 15: Effect of planting dates on three phenological events as observed in experimental plots at Manikganj *

Phenological event	Year	Calendar days D1	D2	D3	D4	Growing degree days D1	D2	D3	D4
50% Bud	1984	79	94	83	77	563	698	607	546
	1985	78	104	83	78	528	806	639	605
50%Flower	1984	131	136	127	115	956	1029	964	864
	1985	126	134	109	105	963	1060	852	819
Life cycle	1984	230	217	200	198	1742	1651	1515	1437
	1985	830	202	182	176	1814	1636	1437	1471
Coefficient of variation (percentage)									
50% Bud	1984	7.21	5.21	13.2	7.11	7.60	4.54	13.1	8.29
	1985	8.75	4.92	12.8	12.1	9.90	5.78	13.1	10.4
50%Flower	1984	3.55	2.47	5.78	8.55	4.24	2.86	6.62	9.66
	1985	6.11	10.8	4.97	2.83	6.64	7.03	5.30	3.08
Life cycle	1984	3.00	2.77	8.60	3.09	1.58	1.60	1.85	2.75
	1985	3.95	8.41	3.72	3.79	3.50	6.98	3.99	3.05

* Average values of nine different genotypes have been shown in the table. D1 = 15 March, D2 = 30 March, D3 = 14 April and D4 = 29 April.

Table 16: Correlation coefficients on jute planted at different dates at Manikganj (1984, 1985)

Life cycle (CD)			Life cycle (GDD)		
Planting to	D1	0.79**	Planting to	D1	0.63**
flowering	D2	0.90**	flowering	D2	0.58*
(CD)	D3	0.78**	(GDD)	D3	0.77**
	D4	0.71**		D4	0.52*

**, * significant at the 1% and 5% levels.

D1 = 15 March, D2 = 30 March, D3 = 14 April, D4 = 29 April.

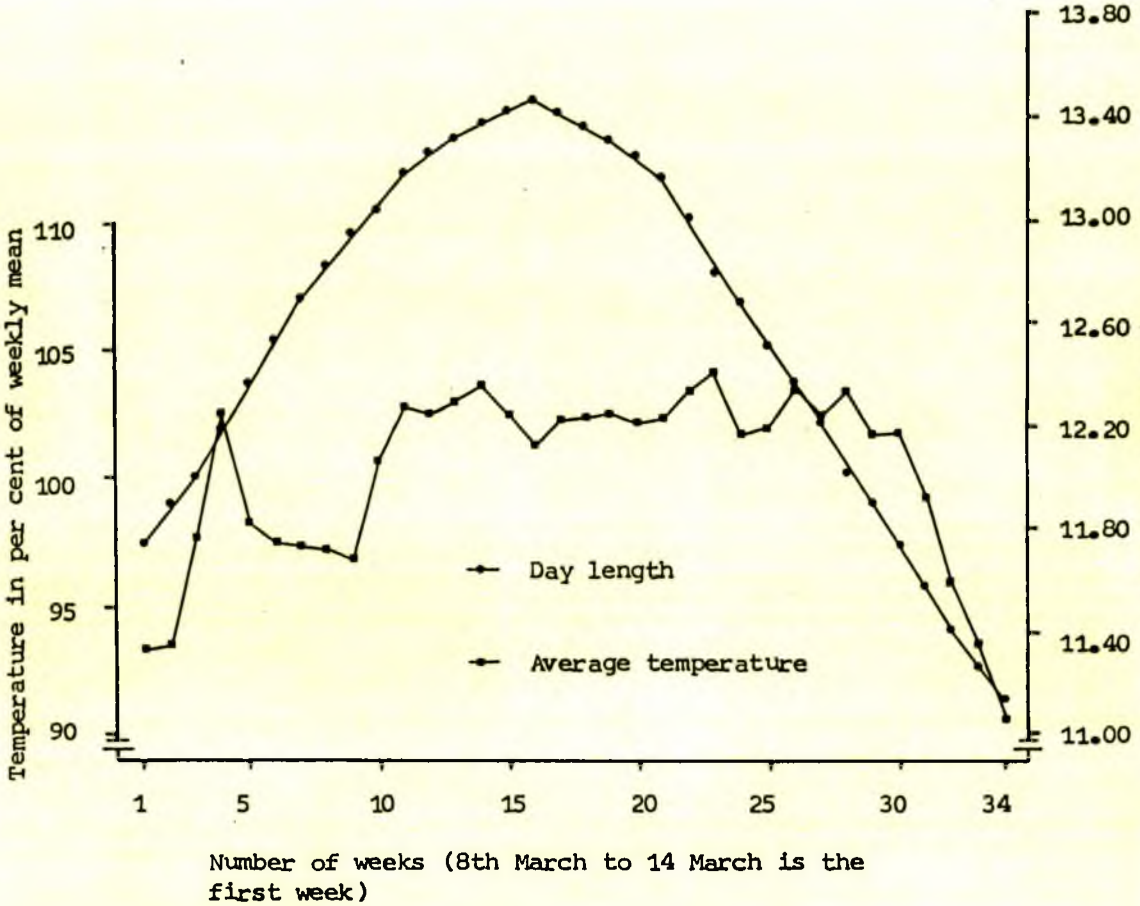


Figure 10 : Mean temperature at weeks interval from March to November, 1980 - 1986, and weekly mean day length for 1986.

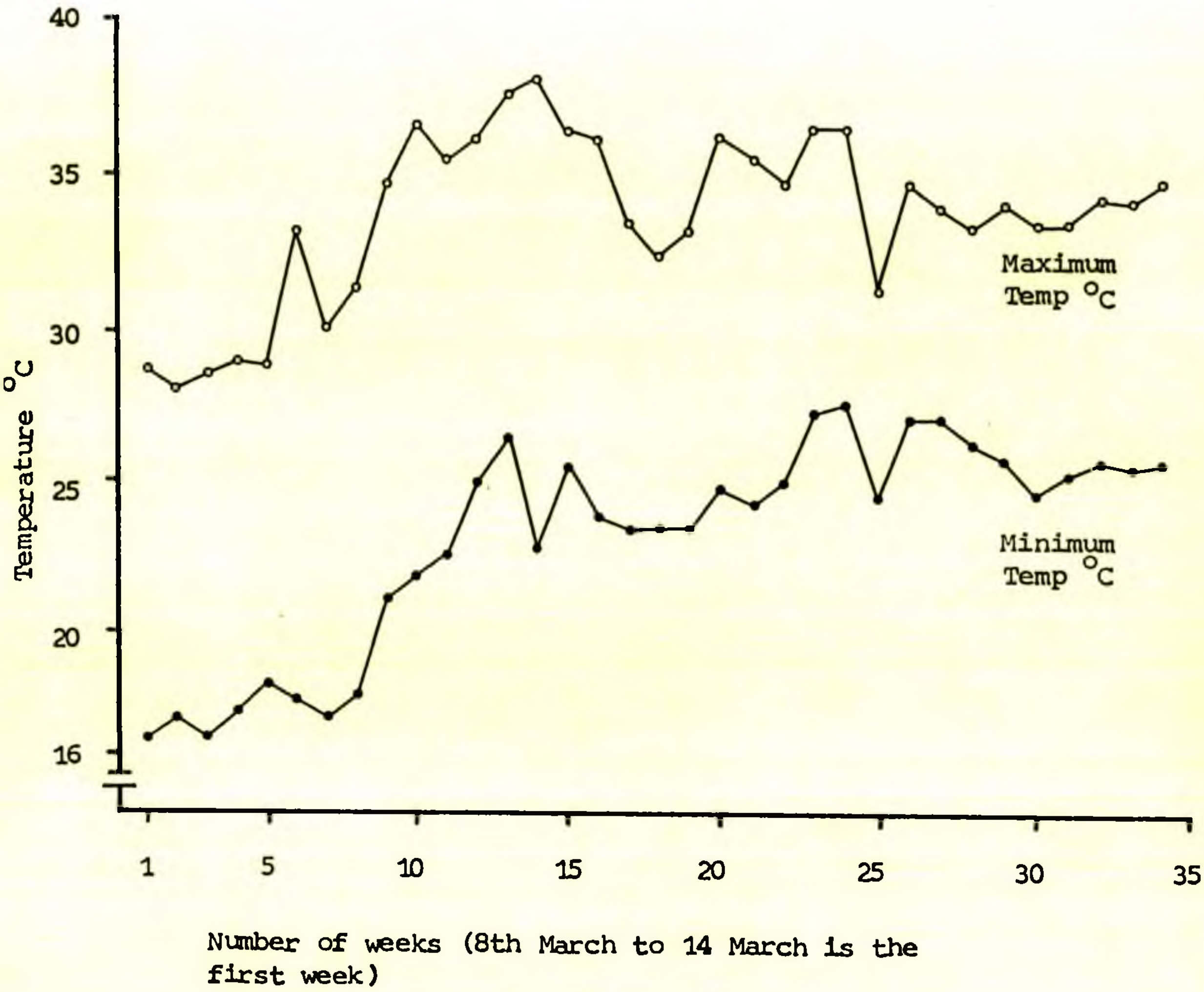


Figure : 11 Weekly average maximum and minimum temperature (1984 to 1986)

