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Influence on productivity and yield contributing characters of blackgram varieties as affected by different plant spacing

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka from March to June 2021 in Kharif I season to study the response of blackgram varieties and different plant spacing. The experiment consisted of two factors and followed split-plot design with three replications. Factor A: Blackgram varieties (3) viz: V_1-BARI Mash 2, V_2-BARI Mash 3, V_3-BARI Mash 4 and Factor B: Different plant spacing (4) viz: S_1 = Broadcasting, S_2 = 15 cm × 10 cm, S_3 = 20 cm × 20 cm, and S_4 = 30 cm × 15 cm. Experimental results revealed that different varieties and plant spacing significantly influenced the yield and yield contributing parameters of blackgram. In case of different blackgram varieties, the maximum seed yield (1.49t ha-1) was recorded from BARI Mash-3 (V_2) treatment and lowest seed yield (0.96 t ha^{-1}) was obtained from V_1 treatment (BARI Mash-2). The highest yield with BARI Mash-3 (V_2) was attributed due to the highest pods plant^{-1} (6.52), pod length (5.22 cm), seeds pod^{-1} (7.78), 1000-seed weight (42.76 g), biological yield (3.25 t ha^{-1}) and harvest index (45.53 %). However the seed yield ranges between (0.92 -1.46 t ha-1) in different plant spacing. The highest seed yield (1.46 t ha^{-1}) was recorded in S_4 (30 cm × 15 cm) treatment, which was achieved with maximum pods plant^{-1} (6.67), pod length (5.36 cm), seeds pod^{-1} (7.40) and 1000-seed weight (44.11 g). In combination, cultivation of BARI Mash-3 (V_2) along with 30 cm × 15 cm spacing (S_4) affected plant growth and yield-contributing characteristics, leading to the maximum seed yield (1.80 t ha^{-1}) compared to other treatment combinations. Therefore, it suggested that cultivation of BARI Mash-3 along with 30 cm × 15 cm spacing (V_2S_4) could be optimum crop management for maximum yield harvest in blackgram.

***Key Words**: Plant spacing, Varieties, Seed yield, Blackgram, Harvest index*

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I. Introduction

Pulses are a crucial component of the human diet and could be a source of protein for the millions of people of Bangladesh. They contribute 2.3% of value added to agriculture in Bangladesh (Rahman, 2017). As the least expensive form of protein, pulses are known as "the meat of the poor" (Jackson et

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al., 2021). The per capita pulse consumption in Bangladesh is only 14.3 g day-1, which is far less than the WHO's recommendation of 45 g and the Indian Council of Medical Research's recommendation of 60 g (Mohiuddin et al., 2018). This will also boost nutritional food security (Singh, 2018). Among the pulses, blackgram is one of the most consumed pulses in Bangladesh and is the third most widely grown crop there in terms of both total cultivated area and consumption (BBS, 2021). Total cultivated area in Bangladesh is 9805360 hectares, of which 44.63%, 18.28% and 10.20% are suitable, moderately suitable and marginally suitable, respectively, for blackgram production (Mohiuddin et al., 2018). Blackgram, a leguminous crop. Improved varieties of different pulse crops promise to increase productivity by 20-25%, whereas latest technology comprising varieties and integrated nutrients management and pests has shown a 25-42% increase in productivity (Pandey et al., 2022). Several high producing varieties, including BARI mash-1, BARI Mash-2, BARI Mash-3, and BARI Mash-4, were developed by the Bangladesh Agricultural Research Institute (BARI) (Islam et al., 2019). Several blackgram cultivars have also been created by the Bangladesh Institute of Nuclear Agriculture (BINA). However, farmers typically grow local varieties, which does not impact production. Thus, yield should be increased by selecting high producing varieties (Pandey et al., 2022).

Plant density can significantly affect the final yield of most legumes, and the general response of yield to increasing population is well documented. To realize the maximum yield potential of blackgram during summer and rainy seasons, maintenance of optimum space made available to individual plants is of prime importance. Row and plant spacing must be worked out to get desired spacing (Veeramani, 2019). The spacing requirement depends upon the growth behaviour of genotype. Optimum spacing between rows is required to efficiently utilize available production factors such as moisture, nutrients, sunlight and space, which impact seed yield (Amare and Gebremedhin, 2020). However, the farmers do not follow the above recommendations for crop establishment mainly due to labor shortage, as labor demand for rice cultivation is higher during the same period. Therefore, farmers usually broadcast seeds on the harrowed land at different seed rates since there is no recommended package of practices for broadcast blackgram (Ekanayake et al., 2011). Optimum plant density is a primary requirement for better crop growth to minimize intra-species competition (Zhang et al., 2021). So, spacing required to obtain a higher yield (Veeramani, 2019). Considering the above facts, an experiment was planned and undertaken to determine the performance of varieties and effect of different plant spacings along with their combined effect towards maximum yield of blackgram.

II. Materials and Methods

The experiment was conducted from March to June 2021 in Kharif season in the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77' N latitude and 90°33' E longitude at an altitude of 8.6 meters above sea level (Anon., 2004) and belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988). The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils, under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989).

Experimental design and layout

BARI mash-2, BARI mash-3 and BARI mash-4 were used as experimental materials for this experiment, collected from Pulses Research Centre, Ishurdi, Pabna and Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The experiment was laid out in split-plot design having 3 replications. In main plot, there was blackgram variety and in subplot, there were sowing method treatments. There are 12 treatment combinations and 36 unit plots. The unit plot size was 5.4 m^2 (2.7 m × 2 m). The blocks and unit plots were separated by 1.0 m and 0.50 m spacing, respectively. There were two factors in the experiment, namely blackgram variety and different plant spacing as mentioned below:

Factor A. Blackgram varieties (3)	**Factor B**. Different plant spacing (4)
V_1= BARI Mash 2	S_1 = Broadcasting
V_2= BARI Mash 3	S_2 = 15 cm × 10 cm
V_3=BARI Mash 4	S_3 = 20 cm × 20 cm
	S_4 = 30 cm × 15 cm

Land preparation

Initially, the field was prepared with the help of tractor drawn disc plough. After one deep ploughing the experimental field was cross harrowed and levelled properly to break the clods and bring the soil

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to the desired tilth. On March 25th, 2021, a power tiller opened the experimental land. Cross-plowing and laddering were performed using a power tiller. On March 27, 2021, the land was prepared for seed sowing. Seeds were sown at the rate of 35 kg ha^{-1} in the furrow on 28 March, 2021 and the furrows were covered with the soils soon after seed sowing.

Fertilizer application

Utilized urea, TSP, MP, gypsum and boric acid, the fertilizer doses were 45, 90, 40, 55 and 10 kg ha^{-1}, respectively. Urea, TSP, MP, Gypsum and boric acid were treated at basal doses during the final land preparation (BARI krishi projukti hat boi-2019). All fertilizers were applied by broadcasting and mixed thoroughly with soil.

