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Bunal Siva Rama Raju
M. Sc Student, MSSSOA,
Centurion University of
Technology and Management
Paralakhemundi, Odisha, India

Pakalpati Satyanarayana Raju
Professor Emeritus, MSSSOA,
Centurion University of
Technology and Management
Paralakhemundi, Odisha, India

Chandaka Deepthi
Assistant Professor, MSSSOA,
Centurion University of
Technology and Management
Paralakhemundi, Odisha, India

Mandapati Roja
Assistant Professor, MSSSOA,
Centurion University of
Technology and Management
Paralakhemundi, Odisha, India

Correspondence
Bunal Siva Rama Raju
M. Sc Student, MSSSOA,
Centurion University of
Technology and Management
Paralakhemundi, Odisha, India

Effects of plant population density on growth parameters of blackgram (*Vigna mungo* L. Hepper)

Bunal Siva Rama Raju, Pakalpati Satyanarayana Raju, Chandaka Deepthi and Mandapati Roja

Abstract
Blackgram (*Vigna mungo* L. Hepper) is an important pulse crop grown widely in India. The grain is consumed by humans as 'dal' and is used to cook several delicacies. The stover is used as a nutritive fodder for milch cattle. The effects of plant population density on black gram plant growth and development were studied in an experiment during *rabi* 2018-19 on the sandy loam soil at Bagusala Farm (23^{o}39' N latitude, 87^{o}42' E longitude), M.S. Swaminathan School of Agriculture, Gosani Block, Gajapati District, Odisha. The experiment was layed out in a randomized complete block design with five replications. The plants of the blackgram variety PU-30 spaced 8, 10, 12, and 14 cm within rows 60 cm apart formed the four treatments. The growth parameters, viz plant height, branches/plant, leaves/plant, and plant dry weight were measured at 15, 30, 45 and 60 days after sowing, and LAI and CGR were calculated. Plant dry matter of blackgram was affected by plant spacing. The maximum dry matter was recorded at 30, 45, and 60 DAS in 8 cm spacing and the minimum in 14 cm. The plant dry matter increased with decreased plant spacing from 14 to 8 cm. The closer spacing of 8 cm x 60 cm, corresponding to a plant density of 2,08,333 plants/ha, gave higher crop growth rate of the black gram variety PU-30 during the *rabi* season compared to the wider spacings of 10 cm x 60 cm, 12 cm x 60 cm, and 14 cm x 60 cm, corresponding to plant densities of 1,66,666, 1,37,500, and 1,16,666 plants/ha, respectively.

Keywords: Blackgram, plant growth, plant spacing, population density, *Vigna mungo*

Introduction

Blackgram (*Vigna mungo* L. Hepper) belongs to the family Fabaceae. In India, Madhya Pradesh, Uttar Pradesh, and Andhra Pradesh are major blackgram growing States area-wise. Blackgram has a perfect combination of all nutrients, which includes proteins (25-26%), carbohydrates (60%), fat (1.5%), minerals, with favourable composition of amino acids, and vitamins A, B1, B3, thiamine, riboflavin, niacin, and vitamin C. Being a leguminous crop, blackgram is a mini-fertilizer factory, as it has unique characteristics of maintaining and restoring soil fertility through fixing atmospheric nitrogen by symbiotic association with *Rhizobium* bacteria present in the root nodules. It proves to be a great rotation crop enhancing the yield of main crop as well. It is mainly cultivated in a cereal-pulse cropping system, primarily to conserve soil nutrients and utilize the left over soil moisture, particularly after rice cultivation. It is a short duration pulse crop, usually flowering within 30-60 days of sowing and maturing in 60-90 days. It is generally cultivated as *kharif* crop but also does well in summer season as a catch crop.

It is necessary to find the optimum population density for any given location to increase yield of blackgram. Population density is very important as the plants compete with each other for the yield governing resources, such as moisture, light, and mineral nutrients. The present experiment was conducted to determine the optimum plant population density to obtain optimum plant growth of blackgram in *rabi*.