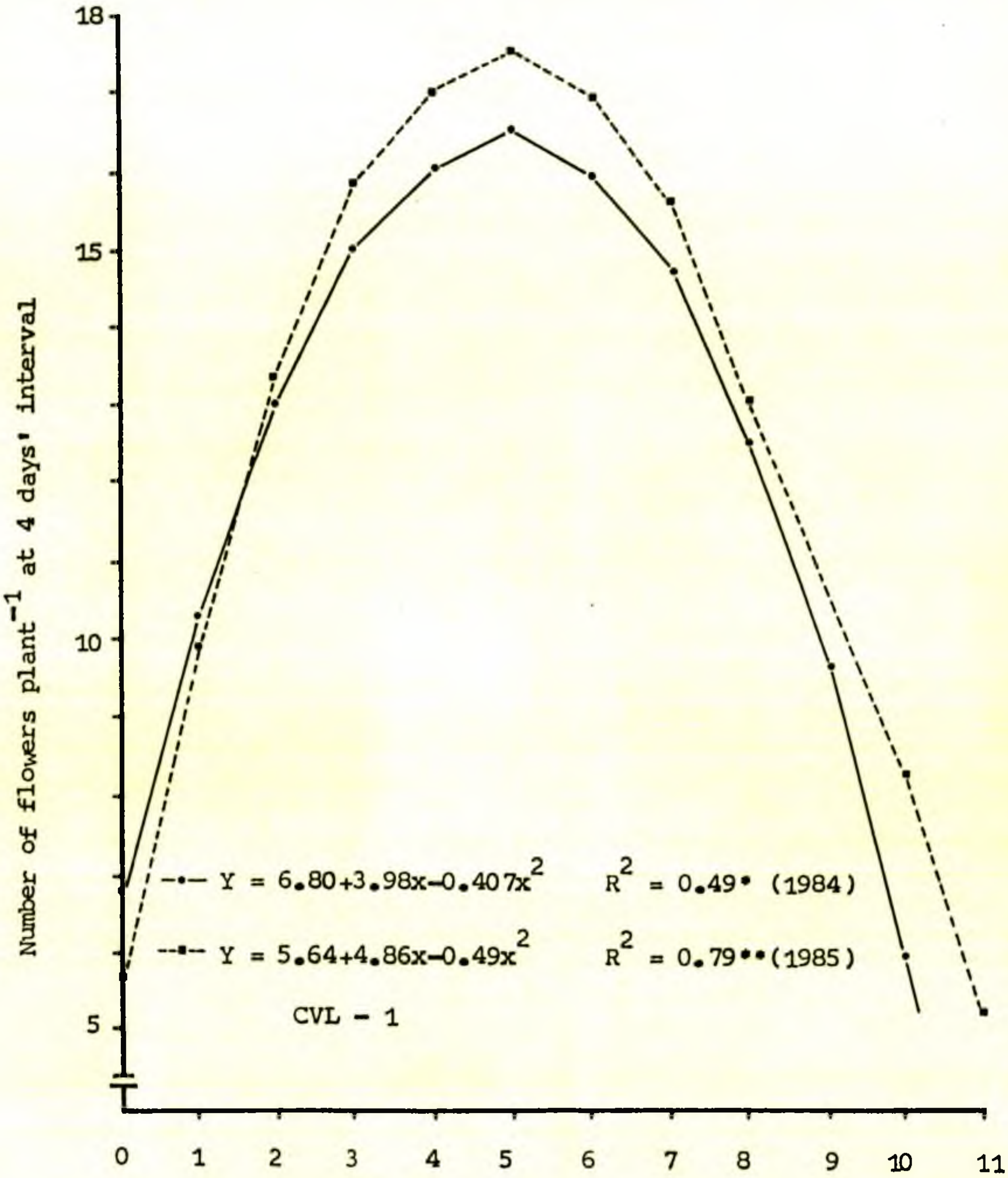
The CDs from planting to flowering were positively correlated with the length of life cycle for all the four planting dates. The 'r' values in 4 planting dates were 0.79**, 0.90**, 0.78** and 0.71**, respectively (Table 16). Similarly GDDs from planting to flowering time and that of life cycle were positively correlated (r=0.63**, r=0.58* , r=0.77** and r=0.52*).

3.2. The beginning and termination of flowering and pod formation in the potted plants:

The duration of flowering period of CVL-1 was 48 days in both years. The regression equation was significant in both years, i.e., F=4.27* in 1984 and F=16.99** in 1985. The variation from 49 to 79 per cent observed in the total number of flowers can be explained by the equations shown in Fig.12. Maximum number of flowers were recorded on the 24th day from the time of the visibility of first flower. The maximum number of flowers was observed during the period between 20 and 28 days.

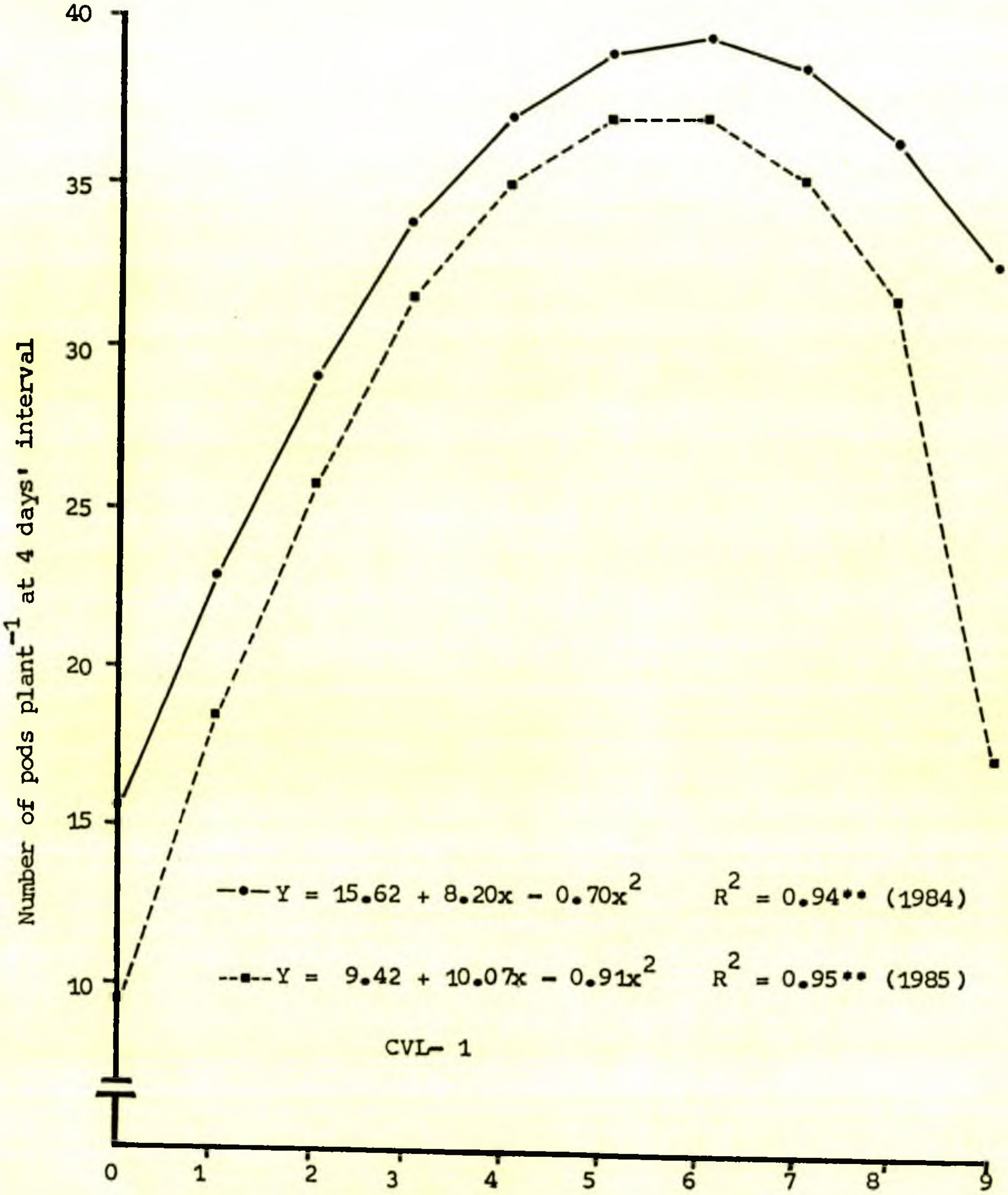
The estimated regression equations on number of pods/unit of 4 days were significant in both years (i.e., F=56.70** and 68.08**) and about 94 and 95 per cent of the total variation in pod bearing capacity can be explained by the equations (Fig 13).

Maximum number of fruits were observed during the period between 24 and 32 days in 1984 and between 24 and 28 days in



Time interval in terms of 4 days as a unit i.e. 0,1,2, indicating 4,8,12 days interval (see page 13 for details)

Figure:12 Number of flowers that bloomed at 4 days' interval from the time of the visibility of first flower.