Intercultural operation

The field was irrigated twice- one at 20 days and the other at 35 DAS. Early in its development, the crop was afflicted with insects and pests. Worms (*Agrotis ipsilon*) and virus-carrying jassids attacked the plants at young stage, and at a later stage, the pod borer (*Maruca testulalis*) attacked the plant. Dimacron 50EC (Emulsifiable concentrate) was sprayed at 1 liter ha^{-1} to control worms, virus vectors, and pod borer insects.

Recording of data

The data were recorded 15 days after sowing and continued until the end of recording the yield contributing characteristics of the crop after harvest. Dry plant weights were collected from the inner rows, leaving border rows by destructive sampling of 5 plants at harvest. The following data were recorded during the experiment.

i. Pods $plant^{-1}$ (no.)
ii. Pod length
iii. Seeds pod^{-1} (no.)
iv. 1000 seeds weight (g)
v. Seed yield (t ha^{-1})
vi. Stover yield (t ha^{-1})
vii. Biological yield (t ha^{-1})
viii. Harvest index (%)

Data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program named Statistix 10 data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at a 5% level of probability (Gomez and Gomez, 1984).

III. Results and Discussion

Pods $plant^{-1}$

Effect of varieties: Experimental results revealed that highest number of pods $plant^{-1}$ of blackgram (6.52) was found in V_2 (BARI Mash-3) treatment. The lowest number of pods $plant^{-1}$ of blackgram (5.89) was found in V_1 (BARI Mash-2) treatment (Figure 01). Different blackgram varieties had different numbers of pods $plant^{-1}$ due to the genetic makeup of the variety and maximum number of pods $plant^{-1}$ was obtained from high yielding varieties comparable to low-yielding blackgram varieties.

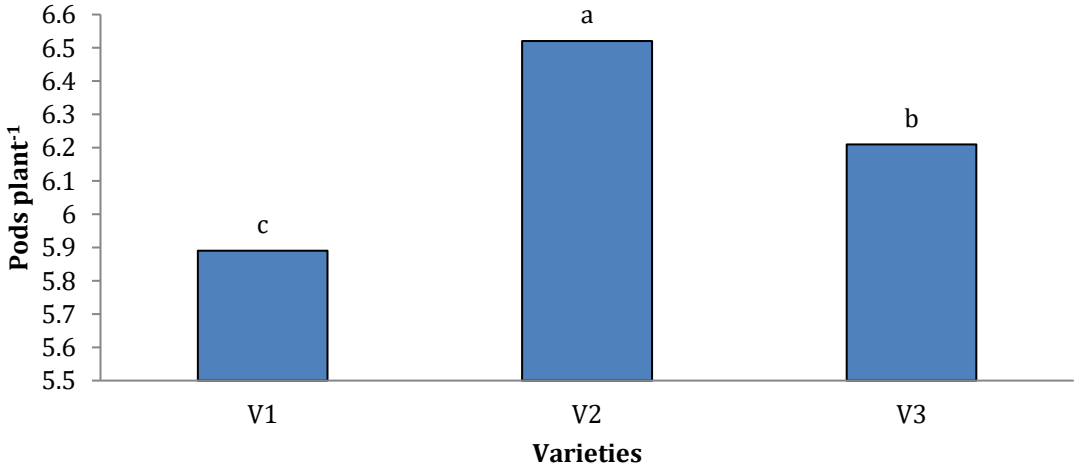

Figure 01. Effect of varieties on pods $plant^{-1}$ of blackgram ($LSD_{(0.05)}$= 0.19)

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The result obtained from the present study was similar to the findings of Mane et al. (2018), who reported that the blackgram variety BDU-1 was highly productive compared to TAU-1 and AKU-15. Variety BDU-1 produced maximum pods plant^{-1} i.e. (24.54) was significantly superior over variety TAU-1, i.e. 23.77 and variety AKU-15, i.e. (21.83).

Effect of plant spacing: According to the experimental results, the highest number of pods plant^{-1} of blackgram (6.67) was observed in the S_4 (30 cm × 15 cm) treatment which was statistically similar to S_3 (6.53) treatment. However, the S_1 (Broadcasting) treatment had the lowest number of pods plant^{-1} of blackgram (5.38) (Figure 02). This could be because high plant density or closer spacing leads to competition for air, light, and nutrients, forcing plants to go through less reproductive growth and, as a result, reducing the number of pods plant^{-1}. A similar result was also observed by Bonepally et al. (2021), who reported that the number of pods per plant (66.30) was found to be maximum in treatment combination with 30 × 10 cm^2 + 40 kg/ha of phosphorus as compared to rest of the treatments which is beneficial for blackgram production.

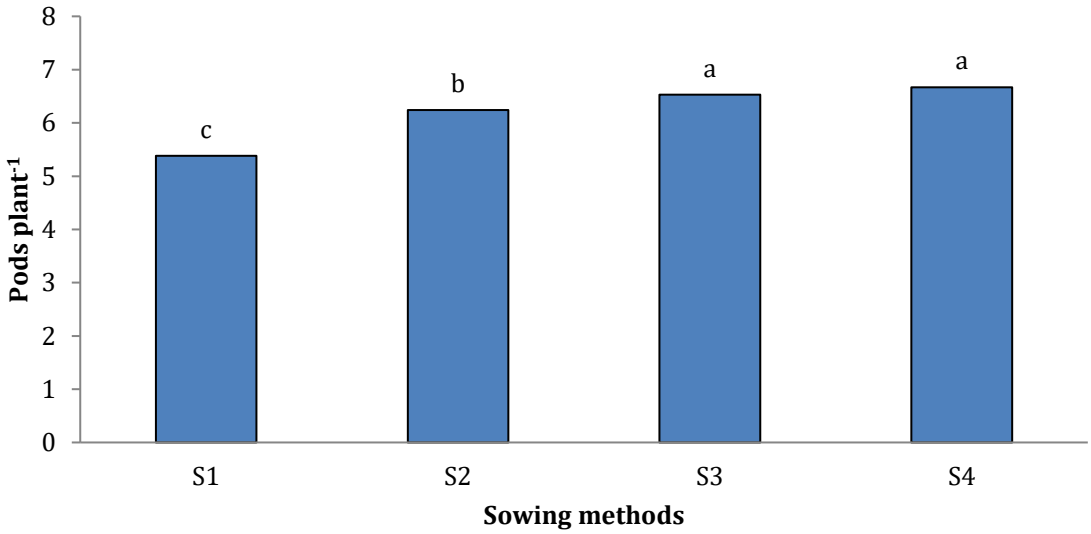

Figure 02. Effect of sowing methods on pods plant^{-1} of blackgram ($LSD_{(0.05)}$= 0.25)
In the bar graphs, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5.0 % level of probability.

Combined effect of variety and plant spacing: the highest number of pods plant^{-1} of blackgram (6.94) was observed in V_2S_4 treatment combination, which was statistically similar to V_3S_4 (6.60) treatment combination. While the lowest number of pods plant^{-1} of blackgram (4.54) was observed in V_1S_1 treatment combination (Table 01).

