

Influence of Spacing on Growth and Yield of Blackgram Varieties

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ABSTRACT

The productivity of blackgram (*Vigna mungo* L.), a vital pulse crop in South Asia, remains suboptimal in Bangladesh due to improper agronomic practices, particularly inadequate plant spacing. This study was conducted at the Agronomy Field Laboratory of Sher-e-Bangla Agricultural University, Dhaka, during the kharif season of 2015 to assess the influence of different spacing regimes on the growth and yield performance of three blackgram varieties—Munshigonj Local, BARI Mash-2, and BARI Mash-3—under the System of Crop Intensification (SCI). A split-plot design was employed with five spacing treatments (30×10 cm, 20×20 cm, 30×30 cm, 40×40 cm, and 50×50 cm). The results showed significant variation in plant height, aboveground biomass, crop growth rate, pods per plant, 1000-seed weight, and grain yield. Closer spacing (30×10 cm) enhanced vertical growth but reduced seed yield due to high competition, while wider spacing (50×50 cm) improved individual plant biomass but reduced yield per unit area. Moderate spacings (20×20 cm and 30×30 cm) provided a balance between growth and yield parameters, with BARI Mash-2 at 30×30 cm yielding the highest (1.82 t ha⁻¹). These findings suggest that optimized variety-specific spacing under SCI can significantly improve blackgram productivity in subtropical regions of Bangladesh.

Keywords: Blackgram, System of Crop Intensification, Plant Spacing, Yield Optimization

Introduction

Blackgram (*Vigna mungo* L.), commonly referred to as mashkalai in Bangladesh, is a major pulse crop cultivated extensively throughout South and Southeast Asia. It is an annual, herbaceous legume highly valued for its short growth duration, soil-enriching characteristics, and rich nutritional profile, making it a significant part of smallholder farming systems. Blackgram is primarily grown during the *kharif* and *rabi* seasons and contributes notably to the protein intake of rural populations due to its high protein content (approximately 24%) along with essential minerals and vitamins [1].

In Bangladesh, blackgram cultivation has expanded steadily in both irrigated and rainfed ecosystems, particularly in regions such as Jessore, Kushtia, Pabna, Rajshahi, and Barishal, where farmers traditionally grow pulses on residual soil moisture after rice harvest [2,3]. As reported by the Bangladesh Bureau of Statistics [4], blackgram is cultivated on about 46,000 hectares in Bangladesh, producing an average yield of 0.85 to 1.0 tons per hectare, which remains considerably below its attainable productivity level.

Despite its resilience to marginal soil and low-input conditions, national yields remain suboptimal due to multiple biotic and abiotic constraints.

Among various agronomic factors, plant spacing is a critical determinant of crop performance. Maintaining an ideal plant population facilitates the effective utilization of essential resources like sunlight, moisture, and soil nutrients, ultimately leading to increased biomass production and grain yield. [5].

However, in many pulse-growing areas of Bangladesh, farmers often adopt arbitrary sowing densities without considering varietal differences or local agro-ecological conditions, leading to excessive competition or underutilization of space [6]. In addition, there is a scarcity of research investigating how various plant spacing regimes interact with different blackgram varieties across the diverse agro-ecological conditions of Bangladesh. [7].

To address this gap, strategic evaluation of row and plant spacing is essential for identifying variety-specific spacing regimes that can maximize growth and yield potential. Hence, this study was conducted to evaluate the effects of varying inter- and intra-row spacing on the growth traits and yield attributes of selected blackgram varieties. The outcome of this research aims to generate regionally relevant agronomic recommendations for enhancing blackgram productivity and supporting sustainable pulse-based cropping systems in Bangladesh.

This study aims to determine the optimal variety and plant spacing combination for enhancing blackgram productivity under SCI in Bangladesh's subtropical conditions. Additionally, it seeks to develop sustainable agronomic practices suitable for smallholder farmers.

2. Materials and Methods

2.1. Experimental Location and Objectives

A field experiment was carried out at the Agronomy Field Laboratory of Sher-e-Bangla Agricultural University (SAU), Dhaka, during the 2015 kharif season to examine the effects of plant spacing on the growth and yield attributes of blackgram (*Vigna mungo* L.) varieties under the System of Crop Intensification (SCI). The SCI methodology focuses on maximizing productivity by optimizing plant population, managing inputs effectively, and improving agronomic practices to ensure efficient utilization of resources.

