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Yield maximization of cowpea (*Vigna unguiculata* L. Walp) through different spacings and varieties in Marathwada region of Maharashtra, India

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ABSTRACT

A field experiment was conducted on Growth and yield of cowpea (*Vigna unguiculata* L. Walp) varieties as influenced by different spacings during *kharif* season of 2017. The soil of experimental plot was medium and black in color with good drainage. Soil of experimental plot was clayey in texture with chemical composition such as low in available nitrogen (119.31 kg ha^{-1}), medium in available phosphorous (17.86 kg ha^{-1}) and very high in available potassium (498.58 kg ha^{-1}). The soil was moderately alkaline in reaction having pH (7.8). The results from experiments revealed that, the growth parameters such as number of functional branches per plant (5.57), leaf area per plant (20.88 dm^2) and number of nodules per plant (24.83), the yield parameters viz. pod yield per plant (7.55 g), seeds yield per pod (6.30 g), and straw yield (2710 kg ha^{-1}) and economic studies include GMR and NMR (85330 and 54023 Rs ha^{-1}, respectively) were found significantly superior by adopted larger spacing of 45 X 10 cm as compared to other spacings and among the two different varieties, the konkan safed recorded highest values of above parameters than Konkan sadabahar. The interaction effect for all the growth, yield and quality parameters were noted non significant for cowpea crop.

Key words: *Growth, Yield, Economics, Varieties, Spacings and Cowpea*

Introduction

Cowpea is a native to Central Africa and belongs to the family Leguminaceae with subfamily Papilionaceae. The common names are 'Black-eye-pea', 'Southern pea', 'China pea', 'Marble pea'. Cowpea is known as 'vegetable meat' or 'Poor man's meat' due to high amount of protein in the green leaves with better biological value on dry weight basis. The grain contains 24.8 per cent protein, 1.9 per cent fat, 63.6 per cent carbohydrates, 6.3 per cent fiber, 0.00074 per cent thiamine, 0.00042 per cent Riboflavin, 0.00281 per cent Niacin (Shaw, 2007). It also has the useful ability to fix atmospheric nitrogen through its root nodules. It grows well in poor soils with more than 85 per cent sand and with less than 0.2 per cent organic matter and low level of phosphorous.

A plant population is one such factor that has a direct influence on the yield level of any particular genotype. Growth parameters of cowpea such as plant height, lateral branches and trifoliate leaves increased with increased spacing from 20 cm through 30 cm to 45 cm. (Gill *et al*., 1977). Also, the yield potential of high yielding varieties can be further exploited through better agronomic practices

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with respect to spacing. The yield of any crop depends on the production potential of the cultivar and climatic, edaphic and management practices to which cultivar is exposed.

There are many different reasons for low productivity of cowpea in India and also Maharashtra *viz*. weeds population, insect- pest infestation, nutrient supply, plant population etc. Hence, efforts are to be made to boost up the yield per hectare of cowpea by using appropriate spacing and varieties. The appropriate spacing and varieties contributes towards establishment of the crop stand, growth of the plant and ultimately the final quality yield of crop. Though the different combination of spacing and varieties had been given due importance, the perfect combination of spacing and variety yet to be quantified in Marathwada region.

Keeping in view, the present investigation entitled "Yield maximization of cowpea (*Vigna unguiculata* L. Walp) through different spacings and varieties in Marathwada region of Maharashtra" was carried out to assess the plant spacing and variety for cowpea crop.

Materials and Methods

The present field experiment was conducted during *Kharif* season of 2017 at College of Agriculture, Latur (Maharashtra).The soil of experimental plot was medium and black in color with good drainage. The topography of experimental field was uniform and fairly leveled. Soil of experimental plot was clayey in texture with chemical composition such as low in available nitrogen (119.31 kg ha^{-1}), medium in available phosphorous (17.86 kg ha^{-1}) and very high in available potassium (498.58 kg ha^{-1}). The soil was moderately alkaline in reaction having pH (7.8).