Materials and Methods

Experiment Site and Design

The field experiment was conducted during r*abi* season of 2018-19 at Bagusala Instructional Farm M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Gosani Block, Gajapathi District, Odisha. The soil was sandy loam, where the

percentages of sand, silt, and clay were 55.2, 20.4, & 18.5, respectively. The soil pH was 6.2, EC 0.35 dS m^{-1}, and organic carbon 0.31%. The minimum and maximum temperatures ranged from 15 to 18 C and 41 to 48 C, respectively during the period of the experiment. The crop received rainfall of 16.36, 4.43, and 0.08 mm during the months of December, January, and February, respectively.
The experiment was conducted in a randomozed complete block design with five replications. Blackgram seeds of the variety PU-30 were sown in rows on ridges spaced at 60 cm. Within row plant to plant spacings of 8, 10, 12, and 14 cm comprised the four treatments, *viz.* T1 of 8 cm, T2 of 10 cm, T3 of 12 cm, and T4 of 14 cm. Each plot was 19.2 m^2 in area and consisted of 8 rows, each 4 m long.

Experiment Procedure

The land was ploughed twice with a mouldboard plough and then harrowed, levelled, and ridged. Fertilizer was applied basally at the rate of 25 kg N, 50 kg P_2O_5, and 25 kg K_2O per hectare in the form of urea, single super phosphate, and muriate of potash, respectively. The blackgram seeds were sown at 4 cm depth on 7th December, 2018 and the field irrigated. Irrigations were applied thereafter when needed. Two hand weedings were done at 15 and 30 DAS. To maintain plant populations in treatments, thinning was done after 15 DAS when the plants had 3-4 leaves.
Plant height was recorded on five randomly selected and tagged plants at 15, 30, 45 DAS and at harvest stage (60 DAS). Samples of 5 randomly selected plants each were collected at 15, 30, 45, and 60 DAS and taken for growth analysis. Leaf area was measured by a leaf area meter. Numbers of branches/plant and leaves/plant were recorded. The plant parts were dried for two days, till a stable weight was attained, in a forced draft oven set at a temperature of 80 C, allowed to cool, and weighed. Leaf area index (LAI) was calculated as the ratio of the leaf area of the plants to the land area occupied by the plants. Crop growth rate (CGR) was calculated using the formula (Watson, 1952) [1]: CGR (g m^{-2} day^{-1}) = $(W_2 - W_1) / (t_2 - t_1)$, where W_1 and W_2 are plant dry weights per unit area at t_1 and t_2 days, respectively.
Statistical analysis of the data recorded for various plant growth characters was done using statistical procedures appropriate for the randomized complete block design and the treatment variances were tested by the "F" test. Treatment means, standard errors of means, co-efficient of variation percentages, critical differences (CDs) at 5% probability level were calculated, and obtained CD values compared with table values to test whether the various plant characters showed signify canttreatment means where treatment effects were found significant.

Results and Discussion

Plant height (Table 1), branches/plant (Table 2), and number of leaves/plant (Table 3) of blackgram at 15, 30, 45, and 60 DAS were significantly influenced by plant population density. Maximum plant height at 30 DAS was recorded at the widest plant spacing of 14 cm and the minimum was observed at the closest spacing of 8 cm. Maximum plant height was recorded at 60 DAS in the spacing of 14 cm and minimum at spacing of 8 cm. Plant height

Table 1: Effect of plant spacing on plant height (cm) at different growth stages of black gram.

Treatment	15 DAS	30DAS	45DAS	60DAS
T1 (8cm)	3.92	17.56	18.98	28.28
T2 (10cm)	4.04	19.6	20.82	29.7
T3 (12cm)	4.34	20.98	24.78	30.06
T4 (14cm)	5.4	21.26	25.66	33.2
SE m±	0.11	0.37	0.41	0.56
CD (P=0.05)	0.24	0.81	0.89	1.24
CV%	12.4	9.42	9.09	9.39

decreased with decrease of plant spacing from 14 to 8 cm. The plant height was less at 8 cm probably due to more plant population. Miftah (2002) [2] and Halavankar *et al.* (1993) [3] observed similar trends.

Table 2: Effect of plant spacing on branches/plant at different growth stages of black gram.

Treatment	15 DAS	30DAS	45DAS	60DAS
T1 (8cm)	4.86	5.95	7.52	10.46
T2 (10cm)	5.3	5.92	7.78	11.18
T3 (12cm)	5.51	6.15	8.54	12.28
T4 (14cm)	5.92	7.12	9.01	13.21
SE m±	0.13	0.16	0.21	0.22
CD (P=0.05)	0.30	0.35	0.47	0.47
CV%	12.94	12.9	13.34	9.33

There was no significant difference in the number of branches/plant at 15 DAS in the 10 and 12 cm spacing treatments (Table 2). The maximum number of branches was observed in 14 cm spacing and minimum in 8 cm. At 30 DAS, maximum number of branches/plant was at 14 cm spacing and minimum at 10 cm spacing. At 60 DAS, the maximum number of branches/plant was observed at 14 cm spacing and the minimum number of branches 8 cm spacing. The number of branches/plant increased with decreased plant spacing from 14 to 8 cm spacing. Data on number of leaves/plant showed similar trends (Table 3). This might be due to increased plant growth in wider spacing, where plants got better opportunity to avail

Table 3: Effect of plant spacing on leaves/plant at different growth stages of black gram.