2.2. Description of the Experimental Site

2.2.1. Geographical and Soil Characteristics

The experimental field is situated at 23°77' N latitude and 90°33' E longitude, with an approximate elevation of 9 meters above mean sea level. This location is part of the Modhupur Tract (Agro-Ecological Zone 28), which is characterized by upland topography and red-brown terrace soils. The soil at the study site has a silty clay texture, is moderately acidic with a pH of 6.1, and is classified under the Eutric Gleysol soil order. Prior to the experiment, the soil exhibited low levels of organic matter and available nitrogen, moderate phosphorus content, and sufficient potassium.

2.2.2. Climate and Weather Conditions

The region experiences a typical subtropical monsoon climate with three distinct seasons: hot and humid kharif (April–September), dry and cool rabi (October–February), and a transitional pre-monsoon period. Throughout the experiment, the average maximum temperatures fluctuated between 30°C and 36°C, while minimum temperatures ranged from 20°C to 26°C, accompanied by sporadic rainfall characteristic of the early kharif season. The relative humidity levels varied between 65% and 85%, providing sufficient moisture to support the initial growth phases of the crop.

2.3. Experimental Materials

2.3.1. Planting Materials

Three blackgram varieties differing in genetic background, maturity duration, and yield potential were used in the study:

- I. Munshigonj Local – A widely cultivated landrace known for its adaptability and seed quality.
- II. BARI Mash-2 – A high-yielding improved variety.
- III. BARI Mash-3 – A short-duration, disease-tolerant variety suitable for intercropping and sequential cropping.

2.4. Treatments and Experimental Design

2.4.1. Treatment Structure

Treatment Details

The experiment investigated five plant spacing treatments under the System of Crop Intensification (SCI):

- I. Sp₁: 30 × 10 cm
- II. Sp₂: 20 × 20 cm
- III. Sp₃: 30 × 30 cm
- IV. Sp₄: 40 × 40 cm
- V. Sp₅: 50 × 50 cm

These spacings were selected to evaluate the influence of geometric planting patterns and inter plant competition under SCI protocols.

2.4.2. Layout and Design

A split-plot design (SPD) with three replications was employed for the experiment. The main plots were assigned to different blackgram varieties, while various plant spacing treatments were arranged in the subplots. Each plot measured 3 m × 2 m in size. The main plots were separated by 1.0 meter, subplots by 0.5 meter, and replications were spaced 1.0 meter apart. Altogether, 45 experimental plots were established for the study.

2.5. Land Preparation and Crop Management

Land preparation began on 15 March 2015 and was completed by 20 March, involving power tilling, cross-ploughing, and laddering to achieve a fine soil tilth. Basal fertilizers were applied at the recommended rates of 20 kg N, 17.2 kg P, and 17.6 kg K per hectare, using urea, TSP, and MoP as sources, respectively. Manual sowing of seeds was carried out on 21 March 2015, adhering to the specified spacing arrangements. A seeding rate of 40 kg per hectare was maintained to ensure uniform crop establishment.

Standard intercultural operations were conducted, including:

I. Weeding at 20 and 35 Days After Sowing (DAS)

II. Irrigation at critical stages (germination, flowering, and pod filling)

III. Insect pest control using Ripcord 10EC (cypermethrin) at 30 and 45 DAS

Harvesting was performed manually at physiological maturity (65 DAS). Plants were sun-dried, threshed manually, cleaned, and seeds weighed at safe moisture levels (~12%).

2.6. Data Collection and Measurement Protocols

I. Observations were recorded from five randomly selected plants per plot at 20, 35, and 50 DAS, and at harvest. The following parameters were measured using standard methods:

II. Plant height (cm).

III. Aboveground dry matter (g plant⁻¹).

IV. Crop Growth Rate (CGR, g m⁻² d⁻¹) – Calculated using standard formula:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{1}{A}$$

Where W = dry weight at times T₁ and T₂, A = area sampled.

V. Number of pods plant⁻¹ – Counted manually.

VI. 1000-seed weight (g) – Weighed using an electronic balance.

VII. Grain yield (t ha⁻¹) – Determined from a 1.5 m² harvested area, extrapolated to hectare basis.

VIII. Harvest Index (%) – Calculated as:

$$HI = \frac{\text{Grain yield}}{\text{Total aboveground biomass}} \times 100$$

2.7. Statistical Analysis

The collected data were analyzed through Analysis of Variance (ANOVA) using MSTAT-C statistical software. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% significance level, following the procedure outlined by Gomez and Gomez [8]. Prior to analysis, tests for homogeneity of variance and normal distribution were conducted, and interaction effects between variety and spacing treatments were evaluated.

