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Performance of black gram (*Phaseolus mungo* L.) Varieties to spacing's in *Kharif* for seed production

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Abstract
The present investigatio "Performance of black gram (*Phaseolus mungo* L.) Varieties to spacings in *kharif* for seed production" was conducted on the Agronomy Farm, College of Agriculture, Pune during *Kharif*, 2018 in spilt plot design using three replications. In the present investigation, main plot treatment consists three varieties (BDU-1, TAU-1 and AKU-10- 1(Black gold) and four spacings 30 x 05, 30 x 10, 45 x 05 and 45 x 10 cm2 as sub plot treatments. The results revealed that the significantly higher growth characters, seed and straw yields, as well as quality parameters were obtained at variety AKU-10-1(Black gold) sown with spacing 45 x 10 cm^2.

Keywords: *Phaseolus mungo* L. varieties and spacings interaction

Introduction
Pulses play a vital role in Indian agriculture. They are important not only for maintaining fertility of soil, but also providing fearful diet to the predominantly vegetarian population of the country and nutritious fodder to the livestock. Pulse crops have special significance in India as they contribute to the income and purchasing power of the poor farmers in semi-arid regions.

It has the cheapest source of protein and the milk is becoming expensive day by day. Protein requirement for growth and development of the human being is mostly met by pulses. It contains 24.0% protein, 59.6% carbohydrate, 1.3% fat, 3.2% minerals. It also contains 154 mg calcium, 9.1 mg iron, 38 mg B-carotene per 100 g of split dal.

It is one of the most important pulse crops of rainfed areas, grown throughout the country. It accounts for about 11.92% of India's total pulse production. India is the largest producer of pulses in the world, accounting for about 29% global share. During 2017-18, in India black gram produce 3280.00 thousand tonnes and 13.48% share in total production out of total pulse productions 24510.00 thousand tonnes.

Black gram (*Phaseolus mungo* L.) is pulse crop belonging to family Leguminacae which is originated in India. It is also known as urd bean, mash, mung bean etc. It is grown in India, Pakistan, Sri Lanka, Burma and some countries of south-east Asia, Africa and America. In India black gram is the fourth most important pulse crop which is mostly grown in southern and eastern states of India. It is predominantly grown in Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat, Madhya Pradesh, Punjab, Orissa, Bihar, Uttar Pradesh and West Bengal. Madhya Pradesh has been the major pulse producing state in the country.

Present strategies of Govt. of India are to increase the production and productivity of pulses in coming year to meet the increasing demand of pulses due to over growing population. Therefore, in the five year plan, emphasis has been laid to improve the yields of pulses and oilseeds. The cultivation of grain legumes such as black gram, green gram, pigeon pea and cowpea is adopted customarily during rainy season.

Materials and Methods
The present investigation was conducted on the farm of Agronomy Farm, College of Agriculture, Pune during *Kharif*, 2018. The experiment was laid out in split plot design with three replications, three main plot and four sub plot treatments. Main plot treatment consists of three varieties V1: BDU-1, V2: TAU-1 and V3: AKU-10-1(Black gold) and sub plot consist S1: 30 x 05 cm2, S2: 30 x 10 cm2, S3: 45 x 05 cm2 and S4: 45 x 10 cm^2. The gross and net plot sizes were 4.00 x 3.60 m2 and 3.80 x 3.00 m^2, respectively.

The soil of experimental plot was clayey in texture, neutral to slightly alkaline in reaction (pH 7.8), medium in organic carbon (0.50%), low in available nitrogen (165.14 kg ha-1), medium in available phosphorus (21.58 kg ha-1) and very high in available potassium (405.20 kg ha-1). The seed treatment of *Rhizobium*, PSB and *Trichoderma* were given common to all treatments at the time of sowing and RDF (i.e. 25: 50: 00 kg NPK ha^{-1}) was applied as basal application. The sowing was carried out manually by dibbling method. The optimum plant population was maintained by thinning and gap filling and the crop was irrigated as and when required. The cultural operations were carried out mechanically in all treatments. Plant protection measures were carried out time to time during the period of experiment. Climate was favorable for growth and development of black gram crop.

Biometric observations on growth characters *viz.*, mean plant height, number of functional leaves, leaf area, plant spread, number of branches and dry matter plant-1(g) were recorded periodically at an interval of 15 days after sowing. The observations on days required to 50 per cent flowering and days required for maturity were recorded at particular time. The important yield attributes and yield *viz.*, mean number of pods plant-1, dry weight plant-1, number of seeds pod-1, weight of seeds plant-1, straw yield plant-1, 1000 seed weight (g), seed yield and straw yields (kg ha-1) and shattering per cent were recorded at harvesting of black gram. Seed quality study *viz.*, protein content, germination, purity and moisture per cent were recorded after the harvesting of black gram.