Treatment	15 DAS	30DAS	45DAS	60DAS
T1 (8 cm)	4.08	10.28	19.68	26.68
T2 (10 cm)	5.12	10.52	19.8	27.7
T3 (12 cm)	5.32	11.42	21.82	28.7
T4 (14 cm)	6.08	12.08	23.1	30.3
SEm±	0.10	0.22	0.37	0.37
CD (P=0.05)	0.22	0.49	0.81	0.81
CV%	9.84	10.2	8.89	6.61

maximum space, light, and nutrients. These findings are in complete agreement with earlier work of Nimje *et al.* (2003) [4] in soybean, and Dhanjal *et al.* (2001) [5] in French bean.
Plant dry matter of blackgram was affected by plant spacing (Table 4). The maximum dry matter was recorded at 30, 45, and 60 DAS in 8 cm spacing and the minimum in 14 cm. The plant dry matter increased with decreased plant spacing from 14 to 8 cm. Accumulation of total plant dry matter of two black gram varieties differed with population (Biswas *et al.*, 2002) [6].

Table 4: Effect of plant spacing on plant dry matter (g) at different growth stages in blackgram.

Treatment	30 DAS	45 DAS	60 DAS
T1 (8 cm)	17.14	27.72	38.94
T2 (10 cm)	14.9	24.54	33.4
T3 (12 cm)	14.06	23.96	31.82
T4 (14 cm)	11.58	19.78	26.58
SEm±	0.24	0.64	0.65
CD (P=0.05)	0.53	1.40	1.42
CV%	8.49	13.43	9.98

The leaf area index of blackgram was influenced by the plant population density (Table 5). At 30 and 60 DAS, LAI differed significantly amongst the spacing treatments. The maximum

Table 5: Effect of plant spacing on leaf area index at 30 and 60 DAS in blackgram.

Treatment	30 DAS	60 DAS
T1 (8 cm)	2.26	3.01
T2 (10 cm)	3.02	3.63
T3 (12 cm)	3.48	3.42
T4 (14 cm)	4.04	3.29
SEm±	0.09	0.09
CD (P=0.05)	0.20	0.20
CV%	14.91	14.2

The crop growth rates of blackgram at 35 to 45 DAS and 45 to 60 DAS were influenced significantly by plant population densities (Table 6). The maximum crop growth rates at 30-45 DAS and 45-60 DAS were noted at 8 cm spacing and the minimum at 14 cm spacing.

Table 6: Effect of plant spacing on crop growth rate (g m^{-2} day^{-1}) at 30-45 DAS and 45-60 DAS in blackgram.

Treatment	30-45 DAS	45-60 DAS
T1 (8 cm)	38.54	55.94
T2 (10 cm)	33	50.62
T3 (12 cm)	28.02	46.6
T4 (14 cm)	25.18	41.06
SEm±	0.78	0.84
CD (P=0.05)	1.72	1.83
CV%	12.6	8.66

LAI at 30 DAS was in 14 cm spacing, whereas at 60 DAS it was in 10 cm spacing; the minimum LAI at both 30 and 60 DAS was in 8 cm spacing. Renthunglo *et al.* (2018) [7] found LAI was the maximum at plant spacing of 20 x 10 cm, followed by 30 x 10 cm spacing, and the minimum at 45 x 10 cm spacing.

Significant differences were observed between all spacing treatments. The crop growth rates decreased as plant spacing increased from 8 to 14 cm. According to Biswas *et al.* (2002) [6], lower population density had significant effect on crop growth rate. The crop growth rate increased gradually and attained a peak with the minimum noted at higher plant spacing.

Conclusion

The closer spacing of 8 cm x 60 cm, corresponding to a plant density of 2,08,333 plants/ha, gave higher crop growth rate of the black gram variety PU-30 during the *rabi* season in the sandy loam soil at Bagusala, southern Odisha, compared to the wider spacings of 10 cm x 60 cm, 12 cm x 60 cm, and 14 cm x 60 cm, corresponding to a plant densities of 1,66,666, 137,500, and 116,666 plants/ha, respectively, tested in the present study.

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