3. Results and Discussion

3.1 Plant Height

Plant height (Fig.1) of blackgram was significantly influenced by both spacing and variety. Among the treatments, the highest plant height (45.89 cm) was observed in $Sp_1 \times V_1$ (30 × 10) cm with Munshigonj Local), while the shortest plants (36.89 cm) were recorded in $Sp_5 \times V_3$ (50 × 50) cm with BARI Mash-3). The trend suggests that closer spacing promoted vertical growth due to inter-plant competition for light, a finding corroborated by Islam [9], who reported increased stem elongation under denser planting in legumes. Shamsi and Kobraee [10], found taller plants at narrow spacing area and in term of shortest plants vise varsa. Among varieties, Munshigonj Local consistently produced taller plants across all spacings, indicating its vigorous vegetative growth potential under SCI.

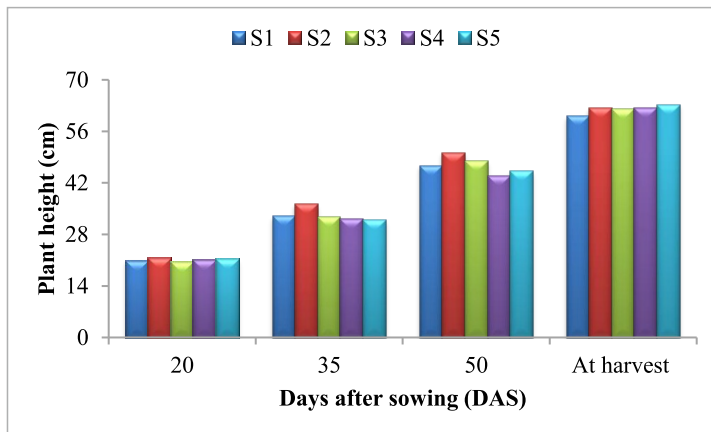


Figure 1. Plant height of blackgram at different days after sowing

3.2 Above Ground Dry Weight

From the (Fig 2) dry weight per plant increased with wider spacing, likely due to greater access to light and soil resources. The maximum dry biomass (13.56 g plant⁻¹) was recorded in $Sp_5 \times V_3$ (50 × 50 cm with BARI Mash-3), while the lowest (7.50 g plant⁻¹) occurred in $Sp_1 \times V_1$. This is consistent with the findings of Hasan [11], where wider spacing enhanced biomass accumulation due to reduced intra-specific competition. During haricot bean, Abate [12] reported the increasing of dry biomass with increasing plant density.

Among the varieties, BARI Mash-3 produced more dry matter compared to Munshigonj Local, suggesting better resource use efficiency in this modern cultivar.

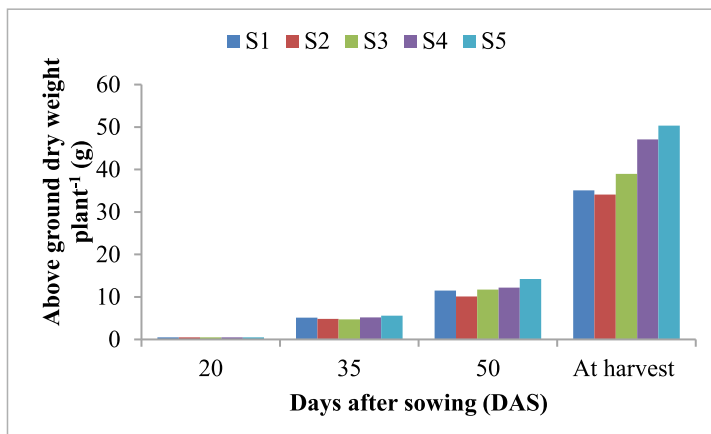


Figure 2. Above-ground dry weight plant⁻¹ of blackgram at different days after sowing

3.3 Crop Growth Rate (CGR)

The highest crop growth rate (Fig.3) (3.25 g m⁻² d⁻¹) was observed in $Sp_2 \times V_2$ (20 × 20 cm with BARI Mash-2), which may be attributed to optimal canopy development balancing light interception and air circulation. In contrast, extremely close (Sp_1) or wide (Sp_5) spacings led to suboptimal CGR due to excessive shading or underutilized space, respectively. These results are in agreement with Alemu [13], who demonstrated that moderate spacing yields better CGR in pulses under SCI management.