Results and Discussion

The results obtained from the present investigation are presented in Table 1 and 2.

Effect of varieties and spacing's on growth

Effect on growth characters

The data pertaining to various growth attributes studied *viz.*, plant height, number of leaves plant-1 and dry matter plant-1 as influenced by various treatments are presented in table 3.

Effect of varieties

Significantly maximum plant height was obtained by variety AKU-10-1 (Black gold) than rest of the varieties under study. Higher plant height accounted due to more activities of meristematic tissues of plant, increasing number and size of cells, which is responsible for increased plant height.

Significantly maximum number of leaves and leaf area plant-1 was recorded by variety AKU- 10-1(Black gold) than rest of the varieties. This might be due to genetical character of the variety. Similar results was recorded by Jadhav *et al*. 2014.

Significantly maximum dry matter plant-1 (g) was recorded in variety AKU-10-1 (Black gold) than rest of varieties. This might be due to higher biomass potential of the variety.

Table 1: Growth of Black gram as influenced periodically by different treatments.

Treatment	Plant height (cm)	Number of functional leaves plant-1	Leaf area plant-1 (dm2)	Dry matter plant-1 (g)
A. Varieties (V)				
V1: BDU-1	59.68	15.18	11.46	18.62
V2: TAU-1	55.09	14.87	11.09	17.22
V3: AKU-10-1(Black gold)	62.52	20.71	15.77	21.40
S.Em±	0.23	0.33	0.48	0.55
C.D. at 5%	0.82	1.14	1.69	2.04
B. Spacings (S)				
S1: 30 x 05 cm2	57.46	14.42	11.20	15.44
S2: 30 x 10 cm2	58.16	15.70	11.62	19.08
S3: 45 x 05 cm2	58.27	17.38	12.58	20.84
S4: 45 x 10 cm2	62.51	20.17	15.70	23.95
S.Em±	0.84	0.70	0.84	1.17
C.D. at 5%	2.53	2.12	2.52	3.39
C. Interaction (A×B)				
S.Em±	1.46	1.22	1.46	1.03
C.D. at 5%	NS	3.67	NS	4.81
General Mean	59.10	16.92	12.77	19.32

Effect of spacings

Significantly maximum plant height, number of functional leaves, leaf area plant-1 and dry matter (g) was obtained at spacing 45 x 10 cm2 than rest of the spacings. However, it was at par with 45 x 05 cm2. The increase in plant height was due to beneficial effect on various metabolic activities due to wider row spacing.

Significantly maximum leaf area plant-1 (dm2) is a result of cell division and expansion of cell of leaf primordial which plays role in leaf in interception of solar (energy) radiation necessary for photosynthesis and wider spacings provides more lateral space for the same, because of this reason leaf area plant-1 (dm2) was found higher at 45 x 10 cm2 than other spacings.

Significantly maximum dry matter plant-1 (g) recorded at 45 x 10 cm2 than rest of the spacings. This might be due to more lateral space available for plant development as well as enough inter plant spacing, which may attributed to vigours growth of plant and also in other growth contributing parameters. Similarly reported by Biswas *et al.* 2002.

Table 2: Number of functional leaves plant-1 of black gram at 60 DAS and at harvest as influenced by interaction between varieties and spacings

Main x Sub Interaction								
Varieties Spacings (cm^2)	60 DAS				At harvest			
	V1: BDU-1	V2: TAU-1	V3: Black gold	Mean	V1: BDU-1	V2: TAU-1	V3: Black gold	Mean
S1: 30 X 05	19.27	14.00	18.33	17.20	15.40	13.53	14.33	14.42
S2: 30 X 10	17.55	20.37	24.33	20.75	13.97	14.80	18.33	15.70
S3: 45 X 05	19.78	16.67	27.00	21.15	17.41	13.00	21.73	17.38
S4: 45 X 10	19.57	21.20	29.37	23.38	13.93	18.13	28.43	20.17
S.Em±	1.34				1.11			
C.D. at 5%	4.02				3.37			
Mean	19.04	18.06	24.75	20.62	15.18	14.87	20.71	16.92

Table 3: Dry matter plant-1 (g) of black gram at 60 DAS and at harvest as influenced by interaction between varieties and spacings

