

**" EFFECT OF PLANT GEOMETRY ON GROWTH
AND YIELD OF COWPEA VARIETIES"**

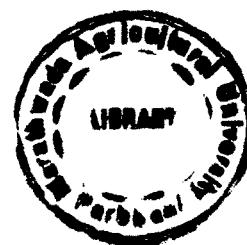
BY
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B.Sc.(Agri.)

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Dissertation

*Submitted to the Marathwada Agricultural University
in partial fulfilment of the requirement for the degree of*

MASTER OF SCIENCE
(Agriculture)

IN
AGRONOMY



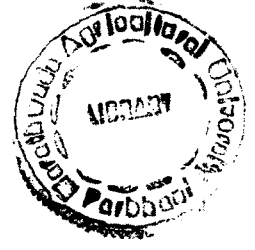
DEPARTMENT OF AGRONOMY
MARATHWADA AGRICULTURAL UNIVERSITY
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1999

To

Sou. Aai, Baba & Dada





CANDIDATE'S DECLARATION

I here by declare that the dissertation or part
thereof has not been previously submitted
by me to any other University or
Institution for a degree or
diploma.

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CERTIFICATE I

This is to certify that **Shri. MILIND MANOHAR SADHALE** has satisfactorily prosecuted his course of research for a period of not less than one year and that the dissertation entitled “ **EFFECT OF PLANT GEOMETRY ON GROWTH AND YIELD OF COWPEA (VIGNA UNGICULATA (L.) WALP.) VARIETIES.**” submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination for the degree of **Master of Science (Agriculture).**

I also certify that, the dissertation or part thereof has not been previously submitted by him for a degree of any university.

PLACE : Parbhani

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Research Guide



CERTIFICATE II

This is to certify that the dissertation entitled “ **EFFECT OF PLANT GEOMETRY ON GROWTH AND YIELD OF COWPEA (VIGNA UNGICULATA (L.) WALP.) VARIETIES.**” submitted by **Shri. Milind Manohar Sadhale** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE** (Agriculture) in the subject of **AGRONOMY** has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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(M.M. Sadhale)

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ABBREVIATIONS



mm	Millimetre
cm	Centimetre
cm ²	Square centimetre
m	Metre
g	Gram
kg	Kilogram
q	Quintal
ha	Hectare
/	Per
@	At the rate of
WSC	Water soluble concentrate
EC	Emulsifiable concentrate
°C	Degree centigrade
et al.	et alia (and others)
viz.	Namely
i.e.	id est (that is to say)
N.S.	Non-significant
S.E.	Standard error
C.D. at 5 %	Critical difference at 5 per cent level
G.M.	General mean
DAS	Days after sowing



INTRODUCTION



1 INTRODUCTION

Pulses form an important constituent of Indian diet. Pulses are important from two main aspects, firstly, they are important source of protein (22 to 24 per cent), therefore, production and consumption of more pulses is one of the way to overcome malnutrition in population. secondly, pulses play a pivotal role in agricultural economy due to their remunerative prices. They have the built-in-capacity of fixing atmospheric nitrogen and thus helps to enrich the soil fertility. Therefore, they are the essential component of cropping system.

Eventhough, pulses provide protein rich diets to human being, nutritious fodder to animals and also enrich the soil, but the area (23.1 million hectares) and production (14.1 million tonnes) of pulses in the country is stagnated for last two decades (Anonymous, 1996). There is thus, an urgent need to increase the production of these crops through proper agronomic manipulations.

A two pronged strategy is required to increase pulse production in the country as a whole, one is to develop improved varieties with suitable production technology in traditional pulse growing areas, whereas

second is to develop short duration varieties to fit well in the available multiple cropping system.

Among the pulses grown in India, cowpea (Vigna unguiculata (L.) Walp.), known as black eyebean or southern pea, occupies a prominent place. In India, cowpea is known since vedic times and is popularly called Lobia, Ronghi or Chavlai.

As a food, cowpea is consumed in the form of dry seeds, green pods and tender leaves (Rachie, 1985). It is high in protein as well as other essential amino acids. The dry seed contains about 24 per cent protein, 62 per cent soluble carbohydrates and small amount of other nutrients (Elias et al., 1964). Variability in protein content has been reported from 23 to 30 per cent (Bliss, 1975). Lysine content is relatively high (467 - 497 mg/gm N), making cowpea an excellent improver of the protein quality of cereal grains (Bressani, 1985).

As a green manure crop, when incorporated in the soil, cowpea can fix up to 240 kg N/ha and leave a fixed -N deposite in soil of about 30 - 70 kg N /ha. (Rachie, 1985).

Cowpea is mostly cultivated as a mixed crop with a cereal or in association with a root and tuber crop or in

rice fallows. A maize - wheat - cowpea sequence is common in some parts of Northern India. The crop is also grown for grain and also for fodder in wheat fallows. In Marathwada, cowpea is mainly grown in intercropping with crops like cotton, sugarcane or jowar, in some patches, to get additional income and to suppress weed growth in early growth period of main crop.

Area under cowpea would increase when high yielding varieties with better stability are evolved and for best yields the management level is to be enhanced.

Among the various factors that contribute towards the attainment of potential yield of cowpea, optimum plant spacing or plant population is of considerable importance. Optimization of plant density for high yielding genotypes by following suitable inter as well as intra row spacing is essential. Maintaining a greater than optimum plant density adversely affect the per plant yield. On the other hand, sub-optimal plant density tends to produce higher or more per plant yield, but can not produce higher yield per unit area. Optimum plant density is therefore necessary for getting higher yields of the crop.

Closer spacing within and between rows increased

the yields of cowpea (Ezedinma, 1974; Herberts and Baggerman, 1983; Jallow and Ferguson, 1985). Most of the states in India have recommended 45 x 15 cm plant spacing for cowpea (Tandon, 1987).

In Marathwada, very few attempts have been made to grow this crop as a sole crop. It could be a economical crop for Marathwada region, if high yielding and short duration genotypes are grown with optimum plant population in the region. Therefore, more emphasis needs to be given on increasing the area and productivity of cowpea by adopting suitable genotypes and plant geometry as a sole crop under rainfed condition.

In view of above the present experiment entitled " Effect of plant geometry on growth and yield of cowpea (Vigna unguiculata (L.) Walp.) varieties" was planned with the following objectives

1. To study the effect of row to row and plant to plant spacing on growth and yield of cowpea and to find out suitable spacing for the crop.
2. To study the varietal performance and to find out the suitable variety of cowpea for the region.
3. To find out the interaction effects of crop geometry and varieties on growth and yield of cowpea in kharif season.

**REVIEW
OF
LITERATURE**

2 REVIEW OF LITERATURE

2.1 Effect of plant geometry :

2.1.1 Growth characters :

Sharma (1969) conducted a experiment at Punjab Agricultural University Research Station, Gurudaspur during kharif 1964 and stated that in black-gram, close spacing of 30 cm established significantly higher stand in comparison with wider spacing of 45 and 60 cm.

Erskine and Khan (1976) found that increasing the plant population than 1,00,000 plants/ha ,decreased the lateral branch development in cowpea.

Reddy and Singh (1976) reported that plant height was significantly increased with decrease in row width and also decreased the dry matter per plant of soybean. The number of branches were not affected significantly by row spacing.

Subramanian et al. (1977^a) conducted a field trial on cowpea in clay loam soil and observed that plant height as well as 100 grain weight was not influenced by the spacing.

Remison (1980) observed that cowpea plants generally produced more number of leaves per plant at

lower, than higher plant populations. The number of branches were significantly fewer at higher plant population.

Srivastava *et al.* (1980) observed a decrease in plant height of black-gram with increase in row spacing from 30 to 60 cm.

Singh *et al.* (1980) conducted a experiment on green-gram at IARI, New Delhi during summer 1976 and observed that maximum plant height was produced at 5,00,000 plants/ha.

Singh and Malavia (1981) reported that increase in plant density of mungbean resulted in conspicuous reduction in number of primary branches per plant and increase in plant height.

Saraf *et al.* (1984) conducted a field trial at Vegetable Research Farm, Jabalpur (M.P.) during kharif, 1982 and observed reduction in cowpea plant height (153.77 cm) with increased plant spacing (60 x 20 cm) at 60 days growth. Similarly, higher number of branches / plant (7.59) were noted under wide spacing (60 x 20 cm) as compared to (6.67) at closer plant spacing (60 x 10 cm).

Mahaldar (1986) studied the performance of cowpea under Konkan condition and observed that number of

branches, number of functional leaves, mean spread and dry matter per plant were significantly greater under widest (40 x 15 cm) row spacing, while height was significantly more under narrowest (20 x 15 cm) spacing in cowpea.

Rana and Ahuja (1986) reported that plant height in moongbean was significantly influenced by different row spacings. Plants in 20 cm row spacing attained more height than plants in 40 cm row spacing. But wider row spacing recorded more number of branches and dry matter production per plant.

Rajanna (1988) conducted field trials during rabi 1983, summer and kharif 1984, with two cowpea cultivars viz., CSRR-1 and Pusa dofasli and observed that dry matter production per plant, height of plants, length of internodes, thickness of stem and primary branches per plant were strongly influenced by inter row spacings.

Angne (1989) studied the performance of cowpea at different spacings under Konkan condition. The study revealed that the plant height was significantly higher in case of 20 x 15 cm row spacing than rest of the spacings followed by 30 x 15 cm spacing at all the stages of plant growth. With regards to number of functional leaves, number of branches, dry matter per plant and mean spread

of plant was significantly higher in wider spacing (45 x 15 cm) than rest of the spacings.

BiradarPatil et al. (1991) in a field trial with three varieties of cowpea observed that, wider row spacing (45 cm) induced more branching.

Singh (1993) reported that the plant height, dry matter accumulation per plant and leaf area index of cowpea were higher in crop spacing of 30 x 15 cm than 45 x 10 cm.

Parihar et al. (1996) conducted field trials at JNKVV, Jabalpur (M.P.) during rainy season of 1982 with cowpea cultivar Pusa barsati. The effect of plant density revealed that the population maintained at a distance of 60 x 15 cm had higher (134.33 cm) plant height as compared to lower or higher planting density. At increased plant density, the higher number of branches per plant was noted. The number of leaves were maximum (33.37) at a spacing of 60 x 20 cm.

Deshmukh (1997) conducted a field trial during rabi 1991-92 and observed that plant height of cowpea was significantly highest in case of 15 x 15 cm spacing, whereas, number of functional leaves and number of branches per plant, were highest at wider spacing of 45 x 30 cm and 30 x 30 cm.

2.1.2 Yield attributes :

Erskine and Khan (1976) observed that number of pods/plant in cowpea was decreased as plant density increased. The number of seeds per pod was least at the lowest plant density of 40 x 10 cm.

Subramanian *et al.* (1977^a) observed that closer spacing of 50 x 10 cm (2 lakh plants/ha) was found to be significantly superior and recorded the maximum (16.6) number of pods per plant in cowpea.

Jain *et al.* (1984) conducted a field trial at JNKVV, Jabalpur (M.P.) on cowpea with three cultivars and observed that, the number and weight of pods per plant was more with the row spacing of 45 cm, resulting in the maximum grain yield.

In an experiment conducted at JNKVV, Jabalpur (M.P.), it was observed that significantly higher number of pods (22.58) per plant were produced under wider spacing of 60 x 20 cm than at 60 x 15 cm (16.80) and 60 x 10 cm (15.41). Whereas, number of seeds per pod was higher (14.23) at closer spacing of 60 x 10 cm followed by (13.23) 60 x 15 cm and (12.29) 60 x 20 cm. (Saraf *et al.*, 1984).

Jallow and Ferguson (1985) reported that number of seeds per pod in cowpea was not influenced but pod per plant were consistently reduced by increasing plant density.

Yadav (1986) reported that there was an increase in the expression of yield attributing characters except 1000 grain weight with wider row and plant spacing in cowpea. There was increase in number of pods per plant and number of grains per pod with increased spacing.

BiradarPatil et al. (1991) reported that the differences in the yield levels of cowpea may be attributed to the significant differences observed in the number of pods per plant, pod length, number of seeds per pod and 100 seed weight due to different varieties and inter row spacings of 30 and 45 cm.

Mahaldar et al. (1991) reported that all yield attributes in cowpea were increased significantly due to wider spacing of 45 x 15 cm and 30 x 15 cm.

Mali and Mali (1991) conducted a experiment in rainy season of 1988 at Jobner, Rajasthan, with three varieties of cowpea viz., RC-2, RC-48 and C-152 and observed that, there was improvement in 1000 seed weight with wider row spacing of 45 cm.

Parihar et al. (1996) observed that the increase in plant population reduced the number of pods, seeds per pod and pod length and the lower values were noted at highest density of 1,66,666 plants /ha spaced at 60 x 10 cm. The number of seeds per pod was significantly higher at the lowest plant density spaced at 60 x 20 cm.

2.1.3 Yield :

Sharma (1969) observed higher grain yield of black- gram due to 60 cm row spacing followed by 30 cm and 45 cm row spacing.

Arora et al. (1971) observed an average increase of 9.4 per cent in grain yield by 30 cm row spacing which was significantly higher than 20 cm row spacing in cowpea.

Haizel (1972) found that yield of a bunch type cowpea increased most when square planting was practiced rather than rectangular planting.

Giri et al. (1973) conducted field trials on rabi pulses and noted that row spacing of 30 cm in cowpea recorded 3.0 and 3.9 q/ha more grain yield than 45 and 60 cm spacing. Widening of rows beyond 30 cm registered a decline in yield. Thus, 30 cm appeared optimum distance for cowpea.

Rathi and Verma (1973^a) reported that the highest (6.41 q/ha) grain yield of black-gram, cv.T-9 was recorded from 45 x 30 cm spacing which was significantly higher than the yield (3.15 q/ha) obtained with 45 x 20 cm.

Rathi and Verma (1973^b) reported that no significant effect due to different spacings tried was noted on grain yield of Mung, cv. Type-44 and stressed the need of keeping total spacing between 300 and 375 cm² per plant which can be easily maintained by four geometries viz., 30 x 10 cm, 30 x 15 cm, 45 x 10 cm and 45 x 15 cm.

In an experiment at G.B. Pant University of Agriculture and Technology, Pantnagar, on cowpea with four varieties observed that plant population did not show significant differences in the yield of cowpea (Saxena et al. 1973^a).

Field trials conducted at G.B. Pant University of Agriculture and Technology, Pantnagar, on green-gram revealed that effect of row spacing on grain yield/ha was significant and a row spacing of 15 cm was superior to that of 22.5 and 30 cm spacings (Saxena et al., 1973^b).

Ezedinma (1974) observed that closer spacing within and between rows increased the yields of cowpea.

Maheshwari et al. (1974) while studying the response of green-gram to row spacing observed that the highest (7.69 q/ha) yield of green-gram was obtained at row spacing of 30 cm, followed by row spacing of 20 cm

Morse (1974) recommended that cowpeas should be sown at 5-8 cm apart, on 19 cm rows in order to obtain the highest yields.

Nangju et al. (1975) observed no relationship between within-row and between-row spacings on yields of cowpea, but yields shown positive responses to densities exceeding 18 plants/m².

Bindra and Sagar (1976) found that row to row distances (45 cm and 80 cm) in cowpea did not influence the yield of the varieties significantly.

Subramanian et al. (1977^a) while studying the response of cowpea, cv. C-152 to spacing observed that closer spacing of 50 x 10 cm (2 lakh plants/ha) was found to be significantly superior and had recorded the highest grain yield of 1824 kg/ha over 1733 kg/ha at 50 x 15 cm and 1585 kg/ha at 50 x 20 cm.