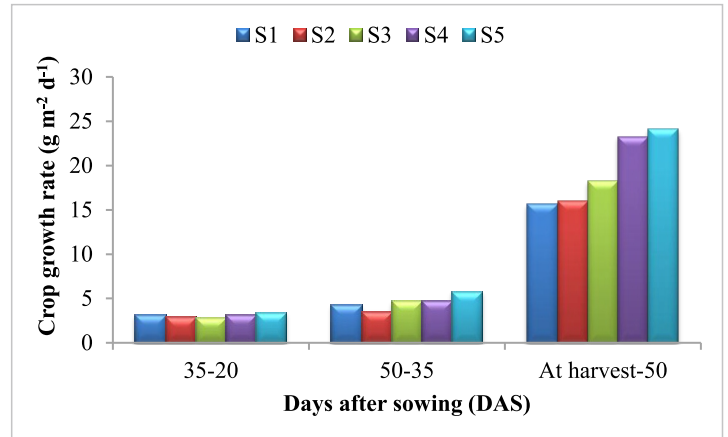


Figure 3. Crop growth rate of blackgram at different days after sowing

3.4 Pods per Plant

From figure 4. We got variation in pod numbers per plant across the treatments. $Sp_5 \times V_3$ produced the highest number of pods (32.67), while $Sp_1 \times V_1$ produced the lowest (14.89). Malek [14] told the numbers were significantly influenced by plant density. This increase at wider spacing reflects reduced competition and better assimilate partitioning towards reproductive structures. BARI Mash-3 outperformed other varieties, indicating strong reproductive potential, in line with results reported by. Pandey [15] for blackgram under similar AEZ conditions.

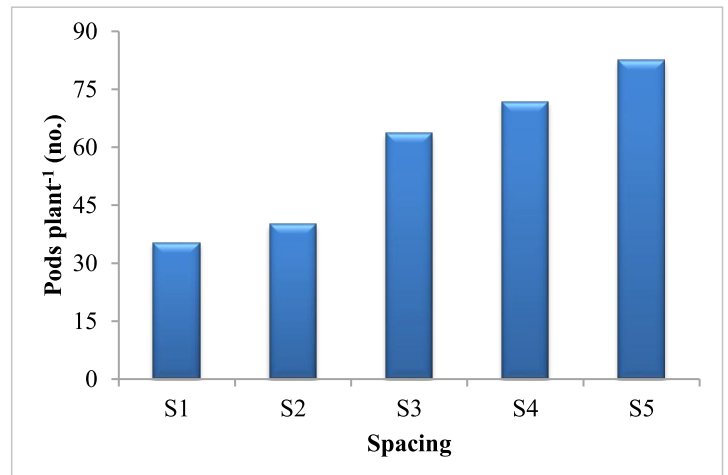


Figure 4. Pods plant⁻¹ of blackgram

3.5 Thousand Seed Weight

Thousand seed weight (Fig.5) varied significantly, with the highest value (41.63 g) recorded under $Sp_5 \times V_2$, and the lowest (33.56 g) under $Sp_1 \times V_1$. Wider spacing might have facilitated more resource allocation per seed, leading to bolder grains. Among varieties, BARI Mash-2 produced heavier seeds, possibly due to genetic advantage and efficient assimilate loading, aligning with previous findings by Kader, K. [16]

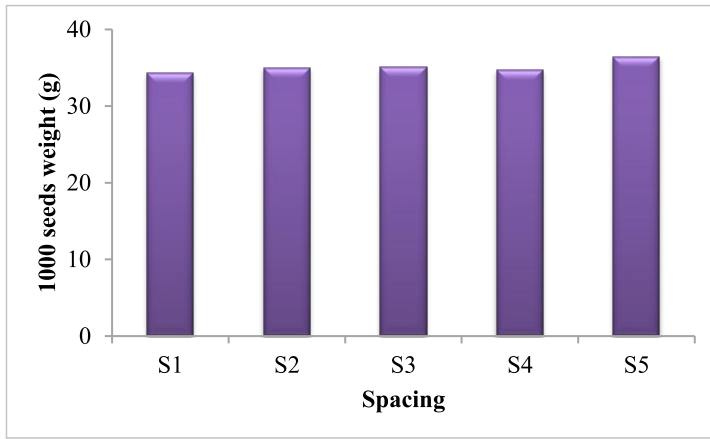


Figure 5. 1000 seeds weight of blackgram

3.6 Seed Yield

Despite higher dry matter and pod number under wider spacing, moderate spacing (Sp_2 and Sp_3) produced significantly greater seed yield (Fig.6) due to optimal plant population per unit area. The maximum seed yield (1.82 t ha^{-1}) was obtained in $Sp_3 \times V_2$, followed by $Sp_2 \times V_2$ (1.78 t ha^{-1}), indicating that $30 \times 30 \text{ cm}$ and $20 \times 20 \text{ cm}$ were ideal for blackgram under SCI. In contrast, $Sp_1 \times V_1$ yielded the least (1.12 t ha^{-1}), likely due to overcrowding and competition. These findings are supported by Christian [17], who noted that excessive plant density limits yield in pulses. Abuzar [18] reported that the highest planting density resulted in the lowest grain yield. Both in Bangladesh and internationally, several studies have shown that inappropriate plant spacing can lead to a 20–40% reduction in mung bean yield [19].