Time interval in terms of 4 days as a unit i.e. 0,1,2 indicating 4,8,12 days' interval (see page 13 for details).

Figure 13 : Number of pods that observed at 4 days' interval from the time of the visibility of first fruit.

1985 (Fig 13).

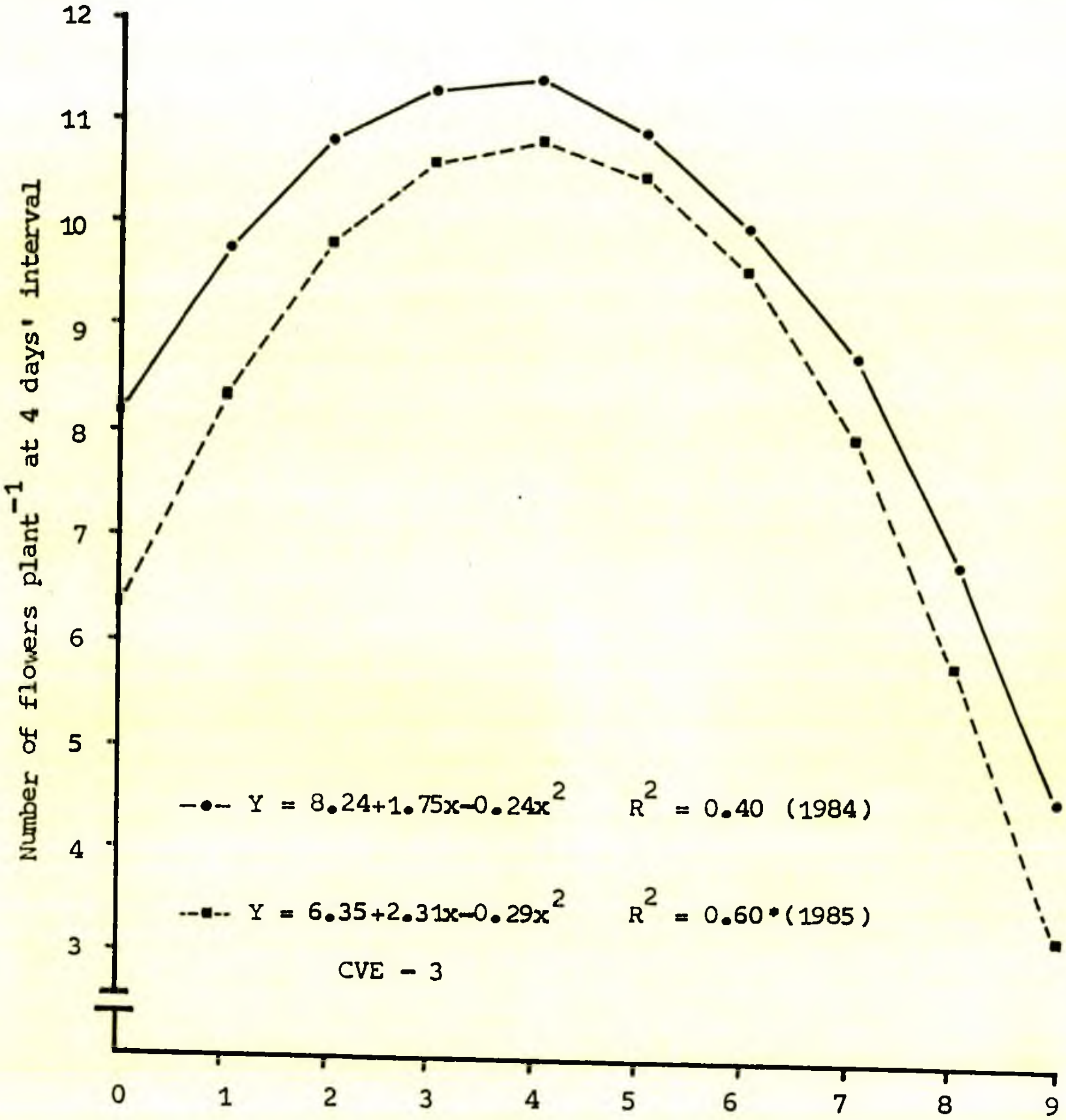
The regression equation of flower bearing in CVE-3 was not significant in 1984. But in 1985 it was significant (F=5.17*) and about 60 per cent of the total variability in flower appearance over time may be explained by the equation (Fig 14). In both years maximum flowers were recorded on the 20th day from the visibility of the first flower. The maximum number of flowers was observed duridng the period between 16 and 24 days.

The estimated regression equations on number of pods/unit of 4 days were significant in both years (F=21.22** and F=17.88*) and about 90 and 88 per cent of the total variation in pod appearance over time can be explained by the equations.

Maximum number of fruit formation was observed during the period between 20 to 24 days in both years (Fig 15).

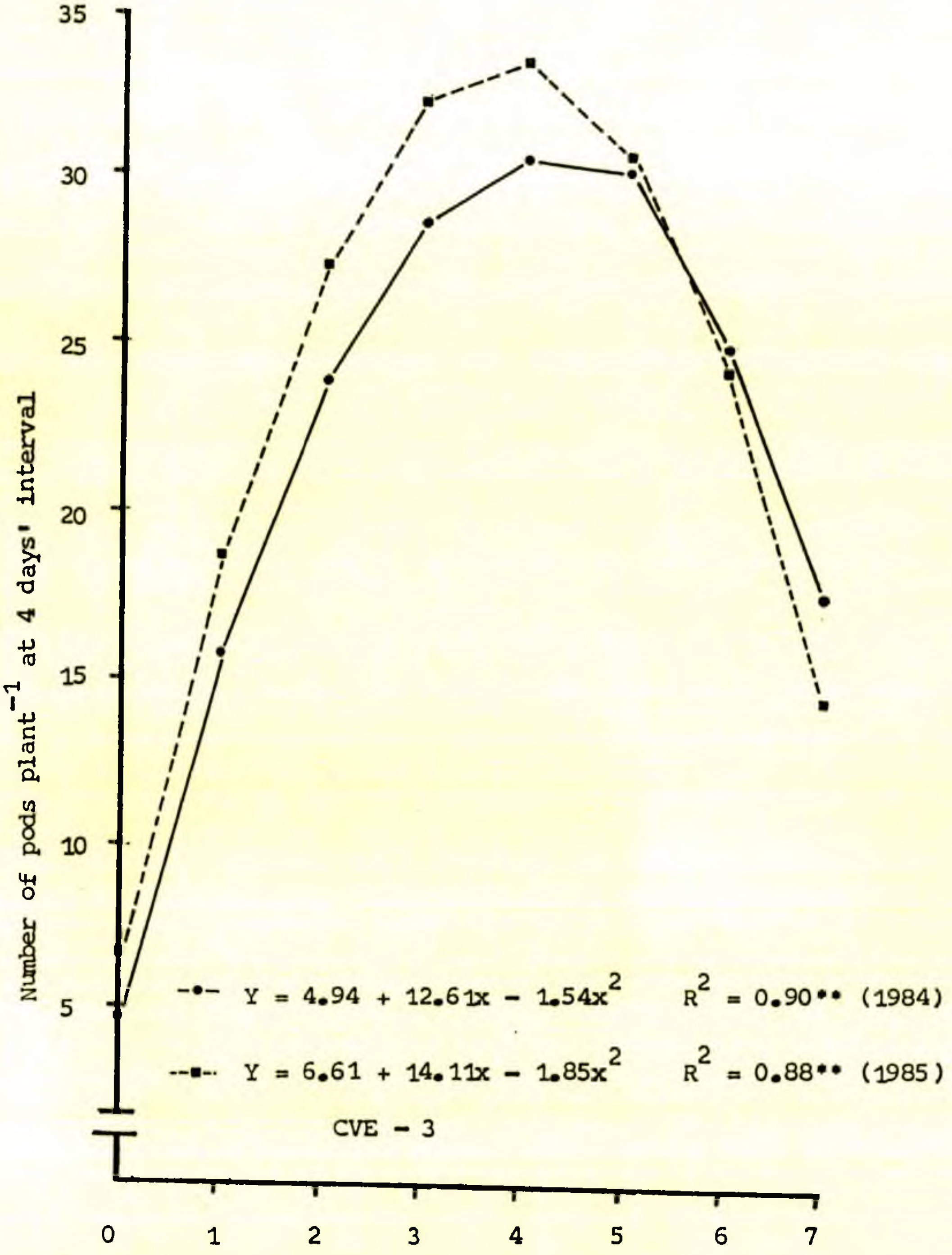
4. Physiological maturity of C.capsularis seeds.

Regression analysis over time showed that dry wt. of seed increased linearly prior to physiological maturity and the point of intersection of two straight lines provided an objective means of determining physiological maturity (Fig 16 and 17). From the regression analysis the physiological maturity of seeds of C.capsularis (cv. CVL-1 and CVE-3) was found to be attained at 60 days following anthesis of the flower. The r2 for the linear period of dry matter accumulation of the seeds was more than 0.98 for both cultivars in



Time interval in terms of 4 days as a unit i.e. 0,1,2, indicating 4,8,12 days' interval (see page 13 for details).