Main X Sub Interaction								
Varieties Spacings (cm^2)	60 DAS				At harvest			
	V1: BDU-1	V2: TAU-1	V3: Black gold	Mean	V1: BDU-1	V2: TAU-1	V3: Black gold	Mean
S1: 30 X 05	12.33	11.27	26.46	17.02	16.09	15.88	14.35	15.44
S2: 30 X 10	26.14	17.78	18.69	20.87	15.91	22.26	19.07	19.08
S3: 45 X 05	18.70	19.92	28.61	22.41	21.32	19.56	21.64	20.84
S4: 45 X 10	19.75	21.67	30.91	24.11	21.16	4.40	30.54	23.95
S.Em±	1.81				1.03			
C.D. at 5%	5.56				4.81			

Interaction effect

The interaction effect between varieties and spacings were found non-significant for all growth contributing, yield attributing and quality aspects, except major growth contributing characters *viz*., number of leaves plant-1, leaf area plant-1 and dry matter plant-1 where black gram variety was same with wider spacing at 45 x 10 cm2.

Yield attributes

The data pertaining to effect of different varieties and spacings on number of seeds pod-1, weight of seeds pod-1 (g), seed yield (kg ha-1), straw yield (kg ha-1), Harvest index (%) and test weight (g) as influenced by various treatments are presented in table 4.

Effect of varieties

Significantly maximum number of pods plant-1, number of seeds pod-1, seed weight plant-1 (g), straw weight plant-1 (g), seed yield (kg ha-1), straw yield (kg ha-1), Harvest index (%) recorded by variety AKU-10-1 (Black gold) than other varieties. Similar results were also supported Kachare *et al*. 2009.

Table 4: Seed and straw yield plant-1, seed and straw yield (kg ha-1) harvest index of black gram as influenced by different treatments

Treatment	Yield plant-1 (g)		Yield (kg ha-1)		
	Seed	Straw	Seed	Straw	Harvest index (%)
A. Varieties: (V)					
V1: BDU-1	8.05	10.03	1775.00	1815.83	49.33
V2: TAU-1	7.37	9.37	1616.67	1635.83	49.59
V3: AKU-10-1	8.11	11.43	1805.00	1930.83	48.22
S.Em±	0.04	0.53	15.22	37.48	0.10
C.D. at 5%	0.15	1.84	52.66	129.72	0.30
B. Spacings: (S)					
S1: 30 x 05 cm2	7.53	9.39	1906.67	2120.00	47.35
S2: 30 x 10 cm2	7.61	10.06	1688.89	1691.11	49.80
S3: 45 x 05 cm2	7.77	10.40	1777.78	1802.22	49.46
S4: 45 x 10 cm2	8.46	11.58	1555.56	1563.33	49.70
S.Em±	0.21	0.70	39.97	63.29	0.11
C.D. at 5%	0.64	2.12	129.82	189.76	0.33
C. Interaction (A×B)					
S.Em±	0.37	1.22	69.22	109.63	0.25
C.D. at 5%	NS	NS	NS	NS	NS
General Mean	7.84	10.32	1732.22	1794.17	9.67

Effect of spacings

Significantly more number pods plant-1, number of seeds pod-1, seed weight plant-1 (g), straw weight plant-1 (g), seed yield (kg ha-1), straw yield (kg ha-1), Harvest index (%) were recorded at spacings 45 x 10 cm2 except seed and straw yields (kg ha-1) higher at 30 x 05 cm2 than rest of the spacings. This might be due to yields compensated due to more plant population at 30 x 05 cm2.

Interaction effect: The interaction effect between varieties and spacings on maximum number of pods plant-1, number of seeds pod-1, seed weight plant-1 (g), straw weight plant-1 (g), seed yield (kg ha-1), straw yield (kg ha-1), Harvest index (%) are non significant.

Uptake of N, P and K

Effect of varieties

The uptake of N, P and K in seed and straw was significantly influenced by different varieties. Significantly higher uptake of N, P and K were recorded with variety AKU-10-1(Black gold) than rest of the varieties (Table 5).

Effect of spacings

The uptake of N, P and K in seed and straw was significantly influenced by different spacings. Significantly higher uptake of N, P and K were recorded at spacing 30 x 05 cm2 than rest of the spacings. This might be due to higher plant population recorded at spacings 30 x 05 cm2. (Table 5).

Table 5: N, P and K uptake (kg ha-1) by seed and straw of black gold as influenced by different treatments.

