OPTIMISING TIME OF SOWING IN THREE SHORT DURATION VARIETIES OF PIGEONPEA DURING SUMMER IN BHADRA COMMAND AREA

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in

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Affectionately Dedicated to

My Beloved Parents

DEPARTMENT OF AGRONOMY

UNIVERSITY OF AGRICULTURAL SCIENCES

BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "OPTIMISING TIME OF SOWING IN THREE SHORT DURATION VARIETIES OF PIGEONPEA DURING SUMMER IN BHADRA COMMAND AREA" submitted by **Mr.M. JAYANNA** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** to the University of Agricultural Sciences, Bangalore, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

BANGALORE

October 7th, 1995

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INTRODUCTION

I. INTRODUCTION

Grain legume crops have occupied a very important niche in our rainfed farming systems both for meeting the dietary requirement of human beings and for restoring soil fertility. Yet, the cultivation of grain legumes is largely confined to marginal and dryland areas. Eventhough great importance is attached to grain legumes during recent times, increase in either area or production is negligible. The total production of grain legumes falls short when compared to nutritional requirement. It is necessary to identify suitable technology for improving the ceiling limit of grain yield of legumes.

Pigeonpea [*Cajanus cajan* (L.) Mill Sp] is one of the major grain legumes grown in tropics and sub-tropics. It is an important source of protein in our daily diet. The leaf fall at maturity not only adds to the organic matter in the soil, but provides additional nitrogen. Its deep and lateral spread of root system breaks open the plough pan thus improving the soil structure. Hence, pigeonpea is often called "Biological plough".

In India pigeonpea occupies an area of 3.73 million hectares with an annual production of 2.19 million tonnes. The major pigeonpea growing States are Uttar Pradesh, Maharashtra, Karnataka and Gujarat. These states occupy about 80 per cent of the area and contribute 85 per cent of the production. The national average yield of pigeonpea is 760 kg per hectare.

In Karnataka, pigeonpea occupies an area of 5.30 lakh hectares with an annual production of 1.76 lakh tonnes. Pigeonpea traditonally is a kharif crop grown as mixed or intercropped with sorghum, millets, maize, oilseeds or as a sole crop on marginal and submarginal land. Hence, the productivity of the crop in the state is only 444 kg per hectare, which is far below the national average.

Bhadra project with 1.06 lakh hectares irrigation potential is one of the major irrigation projects in Southern Karnataka. It was originally planned to provide irrigation water to the light irrigated crops. But, the farmers are in the habit of growing continuously paddy after paddy every year. As a result nearly 24 per cent of the irrigable area suffers due to scarcity of water during summer. It will be possible to give only 2 to 3 irrigations to the summer crop in tail end areas of the canal. This situation necessitates to identify a suitable light irrigated crop with less water requirement for summer season. Pigeonpea is one such crop responding to less irrigation and recently good number of short duration, photoinsensitive varieties have been released from ICRISAT, Patancheru, Hyderabad. Therefore, investigations on pigeonpea were made during summer season of 1991-92 at Agricultural Research Station, Kathalgere in Bhadra Command area with the following objectives.

1. To determine the optimum time of sowing for pigeonpea varieties during summer.

2. To compare the performance of three short duration varieties of pigeonpea during summer.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The review of literature pertaining to the effects of climate, sowing date and varieties on the performance of pigeonpea crop during summer is presented in this chapter.

2.1 Climatic effect

Climate plays an important role in nearly every phase of agricultural activity. Lack of proper knowledge about plant and climate relationship will hamper the land use planning on a larger scale. The interaction of climate and physiological processes of the crop must be well known before hand in raising a good crop as otherwise, the crop production with local climatic condition will be a matter of just a practice. Apart from the physiological processes, climate also affects the crop indirectly through the incidence of pest and diseases.

2.1.1 Growth and yield

Akinola and Whiteman (1975) at Redland Bay in Australia observed that podset in pigeonpea was lower in sowing that flowered in periods of low temperature.

Reddy and Virmani (1980) at ICRISAT in Hyderabad opined that the temperature regime during post rainy season has influence on the selection of pigeonpea genotypes of different maturity classes.

Angus *et al*. (1980) in Eastern Australia estimated that the threshold daily mean temperature as 12.8°C for emergence of pigeonpea under field conditions.

De Jabrun *et al*. (1981) in Queensland, Australia observed that at least 85 per cent of germination occurred at a range of temperatures of 19°C to 43°C, but no germination occurred at either 7.10°C or 46.50°C.

Jain *et al*. (1981) at Rajendranagar, Andhra Pradesh reported that the decrease in seed yield with delay in sowing may be due to low temperature during vegetative period of the crop, which affected the development of the crop.

Morton *et al*. (1982) at Puerto Rico, noticed slow vegetative growth in controlled environments at temperatures below 20°C. They opined that exposure to relatively mild frost was lethal for leaves and meristems.

Mohamed Musa and Ariyanayagam (1983) in Trinidad, West Indies observed that high day temperature of 34°C and low night temperature of 19°C increased the plant height. Long days (14 hrs) combined with high day temperature of 34°C and cooler nights (19°C) has marked effect on plant height, whereas long days (14 hrs) with 32°C and warmer nights with 22°C has little or no effect on cultivars.

Mc Pherson *et al*. (1985) in Newzealand, found that growth related attributes such as plant height, number of nodes, shoot dry mass and leaf area increased with increasing temperature in the range of 16°C to 32°C.

Balakrishnan and Natarajaratnam (1986) at Coimbatore, opined that higher amount of dry matter accumulation was related to high mean temperature of 27.65°C.

Balakrishnan and Natarajaratnam (1987a) at Coimbatore, found reduced vegetative phase due to low temperature, cool climate and shorter day length.

Balakrishnan and Natarajaratnam (1987b) at Coimbatore, observed that light interception, seed yield, leaf area index and crop production progressively decreased from summer to post rainy seasons. Seed yield was positively associated with crop duration and light interception.

Balakrishnan and Natarajaratnam (1989) at Coimbatore, reported higher LAI due to high temprature, solar radiation and sunshine hours during summer season.

2.1.2 **Flowering**

Iswaran (1976) observed that under long day conditions more flowers were produced (308) compared to short day conditions (108).

Mohamed Musa and Ariyanayagam (1983) at Trinidad in West Indies, observed normal and profuse flowering under ambient conditions (12 hrs light/ambient day night temperature) and it occurred within the expected time for each cultivar following a December planting. Increase in day length (14 hrs/ambient day - night temperature) prolonged the time to flowering for cultivars.

Turnbull (1986) at Queensland in Australia, reported increased floral abortion with constant day temperature of 35°C under controlled enviornment.

Balakrishnan and Natarajaratnam (1987b) noticed delayed flowering under longer day length and high temperatures during summer.

2.1.3 **Duration of the crop**

Mc Pherson et al. (1985) in Newzealand, observed shortest duration or most rapid rate of development at 24/24°C temperature, while longest duration at both higher and lower temperatures.

Balakrishnan and Natarajaratnam (1987a) at Coimbatore, noticed short duration under cool climate with shorter day length.

Laxmansingh (1988) at ICRISAT, Hyderabad reported that extra short duration cultivars mature in 90 to 95 days at 17°N latitude and are relatively insensitive to photoperiod and temperature variations. Short duration varieties mature in 100 to 121 days at 17°N latitude and are suitable for multiple cropping and ratooning.

2.2 Effect of date of sowing

Sowing date is a non-cash agronomic input, which has influence on growth, flowering, yield, disease and pest incidence.

2.2.1 Yield

Abrams and Julia (1973) reported good commercial yields by late planting i.e., in months of October, November and December in Puerto Rico and December and January planting in Trinidad.

Roysharma et al. (1980) at Dholi in Bihar found that September sowing with early and extra early maturing groups yielded 12.00 to 17.00 q per ha in about 130 to 160 days.

Jain and Ramasubba Reddy (1981) at Rajendranagar in Andhra Pradesh, reported higher seed yield of 28.20 q per ha under residual moisture conditions in vertisols when sown on 28th October.

Keatinge and Hughes (1981) at Trinidad in West Indies, obtained seed yield of more than 20 q per ha with supplemental irrigation during dry season and also opined that loss of yield due to moisture stress was a consequence of reduction in the number of pods per plant and 100-seed weight.

Ramasheshaiah _et al_. (1981) at Rajendranagar in Andhra Pradesh, reported that highest seed yield was recorded in October 16 sowing (19.42 q/ha) than December sowing (5.06 q/ha).

Madhusudan Rao _et al_. (1983) at ICRISAT, Hyderabad observed drastic reduction in yield due to water stress when sown on 15th September, 15th October and 15th November.

Mohd. Ikramullah and Yogeswara Rao (1983) at Rajendranagar in Andhra Pradesh, reported seed yield of 11.44 q per ha when sowing was done during mid October with closer spacing of 30 cm x 10 cm.

Pandey (1983) at Pantnagar, found that early maturing cultivars produce seed yield of 20 q to 30 q per ha, when planted after the harvest of kharif paddy.

Ahlawat _et al_. (1985) at IARI, New Delhi observed that crop sown in April produced seed yield of 25.70 q per ha compared to that sown during June month (13.8 q/ha).

Rajpurohit and Guar (1986) at Udaipur, stated that sowing of pigeonpea on 1st May gave higher seed yield

(22.90 q/ha) than the crop sown in 1st June (18.60 q/ha) and 1st July (7.90 q/ha).

Balakrishnan and Natarajaratnam (1987a) at Coimbatore, observed that 21st February sown crop produced highest dry matter (6287 g/m^2) and the seed yield of 91.45 g per plant as compared to June and September sown crop.

Dwivedi and Patel (1988) at Jharnapani in Nagaland, reported that pigeonpea sown on 15th May gave the highest seed yield of 20.65 q per ha than 30th April or during June. The reason attributed was the availability of optimum moisture and temperature for seed germination, crop growth and development.

Laxmansingh (1988) at ICRISAT, Hyderabad recorded mean seed yield ranging from 15 q per ha to 40 q per ha due to different sowing dates and locations.

Subbarao et al. (1989) at Lam, Guntur, reported seed yield of 11.70 q per ha when sown just 2 to 3 days before harvest of kharif paddy.

Shinde et al. (1989) at Rahuri in Maharastra, recorded the seed yield of 5.37 q per ha, when sown during summer season.

Govinda Reddy et al. (1991b) at Kharagpur, West Bengal, recorded highest seed yield of 16 q per ha when sowing was done on 20th October, followed by 14 q per ha (5th October) and 11.50 q per ha (4th November) during the year 1985. However, highest seed yield of 12.10 q per ha was recorded with the sowing on 13th October, followed by 4.70 q per ha (4th November) and 4.50 q per ha (20th October) during the year 1986.

Jalapathi Rao (1994) at Warangal, noticed higher plant growth of 114.6 cm and seed yield of 16.48 q per ha, when sown on 15th September compared to that of sown on 30th October.

2.2.2 Varietal performance

Varieties play an important role on yield of crops due to variation in growth and yield attributing characters.

Premsekar and Subramaniam (1961) at Coimbatore, recorded the seed yield of 8.32 q per ha with variety No. 1141 planted during March.

Rangaswamy et al. (1975) at Coimbatore, reported that the pigeonpea variety Co-1 registered maximum grain yield of 6.50 q per ha during summer season.

Sengupta and Sen (1980) at Berhampore, West Bengal found higher seed yield of 25.12 q per ha with variety 20 (105) as compared to 22.39 q per ha with variety 5 (124) and 22.44 q per ha with variety Hyd 3C. They opined that seed yield of varieties sown during Rabi season were comparable to that of sown during kharif.

Sheshaiah et al. (1984) at Lam, Guntur, reported that cultivars LRG-36, ST-1 and LRG-6 gave seed yield of 9.81, 8.24 and 8.33 q per ha, respectively when sown on 14th November.

Dahiya (1985) at Hissar, found that the variety T-2, produced maximum grain yield of 39.27 q per ha, as compared to variety UPAS-120, which registered grain yield of 31.39 q per ha when sown during April month.

Chauvan et al. (1987) at Patancheru, Andhra Pradesh, observed that the variety ICPL-87 had better second and third harvest yield potential than ICPL-4 and ICPL-81, which was related to its higher leaf area retention at first flush maturity. Further, he opined that the genotype ICPL-87 was more perennial than the other genotypes with total seed yield of 43 q per ha from three harvests.

Gurunadha Rao et al. (1987) at Tirupathi, reported higher seed yield of 18.96 q per ha with cultivar ICPL-288, which matured in 112 days. The cultivar ICPL-87 gave a seed yield of 17.80 q per ha maturing in 107 days, when sown during first fortnight of September.

Yadahalli and Balakrishna Reddy (1987) at Hebbal, Bangalore in their studies brought out that the variety

ICPL-8332 registered higher seed yield of 27.95 q per ha, when crop was sown on 8th February and opined that higher seed yield was due to greater partitioning efficiency.

Dwivedi and Patel (1988) at Jharnapani in Nagaland, found that the variety Bahar recorded the higher grain yield of 21.25 q per ha when sown on 15th May than that of sown on 30th April or during June.

Sathyanarayana et al. (1988) at Lam, Guntur, reported that the variety ICPL-84060 gave a higher seed yield of 7.20 q per ha when grown in paddy fallows during Mid November and Mid December than ICPL-87 (6.90 q/ha) and ICPL-151 (6.10 q/ha).

Balakrishnan and Natarajaratnam (1989) at Coimbatore in their studies found that the cultivar SA-1 registered higher grain yield of 198.7 g per plant when sown on 21st February than that of 21st June (59.10 g/plant) or 21st September sowings (32.10 g/plant).

Nizam et al. (1989) at Los Banos, Philippines, in their studies brought out that the cultivar ICPL-87 gave the highest grain yield of 30.9 q per ha than that of QPL-72 (24.80 q/ha) and ICPL-151 (24.40 q/ha) in two harvests, when grown during post rainy season.

Patel et al. (1990) at Baroda, reported that GAUT-84-13 and GAUT-85-12 gave seed yields of 20 q per ha and 19 q per ha respectively, when sown during post rainy season.

Amin *et al*. (1991) at Parbhani, Maharastra observed that among extra early cultivars, the cultivar ICPL-85030 registered higher seed yield of 8.30 q per ha, followed by ICPL-84023 (7.90 q/ha), ICPL-85014 (7.70 q/ha), ICPL-85010 (7.50 q/ha) and ICPL-151 (6.10 q/ha) when sown on 22nd December.

Padmalatha and Gurunadha Rao (1993) at Tirupathi, found that the variety ICPL-1 registered a higher seed yield of 10.10 q per ha than that of ICPL-312 (9.10 q/ha) and ICPL-4 (6.50 q/ha), when sown during winter season.

Sondge *et al*. (1993) at Parbhani, in their studies recorded maximum grain yield of 13.63 q per ha with variety BSMR-II, which was followed by BSMR-I(12.15 q/ha). They further observed that irrigation requirement was 601.7 mm for BSMR-II and 602.8 mm for BSMR-I.

2.2.3 Growth and yield parameters

Spence and Williams (1972) at Trinidad, observed that determinate varieties planted during December induced flowering early and the resulted plants were 1 m in height, 0.9 m in canopy diameter at maturity.

Rangaswamy *et al*. (1975) at Coimbatore, reported highest pod set of 41.30 per cent with variety S-41, whereas the mean pod set of other varieties was limited to

34 per cent. They further opined that the 100 grain weight was stable for all the varieties studied.

Hammerton (1976) at Lawrence field in Jamaica, observed higher number of pods, flowering branch and plant height with May planting compared to December planting. Further, opined that day length was a dominant factor influencing growth and yield, but part of that might be a response to radiation rather than photoperiod.

Misra et al. (1980) at Nayagarh, Orissa, reported that the reduction in plant height was more prominent in long duration varieties compared to early and extra early duration varieties. The number of branches per plant was 6.50 with long duration varieties compared to 3.50 to 4.50 branches per plant in early and extra early varieties, when planted in October. They opined that the reduction in number of branches per plant was due to reduction in plant height and duration of the varieties tried.

Panwar and Yadav (1980) at Kanpur in Uttar Pradesh observed that April planting increased the plant height by 124 cm, number of branches (74.40%), pods (65.50%) bolder and heavier seeds (12.90%) per plant over the June planting.

Roysharma et al. (1980) opined that planting beyond September reduced total dry matter production due to faster development rates and diminished yields. June sowing resulted in higher test weight due to longer period of pod formation, grain development and better exposure of pods to sunlight than in Rabi.

Ramasheshaiah et al. (1981) at Rajendranagar in Andhra Pradesh, observed reduction in number of pods per plant from 81.90 to 28.10 when crop sown from October 16th to December 16th. Similarly 1000-seed weight was also decreased from 91.70 g to 86.20 g during these sowings.

Yadahalli and Balakrishna Reddy (1987) at Hebbal, Bangalore, reported that February planting had a better growth resulting in higher number of pods per plant, higher number of seeds per pod and 100-seed weight.