Figure 14 : Number of flowers that bloomed at 4 days' interval from the time of the visibility of first flower.



Time interval in terms of 4 days as a unit i.e. 0,1,2, indicating 4,8,12 days' interval (see page 13 for details).

Figure 15 : Number of pods that observed at 4 days' interval from the time of the visibility of first fruit.

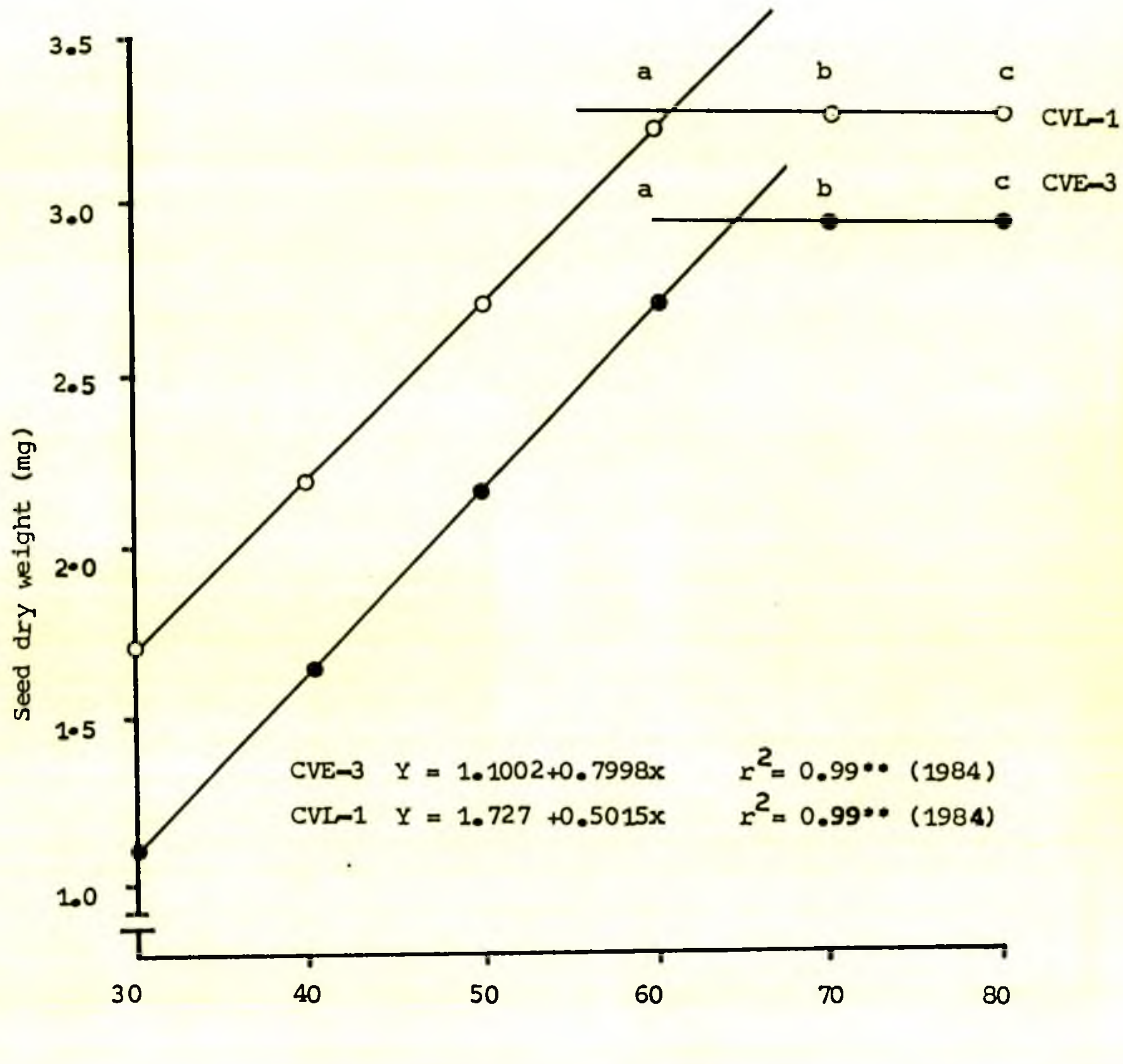


Figure 16 : Estimated physiological maturity of seeds and the corresponding visual indicators.

a. First sign of mature seed coat colour

b. attainment of semi-dry condition of fruit while the stem is still green

c. When stem started showing signs of drying

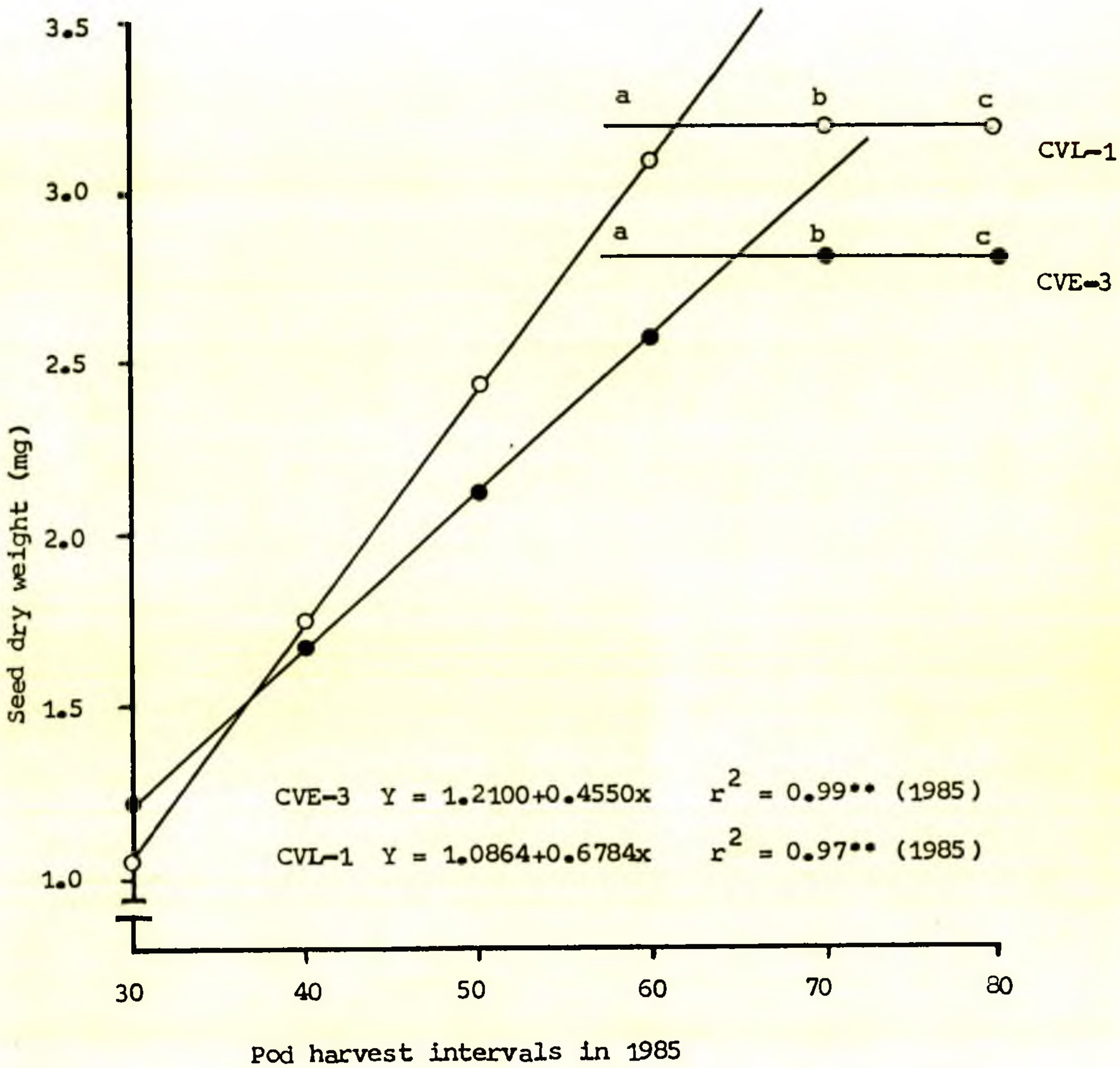


Figure 17 : Estimated physiological maturity of seeds and the corresponding visual indicators

a. First sign of mature seed coat colour

b. attainment of semi-dry condition of fruit while the stem is still green

c. When stem started showing signs of drying both years. Mean mature wts. of CVL-1 and CVE-3 were 3.2 ± 0.04 and 2.7 ± 0.05 (mg/seed) in 1984 while in 1985 these values were 3.2 ± 0.03 in CVL-1 and 2.8 ± 0.04 in CVE-3.