Pod length (cm)

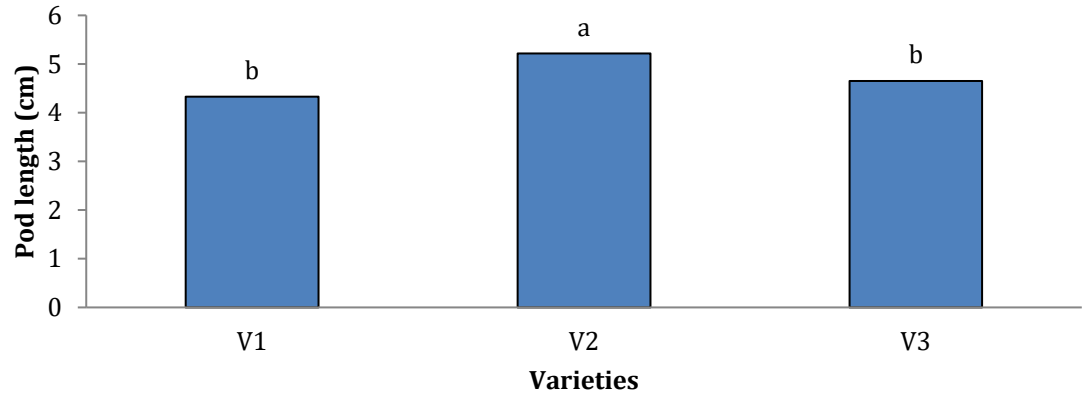

Figure 03. Effect of varieties on pod length of blackgram ($LSD_{(1)}$= 0.37).

Effect of varieties: The highest pod length was observed in the V_2 (BARI Mash-3) treatment. While the V_1 treatment (BARI Mash-2) had the lowest pod length of blackgram (4.33 cm) which was statistically

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similar to V_3 (4.65 cm) treatment (Figure 03). The pod length varies between blackgram varieties because of the variety's genetic makeup. Patra et al. (2001) reported that the variation of pod length of the different blackgram cultivars differed significantly due to the genetic character of the varieties.

Effect of plant spacing: Experimental results showed that the highest pod length of blackgram (5.36 cm) was observed in the S_4 (30 cm × 15 cm) treatment. Meanwhile, the S_1 treatment (Broadcasting) had the lowest pod length of blackgram (8.56 cm) (Figure 04). An increase in pod length might be due to less competition between plants at optimum spacing and availability of nutrients in adequate amounts, resulting in formation of photosynthesis, which promotes metabolic activity, increases cell division, and ultimately increases the pods' length. Patel et al. (2005) reported that pod length increases with increasing plant spacing.

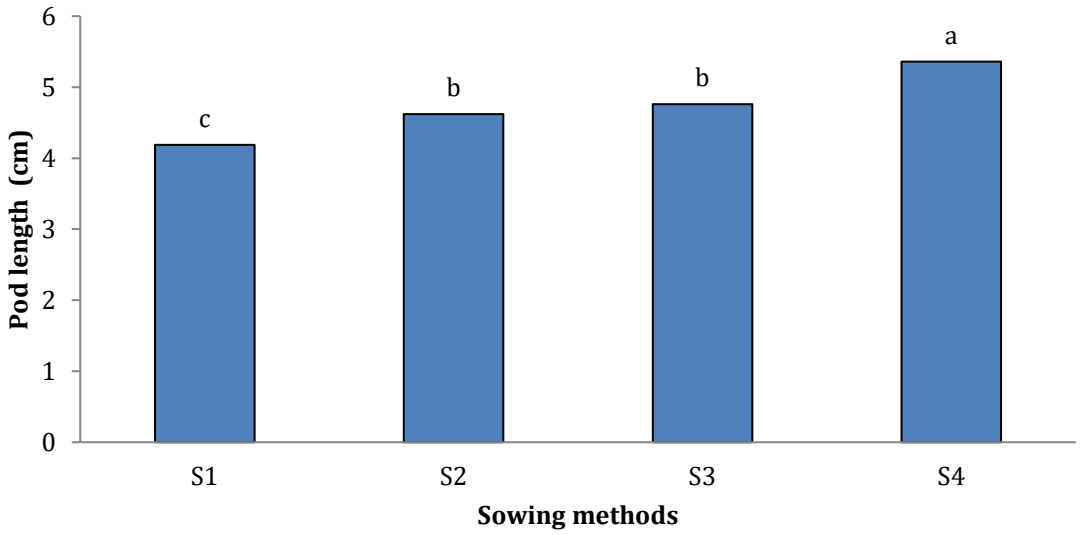

Figure 04. Effect of sowing methods on pod length of blackgram ($LSD_{(0.05)}$= 0.32)

Combined effect of varieties and plant spacing: The results of the experiment showed that the V_2S_4 treatment combination had the largest pod length of blackgram (6.10). Meanwhile, the V_1S_1 treatment combination had the lowest pod length of blackgram (3.42) (Table 01).

Seeds pod^{-1}

Effect of varieties: According to the experimental findings, the V_2 (BARI Mash-3) treatment had the highest number of seeds pod^{-1} of blackgram (7.78). On the other hand, the V_1 (BARI Mash-2) treatment had the lowest seeds pod^{-1} of blackgram (5.43) (Figure 05). A similar result was observed by Vishnu et al. (2022), who reported that the variances in the genetic make-up of the variety, which is mainly controlled by inheritance, cause variations in the number of seeds pod^{-1} among different blackgram varieties. Eswari and Rao (2007) also reported that the genotypes LBG-709, LBG-693, LBG-712 and MBG-207 of black gram were found to be the most desirable genotypes for high seed yield, pods plant^{-1}, earliness, seeds pod^{-1} and seed weight.

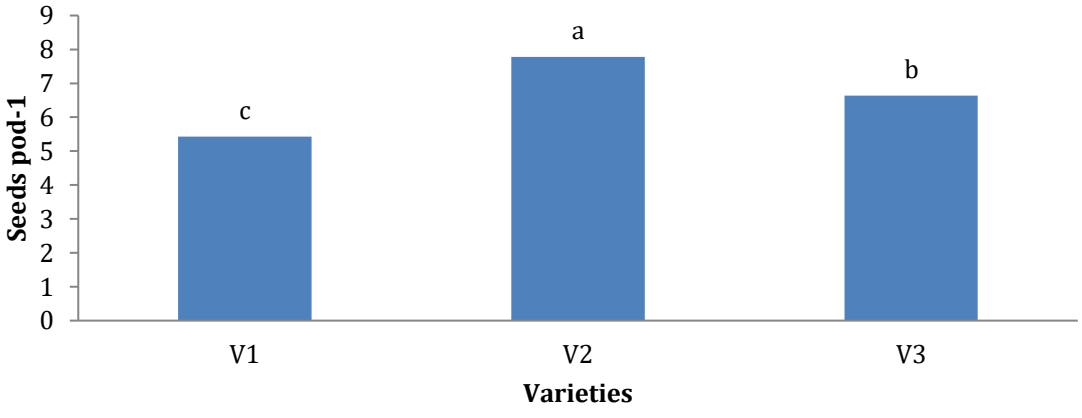

Figure 05. Effect of varieties on seeds pod^{-1} of blackgram ($LSD_{(0.05)}$= 0.33).