Subramanian et al. (1977^b) conducted field trials for three years during rainy season of 1972-75 on cowpea, cv.CO-2 and reported that, closer spacing of 60 x 15 cm

(1,11,000 plants/ha) recorded the highest grain yield of 2099 kg/ha and was superior to the other spacings. The results of three years trials indicated the superiority of the closer spacing of 60 x 15 cm, which had recorded an increased yield of 115 kg and 264 kg grain/ha over the other spacings 60 x 20 cm (86,000 plants/ha) and 60 x 25 cm (67,000 plants/ha), respectively.

Bhat (1980) conducted a field trial on cowpea with three cultivars and observed that, grain yield increased with increase in row spacing from 30 to 45 cm in case of variety C-152 and Chinese Red. But further increase in row spacing to 60 cm decreased the grain yield as compared to 45 cm.

Herbert and Baggerman (1983) observed that seed yield of cowpea showed only a small increase with increase in plant density. But seed yield was highest and increased with increased plant density in wide rows in contrary in narrow rows.

Ceylan and Septoglu (1984) found that seed yields in cowpeas were increased with increased distance between rows. The prostrate cultivar of cowpea gave higher yields at low density.

Jain et al. (1984) reported that 45 cm row

spacing gave 6 and 30.6 per cent higher grain yield than 30 and 60 cm row spacing in cowpea, respectively.

Saraf et al. (1984) conducted a field trial at JNKVV, Jabalpur (M.P.) and observed that higher seed yield per plant (24.81 g) under wider spacing of 60 x 20 cm as compared to (18.66 g) closer spacing of 60 x 10 cm, in cowpea.

Tripathi et al. (1984) reported that row spacing of 75 cm recorded maximum (1039 kg/ha) seed yield in cowpea, which was significantly higher than 100 cm (854 kg/ha) and 50 cm (801 kg/ha) row spacings. The difference in the seed yield between 50 and 100 cm row spacing was not significant.

Jallow and Ferguson (1985) reported that mean seed yield of cowpea averaged over all cultivars increased with closer planting and reached a maximum of 1326 kg/ha at 1,48,000 plants/ha with 30 x 22.5 cm spacing.

Vijaykumar and Rao (1987) reported that population levels showed no significant effect on grain yield of cowpea.

BiradarPatil et al. (1991) while studying the response of three cowpea cultivars to inter row spacing observed that the differences in the seed yield due to

different spacings was significant. The seed yields were 16 per cent higher at wider (45 cm) row spacing over closer (30 cm) row spacing.

Mali and Mali (1991) observed that narrow spacing of 30 cm recorded the highest seed yield (870 kg/ha) of cowpea, giving 44 per cent increase as compared with 45 cm row spacing (600 kg/ha).

Sharma (1991) while working on cowpea found that row spacing of 22.5 cm, 30 cm and 45 cm did not show significant variation with each other in terms of grain yield, but gave significantly higher grain yield over 60 cm spacing during 1978. However, during 1979, row spacing of 30 cm and 45 cm recorded higher grain yield as compared to closer (22.5 cm) and wider (60 cm) spacing.

Singh et al. (1992) reported that spacing of 60 x 15 cm was best over rest of the spacings for obtaining higher green pod yield from new cultivar Cowpea-263 during both spring and rainy season.

Angne et al. (1993) observed that cowpea planted at 30 x 15 cm spacing produced significantly higher grain yield (14.92 q/ha) than 20 x 15 cm (11.92 q/ha) and 45 x 15 cm (11.98 q/ha) spacing.

Singh (1993) reported that the crop spacing of 30 x 15 cm gave 14.4 per cent and 16.5 per cent higher seed yield of cowpea than crop spacing of 45 x 10 cm during 1988 and 1989, respectively at H.A.U., Hissar.

Kumar R. (1994) reported that the highest (11.45 q/ha) seed yield of cowpea was recorded with 45 cm inter row spacing which was significantly better than 30 cm (9.89 q/ha) and 60 cm (8.31 q/ha) row spacing.

Parihar et al. (1996) studied the response of cowpea, cv. Pusa barsati to plant density and observed that, the seed yield of cowpea increased linearly and significantly due to levels of plant density. Higher seed yield (22.46 q/ha) was produced at 60 x 15 cm spacing.

2.2 Varietal differences :

2.2.1 Growth characters :

Erskine and Khan (1976) observed the significant genotypic differences in the cowpea for main stem height and genotypes UV-53 had a longer main stem than UV-19.

Gowda (1982) reported that among three cowpea genotypes tested, cv. C-152 was higher in number of branches /plant whereas, cv. TVX-289 was higher in number of leaves per plant.

BiradarPatil et al. (1991) reported that the number of branches per plant was not significantly affected by the varieties in cowpea.

2.2.2 Yield attributes :

Erskine and Khan (1976) reported that no significant genotypic differences in the number of pods per plant in cowpea was observed in either of experimental seasons.

Remison (1980) reported that number of pods/plant, weight of seeds per pod and 100 seed weight in cowpea were higher for cv. Ife Brown than cv.Vita-5.

Gowda (1982) while studying three cowpea varieties performance under supplemental irrigation during rainy season of 1980 at U.A.S., Bangalore and observed that cowpea cv. C-152 produced higher pod weight /plant, number of pods/plant, number of seeds/pod, seed to pod ratio and per cent seed set in pod than other two varieties viz., cv. S-488 and cv. TVX-289. Whereas, pod length was higher in cv. S-488 and 100 seed weight was higher in cv. TVX-289.

Rajanna (1988) conducted a field trial with two cowpea cultivars and observed that, cowpea cv. Pusa dofasli produced more number of pods/plant than cv.CSRR -1

during all the experimental seasons. The yield of green pods /ha was significantly higher in cv. Pusa dofasli during kharif only.

BiradarPatil et al. (1991) reported that the differences in the yields levels in three cowpea varieties may be attributed to the significant differences observed in number of pods/plant, pod length, number of seeds/pod and 100 seed weight. All the yield parameters in cv. V-37 were significantly higher compared to cv.V-118 and cv. C-152, except 100 seed weight which was significantly higher in cv. V-118 .

Mahaldar et al. (1991) reported that cowpea cv. C-152 produced significantly more number of pods/plant, number of grains/pod, weight of grains/ plant, 100 grain weight and higher pod length as compared to cv. V-16 .

Mali and Mali (1991) observed that cowpea, cv.RC-2 produced maximum (29.7) number of pods/plant and maximum (13.9) number of seeds per pod than other two cultivars viz., cv.RC-48 and cv.C-152.

2.2.3 Yield :

Saxena et al. (1973^a) reported that cowpea cv. FS-68 gave the highest seed yield, which was significantly higher over cv. Pusa dofasli, cv.C-152 and cv. 5269.

Purushotma et al. (1975) observed that among ten cowpea cultivars tested, cv.Selection No.2 and cv.C-152 were superior in yield over rest of the cultivars.

Erskine and Khan (1976) reported that cowpea cv. UV-53 gave more (1593 kg/ha) grain yield than cv.UV-19 (1040 kg/ha), although this difference was only significant in the wet season and not in dry season.

Remison (1980) reported that Ife Brown cultivar of cowpea produced higher grain yield (578.2 kg/ha) than cv. Vita-5 (528.9 kg/ha).

Singh et al. (1980) reported that varieties did not show significant differences in the grain yield per hectare in cowpea.

Bhat (1981) observed that cowpea cv. C-152 recorded significantly higher grain yield than cv.Chinese Red and cv.New Era which were on par.

Pothiraj (1981) reported that among two cowpea varieties tested, var. Co-3 was found superior to var. V-16 with the grain yield of 335 kg/ha as against 226 kg/ha in var. V-16 .

Gowda (1982) observed that among three cowpea cultivars tested, cv.C-152 gave highest grain yield of

2438 kg/ha, which was 10.3 and 34.3 per cent more than grain yield of cv.TVX-289 and cv.S-488, respectively. Ceylan and Septoglu (1984) observed that the prostrate type cowpea cultivars gave more grain yields than erect type cowpea cultivars.

Tripathi et al. (1984) while studying five cowpea varieties at IGFRI, Jhansi (U.P.) observed that there were significant differences in the seed yields of different cowpea varieties and var. N.P.-3, EC-4216 recorded the higher (11.38 q/ha) seed yields over other varieties viz., IGFRI-S-450, IGFRI-S-457, IGFRI-S-978 and IGFRI-S-985 during both the years of experimental trial.

Jallow and Ferguson (1985) reported that differences in the mean seed yield between cowpea cultivars tested were highly significant. Cowpea cv. Vita-5 was significantly outyielded by all other varieties and cultivar California No. 5 had the highest mean seed yield of 1239 kg/ha.

In an experiment conducted at GKVK, Bangalore, it was observed that cowpea cv. V-16 gave maximum grain yield (18.22 q/ha) followed by cv. V-37 (16.81 q/ha) and cv. KBC-1 (15.38 q/ha) as compared to cv. C-152 (11.24 q/ha) (Anonymous, 1986).

Rajanna (1988) reported that variety Pusa dofasli of cowpea produced more number of green pod yield /ha during kharif only. Whereas, dry seed yield of cv. CSRR-1 was significantly higher than cv. Pusa dofasli in summer only.

In field trial conducted at GKVK, Bangalore, it was seen that among ten varieties of cowpea evaluated for summer cultivation, cv. C-152 performed better with an yield 2296 kg/ha (Anonymous, 1990^a).

In kharif cowpea co-ordinated trial at GKVK, Bangalore, it was observed that cowpea cv. KBC-1 recorded the highest yield of 1058 kg/ha, followed by cv. C-152 and cv.V-16 (Anonymous, 1990^b).

BiradarPatil et al. (1991) reported that among three cowpea genotypes tested, cv.V-37 gave significantly higher seed yield of 12.79 q/ha than cv.V-118 (11.25 q/ha) and cv.C-152 (10.22 q/ha).

Mahaldar et al. (1991) reported that the cv.C-152 of cowpea produced significantly higher yield (18.25 q/ha) as compared to cv. V-16.

Mali and Mali (1991) observed that cowpea cv.RC-2 gave highest seed yield which was 130 and 80 kg/ha more than that of cv. RC-48 and cv. C-152, repectively.

Sharma (1991) reported that amongst various cowpea genotypes tested, cv. C-152 recorded the highest grain yield of 662 kg/ha followed by cv. V-37 with yield 654 kg/ha and cv. V-38 with yield 486 kg/ha.

Kumar, R. (1994) observed that cowpea cv. GC-3 excelled over cv. V-130 by a margin of 27.5 per cent in seed yield.

2.3 Interaction :

Jallow and Ferguson (1985) reported that in cowpea, cultivar and density interaction was non-significant.

BiradarPatil et al. (1991) reported that the interaction between variety and spacing was not significant in cowpea.

2.3.1 Yield attributes :

Remison (1980) reported that the only significant interaction between spacing and variety in cowpea was for the number of pods per plant.

2.3.2 Yield :

Erskine and Khan (1976) observed that spacing and genotypes interaction effects were not significant for

grain yield in cowpea.

Bhat (1981) reported that interaction between genotype and row spacing was significant with respect to grain yield and most of the other characters in cowpea.

Jain et al. (1984) reported that interaction between genotype and row spacing was significant with respect to grain yield in cowpea.

**MATERIALS
AND
METHODS**

3 MATERIALS AND METHODS

The details of the materials used and methods adopted during the present investigation are described in this chapter.

3.1 Experimental site :

The experiment was conducted during kharif season of 1998-99 at Agricultural College Farm, Marathwada Agricultural University, Parbhani.

3.2 Soil :

The topography of the plot was fairly levelled. The physio-chemical properties of soil were studied by taking soil samples from 0-30 cm strata at random all over the experimental area before laying out the field. It was analysed for various physio-chemical properties viz., mechanical analysis by International Pipette method (Piper, 1966), available phosphorus by Metavandate method (Olsen et al., 1954), pH by glass electrode pH meter, electrical conductivity by conductivity bridge. The data obtained are presented in Table 1.

The data presented in Table 1 revealed that the soil of the experimental plot was clayey in texture, low in nitrogen, medium in phosphorus, rich in potassium and slightly alkaline in reaction.

Table 1 : Physio-chemical properties of soil

Particulars	Results
A. Mechanical analysis	
coarse sand (per cent)	9.35
Fine sand (per cent)	4.61
Silt (per cent)	30.23
Clay (per cent)	54.10
Textural class	Clayey
B. Chemical analysis	
Total nitrogen (kg/ha)	456.0
Available phosphorus (kg/ha)	41.0
Soil pH	7.8
Electrical conductivity (mmhos/cm)	0.29

3.3 Cropping history :

The cropping history of the experimental plot for last three years is given in Table 2.

Table 2 : Cropping history of experimental plot

Year	Kharif	Rabi	Summer
1995-96	Pigeonpea	Pigeonpea	--
1996-97	Cotton	Cotton	--
1997-98	Soybean	Sunflower	--
1998-99	Present experiment		

It would be seen from the Table 2 that residual effect of previous cropping pattern on soil fertility was almost uniform.

3.4 Climate and weather :

Parbhani is situated in subtropical region at 409 m above the mean sea level, $19^{\circ} 16'$ North latitude and $76^{\circ} 47'$ East longitude in Marathwada region of Maharashtra state. Mean annual precipitation approximates to 964 mm and it is received mostly during June to September. The winter rains are uncertain and scanty. Most of the rainfall is received from south-west monsoons. The mean maximum temperature varies from 28.6°C in winter to about 40.9°C in summer whereas, the mean minimum temperature varies from 12.1°C to 24.9°C during winter and summer, respectively. Thus, climate of Parbhani is characterised with hot and dry summer and cold winter.

The weather data for the experimental period recorded at Agricultural Meteorological Observatory, Parbhani are presented in Table 3.

Data presented in Table 3 indicated that mean weekly maximum temperature varied from 29.2°C to 42.6°C in June and mean weekly minimum temperature varied from 19.2°C in October (42nd met. week) to 27.3°C in June (22nd met. week).