Climate

Geographically Latur is situated at 18° 5′ to 18° 24′ North latitude and 77° 36′ East longitude. Its height above mean sea level is about 633.85 m and has subtropical climate. The climate of Marathwada region on annual basis can be classified as semi arid type.

Cropping history of the experimental plot

The cropping history of the experimental plot for last five year is given in Table 1. The preceding crops were fertilized with recommended dose of NPK and the residual effect of previous cropping was practically uniform to the crop growth during the course of investigation

Table 1. Cropping history of the experimental plot.

Year	*Kharif*	*Rabi*	Summer
2012-13	Soybean	Gram	Fallow
2013-14	Green gram	Rabi Jowar	Fallow
2014-15	Pigeon pea	—	Fallow
2015-16	Maize	Fallow	Fallow
2016-17	Pigeon pea	Fallow	Fallow
2017-18	Present investigation	—	

Collection of data and sampling techniques

Data on the important biometric observations were collected on five randomly selected and neatly labeled with wooden pages and tags plants in each treatment throughout the crop life by leaving two border rows, one on each side of plot. These plants were separately harvested at maturity for assessing their yield and yield attributes.

Growth attributes

The number of branches emerging directly from main stem was counted and the average of five plants was expressed as number of primary branches per plant. The leaf area per plant (dm^2) was measured by leaf area meter. Since, the crop yield is to be assessed for unit of area, instead of per plant. Therefore leaf area existing on one plant was considered as leaf area produced on unit ground area (actual area of one plant) this was proposed by Watson (1952). The measure is known as leaf area index (LAI), which was calculated by following formula.

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

Number of nodules $plant^{-1}$ was recorded by randomly selected one plant from each gross plot were uprooted and cleaned. Number of nodule arise on uprooted plant roots were counted.

Yield and yield attributes

Pod yield $plant^{-1}$ was noted by the pods obtained from each plant were dried and weight was recorded in gram. The seed obtained from each plant were dried and weight was recorded in gram and expressed as seed yield $plant^{-1}$. One hundred representative seeds counted from the produce of net plot and their weight was recorded in grams as seed index. Before threshing, weight of sun dried biological yield from each net plot was recorded. Weight of dried leaves collected from each net plot was also added in biological yield. Then seed weights were subtracted from total biological yield and remaining weights are counted as straw yield in kg. Harvest index was estimated as per the formula suggested by Donald (1962).

$$HI = \frac{\text{Economic yield}}{\text{Biological yield (seed yield + stalk yield)}} \times 100$$

Economics

The gross monetary returns (Rs ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product, by product and crop residues during the experimental year. The cost of cultivation (Rs ha^{-1}) of each treatment was worked out by considering the price of inputs, charges for cultivation, labour, land and other charges. The net monetary returns (Rs ha^{-1}) of each treatment were worked out by deducting the mean cost of cultivation (Rs ha^{-1}) of each treatment from the gross monetary returns (Rs ha^{-1}) gained from the respective treatments. The benefit: cost ratio of each treatment was calculated by dividing the gross monetary returns with the mean cost of cultivation.

Results and Discussion

A. Growth parameters

Number of branches plant^{-1}

Data presented in Table 2 shown that the maximum number of branches plant^{-1} (5.57) was observed with wider spacing 45 X 10 cm. This treatment was found significantly superior over rest of the spacings except at 30 DAS. At 30 DAS this treatment was found at par with 37.5 X 10 cm (S_3). The significantly lowest number of branches plant^{-1} was produced by closer spacing 30 X 10 cm (S_1). This may probably be due to availability of more space, nutrients, sunlight and moisture to the wider spaced plants. Also wider row spacing not only allows easier intercultivation to remove weeds and improve soil aeration but also induce more branching. Similar results were confined by Patil *et al.* (1991), Achakzai and Panizai (2007), Ndor *et al.* (2012), Chaudhry *et al.* (2014), Murade *et al.* (2014), Joshi and Rahevar (2015) and Tanya *et al.* (2015). The significantly highest number of branches plant^{-1} were obtained with variety Konkan Safed (V_1). The higher number of branches plant^{-1} might be due to genetic variation in growth characteristics of different varieties. Similar trend were obtained by many workers Sutar *et al.* (2016) and Ahmad *et al.* (2017). No significant results were found due to treatment interaction at any growth stage of crop.