Balakrishnan and Natarajaratnam (1989) at Coimbatore, observed maximum dry matter accumulation, higher LAI and CGR when the crop was sown on 21st February, which was due to longer cropping period. Short duration cultivars recorded higher NAR than long duration cultivars only in reproductive phase.

Bapireddy et al.(1991) in Andhra Pradesh, reported that delayed sowing induced early flowering and maturity. Further also reduced the vegetative growth, pods per plant and seed yield due to the senstivity of crop to photoperiod in November sowing compared to September sowing.

Govinda Reddy et al. (1991a) at Kharagpur, noticed significant reduction in yield and yield components when sowing was done after 15th October. Maximum plant height of 117.50 cm, branches per plant (7.00), pods per plant (23.00), seeds per pod (3.60) was reported when sown on 15th October compared to 30th October and 14th November.

Padmalatha and Gurunadha Rao (1993) at Tirupathi, observed dry matter accumulation of 9.90 per cent between 0 to 40 days and 67.4 per cent between 40-80 days, when sowing was done during winter seasons. Out of 67.40 per cent, stem contributed 20.20 per cent, leaves 24.30 per cent and pods 22.90 per cent.

2.2.4 Flowering

Flowering in plants is controlled by its genetic constitution and enviornment to which the plant is exposed during its growth.

Phenology of pigeonpea crop is highly variable under different environmental conditions. Because flowering is primarily induced by photoperiod, planting date largely determines the duration of vegetative growth, plant height and number of branches at flowering.

Akinola and Whiteman (1975) at Red Bay, Queensland, observed that period from sowing to 50 per cent flowering in cultivars UQ_1 and UQ_{38} declined from 219 days to 115 days when sown between 1st September and 19th January. Period of preflowering phase exceeded by 8 to 22 days when sown on 16th February compared to January sowing.

Rangaswamy et al. (1975) at Coimbatore, noticed that number of days for 1st flowering varied from 60th day to 72nd day and the period of flowering ranged from 37 to 46 days among the varieties during summer season.

Singh and Saxena (1981) at Pantnagar, observed positive correlation between temperature and days to flower in UPAS-120 (0.4569) and Prabhat (0.4040), when sowing was done during summer season.

Balakrishnan and Natarajaratnam (1987a) at Coimbatore, reported that days to first flower opening, 50 per cent flowering were reduced progressively from February to September planting. Early flowering was observed in September planting.

Amin et al. (1991) at Tangadencha in Andhra Pradesh, observed flower drop because of high temperature in April-May when sown during January. He opined that flower withered in Nilwali, Maharashtra because of rise in temperature when sown on 6th February.

Bapireddy et al. (1991) in Coastal Andhra Pradesh, in their studies found that delayed sowing from September to

November induced early flowering with less vegetative growth and early maturity.

2.2.5 **Duration of the crop**

Hammerton (1976) at Lawrence field in Jamaica, reported that duration of the crop varied from 120 days in September-February planting to more than 225 days in March-April planting.

Misra et al. (1980) Nayagarh in Orissa, observed that duration of the crop varied from 106 to 133 days during Rabi season (September-October) compared to 110 to 223 days during kharif season.

Sengupta and Sen (1980) at Berhampore in West Bengal found that the medium duration variety took 150 to 160 days during Rabi season for maturity compared to 220 days during Kharif season.

Dahiya (1985) at Hissar in Haryana, reported that March, April, May sowings reduced crop duration by 15 days compared to June sowing.

Bapireddy et al. (1991) in Coastal Andhra Pradesh found delayed marutity by 13 days in September sown crop compared to 14th November sown crop.

Jalapathi Rao (1994) at Warangal in Andhra Pradesh, observed that delayed sowing from 15th October to 30th October reduced the crop duration by 7 to 10 days.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

A field experiment was conducted during summer season of 1991-92 at Agricultural Research Station, Kathalagere of the University of Agricultural Sciences, Bangalore to find out the optimum time of sowing within the summer season and suitable short duration pigeonpea variety for Bhadra Command area. The details of materials used and techniques adopted during the course of investigation are presented in this chapter.

3.1 General description

3.1.1 Location

The field experiment was conducted in `K' Block of the Agricultural Research Station, Kathalagere, Shimoga district in the southern transition zone of Karnataka. This research station is located in Bhadra command area with irrigation facility for nearly 10 to 11 months in a year. The Research Station is situated at 13°2' N latitude and 76°12' E longitude with an altitude of 561.6 m above the mean sea level.

3.1.2 Soil characteristics of the experimental site

The soil of the experimental site was sandy clay loam. Composite soil samples were collected from each replication upto a depth of 15 cm before sowing and analyzed for various physical and chemical characteristics, the details of which are furnished in Table 1.

Table 1. Physical and chemical properties of the soil at the experimental site.

Soil characteristics	Values	Methods followed
I. Mechanical composition		
(a) Coarse sand (%)	29.20	International Pipette method
(b) Fine sand (%)	22.30	(Piper, 1966)
(c) Silt (%)	16.86	
(d) Clay (%)	31.64	
Textural class	Sandy clay loam	
II. Chemical properties		
(a) pH	6.30	pH meter (Jackson, 1967)
(b) Electrical conductivity dSM^{-1} at 25°C	0.20	Conductivity bridge (Jackson, 1973)
(c) Organic carbon (%)	0.44	Walkley and Black's method (Jackson, 1967)
(d) Available nitrogen (kg/ha)	167.00	Kjeldahl's method (Jackson, 1967)
(e) Available phosphorus (kg/ha)	74.60	Bray's extraction method (Jackson, 1973)
(f) Available potassium (kg/ha)	356.80	Neutral N NH_4OAC extract; flame photometer (Jackson, 1973)

The soil was slightly acidic (pH 6.3) in reaction and normal with respect to salt content (electrical conductivity at 25°C was 0.20 dSM^{-1}). The organic carbon content (0.44%) and available nitrogen (167 kg/ha) status were low, while the soil was high in available P_2O_5 (74.6 kg/ha) and available potassium (356.8 kg/ha).

3.2 Climatic conditions

The normal and actual meteorological data prevailed during 1991 and upto May 1992 are presented in Table 2 and Fig. 1.

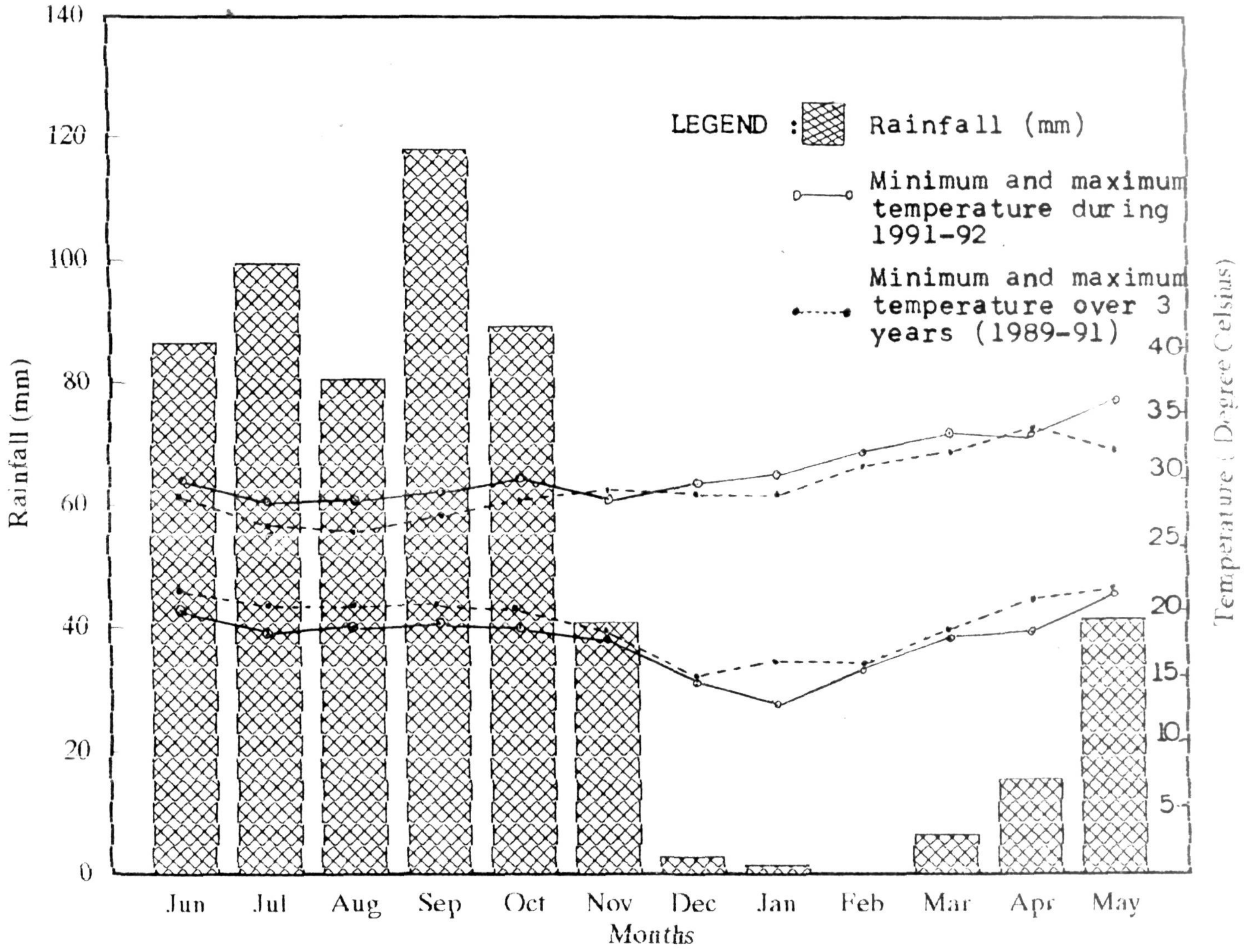
The average normal rainfall over 16 years from 1976 to 1991 was 564.5 mm. Rainfall received during the year 1991 was 900.5 mm, which was the highest recorded. About 132.8 mm of rainfall was received during 1992 upto May. The crop growth period was from December 1991 to May 1992 which received only 132.80 mm of rainfall.

The maximum and minimum temperatures recorded during the year 1991-1992 and average of three years 1989 to 1991 is also depicted. The average data of three years from 1989 to 1991 reveals that the lowest minimum temperature recorded was 15.23°C during December, whereas the highest maximum temperature 34.04°C was recorded during April. During 1991-92 the lowest minimum temperature of 13.24°C was recorded during January which increased to 16.20°C in

Table 2. The meteorological data of mean monthly rainfall over 16 years (1976-1991) and during crop growth period as well as mean monthly temperature for the period of 1989-91 and during 1991-92.

Months	Rain-fall (mm) average of 16 years (1976-1991)	Rainfall (mm) during		Temperature (°C)			
				Average of three years (1989-91)		June 1991 to May 1992	
		1991	1992 (upto May)	Minimum	Maximum	Minimum	Maximum
June	86.4	142.4		21.47	28.77	20.25	30.22
July	99.3	181.4		20.61	26.49	18.60	27.08
Aug.	80.5	113.9		20.56	25.99	18.79	26.92
Sep.	117.9	114.4		20.57	27.55	19.05	29.12
Oct.	89.1	113.9		20.33	28.45	19.27	30.00
Nov.	40.8	23.0		18.58	29.11	18.11	28.52
Dec.	2.8	-		15.23	29.08	14.45	29.54
Jan.	1.4	-	-	16.32	29.18	13.24	30.70
Feb.	0.2	-	-	16.29	31.08	16.20	31.93
Mar.	6.3	-	-	18.76	32.44	18.13	33.67
Apr.	15.5	120.80	72.0	21.26	34.04	18.68	33.99
May	41.3	90.70	60.8	21.84	32.53	21.47	36.21
Total	564.50	900.50	132.80				

FIG. 1. THE METEOROLOGICAL DATA SHOWING MEAN MONTHLY RAINFALL OVER 16 YEARS (1976-91) AND MEAN MONTHLY TEMPERATURE FOR THREE YEARS (1989-91) AND 1991-92.



February, 18.13°C in March, 18.68°C in April and 21.47°C in May. The highest maximum temperature of 36.21°C was recorded during May 1992.

3.3 Plot history

The previous crop grown in the experimental site was greengram during kharif 1991.

3.4 Experimental details

The treatments consisted of three varieties of pigeonpea and four dates as given below. There were twelve treatment combinations.

3.4.1 Treatments

Varieties

V_1 : ICPL-87

V_2 : ICPL-151

V_3 : DT-7

Dates of sowing

D_1 : Sowing on 1st December

D_2 : Sowing on 15th December

D_3 : Sowing on 1st January

D_4 : Sowing on 15th January

Treatment combinations

1. D_1V_1 : Sowing on 1st December with ICPL-87
2. D_1V_2 : Sowing on 1st December with ICPL-151
3. D_1V_3 : Sowing on 1st December with DT-7
4. D_2V_1 : Sowing on 15th December with ICPL-87
5. D_2V_2 : Sowing on 15th December with ICPL-151
6. D_2V_3 : Sowing on 15th December with DT-7
7. D_3V_1 : Sowing on 1st January with ICPL-87
8. D_3V_2 : Sowing on 1st January with ICPL-151
9. D_3V_3 : Sowing on 1st January with DT-7
10. D_4V_1 : Sowing on 15th January with ICPL-87
11. D_4V_2 : Sowing on 15th January with ICPL-151
12. D_4V_3 : Sowing on 15th January with DT-7

3.4.2 Design and layout

The experiment was laid out in Randomized Block Design (factorial), with four replications. The plan of layout of the experiment is shown in Fig. 2.

3.4.3 Plot size

Gross plot : 3.6 m x 3.5 m

Net plot : 2.4 m x 3.1 m

3.4.4 Experimental varieties

The varieties under study were ICPL-87, ICPL-151 and DT-7. The salient features of each variety are given below.

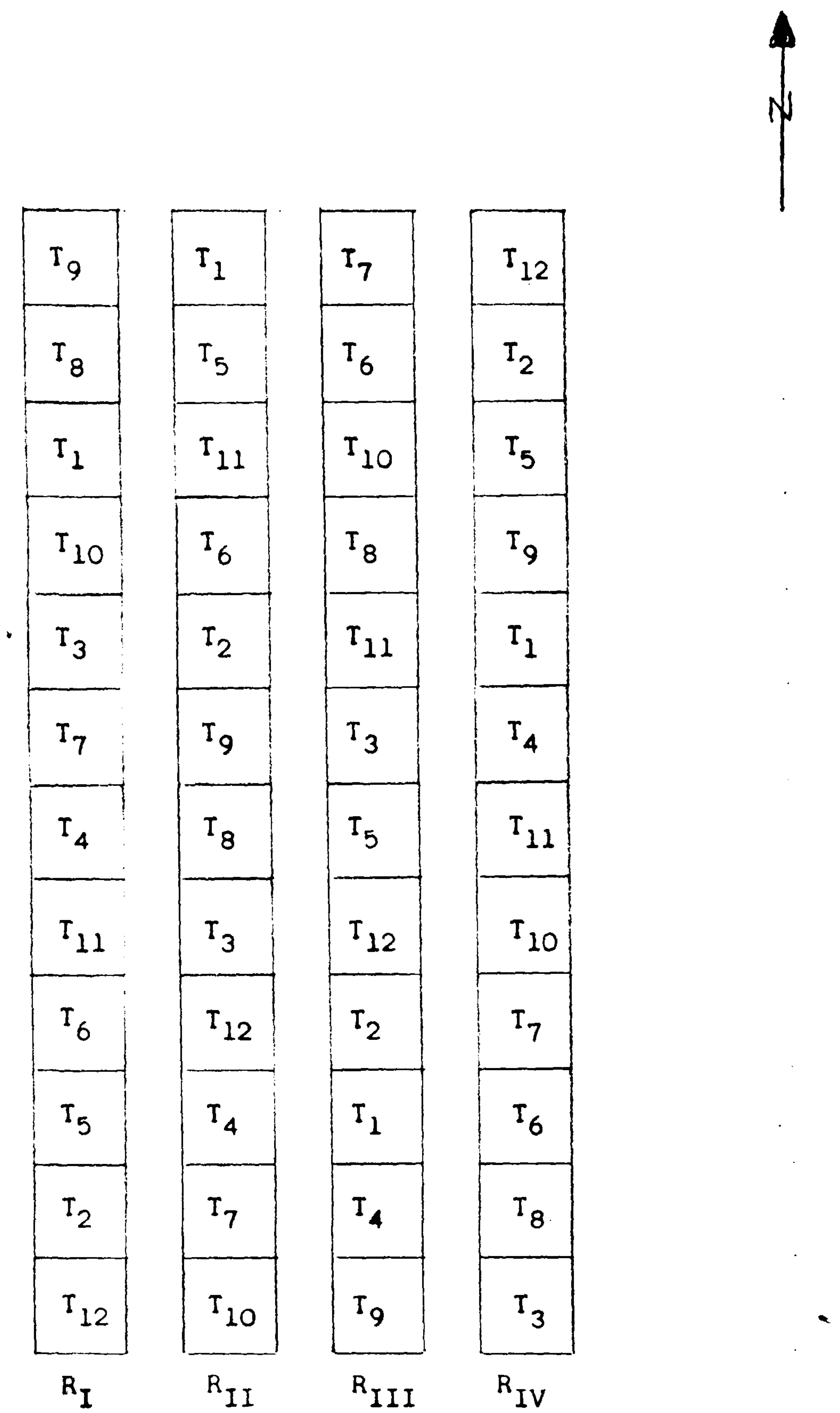


Fig.2. PLAN OF LAYOUT OF THE EXPERIMENT.