Mean monthly maximum rainfall was 271.2 mm in July while minimum rainfall was 162.5 mm in June. Total rainfall received during the period of investigation was 1429.3 mm

3.5 Experimental details :

3.5.1 Design and treatments :

The present experiment was laid out in the split plot design and replicated thrice. The treatments consisted of two inter row spacings, three intra row spacings and three varieties of cowpea, constituting total eighteen combinations. Six combinations of inter and intra row spacings were laid out in the main plots, while varieties of cowpea were laid in the sub-plots, the particulars of the treatments are given below :

Treatment details :

A. Main plot treatments : (6 Combinations)

Inter row spacings	Intra row spacings
i) R_1 30 cm	i) P_1 15 cm
ii) R_2 45 cm	ii) P_2 22.5 cm
	iii) P_3 30 cm

B. Sub-plot treatments : (3 varieties)

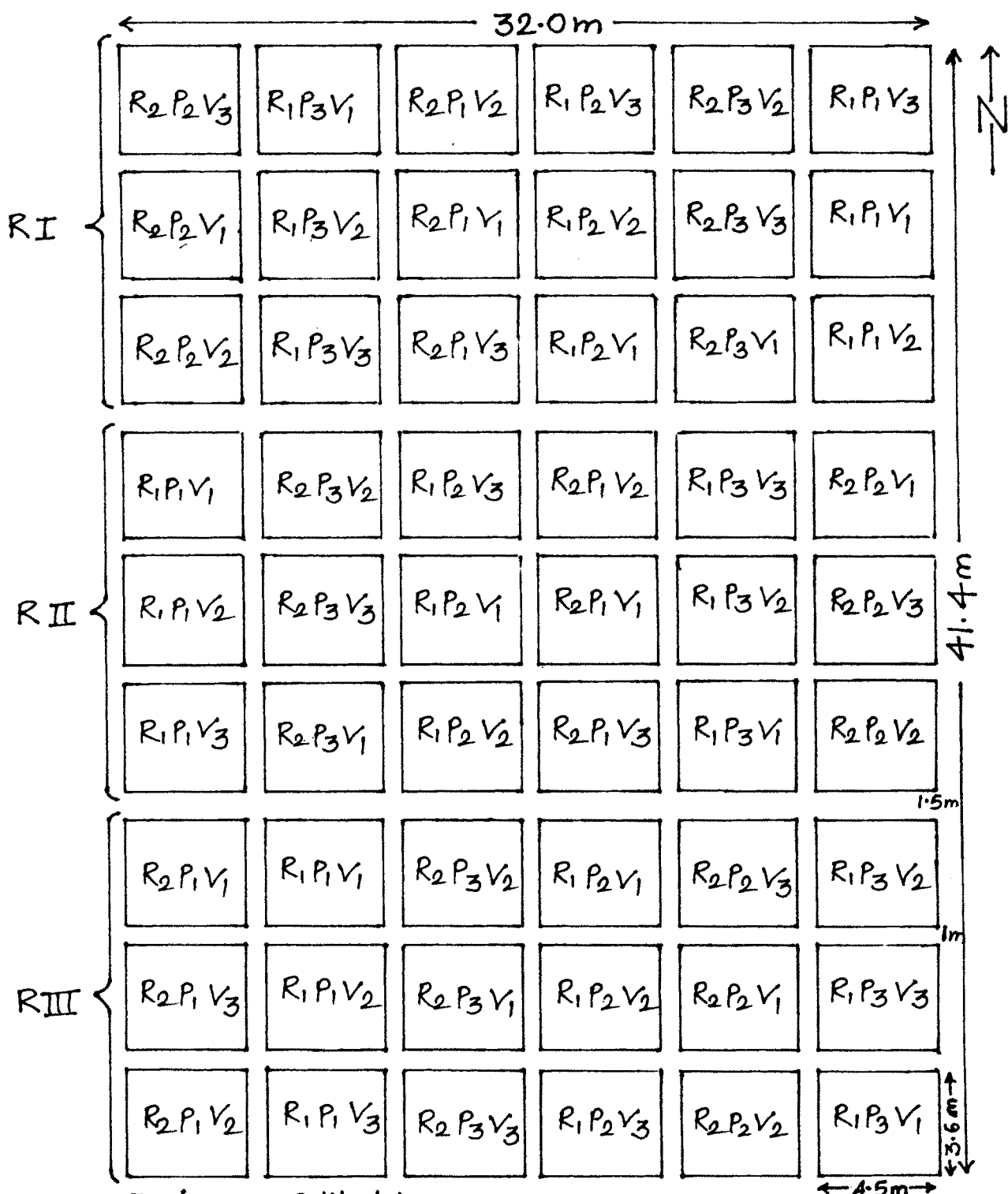
- i) V_1 Konkan sadabahar
- ii) V_2 Pusa barsati
- iii) V_3 Pusa Komal

Table 3 : Mean weekly weather data for experimental period during 1998 - 99

Month	Met. Week	Rainfall	Number of Rainy Days	Temp.		RH	
				Max.	Min.	Max.	Min.
June	22	0.0	0	42.6	27.3	47	20
	23	0.0	0	39.8	25.4	55	29
	24	93.3	3	33.7	24.1	77	58
	25	32.0	2	34.2	24.0	83	49
	26	37.2	3	33.3	23.7	83	56
July	27	10.0	1	31.1	23.7	85	64
	28	6.4	1	33.6	23.1	81	48
	29	1.0	0	33.0	23.5	76	52
	30	253.8	6	31.6	22.6	90	69
August	31	173.8	5	29.2	22.4	91	77
	32	116.6	5	29.5	23.4	91	77
	33	18.0	3	30.5	23.2	85	68
	34	133.0	4	31.2	22.7	92	76
Sept.	35	28.4	1	30.6	23.0	84	64
	36	124.7	2	30.8	23.0	90	71
	37	24.5	4	29.2	22.8	87	73
	38	123.0	3	30.2	22.0	90	68
	39	27.0	3	30.6	22.8	89	70
Octo.	40	32.6	2	32.0	22.1	84	64
	41	86.0	5	30.8	22.3	91	75
	42	107.0	2	29.3	19.2	91	63
	43	1.0	0	29.2	19.6	83	66

3.5.2 Layout :

Plan of layout is depicted in fig. 1. The experimental field was laid out as per plan after preparatory cultivation. The gross plot size was 4.5 m x 3.6 m and the net plot size was 3.6 m x 1.8 m. The distance between two plots was 1.0 m and between two replications was 1.5 m. The treatments were allocated to different plots randomly within each replication.



Design : Split plot

Replication : Three

Plot size : Gross 4.5x3.6 m
Net 3.6x1.8 m

R₁ : 30cm

R₂ : 45cm V₁ : Konkansadabhar

P₁ : 15cm V₂ : Pusa barsati

P₂ : 22.5cm V₃ : Pusa komal

P₃ : 30cm

Fig.1 PLAN OF LAYOUT

3.6 Details of cultural operations :

Details of cultural and other operations carried out during experimental period are given in Table 4.

3.6.1 Preparatory tillage :

The land was ploughed with mould board plough and brought to the fine tilth by subsequent harrowings, stubbles of previous crop were collected and field was kept ready for sowing.

3.6.2 Seed sowing and gap filling :

After sufficient rains sowing was undertaken on 4th July, 1998, following the spacings as per treatments by dibbling. The dibbled seeds were covered with moist soil.

Gap filling was done at 10 days after sowing (DAS). Thinning was done at 14 DAS. The gap filling and thinning were done to maintain the required population as per the treatments.

3.6.3 Fertilizer application :

Recommended dose of fertilizer at the rate of 25 Kg N and 50 Kg P₂O₅ per hectare was applied through urea and single super phosphate. Entire dose of fertilizer was applied as a basal in lines.

Table 4 : Schedule of cultural operations carried out in the experimental plot

Sr. No.	Particulars	Frequency	Date	Days after sowing
A . Preparatory tillage :				
1.	Ploughing	1	29-05-98	
2.	Harrowing	2	15-06-98	
3.	Cleaning	1	30-06-98	
B. Sowing :				
1.	Layout of field and fertilizer application	1	03-07-98	
2.	Sowing	1	04-07-98	
3.	Gap filling	1	14-07-98	10
4.	Thinning	1	18-07-98	14
C. Interculture operations :				
1.	Hand weeding	3	18-07-98 06-08-98 24-08-98	14 33 51
D. Plant protection : Insecticide spraying				
1.	Monocrotophos (36 WSC)	2	22-07-98 08-08-98	18 35
2.	Endosulfan (35 EC)	2	14-08-98 24-08-98	41 51
3.	Demecron	2	06-08-98 04-09-98	33 62
E. Harvesting :				
V ₁	Konkan sadabahar	1	11-09-98	69
V ₂	Pusa barsati	1	01-10-98	89
V ₃	Pusa komal	1	15-10-98	73



3.6.4 Intercultivation :

Three hand weedings were undertaken to conserve the soil moisture and control the weeds.

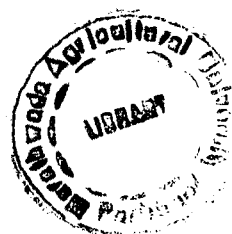
3.6.5 Plant protection :

Seeds were treated with Rhizobium culture and also with Thirum @ 3 g/kg of seeds.

The infestation of leaf eating catterpillar and pod borer was noticed on the crop which was controlled by spraying Monocrotophos 36 WSC (0.07 per cent) and Enosulfan 35 EC (0.07 per cent). Demecron sprays were undertaken to control the sucking pests.

3.6.6 Harvesting and threshing :

Before harvesting the pods from net plot, observation plants from each net plot were taken out for recording post harvest observations per plant. The net plots were marked and the pods from the plants in border lines were harvested first. Then the pods from net plot plants were harvested and pods were sundried for a period of week. The seeds were separated by hand threshing and winnowings. The grain yield from each net plot was recorded.



3.7 Collection of data :

The data on important biometric observations were recorded on randomly selected five plants (observaion plants) in each net plot with an interval of 15 days, from 30 days onwards after sowing to harvest. The details of biometric observaitons recorded are specified in Table 5.

3.7.1 Emergence count and final plant stand :

The number of emerged plants from each net plot recorded at 12 days after sowing and expressed as percentage to the theorotical popul^uation. Similarly, the final plant stand from each net plot was recorded at harvest.

3.7.2 Height of plant :

The height of the main shoot of each plant was recorded from ground level to the base of apical bud with an interval of 15 days.

3.7.3 Number of functional leaves per plant :

Progressive number of functional leaves per plant was counted on observation plants at 15 days interval and recorded.

3.7.4 Leaf area per plant :

The leaf area was calculated by using the plant uprooted for dry matter accumulation study, from each net

Table 5 : Details of biometric observations recorded during the present investigation

Sr. No.	Particulars	Days after sowing	Frequency
1	Emergence count	12	once
2	Plant height	30,45,60 and at harvest	four
3	Number of functional leaves/ plant	30,45,60 and at harvest	four
4	Number of branches/ Plant	30,45,60 and at harvest	four
5	Leaf area/plant	30,45,60 and at harvest	four
6	Total dry matter/ plant	30,45,60 and at harvest	four
7	Number of pods/ plant	45,60 and at harvest	three
8	Number of grains/plant	at harvest	once
9	Weight of pods/plant	at harvest	once
10	Weight of grains/plant	at harvest	once
11	Test weight	at harvest	once
12	Grain yield / plot	at harvest	once
13	pod yield / plot	at harvest	once
14	straw yield / plot	at harvest	once
15	Biological yield / plot	at harvest	once
16	Harvest index	at harvest	once

plot periodically. The leaves were separated and grouped into three grades viz., small, medium and big by visual observation. The gradewise leaves were counted and their frequency was recorded. The maximum length and maximum breadth of two representative leaves from each grade was measured and the mean was worked out. The leaf area was calculated by using the formula for each grade,

$$A = L \times B \times K \times N$$

where,

A = Leaf area in sq.cm. under particular group

L = Maximum average length of leaf in cm.

B = Maximum average breadth of leaf in cm.

N = Number of functional leaves under particular group.

K = Leaf area constant 0.6654, Sharma et al., (1987).

The leaf area of three grades was summed up and total leaf area in sq.cm per plant was calculated.

3.7.5 Number of branches per plant :

Number of branches per plant was counted and recorded on observation plants from 30 days to harvest at 15 days interval.

3.7.6 Dry matter accumulation studies :

The selected plants were uprooted carefully at every observation. The roots were removed and cleaned

plants were labled properly, air dried in the first instance and then oven dried at 70°C for 48 hrs. Their final constant dry wieghts excluding roots were recorded.

3.7.7 Number of pods per plant :

Number of pods per plant were counted and recorded on observation plants from 45 days to harvest at 15 days interval.

3.8 Growth analysis :

Data on growth charcters viz., plant height, dry matter ^{and} leaf area per plant were further subjected to workout various growth functions.

3.8.1 Absolute growth rate (AGR) :

Absolute growth rate is the total gain in height or weight of plant within a specific time interval. It is generally expressed as cm/day in case of plant height and g/day in case of dry matter production and is caluclated by formula given by Richards (1969).

$$i) \text{ AGR for plant height} = \frac{H_2 - H_1}{T_2 - T_1}$$

Where,

H_2 and H_1 referes to plant height recorded at T_2 and T_1 times, respectively.

$$\text{ii) AGR for dry matter (g/day)} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_2 and W_1 refers to total dry matter weight of plant recorded at T_2 and T_1 times, respectively.

3.8.2 Relative growth rate (RGR) :

According to Blackman (1919) the increase in the dry matter of a plant is a process of continuous compound interests, where in the increment in any time interval adds to the capital for the subsequent growth. This rate of increment is called as relative growth rate (RGR) and is expressed in g/g/day. This growth constant was worked out at 15 days interval by using the following formula given by Fisher (1921).

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{T_2 - T_1}$$

Where,

Log_e - Natural Logarithm = 2.3026

W_2 and W_1 are the total dry weights, at T_2 and T_1 times, respectively.

3.8.3 Net assimilation rate (NAR) :

According to Gregori (1926) net assimilation rate is the rate of increase of dry weight per unit leaf area and it is expressed in g/cm²/day. This growth function was calculated by using following formula,

$$\text{NAR} = \frac{(W_2 - W_1) (\text{Log}_e A_2 - \text{Log}_e A_1)}{(T_2 - T_1) (A_2 - A_1)}$$

Where,

Log_e - Natural Logarithm = 2.3026

A_2 and A_1 refers to total leaf area per plant and W_2 and W_1 refers to dry weight recorded at time T_2 and T_1 respectively.

3.8.4 Leaf area index (LAI) :

Since, the crop yield is to be expressed per unit of ground area instead of per plant, the leaf area existing on unit ground area was proposed by Watson (1952) as an appropriate measure of crop growth. This measure is known as leaf area index (LAI). It is dimensionless ratio and calculated by following formula,

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Ground area per plant (cm}^2\text{)}}$$

3.9 Post harvest studies :

3.9.1 Number of pods per plant at harvest :

The number of developed pods from five observation plants were counted and average per plant was worked out.

3.9.2 Pod weight per plant :

The dry weight of the pods separated from five observation plants were recorded and the average weight (g) per plant was worked out.

3.9.3 Grain weight per plant :

Total weight of grains after threshing pods of five observation plants was recorded and average grain weight per plant was worked out.

3.9.4 Number of grains/ pod :

The number of grains per pod of the five observation plants were counted after threshing the pods and the average number of grains was worked out.

3.9.5 Test weight :

Weight of 1000 grains from produce of each net plot was recorded in g as test weight.

3.9.6 Pod yield per plot :

The pods from each net plot were harvested and sun dried for a week. Then pods are weighed and recorded as pod yield per plot in Kg, which was converted to quintals / ha.

3.9.7 Grain yield per plot :

The dried pods from each net plot were hand threshed by using a wooden stick. Grains were cleaned after winnowing. The grain weight of clean grain per plot was recorded in Kg, which was converted to quintals /ha.

3.9.8 Straw yield :

The plants from net plot after harvesting the pods, were sun dried for a week and weighed with pod husk.

This was recorded as straw weight/ plot in kg and converted to straw yield in quintals/ha

3.9.9 Biological yield :

The weight of the harvested and sun dried plants and pods was recorded as biological yield per plot and then converted to biological yield per hectare.

3.10 Harvest index :

Harvest index indicates the yielding ability and efficiency of a crop to produce grain per unit of total

biological yield, It was calculated by following formula,

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (g/ha)}}{\text{Biological yield (g/ha)}} \times 100$$

3.11 Statistical analysis and interpretation of data :

The data obtained on various variables was analysed by " Analysis of Variance " method (Panse and Sukhatme, 1967). The total variance and degrees of freedom (n-1) were partitioned in to different possible sources. The variance due to inter row spacings, intra row spacings, varieties and interactions were compared with error variance to find out 'F' value and ultimately for testing the significances at P = 0.05. The standard errors for the treatments based on error variance were calculated. Whenever, the results were found significant, critical difference (CD) was calculated for the comparison of treatment means at 5 per cent level of significance (CD at P = 0.05).