Leaf area plant^{-1}

Data presented in Table 2 noted that the leaf area with wider spacing 45 X 10 cm was (20.88 dm^2). The leaf area plant^{-1} was observed significantly superior over narrow spacings (S_1), (S_2) and (S_3). A wider plant spacing which intercepted more photosynthetically active radiation owing to better geometric situation that might be resulted in vigorous plant growth and more leaves and leaf area than narrow spacing. The similar findings were given by Achakzai and Panizai (2007), Lone *et al.* (2009), Ndor *et al.*, (2012), Murade *et al.* (2014), Amruta *et al.* (2015) and Tanya *et al.* (2015). The maximum leaf area (18.86 dm^2) was recorded with Konkan Safed. This variety was observed significantly superior over Konkan Sadabahar (V_2). This might be because of leaf senescence towards maturity of the crop. The results of the present study are in accordance with the finding of Sutar *et al.* (2016).

Interaction effect was not evident due to various treatment effects.

Number of nodules plant^{-1}

Data showd in Table 2 revealed that the maximum number of nodules plant^{-1} was obtained (24.83) from wider spacing 45 X 10 cm which was observed to be significantly higher over rest of the treatments. It may happen due to less competition for space, moisture and nutrients might have probably increased root nodules spread as compared to closer spacing leading to maximum number of nodules plant^{-1}. Close confining results were given by Lone *et al.* (2009), Ndor *et al.* (2012), Joshi and Rahevar (2015) and Tanya *et al.* (2015). The highest number of nodules plant^{-1} was recorded as 22.67 with variety Konkan Safed (V_1) which was found significantly superior over Konkan Sadabahar (V_2). The variation in nodulation count among two varieties may be due to their inherent genetic character. Result was also supported with those of Ahmad *et al.* (2017). None of the interactions was found significantly superior in respect of number of nodules per plant.

Table 2. Growth attributes of cowpea as influenced by different treatment.

Treatment	Number of branches plant^{-1}	Leaf area plant^{-1} (dm^2)	Number of nodules plant^{-1}
Spacing (S)			
S_1 – 30 X 10 cm	3.67	16.00	19.00
S_2 – 30 X 15 cm	4.27	17.06	20.83
S_3 – 37.5 X 10 cm	4.87	18.05	22.42
S_4 – 45 X 10 cm	5.57	20.88	24.83
SEm ±	0.15	0.58	0.75
CD at 5%	0.47	1.78	2.29
Varieties (V)			
V_1 – Konkan Safed	4.82	18.86	22.67
V_2 – Konkan Sadabahar	4.37	17.14	20.88
SEm ±	0.11	0.41	0.53
CD at 5%	0.33	1.26	1.62
Interaction (S X V)			
SEm ±	0.22	0.83	1.06
CD at 5%	NS	NS	NS
General mean	4.59	18.00	21.77

Leaf area index

Data in Table 3 showed the maximum leaf area index was found with narrow spacing 30 X 10 cm at all growth stages of crop. This might be due to comparatively higher leaf area per unit ground area. Taipodia and Nabam (2013) and Nayak *et al*. (2014) has corroborate the similar result. The Konkan Safed (V_1) gave the highest leaf area leaf area index than Konkan Sadabahar (V_2).