4.1. Identification of visual indicators at different stages of physiological maturity:

The seeds of both cultivars were found to attain physiological maturity within 60 days following anthesis although at this time the stem still green and the pod was not fully dry. In other words colour of the seeds turns brown in 2 months indicating that physiological maturity is attained about a month earlier than what is usually assumed (Fig 16 and 17).

4.2. Relationship between maturity of seeds and different seed attributes:

a) Seed weight: On partitioning the sum of squares of seed wt. accumulation, linear (843.10) and quadratic (8.99) components were found significant (1 per cent level) at 1 and 44 degrees of freedom (Fig 18).

b) Viability: Regression analysis showed that more the maturity of seeds, the more the rate of germination percentage and it increased positively with the maturity of the seeds. The best fitted response curve was found to be linear. The r value was 0.97**. The increment of germination percentage was 18.75 as the seeds advanced from earlier maturity stage to the full mature stage (Fig 19).

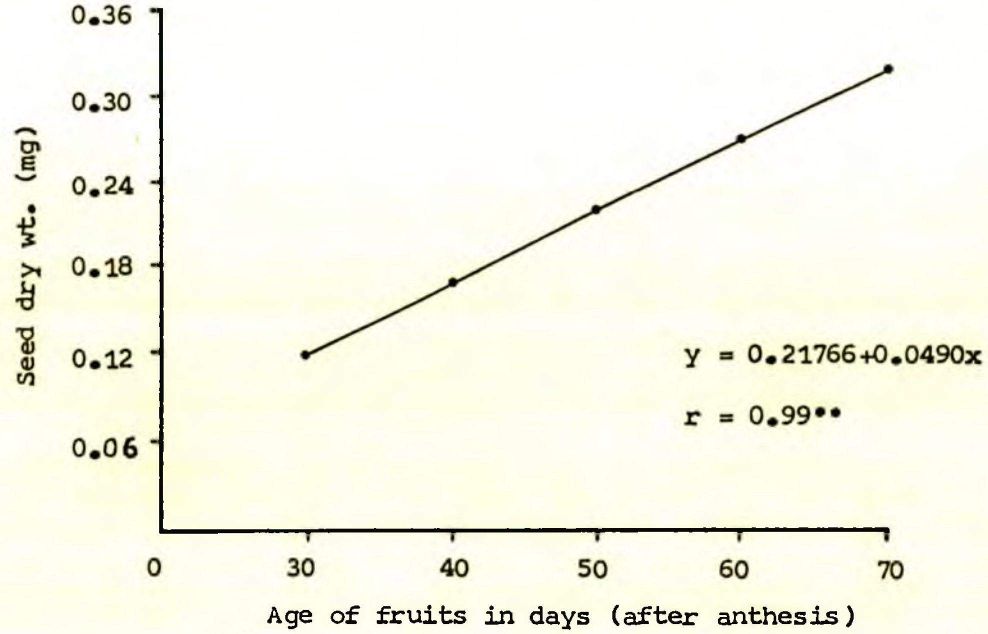


Figure 18 : Relationship between age of fruits and seed dry wt.

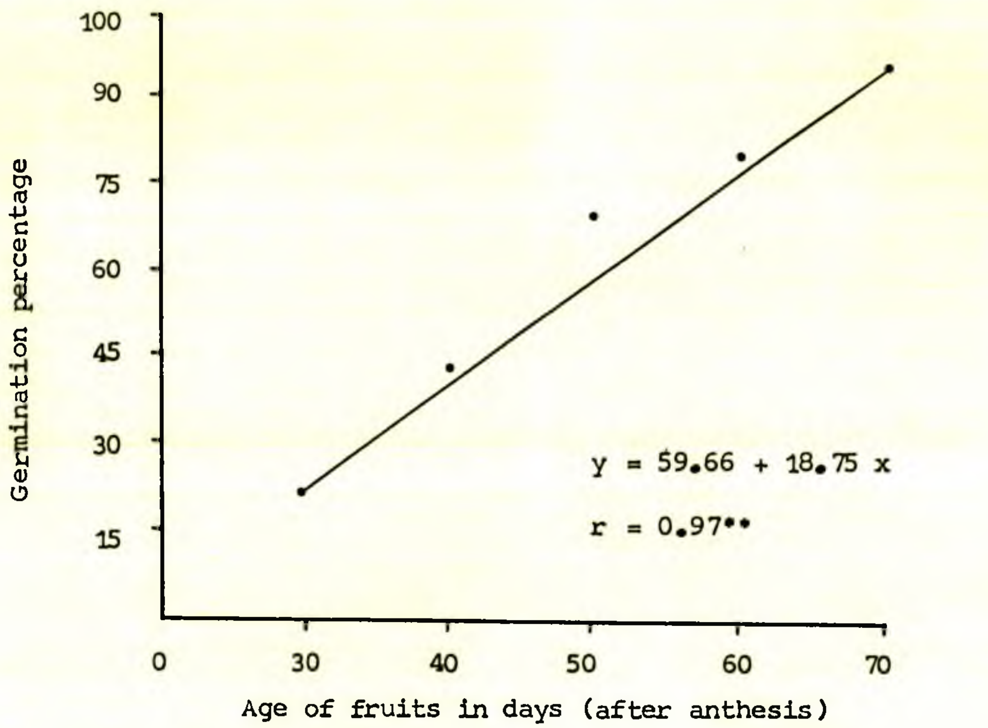


Figure 19 : Relationship between age of fruits and germinability.

c) Vigour value: Regression analysis showed that the vigour of the seeds increased positively with the maturity of the seeds. The best fitted response curve was found to be linear. Vigour increased at the rate of 10.08 for the change of maturity of seed from earlier stage through subsequent stages. The r value was 0.96** (Fig 20).

d) Dry wt. of seedling: Increase in dry wt. of seedling was 0.012 (mg/seedling) at the time of change from earlier through successive maturity stages. The correlation coefficient was 0.63** and significant at 1 per cent level with 9 df (Fig 21).

5. Genotype x environment interactions and their influence on maintaining stability of *C.capsularis* genotypes.

5.1. Genotype x environment interactions:

In combined analysis the differences in fibre yield among genotypes were highly significant. The performance of the genotypes among dates of planting was also highly significant. The interaction effect of genotype x date was highly significant (Table 17).

In regression analysis the difference among genotype means was significant at 1 per cent level. The environmental effect was also significant at 1 per cent level. The genotype x environment (linear) regression calculated on the environmental index was significant both against pooled error and pooled deviation from regression. Pooled deviation was also

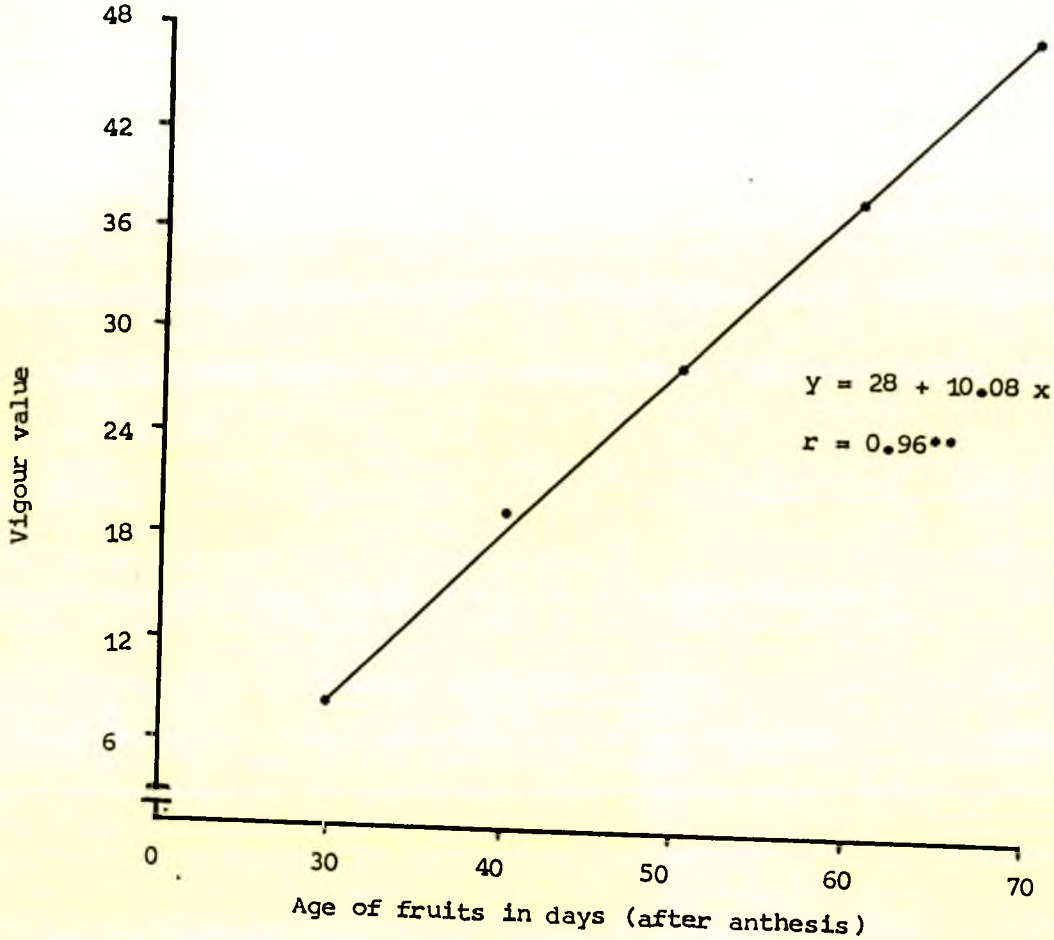


Figure 20 : Relationship between age of fruits and speed of germination.