Treatments	Nutrient uptake (kg ha-1)					
	Seed			Straw		
	N	P	K	N	P	K
A) Main plot: Varieties						
V1: BDU-1	66.74	7.81	8.16	14.06	3.19	29.46
V2: TAU-1	60.62	7.11	7.43	12.67	2.74	26.83
V3: AKU-10-1(Black gold)	68.95	8.48	8.66	16.32	3.40	31.58
S.E m±	1.70	0.22	0.22	0.10	0.14	1.30
C.D. at 5%	5.89	0.78	0.77	0.37	0.50	4.52
B) Sub plot: Spacings (cm2)						
S1: 30 X 05	71.30	8.00	8.58	16.69	3.24	31.65
S2: 30 X 10	63.50	7.76	7.76	13.16	3.04	28.03
S3: 45 X 05	67.20	8.17	8.35	14.57	3.20	29.68
S4: 45 X 10	59.11	7.46	8.35	12.06	3.11	27.53
S.Em±	3.71	0.46	0.46	0.23	0.29	1.88
C.D. at 5%	11.13	1.40	1.38	0.70	0.87	5.66
C) Interaction (AXB)						
S.Em±	6.43	0.81	0.79	0.41	0.502	3.27
C.D. at 5%	NS	NS	NS	NS	NS	NS
General Mean	67.06	7.31	7.24	7.95	8.26	74.96

Table 6: Available N, P and K (kg ha-1) by black gram as influenced by different treatments

Treatment	Available nutrients (Kg ha-1)		
	N	P	K
A) Main plot: Varieties			
V1: BDU-1	161.00	19.92	376.50
V2: TAU-1	160.83	19.32	375.50
V3: AKU-10-1(Black gold)	161.75	20.00	377.67
S.Em±	0.43	0.60	0.95
C.D. at 5%	NS	NS	NS
B) Sub plot: Spacings (cm2)			
S1: 30 X 05	160.89	18.89	374.67
S2: 30 X 10	161.22	19.89	376.89
S3: 45 X 05	163.77	19.94	377.22
S4: 45 X 10	164.56	19.78	379.11
S.Em±	0.30	0.37	1.16
C.D. at 5%	NS	NS	NS
C) Interaction (A×B)			
S.Em±	0.52	0.65	2.01
C.D. at 5%	NS	NS	NS
General Mean	161.88	19.67	376.79
Initial	165.14	21.58	405.20

Interaction effect

Interaction effect between varieties and spacings on total uptake of N, P and K (kg ha-1) of black gram was found non significant.

Effect of varieties

The data regarding protein content, germination per cent, physical purity and moisture per cent in seeds of black gram after harvest as influenced by different varieties and spacings are presented in Table 7 and significantly higher by variety AKU-10-1 (Black gold) than other varieties.

Effect of spacings

Among different spacings maximum protein content, germination per cent recorded at spacing 45 x 10 cm2 than other spacings while physical purity and moisture per cent recorded at 45 x 05 cm2. Similarly reported by Jain *et al.* 1988.

Table 7: Quality studies of black gram as influenced by different treatments

Treatment	Protein content (%)	Germination (%)	Physical purity (%)	Moisture (%)
A) Main plot: Varieties				
V1: BDU-1	23.48	99.17	98.76	9.33
V2: TAU-1	23.45	99.10	98.77	9.17
V3: AKU-10-1(Black gold)	23.85	99.18	98.72	9.33
S.E m±	0.070	0.061	0.060	0.15
C.D. at 5%	0.242	NS	NS	NS
B) Sub plot: Spacings (cm2)				
S1: 30 X 05	23.38	98.14	98.71	9.11
S2: 30 X 10	23.52	99.54	98.77	9.33
S3: 45 X 05	23.65	99.40	98.84	9.44
S4: 45 X 10	23.83	99.51	98.69	9.22
S.Em±	0.099	0.096	0.049	0.17
C.D. at 5%	NS	NS	NS	NS
C) Interaction (AXB)				
S.Em±	0.171	0.166	0.085	0.29
C.D. at 5%	NS	NS	NS	NS
General Mean	23.59	99.15	98.75	9.28
Treatment	**Protein content (%)**	**Germination (%)**	**Physical purity (%)**	**Moisture (%)**
A) Main plot: Varieties				
V1: BDU-1	23.48	99.17	98.76	9.33
V2: TAU-1	23.45	99.10	98.77	9.17
V3: AKU-10-1(Black gold)	23.85	99.18	98.72	9.33
S.E m±	0.070	0.061	0.060	0.15
C.D. at 5%	0.242	NS	NS	NS
B) Sub plot: Spacings (cm2)				
S1: 30 X 05	23.38	98.14	98.71	9.11
S2: 30 X 10	23.52	99.54	98.77	9.33
S3: 45 X 05	23.65	99.40	98.84	9.44
S4: 45 X 10	23.83	99.51	98.69	9.22
S.Em±	0.099	0.096	0.049	0.17
C.D. at 5%	NS	NS	NS	NS
C) Interaction (AXB)				
S.Em±	0.171	0.166	0.085	0.29
C.D. at 5%	NS	NS	NS	NS
General Mean	23.59	99.15	98.75	9.28

