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Effect of Nitrogen Sources on the Yield of Different Blackgram (*Vigna mungo*) Varieties

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Bangladesh, the average yield of blackgram is not satisfactory level. There are many reasons for a lower yield of blackgram. Nitrogen and weed management in winter season is of them. This study is to find out the effect of nitrogen sources on the yield of different black gram varieties. The experiment was laid out in a split-plot Design with three replications. Nitrogen source was assigned to main plots and varieties to sub-plots. The field experiment was conducted at the Agronomy field of Central Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from September 2014 to January 2015. The experiment consisted of two factors such as nitrogen sources and blackgram varieties. The treatments were as follows: Factor A: nitrogen sources (3 types) viz. T_1: prilled urea, T_2: biofertilizer, T_3: no nitrogen (control) and Factor B: varieties (4 types) viz. V_1: BARI mash-1, V_2: BARI mash-2, V_3: BARI mash-3 and V_4: local mash. In case of different nitrogen sources, the highest grain yield and harvest index (1.45 t ha^{-1} and 40.05%) was found from biofertilizer application. This treatment also showed highest pod length (5.28 cm), pods $plant^{-1}$ (34.80), seeds pod^{-1} (7.08) and 1000-seed weight (40.55 g). Among the blackgram

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varieties, BARI Mash-3 gave the highest pod length (5.60 cm), pods plant^{-1} (39.93), seeds pod^{-1} (7.57) and 1000-seed weight (45.73 g), grain yield and harvest index (1.49 t ha^{-1} and 40.49%). These findings we observed that BARI Mash-3 applied with biofertilizer produced the highest grain yield and harvest index (1.84 t ha^{-1} and 48.04%).

Keywords: Blackgram; Prilled urea; biofertilizer; BARI mash variety.

1. INTRODUCTION

Among the pulses grasspea, lentil, mungbean, blackgram, chickpea, fieldpea and cowpea are important. Pulses are grown over 45 countries of the world, and is playing an important role in the agro-economy and human health of Bangladesh [1]. Pulse protein is rich in amino acids like isoleucine, leucine, lysine, valine etc. FAO [2] recommends a minimum pulse intake of 80 g head^{-1} day^{-1} whereas; it is only 14.19 g in Bangladesh [3]. This is because of the fact that production of the pulses are not adequate to meet the national demand.

Among the pulse crops, blackgram (*Vigna mungo*) is one of the main edible pulse crops of Bangladesh. It ranks fourth among the pulses with an area of about 82,000 ha [4]. As an excellent source of plant protein it is cultivated extensively in the tropics and subtropics. Blackgram seeds contain 59% carbohydrates, 24% protein, 10% moisture, 4% mineral and 3% vitamins [5]. The green plants can also be used as animal feed and its residues have manurial value. The crop is potentially useful in improving cropping pattern. It plays an important role to supplement protein in the cereal-based low-protein diet of the people of Bangladesh, but the area and production of blackgram are steadily declining [4].

Pulse can fix atmospheric nitrogen through the symbiotic relationship between the host blackgram roots and soil bacteria and thus improves soil fertility. In general, pulses do not require to be provided with external N-application. But slow rate of dry matter accumulation during pre-flowering phase, leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain, which is identified as the main physiological constraints for increasing yield. But, these are also attributed in blackgram for as key factors highly responsive to nitrogen. For the pulse crops, nitrogen is most useful because it is the main component of protein. The management of fertilizer greatly affects the growth, development and yield of this crop. Moreover, there is evidence that application of nitrogenous fertilizers at the flowering stage is helpful in increasing the yield [6,7,8].

There is also report that process of nodulation and nitrogen fixation is inhibited at higher levels of fertilizer nitrogen in the soil [9]. The rate of dry matter production in many crops is proportional to the intercepted radiation. The growth of crop is, therefore, often analysed in term of intercepted radiation and the efficiency of conversion of solar radiation to dry weight [10].