B. yield and yield attributes

Pod yield plant^{-1} (g)

The data in respect to pod yield plant^{-1} (g) as influenced by various treatments at harvest is given in Table 4. The maximum pod yield plant^{-1} was observed with wider spacing 45 X 10 cm (7.55 g) which was found significantly superior over remaining spacing (S_1, S_2 and S_3). The more accumulation of photosynthates and their translocation from source to sink in reproductive crop growth phase which resulted in improvement of all yield attribute . These results are in line with Patil *et al*. (1991), Singh and Sekhon (2006), Patel *et al*. (2011), Ndor *et al*. (2012), Jakusko *et al*. (2013), Chaudhry *et al*. (2014), Murade *et al*. (2014), Amruta *et al*. (2015), Joshi and Rahevar (2015) and Kumar *et al*. (2016). Among both of varieties the Konkan Safed (V_1) was recorded the maximum pod yield plant^{-1} (6.32 g) and it was observed to be significantly higher than Konkan Sadabahar (V_2). Interaction effect was not evident due to treatment effect in pod yield plant^{-1}.

Table 3. Leaf area index (LAI) of cowpea as influenced by various treatment

Treatment	Leaf area index
Spacing (S)	
S_1 – 30 X 10 cm	5.33
S_2 – 30 X 15 cm	3.79
S_3 – 37.5 X 10 cm	4.81
S_4 – 45 X 10 cm	4.64
Varieties (V)	
V_1 – Konkan Safed	6.28
V_2 – Konkan Sadabahar	5.71
General mean	5.09

Seed yield plant^{-1} (g)

The data pertaining to seed yield plant^{-1} as influenced by various treatments at harvest is presented in Table 4. The significantly higher values are obtained from seed yield plant^{-1} (6.30 g) by adopting wider spacing 45 X 10 cm. Among the two varieties Konkan Safed (V_1) recorded significantly maximum seed yield plant^{-1} (4.73 g) than Konkan Sadabahar (V_2). Significant variation in seed yield among two varieties may probably be due to variation in the expression of growth and yield attributes. Highest yield produced by variety Konkan Safed compared with Konkan Sadabahar variety tested could be due to its superior genetic composition which efficiently utilize the available resources for growth and development that eventually translated to higher yield and yield characters. Other scientist Pekson *et al*. (2002), Haruna and Usman (2013), Jakusko *et al*. (2013), Shilpa *et al*. (2015), Sutar *et al*. (2016) and Ahmad *et al*. (2017) also reported similar results. Interaction was found non significant.

Seed index (g)

Data presented in Table 4 revealed that the seed index (g) was not influenced significantly by the various treatments of spacing and varieties. However the maximum seed index was 10.12 g. The higher value for seed index (10.84 g) was observed with wider spacing 45 X 10 cm. The maximum value for seed index (10.58 g) was observed with Konkan Safed (V_1). These differences in seed weight might be due to the time factor for the accumulation of assimilates in the seeds and differences in the genetic makeup of different genotypes. Acclimatization factor might also be responsible for higher seed weight.

These collaborate with the finding of Khan *et al*. (2010), Naim *et al*. (2010), Jakusko *et al*. (2013) and Sutar *et al*. (2016). Interaction effect was found non significant for seed index (g).

Straw yield (kg ha^{-1})

The straw yield data showed in Table 4 was affected by different treatments of spacing and varieties. The maximum straw yield was 2604 kg ha^{-1}. Maximum straw yield (2906 kg ha^{-1}) was obtained by adopting narrow spacing 30 X 10 cm. This treatment was observed significantly superior over wider spacings except 45 X 10 cm which was at par and recorded straw yield 2710 kg ha^{-1}. This was mainly due to more number of branches plant^{-1} and rapid vigorous vegetative growth of crop plants. Similar results were discussed by Kabir and Sarkar (2008), Chaudhry *et al*. (2014) and Nayak *et al*. (2014). Higher straw yield 2741 kg ha^{-1} was recorded with konkan Safed (V_1) and found significantly superior over Konkan Sadabahar (V_2). This might be due to higher growth and development of leaves and branches. The present results are in consonance with those of Sutar *et al*. (2016). Interaction was not found significant for straw yield.