3.12 Correlation and regression Studies :

Simple correlation coefficient (r) and regression co-efficients (b) were worked out between weight of grains per plant (Y) and following morphological characters for each variety of cowpea under study,

X_1 = Plant height

X_2 = Number of branches per plant at harvest.

X_3 = Leaf area per plant (dm^2) at 75 days after sowing

X_4 = Test weight (g)

X_5 = Number of grains / pod

X_6 = Number of pods / plant

X_7 = Harvest index

X_8 = Dry matter per plant (g)

Simple correlation co-efficients (r) were computed with the help of mini-computer of DCM. The ' r ' values obtained were tested for their significances as per the procedure described by Snedecor and Cochran (1967).

$$1. \text{ Simple correlation co-efficient (r)} = \frac{\sum X Y}{\sqrt{\sum X^2 \sum Y^2}}$$

$$2. \text{ Simple regression co-efficient (b)} = \frac{SP (X Y)}{SS (X)}$$

Where,

r = Correlation co-efficient

y = Deviation of dependent variable (Y) from its means

x = Deviation of independent variable (X) from its mean

b = regression co-efficient

$SP.XY$ = corrected co-variance of X and Y

$SS.X$ = The sum of total variation in 'X'

3.13 Yield density relation in cowpea :

The yield reciprocal of seed yield per plant was defined as the function of plant population and the relationship between them were established by least square technique. The mathematical models adopted for describing the different parameters of at these relations were as described below.

$$Y^{-1} = a + bp \dots\dots\dots (I)$$

$$Y' = p/(a+bp) \dots\dots\dots(II)$$

$$Y = Y' \times p \dots\dots\dots(III)$$

$$CI = (1 - \frac{1}{1 + Abp} \times 100) \dots\dots\dots(IV)$$

Where,

Y^{-1} - Reciprocal of yield (g/plant)

p - Plant population density (,000/ha.)

Y' - Yield per hectare (kg)

CI - Competition index

A - $1/a$



**EXPERIMENTAL
FINDINGS**



4 EXPERIMENTAL FINDINGS

The summarised data on different aspects of present investigation with statistics and their interpretations are presented in this chapter.

4.1 Emergence count and final plant stand :

Data on per cent emergene count and final plant stand are presented in Table 6.

Data presented in Table 6 indicated that there were no significant differences in emergence count as well as final plant stand at harvest indicating that the variations obtained in the different parameters under study were due to the real effects of the treatments.

4.2 Biometric observations :

3.2.1 Height of the plant :

Data on mean plant height (cm) recorded at different growth stages of the crop are presented in Table 7.

The data presented in Table 7 revealed that plant height was found to increase progressively at every stage of crop growth till maturity. The rate of increase in height was comparatively slow during early period of crop

Table 6 : Emergence count and final plant stand in per cent as influenced by the treatments

Treatments	Emergence count(per cent)	Final stand (per cent)
Inter row spacings		
R ₁ 30 cm	98.09	95.57
R ₂ 45 cm	98.16	95.27
S.E. $\pm$	0.09	0.09
C.D. at 5 %	N.S.	N.S.
Intra row spacings		
P ₁ 15 cm	98.10	95.62
P ₂ 22.5 cm	98.24	95.24
P ₃ 30 cm	98.03	95.40
S.E. $\pm$	0.11	0.12
C.D. at 5 %	N.S.	N.S.
Varieties		
V ₁ Konkan Sadabahar	98.14	95.59
V ₂ Pusa barsati	98.10	95.32
V ₃ Pusa komal	98.13	95.35
S.E. $\pm$	0.16	0.12
C.D. at 5 %	N.S.	N.S.
Interactions		
R X P		
S.E. $\pm$	0.16	0.17
C.D. at 5 %	N.S.	N.S.
R x V		
S.E. $\pm$	0.23	0.15
C.D. at 5 %	N.S.	N.S.
P x V		
S.E. $\pm$	0.28	0.19
C.D. at 5 %	N.S.	N.S.
R x P x V		
S.E. $\pm$	0.40	0.27
C.D. at 5 %	N.S.	N.S.
G.M.	98.12	95.42

growth (up to 30 days), very fast during 30 to 60 days and slowed markedly thereafter upto maturity.

Inter row spacings :

The mean plant height was not influenced by inter row spacings.

Intra row spacings :

The mean plant height was not significantly influenced by intra row spacings.

Varieties :

The effects of varieties on plant height was significant at all growth stages of crop except at 30 days.

At 45, 60 days and at harvest, variety Pusa barsati recorded significantly more plant height over Pusa Komal and Konkan sadabahar. Variety Pusa komal was also significantly superior in plant height over Konkan sadabahar at all these stages.

Interactions :

None of the interactions were observed to be significant.

Table 7 : Mean plant height (cm) at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	30	45	60	At harvest
Inter row spacings				
R ₁ 30 cm	19.75	38.19	53.74	59.12
R ₂ 45 cm	18.77	37.37	52.07	58.80
S.E. $\pm$	0.63	1.84	1.82	1.83
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Intra row spacings				
P ₁ 15 cm	19.60	37.13	50.41	56.46
P ₂ 22.5 cm	20.31	39.50	54.77	61.51
P ₃ 30 cm	17.87	36.71	53.53	58.91
S.E. $\pm$	0.77	2.26	2.23	2.25
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Varieties				
V ₁ Konkan Sadabahar	19.11	34.36	40.64	42.85
V ₂ Pusa barsati	19.28	42.61	75.12	88.46
V ₃ Pusa komal	19.38	36.36	42.96	45.57
S.E. $\pm$	1.22	1.45	1.79	1.68
C.D. at 5 %	N.S.	4.24	5.24	4.91
Interactions				
R X P				
S.E. $\pm$	1.09	3.20	3.16	3.18
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x V				
S.E. $\pm$	1.72	2.06	2.54	2.38
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
P x V				
S.E. $\pm$	2.11	2.52	3.11	2.92
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x P x V				
S.E. $\pm$	2.99	3.57	4.40	4.13
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
G.M.	19.25	37.77	52.87	58.96

4.2.2 Number of functional leaves per plant :

Data on the mean number of functional leaves per plant recorded at various growth stages of the crop are presented in Table 8.

Data presented in Table 8 revealed that, the number of functional leaves per plant increased rapidly upto 45 days and decreased thereafter till maturity.

Inter row spacings :

The effects of inter row spacings on number of functional leaves per plant were non-significant at all crop growth stages.

Intra row spacings :

The effects of intra row spacings on number of functional leaves per plant were evident at all the growth stages except at 30 days and harvest.

At 45 days after sowing intra row spacing of 30 cm and 22.5 cm were on par and they recorded significantly more number of functional leaves than 15 cm. Whereas, at 60 days, 30 cm recorded significantly higher number of functional leaves than both 15 and 22.5 cm plant spacings which were on par with each other.

Table 8 : Mean number of leaves per plant at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	30	45	60	At harvest
Inter row spacings				
R ₁ 30 cm	7.62	12.14	6.43	4.75
R ₂ 45 cm	7.42	13.68	7.69	5.34
S.E. $\pm$	0.20	0.53	0.56	0.37
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Intra row spacings				
P ₁ 15 cm	7.28	11.53	5.48	4.24
P ₂ 22.5 cm	7.30	12.73	6.59	5.14
P ₃ 30 cm	7.98	14.47	9.11	5.76
S.E. $\pm$	0.24	0.65	0.69	0.46
C.D. at 5 %	N.S.	2.05	2.19	N.S.
Varieties				
V ₁ Konkan sadabahar	8.40	15.11	9.68	8.65
V ₂ Pusa barsati	6.97	11.98	6.74	4.73
V ₃ Pusa komal	7.10	11.64	4.76	1.76
S.E. $\pm$	0.39	0.71	0.49	0.75
C.D. at 5 %	1.15	2.07	1.45	2.20
Interactions				
R X P				
S.E. $\pm$	0.34	0.92	0.98	0.65
C.D. at 5 %	N.S.	2.90	N.S.	N.S.
R x V				
S.E. $\pm$	0.56	1.00	0.70	1.07
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
P x V				
S.E. $\pm$	0.68	1.23	0.86	1.31
C.D. at 5 %	N.S.	N.S.	2.51	N.S.
R x P x V				
S.E. $\pm$	0.97	1.74	1.22	1.85
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
G.M.	7.52	12.91	7.06	5.04

Varieties :

The number of functional leaves per plant were significantly influenced by the varieties at all growth stages.

The variety Konkan sadabahar produced significantly more number of functional leaves than variety Pusa barsati and Pusa komal. Similarly, Pusa barsati produced more number of functional leaves than Pusa komal except at 30 days and 45 days, where Pusa barsati and Pusa komal were on par.

Interactions :

None of the interactions was found to be significant except the interaction effect of row x plant spacing at 45 DAS and plant spacing x variety at 60 DAS and the relevant data are presented in Table 9 and Table 10, respectively. Data presented in Table 9 revealed that, the maximum number of leaves per plant (15.33) was recorded by $R_1 \times P_3$ (30 x 30 cm) and the lowest (10.00) by $R_1 \times P_1$ (30 x 15 cm) treatment combination. Every increase in plant spacing significantly increased the number of leaves only under 30 cm row spacing indicating the superiority of square planting. The 45 cm row spacing

Table 9 : Mean number of leaves per plant as influenced by the interaction of row and plant spacing at 45 days.

Row Spacings (cm)	Plant spacings (cm)		
	P ₁ (15)	P ₂ (22.5)	P ₃ (30)
R ₁ (30)	10.00	11.11	15.33
R ₂ (45)	13.06	14.35	13.62
S.E. $\pm$	0.92		
C.D. at 5%	2.90		

Table 10 : Mean number of leaves per plant as influenced by the interaction of plant spacing and variety at 60 days

Varieties	Plant spacings (cm)		
	P ₁ (15)	P ₂ (22.5)	P ₃ (30)
V ₁ (Konkan Sadabahar)	5.60	6.76	4.10
V ₂ (Pusa barsati)	10.36	5.33	4.10
V ₃ (Pusa komal)	13.10	8.13	6.10
S.E. $\pm$	0.86		
C.D. at 5%	2.51		

proved superior over 30 cm row spacing under 15 cm and 22.5 cm plant spacing.

Data presented in Table 10 on interaction effect of P x V at 60 DAS indicated that number of leaves per plant for variety Pusa komal were significantly superior over Pusa barsati and Konkan sadabahar at 15 cm plant spacing. While Pusa komal was superior to Pusa barsati but on par with Konkan sadabahar at 22.5 cm plant spacing, however, varieties did not differed in number of functional leaves per plant at 30 cm plant spacing. The maximum number of functional leaves per plant were recorded at treatment combination Pusa komal x 15 cm (13.1) and minimum (4.1) with Konkan sadabahar and Pusa barsati at 30 cm.

4.2.3 Leaf area per plant :

Data on mean leaf area per plant (dm^2) as influenced by various treatments at different growth stages of crop are presented in Table 11.

Mean leaf area per plant increased rapidly upto 45 days and thereafter rate of increase was observed to be slow.

Inter row spacings :

Mean leaf area per plant was not significantly influenced by inter row spacing during all the stages of crop growth.

Intra row spacing :

The effect of different intra row spacings on leaf area per plant was found to be non-significant at all stages except at 45 DAS.

At 45 DAS, the plant spacing of 30 and 22.5 cm were on par and they recorded significantly higher leaf area than plant spacing of 15 cm.

Varieties :

Varietal differences in respect of leaf area per plant were observed significant at all stages of crop growth.

At 30 DAS, Pusa komal recorded significantly higher leaf area per plant than Pusa barsati and Konkan sadabahar. However, at 45 DAS, Pusa komal and Pusa barsati were on par and they produced significantly higher leaf area over Konkan sadabahar.

Table 11 : Mean leaf area per plant (dm²) at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	30	45	60	At harvest
Inter row spacings				
R ₁ 30 cm	5.15	11.80	12.49	14.33
R ₂ 45 cm	5.18	12.69	13.02	18.02
S.E. $\pm$	0.54	0.66	2.31	1.51
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Intra row spacings				
P ₁ 15 cm	4.44	9.55	10.63	14.00
P ₂ 22.5 cm	5.10	12.82	11.16	16.21
P ₃ 30 cm	5.95	14.36	16.47	18.32
S.E. $\pm$	0.66	0.81	2.84	1.85
C.D. at 5 %	N.S.	2.55	N.S.	N.S.
Varieties				
V ₁ Konkan sadabahar	4.39	7.84	7.26	18.33
V ₂ Pusa barsati	4.41	15.80	22.60	25.71
V ₃ Pusa komal	6.70	13.09	8.40	4.49
S.E. $\pm$	0.52	1.39	2.47	1.80
C.D. at 5 %	1.52	4.06	7.22	5.25
Interactions				
R X P				
S.E. $\pm$	0.94	1.14	4.01	2.62
C.D. at 5 %	0.29	3.60	N.S.	N.S.
R x V				
S.E. $\pm$	0.74	1.97	3.50	2.55
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
P x V				
S.E. $\pm$	0.97	2.14	4.29	3.12
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x P x V				
S.E. $\pm$	1.2	3.41	6.06	4.41
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
G.M.	5.16	12.24	12.75	16.17

At 60 DAS, the variety Pusa barsati proved significantly superior over Konkan sadabahar and Pusa Komal. Same trend of variation in leaf area per plant due to varieties was observed at harvest.

Interactions :

The interaction effects of row and plant spacing were observed significant at 30 and 45 DAS and relevant data are presented in Table 12 and 13, respectively.

Data presented in Table 12 revealed that the inter row spacing of 30 cm was significantly superior over 45 cm row spacing at 15 and 30 cm plant spacing. However, at 22.5 cm plant spacing, the row spacing of 45 cm was superior over 30 cm. The maximum leaf area per plant (7.5 dm^2) was observed at treatment combination of $R_1 \times P_3$ and minimum at $R_2 \times P_1$ (4.01 dm^2).

At 45 DAS, (Table 13) the inter row spacing of 45 cm was significantly superior than 30 cm in respect of leaf area per plant at 15 and 22.5 cm plant spacing only.

However, under 30 cm plant spacing, a spacing of 30 x 30 cm proved significantly superior over 45 x 30 cm in respect of leaf area per plant.

Table 12 : Mean leaf area (dm^2) per plant as influenced by the interaction of row and plant spacing at 30 days.

Row Spacings (cm)	Plant spacings (cm)		
	P ₁ (15)	P ₂ (22.5)	P ₃ (30)
R ₁ (30)	4.88	3.08	7.50
R ₂ (45)	4.01	7.13	4.41
S.E. $\pm$	0.94		
C.D. at 5%	2.96		

Table 13 : Mean leaf area (dm^2) per plant as influenced by the interaction of row and plant spacing at 45 days.

Row Spacings (cm)	Plant spacings (cm)		
	P ₁ (15)	P ₂ (22.5)	P ₃ (30)
R ₁ (30)	7.89	11.09	16.40
R ₂ (45)	11.20	14.55	12.32
S.E. $\pm$	1.14		
C.D. at 5%	3.60		

The maximum (16.40 dm²) leaf area per plant was noted at treatment combination R₁ x P₃ and minimum (7.89 dm²) at R₁ x P₁.

4.2.4 Number of branches per plant :

Data on mean number of branches per plant as influenced by treatments at various growth stages are presented in Table 14.