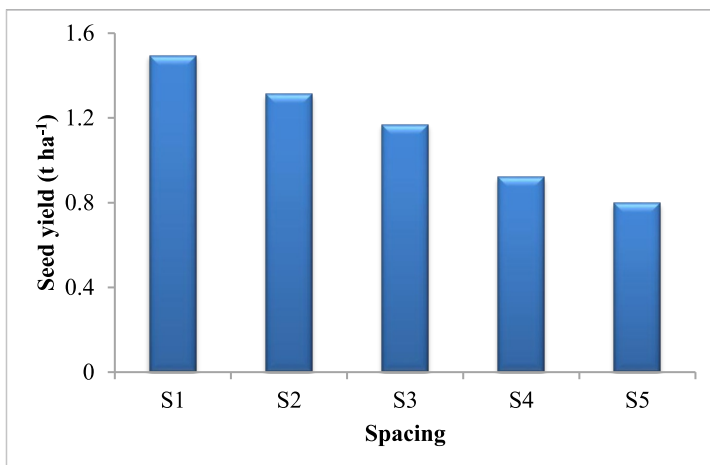


Figure 6. Seed yield of blackgram

3.7 Harvest Index

Harvest index (HI) (Fig.7) was significantly affected by spacing and variety interactions. The highest HI (41.67%) was noted in $Sp_2 \times V_2$, suggesting efficient translocation of photosynthates to economic yield. Lower HI under wider spacing, despite high biomass, indicates suboptimal reproductive efficiency. Khan [20] observed the highest harvest index of 41.66% at a wider row spacing of 45 cm in chickpea, compared to a lower harvest index of 32.6% recorded at a narrower spacing of 15 cm. BARI Mash-2 maintained superior HI across spacings, implying better source–sink dynamics.

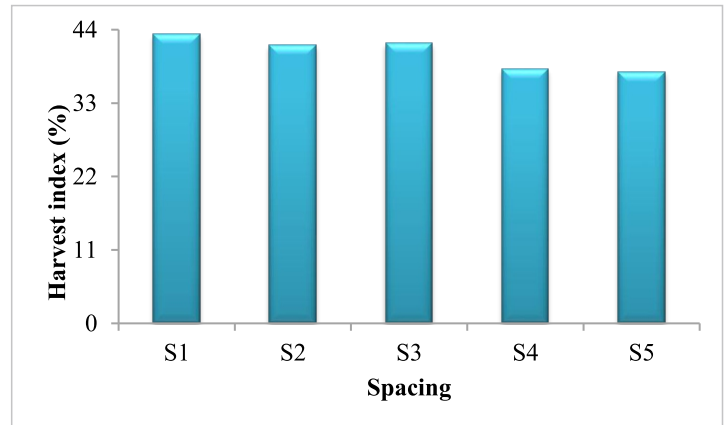


Figure 7. Harvest index of blackgram

The results reveal that spacing and varietal selection play critical roles in optimizing blackgram performance under the SCI framework. Moderate spacing ($20 \times 20 \text{ cm}$ and $30 \times 30 \text{ cm}$) emerged as the most effective for balancing vegetative growth, reproductive success, and yield. Among the tested genotypes, BARI Mash-2 consistently outperformed others across key parameters, making it a suitable candidate for SCI-based intensification. These outcomes support the broader utility of SCI in improving pulse productivity in Bangladesh's subtropical environments and reinforce findings from recent legume research [21,22].

Conclusion

The results revealed that plant spacing and varietal differences significantly influence the growth, biomass accumulation, reproductive performance, and yield of blackgram under SCI management. Among the spacing treatments, moderate spacing ($20 \times 20 \text{ cm}$ and $30 \times 30 \text{ cm}$) proved most effective in balancing vegetative growth and reproductive success, resulting in higher grain yield and harvest index. Among the three tested varieties, BARI Mash-2 consistently outperformed others in terms of crop growth rate, seed yield, and resource use efficiency. Therefore, the $30 \times 30 \text{ cm}$ spacing with BARI Mash-2 is recommended as the most productive and efficient combination for blackgram cultivation under SCI in the subtropical environment of Bangladesh. This study underscores the importance of spacing optimization tailored to a variety of characteristics, which can substantially enhance blackgram productivity and support sustainable pulse-based cropping systems in the region.

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