Harvest index (%) Data regarding harvest index (%) as affected by various spacing and varieties are presented in Table 4. The average harvest index for cowpea crop recorded as 30.31 %. The data on harvest index revealed that the highest harvest index 34.14 % with spacing 37.5 X 10 cm (S_3) followed by the spacing 45 X 10 cm (S_4), 30 x 15 cm (S_2) and 30 X 10 cm (S_1). Similar trend was observed by Achakzai and Panizai (2007). The maximum harvest index (30.81 %) was received from Konkan Safed (V_1) than Konkan Sadabahar (V_2). This indicates that the cowpea cultivar differ in the partitioning of assimilates to the grain and this may identify Konkan Safed was more efficient in assimilate utilization for improved yield. Ahmad *et al*. (2017) noted the relevant results.

C. Economics

Gross monetary return (Rs ha^{-1})

Data pertaining to the gross monetary return (GMR) as influenced by various treatments are presented in Table 5. The mean gross monetary return of cowpea was 73142 Rs ha^{-1}. The effect of various spacing on gross monetary returns (GMR) was found significant. The maximum gross monetary return 85330 Rs ha^{-1} was obtained from wider spacing of 45 X 10 cm and was found significantly higher over rest of treatments. This may be due to higher economic yield produced by the wider range of spacing. Similar trends were showed by Joshi and Rahevar (2015). Among the varieties the highest GMR (78722 Rs ha^{-1}) was recorded from Konkan Safed (V_1) and was found significantly superior over Konkan Sadabahar (V_1). This might be due to higher growth and yield parameters supported to variety Konkan Safed lead to got highest economic benefit from cowpea crop. This report is in conformity with finding of Sutar *et al*. (2016). The gross monetary returns obtained from

Table 4. Yield and quality of cowpea as influenced by different treatment.

Treatment	Pod yield plant^{-1} (g)	Seed yield plant^{-1} (g)	Seed index (g)	Straw yield (kg ha^{-1})	Harvest index (%)
Spacing (S)					
S_1 – 30 X 10 cm	4.15	3.14	9.00	2906	24.99
S_2 – 30 X 15 cm	5.34	3.83	10.01	2493	29.29
S_3 – 37.5 X 10 cm	6.70	4.83	10.65	2307	34.14
S_4 – 45 X 10 cm	7.55	6.30	10.84	2710	32.94
SEm ±	0.28	0.17	0.48	92.25	-
CD at 5%	0.86	0.53	NS	279.77	-
Varieties (V)					
V_1 – Konkan Safed	6.32	4.73	10.58	2741	30.81
V_2 – Konkan Sadabahar	5.54	4.32	9.67	2467	29.73
SEm ±	0.20	0.12	0.34	65.23	-
CD at 5%	0.61	0.37	NS	197.82	-
Interaction (S X V)					
SEm ±	0.40	0.24	0.69	130.46	-
CD at 5%	NS	NS	NS	NS	-
General mean	5.93	4.52	10.12	2604	30.31

interaction between spacing and varieties did not differ significantly.

Net monetary return (Rs ha^{-1})

The data on net monetary return (Rs ha^{-1}) as influenced by various treatments are presented in Table 5. The mean net monetary return was recorded as (41599 Rs ha^{-1}). The maximum net monetary return (54023 Rs ha^{-1}) was obtained by using 45 X 10 cm as a wider spacing for cowpea crop and which was found significantly superior over rest of spacings. The lowest NMR (31929 Rs ha^{-1}) was recorded from spacing 30 X 10 cm. Similar trends were showed by Joshi and Rahevar (2015). The NMR was found significantly superior with Konkan Safed over Konkan Sadabahar. This report is in line with finding of Sutar *et al*. (2016). The interaction results did not reach to the level of significance.