Data presented in Table 14 revealed that, the number of branches per plant increased gradually and reached maximum at maturity.

Inter row spacing :

The effects of inter row spacings on number of branches per plant were non-significant at all stages of crop growth.

Intra row spacings :

The effects of intra row spacings on mean number of branches per plant were significant only at 60 days and harvest.

The wider plant spacing of 30 cm being on par with 22.5 cm recorded significantly more number of branches per plant than 15 cm at 60 days and harvest.

Table 14 : Mean number of branches per plant at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	30	45	60	At harvest
Inter row spacings				
R ₁ 30 cm	0.94	3.40	5.77	6.12
R ₂ 45 cm	1.00	3.48	6.45	6.61
S.E. $\pm$	0.26	0.18	0.25	0.31
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Intra row spacings				
P ₁ 15 cm	0.78	2.97	5.07	5.41
P ₂ 22.5 cm	1.17	3.46	6.30	6.83
P ₃ 30 cm	0.94	3.87	6.96	7.16
S.E. $\pm$	0.32	0.22	0.31	0.38
C.D. at 5 %	N.S.	N.S.	0.99	1.20
Varieties				
V ₁ Konkan sadabahar	1.12	4.67	7.44	7.37
V ₂ Pusa barsati	1.06	2.55	4.65	5.16
V ₃ Pusa komal	0.72	3.68	6.55	6.56
S.E. $\pm$	0.29	0.22	0.22	0.24
C.D. at 5 %	N.S.	0.64	0.66	0.71
Interactions				
R X P				
S.E. $\pm$	0.46	0.31	0.44	0.54
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x V				
S.E. $\pm$	0.41	0.31	0.32	0.34
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
P x V				
S.E. $\pm$	0.50	0.38	0.39	0.42
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x P x V				
S.E. $\pm$	0.71	0.54	0.56	0.60
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
G.M.	0.96	3.48	6.11	6.36

Varieties :

The number of branches per plant were significantly influenced by the varieties at all the stages except at 30 DAS.

It was found that, variety Konkan sadabahar produced significantly more number of branches per plant followed by Pusa komal and Pusa barsati.

Interactions :

None of the interaction was significant.

4.2.5 Dry matter accumulation per plant :

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

The data presented in Table 15 indicated that the total dry matter accumulation per plant was increased up to 60 days after sowing and slightly decreased at harvest. The increase in dry matter was comparatively very slow during early period of crop growth (up to 30 days), fast during 30 to 60 days and decreased slightly at harvest.

Inter row spacings :

The effects of inter row spacings on dry matter accumulation per plant were non-significant at all crop growth stages.

Intra row spacing :

The effect of intra row spacing on dry matter accumulation per plant was significant only at 60 days after sowing and at harvest. At both these stages, the dry matter accumulation per plant was increased with increase in intra row spacing.

Varieties :

The varieties influenced the dry matter accumulation per plant only at 60 days and harvest. The variety Pusa barsati recorded significantly more dry matter weight per plant than Pusa komal and Konkan sadabahar at both these stages. Similarly, Konkan sadabahar was superior to Pusa komal at harvest.

Interactions :

None of the interaction was found significant.

Table 15 : Mean dry matter weight (g) per plant at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	30	45	60	At harvest
Inter row spacings				
R ₁ 30 cm	3.03	12.73	18.65	16.27
R ₂ 45 cm	2.91	11.71	18.64	18.47
S.E. $\pm$	0.23	1.11	1.41	1.39
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
Intra row spacings				
P ₁ 15 cm	2.84	10.50	14.52	14.88
P ₂ 22.5 cm	2.80	13.29	17.80	16.56
P ₃ 30 cm	3.27	12.86	23.62	22.66
S.E. $\pm$	0.28	1.36	1.72	1.70
C.D. at 5 %	N.S.	N.S.	5.43	5.10
Varieties				
V ₁ Konkan sadabahar	2.88	13.18	17.06	16.40
V ₂ Pusa barsati	2.46	11.13	23.60	23.92
V ₃ Pusa komal	3.58	12.34	15.28	11.79
S.E. $\pm$	0.36	1.40	1.99	1.58
C.D. at 5 %	N.S.	N.S.	5.80	4.60
Interactions				
R X P				
S.E. $\pm$	0.40	1.93	2.44	2.40
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x V				
S.E. $\pm$	0.52	1.98	2.81	2.23
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
P x V				
S.E. $\pm$	0.63	2.42	3.44	2.73
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
R x P x V				
S.E. $\pm$	0.90	3.43	4.87	3.87
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.
G.M.	2.97	12.21	18.90	17.36

4.2.6 Number of pods per plant :

Data on mean number of pods per plant at different growth stages as influenced by various treatments are presented in Table 16. The data revealed that the increase in pod number was observed to be comparatively more during 45 to 60 DAS.

Inter row spacings :

The mean number of pods per plant were significantly influenced by inter row spacing. Wider inter row spacing of 45 cm recorded significantly more number of pods per plant than 30 cm at all stages of crop growth.

Intra row spacing :

The intra row spacings significantly influenced the mean number of pods per plant at 60 days and harvest.

At 60 days after sowing the mean number of pods per plant were increased significantly with every increase in intra row spacing. Whereas, at harvest, the intra row spacing of 30 cm and 22.5 cm were on par and they recorded significantly higher mean number of pods per plant than 15 cm.

Table 16 : Mean number of pods per plant at various growth stages as influenced by the treatments

Treatments	Days after sowing		
	45	60	At harvest
Inter row spacings			
R ₁ 30 cm	4.94	6.66	8.23
R ₂ 45 cm	6.77	8.65	9.74
S.E. $\pm$	0.56	0.32	0.46
C.D. at 5 %	1.78	1.00	1.45
Intra row spacings			
P ₁ 15 cm	4.94	5.73	6.62
P ₂ 22.5 cm	5.67	7.60	9.93
P ₃ 30 cm	6.95	9.64	10.42
S.E. $\pm$	0.69	0.39	0.56
C.D. at 5 %	N.S.	1.24	1.78
Varieties			
V ₁ Konkan sadabahar	8.28	9.91	10.93
V ₂ Pusa barsati	1.18	3.38	6.12
V ₃ Pusa komal	8.10	9.61	9.92
S.E. $\pm$	0.54	0.52	0.81
C.D. at 5 %	1.58	1.53	2.36
Interactions			
R X P			
S.E. $\pm$	0.98	0.55	0.80
C.D. at 5 %	N.S.	N.S.	N.S.
R x V			
S.E. $\pm$	0.77	0.83	1.14
C.D. at 5 %	N.S.	2.44	N.S.
P x V			
S.E. $\pm$	0.94	1.02	1.40
C.D. at 5 %	N.S.	2.99	N.S.
R x P x V			
S.E. $\pm$	1.33	1.45	1.98
C.D. at 5 %	N.S.	N.S.	N.S.
G.M.	5.85	7.64	8.98

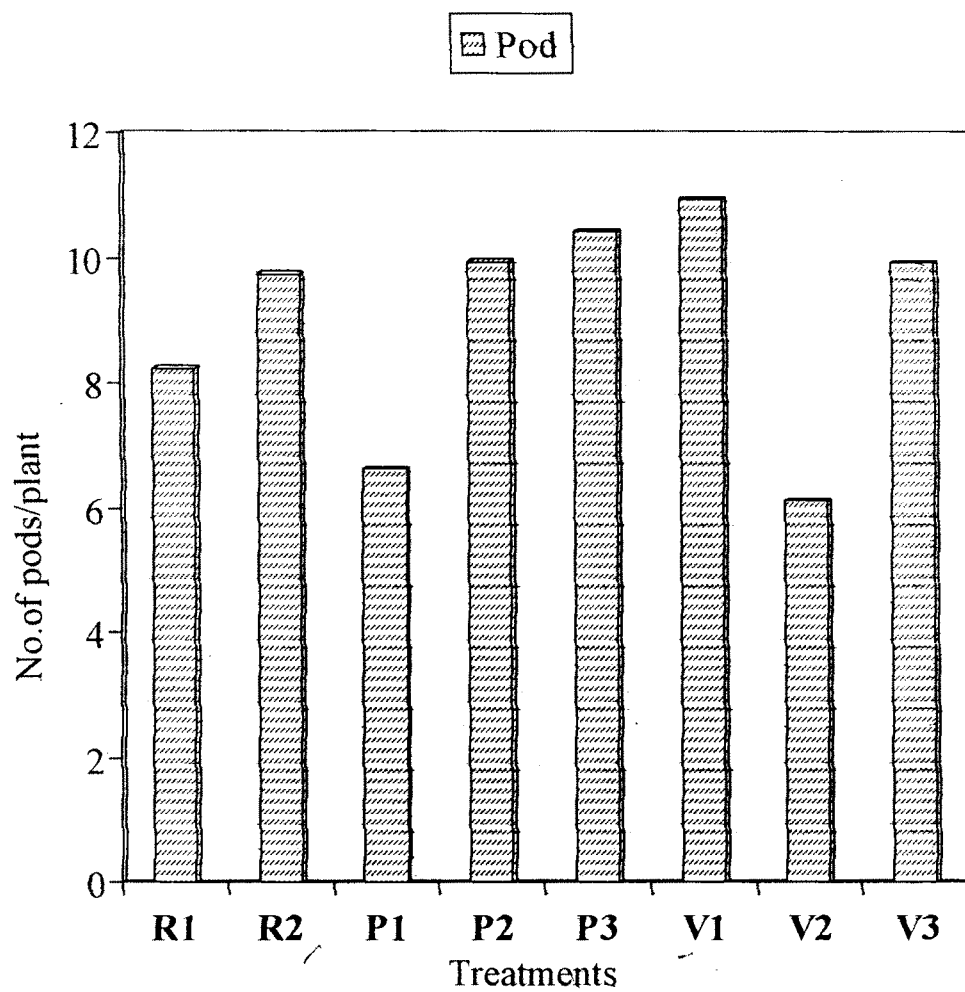


Fig 2: Number of Pods per plant at harvest as influenced by the treatments

Varieties :

The mean number of pods per plant were significantly influenced by different varieties at all stages of crop growth.

At all crop growth stages, variety Konkan sadabahar recorded significantly higher mean number of pods per plant than Pusa barsati and was on par with variety Pusa komal.

Interactions :

The interaction effects of row spacing x variety and plant spacing x variety were found significant at 60 days after sowing and the relevant data are presented in Table 17 and 18, respectively.

Data presented in Table 17 revealed that, the mean number of pods were increased with increased row spacing under each variety. The treatment combination of, 45 cm row spacing x Konkan sadabahar recorded the highest (13.44) mean number of pods per plant, whereas 30 cm row spacing x Pusa barsati recorded the lowest (1.82) mean number of pods per plant.

Data presented in Table 18 revealed that, the maximum number of pods (14.10) per plant was recorded by

Table 17 : Mean number of pods per plant as influenced by interaction of row spacing and variety at 60 days.

Row Spacings (cm)	Varieties		
	Konkan Sadabahar	Pusa barsati	Pusa komal
R ₁ (30)	9.37	1.82	8.80
R ₂ (45)	13.44	3.98	10.35
S.E. $\pm$	0.83		
C.D. at 5%	2.14		

Table 18 : Mean number of pods per plant as influenced by interaction of plant spacing and variety at 60 days

Row Spacings (cm)	Varieties		
	Konkan Sadabahar	Pusa barsati	Pusa komal
P ₁ (15)	8.56	2.00	6.63
P ₂ (22.5)	10.70	2.03	10.06
P ₃ (30)	14.10	1.93	12.90
S.E. $\pm$	1.02		
C.D. at 5%	2.99		

The treatment combination of 30 cm plant spacing x Konkan sadabahar and the lowest (1.93) by same plant spacing with Pusa barsati. The intra row spacing of 30 and 22.5 cm were on par and they produced significantly more number of pods per plant than intra row spacing of 15 cm in variety Konkan sadabahar and Pusa komal but, pod number did not differ significantly in variety Pusa barsati due to plant spacings.

4.3 Growth analysis :

4.3.1 Absolute growth rate (AGR) (plant height) :

Mean values of absolute growth rate (AGR) of plant height in cm/day/plant obtained at various stages of crop growth are presented in Table 19.

Data presented in Table 19 indicated that, AGR for plant height was slow during early stage (up to 30 days), increased rapidly during 30 to 45 days and decreased slowly thereafter till maturity.

Inter row spacings :

The inter row spacing of 30 cm recorded higher AGR on plant height at 30 and 60 days and reverse trend was observed at 45 days and harvest.

Table 19 : Mean absolute growth rate (AGR) (cm/day/plant) of plant height at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	0-30	30-45	45-60	At harvest

Inter row spacings				
R ₁ 30 cm	0.6583	1.2293	1.0366	0.3586
R ₂ 45 cm	0.6256	1.2400	0.9800	0.4486
Intra row spacings				
P ₁ 15 cm	0.6553	1.1686	0.8853	0.4033
P ₂ 22.5 cm	0.6770	1.2786	1.1086	0.4493
P ₃ 30 cm	0.5956	1.2560	1.1073	0.3726
Varieties				
V ₁ Konkan sadabahar	0.6370	1.0166	0.4186	0.1473
V ₂ Pusa Barsati	0.6426	1.5553	2.1673	0.8893
V ₃ Pusa Komal	0.6460	1.1320	0.4400	0.1740

G.M.	0.6419	1.2345	1.0067	0.4053

Intra row spacings :

The intra row spacing of 22.5 cm recorded higher AGR on plant height than 30 cm and 15 cm at all stages of crop growth.

Varieties :

The variety Pusa barsati recorded comparatively higher AGR on plant height than Pusa komal and Konkan sadabahar at all stages of crop growth except at 30 days, where Pusa komal recorded higher value of AGR than Pusa barsati and Konkan sadabahar.

4.3.2 Absolute growth rate (AGR) (dry matter) :

Mean values of AGR on dry matter (g/day/plant) obtained at various growth stages are presented in Table 20. Data presented in Table 20 in general indicated that AGR for total dry matter was increased upto 45 DAS and thereafter decreased up to maturity.

Inter row spacings :

The AGR on dry matter per plant were decreased with increased row spacing at all crop growth stages except at 60 DAS.

Table 20 : Mean absolute growth rate (AGR)(g/day/plant)
of dry matter at various growth stages as
influenced the by the treatments

Treatments	Days after sowing			
	0-30	30-45	45-60	At harvest
Inter row spacings				
R ₁ 30 cm	0.1010	0.6466	0.3946	0.1586
R ₂ 45 cm	0.097	0.5866	0.4620	0.0113
Intra row spacings				
P ₁ 15 cm	0.0946	0.5106	0.4146	0.1226
P ₂ 22.5 cm	0.0933	0.6090	0.3006	0.0826
P ₃ 30 cm	0.1090	0.6393	0.7173	0.1973
Varieties				
V ₁ Konkan sadabahar	0.0960	0.6866	0.1293	0.2220
V ₂ Pusa Barsati	0.0820	0.5780	0.8313	0.0213
V ₃ Pusa Komal	0.1193	0.5840	0.3146	0.0440
G.M.	0.0990	0.6163	0.4455	0.1074

Intra row spacings :

The intra row spacing of 30 cm recorded higher AGR on dry matter per plant than 22.5 cm and 15 cm at all stages of crop growth. Similarly intra row spacing of 15 cm observed superior over 22.5 cm at these stages except at 45 DAS.

Varieties :

No consistent trend of variation in AGR was observed due to varieties.