Generally, the nutrient requirement is determined by the variety of crops [11]. The yield of blackgram is very poor as compared to many other legume crops [12]. Adequate supply of nitrogen may minimize the yield reduction through reduced some physiological constraints. Probably that is why blackgram is highly responsive to nitrogen. Soils of Bangladesh are mostly deficient in nitrogen. Nitrogen increases the dry matter and protein percentage of grain as well as methionine and triptophan contents in seed with increases of levels of enhanced nitrogen [13]. Greater leaf area is necessary to have superior yield and quality of grain legumes [14]. Considering the above facts, the present study was undertaken to find out the suitable nitrogen source and blackgram variety for increasing the productivity of blackgram varieties. In addition, to find out the interaction effect of variety and nitrogen source for increase the productivity of blackgram.

2. MATERIALS AND METHODS

2.1 Experimental Site

The present piece of research work was conducted at the Agronomy field of Central Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from September 2014 to January 2015. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level. The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons,

winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. The soil belongs to "The Modhupur Tract", AEZ – 28 [15]. Topsoil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%.

2.2 Planting Material

BARI mash-1, BARI mash-2, BARI mash-3 and local mash were the test crop. Seeds of BARI mash-1, BARI mash-2, BARI mash-3 was collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur and local mash were collected from Local market, Kazipur upazilla, Shiragjong, Bangladesh.

2.3 Fertilizers and Manure Application

The fertilizers P, K, S and B in the form of Triple superphosphate (TSP), Muriate of Potash (MP), Gypsum and borax, respectively were applied @ 90, 40, 10 and 10 kg ha^{-1}. TSP, MP, Gypsum, Zinc sulphate and borax were applied during the final preparation of land (BARI, 2012). The plots were supplied with Prilled urea (35 kg/ha) and biofertilizer (Rhizobium inoculum, 1.5 kg per hectare) were applied only to fulfill the need of major nutrient (N) in the crop as per recommendation (BARI, 2012) on per hectare area basis. Nitrogen from a different source was applied during the final preparation of land as per treatment.

2.4 Experimental Design and Treatment

The experiment was laid out in a Split-plot design with three replications thus comprised 36 plots. Nitrogen source was assigned to main plots and variety to sub-plots. The 12 treatment combinations of the experiment were assigned at random into 12 plots of each replication. The size of each unit plot 4.0 × 2.5 m. The spacing between blocks and plots were 1.0 m and 0.5 m, respectively. The treatments were as follows: Factor A: nitrogen sources (3 types) viz. N_1- Prilled urea (100 % nitrogen through prilled urea), N_2- bio fertilizer (100 % nitrogen through bio fertilizer), N_3- no nitrogen (control) and Factor B: varieties (4 types) viz. V_1 – BARI mash-1, V_2 - BARI mash-2, V_3 - BARI mash-3, V_4- local mash.

2.5 Data Collection

Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. A number of total pods of ten plants from each plot was noted and the mean number was expressed per plant basis. Ten pods were randomly selected from the pods collected from 10 sample plants and length of selected 10 pods were measured and was averaged.Ten randomly selected pods from ten sample plants were considered plot wise to measure seed number per pod. One thousand cleaned and dried seeds were counted randomly from each plot and weighted by using a digital electric balance and expressed in gram. The plants of the central 3.0 m^2 from the plot were harvested for taking grain yield and converted to ton per hectare. Grain yield and haulm yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Grain yield + Haulm yield.

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI}\ (\%) = \frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain yield + Haulm yield)}} \times 100$$

2.6 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The significance of the difference among the treatments means was estimated by the Least Significant Different (LSD) at 5% level of probability [16].

3. RESULTS AND DISCUSSION

3.1 Growth Parameter

Plant height, number of branches $plant^{-1}$ and dry weight $plant^{-1}$ of blackgram was significantly influenced by the different source of nitrogen at different days after sowing (Figs. 1, 2, 3). At 30, 45, 60, 75 DAS and at harvest; biofertilizer produced the tallest plant (37.17, 49.47, 59.05, 62.42 and 66.15 cm, respectively). In comparison, the shortest plant height (25.90, 35.34, 40.08, 41.90 and 43.53 cm, respectively) was recorded from control treatment. Similar views were also reported for pea [17], for mungbean [18] and for edible podded pea [19].