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Effect of plant spacing: The results of the experiment showed that the S_4 treatment (30 cm × 15 cm) had the highest number of seeds pod^{-1} of blackgram (7.40). Meanwhile, the S_1 (Broadcasting) treatment had the lowest number of seeds pod^{-1} of blackgram (5.33) (Figure 06). Similar findings were made by Bonepally et al. (2021), who claimed that the combination of 30 ×10 cm^2 + 40 kg/ha of phosphorus produced the maximum number of seeds pod^{-1} (7.80), as compared to rest of the treatments, which is beneficial for blackgram production.

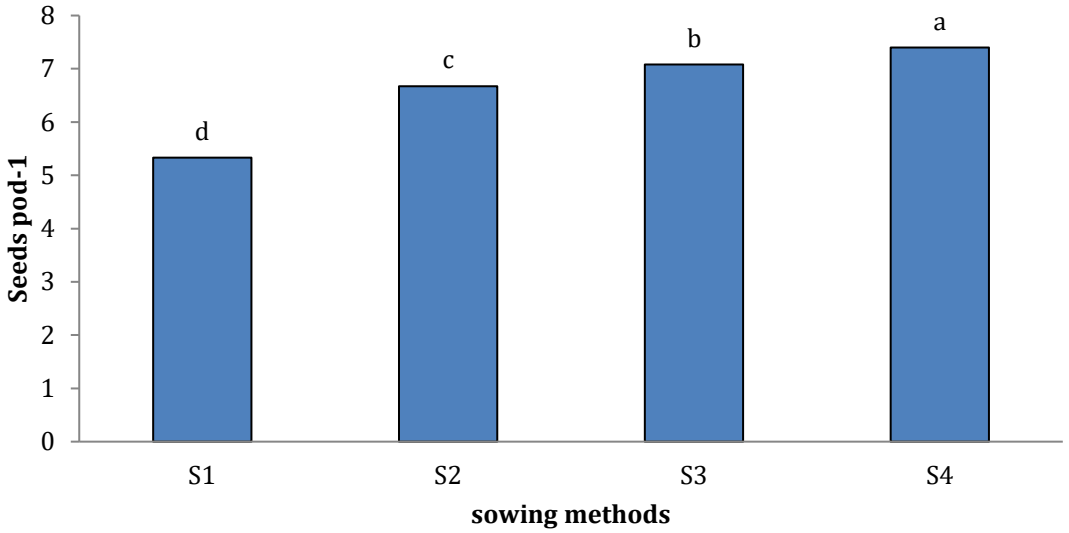

Figure 06. Effect of sowing methods on seeds pod^{-1} of blackgram ($LSD_{(0.05)}$= 0.28)

Combined effect of varieties and plant spacing: According to the experimental findings, the V_2S_4 treatment combination had the highest number of seeds pod^{-1} of blackgram (8.80). The lowest number of seed pod-1 (3.27) of blackgrams were seen with the V_1S_1 treatment combination.

1000-seed weight (g)

Effect of varieties: The results of the experiment showed that the V_2 (BARI Mash-3) treatment had highest 1000-seed weight of blackgram (42.76 g), which was statistically similar to V_3 (42.25 g) treatment. Meanwhile, the V_1 (BARI Mash-2) treatment had the lowest 1000-seed weight of blackgram (38.25 g) (Figure 07). The differences in 1000 seed weight among the various blackgram varieties could be attributed to the traits of the blackgram varieties and their genetic makeup. Gupta et al. (2006) reported that UG-218 urd bean variety produces significantly higher pods/plant, 1000 seed weight, seed yield, and straw yield over other two varieties.

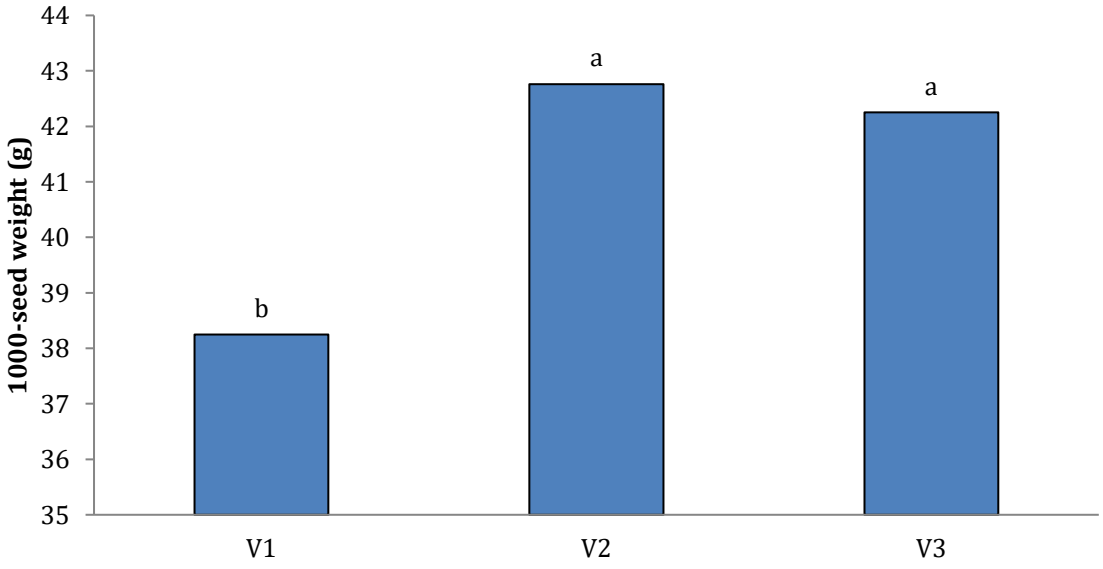

Figure 07. Effect of variety on 1000-seed weight of blackgram ($LSD_{(0.05)}$= 0.73).

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Effect of plant spacing: The experiment's findings revealed that the S_4 treatment (30 cm × 15 cm) had the highest 1000-seed weight of blackgram (44.11 g). Meanwhile, the S_1 (Broadcasting) treatment had the lowest 1000-seed weight of blackgrams (37.22 g) (Figure 08). Kumar and Rajput (2020) reported that crop geometry 30×10 (cm^2) recorded significantly higher 1000 seed weight than other treatments.