ICPL-87 (PRAGATHI) : It is a short duration variety maturing in about 116 days and is suitable for kharif. It has a semi-spreading determinate growth habit and grows to a height of 80-90 cm. It has green colour stem and dark green colour leaves. Pods are grey with purple colour streaks. It is tolerant to wilt disease. It is suitable for multiple harvesting. It yields upto 25 to 30 quintals per ha under optimum conditions.

ICPL-151 (JAGRITI) : It is a medium duration variety maturing in about 110 days and is suitable for kharif in non-traditional areas. It has a semi-spreading, determinate growth habit and grows to a height of 85 cm. It has green colour stem, dark green colour leaves. Flower colour is yellow with red streaks on the back of standard petal. It has field resistance to sterility mosaic. It is suitable for double cropping. Its yield potential is upto 25 to 30 quintals per ha under optimum conditions.

DT-7 : It is a short duration variety, maturing in about 90 days and is suitable for kharif. It has semi-spreading, determinate growth habit and grows to a height of 70 cm. It has green colour stem and light green colour leaves. It is suitable for double cropping. Its yield potential is upto 10-15 quintals per ha under optimum conditions.

3.5 Cultural operations

3.5.1 Preparation of exprimental land

The land was ploughed once by bullock drawn wooden plough during second fortnight of November 1991, followed by three harrowings. After harrowing the clods were crushed manually to attain good soil tilth and stubbles were collected. Further, after layout, all the individual plots were manually levelled. Small bunds were prepared on all the four sides of the plot and provision was made for irrigation and drainage between the replications.

3.5.2 Fertilizer application

Furrows were opened at a distance of 30 cm with the help of marker. Recommended dose of fertilizers 25 kg N, 50 kg P_2O_5 per ha in the form of urea and single super phosphate were applied in the furrows and stirred with soil thoroughly before sowing.

3.5.3 Sowing

New furrows, 5 cm away from fertilizer line at a distance of 30 cm were opened for sowing the pigeonpea seeds. The seeds of the three varieties of pigeonpea were dibbled in lines at 10 cm apart with the seed rate of 30 kg per ha as per the treatment. Care was taken to avoid direct contact of seeds with the fertilizer.

3.5.4 Irrigation

One pre-sowing irrigation was given. After sowing subsequent irrigations were given at 30 days interval throughout the growing period. In all, three irrigations were given after sowing.

3.5.5 After care

3.5.5.1 **Gap filling** : Gap filling was carried out wherever gaps were noticed immediately after the germination. Thinning was done after 15 days of sowing depending upon the growth of the crop. Single seedling per hill was maintained at a spacing of 10 cm in line.

3.5.5.2 **Interculturing and weeding** : The weedicide alachlor was applied a day after sowing as a pre-emergent spray at the rate of 2.5 litres per ha. Two hand weedings at 30 and 45 days after sowing and three hoeings at 15, 30 and 45 days after sowing were done for better weed management and loosen the soil.

3.5.5.3 **Harvesting** : Harvesting was done when pods were completely matured as per the sowing dates. Pods were hand picked, hand threshed and cleaned. The seeds were sun dried and weight was recorded. The plants were cut at ground level, sundried for a week. The seed yield per plot was recorded.

3.6 Collection of **experimental data**

Growth and yield parameters were recorded by periodical sampling at 30, 60, 90 days after sowing and at harvest. Five plants representing the population were selected at ramdom in each plot. These plants were cleaned free of soil and used for recording various observations.

3.6.1 **Pre-harvest studies**

3.6.1.1 **Plant height** : The plant height of the main shoot was recorded from ground level to the tip of the unfolded leaf. Mean plant height of 5 plants was expressed in cm.

3.6.1.2 **Number of compound leaves** : The number of compound leaves of five plants were counted and mean number of compound leaves of five plants worked out.

3.6.1.3 **Number of primary branches** : All the surviving primary branches emerging from the main shoot were counted in five plants, mean values expressed per plant basis.

3.6.1.4 **Leaf area per plant** : The leaves of five plants were separated by cutting to the base and fed to the Leaf area meter (Model LI 3100 from LICOR Co; Nebraska). From the total leaf area of five plants, leaf area per plant was computed and expressed in cm^2.

3.6.1.5 **Dry matter accumulation and distribution** : Dry matter accumulation was determined for only the above ground portion of the plant. The plant samples selected were partitioned into different parts like leaf, stem and pods and dried at 65-70°C in hot air oven. The completely dried samples were weighed to constant weight and recorded as g per plant. These primary data were used to estimate the total dry weight per plant and its distribution into various plant parts.

3.6.1.6 **Number of days to 50 per cent flowering** : Number of days taken from sowing to 50 per cent flowering was recorded, when 50 per cent of the total number of plants in the plot flowered.

3.6.1.7 **Number of pods per plant** : The number of pods produced on five sample plants were counted and mean number of pods per plant was computed.

3.6.2 Post-harvest studies

3.6.2.1 **Number of seeds per pod** : The pods produced on five sample plants were threshed and cleaned. The total number of seeds were counted and divided by number of pods. The value obtained recorded as number of seeds per pod.

3.6.2.2 **Seed yield** : At harvest, the grain yield of net plot was recorded and it was converted to kg per ha.

3.6.2.3 **Pod yield** : Weight of pods from the net plot was recorded after thorough sundrying and expressed in kg per ha.

3.6.2.4 **Test weight** : A sample of 100-grains for each treatment was drawn at random and its weight was recorded in g.

3.6.2.5 **Harvest index (HI)** : It is the ratio of economic or grain yield to the total biological yield produced by the crop. It was calculated by the formula suggested by Donald (1962).

$$H.I. = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.6.3 **Growth analysis studies**

3.6.3.1 **Leaf area index (LAI)** : Leaf area index is a measure of the extent of crop canopy covering the land. LAI was calculated by using the formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Land area covered by plant}}$$

It was calculated at 30, 60, 90 days after sowing and at harvest.

3.6.3.2 **Leaf area duration (LAD)** : It is the integral of leaf area index over the growing season expressed in days.

LAD was calculated from LAI as per the formula suggested by Power *et al*. (1967).

$$LAD = \frac{LAI_1 + LAI_2}{2} \times t_2 - t_1$$

where, LAI_1 and LAI_2 are the periodical observations of leaf area index at an interval between t_1 and t_2 times.

It was calculated at 30-60, 60-90 and 90 to harvest periods.

3.6.3.3 **Relative growth rate (RGR)** : it is the rate of increase in dry weight per unit time and expressed as g per g per day. It was computed for 30-60, 60-90 and 90 to harvest period. It was calculated by using the formula suggested by Fischer (1921).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \quad g/g/day$$

where, $\log_e$ = logrithm to the base `e' (Naperian constant)

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

3.6.3.4 **Net assimilation rate (NAR)** : NAR is the rate of increase in the dry matter per unit leaf area per unit time and expressed as g per cm^2 per day. NAR was calculated by the formula as suggested by Gregory (1926). It was calculated for 30-60, 60-90 and 90 to harvest periods.

$$NAR = \frac{(W_2 - W_1)\ (\log_e L_2 - \log_e L_1)}{(t_2 - t_1)\ (L_2 - L_1)}$$

where $\log_e$ = Logrithm to the base `e' (Naperian constant)

L_1 and W_1 = Leaf area and dry weight of the plant respectively at time t_1

L_2 and W_2 = Leaf area and dry weight of the plant respectively at time t_2

3.6.3.5 **Crop growth rate (CGR)** : CGR is the absolute growth rate per unit area of ground expressed as g per cm^2 per day. It was computed for 30-60, 60-90 and 90 to harvest periods by using the formula suggested by Watson (1952).

$$CGR = NAR \times \text{Mean LAI}$$

where, NAR = is net assimilation rate for the corresponding period

LAI = Average of leaf area index at times t_1 and t_2

3.7 Statistical analysis and interpretation of experimental data

Fischer's method of "Analysis of variance" for Randomised Block Design (Factorial) described by Sundararaj et al. (1972) was applied for the analysis and interpretation of the experimental data. The levels of significance used in `F' and `t' tests were at 0.05 probability. Standard error of mean and critical differnce has been provided. The critical difference was calculated whenever the data was found significant.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the experiment entitled "Optimising time of sowing in three short duration varieties of pigeonpea during summer in Bhadra command area" conducted during summer season of 1991-92 at Agricultural Research Station, Kathalagere, University of Agricultural Sciences, Bangalore are presented in this chapter.

4.1 Growth parameters

4.1.1 Plant height

The data on plant height at 30, 60, 90 days after sowing and at harvest as influenced by varieties and dates of sowing are presented in Table 3.

At 30 days after sowing, the plant height differed significantly with dates of sowing and varieties. Sowing on 15th January recorded maximum plant height (25.70 cm) and was significantly superior to 15th December sowing (22.08 cm), 1st January sowing (16.77 cm) and 1st December sowing (12.87 cm). Among the varieties, ICPL-151 recorded maximum plant height (20.42 cm) and was on par with DT-7 (19.55 cm). Both ICPL-151 and DT-7 were significantly superior to ICPL-87 (18.10 cm). Significant differences among interactions were not observed.

Table 3. Plant height as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Plant height (cm) Days after sowing 30	60	90	At harvest
Interactions					
1.	D_1V_1	10.95	29.60	36.66	38.67
2.	D_1V_2	14.25	29.80	39.93	41.28
3.	D_1V_3	13.40	23.05	34.61	37.03
4.	D_2V_1	21.11	46.62	48.97	50.19
5.	D_2V_2	22.80	49.66	52.44	56.32
6.	D_2V_3	22.32	39.07	42.01	46.75
7.	D_3V_1	15.72	48.25	52.94	55.96
8.	D_3V_2	18.80	47.76	47.86	48.05
9.	D_3V_3	15.80	38.41	40.92	41.58
10.	D_4V_1	24.60	54.34	56.83	60.34
11.	D_4V_2	25.83	49.33	54.47	56.87
12.	D_4V_3	26.67	42.81	46.84	50.60
	F test	NS	NS	*	*
	S.Em ±	0.91	1.28	1.27	1.35
	C.D. at 5%	-	-	3.64	3.89
Dates of sowing					
1st December	(D_1)	12.87	27.48	37.07	38.99
15th December	(D_2)	22.08	45.12	47.79	51.09
1st January	(D_3)	16.77	44.81	47.24	48.53
15th January	(D_4)	25.70	48.83	52.71	55.94
	F test	*	*	*	*
	S.Em ±	0.52	0.74	0.73	0.78
	C.D. at 5%	1.50	2.13	2.10	2.25
Varieties					
ICPL-87	(V_1)	18.10	44.70	48.85	51.29
ICPL-151	(V_2	20.42	44.14	48.66	50.63
DT-7	(V_3)	19.55	35.84	41.09	43.99
F test		*	*	*	*
S.Em ±		0.45	0.64	0.63	0.68
C.D. at 5%		1.30	1.84	1.82	1.95
Grand Mean		19.35	41.56	46.20	48.64

At 60 days after sowing, the plant height differed significantly due to sowing dates and varieties. Significant differences among interactions were not observed. The maximum plant height was recorded with 15th January sown crop (48.83 cm) and was significantly superior over 15th December (45.12 cm), 1st January (44.81 cm) and 1st December (27.48 cm) sown crop. The 15th December and 1st January sown crop were on par with each other. Among the varieties ICPL-87 and ICPL-151 recorded 44.70 cm and 44.14 cm per plant respectively, which were on par with each other and were significantly superior to DT-7 (35.84 cm).

At 90 days after sowing, the plant height differed significantly due to sowing dates, varieties as well as their interactions. The sowing on 15th January registered maximum plant height of 52.71 cm which was significantly superior to that of sowing on 15th December (47.79 cm), 1st January (47.24 cm) and 1st December (37.07 cm). The plant height of 15th December and 1st January sown crop were on par with each other and significantly superior to 1st December sown crop. Among the varieties, ICPL-87 and ICPL-151 recorded 48.85 cm and 48.66 cm per plant respectively, which were on par with each other and were significantly superior to DT-7 (41.09 cm). Among the interactions, ICPL-87 sown on 15th January recorded significantly highe. plant height of 56.83 cm than others.

At harvest, significant differences among sowing dates, varieties, as well as their interactions were observed with respect to plant height. The plant height of 15th January sown crop (55.94 cm) was significantly superior to 15th December (51.09 cm), 1st January (48.53 cm) and 1st December (38.99 cm). Among the varieties ICPL-87 and ICPL-151 recorded plant height of 51.29 cm and 50.63 cm, respectively which were on par with each other. Both the varieties were significantly superior to DT-7 (43.99 cm). Among the interactions ICPL-87 sown on 15th January recorded significantly higher plant height (60.34 cm) than others.

4.1.2 **Number of compound leaves per plant**

The data on number of compound leaves per plant at different growth stages as influenced by various treatments are presented in Table 4.

At 30 days after sowing, the number of compound leaves per plant differed significantly due to sowing dates and varieties. Sowing on 15th December and 1st December produced 8.57 and 8.20 higher number of compound leaves per plant respectively, which were on par with each other and differed significantly from 15th January sowing (7.48) and 1st January sowing (5.67). Among the varieties ICPL-87 produced maximum number of compound leaves per plant (7.90) which was on par with ICPL-151 (7.66) and were significantly superior to that

Table 4. Number of compound leaves as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Number of compound leaves: Days after sowing 30	60	90	At harvest
Interactions					
1.	D_1V_1	8.90	29.10	30.45	6.70
2.	D_1V_2	8.75	23.50	29.80	5.35
3.	D_1V_3	6.95	19.25	22.40	5.10
4.	D_2V_1	8.65	30.90	32.85	8.60
5.	D_2V_2	8.45	29.50	31.30	4.05
6.	D_2V_3	8.60	26.60	27.35	3.60
7.	D_3V_1	6.20	26.55	26.75	6.90
8.	D_3V_2	5.85	24.55	25.32	6.65
9.	D_3V_3	4.95	21.60	22.75	5.45
10.	D_4V_1	7.85	26.00	26.27	7.45
11.	D_4V_2	7.60	21.45	22.17	6.65
12.	D_4V_3	7.00	21.05	21.77	4.20
	F test	NS	*	*	*
	S.Em ±	0.35	0.96	0.98	0.27
	C.D. at 5%	-	2.75	2.81	0.78
Dates of sowing					
	1st December (D_1)	8.20	23.95	27.55	5.72
	15th December (D_2)	8.57	29.00	30.50	5.42
	1st January (D_3)	5.67	24.33	24.94	6.33
	15th January (D_4)	7.48	22.83	23.41	6.10
	F test	*	*	*	*
	S.Em ±	0.20	0.55	0.56	0.16
	C.D. at 5%	0.59	1.59	1.62	0.45
Varieties					
	ICPL-87 (V_1)	7.90	28.14	29.08	7.41
	ICPL-151 (V_2	7.66	24.75	27.15	5.67
	DT-7 (V_3)	6.87	22.12	23.57	4.59
	F test	*	*	*	*
	S.Em ±	0.18	0.48	0.49	0.14
	C.D. at 5%	0.51	1.38	1.40	0.39
Grand Mean		7.48	25.00	26.60	5.80

of DT-7 (6.87). Significant differences among interactions were not observed.

At 60 days after sowing, the sowing dates, varieties as well as their interactions had significant influence on the number of compound leaves per plant. The sowing on 15th December produced significantly higher number of compound leaves (29.00) than 1st January (24.33), 1st December (23.95) and 15th January (22.83)and were on par with each other. Among the varieties, ICPL-87 produced significantly higher number of compound leaves per plant (28.14) than ICPL-151 (24.75) and DT-7 (22.12). Among the interactions, ICPL-87 sown on 15th December produced higher number of compound leaves per plant (30.90) which was on par with ICPL-151 sown on 15th December (29.50) and ICPL-87 sown on 1st December (29.10) and were significantly superior to other interactions.

At 90 days after sowing, the sowing dates, varieties as well as their interactions had significant influence on the number of compound leaves per plant. The sowing on 15th December produced higher number of compound leaves per plant (30.50) and differed significantly than 1st December (27.55), 1st January (24.94) and 15th January (23.41). The sowing on 1st January and 15th January were on par with each other. Among the varieties ICPL-87 produced maximum number of comopound leaves of 29.08 and differed significantly with

ICPL-151 (27.15) and DT-7 (23.57). Among the interactions ICPL-87 sown on 15th December produced higher number of compound leaves per plant (32.85), which was on par with ICPL-151 sown on 15th December (31.30) and ICPL-87 sown on 1st December (30.45).