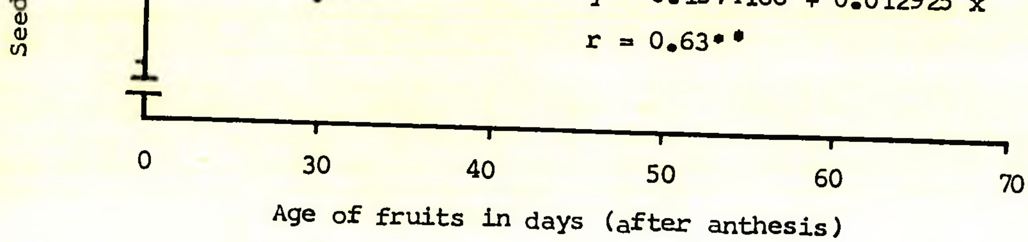


Figure 21 : Relationship between age of fruits and seedling dry weight.

Table 17: Combined analysis of variance on fibre yield of five *C.capsularis* genotypes

Source of variation	d.f.	Mean squares
Year (Y)	2	0.0032268
Dates of sowing (D)	5	0.1048634**
YxD	10	0.0007470
Genotype (G)	4	0.0530756**
GxY	8	0.0004629
GxD	20	0.0083096**
GxYxD	40	0.0011929
Pooled error	144	0.0033596

** significant at the 1% level of probability.

Table 18: Analysis of variance when stability parameters of fibre yield of five C.capsularis genotypes were estimated (based on 18 environments)

Source of variation	d.f.	Meam squares
Total	89	0.032634
Genotype(G)	4	0.159227**
Environment (Env)	17	0.094983**
GxEnv	68	0.333465
Env + (G x Env)	85	0.026677
Env (Linear)	1	1.614732
G x Env (Linear)	4	0.054876**
Pooled deviation	80	0.005416**
Pooled error	144	0.003359

** significant at 1% level of probability.

Table 19: Mean yields and estimate of stability parameters of fibre yield in five C.capsularis genotypes (based on 18 environments)

Genotypes	Yi	bi	s2di +
CVE-3	0.4458	0.5644	0.0069**
CC-45	0.5957	0.9720**	0.0049*
Dhabdhabey	0.4135	0.7127**	0.0014
D-154	0.6290	1.6238**	0.0040
CVL-1	0.5552	1.1275**	0.0041
Average	0.5278	1.0000	0.0042
L S D (5%)	0.0219		

**, * significant at the 1% and 5% levels,

\+ Yi = Mean yield in Kg/1.83 sq. meter, bi = regression coefficient and s2di= deviation mean square from regression.

significant at 1 per cent level (Table 18).

5.2. Regression on individual genotypes:

The mean yield for the genotypes ranged from 0.4135 to 0.6292 kg/1.83 sq. meter (Table 19).

Except for CVE-3 the regression coefficient of each genotype was significant. Regression coefficient value (bi) ranged from 0.56 to 1.62. The deviation from regression (s2di) was significant in CVE-3 at 1 per cent level (F=2.41) and CC-45 at 5 per cent level (F=1.78). Deviation from regression values ranged from 0.001 to 0.006 in all the genotypes (Table 19).

DISCUSSION

1. Effect of dates of sowing and stages of harvest on yield.

1.1. Stage of harvest:

Individual and combined analysis indicated that the main effect of genotype was significant (Table 1). It further indicated that real difference exists between the yields of the genotypes.

The yield of C.*olitorius* was not significantly different from that of the genotypes of C.*capsularis*. It indicated that CVE-3 and CC-45 can be replaced by either OVT-3, Chaitali or O-9897, if the crop is intended to be grown for a field duration of 120 to 150 days (Table 2). The above results are in agreement with earlier findings of Mandal *et al*.(1976-77) who suggested that some C.*olitorius* varieties can efficiently replace C.*capsularis* cultivars at least in medium and high lands.

Either of the two genotypes, CC-45, O-9897 would be the farmers' choice if they intend to do sowing around 15th of March without the risk of premature flowering and growing the crop for a period of 120-150 days (Table 5). Chakrabarty and Ghose (1969), Rao and Prasad (1978) and Mandal *et al*.(l.c.) reported that to avoid the risk of premature flowering in JRO-878, JRO-7835 and JRO-524 varieties of C.*olitorius*, the best time for sowing is first half of March.

If the crop is grown only for 90 to 105 days, CVE-3 and CC-45 could be replaced by O-9897. Kundu et al.(1959) reported that *C.olitorius* fibre is generally finer, softer, stronger and more lustrous than that of *C.capsularis*. Moreover, if quality of fibre is preferred over yield, then O-9897 is the best genotype to grow in 15 March's sowing.

The main effect of harvest was significant (Table 1) and the sum of squares of harvest on partitioning showed linear component to be significant; these findings suggested that the fibre yield increased linearly with the time of harvest (Fig 1). It was pointed out (Patel and Ghose, 1940) that the best quality of fibre could be obtained by harvesting the crop at flowering stage. The yield increases at later harvests but quality deteriorates progressively at every subsequent harvest. Pandey et al.(1969) and Dargan et al.(1970) reported that the yield was enhanced as the field duration of the crop increased.

The significant first degree interaction i.e., year x harvest indicated that yield at different harvest stages was influenced by the change of environmental conditions between the years. In 1986, H3, H4 and H5 harvests differed significantly with the corresponding harvest in 1984 and 1985 (Table 4).

One of the main factors accounting for lower yield in 1986 may be attributed to waterlogging and subsequent flooding in that particular year. It may be mentioned here that the crop in 1986 occupied field at lower elevation compared to the previous two years. Kar and De Sarker (1961) reported that C.olitorius is better suited to well drained upland situations while C.capsularis can withstand inundation for a considerable length of time. Talukder (1970) and Sobhan et al.(1975) reported that C.capsularis can tolerate flooding of different depths and duration unlike C.olitorius.

The main effect of year was significant which indicated that yield differed significantly between the years (Table 4).

Variety x harvest interaction was not significant which indicated that regardless of the kind of genotype, the yield was the same when the harvest was made at the same date. Year x genotype x harvest interaction was not significant which indicated that the general trend in yield within genotypes and within harvests was virtually the same for all the years.

1.2. Dates of sowing x stage of harvest.

The main effect of sowing dates showed quadratic relationship with yield (Fig 2) which suggests that an increase in yield was not uniform in relation to the sowing dates. Ali and Shahidulla (1964), Mallick et al.(1964), and Singh (1976) reported higher fibre yield of C.capsularis in the planting of early part of April. Again Ali and Shahidulla (1964), Sen Gupta (1953a) and Sobhan et al.(1981) observed that yield components and yield of fibre gradually declined with the delay in sowing and indeed it was so. The yield increased in first three (D1 to D3) sowings while it decreased at the last (Fig 2).

The main effect of different harvest dates showed a positive linear relationship in that the yield increases in successive harvests i.e., the more the harvest was delayed, the greater was the yield (Fig 3). It was reported (Patel and Ghose, 1940) that late harvests gave higher yield.

Significant interaction between genotype x date indicated that the performance of genotypes in yield varied in relation to dates of sowing. Among the genotypes D-154 gave highest yield at the first two (D1 and D2) sowings (Table 9). The results demonstrated clearly that D-154 is the best genotype if sowing is restricted to the first two dates, namely D1 and D2. In D3 and D4 sowings, the yield in both D-154 and CVL-1 was not significantly different.

Significant interaction of date x harvest indicated that the yield at different stages was influenced by the date of sowing. In all the years the third sowing and last harvest (D3H4) gave significantly higher yield followed by D4H3 and D2H4. There was no difference in yield among D1H4, D2H4 and D4H4.No difference in yield was observed between D2H3, D3H3 and D4H3 (Table 10). Experimental evidence presented here suggests that harvest at 120 days in D1H3,D2H3 and D3H3 would be a better propositon to get a good yield of jute and at the same time releasing the land for planting rice with no risk of yield loss. Mahanta and Barthakur (1968) reached the same conclusion.Further confirmation that this is the best strategy comes from the results of the coordinated jute-rice rotational trial (Pandey et al., 1969; Dargan et al., 1970). They observed that planting rice after harvest of jute at 120 days give higher yield of rice although earlier harvest reduced the yield of jute compared to its harvest at 135 and 150 days.