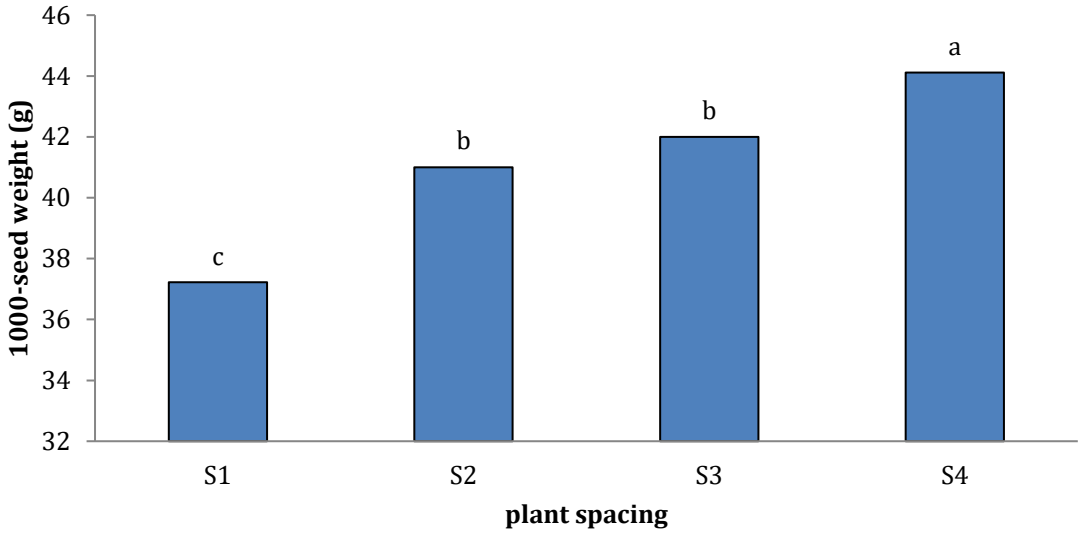

Figure 08. Effect of sowing methods on 1000-seed weight of blackgram ($LSD_{(0.05)}$= 1.26)

Combined effect of varieties and plant spacing: The highest 1000 seeds weight of blackgram (46.67 g) was found in V_2S_4 treatment combination. However, the lowest 1000 seed weight was indicated by the V_1S_1 treatment combination (33.34 g) (Table 01).

Table 01. Combined effect of varieties and plant spacing on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-seed weight of blackgram.

Treatment combinations	Pods plant^{-1} (no)	Pod length (no)	Seeds pod^{-1} (no)	1000-seed weight (g)
V_1S_1	4.54 g	3.42 e	3.27 h	33.34 g
V_1S_2	6.14 de	4.43 d	5.73 g	39.00 f
V_1S_3	6.40 b-d	4.64 b-d	6.33 ef	39.00 f
V_1S_4	6.47 b-d	4.81 b-d	6.40 ef	41.67 cd
V_2S_1	5.94 ef	4.80 b-d	6.80 de	39.34 ef
V_2S_2	6.40 b-d	4.82 b-d	7.40 c	41.34 de
V_2S_3	6.80 ab	5.16 bc	8.13 b	43.67 bc
V_2S_4	6.94 a	6.10 a	8.80 a	46.67 a
V_3S_1	5.67 f	4.34 d	5.93 fg	38.99 f
V_3S_2	6.17 c-e	4.60 cd	6.87 c-e	42.67 b-d
V_3S_3	6.40 b-d	4.49 d	6.77 de	43.34 b-d
V_3S_4	6.60 a-c	5.18 b	7.00 cd	44.00 b
$LSD_{(0.05)}$	0.43	0.60	0.54	2.03
CV(%)	4.13	7.03	4.52	3.11

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; .Here, V_1 = BARI Mash-2, V_2 = BARI Mash-3, V_3 = BARI Mash-4, S_1 = Broadcasting, S_2 = 15 cm × 10 cm, S_3 = 20 cm × 20 cm and S_4 = 30 cm × 15 cm.

Yield characters

Seed yield (t ha^{-1})

Effect of varieties: This experiment revealed that the V_2 (BARI Mash-3) treatment recorded the highest seed yield of blackgram (1.49 t ha^{-1}). While V_1 (BARI Mash-2) treatment had the lowest seed yield (0.96 t ha^{-1}) (Figure 09). The differences in seed yield among different varieties might be due to the inherent variation in the genetic makeup for photosynthesis and translocation of dry matter to grain yield production. Rathore et al. (2010) reported that yield varies among different varieties and

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the maximum seed yield of urban (1103 kg ha^{-1}) was observed by the variety Barkha, which had lower maturity period than other varieties to give higher seed yield than T-9 and TAU-1.

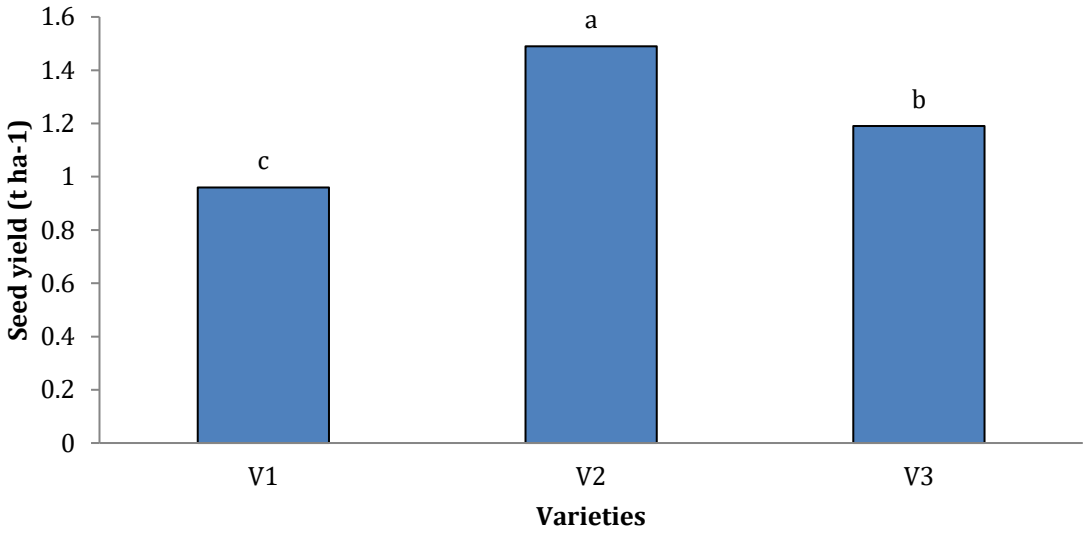

Figure 09. Effect of variety on seed yield of blackgram (LSD$_{(0.05)}$= 0.08).

Effect of plant spacing: The experiment's results showed that the S_4 treatment (30 cm × 15 cm) had the highest seed yield of blackgram (1.46 t ha^{-1}). Meanwhile, the lowest seed yield of blackgram (0.92 t ha^{-1}) was found in the S_1 (Broadcasting) treatment (Figure 10). The optimum spacing of 30 cm×15 cm helped plants to receive sufficient heat, water and nutrients from soil, which increased number of pods plant^{-1}, seeds pod^{-1} and 1000-seed weight, which directly helped increase seed yield in blackgram. The results were similar to that of Singh and Yadav (2013), who reported that the seed yield of blackgram was maximum with 30 cm spacing (641 kg ha^{-1}). However, the grain yield with 30 cm spacing was significantly superior over 45 cm. Rasul et al. (2012) reported that the highest seed yield (675.84 kg ha^{-1}) of blackgram was found with 30 cm row spacing.