At harvest, the sowing dates, varieties as well as their interactions had significant influence on the number of compound leaves per plant. The sowing on 1st January produced higher number of compound leaves per plant (6.33) which was on par with 15th January (6.10) and differed significantly with 1st December sowing (5.72) and 15th December sowing (5.42). Among the varieties ICPL-87 produced maximum number of compound leaves per plant (7.41) which was significantly superior to ICPL-151 (5.67) and DT-7 (4.59). Among the interactions ICPL-87 sown on 15th December produced significantly higher number of compound leaves per plant (8.60) than others.

4.1.3 **Number of primary branches per plant**

The data on number of primary branches per plant at different growth stages as influenced by various treatments are presented in Table 5.

At 60 days after sowing, significant differences among sowing dates and interactions were observed in respect of number of primary branches per plant. The 15th December

Table 5. Number of primary branches as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Number of primary branches: Days after sowing 60	Days after sowing 90	At harvest
Interactions				
1.	D_1V_1	3.65	4.50	5.85
2.	D_1V_2	3.65	5.20	5.85
3.	D_1V_3	3.15	4.60	5.50
4.	D_2V_1	7.35	7.55	7.80
5.	D_2V_2	7.75	7.75	8.05
6.	D_2V_3	7.90	8.00	8.10
7.	D_3V_1	5.60	5.75	6.00
8.	D_3V_2	5.50	5.75	5.90
9.	D_3V_3	6.25	6.45	6.50
10.	D_4V_1	6.75	6.85	7.00
11.	D_4V_2	5.75	6.05	6.85
12.	D_4V_3	7.15	7.65	7.70
	F test	*	NS	NS
	S.Em ±	0.29	0.37	0.29
	C.D. at 5%	0.83	-	-
Dates of sowing				
	1st December (D_1)	3.48	4.77	5.73
	15th December (D_2)	7.67	7.67	7.98
	1st January (D_3)	5.78	5.98	6.13
	15th January (D_4)	6.55	6.85	7.18
	F test	*	*	*
	S.Em ±	0.17	0.21	0.17
	C.D. at 5%	0.48	0.61	0.49
Varieties				
	ICPL-87 (V_1)	5.84	6.16	6.66
	ICPL-151 (V_2	5.66	6.19	6.66
	DT-7 (V_3)	6.11	6.67	6.95
	F test	NS	NS	NS
	S.Em ±	0.14	0.18	0.15
	C.D. at 5%	-	-	-
Grand Mean		5.87	6.34	6.76

sowing registered higher number of primary branches of 7.67 per plant and was significantly superior to that of 15th January sowing (6.55), 1st January sowing (5.78) and 1st December sowing (3.48). Among the varieties DT-7 recorded higher number of primary branches per plant (6.11), followed by ICPL-87 (5.84) which were on par with each other. Minimum number of primary branches per plant was observed with ICPL-151 (5.66) which was on par with ICPL-87 (5.84). Among the interactions DT-7 sown on 15th December produced higher number of primary branches per plant (7.90) which was on par with ICPL-151 (7.75), ICPL-87 (7.35) sown on 15th December and DT-7 (7.15) sown on 15th January and significantly superior to others.

At 90 days after sowing, the number of primary branches per plant differed significantly due to sowing dates and varieties. The sowing on 15th December recorded higher number of primary branches per plant (7.67) and was significantly superior to 15th January sowing (6.85), 1st January sowing (5.98) and 1st December sowing (4.77). Among the varieties, DT-7 produced higher number of primary branches per plant (6.67), which was on par with ICPL-151 (6.19). Minimum number of primary branches per plant was noticed with ICPL-87 (6.16), which was on par with ICPL-151 (6.19). Significant differences among interactions were not observed with respect to number of primary branches per plant.

At harvest, the varieties as well as interactions had no effect on the number of primary branches per plant. However, significant differences were observed due to sowing dates. Significantly higher number of primary branches per plant was registered with 15th December sowing (7.98) than 15th January sowing (7.18), 1st January sowing (6.13) and 1st December sowing (5.73). The 1st January sowing and 1st December sowing were on par with each other.

4.1.4 Leaf area per plant

Leaf area per plant at different growth stages as influenced by various treatments are presented in Table 6.

Significant differences among sowing dates, varieties as well as their interaction were observed with respect to leaf area per plant.

At 30 days after sowing, the leaf area per plant was maximum with 15th December sowing (139.82 cm^2) and was significantly superior to 1st January (89.70 cm^2), 15th January sowing (77.37 cm^2). The leaf area per plant was minimum with 1st December sowing (38.32 cm^2). Among the varieties, ICPL-151 recorded maximum leaf area per plant (91.32 cm^2), which was superior to ICPL-87 (87.60 cm^2) and DT-7 (79.98 cm^2). Regarding interaction, ICPL-87 sown on 15th December registered significantly higher leaf area per plant (149.15 cm^2) than others.

Table 6. Leaf area of pigeonpea varieties as influenced by dates of sowing.

Sl. No.	Treatments	Leaf area cm^2 per plant: Days after sowing 30	60	90	At harvest
Interactions					
1.	D_1V_1	38.32	351.68	424.55	169.48
2.	D_1V_2	47.28	374.38	445.08	165.66
3.	D_1V_3	29.36	213.33	332.25	136.94
4.	D_2V_1	149.15	648.75	752.76	181.27
5.	D_2V_2	138.91	603.75	708.00	156.27
6.	D_2V_3	131.41	487.18	565.68	106.85
7.	D_3V_1	87.27	491.52	683.04	239.62
8.	D_3V_2	97.57	499.29	698.59	246.77
9.	D_3V_3	84.26	447.04	654.10	150.37
10.	D_4V_1	75.68	842.09	935.35	219.39
11.	D_4V_2	81.54	664.94	810.32	183.36
12.	D_4V_3	74.88	627.01	790.19	115.22
	F test	*	*	*	*
	S.Em ±	1.45	12.48	10.64	3.94
	C.D. at 5%	4.17	35.91	30.61	11.34
Dates of sowing					
	1st December (D_1)	38.32	313.13	400.63	157.36
	15th December (D_2)	139.82	579.89	675.48	148.13
	1st January (D_3)	89.70	479.28	678.58	212.25
	15th January (D_4)	77.37	711.35	845.29	172.66
	F test	*	*	*	*
	S.Em ±	0.84	7.21	6.14	2.28
	C.D. at 5%	2.42	20.74	17.67	6.56
Varieties					
	ICPL-87 (V_1)	87.60	583.51	698.92	202.44
	ICPL-151 (V_2	91.32	535.59	665.50	188.01
	DT-7 (V_3)	79.98	443.64	585.55	127.34
	F test	*	*	*	*
	S.Em ±	0.72	6.24	5.32	1.97
	C.D. at 5%	2.07	17.95	15.31	5.67
Grand Mean		86.30	520.91	649.99	172.60

At 60 days after sowing, the leaf area per plant observed was highest with 15th January sowing (711.35 cm^2) and was superior to 15th December sowing (579.89 cm^2), 1st January sowing (479.28 cm^2) and 1st December sowing (313.13 cm^2). Among the varieties, ICPL-87 recorded maximum leaf area per plant (583.51 cm^2), which was significantly superior to ICPL-151 (535.59 cm^2) and DT-7 (443.64 cm^2). The interaction, ICPL-87 sown on 15th January recorded significantly higher leaf area per plant (842.09 cm^2) than others.

At 90 days after sowing, significant differences in leaf area per plant were registered due to sowing dates, varieties as well as their interactions. The sowing on 15th January recorded maximum leaf area per plant (845.29cm^2), which was significantly superior to 1st January sowing (678.58 cm^2), 15th December sowing (675.48 cm^2) and 1st December sowing (400.63 cm^2). The leaf area per plant recorded for 1st January sowing and 15th December sowing dates were on par with each other. Among the varieties, significantly higher leaf area per plant was noticed with ICPL-87 (698.92 cm^2) than ICPL-151 (665.50 cm^2) and DT-7 (585.55 cm^2). Among the interactions, maximum leaf area per plant was observed with ICPL-87 sown on 1st January (935.35 cm^2), which was significantly superior to other interactions.

At harvest, the leaf area per plant differed significantly due to sowing dates, varieties as well as their interactions. Decline in leaf area per plant was observed after 90 days of sowing. The sowing on 1st January recorded maximum leaf area per plant (212.25 cm^2), which was significantly superior to 15th January sowing (172.66 cm^2), 1st December sowing (157.36 cm^2) and 15th December sowing (148.13 cm^2). Among the varieties, ICPL-87 registered higher leaf area per plant (202.44 cm^2), which was significantly superior to ICPL-151 (181.01 cm^2) and DT-7 (127.34 cm^2). Among interactions, ICPL-151 and ICPL-87 sown on 1st January recorded significantly higher leaf area of 246.77 cm^2 and 239.62 cm^2, respectively than other interactions.

4.1.5 **Leaf area index (LAI)**

The data on leaf area index at 30, 60, 90 days after sowing and at harvest as influenced by various treatments are presented in Table 7.

Leaf area index increased from 30 days after sowing upto 90 days after sowing and then declined at the time of harvest. The maximum values of leaf area index were recorded at 90 days after sowing. The mean leaf area index was 0.285 at 30 days after sowing, 1.734 at 60 days after sowing, 2.161 at 90 days after sowing and 0.576 at harvest.

Table 7. Leaf area index as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Leaf area index			
		Days after sowing			At harvest
		30	60	90	
Interactions					
1.	D_1V_1	0.125	1.170	1.417	0.565
2.	D_1V_2	0.155	1.245	1.482	0.552
3.	D_1V_3	0.095	0.710	1.107	0.457
4.	D_2V_1	0.492	2.162	2.510	0.605
5.	D_2V_2	0.462	2.010	2.360	0.520
6.	D_2V_3	0.437	1.622	1.885	0.352
7.	D_3V_1	0.287	1.640	2.272	0.797
8.	D_3V_2	0.325	1.662	2.327	0.822
9.	D_3V_3	0.277	1.480	2.130	0.500
10.	D_4V_1	0.252	2.807	3.117	0.732
11.	D_4V_2	0.270	2.212	2.700	0.607
12.	D_4V_3	0.250	2.090	2.632	0.410
	F test	*	*	*	*
	S.Em ±	0.003	0.042	0.039	0.012
	C.D. at 5%	0.009	0.121	0.112	0.034
Dates of sowing					
	1st December (D_1)	0.125	1.042	1.335	0.525
	15th December (D_2)	0.464	1.931	2.252	0.492
	1st January (D_3)	0.296	1.594	2.243	0.706
	15th January (D_4)	0.257	2.370	2.816	0.583
	F test	*	*	*	*
	S.Em ±	0.002	0.024	0.022	0.007
	C.D. at 5%	0.005	0.069	0.063	0.020
Varieties					
	ICPL-87 (V_1)	0.289	1.945	2.329	0.674
	ICPL-151 (V_2	0.303	1.782	2.217	0.625
	DT-7 (V_3)	0.265	1.475	1.983	0.430
	F test	*	*	*	*
	S.Em ±	0.001	0.021	0.019	0.006
	C.D. at 5%	0.003	0.060	0.055	0.017
Grand Mean		0.285	1.734	2.161	0.576

At 30 days after sowing, significant differences among sowing dates, varieties as well as their interactions were observed with respect to leaf area index. Significantly higher leaf area index values were observed with 15th December sowing (0.464) than that of 1st January sowing (0.296), 15th January sowing (0.257) and 1st December sowing (0.125). Significantly higher leaf area index values were registered with ICPL-151 (0.303) than ICPL-87 (0.289) and DT-7 (0.265), which were on par with each other. The maximum leaf area index was registered with ICPL-87 sown on 15th December (0.492) which was significantly superior to other interactions.

At 60 days after sowing, significant differences among sowing dates, varieties, as well as their interactions were observed in respect of leaf area index. The maximum leaf area index was recorded with 15th January sowing (2.370) which was superior to 15th December sowing (1.931), 1st January sowing (1.594) and 1st December sowing (1.042). The variety ICPL-87 recorded significantly higher leaf area index (1.945) than ICPL-151 (1.782)and DT-7 (1.475). Among the interactions, maximum leaf area index per plant was registered with ICPL-87 sown on 15th January (2.807), which was significantly superior to other interactions.

At 90 days after sowing, significant differences in leaf area index was observed due to sowing dates, varieties, as well as their interactions. Significantly higher leaf area index was recorded with 15th January sowing (2.816) than 15th December sowing (2.252), 1st January sowing (2.243)and 1st December sowing (1.335). The 15th December and 1st January sowing were on par with each other. The variety ICPL-87 recorded significantly higher leaf area index (2.329) than ICPL-151 (2.217) and DT-7 (1.983). The interaction ICPL-87 sown on 15th January recorded maximum leaf area index (3.117), which was significantly superior to other interactions.

At harvest, significant differences in leaf area index was noticed due to sowing dates, varieties, as well as their interaction. Significantly higher leaf area index was recorded with 1st January sowing (0.706) than 15th January sowing (0.583), 1st December sowing (0.525) and 15th December sowing (0.492). The variety ICPL-87 recorded maximum leaf area index (0.674), which was significantly superior to ICPL-151 (0.625) and DT-7 (0.430). Among the interactions, the varieties ICPL-151 and ICPL-87 sown on 1st January recorded higher leaf area index per plant of 0.822 and 0.797, respectively, which were significantly superior to other interactions.

4.1.6 Leaf area duration

The data on leaf area duration at different growth periods as inflluenced by various treatments are presented in Table 8.

Significant differences among sowing dates, varieties, as well as their interactions were observed with respect to leaf area duration.

During 30-60 days period, significantly higher leaf area duration values were recorded with 15th January sowing (39.415 days) than 15th December sowing (35.937 days), 1st January sowing (28.362 days) and 1st December sowing (17.500 days). Among the varieties ICPL-87 recorded significantly higher leaf area duration of 33.515 days than ICPL-151 (31.284 days) and DT-7 (26.111 days). Among the interactions ICPL-87 sown on 15th January recorded significantly higher leaf area duration of 45.900 days than other interactions.

During 60-90 days period, the leaf area duration recorded was maximum with 15th January sowing (77.800 days) which was significantly superior to 15th December (62.750 days), 1st January sowing (57.562 days) and 1st December sowing (35.662 days). The variety ICPL-87 recorded significantly higher leaf area duration of 64.115 days than ICPL-151 (60.00 days) and DT-7 (51.215 days). Among

Table 8. Leaf area duration (LAD in days) as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Days after sowing 30-60	Days after sowing 60-90	90-harvest
Interactions				
1.	D_1V_1	19.425	38.812	24.780
2.	D_1V_2	21.000	40.912	20.350
3.	D_1V_3	12.075	27.262	7.825
4.	D_2V_1	39.825	70.087	35.820
5.	D_2V_2	37.087	65.550	28.800
6.	D_2V_3	30.900	52.612	11.175
7.	D_3V_1	28.912	58.687	30.700
8.	D_3V_2	29.812	59.850	23.605
9.	D_3V_3	26.362	54.150	6.575
10.	D_4V_1	45.900	88.875	44.272
11.	D_4V_2	37.237	73.687	24.802
12.	D_4V_3	35.107	70.837	7.605
	F test	*	*	*
	S.Em ±	0.626	0.910	0.330
	C.D. at 5%	1.801	2.618	0.950
Dates of sowing				
	1st December (D_1)	17.500	35.662	17.652
	15th December (D_2)	35.937	62.750	25.265
	1st January (D_3)	28.362	57.562	20.113
	15th January (D_4)	39.415	77.800	25.560
	F test	*	*	*
	S.Em ±	0.362	0.520	0.190
	C.D. at 5%	1.041	1.500	0.550
Varieties				
	ICPL-87 (V_1)	33.515	64.115	33.893
	ICPL-151 (V_2	31.284	60.000	24.389
	DT-7 (V_3)	26.111	51.215	8.295
	F test	*	*	*
	S.Em ±	0.313	0.450	0.170
	C.D. at 5%	0.900	1.295	0.490
Grand Mean		30.303	58.443	22.192

interactions, ICPL-87 sown on 15th January recorded significantly higher leaf area duration of 88.875 days than other interactions.

From 90 days to harvest period, the leaf area duration showed declining trend. The leaf area duration observed was 25.560 days on 15th January sowing and 22.265 days on 15th December sowing which were on par with each other and were significantly superior to those of 1st January sowing and 1st December sowing (20.113 days and 17.652 days, respectively). Among the varieties, ICPL-87 recorded significantly higher leaf area duration values (33.893 days) than ICPL-151 (24.389 days) and DT-7 (8.295 days). ICPL-87 sown on 15th January recorded maximum leaf area duration of 44.272 days.

4.1.7 Crop growth rate (CGR)

The data on crop growth rate at different growth periods as influenced by various treatments are presented in Table 9.

The crop growth rate was initially slow, increased upto 90 days and then declined. The mean crop growth rate was 0.079 g per cm^2 per day during 30-60 days, 0.445 g per cm^2 per day during 60-90 days and 0.224 g per cm^2 per day during 90-harvest.