The highest number of branches plant^{-1} at 30, 45, 60, 75 DAS and at harvest (1.50, 2.70, 3.60, 4.85 and 4.38, respectively) was recorded from bio fertilizer. In comparison, the lowest number of branches plant^{-1} (1.05, 1.60, 2.25, 3.65 and 2.60, respectively) was recorded from control treatment. At 30, 45, 60, 75 DAS and at harvest, bio fertilizer produced the maximum dry weight plant^{-1} (1.27, 6.55, 16.14, 28.33 and 34.38 g, respectively). In comparison, the minimum dry weight plant^{-1} at 30, 45, 60, 75 DAS and at harvest (0.48, 5.33, 13.06, 18.61 and 23.06 g, respectively) was recorded from control treatment.

At 30, 45, 60, 75 DAS and at harvest; BARI Mash-3 produced the tallest plant (34.20, 43.82, 53.31, 57.93 and 60.95 cm, respectively). In comparison, the shortest plant height (27.03, 37.37, 41.62, 43.89 and 46.93 cm, respectively) was recorded from local variety. At 30, 45, 60, 75 DAS and at harvest; BARI Mash-3 produced the maximum number of branches plant^{-1} (1.67, 2.67, 3.53, 4.87 and 4.40, respectively). In comparison, the minimum number of branches plant^{-1} (0.87, 1.53, 2.33, 3.80 and 3.07, respectively) was recorded from local variety. At 30, 45, 60, 75 DAS and at harvest; BARI Mash-3 produced the maximum dry weight plant-1 (1.17, 6.87, 16.79, 30.00 and 34.94 g, respectively). On the other hand, the minimum dry weight plant-1 (0.43, 5.07, 11.75, 18.69 and 23.92 g, respectively) was recorded from local variety.

3.2 Yield Attributes

3.2.1 Nitrogen source response

Different yield attributing characters viz. number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1} and 1000-seeds weight of blackgram was significantly influenced by the different source of nitrogen (Table 2). The highest number of pods plant^{-1} (34.80), longest pod (5.28 cm),

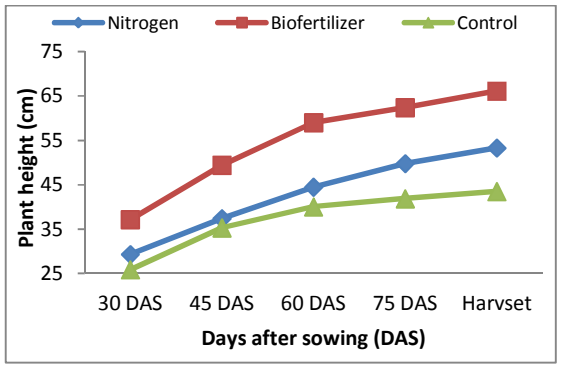

Fig. 1. Effect of nitrogen source on plant height of blackgram

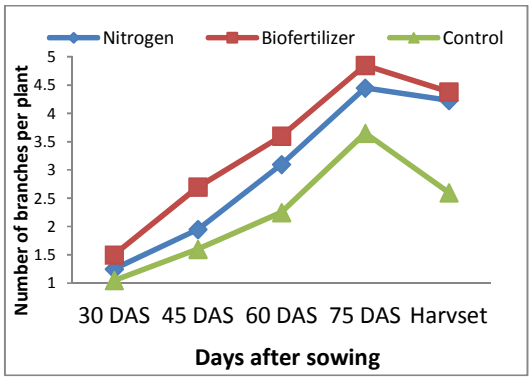

Fig. 2. Effect of nitrogen source on number of branches per plant of blackgram

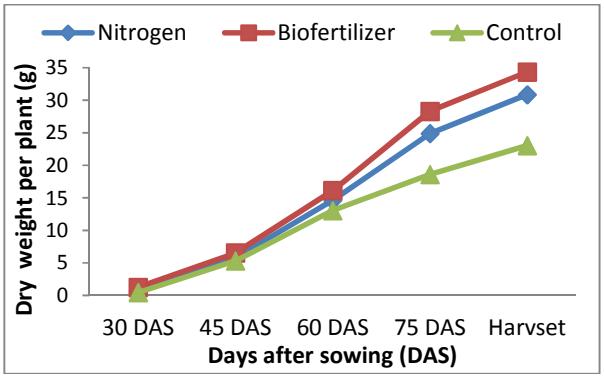

Fig. 3. Effect of nitrogen source on dry weight per plant of blackgram

Table 1. Interaction effect of nitrogen source and variety on plant height, number of branches plant-1 and dry weight per plant of blackgram at different days after sowing