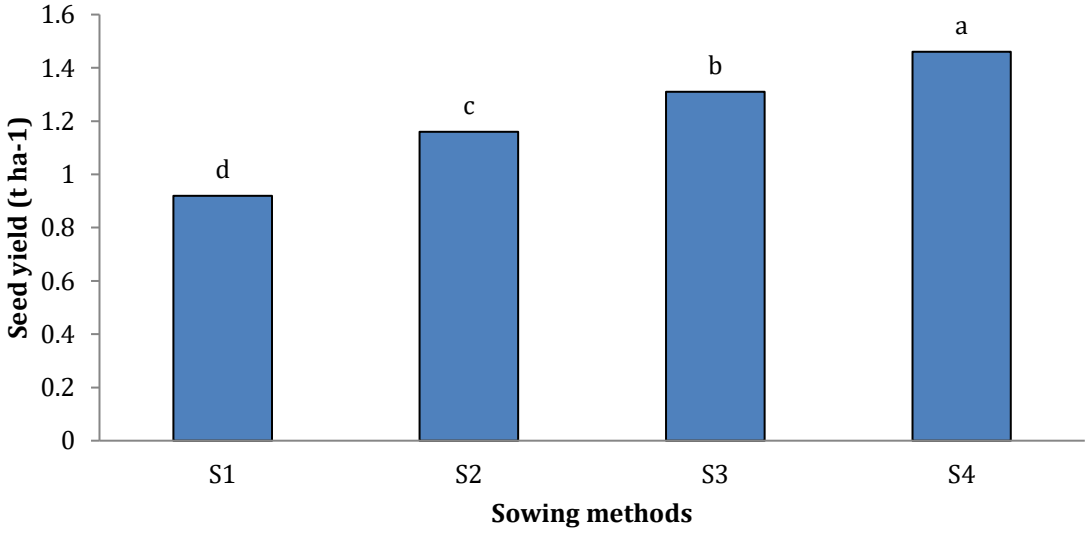

Figure 10. Effect of sowing methods on seed yield of blackgram (LSD$_{(0.05)}$= 0.06).

Combined effect of varieties and plant spacing: V_2S_4 treatment combination (1.80 t ha^{-1}) had the highest seed yield. Meanwhile, the V1S1 treatment combination indicated the lowest seed yield (0.78 t ha-1), which was statistically similar to the V1S2 (0.87 t ha-1) and V2S4 (1.80 t ha-1) treatment combinations (Table 02).

Stover yield (t ha^{-1})

Effect of varieties: The results of the experiment indicated that the V_1 (BARI Mash-2) treatment had the highest stover yield (1.98 t ha^{-1}). While V_3 (BARI Mash-4) treatment had the lowest stover yield

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(1.53 t ha^{-1}) (Figure 11). Sharma (2015) also found similar results to the present study and reported that stover yield of blackgram varied with different varieties.

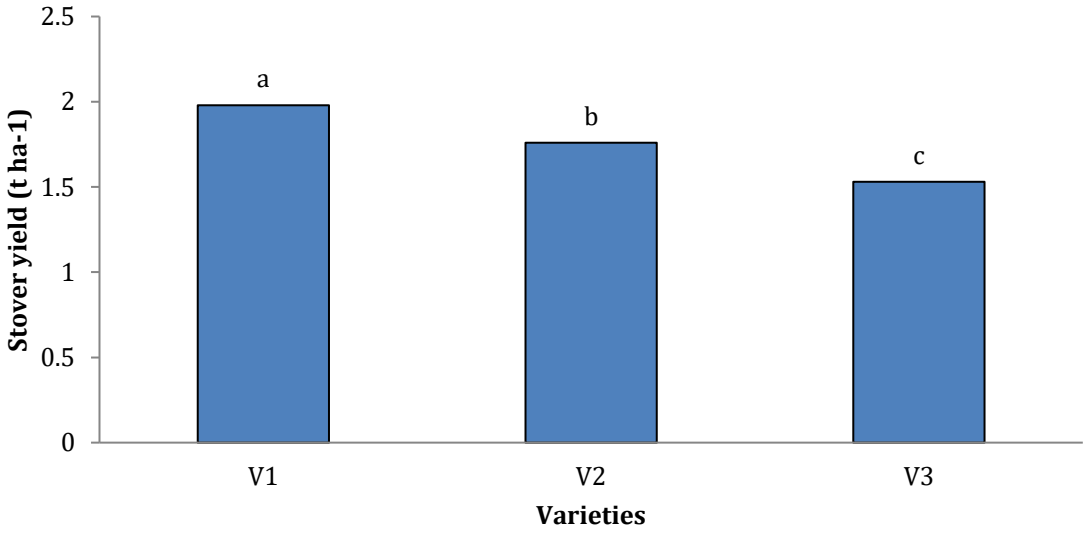

Figure 11. Effect of varieties on stover yield of blackgram (LSD$_{(0.05)}$= 0.05)

Effect of plant spacing: The experiment showed that the S_4 (30 cm × 15 cm) treatment recorded the highest stover yield (1.95 t ha^{-1}). Meanwhile, the lowest stover yield was achieved with the S_1 treatment (1.51 t ha^{-1}) (Figure 12). Stover yield is chiefly a product of growth parameters like plant height, number of branches and dry matter accumulation. So, the increase in these characters due to adequate spacing increased straw yield of blackgram. Khan and Asif (2001) reported that the plant spacing significantly affected the stover yield (kg ha^{-1}) of blackgram.

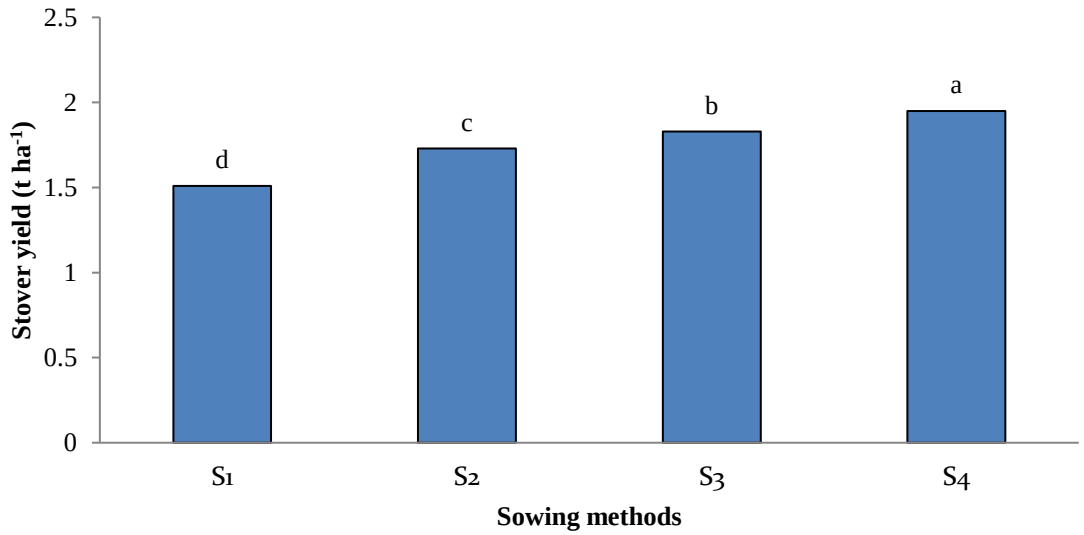

Figure 12. Effect of plant spacing on stover yield of blackgram (LSD$_{(0.05)}$= 0.07).