Table 9. Crop growth rate ($g/cm^2/day$) as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Days after sowing 30-60	60-90	90-harvest
Interactions				
1.	D_1V_1	0.090	0.452	0.277
2.	D_1V_2	0.077	0.417	0.325
3.	D_1V_3	0.055	0.375	0.255
4.	D_2V_1	0.085	0.522	0.245
5.	D_2V_2	0.080	0.485	0.287
6.	D_2V_3	0.070	0.440	0.235
7.	D_3V_1	0.085	0.502	0.242
8.	D_3V_2	0.070	0.465	0.252
9.	D_3V_3	0.055	0.357	0.212
10.	D_4V_1	0.107	0.507	0.107
11.	D_4V_2	0.092	0.465	0.150
12.	D_4V_3	0.082	0.352	0.147
	F test	NS	*	*
	S.Em ±	0.003	0.009	0.009
	C.D. at 5%	-	0.028	0.026
Dates of sowing				
	1st December (D_1)	0.074	0.415	0.286
	15th December (D_2)	0.078	0.482	0.256
	1st January (D_3)	0.070	0.442	0.236
	15th January (D_4)	0.094	0.442	0.135
	F test	*	*	*
	S.Em ±	0.002	0.005	0.005
	C.D. at 5%	0.006	0.014	0.014
Varieties				
	ICPL-87 (V_1)	0.092	0.496	0.218
	ICPL-151 (V_2	0.080	0.458	0.254
	DT-7 (V_3)	0.066	0.381	0.212
	F test	*	*	*
	S.Em ±	0.002	0.004	0.004
	C.D. at 5%	0.005	0.012	0.011
Grand Mean		0.079	0.445	0.224

During 30-60 days, significant differences in crop growth rate were recorded due to sowing dates and varieties. The 15th January sowing recorded maximum crop growth rate (0.094 g/cm^2/day) followed by that of 15th December sowing (0.078 g/cm^2/day), 1st December (0.074 g/cm^2/day), which were on par with each other. Among the varieties ICPL-87 differed significantly with maximum crop growth rate (0.092 g/cm^2/day) followed by ICPL-151 (0.080 g/cm^2/day) and DT-7 (0.056 g/cm^2/day). Significant differences among interactions were not observed.

During 60-90 days, significant differences among sowing dates, varieties, as well as their interactions were observed with respect to crop growth rate. The maximum crop growth rate was recorded with 15th December sowing (0.482 g/cm^2/day) followed by 1st January sowing (0.442 g/cm^2/day) and 15th January sowing (0.442 g/cm^2/day), which were on par with each other. The minimum crop growth rate of 0.415 g per cm^2 per day was recorded with 1st December sowing. Among the varieties, ICPL-87 recorded maximum crop growth rate of 0.496 g per cm^2 per day, which was significantly superior to ICPL-151 (0.458 g/cm^2/day) and DT-7 (0.381 g/cm^2/day). The interaction ICPL-87 sown on 15th December recorded significantly higher crop growth rate (0.522 g/cm^2/day) than other interactions.

During 90 days to harvest period, the crop growth rate differed significantly due to sowing dates, varieties as well as their interactions. Sowing on 1st December recorded maximum crop growth rate of 0.286 g per cm^2 per day, which was significantly superior to 15th December sowing (0.256 $g/cm^2/day$), 1st January sowing (0.236 $g/cm^2/day$) and 15th January sowing (0.135 $g/cm^2/day$).

Among the varieties, ICPL-151 recorded maximum crop growth rate of 0.254 g per cm^2 per day which was significantly superior to ICPL-87 (0.218 $g/cm^2/day$) and DT-7 (0.212 $g/cm^2/day$) and they were on par with each other. The interaction, ICPL-151 sown on 1st December recorded maximum crop growth rate of 0.325 g per cm^2 per day, which was significantly superior to other interactions.

4.1.8 **Net assimilation rate (NAR)**

The data on net assimilation rate at different growth periods as influenced by various treatments are presented in Table 10.

The significant differences in net assimilation rates were observed due to sowing dates, varieties and their interactions, except for interactions at 90-harvest periods.

The net assimilation rate was initially slow, increased upto 60-90 days period and then declined. The mean net

Table 10. Net assimilation rate (NAR g/cm^2/day) as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Days after sowing 30-60	60-90	90-harvest
Interactions				
1.	D_1V_1	0.142	0.345	0.277
2.	D_1V_2	0.112	0.307	0.320
3.	D_1V_3	0.140	0.415	0.327
4.	D_2V_1	0.065	0.225	0.157
5.	D_2V_2	0.067	0.220	0.192
6.	D_2V_3	0.065	0.252	0.212
7.	D_3V_1	0.087	0.255	0.155
8.	D_3V_2	0.070	0.232	0.160
9.	D_3V_3	0.062	0.195	0.162
10.	D_4V_1	0.070	0.167	0.055
11.	D_4V_2	0.075	0.190	0.092
12.	D_4V_3	0.072	0.147	0.095
	F test	*	*	NS
	S.Em ±	0.004	0.007	0.008
	C.D. at 5%	0.011	0.020	-
Dates of sowing				
	1st December (D_1)	0.132	0.356	0.308
	15th December (D_2)	0.066	0.232	0.187
	1st January (D_3)	0.073	0.227	0.159
	15th January (D_4)	0.072	0.168	0.081
	F test	*	*	*
	S.Em ±	0.002	0.004	0.005
	C.D. at 5%	0.006	0.011	0.013
Varieties				
	ICPL-87 (V_1)	0.091	0.248	0.161
	ICPL-151 (V_2	0.081	0.237	0.191
	DT-7 (V_3)	0.085	0.252	0.199
	F test	*	*	*
	S.Em ±	0.002	0.003	0.004
	C.D. at 5%	0.005	0.009	0.011
Grand Mean		0.086	0.246	0.184

assimilation rate was 0.086 g per cm^2 per day during 30-60 days period, 0.246 g per cm^2 per day during 60-90 days period and 0.184 g per cm^2 per day during 90-harvest period.

During 30-60 days period, the net assimilation rate was influenced by sowing dates, varieties and their interactions. The maximum net assimilation rate of 0.132 g per cm^2 per day was recorded with 1st December sowing, which was significantly superior to 1st January sowing (0.073 $g/cm^2/day$), 15th January sowing (0.072 $g/cm^2/day$) and were on par with each other and 15th December sowing (0.066 $g/cm^2/day$). Among the varieties, ICPL-87 recorded maximum net assimilation rate of 0.091 g per cm^2 per day and was significantly superior to DT-7 (0.085 g per cm^2 per day) and ICPL-151 (0.081 $g/cm^2/day$), which were on par with each other. Among the interactions, ICPL-87 sown on 1st December recorded maximum net assimilation rate of 0.142 g per cm^2 per day followed by DT-7 (0.140 g per cm^2 per day) which were on par with each other and significantly superior to others.

During 60-90 days period, significant differences in net assimilation rate were noticed due to sowing dates, varieties, as well as their interactions. The sowing on 1st December recorded higher net assimilation rate of 0.356 g per cm^2 per day and was significantly superior to 15th December sowing (0.232 $g/cm^2/day$), 1st January sowing (0.227

g/cm^2/day) which were on par with each other and 15th January sowing (0.168 g/cm^2/day). Among the varieties DT-7 recorded maximum net assimilation rate of 0.252 g per cm^2 per day, followed by ICPL-87 (0.248 g/cm^2/day) which were on par with each other and significantly superior to ICPL-151 (0.237 g/cm^2/day). Among the interactions, the variety DT-7 sown on 1st December recorded significantly higher net assimilation rate of 0.415 g per cm^2 per day than other interactions.

During 90-harvest period, significant differences in net assimilation rate were recorded due to sowing dates and varieties. All the sowing dates differed significantly. The sowing on 1st December recorded higher net assimilation rate of 0.308 g per cm^2 per day which was significantly superior to 15th December (0.187 g/cm^2/day), 1st January (0.159 g/cm^2/day) and 15th January (0.081 g/cm^2/day). Among the varieties, DT-7 recorded significantly higher net assimilation rate of 0.199 g per cm^2 per day than ICPL-151 (0.191 g/cm^2/day) and ICPL-87 (0.161 g/cm^2/day). Significant differences among interactions were not observed.

4.1.9 Relative growth rate (RGR)

The data on relative growth rate at different growth periods as influenced by various treatments are presented in Table 11.

Table 11. Relative growth rate (RGR g/g/day) as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Days after sowing 30-60	60-90	90-harvest
Interactions				
1.	D_1V_1	0.056	0.062	0.013
2.	D_1V_2	0.055	0.063	0.017
3.	D_1V_3	0.050	0.068	0.017
4.	D_2V_1	0.060	0.064	0.010
5.	D_2V_2	0.061	0.064	0.012
6.	D_2V_3	0.058	0.065	0.012
7.	D_3V_1	0.055	0.065	0.011
8.	D_3V_2	0.054	0.066	0.013
9.	D_3V_3	0.048	0.065	0.014
10.	D_4V_1	0.058	0.063	0.005
11.	D_4V_2	0.057	0.062	0.007
12.	D_4V_3	0.057	0.058	0.009
	F test	NS	*	NS
	S.Em ±	0.001	0.001	0.001
	C.D. at 5%	-	0.003	-
Dates of sowing				
1st December	(D_1)	0.054	0.065	0.016
15th December	(D_2)	0.060	0.064	0.011
1st January	(D_3)	0.052	0.065	0.013
15th January	(D_4)	0.058	0.061	0.007
F test		*	*	*
S.Em ±		0.001	0.0007	0.0005
C.D. at 5%		0.003	0.0020	0.0014
Varieties				
ICPL-87	(V_1)	0.057	0.064	0.010
ICPL-151	(V_2	0.057	0.064	0.012
DT-7	(V_3)	0.054	0.064	0.013
F test		*	NS	*
S.Em ±		0.0007	0.0006	0.0004
C.D. at 5%		0.0022	-	0.0012
Grand Mean		0.0560	0.0640	0.0120

Relative growth rate was higher at 60-90 days and then declined at harvest. Significant differences in RGR were not noticed due to interactions at 30-60 days and at harvest. The varieties did not differ significantly for relative growth rate at 60-90days.

During 30-60 days, significant differences in relative growth rate were observed due to sowing dates and varieties. The relative growth rate of 15th December sowing (0.060 g/g/day) and 15th January sowing (0.058 g/g/day) were on par with each other and were significantly superior to 1st December sowing (0.054 g/g/day) and 1st January sowing (0.052 g/g/day). The maximum relative growth rate of 0.057 g per g per day was recorded with ICPL-87 and ICPL-151 (0.057 g/g/day) which were significantly superior to DT-7 (0.054 g/g/day).

During 60-90 days, significant differences among sowing dates and interactions were observed in respect of relative growth rate. Maximum relative growth rate of 0.065 g per g per day was recorded with 1st January sowing as well as 1st December sowing (0.065 g/g/day) which was followed by that of 15th December sowing (0.064 g/g/day) which were on par with each other and significantly superior to 15th January sowing (0.061 g/g/day). Among the interactions, DT-7 sown on 1st December recorded maximum relative growth rate of 0.068 g per g per day, followed by ICPL-151 sown on 1st January (0.066 g/g/day), DT-7 sown on 1st January (0.065 g/g/day), which were on par with each other and significantly superior to other interactions.

During 90 days to harvest period, significant differences among sowing dates and varieties were observed in respect of relative growth rate. The maximum relative growth rate was observed with 1st December sowing (0.016 g/g/day) which was significantly superior to 1st January sowing (0.013 g/g/day), 15th December sowing (0.011 g/g/day), which were on par with each other and 15th January sowing (0.007 g/g/day). Among the varieties, DT-7 recorded the maximum relative growth rate of 0.013 g per g per day, followed by ICPL-151 (0.012 g/g/day), which were on par with each other and were significantly superior to ICPL-87 (0.010 g/g/day).

4.1.10 **Number of days to 50 per cent flowering**

The data on number of days to 50 per cent flowering as influenced by various treatments are presented in Table 12.

Significant differences in number of days to 50 per cent flowering were noticed due to sowing dates, varieties, as well as their interactions. The mean number of days for 50 per cent flowering was 62.46.

Table 12. Number of days to 50 per cent flowering as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	No. of days to 50% flowering
Interactions		
1.	D_1V_1	66.50
2.	D_1V_2	67.75
3.	D_1V_3	65.00
4.	D_2V_1	64.50
5.	D_2V_2	65.00
6.	D_2V_3	60.00
7.	D_3V_1	62.75
8.	D_3V_2	62.00
9.	D_3V_3	59.00
10.	D_4V_1	60.75
11.	D_4V_2	60.00
12.	D_4V_3	56.25
	F test	*
	S.Em ±	0.38
	C.D. at 5%	1.09
Dates of sowing		
1st December (D_1)		66.42
15th December (D_2)		63.17
1st January (D_3)		61.25
15th January (D_4)		59.00
F test		*
S.Em ±		0.22
C.D. at 5%		0.63
Varieties		
ICPL-87 (V_1)		63.62
ICPL-151 (V_2		63.69
DT-7 (V_3)		60.06
F test		*
S.Em ±		0.19
C.D. at 5%		0.55
Grand Mean		62.46

Significant differences were noticed for number of days taken to 50 per cent flowering in all the sowing dates. The sowing on 1st December registered higher number of days to 50 per cent flowering (66.42 days) compared to 15th December sowing (63.17 days), 1st January sowing (61.25 days) and 15th January sowing (59.00 days). The early sowings recorded higher number of days to 50 per cent flowering. Among the varieties, ICPL-151 took maximum number of days to 50 per cent flowering (63.69 days) followed by ICPL-87 (63.62 days), which were on par with each other and significantly superior to DT-7 (60.06 days). Among the interactions, ICPL-151 sown on 1st December (67.75 days) took significantly higher number of days to 50 per cent flowering. The minimum number of days to 50 per cent flowering was recorded with DT-7 sown on 15th January (56.25 days).

4.2 Yield and yield comoponents

4.2.1 Total dry matter accumulation per plant

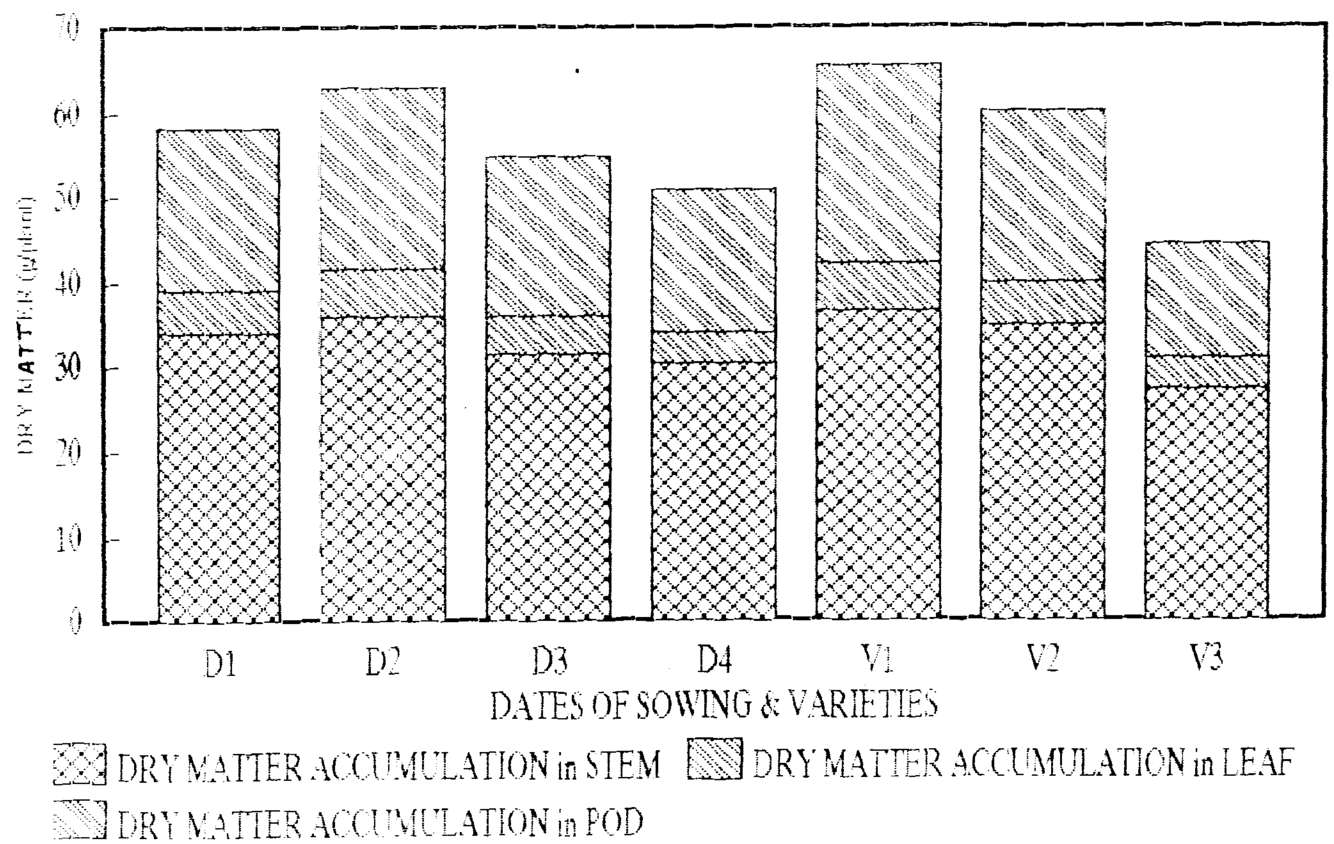
The data on total dry matter production per plant at different growth stages as influenced by various treatments are presented in Table 13 and Fig. 3.