If jute is harvested after 90 days (H1) the first three (D1-D3) sowings would give no difference in their yield. However, these yield would be significantly lower than that of subsequent harvests of different dates of sowing. The harvest at H2 in the first three sowings gave significantly higher yield as compared to D4. Mahanta and Barthakur (1968) reported that 120-150 day old jute crop from the planting of 17 March provided an economic yield and an adequate turn-around period for subsequent 'aman' crop.

H3 and H4 harvests in D4 and D3 sowings would give significantly higher yield respectively (Table 10). It was reported (Kundu et al., 1959) that in late sowings the rate of fibre formation was faster compared to that in plantings after April. Critical examination of their data revealed that the fibre formation was 2.5 per cent* more in 105-day crop as compared to 90-day crop in later plantings.

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* The numerical figure 2.5 per cent was calculated from the data given in their table No.X in page 61.

Genotype x harvest interaction was not significant in any of the three years; the results indicated that the yield of different genotypes at a particular harvest date was more or less the same.

2. Quantum of growth and yield of the crops planted with jute in an intercropping.

2.1. Competitive abilities of the component crops:

Competitive abilities of the component crops in the intercrop combinations assessed by aggressivity and relative yield showed conformity as the dominant crop gave higher relative yield. The LER gave the measure of yield advantage or disadvantage of the combined intercrop yield.

LER showed variation from year to year, which indicates that the differences lay in the availability and utilization of resources from year to year (Table 11).

Willey and Osiru (1972) pointed out that competitive ability is not a constant and quantifiable function for a given crop as the competitive ability is dependent on population. Again, Osiru and Willey (1976) suggested that time of sowing gives yield advantage in intercropping. Fisher (1977) reported that wet season gives yield advantage in crop mixtures than in dry season.

2.2. Influence of intercropping on yield contributing characters:

<u>C</u>.<u>capsularis</u> Cv. D-154 gave more yield than <u>C</u>.<u>olitorius</u> Cv. O-4 in intercrop. This is perhaps due to more biological efficiency of the former (D-154) in intercropping. The above suggestion is substantiated by the relative greater yield and higher LER values. D-154 in combination with 'aus' and 'millet' gives higher LER values and RYT when compared to O-4 in the same two combinations (Table 11).

Cultivar O-4 and D-154 gave higher yield in combination with 'aus' than that with millet, this is because the growth of 'aus' was retarded by limited light and nutrient. The per cent of mature grain and caryopsis wt. of intercropped aus were lower substantiating the former suggestion (Table 14). According to Matsushima (1966) the proportion of ripened grains was less than 80 per cent when assimilate supply was a limiting factor for grain yield. Matsushima and Manaka (1959) were of the opinion that when assimilate supply was considered to be balanced with yield capacity, it gave higher caryopsis wt. and grain yield.

Though aggressivity of D-154 was higher in D-154 + aus combination, ripened grain percentage and caryopsis wt. was higher in D-154 + aus than O-4 (Table 11 and 14). This may be on account of more culm length of aus with D-154 and it might have resulted from utilization of light. Murata (1961) and Hayashi (1972) reported the advantage of culm length in the utilization of light by rice plants.

Millet with long and broad leaves appeared less disturbed by light scarcity due to tallness of plants in intercrop situation and gave higher grain yield as compared to that of aus. However, as millet was sown late its yield was highly reduced compared to optimum sowing condition in sole crop.

2.3. Influence of intercropping on the growth parameters of the component crops:

a) An increase in LAR of intercropped jute has compensated NAR and hence RGR during the 3rd growth period (90 to 120 days). Jute intercropped with aus (ja) showed much higher NAR and almost similar LAR to that of jm during the same period of growth. The ja was dominant and out weighed aj and the combination showed yield advantage. Growth analysis indicated that vegetative growth of jute was compensated after the harvest of the earlier maturing component crops i.e., millet or aus. Jute is the sole crop in the field deriving all the nutrients from the soil after the harvest of millet/aus (Fig 4-6). Similar results were reported by Andrews (1972, 1974), Baker (1974), Baker and Yusuf (1976), Francis et al.(1975) and Krantz et al.(1976) in various mixed crops.

b) NAR was much higher during the period at 60-90 days of growth in intercropped millet as compared to that in sole millet (Fig 8). This is because LAR in sole and intercropped millet was about the same. As in millet NAR was higher during that period, it behaved as a dominant crop and increased the relative yield (Table 11). The reduction in yield of millet in intecropping compared to sole millet in spite of its greater height is in all probability on account of a smaller number of tillers and less fertile panicle in the intercropped millet. Due to the extra height of the latter assimilates were perhaps utilized for vegetative rather than reproductive phase.

Intercropped aus had higher LAR at 60-90 days (Fig 9). Higher LAR compensated the NAR and RGR. Though these values became similar to sole aus, the relative yield reduction occurred compared to sole aus (Fig 7 and 8). As LAR differed greatly between 30 to 60 and 60 to 90 days growth period, the increase in LAR in later period (60 to 90 days) could not compensate the lag period in the earlier growth of grain filling. Moreover, assimilate distribution to reproductive parts might have been disturbed by culm and tiller growth. The difference of ripened grain percentage and caryopsis weight given by sole and intercropped aus in combination with both the cultivars of jute justify the above contention (Table 14).

3. Phenology and correlation of growth phases of jute planted on different dates.

3.1. Growth stages at different dates:

Both CD and GDD for average floral bud and flowering were higher in March 30 planting than other sowings. The above set of observations suggest that the appearance of floral bud will require a small number of CD and GDD when planting either earlier or later than 30 March. However, in March 15 planting average flowering was delayed and higher GDD required compared to April 14 and April 29 plantings. This indicates that the difference in temperature influences flower induction process (Cf Fig 10). Kar (1962) reported that interaction between low temperature and short-day photoperiod hastens flowering. C.capsularis is less sensitive compared to C.olitorius varieties to this interaction under the same regime of photoperiod. According to Bose (1976) low temperature caused delay in flowering.

The data on average flowering date at different sowings indicated that increased temperature and decreased photoperiod hasten flower induction process as was observed in the plantings of April 14 and 29 (Fig 10 and 11). Riddell and Gries (1958) reported that two spring wheat varieties were much less sensitive to change in temperature at the longer photoperiods than at the shorter ones. The difference in days to flower initiation increased with increased temperature and longer photoperiods.

As the results obtained the CV and correlation studies were more or less the same it is suggested that measurement of growth stage, study of GDD is not absolutely essential (Table 15 and 16).

Correlation studies between the period (days) from planting to flowering and total life cycle of the genotypes indicated that the longer the period from planting to flowering the longer the life cycle. The period from planting to flowering and the duration of life cycle differed (Table 15) dependening on the planting dates and were shorter as the plantings were delayed from optimum sowing dates from 15 March to 30 March. Similar phenomenon was observed by Ali (1961) in D-154 and Akhanda et al. (1981) in soybean planted on different dates.

3.2. The beginning and termination of flowering and pod formation in the potted plants:

In both CVL-1 and CVE-3, maximum flowering occurred in the middle of the flowering period. The same was reported for capsularis varieties by Kar (1962) and Talukder and Ali (1977).

The results of the present study showed that flowering and fruiting period were longer in CVL-1 compared to CVE-3.

4. Physiological maturity of C.capsularis seeds.

The physiological maturity of the seeds of both CVL-1 and CVE-3 was attained around 60 days after anthesis although the two varieties flowered at two different timings (Fig 16 and 17). Shaw and Thom (1951) found that three corn hybrids of divergent maturity required a period of 51 days from silking to grain maturity.

4.1. Identification of visual indicators at different stages of physiological maturity:

The criterion number 1 and 2 (criterion number 1 first sign of mature seed coat colour and criterion number 2 attainment of semi-dry condition of fruit while the stem is still green) coincided with the physiological maturity of both varieties (Figs 16 and 17). In the light of the present observation the characteristics of C.capsularis seeds were reliable indicators of physiological maturity.

4.2. Relationship between maturity of seeds and different seed attributes:

a) Seed weight: The quadratic component controlling accumulation of dry matter in seed varied significantly with time at 1 per cent level. This trend suggests clearly that the linear rate of dry matter accumulation in seed at its last phase approached plateau in a curvilinear manner. Thus an idea of physiological maturity of jute seeds at present work has been completed only in 2 varieties of C.capsularis can be obtained from criterion number 1 and 2. This finding corresponds with that of Crookston and Hill (1978), who arrived at the same conclusion on soybeans.

b-d) Viability, vigour and dry weight of seedlings:

Regression analysis on different stages of maturity showed that all the three attributes, namely germination percentage, vigour and dry wt. of seedlings increased in a linear manner. Talukder and Ali (1979) reported that in jute the percentage of seed germination and vigour increased consistently with the age of the fruit. In other words, the maturer the seeds, the greater is the rate and speed of germination. Seeds of D-154 harvested at 60 days from the day of anthesis produced tallest seedlings and exhibited higher vigour compared to individuals from the earlier harvested seeds.