Combined effect of varieties and plant spacing: The highest stover yield (2.23 t ha^{-1}) was observed in V_1S_4 treatment combination. Meanwhile, the lowest stover yield (1.23 t ha^{-1}) was revealed by the V_3S_1 treatment combination (Table 02).

Biological yield

Effect of varieties (t ha^{-1}): The experiment showed that the V_2 (BARI Mash-3) treatment recorded the highest biological (3.25 t ha^{-1}). While the least biological yield was found in V_3 (BARI Mash-4) treatment (2.72 t ha^{-1}) (Figure 13). The variation of biological yield by different varieties might be due to the contribution of cumulative favourable effects of the crop characteristics viz., seed and stover yield. Sharma et al. (2012) found similar results, which supported the present finding and reported that the variation in biological yield differs among genotypes of blackgrams and different genotype

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blackgram genotypes Mash-1 recorded the highest biological yield (8313 kg ha^{-1}) over Mash338 (6110 kg ha^{-1}).

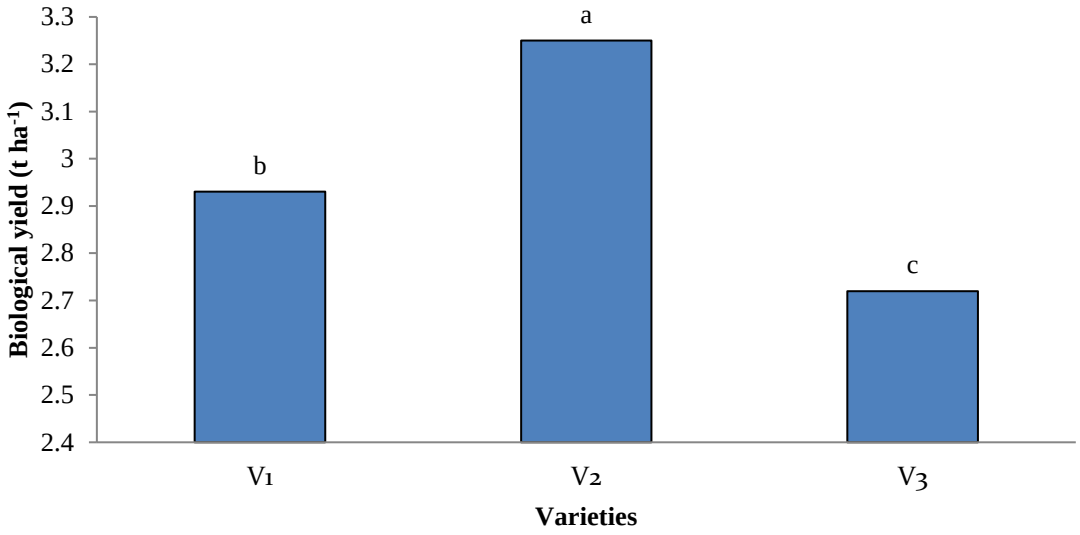

Figure 13. Effect of varieties on biological yield of blackgram (LSD$_{(0.05)}$= 0.08).

Effect of plant spacing: The results of the experiment demonstrated that the highest biological yield (3.41 t ha^{-1}) was obtained by the S_4 (30 cm × 15 cm) treatment. While the S_1 (Broadcasting) treatment resulted in the lowest biological yield (2.43 t ha^{-1}) (Figure 14). Higher biological yield might be observed in adequate spacing due to more vigour and strength attained by the plants due to better photosynthetic activities with sufficient availability of light, and supply of nutrients in balanced quantity of the plants at growing stages". Bonepally et al. (2021) reported that the biological yield (2926 kg ha^{-1}) was found to be maximum in treatment combination with 30 × 10 cm^2 + 40 kg/ha of phosphorus as compared to rest of the treatments, which is beneficial for blackgram production.

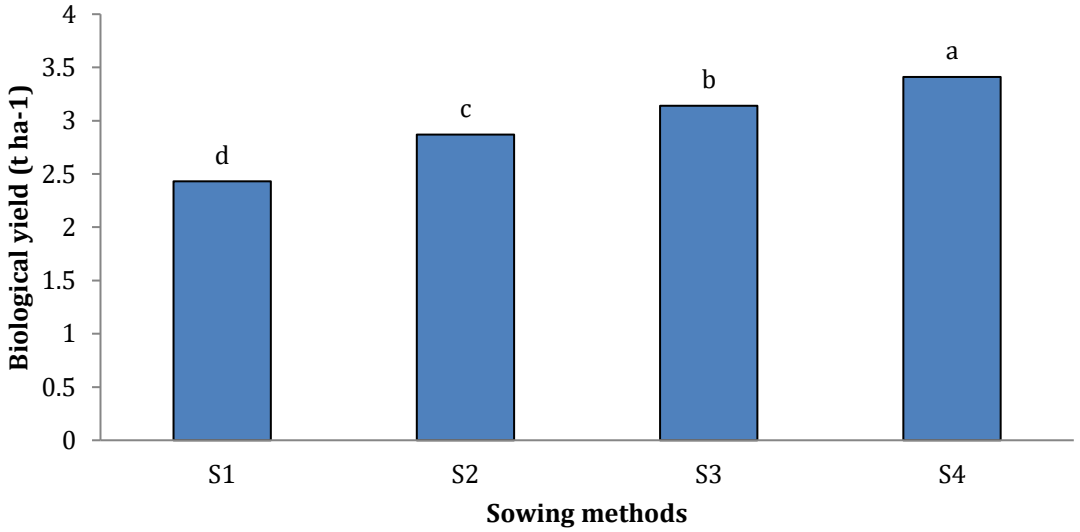

Figure 14. Effect of plant spacing on biological yield of blackgram (LSD$_{(0.05)}$= 0.08).

Combined effect of varieties and plant spacing: The V_2S_4 treatment combination had the highest biological yield (3.67 t ha^{-1}). At the same time, the V_3S_1 treatment combination recorded the lowest biological yield (2.13 t ha^{-1}) (Table 02).

Harvest index

Effect of varieties: The investigation results showed that the V2 (BARI Mash-3) treatment recorded the highest harvest index (45.53 %) over other varieties, which might be due to the higher production efficiency reflected through improvement in different yield attributing characters. Meanwhile, V_1 (BARI Mash-2) treatment had the lowest harvest index (32.45 %) (Figure 15). Due to genetic diversity,

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the harvest index varied greatly between varieties. Mondal et al. (2011) reported that harvest index of blackgram significantly influenced due to varieties.