The total dry matter production per plant increased from 30 days after sowing upto harvest. It was 1.26 g per plant at 30 days after sowing, 6.88 g per plant at 60 days

Table 13. Total dry matter accumulation in plants of pigeon-pea varieties as influenced by dates of sowing.

Sl. No.	Treatments	Dry matter (g/plant) Days after sowing 30	60	90	At harvest
Interactions					
1.	D_1V_1	1.337	7.325	47.750	67.295
2.	D_1V_2	1.225	6.500	44.050	62.075
3.	D_1V_3	1.037	4.975	38.287	45.512
4.	D_2V_1	1.310	7.995	55.455	70.412
5.	D_2V_2	1.212	7.570	51.270	65.510
6.	D_2V_3	1.112	6.640	46.515	52.312
7.	D_3V_1	1.390	7.425	52.280	65.410
8.	D_3V_2	1.300	6.632	48.110	58.575
9.	D_3V_3	1.245	5.325	37.630	40.425
10.	D_4V_1	1.387	8.000	53.445	59.825
11.	D_4V_2	1.352	7.565	49.175	54.950
12.	D_4V_3	1.185	6.640	37.745	39.440
	F test	NS	NS	*	*
	S.Em ±	0.050	0.220	0.700	0.700
	C.D. at 5%	-	-	2.010	2.010
Dates of sowing					
	1st December (D_1)	1.200	6.267	43.362	58.294
	15th December (D_2)	1.211	7.402	51.080	62.745
	1st January (D_3)	1.312	6.461	46.007	54.803
	15th January (D_4)	1.308	7.402	46.788	51.405
	F test	*	*	*	*
	S.Em ±	0.030	0.120	0.410	0.410
	C.D. at 5%	0.080	0.340	1.180	1.180
Varieties					
	ICPL-87 (V_1)	1.356	7.686	52.232	65.735
	ICPL-151 (V_2	1.272	7.067	48.151	60.277
	DT-7 (V_3)	1.145	5.895	40.044	44.422
	F test	*	*	*	*
	S.Em ±	0.024	0.110	0.350	0.350
	C.D. at 5%	0.069	0.320	1.010	1.010
Grand Mean		1.257	6.883	46.809	56.811

Fig:3 Total Drymatter Production and Distribution
as Influenced by Sowing Dates & Varieties



LEGEND : D_1 : 1st December sowing
D_2 : 15th December sowing
D_3 : 1st January sowing
D_4 : 15th January sowing

V_1 : ICPL-87
V_2 : ICPL-151
V_3 : DT-7

after sowing, 46.81 g per plant at 90 days after sowing and 56.81 g per plant at harvest.

At 30 days after sowing, significant differences among sowing dates and varieties were observed in respect of total dry matter production per plant. Significant differences were not observed due to interactions. The sowing on 1st December recorded higher total dry matter production per plant (1.312 g), followed by 15th January sowing (1.308 g), which were on par with each other and significantly superior to 15th December sowing (1.211 g) and 1st December sowing (1.200g). Among varieties, ICPL-87 registered higher total dry matter production per plant (1.356 g) than that of ICPL-151 (1.272 g) and DT-7 (1.145 g).

At 60 days after sowing, significant differences among sowing dates and varieties were observed in respect of total dry matter production per plant. The sowing on 15th December (7.402 g) and 15th January (7.402 g) produced same amount of total dry matter per plant and were significantly superior to 1st January (6.461 g) and 1st December (6.267 g) sowings. The variety ICPL-87 recorded significantly higher total dry matter production per plant (7.686 g) than that of ICPL-151 (7.067 g) and DT-7 (5.895 g). Significant differences due to interactions were not observed.

At 90 days after sowing, significant differences among sowing dates, varieties, as well as their interactions were observed in respect of total dry matter accumulation per plant. The sowing on 15th December recorded higher total dry matter production per plant (51.080 g), which was significantly superior to other sowing dates. The 15th January sowing (46.788 g) and 1st January sowing (46.007 g) were on par with each other. The lowest total dry matter production per plant was observed with 1st December sowing (43.362 g). Among the varieties, ICPL-87 recorded significantly higher total dry matter production per plant (52.232 g) than ICPL-151 (48.151 g) and DT-7 (40.044 g). The interaction, ICPL-87 sown on 15th December recorded significantly higher total dry matter production per plant (55.455 g) than other interactions.

At harvest also, significant differences among sowing dates, varieties, as well as their interactions were observed with respect to total dry matter production per plant. The sowing on 15th December recorded higher total dry matter production per plant (62.745 g) and was significantly superior to 1st December sowing (58.294 g), 1st January sowing (54.803 g) and 15th January sowing (51.405 g). Among the varieties ICPL-87 recorded significantly higher total dry matter production per plant (65.735 g) than ICPL-151 (60.277 g) and DT-7 (44.422 g). The interaction, ICPL-87 sown on

15th December produced higher total dry matter per plant than other interactions.

4.2.2 Dry matter accumulation in leaves per plant

The data on dry matter accumulation in leaves per plant at different growth stages as influenced by various treatments are presented in Table 14.

The dry matter accumulation in leaves per plant increased from 30 days after sowing (0.85 g) to 90 days after sowing (9.53 g), which declined at harvest (4.79 g).

At 30 days after sowing, significant differences in dry matter accumulation in leaves per plant was noticed due to sowing dates and varieties but not due to interactions. Dry matter accumulation in leaves per plant was higher with 15th January sowing (0.897 g), followed by 1st January sowing (0.860 g), 1st December sowing (0.858 g), which were on par with each other and significantly superior to 15th December sowing (0.781 g). The variety ICPL-87 recorded higher dry matter accumulation in leaves per plant (0.912 g) followed by ICPL-151 (0.870 g), which were on par with each other and significantly superior to DT-7 (0.765 g).

At 60 days after sowing, the total dry matter accumulation in leaves per plant was higher due to varieties, as well as their interaction but not due to sowing dates.

Table 14. Dry matter accumulation in leaves of pigeonpea varieties as influenced by dates of sowing.

Sl. No.	Treatments	Dry matter of leaf (g/plant)			
		Days after sowing			At harvest
		30	60	90	
Interactions					
1.	D_1V_1	0.937	4.600	9.075	6.142
2.	D_1V_2	0.900	4.237	8.262	5.400
3.	D_1V_3	0.737	3.037	7.150	3.662
4.	D_2V_1	0.840	4.370	10.175	6.712
5.	D_2V_2	0.790	4.170	9.725	5.875
6.	D_2V_3	0.714	3.940	8.900	4.362
7.	D_3V_1	0.910	4.500	9.850	4.910
8.	D_3V_2	0.850	4.170	9.250	4.550
9.	D_3V_3	0.820	3.462	8.200	4.020
10.	D_4V_1	0.960	4.437	12.975	4.520
11.	D_4V_2	0.940	4.190	12.375	4.375
12.	D_4V_3	0.790	3.890	8.475	2.750
	F test	NS	*	*	*
	S.Em ±	0.042	0.165	0.360	0.240
	C.D. at 5%	-	0.475	1.030	0.690
Dates of sowing					
	1st December (D_1)	0.858	3.958	8.170	5.068
	15th December (D_2)	0.781	4.160	9.600	5.650
	1st January (D_3)	0.860	4.044	9.100	4.493
	15th January (D_4)	0.897	4.172	11.275	3.882
	F test	*	NS	*	*
	S.Em ±	0.024	0.090	0.200	0.140
	C.D. at 5%	0.069	-	0.570	0.400
Varieties					
	ICPL-87 (V_1)	0.912	4.478	10.519	5.571
	ICPL-151 (V_2)	0.870	4.192	9.903	5.050
	DT-7 (V_3)	0.765	3.582	8.181	3.698
	F test	*	*	*	*
	S.Em ±	0.021	0.082	0.180	0.120
	C.D. at 5%	0.060	0.235	0.520	0.340
Grand Mean		0.849	4.083	9.534	4.773

Significantly higher dry matter accumulation in leaves per plant was registered with ICPL-87 (4.478 g) than that of ICPL-151 (4.192 g) and DT-7 (3.582 g). Among the interactions ICPL-87 sown on 1st December produced significantly higher dry matter accumulation in leaves per plant (4.600 g) than DT-7 in all the sowing dates and was on par with ICPL-151.

At 90 days after sowing, the total dry matter accumulation in leaves per plant was higher due to sowing dates, varieties, as well as their interactions. Significantly higher total dry matter accumulations in leaves per plant was recorded with 15th January sowing (11.275 g) compared to other sowing dates. The 15th December sowing and 1st January sowing recorded 9.600 g and 9.100 g per plant, respectively which were on par with each other. The lowest dry matter accumulation in leaves per plant was observed with 1st December sowing (8.170 g). Among the varieties, ICPL-87 recorded significantly higher dry matter accumulation in leaves per plant (10.519 g) than ICPL-151 (9.903 g) and DT-7 (8.181 g). The interactions ICPL-87 sown on 15th January (12.975 g) and ICPL-151 sown on 15th January (12.375 g) were on par with each other and significantly superior to other interactions.

At harvest, significant differences in dry matter accumulation in leaves were noticed due to sowing dates, varieties as well as their interactions. All the sowing dates differed significantly with each other. The maximum dry matter accumulation in leaves per plant was recorded with 15th December sowing (5.650 g) followed by 1st December sowing (5.068 g), 1st January sowing (4.493 g) and 15th January sowing (3.882 g). Among the varieties, ICPL-87 registered significantly higher dry matter accumulation in leaves per plant (5.571 g) than ICPL-151 (5.050 g) and DT-7 (3.698 g). Among the interactions, ICPL-87 sown on 15th December produced significantly higher dry matter accumulation in leaves per plant (6.712 g) than others, which was on par with ICPL-87 sown on 1st December (6.142 g).

4.2.3 **Dry matter accumulation in stem per plant**

The dry matter accumulation in stem per plant at different growth stages as influenced by various treatments are presented in Table 15.

The mean dry matter accumulation in stem per plant was 0.41 g at 30 days after sowing, 2.80 g at 60 days after sowing, 26.75 g at 90 days after sowing and 32.97 g at harvest.

At 30 days after sowing, the dry matter accumulation in stem per plant differed significantly due to sowing dates as well as varieties. The 1st January sowing recorded

Table 15. Dry matter accumulation in stem as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Dry matter of stem (g/plant)			
		Days after sowing			At harvest
		30	60	90	
Interactions					
1.	D_1V_1	0.400	2.725	26.800	38.182
2.	D_1V_2	0.325	2.262	24.937	35.175
3.	D_1V_3	0.300	1.937	22.787	28.850
4.	D_2V_1	0.470	3.625	31.000	37.300
5.	D_2V_2	0.422	3.400	30.125	38.575
6.	D_2V_3	0.402	2.700	28.000	32.090
7.	D_3V_1	0.480	2.925	29.760	36.975
8.	D_3V_2	0.450	2.462	28.500	34.600
9.	D_3V_3	0.425	1.862	20.390	23.025
10.	D_4V_1	0.437	3.562	28.750	34.180
11.	D_4V_2	0.412	3.375	26.750	31.625
12.	D_4V_3	0.395	2.750	23.250	25.090
	F test	NS	NS	*	*
	S.Em ±	0.027	0.140	0.500	0.520
	C.D. at 5%	-	-	1.440	1.500
Dates of sowing					
1st December	(D_1)	0.342	2.308	24.841	34.069
15th December	(D_2)	0.431	3.242	29.708	35.988
1st January	(D_3)	0.452	2.416	26.467	31.533
15th January	(D_4)	0.415	3.229	26.375	30.298
F test		*	*	*	*
S.Em ±		0.016	0.081	0.290	0.300
C.D. at 5%		0.046	0.233	0.830	0.860
Varieties					
ICPL-87	(V_1)	0.447	3.209	29.077	36.659
ICPL-151	(V_2	0.402	2.875	27.515	34.994
DT-7	(V_3)	0.380	2.312	23.950	27.264
F test		*	*	*	*
S.Em ±		0.014	0.070	0.250	0.260
C.D. at 5%		0.040	0.200	0.720	0.750
Grand Mean		0.410	2.799	26.754	32.972

significantly higher dry matter accumulation per plant (0.452 g) than 1st December sowing (0.342 g). The 1st January sowing (0.452 g), 15th December sowing (0.431 g) and 15th January sowing (0.415 g) were on par with each other. Among the varieties, ICPL-87 registered higher dry matter accumulation in stem per plant (0.447 g) and was significantly superior to ICPL-151 (0.402 g) and DT-7 (0.380 g). Significant differences among interactions were not observed.

At 60 days after sowing, significant differences among sowing dates and varieties were observed in respect of dry matter accumulation in stem per plant. Sowing on 15th December recorded maximum dry matter accumulation in stem per plant (3.242 g), followed by 15th January sowing (3.229 g), which were on par with each other and significantly superior to 1st January sowing (2.416 g) and 1st December sowing (2.308 g). The variety ICPL-87 registered significantly higher dry matter accumulation in stem per plant (3.209 g) than ICPL-151 (2.875 g) and DT-7 (2.312 g). Significant differences among interactions were not noticed in respect of dry matter accumulation in stems per plant.

At 90 days after sowing, significant differences among sowing dates, varieties, as well as their interactions were observed in respect of dry matter accumulation in stems per plant.

The 15th December sowing recorded maximum dry matter accumulation in stem per plant (29.708 g) and was significantly superior to all the sowing dates. The 1st January sowing and 15th January sowing recorded 26.467 g and 26.375 g per plant, respectively which were on par with each other. The minimum dry matter accumulation in stem per plant was observed with 1st December sowing (24.841 g). The variety ICPL-87 produced significantly higher dry matter accumulation in stem per plant (29.077 g) followed by ICPL-151 (27.515 g) and DT-7 (23.950 g). The varieties ICPL-87 (31.000 g) and ICPL-151 (30.125 g) sown on 15th December registered higher dry matter accumulation in stem per plant, which were on par with each other and were significantly superior to other interactions.

At harvest significant differences among sowing dates, varieties, as well as their interactions were observed in respect of dry matter accumulation in stem per plant. All the sowing dates differed significantly with each other. The maximum dry matter accumulation in stem per plant of 35.988 g recorded with 15th December sowing, followed by 1st December sowing (34.069 g), 1st January sowing (31.533 g) and 15th January sowing (30.298 g). The variety ICPL-87 recorded maximum dry matter accumulation in stem per plant of 36.659 g and was significantly superior to ICPL-151 (34.994 g) and DT-7 (27.264 g). Among the interactions, ICPL-151 sown on

15th December recorded maximum dry matter accumulation in stem per plant (38.575 g) followed by ICPL-87 sown on 1st December (38.182 g), which were on par with each other and significantly superior to other interactions.

4.2.4 Dry matter accumulation in pods per plant

The data on dry matter accumulation in pods per plant at 90 days after sowing and at harvest as influenced by various treatments are presented in Table 16.

The mean dry matter accumulation in pods per plant was 10.53 g at 90 days after sowing and 19.06 g at harvest.

At 90 days after sowing significant differences among sowing dates, varieties as well as their interactions were observed in respect of dry matter accumulation in pods per plant. Sowing on 15th December recorded significantly higher dry matter accumulation in pods per plant (11.772 g) than other sowing dates. Sowing on 1st January and on 1st December recorded 10.690 g and 10.358 g per plant, respectively which were on par with each other. The minimum dry matter accumulation in pods per plant was observed with 15th January sowing (9.305 g). Among the varieties, ICPL-87 recorded significantly higher dry matter accumulation in pods per plant (12.636 g) than that of ICPL-151 (10.670 g) and DT-7 (8.287 g). Among the interactions, ICPL-87 sown on 15th

Table 16. Dry matter accumulation in pods as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Pod dry matter (g/plant) 90 days after sowing	At harvest
Interactions			
1.	D_1V_1	11.875	22.700
2.	D_1V_2	10.850	21.750
3.	D_1V_3	8.350	13.000
4.	D_2V_1	14.280	26.400
5.	D_2V_2	11.420	21.060
6.	D_2V_3	9.615	15.860
7.	D_3V_1	12.670	23.525
8.	D_3V_2	10.360	19.425
9.	D_3V_3	9.040	13.380
10.	D_4V_1	11.720	21.120
11.	D_4V_2	10.050	18.950
12.	D_4V_3	6.145	11.600
	F test	*	*
	S.Em ±	0.400	0.420
	C.D. at 5%	1.151	1.210
Dates of sowing			
1st December	(D_1)	10.358	19.058
15th December	(D_2)	11.772	21.273
1st January	(D_3)	10.690	18.777
15th January	(D_4)	9.305	16.808
F test		*	*
S.Em ±		0.230	0.240
C.D. at 5%		0.660	0.690
Varieties			
ICPL-87	(V_1)	12.636	23.244
ICPL-151	(V_2	10.670	20.296
DT-7	(V_3)	8.287	13.397
F test		*	*
S.Em ±		0.200	0.210
C.D. at 5%		0.570	0.600
Grand Mean		10.531	19.064

December registered maximum dry matter accumulation in pods per plant (14.280 g) and was significantly superior to other interactions.