Cost of cultivation

The higher cost of cultivation was observed with closer spacing 30 X 10 cm^2 (31982 Rs ha^{-1}) followed by 37.5 X 10 cm, 30 X 15 cm and 45 X 10 cm respectively. These variations among costs are attributed to higher cost of seed material required in closer spacing of plant. These results are in conformity with those of Chaudhry *et al*. (2014).

Benefit : cost ratio

Data in respect to B: C ratio were presented in Table 21 revealed that the average B: C ratio was 2.31. The wider spacing of 45 X 10 cm (S_4) recorded highest B: C ratio (2.72) and it was lower with narrow spacings (2.41, 2.13 and 1.99) at 37.5 X 10 cm (S_3), 30 X 15 cm (S_2) and 30 X 10 cm (S_1) respectively. Among the varieties the maximum B: C ratio was obtained from Konkan Safed (2.49) followed by Konkan Sadabahar (2.14). This report is in conformity with finding of Sutar *et al*. (2016).

Correlation

Data on simple correlation (r) between seed yield plant^{-1} as depended variable (Y) no. of branches plant^{-1}, leaf area plant^{-1} (dm^2), no. of nodule plant^{-1}, leaf area indices, pod yield plant^{-1} and seed index (g) as independent variable (Xn) were established and resultant data are predicted in Table 6.

Data presented in Table 6 revealed that negative correlation was observed between leaf area indices with number of branches plant^{-1} (-0.0661), leaf area plant^{-1} (-0.0104) and number of nodules plant^{-1} (-0.0552). Also it established between pod yield plant^{-1} (-0.0737) seed index (-0.1071g) and seed yield plant^{-1} (-0.0419) with leaf area indices. The positive and highly significant correlation were observed between all the parameters except leaf area indices.

Conclusion

From the present study it was concluded that the

Table 5. Gross monetary returns (Rs ha^{-1}), Cost of cultivation (Rs ha^{-1}), Net monetary returns (Rs ha^{-1}) and benefit: cost ratio (B:C) ratio as influenced by various treatment.

Treatment	Gross monetary returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C ratio
Spacing (S)				
S_1 – 30 X 10 cm	63911	31982	31929	1.99
S_2– 30 X 15 cm	66945	31307	35638	2.13
S_3 – 37.5 X 10 cm	76384	31577	44807	2.41
S_4– 45 X 10 cm	85330	31307	54023	2.72
SEm ±	2446.91	-	2446.91	-
CD at 5%	7420.82	-	7420.82	-
Varieties (V)				
V_1 – Konkan Safed	78722	31543	47179	2.49
V_2– Konkan Sadabahar	67563	31543	36020	2.14
SEm ±	1730.22	-	1730.22	-
CD at 5%	5247.31	-	5247.31	-
Interaction (S X V)				
SEm ±	3460.45	-	3460.45	-
CD at 5%	NS	-	NS	-
General mean	73142	31543	41599	2.31

Table 6. Simple correlation between growth and yield parameters of cowpea.

Particulars	No. of branches plant^{-1}	Leaf area plant^{-1} (dm^2)	No. of nodule plant^{-1}	Leaf area indices	Pod yield plant^{-1}	Seed index	Seed yield plant^{-1} (g)
No. of branches plant^{-1}	1						
Leaf area plant^{-1} (dm^2)	0.9694	1					
No. of nodule plant^{-1}	0.9966	0.9830	1				
Leaf area indices	-0.0661	-0.0104	-0.0552	1			
Pod yield plant^{-1}	0.9924	0.9342	0.9825	-0.0737	1		
Seed index (g)	0.9334	0.8668	0.9339	-0.1071	0.9546	1	
Seed yield plant^{-1}	0.9868	0.9715	0.9810	-0.0419	0.9678	0.8633	1

* Significance at 5 per cent: 0.7067
** Significance at 1 per cent: 0.8343

wider spacing of 45 X 10 cm was best spacing for obtaining higher growth yield and economics of cowpea crop in Marathwada region. Also the variety Konkan safed variety was responded more growth, yield and economics of cowpea under Marathwada region.

Conflict of Interest: None

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