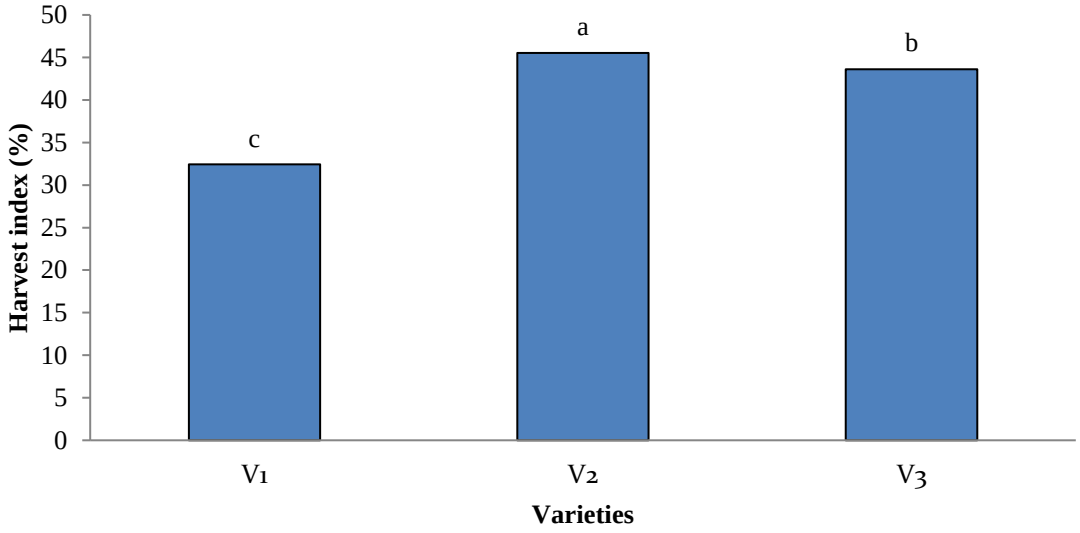

Figure 15. Effect of variety on harvest index of blackgram ($LSD_{(0.05)}$= 0.58).

Effect of plant spacing

The experiment showed that the S_4 (30 cm × 15 cm) treatment, which was statistically equal to the S_3 (41.55 %) treatment, had the highest harvest index (42.65 %) and lowest found in S_1 (38.04 %) (Figure 16). Achakzai and Panizai (2007) reported that the maximum harvest index of blackgram (61.44%) was obtained in row spacing of 40 cm, which is statistically at par with four other spacing *viz;* 20, 25, 30 and 35 cm. Achakzai and Panizai (2007) stated that maximum harvest index of 0.61 was obtained in row spacing of 40 cm, which is statistically at par with four other spacing *viz*; 20, 25, 30 and 35 cm.

Table 02. Combined effect of varieties and plant spacing on seed, stover, biological yield and harvest index of blackgram.

Treatment combinations	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	0.78 f	1.74 d	2.52 g	30.95 g
V_1S_2	0.87 f	1.88 c	2.75 ef	31.64 fg
V_1S_3	1.05 e	2.06 b	3.11 d	33.76 f
V_1S_4	1.12 e	2.23 a	3.35 bc	33.43 f
V_2S_1	1.08 e	1.56 e	2.64 fg	40.91 e
V_2S_2	1.47 c	1.78 cd	3.25 cd	45.23 bc
V_2S_3	1.61 b	1.82 cd	3.43 b	46.94 ab
V_2S_4	1.80 a	1.87 c	3.67 a	49.05 a
V_3S_1	0.90 f	1.23 f	2.13 h	42.25 de
V_3S_2	1.14 de	1.52 e	2.66 fg	42.86 de
V_3S_3	1.27 d	1.62 e	2.89 e	43.94 cd
V_3S_4	1.46 c	1.75 d	3.21 cd	45.48 bc
$LSD_{(0.05)}$	0.13	0.11	0.16	2.16
CV(%)	5.14	3.79	3.08	3.45

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. V_1 = BARI Mash-2, V_2 = BARI Mash-3, V_3 = BARI Mash-4, S_1 = Broadcasting, S_2 = 15 cm × 10 cm, S_3 = 20 cm × 20 cm, and S_4 = 30 cm × 15 cm.

Combined effect of varieties and plant spacing: The highest index yield (49.05 %) was recorded by the V_2S_4 treatment combination, statistically equal to the V_2S_3 (46.94 %) treatment combination. The lowest harvest index (30.95 %) was recorded by the V_1S_1 treatment combination, which was statistically similar to the V_1S_2 (31.64 %) treatment combination (Table 02).

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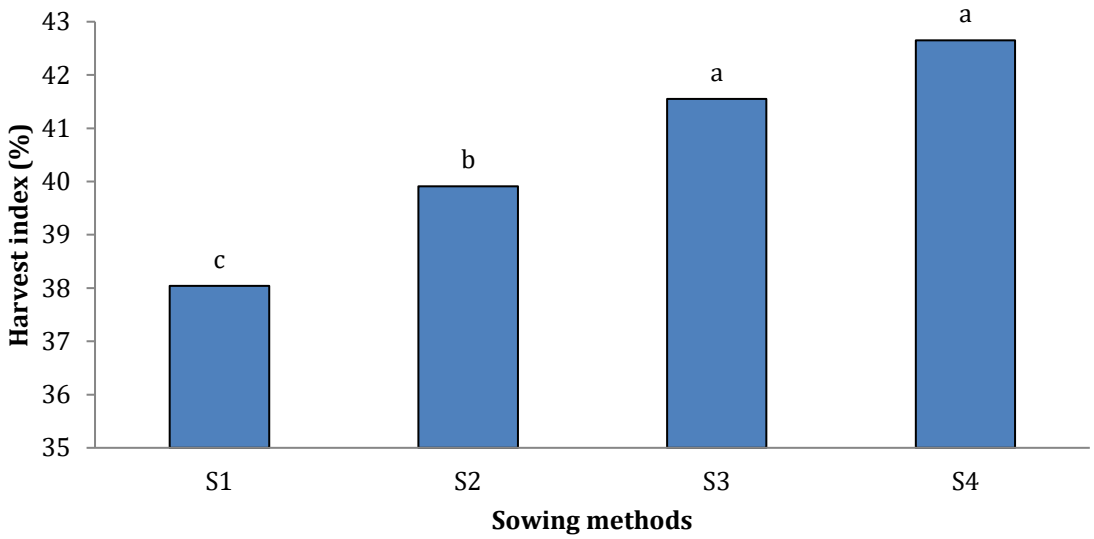

Figure 16. Effect of plant spacing on harvest index of blackgram ($LSD_{(0.05)}$= 1.38)

IV. Conclusion

From the above study, it was found that cultivation of BARI Mash-3 (V_2) along with 30 cm × 15 cm spacing (S_4) affected plant growth and yield-contributing characteristics, leading to the maximum seed yield (1.80 t ha^{-1}) compared to other treatment combinations. Therefore, it is suggested that cultivation of BARI Mash-3 along with 30 cm × 15 cm spacing (V_2S_4) could be optimum crop management for maximum yield harvest in blackgram.

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