At harvest, significant differences in dry matter accumulation in pods per plant were noticed due to sowing dates, varieties, as well as their interactions. Sowing on 15th December recorded maximum dry matter accumulation in pod per plant (21.273 g) and was significantly superior to 1st December sowing (19.058 g), 1st January sowing (18.777 g) were on par with each other and 15th January sowing recorded lowest dry matter accumulation of 16.808 g in pod. All the varieties differed significantly with each other in respect of dry matter accumulation in pod per plant. The dry matter accumulation in pods per plant was highest in ICPL-87 (23.244 g) followed by ICPL-151 (20.296 g) and DT-7 (13.397 g). Among the interactions, ICPL-87 sown on 15th December recorded maximum dry matter accumulation in pods per plant and was significantly superior to other interactions.

4.2.5 Course of dry matter distribution (% to total)

The data on the course of dry matter distribution (% to total) into different parts of the plant in pigeonpea varieties as influenced by sowing dates are presented in Table 17.

Table 17. Dry matter accumulation (g/plant) and its distribution in different parts (% to total) of pigeonpea varieties as influenced by dates of sowing.

Sl. No. Treatments	30 DAS			60 DAS			90 DAS				At harvest			
	Stem	Leaf	Total	Stem	Leaf	Total	Stem	Leaf	Pod	Total	Stem	Leaf	Pod	Total
Varieties														
1. ICPL-87	0.447 (32.89)	0.912 (67.11)	1.359	3.209 (41.75)	4.478 (58.25)	7.687	29.077 (55.67)	10.519 (20.14)	12.636 (24.19)	52.232	36.659 (55.00)	5.571 (8.51)	23.244 (35.50)	65.474
2. ICPL-151	0.402 (31.60)	0.870 (68.40)	1.272	2.875 (40.68)	4.192 (59.32)	7.067	27.515 (57.22)	9.903 (20.59)	10.670 (22.19)	48.088	34.994 (57.99)	5.050 (8.37)	20.296 (33.64)	60.340
3. DT-7	0.380 (33.19)	0.765 (66.81)	1.145	2.312 (39.23)	3.582 (60.77)	5.894	23.950 (59.26)	8.181 (20.24)	8.287 (20.50)	40.418	27.264 (61.46)	3.698 (8.34)	13.397 (30.20)	44.359
Dates of sowing														
1st December	0.342 (28.50)	0.858 (71.50)	1.200	2.308 (36.83)	3.958 (63.17)	6.266	24.841 (57.28)	8.170 (18.84)	10.358 (23.88)	43.369	34.069 (58.54)	5.068 (8.71)	19.058 (32.75)	58.195
15th December	0.431 (35.56)	0.781 (64.44)	1.212	3.242 (43.80)	4.160 (56.20)	7.402	29.708 (58.16)	9.600 (18.79)	11.772 (23.05)	51.080	35.988 (57.20)	5.650 (8.99)	21.273 (33.81)	62.911
1st January	0.452 (34.45)	0.860 (65.55)	1.312	2.416 (37.40)	4.044 (62.60)	6.460	26.467 (57.22)	9.100 (19.67)	10.690 (23.11)	46.257	31.533 (57.54)	4.493 (8.20)	18.777 (34.26)	54.803
15th January	0.415 (31.63)	0.897 (68.37)	1.312	3.229 (43.63)	4.172 (56.37)	7.401	26.375 (56.17)	11.275 (24.01)	9.305 (19.82)	46.955	30.298 (59.42)	3.882 (7.61)	16.808 (32.97)	50.988

Figures in parantheses indicate the percentage distribution dry matter into different plant parts.

4.2.5.1 Course of dry matter distribution into leaf (% to total) : In general, the dry matter partitioning into leaf was highest at 30 days after sowing and it went on decreasing to its lowest at maturity in all the varieties.

At 30 days after sowing, the dry matter partitioning into leaf was highest with the variety ICPL-151 (68.40%) followed by ICPL-87 (67.11%) and DT-7 (67.81%). Among the sowing dates, 1st December sowing registered maximum partitioning of dry matter into leaf (71.50%), followed by 15th January sowing (68.37%), 1st January sowing (65.55%) and 15th December sowing (64.44%).

At 60 days after sowing, the maximum dry matter partitioning into leaf was observed with the variety DT-7 (60.77%) followed by ICPL-151 (59.32%) and ICPL-87 (58.25%). The maximum partitioning into leaf was recorded with 1st December sowing (63.17%) followed by 1st January sowing (62.60%), 15th January sowing (56.37%) and 15th December sowing (56.20%).

At 90 days after sowing, the dry matter partitioning into leaf was slightly higher with the variety ICPL-151 (20.59%) followed by DT-7 (20.24%) and ICPL-87 (20.14%). Among the sowing dates 15th January sowing showed higher dry matter partitioning into leaf (24.01%), followed by 1st

January sowing (19.67%), 1st December sowing (18.84%) and 15th December sowing (18.79%).

At harvest the dry matter partitioning was higher with the variety ICPL-87 (8.51%) than with ICPL-151 (8.37%) and DT-7 (8.34%). Sowing on 15th December showed maximum dry matter partitioning into leaf (8.99%) followed by that of 1st December sowing (8.71%), 1st January sowing (8.20%) and 15th January sowing (7.61%).

4.2.5.2 **Course of dry matter distribution into stem (% to total) :** The dry matter partitioning into stem was lowest at 30 days after sowing which increased upto maturity in all the varieties. At 30 days after sowing, dry matter partitioning into stem was highest with the variety DT-7 (33.19) followed by ICPL-87 (32.89%) and ICPL-151 (31.60%). Among the sowing dates, dry matter partitioning into stem was highest with 15th December sowing (35.56%), followed by 1st January sowing (34.45%), 15th January sowing (31.63%) and 1st December sowing (28.50%).

At 60 days after sowing, maximum dry matter partitioning into stem was noticed with the variety ICPL-87 (41.75%) followed by ICPL-151 (40.68%) and DT-7 (39.23%). Among the sowing dates, the dry matter partitioning was maximum with 15th December sowing (43.80%), 15th January sowing (43.63%), 1st January sowing (37.40%) and 1st December sowing (36.83%).

At 90 days after sowing, the variety DT-7 recorded highest dry matter partitioning into stem (59.26%) followed by ICPL-151 (57.22%) and ICPL-87 (55.67%). Among the sowing dates, 15th December sowing showed maximum dry matter partitioning into stem (58.16%) followed by 1st December sowing (57.28%), 1st January sowing (57.22%) and 15th January sowing (56.17%).

At harvest, the dry matter partitioning into stem was highest with the variety DT-7 (61.46%), followed by ICPL-151 (57.99%) and ICPL-87 (55.99%). Among the sowing dates, the maximum dry matter partitioning into stem of 59.42 per cent was noticed with 15th January sowing compared to sowing on 1st December (58.54%), 1st January (57.54%) and 15th December (57.20%).

4.2.5.3 **Course of dry matter distribution into pods (% to total)** : The dry matter partitioning into pods was increased from 90 days after sowing to harvest stage.

At 90 days after sowing, the dry matter partitioning into pods was highest with the variety ICPL-87 (24.19%), followed by ICPL-151 (22.19%) and DT-7 (20.50%). Among the sowing dates, 1st December sowing recorded the highest dry matter partitioning into pods (23.88%), followed by 1st January sowing (23.11%), 15th December sowing (23.05%) and 15th January sowing (19.82%).

At harvest, maximum dry matter partitioning into pods was recorded with the variety ICPL-87 (35.50%) followed by ICPL-151 (33.64%) and DT-7 (30.20%). Among the sowing dates, 1st January sowing recorded the maximum dry matter partitioning into pods (34.26%), followed by 15th December sowing (33.81%), 15th January sowing (32.97%) and 1st December sowing (32.75%).

4.2.6 Number of pods per plant

The data on number of pods per plant at harvest as influenced by various treatments are presented in Table 18.

The mean number of pods per plant at harvest were 19.07.

At harvest, significant differences in number of pods per plant were observed due to sowing dates, varieties, as well as their interactions. The sowing on 1st January recorded higher number of pods per plant (20.28), followed by 15th December sowing (19.90), 1st December sowing (19.20) which were on par with each other and significantly superior to 15th January sowing. Among the varieties, ICPL-87 recorded higher number of pods per plant (20.60) and was superior to

Table 18. Number of pods per plant, number of seeds per pod, 100-seed weight at harvest as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	No. of pods/ plant	No. of seeds/ pod	100-seed weight (g)
Interactions				
1.	D_1V_1	19.25	3.47	8.52
2.	D_1V_2	18.90	3.24	8.32
3.	D_1V_3	19.45	2.70	6.62
4.	D_2V_1	19.70	3.16	8.27
5.	D_2V_2	17.10	3.04	7.80
6.	D_2V_3	22.90	2.81	6.47
7.	D_3V_1	20.20	3.10	7.65
8.	D_3V_2	18.45	3.02	7.45
9.	D_3V_3	22.20	2.72	6.35
10.	D_4V_1	23.25	2.86	7.05
11.	D_4V_2	15.30	2.55	6.62
12.	D_4V_3	12.15	2.45	5.52
	F test	*	NS	NS
	S.Em ±	0.94	0.09	0.31
	C.D. at 5%	2.70	-	-
Dates of sowing				
	1st December (D_1)	19.20	3.14	7.82
	15th December (D_2)	19.90	3.00	7.52
	1st January (D_3)	20.28	2.95	7.15
	15th January (D_4)	16.90	2.62	6.40
	F test	*	*	*
	S.Em ±	0.54	0.05	0.18
	C.D. at 5%	1.56	0.14	0.51
Varieties				
	ICPL-87 (V_1)	20.60	3.15	7.87
	ICPL-151 (V_2	17.44	2.96	7.55
	DT-7 (V_3)	19.17	2.67	6.24
	F test	*	*	*
	S.Em ±	0.47	0.04	0.15
	C.D. at 5%	1.35	0.12	0.44
Grand Mean		19.07	2.93	7.22

DT-7 (19.17) and ICPL-151 (17.44). Among the interactions, ICPL-87 sown on 15th January recorded higher number of pods per plant than other interactions.

4.2.7 **Number of seeds per pod**

The data on number of seeds per pod as influenced by various treatments are presented in Table 18. The mean number of seeds per pod was 2.93. Significant differences in number of seeds per pod were noticed due to sowing dates and varieties. All the sowing dates differed significantly with higher number of seeds per pod when sown on 1st December (3.14) followed by 15th December (3.00), 1st January (2.95) and 15th January (2.62). Significantly higher number of seeds per pod were noticed with ICPL-87 (3.17) than ICPL-151 (2.96) and DT-7(2.67). Number of seeds per pod were not influenced by the interactions.

4.2.8 **100-seed weight**

The data on 100-seed weight as influenced by various treatments are presented in Table 18. The mean 100-seed weight was 7.22 g.

Significant differences in seed weight were noticed due to sowing dates and varieties, but not due to their interactions.

The sowing on 1st December registered maximum 100-seed weight of 7.82 g followed by that of 15th December sowing (7.52 g), 1st January sowing (7.15 g), which were on par with each other and significantly superior to that of 15th January sowing (6.40 g).

Maximum 100-seed weight of 7.87 g was recorded with ICPL-87, followed by ICPL-151 (7.55 g), which were on par with each other and significantly superior to DT-7 (6.24 g).

4.2.9 **Seed yield**

The data on seed yield per ha as influenced by various treatments are given in Table 19 and Fig. 4.

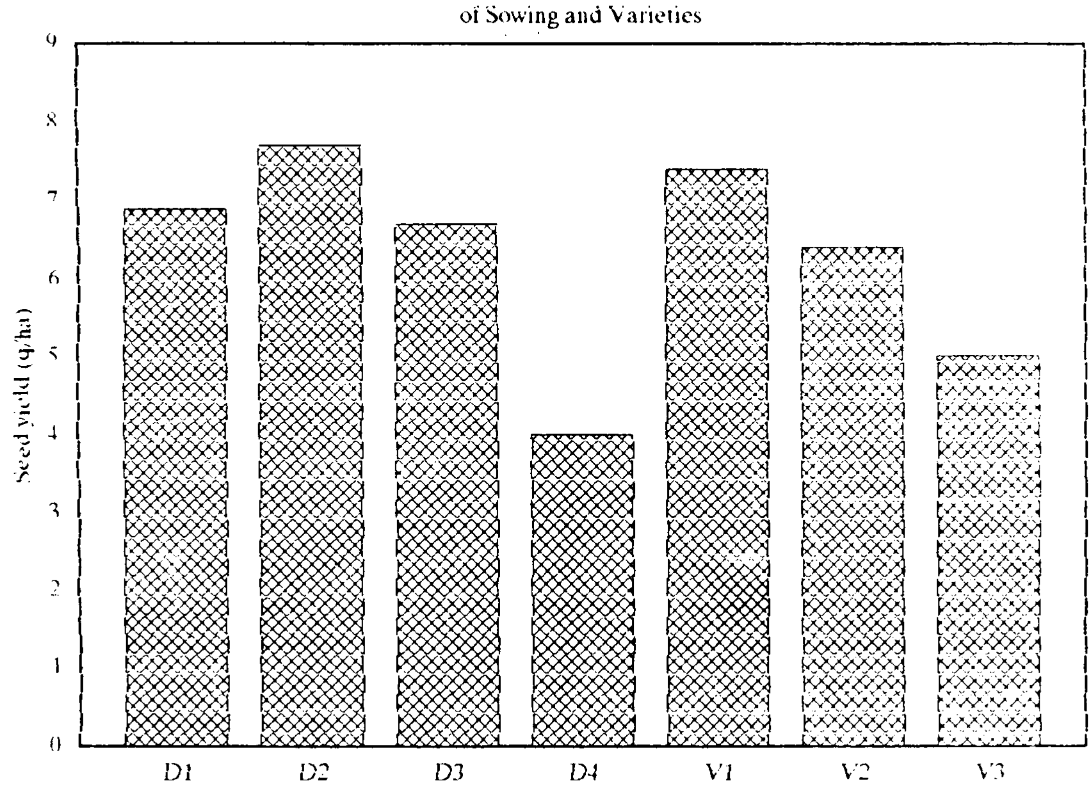
Significant differences in seed yield were noticed due to sowing dates, varieties, as well as their interactions. The mean seed yield was 6.30 q per ha.

The seed yield was highest with 15th December sown crop (7.66 q/ha) followed by 1st December sown crop (6.88 q/ha), 1st January sown crop (6.71 q/ha), which were on par with each other and significantly superior to 15th January sown crop (3.95 q/ha). Among the varieties ICPL-87 recorded significantly higher seed yield of 7.40 q per ha than ICPL-151 (6.44 q/ha) and DT-7 (5.06 q/ha). Among the interactions ICPL-87 sown on 15th December recorded highest seed yield of 8.90 q per ha than other interactions. The

Table 19. Grain yield (q/ha), pod yield (q/ha), and harvest index as influenced by dates of sowing of pigeonpea varieties.

Sl. No.	Treatments	Seed yield (q/ha)	Pod yield (q/ha)	Harvest index
Interactions				
1.	D_1V_1	8.49	16.91	0.240
2.	D_1V_2	7.80	14.48	0.237
3.	D_1V_3	4.35	8.70	0.230
4.	D_2V_1	8.90	19.43	0.240
5.	D_2V_2	7.53	15.32	0.225
6.	D_2V_3	6.55	12.98	0.232
7.	D_3V_1	7.63	17.63	0.185
8.	D_3V_2	6.52	16.90	0.167
9.	D_3V_3	5.98	16.43	0.150
10.	D_4V_1	4.57	13.94	0.155
11.	D_4V_2	3.93	12.14	0.140
12.	D_4V_3	3.36	11.39	0.127
	F test	*	*	NS
	S.Em ±	0.61	0.66	0.005
	C.D. at 5%	1.75	1.91	-
Dates of sowing				
	1st December (D_1)	6.88	13.36	0.236
	15th December (D_2)	7.66	15.91	0.232
	1st January (D_3)	6.71	16.99	0.167
	15th January (D_4)	3.95	12.49	0.141
	F test	*	*	*
	S.Em ±	0.35	0.38	0.003
	C.D. at 5%	1.01	1.10	0.008
Varieties				
	ICPL-87 (V_1)	7.40	16.97	0.205
	ICPL-151 (V_2	6.44	14.71	0.192
	DT-7 (V_3)	5.06	12.38	0.185
	F test	*	*	*
	S.Em ±	0.31	0.33	0.002
	C.D. at 5%	0.89	0.96	0.007
Grand Mean		6.30	14.69	0.194

Fig: 4 Seed Yield as Influenced by Dates of Sowing and Varieties



LEGEND : D_1 - 1st December sowing
D_2 - 15th December sowing
D_3 - 1st January sowing
D_4 - 15th January sowing

V_1 - ICPL-87
V_2 - ICPL-151
V_3 - DT-7

minimum seed yield was recorded with DT-7 sown on 15th January (3.36 q/ha).