Nitrogen source× variety	plant height (cm) at					number of branches plant-1 at					dry weight plant-1 (g) at				
	30 das	45 das	60 das	75 das	harvest	30 das	45 das	60 das	75 das	harvest	30 das	45 das	60 das	75 das	harvest
T1 V1	29.50 f	37.83g	44.27 f	49.00g	52.83 f	1.00 d	1.80 ef	2.80c	4.40de	4.00 e	0.50fg	5.70cd	15.00e	24.52e	30.50 f
T1 V2	30.00 f	36.48h	43.97 f	52.90 e	55.80 e	1.40bc	2.20cd	3.40b	4.60cd	4.30 d	0.70de	5.90 c	15.30d	26.13d	32.30 e
T1 V3	31.60e	39.48 e	47.93d	53.60d	56.67 d	1.60 b	2.40 c	3.60b	4.80bc	4.60 c	0.80 d	6.70 b	16.00c	28.67c	34.00 c
T1 V4	26.30g	35.90 i	41.87g	43.83 i	48.00 h	1.00 d	1.40gh	2.60c	4.00fg	4.00 e	0.40 g	4.80 f	12.30 i	20.27h	26.70 g
T2 V1	36.80c	49.63 c	60.67 c	60.30 c	62.30 c	1.40bc	2.40 c	3.60b	4.40de	4.00 e	1.07 c	6.50 b	15.27d	23.97 f	32.97 d
T2 V2	38.00b	51.07b	62.00b	66.73b	69.51 b	1.60 b	3.00 b	3.60b	5.00 b	4.80 b	1.30 b	6.80 b	17.20b	30.17b	35.17 b
T2 V3	41.50a	53.67 a	65.73 a	72.60 a	75.51 a	2.00 a	3.40 a	4.40a	5.80 a	5.50 a	2.00 a	7.50 a	19.03a	39.20a	44.03 a
T2 V4	32.40d	43.50d	47.80d	50.07 f	57.30 d	1.00 d	2.00de	2.80c	4.20 e	3.20 f	0.70de	5.40de	13.07g	19.97 i	25.37 h
T3V1	25.20h	35.52 i	38.50 i	40.49k	40.97 j	1.00 d	1.40fg	2.20d	3.60 h	2.50 h	0.40 g	5.40de	12.73h	17.83k	22.52 j
T3V2	26.50g	34.83 j	40.33h	41.73 j	47.00 i	1.20cd	1.60fg	2.60c	3.80gh	2.80 g	0.60ef	5.70cd	14.30 f	18.67 j	23.23 i
T3V3	29.50 f	38.30 f	46.27 e	47.60h	50.67 g	1.40bc	2.20cd	2.60c	4.00fg	3.10 f	0.70de	6.40 b	15.33d	22.13g	26.80 g
T3V4	22.40 i	32.70k	35.20 j	37.77 l	35.49 k	0.60 e	1.20 h	1.60e	3.20 i	2.00 i	0.20 h	5.00ef	9.87 j	15.83 l	9.70 k
lsd(0.05)	0.61	0.47	1.03	0.57	0.78	0.37	0.28	0.25	0.25	0.18	0.11	0.43	0.25	0.29	0.64
cv (%)	1.15	3.67	1.25	3.65	4.84	7.05	7.84	4.87	3.45	2.79	7.7	4.16	5.01	4.7	3.12

T_1- Prilled urea, T_2- biofertilizer, T_3- no nitrogen, V_1 - BARI mash-1, V_2 - BARI mash-2, V_3 - BARI mash-3, V_4- local mash.