5. Genotype x environment interactions and their influence on maintaining yield stability of *C.capsularis* genotypes.

5.1. Genotype x environment interactions:

In combined analysis the significant genotype effect indicated that there were fluctuations in the yield among the genotypes. The differential performance of genotypes over dates of sowing was significantly influenced by planting dates. The significant GxD interaction indicated that there were noticeable changes in the relative magnitude of differences among genotypes over dates (Table 17). The absence of significance in GxYxD interaction indicated that there were no changes in GxD effects between the years.

In regression analysis the highly significant environmental effects demonstrated the variability in environmental conditions (Table 18). The highly significant GxE (linear) interactions indicated that the regression values among the five genotypes differed appreciably (Table 18). Both the components of GxE, namely GxE (linear) and pooled deviations were significantly greater than the pooled error, indicating the presence of GxE interactions.

5.2. Regression on individual genotypes:

The large variation observed in regression coefficients showed that the genotypes responded differently to different environments. As s2di values were small the regression lines gave nearly perfect fits, to the actual yield in three out of five genotypes under investigations. Without further experimentation the behaviour of CVE-3 and CC-45 against the remaining three is difficult to explain.

Finley and Wilkinson (1963) used bi values as a measure of both stability and adaptation. Cultivars with bi values grater than 1.0 were considered below average in stability and can only perform optimally in favourable environments; cultivars with bi less than 1.0 were considered above average in stability and specifically adapted to unfavourable environment ; and cultivars with bi=1.0 were described as average in stability and either poorly or well adapted to all environments, depending upon the cultivar mean yield. According to their definition D-154 and CVL-1 were specifically adapted to environment conducive to higher yield; therefore small changes in the environment were expected to produce large variation in their yield. CC-45 showed average stability but was poorly adapted to all environments (Table 19).

Eberhart and Russell (1966) proposed that a stable cultivar is the one with a regression coefficient equal to 1.0, and with mean square deviation from regression equal to zero. Hence according to them, apparently, a cultivar that did not meet both these criteria is unstable. None of the five genotypes fulfilled the above two criteria and hence according to the definition of Eberhart and Russell (l.c) none of them could be considered stable.

Becker et al.(1982) regarded mean square for deviation from regression to be the most appropriate criterion for measuring phenotypic stability in an agronomic sense because by this parameter genotypic reaction to environments can be predicted.

If only s2di values (not significantly different from zero) are considered then the genotypes Dhababdhabey, D-154 and CVL-1 may be regarded stable. The farmers' experience point more or less to the same conclusion. In CVE-3 and CC-45 deviation from regression is significant and hence these two genotypes are unstable (Table 19) which also match with their performance in the field.

As compared to the four genotypes,Dhabdhabey gave low yield but whereas the yield of 4 genotypes fluctuated a good deal depending on the environmental conditions that of Dhabdhabey remained stable under all conditions. The s2di values clearly show as to why Dhabdhabey remains stable under all environmental conditions.

However, considering bi values CVL-1 appeared to be more stable than other genotypes. High mean performance and bi values higher than 1.0 in CVL-1 and D-154 (1.12 and 1.62; respectively) indicate that the yield of these genotypes are dependent on the type of environment they are subjected to i.e., favourable environment giving high yield and vice versa. In the light of these results the above two genotypes (namely,D-154 and CVL-1) should be planted in optimum sowing time to take advantage of best growing season. On the other hand CC-45 showing a lower bi (0.97) and high average performance can be recommended for sowing beyond optimum time by two months i.e., up to middle of June. For instance in mid February sowing CC-45 does not come into flowering whereas in other genotypes flowering is initiated in 40 days if sowing is done before March 15.

In the recent past considerable change has been noticed in the climate of Bangladesh. Because of this situation optimum sowing time can hardly be maintained all over jute growing area. Due to this uncertainty of the weather the genotype CC-45 has gained considerable importance in spite of its low bi value. Saeed et al. (1987) put forward the same view on grain sorghum. However, Saeed et al. (1987) suggested that the bi values should better be treated as an indication of the type of response a cultivar is expected to show to varying environments rather than a measure of stability.

SUMMARY

1.1. In the 15th March sowing of CVE-3, CC-45 and Dhabdhabey of C.capsularis and OVT-3, Chaitali and O-9897 of C.olitorius harvested at 15 days' interval beginning from 90 up to 150 days no significant yield difference was observed between the C.capsularis and C.olitorius genotypes.

In the above sowings it was observed that the yield increased consistently with time from first harvest to the last harvest (first and last harvest were made when plants were 90 and 150 days old respectively).

Earlier reports of photoinsensitivity of CC-45 and O-9897 and sensitivity of other genotypes were confirmed; while only 1 per cent of CC-45 and O-9897 flowered at 120 days, the other genotyes showed 51 to 57 per cent flowering by this time.

1.2. The results of harvest of five genotypes of C.capsularis (CVE-3, CVL-1, Dhabdhabey, D-154 and CC-45) made at four different dates (90, 105, 120 and 135 days after sowing) in plantings at four different dates (15 March, 30 March, 14 April and 29 April) showed that the genotypes CVL-1 and D-154 in all the three years (1984 to 1986) gave highest yield when the sowing was made on the 14 April. As against this the yield of CVE-3 was maximum at 15 March's sowing.

Yield increased linearly with the duration of the crop in the field up to 135 days. All the genotypes gave maximum yield

at the age of 135 days. However, among the harvests made from the sowings of different dates no significant yield difference was observed between the last and last but one harvest.

Fourteen April's sowing of all C.capsularis genotypes gave maximum yield; the yield in sowings made before or after that date declined i.e., the response was quadratic in sowing dates; and in harvests at different field durations it showed linear relationship.

2.1. When intercropped with millet or aus, C.capsularis cv.D-154 was found to have better biological efficiency than C.olitorius cv.O-4. The results indicated that millet was a dominant species in combination with D-154 or O-4; 'aus' was a dominated species in both combinations.

Combined intercrop yield of D-154 + millet and D-154 + aus gave yield advantage over pure stand in both the years i.e., 1982 and 1983.

2.2. Intercropped 'aus' had less than 80 per cent ripened grain per panicle and lower caryopsis weight as compared to sole 'aus'.

2.3. RGR increased in the intercropped jute in the third growth period (90 to 120 days) than when jute was the sole crop probably on account of the former's getting more space in the field after the harvest of earlier maturing component aus or millet.

3.1. When nine C.capsularis taxa were sown on four different dates (15 March, 30 March, 14 April and 29 April) the planting on the 30 March took highest number of calendar (136 and 134) as well as growing degree days(1029 and 1060) for 50 per cent flowering compared to the other three sowings in both the years. In all the four plantings, positive correlation in both calendar and growing degree days was found between the time of 50 per cent flowering and the total period the crop stands in the field before drying up.

3.2. Maximum flowering and highest pod formation took place in the middle of the period between the appearance of first blossom and pod and their termination.

4.1. In the plantings in pots on March 30, plants of CVL-1 and CVE-3 were found to attain physiological maturity within a period of sixty days from anthesis.

In the pods, harvested at sixty days, the seed colour intensity was about the same as that of the full mature seeds although the stem remained green and pods were partially dry (at the 60-day old harvest).

4.2. The germination capacity, emergence, vigour and dry weight of seedlings were found directly related to accumulation of dry matter in seeds.

5.1. Results based on the sowing of the cultivars, CVE-3, CC-45, Dhabdhabey, D-154 and CVL-1 at 6 different dates (March 15, 30; April 14, 29 and May 14,29) from 1984 to 1986 showed that interaction between genotype x environment on yield was significant i.e. environment responses differed from genotype to genotype significantly (1% level).

5.2. Although Dhabdhabey gave comparatively lower yield than the four other cultivars its performance was found to be stable under all the 18 environments examined.

While CC-45 was adopted to less favourable environment other cultivars namely CVL-1 and D-154 were suited particularly to favourable environment.

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ACKNOWLEDGEMENT

Dr.A.S.Islam, Professor of Botany, University of Dhaka, deserves special recognition. He helped create an environment conducive to the author's academic development and imparted his personal philosophy and the need for adapting a practical programme. Dr.M.A. Khan Majlis, C.S.O., BJRI helped and gave logistic support in field work. Both gave invaluable guidance in conducting the research and in the preparation of the manuscript.

Acknowledgement are due to Dr.M. Kasem Ali, former D.G., BJRI, Dr. M.Hossain, Ex- D.G., BJRI, Dr. Ameerul Islam, D.G., BJRI and Dr. M. Myser Ali, Director (Agri), BJRI and Dr. A.M. Akhanda, Consultant FAO for their helpful suggestions, constructive criticism of the manuscript and encouragement.

Thanks are due to the author's colleagues M.A.Sobhan, Abu Taher, S.A.Mannan, N.Nabi, M.A. Hossain and Shafiul Alam of BJRI for their valuable assistance in field operation and data analysis.

Dr. B.A.Greene, Ex-Consultant, BARC, and M.A.Rouf of BJRI for providing useful scientific papers are thankfully acknowledged.

Finally, the author wishes to express thanks to his wife, S. Shamsunnahar Akhter and daughter, Rehnuma Ferdous for their constant encouragement, great understanding and generous sacrifices.