Economics of black gram

The data regarding economic evaluation of black gram in terms of gross monetary returns, cost of cultivation, net monetary returns and benefit: cost ratio are given in Table 8.

Cost of cultivation

The mean cost of cultivation of *kharif* black gram as influenced by different treatment was ₹ 23743 ha-1 (Table 8). It was slightly varied due to seed rate and cost of seeds ha-1.

Effect of varieties

Among different varieties, the maximum cost of cultivation was noted by AKU-10-1 (Black gold) ₹ 24100 ha-1 than other varieties. This might be due to more seed cost compared to other varieties.

Effect of spacings

Among different spacings treatments, the cost of cultivation was higher in (S1) 30 x 05 cm2 (₹ 24700 ha-1) than other spacings. This might be due to higher seed rate and more seed cost compared to other spacings.

Gross monetary returns: Gross monetary returns as influenced by different treatments are given in Table 8.

Effect of varieties

Maximum gross monetary returns ₹ 74130 ha-1 was obtained when black gram variety AKU- 10-1 (Black gold) was sown during *kharif.*

The minimum gross monetary returns ₹ 66303 ha-1 was obtained by TAU-1.

Effect of spacings

Gross monetary returns were affected by different spacings and maximum gross monetary returns of ₹ 78387 ha-1 were obtained by (S1) 30 x 05 cm2 than rest of spacings. Minimum gross monetary returns of ₹ 63786 ha-1 observed under (S3) 45 x 05 cm2. Same results were found by Dhanjal *et al.* (2001).

Effect of interaction

The interaction effect between different varieties and spacings on gross monetary returns were found non-significant (Table 8).

Net monetary returns

Data on net monetary returns as influenced by different treatments furnished in Table 8.

Effect of varieties

Among different varieties, the maximum net monetary returns ₹50030 ha-1 was obtained by AKU-10-1 (Black gold) variety of black gram than other varieties.

Effect of spacings: Net monetary returns were affected by different spacings and maximum net monetary returns of ₹ 53687 ha-1 was obtained when black gram was sown at (S1) 30 x 05 cm2 whereas, minimum net monetary returns ₹ 40886 ha-1 was obtained in spacing (S4) 45 x 10 cm2.

Effect of interaction

The interaction effect between different varieties and spacings on net monetary returns was found non-significant (Table 8).

Benefit: Cost ratio

Benefit: cost ratio of *Kharif* black gram under different varieties and spacings showed variation. The average value of benefit: cost ratio was 2.98 (Table 8).

Effect of varieties

Under different varieties, higher benefit: cost ratio (3.07) was registered by AKU-10-1 (Black gold) among rest of the varieties.

Effect of spacings

Under different spacings, higher benefit: cost ratio (3.17) was obtained under 30 x 05 cm2 (V1).

Table 8: Economics of *kharif* black gram as influenced by different treatments

Treatment	Cost of cultivation (₹ha-1)	Monetary returns (₹ ha-1)		B:C ratio
		Gross	Net	
A) Main plot: Varieties				
V1: BDU-1	23800	72816	49016	3.05
V2: TAU-1	23650	66303	42653	2.80
V3: PDKV. black gold	24100	74130	50030	3.07
S.Em±	-	-	-	-
C.D. at 5%	-	-	-	-
B) Sub plot: Spacings (cm)				
S1: 30 X 05	24700	78387	53687	3.17
S2: 30 X 10	23300	69247	45947	2.97
S3: 45 X 05	23750	72913	49163	3.07
S4: 45 X 10	22900	63786	40886	2.78
S.Em±	-	-	-	-
C.D. at 5%	-	-	-	-
C) Interaction (A×B)				
S.Em±	-	-	-	-
C.D. at 5%	-	-	-	-
General Mean	23743	71083	47340	2.98

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