Table 2. Effect of nitrogen source on yield and harvest index of blackgram

Nitrogen source	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seeds weight (g)	Seed yield (t ha^{-1})	Haulm yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1	32.05 b	4.90 b	6.55 b	39.15 b	1.28 b	2.36 b	3.64 a	35.26 b
T_2	34.80 a	5.28 a	7.08 a	40.55 a	1.45 a	2.17 c	3.62 a	40.05 a
T_3	26.05 c	4.45 c	5.55 c	37.03 c	0.99 c	2.46 a	3.44 b	28.77 b
$LSD_{(0.05)}$	0.79	0.29	0.51	1.4	0.06	0.06	0.05	1.76
CV (%)	1.03	2.18	2.24	1.39	2.17	2.32	1.06	1.79

T_1 = Prilled Urea, T_2 = Bio fertilizer, T_3 = No nitrogen

maximum number of seeds pod^{-1}(7.08) and heaviest 1000 seeds weight (40.55 g) was recorded from biofertilizer than urea and control, respectively. Yield attributes due to the application of different nitrogen sources which resulted in enhanced availability of nutrients and helped in better growth resulting in increased photosynthesis. This helped in storage of more photosynthates and their translocation towards the sink and this contributed to increased yield. These findings are in close conformity with the results of Murugan et al. [20] and Bhuiya et al. [21]. Hoshang Naserirad et al. [22] and Rokhzadi et al. [23] indicated that inoculation with biofertilizers containing Azotobacter and Azospirillum increased plant height, leaf number per plant, fruit mean weight and yield in comparison to control (without biofertilizer). Azotobacter and Azospirillum fixed N from the atmosphere and released plant available N forms to soil, resulting in increased uptake and plant height. These data agree with the previously reported results on the effects Azotobacter and Azospirillum on the plant height of bhendi.

Highest seed yield (1.45 ton ha^{-1}) and harvest index (40.05%) was recorded from bio-fertilizer, lowest seed yield (0.99 ton ha^{-1}) and harvest index (28.77%) from control than prilled urea respectively. Highest stover yield (2.46 ton ha^{-1}) and biological yield (3.64 ton ha-1) from control than prilled urea respectively. On the other hand lowest haulm yield (2.17 ton ha-1) and biological yield (3.44 ton ha-1) from bio-fertilizer than control respectively.

3.2.2 Varietal response

Varieties showed a significant effect on number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1} and 1000-seeds weight of blackgram. The highest number of pods plant^{-1} (39.93), longest pod (5.28 cm), maximum number of seeds pod^{-1} (7.57) maximum 1000 seeds weight (45.73 g) was recorded from BARI Mash-3 and the lowest number of pods plant^{-1} (20.73), was recorded from local variety, the shortest pod length (4.40 cm), the minimum number of seeds pod^{-1} (5.57) and the minimum1000 seeds weight (26.50 g) was recorded from local variety. Hasan et al. [24] indicated that high yielding variety requires more nutrients than the local or wild variety.

Different variety had a significant effect on seed yield (t ha^{-1}), haulm yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (t ha^{-1}) of blackgram. The maximum seed yield (1.49 t ha^{-1}), biological yield (3.68 t ha^{-1}), harvest index (40.49%) was recorded from BARI Mash-3 and maximum haulm yield (2.36 t ha^{-1}) was recorded from local.

3.2.3 Interaction of nitrogen source and variety

Interaction of nitrogen source and variety showed a significant effect on number of pods plant^{-1}, pod length (cm), number of seeds pod^{-1} and 1000-seeds weight of blackgram. The highest number of pods plant^{-1} (45.80), longest pod length (6.30 cm), maximum number of seeds per pod (8.20), maximum 1000 seeds weight (46.90 g) was recorded from the combination of bio fertilizer and BARI Mash-3. In comparison, the lowest number of pods plant^{-1} (17.40) was recorded from the combination of control treatment and local variety.

Interaction of nitrogen source and variety showed a significant effect on Seed yield, haulm yield, biological yield and harvest index of blackgram. The maximum seed yield (1.84 t ha^{-1}) and maximum biological yield (3.83 t ha^{-1}) was recorded from the combination of bio fertilizer and BARI Mash-3. The maximum haulm yield (2.56 t ha^{-1}) was recorded from the combination of control treatment and local variety and the combination of biofertilizer treatment and BARI Mash-3 provided the highest value for harvest index (48.04%).