4.3.2 Relative growth rate (RGR) :

Mean values of relative growth rate (RGR) in g/g/day at various growth stages are presented in Table 21.

Data presented in Table 21 revealed that the RGR reached to its maximum (0.0885) during 30 to 45 days of crop growth and thereafter there was decrease in the values of RGR, till maturity.

Inter row spacings :

The differences in RGR values due to row spacings were marginal at 30 days and thereafter the differences in RGR values were substantial. The narrow row spacing of

Table 21 : Mean relative growth rate (RGR) (g/g/day)
per plant as influenced by the treatments

Treatments	Days after sowing			
	0-30	30-45	45-60	At harvest
Inter row spacings				
R ₁ 30 cm	0.0369	0.0956	0.0354	0.0091
R ₂ 45 cm	0.0356	0.0464	0.0309	0.0012
Intra row spacings				
P ₁ 15 cm	0.0347	0.0871	0.0310	0.0077
P ₂ 22.5 cm	0.0343	0.0838	0.0194	0.0048
P ₃ 30 cm	0.0394	0.0912	0.0405	0.0089
Varieties				
V ₁ Konkan sadabahar	0.0352	0.1014	0.0091	0.0165
V ₂ Pusa barsati	0.0300	0.1006	0.0501	0.0009
V ₃ Pusa Komal	0.0425	0.0825	0.0215	0.0026
G.M.	0.0360	0.0885	0.0284	0.0064

30 cm recorded higher values of RGR than 45 cm, at all stages of crop growth.

Intra row spacings :

The intra row spacing of 30 cm recorded higher values of RGR at all stages of crop growth. Similarly, intra row spacing of 15 cm was superior to 22.5 cm in respect of RGR values at all these stages.

Varieties :

Varietal differences in respect of RGR at various growth stages were inconsistent.

4.3.4 Net assimilation rate (NAR) :

Mean values of NAR ($\text{g/cm}^2/\text{day}$) computed from the data on total dry matter and leaf area at various growth stages are presented in Table 22.

Data presented in Table 22 revealed that, NAR found to be increased rapidly up to 60 DAS and decreased later on till harvest.

In general, row spacing of 30 cm recorded higher values of NAR than 45 cm during advanced life period of the crop but during later stages, 45 cm recorded more values of NAR.

Table 22 : Mean net assimilation rate (NAR) (g/cm²/day) at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	0-30	30-45	45-60	At harvest
Inter row spacings				
R ₁ 30 cm	0.000321	0.000806	0.000325	0.000118
R ₂ 45 cm	0.000300	0.000699	0.000359	0.000736
Intra row spacings				
P ₁ 15 cm	0.000317	0.000765	0.000441	0.000183
P ₂ 22.5 cm	0.000298	0.000835	0.000251	0.000611
P ₃ 30 cm	0.000326	0.000669	0.000466	0.000113
Varieties				
V ₁ Konkan sadabahar	0.000323	0.001154	0.000171	0.000185
V ₂ Pusa barsati	0.000275	0.000647	0.000437	0.000884
V ₃ Pusa Komal	0.000338	0.000612	0.000297	0.006839
G.M.	0.002506	0.006187	0.005672	0.005168

Varirations in NAR values due to intra row spacings and varieties were inconsistant.

4.3.5 Leaf area index (LAI) :

Data on mean leaf area index (LAI) at various growth stages are presented in Table 23.

Inter row spacings :

The narrow inter row spacings of 30 cm recorded higher LAI than the wider spacing of 45 cm at all growth stages.

Intra row spacings :

The narrow intra row spacing of 15 cm recorded higher LAI than the wider spacing of 22.5 cm and 30 cm at all stages of crop growth. Similarly, 22.5 cm intra row spacing was superior over 30 cm at all the stages of crop growth.

Varieties :

The LAI values of variety Pusa barsati were higher than other varieties at all stages of crop growth except at 30 DAS, where Pusa komal recorded the highest LAI.

Table 23 : Mean leaf area index (LAI) at various growth stages as influenced by the treatments

Treatments	Days after sowing			
	0-30	30-45	45-60	At harvest
Inter row spacings				
R ₁ 30 cm	0.791	1.740	1.931	2.278
R ₂ 45 cm	0.541	1.336	1.311	1.835
Intra row spacings				
P ₁ 15 cm	0.839	1.706	1.959	2.590
P ₂ 22.5 cm	0.580	1.540	1.420	1.941
P ₃ 30 cm	0.570	1.367	1.403	1.640
Varieties				
V ₁ Konkan sadabahar	0.548	0.980	0.940	2.259
V ₂ Pusa Barsati	0.598	1.983	2.863	3.259
V ₃ Pusa komal	0.852	1.650	1.059	0.652
G.M.	0.6648	1.5377	1.6107	2.0567

4.4 Post harvest studies :

Data on post harvest yield attributes viz., number of pods per plant at harvest, weight of pods per plant, number of grains per pod, grain weight per plant and test weight are presented in Table 24.

4.4.1 Number of pods per plant :

Data on mean number of pods per plant as influenced by various treatments are presented in Table 24, which indicated that mean number of pods were 8.98 per plant.

Inter row spacings :

The number of pods per plant were significantly influenced due to inter row spacings. The wider row spacing of 45 cm produced significantly more number of pods per plant than 30 cm row spacing.

Intra row spacings :

The number of pods per plant were increased with increased intra row spacing. The intra row spacing of 30 cm was found significantly superior over 15 and on par with 22.5 cm. Similarly, intra row spacing of 22.5 cm was significantly superior over 15 cm in respect of number of pods per plant.

Varieties :

The number pods per plant were influenced significantly by various varieties.

Variety Konkan sadabahar and Pusa komal were on par in producing number of pods per plant and they were significantly superior over Pusa barsati.

Interactions :

None of the interaction was found to be significant.

4.4.2 Pod Weight per plant :

Data on pod weight per plant presented in Table 24 revealed that, mean pod weight per plant was 7.13 g.

Inter row spacings :

Inter row spacings significantly influenced the weight of pods per plant. Wider row spacing of 45 cm produced significantly more pod weight per plant than 30 cm.

Intra row spacings :

The weight of pods per plant was significantly influenced by the intra row spacings. Intra row spacings

Table 24 : Mean number of pods per plant at harvest, weight of pods per plant, number of grains per pod, grain weight per plant and test weight as influenced by the treatments

Treatments	No.of pods/ plant	Wt.of pods/ plant(g)	No.of Grains/ pod	Grain wt./ plant(g)	1000 seed wt.
Inter row spacings					
R ₁ 30 cm	8.23	6.41	6.66	4.29	78.63
R ₂ 45 cm	9.74	7.83	6.96	5.21	78.65
S.E. $\pm$	0.46	0.42	0.32	0.23	0.94
C.D. at 5 %	1.45	1.34	N.S.	0.72	N.S.
Intra row spacings					
P ₁ 15 cm	6.62	5.05	6.64	3.51	79.08
P ₂ 22.5 cm	9.93	7.58	6.68	4.90	77.59
P ₃ 30 cm	10.42	8.79	7.10	5.84	79.25
S.E. $\pm$	0.56	0.52	0.40	0.28	1.16
C.D. at 5 %	1.78	1.65	N.S.	0.89	N.S.
Varieties					
V ₁ Konkan sadabahar	10.93	8.84	7.79	5.92	85.00
V ₂ Pusa barsati	6.12	5.21	5.58	3.13	88.78
V ₃ Pusa komal	9.92	7.38	6.88	5.20	82.14
S.E. $\pm$	0.81	0.50	0.42	0.38	1.22
C.D. at 5 %	2.36	1.48	1.23	1.13	3.56
Interactions					
R x P					
S.E. $\pm$	0.80	0.74	0.56	0.40	1.64
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
R x V					
S.E. $\pm$	1.14	0.71	0.59	0.55	1.72
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
P x V					
S.E. $\pm$	1.40	0.88	0.73	0.67	2.11
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
R x P x V					
S.E. $\pm$	1.98	1.24	1.03	0.95	2.99
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
G.M.	8.98	7.13	6.80	4.75	81.14

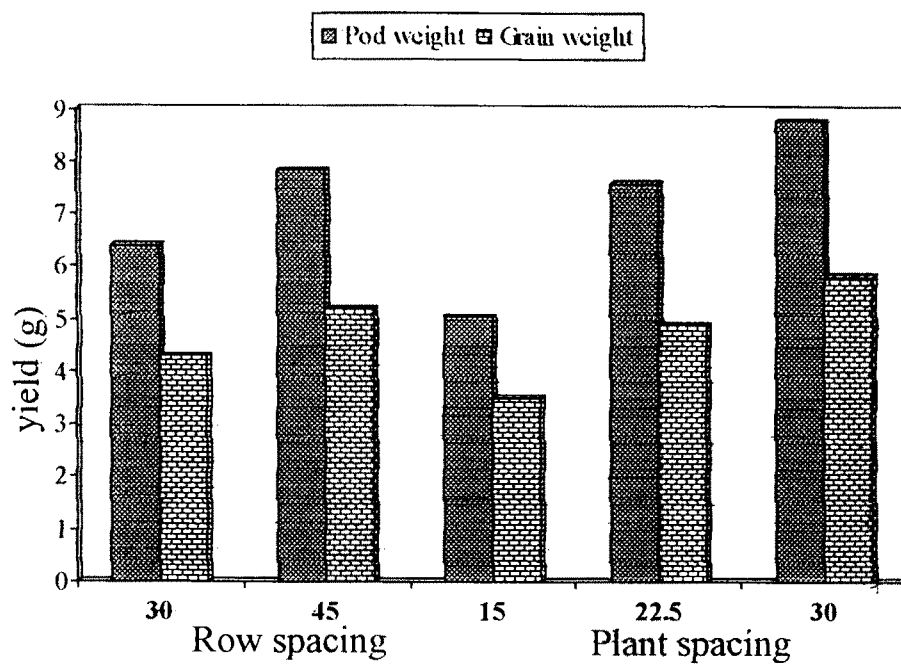


Fig 3 : Pod weight and Grain weight (g) per plant as influenced by the row and plant spacings.

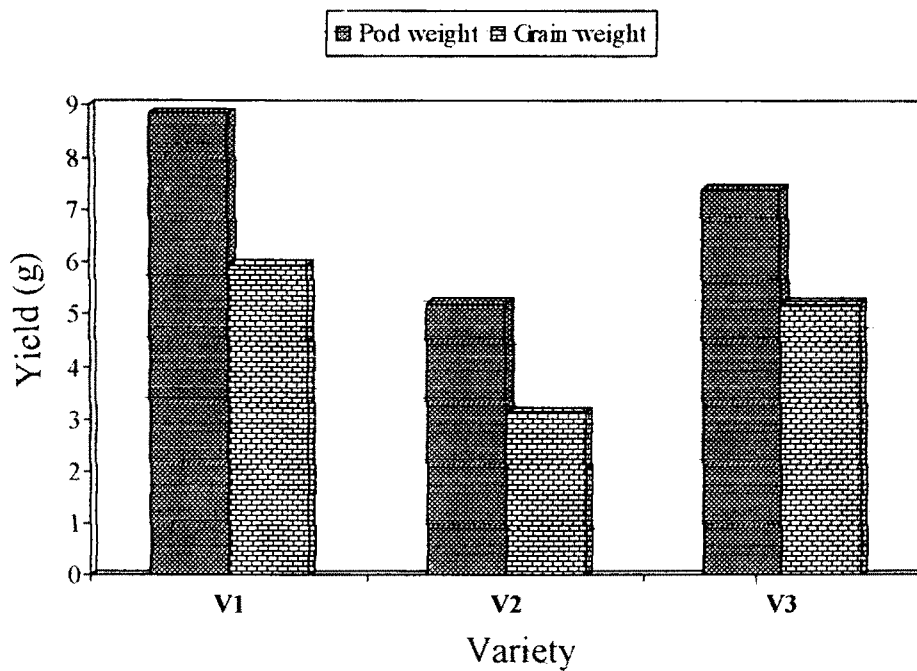


Fig 4 : Pod weight and grain weight (g) per plant as influenced by the varieties

of 30 and 22.5 cm were on par and they recorded significantly higher pod weight per plant than the intra row spacing of 15 cm.

Varieties :

The weight of pods per plant was significantly influenced by different varieties.

Variety Konkan sadabahar was significantly superior in pod weight per plant over Pusa barsati but on par with Pusa komal.

Interactions :

None of the interactions found to be significant in influencing the pod weight per plant.

4.4.3 Number of grains per pod :

Data presented in Table 24 indicated that the mean number of grains per pod was 6.80.

Inter row spacings :

The effects of inter row spacings on mean number of grains per pod was non-significant.

Intra row spacings :

The effects of intra row spacings on mean number

of grains per pod was non-significant.

Varieties :

The varieties significantly influenced the mean number of grains per pod.

Variety konkan sadabahar and pusa komal were on par and they recorded significantly higher number of grains per pod than variety Pusa barsati.

Interactions :

The effects of interactions on mean number of grains per pod observed non-significant.

4.4.4 Grain weight per plant :

Data in Table 24 revealed that mean grain weight per plant was 4.75 g.

Inter row spacings :

Inter row spacings significantly influenced the grain weight per plant. Wider inter row spacing of 45 cm produced more grain weight per plant than narrow spacing of 30 cm.

Intra row spacings :

The effects of intra row spacings on grain weight

per plant were significant and it was observed that the grain weight per plant was significantly increased with every increase in intra row spacing.

Varieties :

The grain weight per plant was significantly influenced by varieties. The variety Konkan sadabahar was significantly superior over Pusa barsati and on par with Pusa komal in respect of grain weight per plant.

Interactions :

The effects of interactions on weight of grain per plant were non-significant.

4.4.5 Test weight :

Data on test weight presented in Table 24 revealed that the test weight was not significantly influenced by various inter and intra row spacings, but was influenced significantly by various varieties.

The significant effects of varieties indicated that, variety Pusa barsati was significantly superior over other varieties. However, Konkan sadabahar and Pusa komal were on par in test weight.

Interactions :

The effects of different interactions on test weight were non-significant.

4.5 Yield :

Data on grain, pod, straw, biological yield per hectare and harvest index as influenced by various treatment are presented in Table 25.

4.5.1 Grain yield :

The data on grain yield (q/ha) presented in Table 25 revealed that, inter as well as intra row spacings did not influence significantly the grain yield. Varieties :

The variety Konkan sadabahar was significantly superior in producing grain yield /ha than Pusa komal and Pusa barsati. The variety Pusa komal also produced significantly higher grain yield /ha than Pusa barsati.

Interactions :

None of the interactions observed significant except the interaction of inter row spacing x variety and the relevant data are presented in Table 26.