4.2.10 **Pod yield**

The data on pod yield per ha as influenced by various treatments are presented in Table 19.

Significant differences in pod yield per ha were noticed due to soiwng dates, varieties, as well as their interactions. The mean pod yield was 14.69 q per ha.

The pod yield per ha was higher with 1st January sown crop (16.99q/ha), followed by 15th December sown crop (15.91 q/ha) which were on par with each other and differ significantly than 1st December sown crop (13.36 q/ha) and 15th January sown crop (12.49 q/ha).

Among the varieties, ICPL-87 recorded significantly higher pod yield (16.97 q/ha) than ICPL-151 (14.71 q/ha) and DT-7 (12.38 q/ha). Among the interactions, ICPL-87 sown on 15th December recorded significantly higher pod yield per ha (19.43 q/ha) than other interactions. The minimum pod yield per ha was noticed with DT-7 sown on 1st December.

4.2.11 **Harvest index (HI)**

The data on harvest index as influenced by various treatments are presented in Table 19.

The mean harvest index of 0.194 was noticed due to treatment.

The harvest index differed significantly due to sowing dates and varieties. Significant differences among interactions were not observed. The harvest index of 1st December sown crop (0.236) and 15th December sown crop (0.232) were on par with each other and significantly superior to that of sowing on 1st January (0.167) and 15th January (0.141). Among the varieties, ICPL-87 recorded significantly higher harvest index of 0.205 than ICPL-151 (0.192) and DT-7 (0.185).

DISCUSSION

V. DISCUSSION

Suitable variety and optimum time of sowing, being non-monetary components of crop production not only help in achieving higher productivity but also minimise the cost of production. Generating such information on pigeonpea has an important bearing in view of increased demand of this popular pulse in daily diet with concurrent and unabated hikes in prices for this food commodity. In recent years, with advances made in genetics and plant breeding there is an advent of short duration photoinsensitive varieties in pigeonpea. Thus, there is a distinct possibility of raising such short duration crops of 90 to 120 days during summer season also under irrigation. With this idea in view, a field investigation was carried out during summer season at Agricultural Research Station, Kathalagere in Bhadra Command Area of the University of Agricultural Sciences, Bangalore to study the optimum time of sowing during summer right from 1st of December to 15th of January for three short duration pigeonpea varieties viz., ICPL-87, ICPL-151 and DT-7. The results obtained from the study have been discussed in this chapter.

5.1 Sowing date

Jalapathi Rao (1994) reported higher seed yield with early sowing than with later sowings. Even in the present study, the pigeonpea cultivars sown early on 15th December

1991 recorded maximum grain yields of 7.66 q per ha which were however on par with the two later dates of sowing on 1st December and 1st January (6.88 and 6.71 q/ha). These yields were significantly superior to yields of 3.95 q per ha obtained with sowing on 15th January. Thus, if 15th December is considered as ideal and normal date of sowing, the per cent reduction in grain yield was to the extent of 11.34 on 1st December sowing and 14.16 on 1st January sowing, while there was a steep fall upto 48.73 per cent on 15th January sowing. The present results confirm the findings of Abrams and Julia (1973) and Amin *et al*. (1991) who recorded higher seed yield with sowing during second fortnight of December than with sowings on 1st January and 15th January. The minimum seed yield recorded with 15th January sowing was due to withering of flowers, which resulted in poor pod setting because of high mean temperatures going upto 33.7°C, 33.9°C and 36.21°C in March, April and May 1992 coinciding with the reproductive and harvest stages. The results are in close confirmity with the findings of Amin *et al*. (1991) who reported decreased seed yield due to flower drop because of high temperatures.

Seed yield is the resultant of the yield attributing characters like number of pods per plant, number of seeds per pod and seed weight. The number of pods per plant is strongly related to assimilation during early pod growth, through the effects on pod formation for the first two weeks after anthesis and on pod retention for the next two weeks (Thirathon _et al._, 1987). The 1st January sowing recorded higher number of pods per plant (20.28), followed by 15th December sowing (19.90) and 1st December sowing (19.20), which were on par with each other. The lowest number of pods per plant was recorded with 15th January sowing (16.90), which was significantly inferior to that of other three sowing dates. Jalapathi Rao (1994) also observed reduced number of pods per plant with delay in sowing. Akinola and Whiteman (1975) reported that pod number per plant was the component through which variation in seed yield expressed due to growing conditions.

The number of seeds per pod decreased with delay in sowing. The maximum number of seeds per pod was recorded with 1st December sowing (3.14), followed by 15th December sowing (3.00) and 1st January sowing (2.95). The least number of seeds per pod was recorded with 15th January sowing (2.62). Number of seeds per pod was significantly higher sowings in 1st December and 15th December than those of sowings during 1st January and 15th January. Jalapathi Rao (1994) also reported higher number of seeds per pod with early sowing than late sowing. Consequent with higher number of seeds per pod with early sowing, the 100 seed weight also followed the same trend. Highest test weight of 7.82 g was recorded with 1st December sowing, followed by 15th December sowing (7.52 g) and 1st January sowing (7.15 g). The least test weight was recorded with 15th January sowing (6.40 g). The test weights with 1st December and 15th December sowings were on par with each other and significantly superior to those of 1st January and 15th January sowing. Akinola and Whiteman (1975) reported that seeds per pod and seed size may be reduced by environmental conditions that restrict the supply of assimilates during the respective growth phases. This may be further examined by the data on dry matter production as influenced by dates of sowing of pigeonpea.

The total dry matter production recorded was maximum on 15th December sowing (62.745 g/plant), followed by 1st December sowing (58.294 g/plant), 1st January sowing (54.803 g/plant) and 15th January sowing (51.405 g/plant). The higher total dry matter production in 15th December sown crop was due to increased dry matter accumulation in leaves at 90 days after sowing and at harvest, increased stem dry matter accumulation at 60 and 90 days after sowing and at harvest, higher dry matter accumulation in pods at 90 days after sowing and at harvest and high number of branches at 90 days after sowing and at harvest. Balakrishnan and Natarajaratnam (1987a) also reported higher dry matter accumulation with sowing during early months in summer. Thus, the higher dry matter production with 15th December sown crop was a result of higher dry matter accumulation both in stem and leaf at almost all the stages with a cumulative total of 62.745 g per plant in this treatment. Besides, it is the greater amount of translocation of photosynthates into pods that was responsible for higher yields in this treatment. This can be examined from the observation that the dry matter distribution in pods was highest on 90th day (11.772 g/plant) and at harvest (21.273 g/plant) in this treatment compared to 10.36 and 19.06 g per plant with 1st December sowing and 10.69 and 18.78 g per plant in 1st January sowing in the two stages respectively. The least was, however, with 15th January sowing with 9.31 g per plant at 90 days and 16.81 g per plant at harvest. Consequently, there was decrease in the yield in this last treatment of sowing on 15th January as accentuated by flower drops, low number of pods, lower translocation of photosynthates and least pod dry weight all resulting in a reduction in yield by over 3 q per ha compared to the yields of 7.66 to 6.71 q per ha in the three other dates of sowing.

The total dry matter distribution in stem with 15th December sown crop was maximum at 60 days after sowing (3.242 g/plant), 90 days after sowing (29.708 g/plant) and at harvest (35.988 g/plant). This could be attributed to increased number of primary branches at 60th day (7.67), 90th day (7.67) and at harvest (7.98) coupled with greater number of compound leaves of 29.00 and 30.50 at 60th and 90th days respectively compared to 22.83 and 23.41 compound leaves per plant in the treatment with 15th January sowing. Pigeonpea being intrinsically perennial, may also conserve the proportion of assimilates produced during the reproductive phase to support subsequent root and shoot growth (Setter et al., 1984; Sheldrake and Narayanan, 1979). This aspect can be observed with greater plant height and higher leaf area (711.35 and 845.29 cm^2 at 60th day and 90th days) compared with 15th December sowing (579.89 and 675.48 cm^2). Even the leaf area duration was higher in this treatment (77.80 days) compared to 62.75 days in the December 15th sowing. This was due to higher CGR during initial stages of 30-60 days with January 15th sowing (0.094 $g/cm^2/day$) compared to December 15th sowing (0.078 $g/cm^2/day$). However, the net assimilation rate was found to decline with the advance of sowing dates from 0.0356 g per cm^2 per day in 1st December sowing to 0.232 and 0.227 g per cm^2 per day with 15th December sowing and 1st January sowing respectively and finally dropping down to 0.168 g per cm^2 per day with January 15th sowing. Thus, though the dry matter accumulation was identical in December 15th sowing and January 15th sowing treatment at the 60th day (7.402 g/plant), 15th December, 91 had high accumulation of 51.080 and 62.745 g per plant at 90th day and at harvest compared to 46.788 and 51.405 g per plant at these two stages, respectively.

The higher seed yield of 15th December sowing may also be attributed to the better harvest index. The highest harvest index was observed on 1st December sowing (0.236), followed by 15th December sowing (0.232) which were on par with each other. The harvest index decreased drastically with 1st January sowing (0.167) and 15th January sowing (0.141). The lower harvest index of 1st January and 15th January sowing may be due to production of poor quality pods as reflected by the number of seeds per pod and test weight.

5.2 **Varieties**

In the present study, three varieties viz., ICPL-87, ICPL-151 and DT-7 were tried during summer season. Among the varieties, ICPL-87 was found to be superior. The variety ICPL-87 recorded highest grain yield of 7.40 q per ha followed by ICPL-151 (6.44 q/ha) and DT-7 (5.06 q/ha). The variety ICPL-87 recorded 14.91 and 46.24 per cent higher seed yield than that of ICPL-151 and DT-7, respectively. Increased seed yield of ICPL-87 by 26.63 per cent over that of ICPL-151 was also reported by Nizam et al. (1989).

In the present study, increased seed yield of ICPL-87 may be attributed to higher number of pods per plant, 100 seed weight, number of seeds per pod, better growth and development. Akinola and Whiteman (1975) opined that number of pods per plant is an yield attributing component. In the present study also the increased seed yield of ICPL-87 was due to higher number of pods per plant (20.60) compared to ICPL-151 (17.44) and DT-7 (19.17). The results are in close confirmity with the findings of Bapireddy et al. (1991) who reported increased seed yield due to more number of pods per plant. Similarly, higher seed yield due to more number of pods per plant in variety Co-1 as compared to S_{19}, S_{31}, S_{42} and S_{41} was also reported byu Rangaswamy et al. (1975).

The number of seeds per pod followed the trend of seed yield. The number of seeds per pod was higher with the variety ICPL-87 (3.15), followed by ICPL-151 (2.96) and DT-7 (2.67). The test weight also followed the trend of seed yield. The test weight of the variety ICPL-87 was higher (7.87 g) compared to that of ICPL-151 (7.55 g) and DT-7 (6.24 g). Higher number of seeds per pod coupled with higher test weight particularly in ICPL-87 could be examined from the dry matter accumulated by the varieties. The total dry matter production was significantly higher at all the growth stages in the variety ICPL-87 compared to ICPL-151 and DT-7. The variety ICPL-87 recorded 65.735 g per plant of total dry matter production compared to ICPL-151 (60.277 g/plant) and DT-7 (44.422 g/plant). The higher total dry matter production in this variety was due to increased dry matter accumulation in leaves, stems, pods and number of compound leaves in almost all the growth stages with a cumulative total of 65.735 g per plant. This can be clearly verified from the observations that the total dry matter distribution in leaves was highest at 30th day (0.912 g/plant), 60th day (4.478 g/plant) and 90th day (10.519 g/plant) in the variety ICPL-87 compared to ICPL-151 and DT-7. The dry matter in stems was highest in all the growth stages of crop in the variety ICPL-87 with a cumulative total of 36.659 g per plant compared to ICPL-151 (34.994 g/plant) and DT-7 (27.264 g/plant). The dry matter distribution in pods was also highest at 90th day (12.636 g/plant) and at harvest (23.244 g/plant) in the variety ICPL-87 compared to ICPL-151 (10.670 and 20.296 g/plant) and DT-7 (8.287 and 13.397 g/plant) in the corresponding growth period. The high dry matter accumulation is also due to high leaf area in the variety ICPL-87 at 60th day (583.51 cm^2/plant) and 90th day (698.92 cm^2/plant) compared to ICPL-151 (535.59 and 665.50 cm^2/plant) and DT-7 (443.64 cm^2 and 585.55 cm^2/plant) at the corresponding growth stages. The leaf area index was also higher in the variety ICPL-87 at 60th day (1.945) and 90th day (2.329) compared to ICPL-151 (1.782 and 2.217) and DT-7 (1.475 and 1.983) at the respective growth stages. Even the leaf area duration was higher in the variety ICPL-87 (64.115 days) compared to 60.00 days in ICPL-151 and 51.215 days in DT-7. This may be due to higher CGR in the early reproductive phase of 60-90 days with the variety ICPL-87

(0.496 g/cm^2/day) compared to ICPL-151 (0.458 g/cm^2/day) and DT-7 (0.381 g/cm^2/day). The results are in close confirmity with the findings of Balakrishnan and Natarajaratnam (1989) who reported high dry matter accumulation due to higher leaf area index and crop growth rate in summer sown pigeonpea crop.

The partitioning of total dry matter also followed the trend of seed yield. The partitioning of total dry matter into pods was highest with the variety ICPL-87 (35.50%) compared to ICPL-151 (33.64%) and DT-7 (30.20%).

The partitioning of total dry matter into stem at harvest was lower in case of ICPL-87 (55.99%) compared to ICPL-151 (57.99%) and DT-7 (61.46%) although the dry matter partitioning was higher at 30 and 60 days after sowing. This indicates the possibility of greater partitioning of assimilates to the pods at later stages i.e., at 90 days and at harvest in the variety ICPL-87 than in other varieties.

The harvest index followed the trend of grain yield. The variety ICPL-87 recorded higher harvest index of 0.205 followed by ICPL-151 (0.192) and DT-7 (0.185). This may be due to greater distribution of dry matter in pods than in stem in case of ICPL-87 compared to other varieties.

5.3 Practical application of results

The variety ICPL-87 which is photoinsensitive has the capacity to yield more than other two varieties and it is possible that pigeonpea can be raised in the summer season in Bhadra Command Area under irrigation. The practice of growing pigeonpea during summer season not only helps to get some renumeration to the tail end farmers of the command area with limited water supply, but also helps in over all increased production to meet the greater demand of this important pulse crop.

This study thus suggests, (1) The possibility of growing pigeonpea variety ICPL-87 during summer season under limited water supply situation. (2) The variety ICPL-87 could be sown right from 1st December to 1st January for achieving higher yield.

5.4 Future line of work

1. It is necessary to evaluate suitable short duration, photoinsensitive pigeonpea genotypes during summer season for different agroclimatic zones.

2. Water requirement of pigeonpea crop during summer season, needs to be studied.

3. Comparative performance of different pulses during summer also can be taken up.

SUMMARY

VI. SUMMARY

An experiment to find out the optimum time of sowing of pigeonpea [Cajanus cajanus Mill Sp (L.)] varieties was conducted at Agricultural Research Station, Kathalagere, University of Agricultural Sciences, Bangalore in Bhadra Command Area during summer 1991-1992. The salient findings are summarised below.

Sowing on 1st December, 15th December, 1st January and 15th January recorded seed yield of 6.88, 7.66, 6.71 and 3.95 q per ha, respectively. Sowing on 1st December, 15th December and 1st January recorded higher seed yield of 74.18, 93.92 and 69.87 per cent respectively over that of 15th January sowing. This increased seed yield was due to higher number of pods per plant and higher test weight. There was a better partitioning of assimilates to reproductive part (pod) at the reproductive stage of the early sowings. The increased seed yield was also a resultant of better crop growth with higher leaf area index and better crop growth rate during early reproductive stage.

Among the varieties, ICPL-87 recorded maximum grain yield of 7.40 q per ha, followed by ICPL-151 (6.44 q/ha) and DT-7 (5.06 q/ha). The variety ICPL-87 out yielded other two varieties by recording 14.91 and 46.24 per cent higher yield than ICPl-151 and DT-7, respectively. The increase in grain yield of ICPL-87 was due to increase in number of pods per plant, number of seeds per pod and test weight than other varieties. The variety ICPL-87 recorded 18.12 and 7.23 per cent higher number of pods per plant compared to ICPL-151 and DT-7. Similarly the variety ICPL-87 recorded 6.42 and 17.98 per cent higher number of seeds per pod than ICPL-151 and DT-7. The total dry matter production was also higher in ICPL-87 than the other two varieties at all the stages of crop growth irrespective of date of sowing. Similarly, leaf area, leaf area index and leaf area duration was also maximum with ICPL-87 at all the stages of crop growth.

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*Original not seen.