Table 3. Effect of variety on yield and harvest index of blackgram

Variety	Pods plant^{-1}	Pod length	Seeds pod^{-1}	1000 seeds weight (g)	Seed yield	Haulm yield	Biological yield	Harvest index (%)
	(no.)	(cm)	(no.)		(t ha^{-1})	(t ha^{-1})	(t ha^{-1})	
V_1	31.73 b	4.87 b	6.57 c	41.90 b	1.30 b	2.36 b	3.66 a	35.51 c
V_2	31.47 b	5.03 b	6.83 b	42.97 b	1.19 c	2.31 b	3.50 b	34.50 b
V_3	39.93 a	5.60 a	7.57 a	45.73 a	1.49 a	2.19 c	3.68 a	40.49 a
V_4	20.73 c	4.40 c	5.57 d	28.50 c	0.97 d	2.46 a	3.43 c	28.28 d
$LSD_{(0.05)}$	**0.62**	**0.2**	**0.2**	**1.07**	**0.05**	**0.05**	**0.05**	**1.05**
CV (%)	**1.17**	**2.39**	**2.34**	**1.56**	**2.53**	**2.5**	**1.39**	**2.3**

V_1 = BARI Mash-1, T_2 = BARI Mash-2, T_3 = BARI Mash-3, T_4 = Local

Table 4. Interaction effect of nitrogen source and variety on yield characteristics and harvest index of blackgram

Nitrogen source × Variety	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000 seeds weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1 V_1	33.40 d	4.80de	7.20 c	43.40b	1.38 cd	2.29 ef	3.67 cd	37.60 e
T_1 V_2	32.20 e	5.00cd	6.10 f	41.80 c	1.28 e	2.37 d	3.65 d	35.07 d
T_1 V_3	41.40 b	5.30 b	7.80 b	44.10b	1.43 c	2.28 ef	3.71 bc	38.54 d
T_1 V_4	20.20 i	4.50 f	4.70 h	29.30d	1.01 h	2.49 bc	3.50 f	28.85 h
T_2 V_1	35.00 c	4.90de	7.20 c	44.00b	1.50 b	2.25 f	3.75 b	40.00 f
T_2 V_2	34.80 c	5.20bc	6.70 d	43.00b	1.36 d	2.12 g	3.48 fg	39.08 c
T_2 V_3	45.80 a	6.30 a	8.20 a	46.90 a	1.84 a	1.99 h	3.83 a	48.04 b
T_2 V_3	23.60 h	4.70ef	6.40 e	29.70d	1.10 g	2.32 de	3.42 g	32.16 g
T_3 V_1	29.00 f	4.90de	6.20 f	41.30 c	1.02 h	2.54 ab	3.56 e	28.65 g
T_3 V_2	25.20 g	4.90de	5.20 g	39.10 c	0.92 i	2.45 c	3.37 h	27.30 d
T_3 V_3	32.60 e	5.20bc	6.40 e	43.20b	1.20 f	2.29 ef	3.49 f	34.38 a
T_3 V_4	17.40 j	4.00 g	4.40 i	26.50 e	0.80 j	2.56 a	3.36 h	23.81 h
$LSD_{(0.05)}$	**0.62**	**0.2**	**0.2**	**1.07**	**0.05**	**0.06**	**0.05**	**1.05**
CV (%)	**1.17**	**2.39**	**2.34**	**1.56**	**2.53**	**2.5**	**1.39**	**2.3**

T_1- Prilled urea, T_2- biofertilizer, T_3- no nitrogen, V_1 – BARI mash-1, V_2 - BARI mash-2, V_3 - BARI mash-3, V_4- local mash

4. CONCLUSION

The application of biofertilizer as a source of nitrogen showed superiority over other sources to produce higher seed yield of blackgram. From these results, it can be generally concluded that BARI Mash-3 gave higher seed yield. Interaction of Biofertilizer with BARI Mash-3 was found more promising to produce a higher amount of blackgram seed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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