Table 25 : The grain, pod, straw, biological yields and harvest index as influenced by the treatments

Treatments	Grain yield q/ha	Pod yield q/ha	Straw yield q/ha	Biological yield q/ha	Harvest Index (%)
Inter row spacings					
R ₁ 30 cm	9.58	14.81	13.91	28.48	33.33
R ₂ 45 cm	8.41	13.02	12.48	25.50	33.52
S.E. $\pm$	0.55	0.78	0.75	1.29	0.84
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
Intra row spacings					
P ₁ 15 cm	8.99	14.12	13.62	27.74	32.25
P ₂ 22.5 cm	9.39	14.07	13.57	27.62	34.30
P ₃ 30 cm	8.61	13.54	12.41	25.61	33.35
S.E. $\pm$	0.67	0.95	0.92	1.59	1.04
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
Varieties					
V ₁ Konkan sadabahar	12.94	20.07	9.24	28.97	44.16
V ₂ Pusa barsati	5.04	7.99	20.69	28.68	17.16
V ₃ Pusa komal	9.01	13.67	9.68	23.32	38.58
S.E. $\pm$	0.46	0.72	0.35	0.91	0.92
C.D. at 5 %	1.35	4.73	1.02	2.67	2.70
Interactions					
R X P					
S.E. $\pm$	0.95	1.35	1.30	2.25	1.47
D.E. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
R x V					
S.E. $\pm$	0.64	1.01	0.49	1.29	1.31
C.D. at 5 %	1.91	2.99	N.S.	0.24	N.S.
P x V					
S.E. $\pm$	0.80	1.25	0.60	1.58	1.60
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
R x P x V					
S.E. $\pm$	1.12	1.77	0.85	2.24	2.27
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.	N.S.
G.M.	8.99	13.91	13.2	26.99	33.3

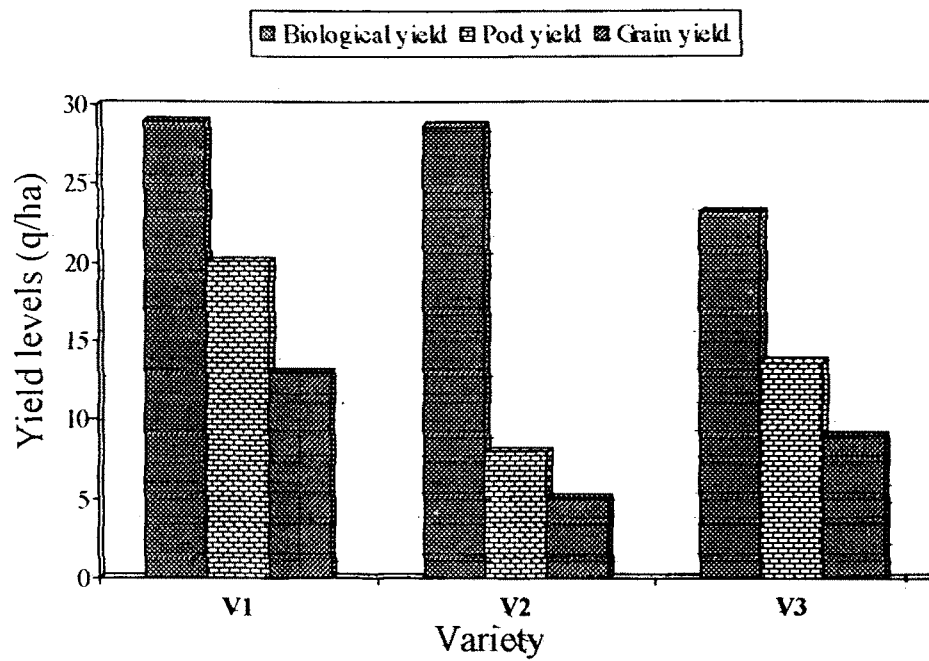


Fig 5: Biological, pod and Grain yields as influenced by the varieties

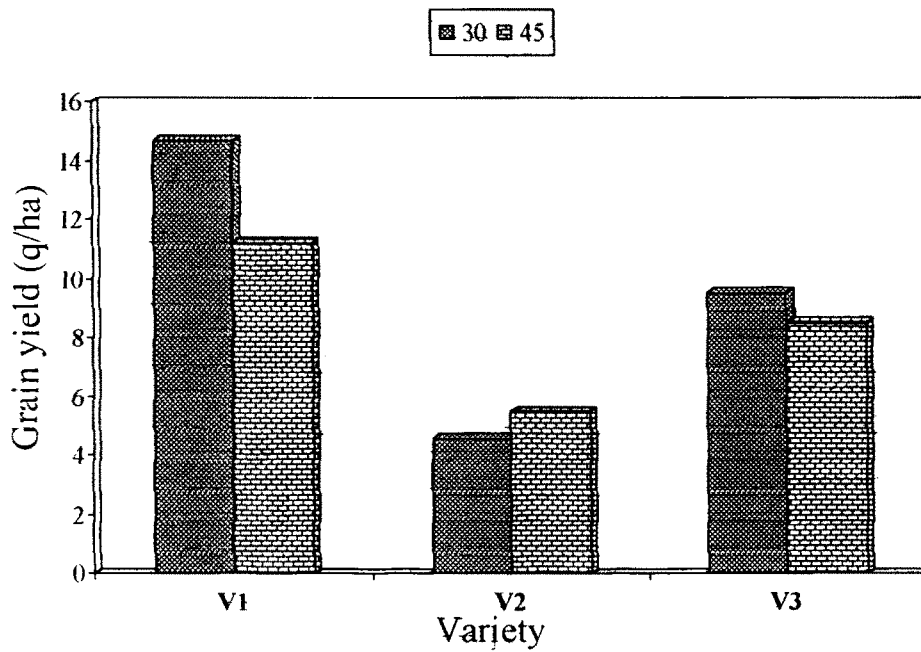


Fig 6: Grain yield (q/ha) of cowpea as influenced by the interaction of row spacing x variety

The data presented in Table 26 revealed that, the treatment combination $R_1 \times V_1$ i.e. variety Konkan sadabahar with 30 cm row spacing recorded significantly higher grain yield /ha than rest of the row spacing and varietal combinations. The lowest grain yield was recorded by Pusa barsati with 30 cm row spacing.

Under both 30 and 45 cm row spacings, variety Konkan sadabahar proved significantly superior followed by Pusa komal and Pusa barsati.

The closer row spacing of 30 cm produced significantly higher yield than wider spacing of 45 cm only with variety Konkan sadabahar. The varieties Pusa barsati and Pusa komal, however, did not differ significantly in grain yield due to the row spacings.

4.5.2 Pod yield :

It is clear from the Table 25 that, the pod yield /ha was significantly influenced only by varieties and not by inter and intra row spacings.

Varieties :

The significant effects of varieties on pod yield /ha indicated that the variety Konkan sadabahar produced significantly higher pod yield /ha than Pusa barsati and

Table 26 : Grain yield (q/ha) of cowpea as influenced by the interaction of row spacing and variety

Row Spacings (cm)	Varieties		
	Konkan sadabahar	Pusa barsati	Pusa komal
R ₁ (30)	14.66	4.56	9.53
R ₂ (45)	11.23	5.50	8.50
S.E. $\pm$	0.64		
C.D. at 5 %	1.91		

Table 27 : Pod yield (q/ha) of cowpea as influenced by the interaction of row spacing and variety

Row Spacings (cm)	Varieties		
	Konkan sadabahar	Pusa barsati	Pusa komal
R ₁ (30)	22.60	7.39	14.41
R ₂ (45)	17.53	8.58	12.93
S.E. $\pm$	1.01		
C.D. at 5 %	2.99		

Pusa komal. Similarly, variety Pusa komal was significantly superior than Pusa barsati in respect of pod yield /ha.

Interactions :

The effects of only row spacing x variety interaction on pod yield /ha was observed significant and the relevant data are presented in Table 27.

The data presented in Table 27 revealed that, maximum pod yield /ha (22.60 q/ha) was obtained by the treatment combination of 30 cm row spacing (R_1) x Konkan sadabahar(V_1) followed by the R_2 X V_1 (17.53 q/ha) and the minimum (7.39 q/ha) by 30 cm row spacing (R_1) x Pusa barsati (V_2).

Under both 30 and 45 cm row spacings, Konkan sadabahar proved to be a significantly superior variety in pod yield followed by Pusa komal and Pusa barsati. Similarly, Pusa komal observed superior in pod yields than Pusa barsati under these two row spacings.

The row spacing of 30 cm recorded significantly higher pod yield than 45 cm only under Konkan sadabahar.

4.5.3 Straw yield :

The data presented in Table 25 revealed that, the straw yield /ha was influenced significantly only by varieties and not by inter or intra row spacings.

Varieties :

The variety Pusa barsati was significantly superior over Pusa komal and Konkan sadabahar in production of straw yield /ha. However, variety Pusa komal and Konkan sadabahar were on par in respect of straw yield /ha.

Interactions :

The effects of all the interactions on straw yield /ha were observed non-significant.

4.5.4 Biological yield :

Data on mean biological yields as influenced by various treatments are presented in Table 25.

The biological yield was not influenced significantly either by inter row or intra row spacings. However, varieties differed significantly in respect of biological yield.

Variety Konkan sadabahar and Pusa barsati were on par and recorded significantly higher biological yield than Pusa komal.

Interactions :

The significant effects were noted only of the interaction of row spacing x variety and the relevant data are presented in Table 28.

The data presented in Table 28 revealed that, significantly highest biological yield was obtained by the treatment combination of 30 cm row spacing (R_1) x Konkan sadabahar (32.38 q/ha) and the lowest by 45 cm row spacing (R_2) x Pusa komal (22.27 q/ha).

Table 28 : Mean biological yield (q/ha) as influenced by the interaction of row spacing and variety

Row Spacing (cm)	Varieties		
	Konkan sadabahar	Pusa barsati	Pusa komal
R ₁ (30)	32.38	28.69	24.37
R ₂ (45)	25.56	28.67	22.27
S.E. $\pm$	0.08		
C.D. at 5 %	0.24		

The row spacing of 30 cm recorded significantly higher biological yield /ha than 45 cm under all varieties.

4.5.5 Harvest index :

The data on harvest index in Table 25 indicated that the mean harvest index was 33.30 per cent.

The harvest index was not influenced significantly either by inter or intra row spacings. However, varietal differences pertaining to harvest index were significant.

The variety Konkan sadabahar was significantly superior over Pusa komal and Pusa barsati in recording harvest index. Similarly, variety Pusa komal was significantly superior over Pusa barsati in respect of harvest index values.

Interactions :

None of interactions influenced the harvest index significantly .

4.6 Simple correlation and regression studies :

The co-efficients of simple correlation and regression were computed respectively for ascertaining the

qualitative and quantitative associationship between the per plant yield (Y) and other plant characters (Xn) as given in Table 29 for each variety.

Simple correlation :

The data presented in Table 29 revealed that per plant grain yield of the variety has positively correlated with all the plant characters except plant height, number of grains per pod and harvest index in variety V₁ (Konkan sadabahar). Further the significant positive correlation of leaf area per plant and number of pods per plant were observed with the yield of variety Konkan sadabahar.

In variety V₂ (Pusa barsati) all the plant characters except test weight were positively correlated with yield per plant. Among the positive correlations, the number of grains per pod and number of pods per plant had strong significant correlations with the grain yield per plant.

In variety V₃ (Pusa komal), the plant characters viz., plant height, number of branches, test weight, number of pods per plant and dry matter were positively correlated with grain yield per plant. Among these characters, however, number of branches, number of pods and dry matter per plant were significantly correlated with the grain yield per plant.

Table 29 : simple correlation and regression of per plant yield (Y) with other plant characters (Xn)

Plant character	a			b			r			t		
	V ₁	V ₂	V ₃	V ₁	V ₂	V ₃	V ₁	V ₂	V ₃	V ₁	V ₂	V ₃
1. Plant height	57.51	-94.62	0.499	-1.236	1.105	0.098	-0.215	0.354	0.023	-0.880	1.514	0.092
2. Number of branches	3.458	2.324	2.758	0.334	0.157	0.339	0.323	0.335	0.473*	1.365	1.422	2.147
3. Leaf area	-718.100	-330.700	45.47	391.70	128.60	-101.200	0.614**	0.194	-0.302	3.111	0.791	-1.267
4. Test weight	-49.26	13.25	-10.63	0.848	-1.457	0.190	0.291	-0.341	0.110	0.774	-1.450	0.442
5. No.of grains/pod	7.47	-0.616	6.948	-0.194	0.672	-0.282	-0.187	0.659**	-0.419	-1.175	3.504	-1.845
6. No.of pods/plant	-15.29	-5.548	-9.597	1.940	1.419	1.470	0.645**	0.881**	0.888**	3.376	7.448	7.724
7. Harvest index	25.17	-17.94	10.58	-0.435	1.228	-0.145	-0.139	0.422	-0.077	-0.560	1.861	-0.308
8. Dry matter	-4.193	-17.05	-26.15	0.662	0.855	1.824	0.203	0.123	0.610**	0.829	0.495	3.079

Table 'r' value at 5% 0.444 and at 1% 0.561

* Significant at 0.05 level of probability.

** Significant at 0.01 level of probability.

Number of pods per plant was strongly correlated with the grain yield per plant in all the three varieties.

Simple regression co-efficients :

The simple regression co-efficients of growth and yield attributes regressing on the yield (Table 29) revealed that the magnitudes of regression co-efficients varied with characters and the varieties.

In variety V_1 (Konkan sadabahar), regression co-efficients of test weight, leaf area, number of pods and dry matter per plant were significant. Whereas, in variety V_2 (Pusa barsati), plant height, leaf area, number of pods per plant and dry matter per plant were highly significant. In variety V_3 (Pusa komal) the number of pods per plant and dry matter per plant were significantly regressing on the yield per plant.

Number of pods and dry matter per plant had significant positive regression co-efficients in all the three varieties.

4.7 Yield plant density relation in cowpea :

The crop yield being the function of interaction between gene architecture, plant structure, crop environment and management practices; the effects of plant

Table 30 : Parameters of reciprocal yield (g/plant) with plant density (,000 plant/ha) relation in cowpea varieties

Co-efficients		Test statistics		Plantdensity (0.5c)	Potential	Productivity
Variety	a	b	r	t	P(,000 plants/ha)	S.E.(y) g/plant) Yield kg/ha (a ⁻¹) (b ⁻¹) at 0.5c
V1	0.107	0.0048	0.854	4.916	445.62	0.0132 9.32 1389.72
V2	0.235	0.0022	0.925	5.405	207.31	0.0484 4.25 293.73
V3	0.151	0.0012	0.919	5.836	251.76	0.0242 6.62 555.62

densities on yield per plant, crop productivity and intra species competition was studied by establishing relations between reciprocal of yield per plant and the densities (,000 plants/ha) in each variety separately and resultant data are persented in Table 30.

Data presented in Table 30 revealed that the relationship between reciprocal of seed yield per plant with plant densities were positively linear and significant in all the varieties.

The further study of the co-efficients of these relations showed that the intercept of reciprocal yield density relation was highest in variety V_1 (Konkan sadabahar) followed by V_3 (Pusa komal) and V_2 (Pusa barsati), respectively. While the slope was highest in variety V_3 (Pusa komal) followed by V_2 (Pusa barsati) and V_1 (Konkan sadabahar), respectively.

The utility of these intercepts revealed that the highest (9.32 g) per plant yield potential under competition free condition was in V_1 followed by V_3 (6.62 g). The potential productivity of seed yield per hectare (b^{-1}) was highest in V_1 (1389.72 kg) followed by V_3 (555.62 kg).



DISCUSSION



5 DISCUSSION

The results of the present investigation are briefly discussed in this chapter.

5.1 Soil and climate :

The physio-chemical composition of the soil revealed that the soil of the experimental plot was clayey in texture, low in total nitrogen, medium in available phosphorus and organic carbon, high in potassium and slightly alkaline in reaction.

The mean weekly weather data indicated that the total rainfall received during the experimental period was 1429.3 mm in total 55 rainy days which was observed to be excess than normal. The mean monthly rainfall received was maximum (271.2 mm) in the month of July and it was properly distributed in total 11 rainy days. The receipt of rains observed to be minimum (162.5 mm) during the month of June in only eight rainy days. The mean maximum temperature varied from the lowest (29.2°C) to the highest (42.6°C) during 22nd meteorological week in the month of June. Relative humidity observed to be comparatively more during the month of July, August and September. The

highest relative humidity was recorded in the month of August during 34th meteorological week. The climatic conditions in general were favourable for growth and yield of cowpea particularly, the receipt of rainfall and its distribution over the growing period which was favourable for the growth of cowpea crop except wet and humid climate of August was congenial for pod borers incidence on crop particularly in Pusa barsati which was controlled by proper plant protection schedule.

5.2 Growth attributes :

The variations observed in growth and yield were due to mere effects of treatments as the emergence and final plant stand were not influenced significantly by any treatments.

The plant height was found to increase at every stage of crop growth reaching to the maximum at maturity. The rate of increases in plant height was comparatively slow during early crop growth period of 30 days, very fast during 45 to 60 days and relatively slowed at maturity. The plant height was not influenced by different inter or intra row spacings. Similar non-significant effect of spacings on plant height was reported by Subramanian *et al.* (1977^a).

The varietal differences in respect of plant height were significant at all growth stages except at 30 days. The variety Pusa barsati recorded more plant height than Pusa komal and konkan sadabahar at all these stages. This indicates that plant height is a genotypic character and variety Pusa barsati observed to be taller variety than Pusa komal and Konkan sadabahar. Significant genotypic difference for main stem height in cowpea was also reported by Erskine and Khan (1976).

Branching in cowpea was initiated at 30 days and increased thereafter progressively till harvest of crop.

The number of branches per plant was not influenced at any stage by inter row spacing. This is in confirmative to the findings reported by Raddy and Singh (1976). The effects of intra row spacings were observed only at 60 days and harvest. The wider intra row spacing of 30 cm was on par with 22.5 cm and recorded significantly more number of branches per plant than closer spacing of 15 cm. Similar decrease in the number of branches due to decrease in plant spacing in cowpea was observed by Saraf et al (1984).

Varietal differences in respect of number of branches per plant were observed only after 45 days onward

to harvest. In advance stage of crop growth, variety Konkan sadabahar recorded more number of branches than Pusa barsati and on par with Pusa komal. However, at harvest, variety Konkan sadabahar remain superior in branching than Pusa barasati and Pusa komal. Varietal differences in respect of branching in cowpea was also reported by Gowda (1982).

The number of functional leaves per plant increased rapidly up to 45 days and thereafter decreased gradually till maturity due to leaf senescence. The inter row spacing did not influence the functional leaves per plant. However the effects of intra row spacings on number of functional leaves per plant were pronounced only at 45 and 60 days. The wider intra row spacing of 30 cm produced more number of functional leaves than close intra row spacing at these stages of observation. Interaction effect of row X plant spacing also proved that square planting (30 X 30 cm) recorded maximum number of functional leaves per plant. It means that number of leaves increased with decreased plant density. Similar observations of the effect of wider spacing in increasing number of functional leaves were reported by Angne (1989), Parihar et al. (1996) and Deshmukh (1997).

Varietal differences in respect to number of functional leaves per plant were observed at all growth stages. Variety Konkan sadabahar recorded significantly more number of functional leaves than Pusa barsati and Pusa komal at all growth stages. The maximum number of functional leaves per plant were produced by variety Pusa komal and Pusa barsati at closer plant spacing of 15 cm than with 30 cm. Similar variations in number of leaves due to varieties in cowpea was reported by Gowda (1982).

Inter row spacing did not influence the leaf area per plant. However intra row spacing influenced the leaf area at 45 DAS where 30 cm intra row spacing was similar to 22.5 cm but, both were superior over closer spacing of 15 cm. Square planting at 30 x 30 cm observed to be superior. This might be due to non-availability of space for expansion of leaves under closer spacing.

Varieties differed in leaf area at all the stages of crop growth. During early 30 days Pusa komal and at 45 days Pusa komal and Pusa barsati produced more leaf area but at 60 days onwards Pusa barsati remained superior in leaf area than other varieties.

The total dry matter production is the cumulative effect of all the growth attributes viz., plant height, number and area of leaves, branching and reproductive

parts. The results on dry matter accumulation revealed that process of dry matter accumulation was continuous from emergence to 60 DAS and thereafter slightly declined at maturity due to leaf senescence. The peak rate of dry matter accumulation per plant was at 45 and 60 days, which might be due to the higher number of leaves , leaf area and branching during this grand growth period of the crop.

The row spacing did not influence the dry matter accumulation but the plant spacing had effect on it. The wider intra row spacing of 30 cm resulted in more dry matter per plant than narrow plant spacing. Similar gain in dry matter due to wider spacing in cowpea was reported by Mahaldar *et al.* (1986), Angne (1989) and singh (1993).

Variety Pusa barsati recorded more dry matter accumulation followed by Konkan sadabahar and Pusa komal. The higher dry matter accumulation in Pusa barsati might be due to its long duration, wider spread and more vegetative growth as compared to other varieties.

Wider spacings produced more number of pods per plant than narrow spacings. This may be due to vigorous growth of individual plant and more reproductive organs at low plant density. Similar beneficial effects of wider spacing on pod number were reported by Saraf *et al.* (1984) and Yadav (1986). Konkan Sadabahar and Pusa komal were

superior in pod number than Pusa barsati. This variation in varieties may be attributed the varied genetic potentials of producing pods of these varieties. Also might be more dry matter partitioning towards reproductive parts in Konkan Sadabahar than mere vegetative development in Pusa barsati. Konkan sadabahar performed well with wider row and plant spacings followed by Pusa Komal. Such genotypic variation pertaining to pod number was also observed by Erskine and Khan (1976), Remison (1980), Gowda (1982), Rajanna (1988), Mahaldar (1991) and Mali and Mali (1991).

AGR on plant height was improved with closer row spacing of 30 cm and medium close plant spacing of 22.5 cm which leads to increase in plant height. However AGR on dry matter was higher with narrow row spacing (30 cm) but wider plant spacing (30 cm). This improvement in AGR might be due to more equal space provided under 30 x 30 cm.

Among the varieties, Pusa barsati showed higher AGR due to its more height and vegetative growth compared to other varieties.

The growth analysis further revealed that RGR values were in general increased with, decreased inter row and increased intra row spacings. This might be

attributed to provision of more light, space, moisture and nutrients for more dry matter production per plant at wider intra row spacing.

The varietal differences in respect of RGR were inconsistent.

NAR values were not much varied due to plant spacing and varieties. However, the marked difference in NAR values due to wider row spacing were observed only after 45 days onwards. This might be due to higher photosynthetic activities mainly due to more leaf area and light interception under wider row spacing.

The LAI of the crop was low during early growth period of 30 days, but it increased thereafter and reached to maximum at maturity.

Narrow row spacing of 30 cm as well as narrow plant spacing of 15 cm helped to increase the LAI values at all the stages. Under closer spacing, leaf area/plant was not decrease in the proportion to increase in ground area available per plant. Therefore, LAI values were increased with closer spacing. The significant effect of inter row spacing on LAI in cowpea was also reported by Rajanna (1988).

LAI values of Pusa barsati at almost all the stages observed to be higher than other varieties.

5.3 Yield attributes :

The number of pods, pod yield and grain yield per plant was observed to increase in wider inter row and intra row spacings. The wider inter row spacing of 45 cm and intra row spacing of 30 cm produced significantly higher number of pods, pod yield and grain yield per plant than closer spacings. This may be due to the fact that wider spacings provide optimum and relatively uniform conditions for the full expression of different yield attributing characters in each plant under low plant density pressure per unit area. Increase in yield attributing characters with increase in spacing were also reported by Jain et al. (1984), Saraf et al. (1984), Yadav (1986), Rajanna (1987), Mahaldar et al. (1991) and Parihar et al. (1996).

In case of varieties, variety Konkan sadabahar produced more number of pods, pod yield and grain yield per plant than Pusa barsati. However, it was on par with Pusa komal in respect of number of pods and grain yield per plant. Similarly, Pusa komal observed to be superior variety over Pusa barsati for all these yield attributes. Similar results of significant varietal differences for

number of pods, pod yield and grain yield per plant are also reported by Remison (1980), Gowda (1982), BiradarPatil *et al.* (1991), Mahaldar *et al.* (1991) and Mali and Mali (1991).

The inter or intra row spacings did not influence the number of grains per pod. These results are in confirmation with the results reported by Jallow and Ferguson (1985). The number of grains per pod were varied significantly among the varieties and variety Konkan sadabahar recorded significantly more number of grains per pod than Pusa barsati but was on par with Pusa komal. Both the inter row and intra row spacings did not influence the test weight. Similar non-significant effect of spacing on test weight was reported by Yadav (1986).

Variety Pusa barsati was superior in test weight than Pusa komal and Konkan sadabahar. This may be attributed to the genetic character of this variety producing comparatively bolder seeds.

The simple correlation studies also revealed that number of pods per plant was strongly correlated with grain yield/plant in all the three varieties.

The regression co-efficients further indicated that the plant characters viz., number of pods and dry

matter per plant were significantly regressing on the grain yield in all the three varieties.

5.5 Yield :

The grain, pod, straw, biological yields /ha and harvest index were influenced by only varieties and not by spacings, both inter and intra row. The non-significant effect of spacings on yield /ha was also reported by Saxena et al. (1973^a) Rath and Verma (1973^b), Nangju et al. (1975) and Bindra and Sagar (1976).

Yield is function of growth and yield attributes. In this study, the growth and yield attributes observed to be higher under wider spacings but the yields per hectare were higher under closer spacing. This may be due to the space under dense plant population suppressing individual plant growth but the resultant yield /ha from closer spacing was ^{more} due to higher number of plants per unit area which compensated the low yield per plant and expressed higher yield on area basis under high plant density pressure.

Variety Konkan sadabahar recorded highest grain, pod yield and harvest index followed by Pusa komal and Pusa barsati . Whereas, Pusa barsati and Konkan sadabahar were on par and they produced higher biomass yield/ha

than Pusa komal. However, Pusa barsati recorded the highest straw yield. Though the total dry matter, straw and biomass yield observed higher with Pusa barsati, its harvest index was very poor. Whereas, dry matter partitioning in Konkan sadabahar and Pusa komal was most proper leading to higher harvest indices of these varieties.

The high yield ability of variety Konkan sadabahar might be due to high genetic yield potential which is reflected through higher values of growth and yield attributes and their cumulative effect on grain and pod yield/ha of this variety than the others. Varietal differences in grain yields are partially due to efficiency of the variety to convert biological yield into economic yield. This is reflected through higher harvest index of variety Konkan sadabahar, as compared to other varieties under similar plant density pressure. Similar significant differences in varieties for grain yields of cowpea were also reported by Saxena *et al.* (1973^a), Bhat (1981), Gowda (1982), Tripathi *et al.* (1984) BiradarPatil *et al.* (1991), Mahaldar *et al.* (1991).

This has been further confirmed by the significant effect of row spacing x variety indicating that variety Konkan sadabahar under closer row spacing of 30 cm gave

the highest grain and pod yield /ha followed by Pusa komal and Pusa barsati with same spacing. In biomass yield /ha also, Konkan sadabahar ranked first followed by Pusa barsati and Pusa komal at same row spacing showing high biomass production ability of Pusa barsati over Pusa Komal. Similar significant interaction effects of row spacing and variety for grain yield of cowpea were also reported by Bhat (1981) and Jain et al. (1984).

**SUMMARY
AND
CONCLUSION**

6 SUMMARY AND CONCLUSION

A field experiment was conducted at college farm, Department of Agronomy, Marathwada Agricultural University, Parbhani during kharif season of 1998 to study the effect of different plant geometries on growth and yield of cowpea varieties.

The site of the experimental field was fairly levelled. The residual effect of previous crop was uniform. The soil in the experimental field was clayey in texture, low in total nitrogen, medium in available phosphorus and rich in potassium and slightly alkaline in reaction. Weather data indicated that the total precipitation received (1429.3 mm) during experimental period was excess than normal (964 mm).

The present experiment was laid out in the split plot design with three replications. The treatment consisted of two inter row spacings (30 cm and 45 cm), three intra row spacings (15 cm, 22.5 cm and 30 cm) and three varieties of cowpea (Konkan sadabahar, Pusa barsati, Pusa komal) constituting total eighteen treatment combinations. Six combinations of inter and intra row spacing in main plots, while varieties of cowpea in the subplot were allotted randomly within each replication.

The gross plot size was 4.5 m x 3.6 m and net plot size was 3.6 m x 1.8 m. The crop was sown on 4th July, 1998 by dibbling method with spacing as per the treatments. The recommended dose of fertilizer i.e. 25 kg N and 50 kg P₂O₅ per hectare was applied at the time of sowing.

Mean emergence was recorded from each net plot on 10th day after sowing. Biometric observations on various characters viz., height of plant, number of branches, number of functional leaves and number of pods per plant were recorded periodically on five randomly selected plants from each net plot. Similarly, studies on leaf area and dry matter accumulation were taken at various growth stages on only one representative plant from each net plot. Growth was analysed by working out AGR (height and dry matter), RGR, NAR and LAI. Post harvest studies were also undertaken which include the pod weight, grain weight, number of pods/plant, number of grains per pod, harvest index and Test weight. The plants from each net plot were threshed and cleaned. The grain, straw, and biomass obtained in each net plot were weighed in kg and converted in q/ha.

Simple correlation co-efficients were worked out between grain weight per plant and other plant characters

to determine which characters are contributing to the ultimate yield.

The most important findings emerged from the present experiment are given below,

1. The mean per cent emergence count and final stand were not influenced significantly by different treatments indicating that the results obtained are mere effects of the treatments.

2. The plant characters viz., number of branches, number of functional leaves, leaf area, dry matter accumulation and number of pods per plant were significantly influenced only by intra row spacings at most of the growth stages where wider plant spacing of 30 cm proved to be superior than narrow plant spacing. Square spacing of 30 x 30 cm improved the number of leaves and leaf area per plant.

As regards varieties variety konkan sadabahar recorded more number of branches, number of leaves and number of pods per plant. While Pusa Barsati recorded more plant height, leaf area and dry matter per plant.

3. AGR on plant height observed more with 30 x 22.5 cm but, AGR on dry matter was more with 30 x 30 cm spacing. Pusa barsati recorded comparatively more AGR. RGR was maximum with narrow row spacing (30 cm) and wider plant

spacing (30 cm). NAR was not varied much due to spacings and varieties. LAI was increased with closer spacings and LAI values of Pusa barsati were the highest than other varieties.

4. The number of pods /plant, pod yield /plant and grain yield /ha were increased with increasing inter row and intra row spacings.

Variety Konkan sadabahar was superior in number of pods per plant , number of grains per pod, pod yield and grain yield per plant than Pusa barsati. However, Pusa barsati was superior in test weight.

5. Among the plant characters number of pods per plant had positive and significant correlation with yield in all the three varieties.

6. The variety Konkan sadabahar observed high yielding followed by Pusa komal and Pusa barsati. Variety Pusa barsati, however produced higher biomass yield per hectare. Konkan sadabahar with row spacing of 30 cm produced highest grain as well as pod yield/ha followed by same variety with 45 cm row spacing.

On the basis of findings of the present investigation it may be finally inferred that the variety Konkan sadabahar appeared to be a high yielding

What about
plant to plant

variety of cowpea and when sown at 30 cm row spacing gave
higher seed and pod yield /ha under rainfed conditions
followed by Pusa komal.

30m x 30cm spacing for
KOPAN Sadabahar →
Seed rate 4



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