# Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 6 (7): 1044-1050, 2007
ISSN 1682-3974


# Effect of Different Nitrogen Levels on Dry Matter Production, Canopy Structure and Light Transmission of Blackgram

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**Abstract:** The performance of blackgram (*Vigna mungo* L.) under various levels of nitrogen was evaluated at the Bangbandhu Sheikh Mujibur Rahman Agricultural University during March to June 2002. Two varieties of blackgram-BARI mash-3 and BINA mash-1 and six levels of nitrogen-0, 20, 40, 60, 80 and 100 kg N $ha^{-1}$ were the treatment variables. Dry matter accumulation in different organs of plant was maximum with 80 kg N $ha^{-1}$. The dry matter accumulation in different vegetative organs continued to increase until pod filling stage and then declined gradually. Contrary, the dry matter accumulation in reproductive organ increased up to maturity. Light Transmission Ratio (LTR) was decreased while Light Interception (LI) increased with the increasing level of nitrogen as well as with the plant ontogeny.

**Key words:** Dry matter, canopy structure, light transmission, blackgram and nitrogen

## INTRODUCTION

Blackgram (*Vigna mungo* L.) is one of the main edible pulse crops of Bangladesh. It ranks forth among the pulses with an area of about 70,000 ha (BBS, 2000). As an excellent source of plant protein it is cultivated extensively in the tropics and subtropics. Nitrogen is an essential element and important determinant of growth and development of crop plant (Tanaka *et al*., 1984). An essential element of agricultural sustainability is the effective management of N in the environment (Rao *et al*., 2005). Nitrogen deficiency constrains leaf area expansion, enhances leaf senescence after canopy structure and subsequently reduces crop yield (Wolfe *et al*., 1988). Distribution of radiation over the leaf surface of the plant community actively photosynthesizing is an important factor in determining the conversion of solar energy to chemical energy and thus for dry matter production (Tripathi and Singh, 1989). Lower Leaf Area Index (LAI) led to inadequate interception of incident radiation resulting in lowest dry matter accumulation and as well as yield (Akhtaruzzaman, 1998). Available reports indicated that optimum combination of NP fertilizers ($N_{40}$ $P_{60}$) were favourable for canopy development as well as for light penetration to the upper and middle strata of the canopy that facilitate for better light interception by the each segment of the canopy because of larger leaf surface availability for photosynthesis as evident by higher leaf dry weight. Studies are insufficient in this direction. Therefore, the present study was undertaken to find out the effect of different levels of nitrogen on dry matter production and light interception of blackgram.

## MATERIALS AND METHODS

A field experiment was conducted at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during Kharif 1 season of 2002. The soil of the experimental field was silty loam in texture slightly acidic in nature (pH = 5.4). The experimental soil initially contains 0.159% total N, 0.619% organic C, 0.312 meq exchangeable P/100 g soil, 0.38 meq exchangeable K/100 g soil and 22.54 CEC (meq/100 g). The experiment was laid out in a factorial Split Plot Design with 3 replications. The varieties were assigned in the main plot and nitrogen levels were assigned in the sub-plot. The unit plot size was 4×3 m. Two varieties of blackgram with six levels of nitrogen fertilizer constituted the following treatment combinations.

$B_1$ $N_0$: BARI mash-3 with 0 kg N $ha^{-1}$, $B_1$ $N_{20}$: BARI mash-3 with 20 kg N $ha^{-1}$, $B_1$ $N_{40}$: BARI mash-3 with 40 kg N $ha^{-1}$, $B_1$ $N_{60}$: BARI mash-3 with 60 kg N $ha^{-1}$, $B_1$ $N_{80}$: BARI mash-3 with 80 kg N $ha^{-1}$, $B_1$ $N_{100}$: BARI mash-3 with 100 kg N $ha^{-1}$, $B_2$ $N_0$: BINA mash-1 with 0 kg N $ha^{-1}$, $B_2$ $N_{20}$: BINA mash-1 with 20 kg N $ha^{-1}$, B2 N40: BINA mash-1 with 40 kg N $ha^{-1}$, $B_2$ $N_{60}$:

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BINA mash-1 with 60 kg N $ha^{-1}$, $B_2 N_{80}$: BINA mash-1 with 80 kg N $ha^{-1}$, $B_2 N_{100}$: BINA mash-1 with 100 kg N $ha^{-1}$.

The well-prepared soil was fertilized at the rate of 50 and 36 kg P and K $ha^{-1}$. Half dose of N and full dose of P and K was applied as basal at the time of seed sowing. Seeds were sown on 9 March 2002 with 10×30 $cm^2$ spacing; light irrigation was given to establish the seedlings properly. Excess seedlings were removed on March 20 to retain one seedling per hill. The crop was top-dressed with rest half of N on April 6, 2002.

**Canopy structure:** Canopy structure of blackgram was determined at pod filling stage. Sampled plants of 1 $m^2$ area were removed by using of scissors. Clipping started from top of the canopy proceeded down ward and the clipped plant parts for individual stratum were separated into leaves, petioles, stems and reproductive organs for determining leaf area and dry matter weight of the plant components.

**Light transmission:** Light interception by crop community was recorded at 7 days interval by sunfleck ceptometer (Model Decagon Pulman, Washington, USA) from the top of the canopy to bottom of the canopy at noon. Photosynthetically Active Radiation (PAR) receiving on the top of the canopy ($I_0$) and at the bottom of the canopy (I) was measured from each plot. Light Transmission Ratio (LTR) was calculated and expressed as percentage as follows:

$$LTR = \frac{I}{I_0} \times 100; \; L1(\text{Light Intensity})\% = 100\% - LTR\%$$

**Light extinction co-efficient (K):** Based on the relationship between the relative light intensity passing through the crop canopy and cumulative LAI, K is determined by the following model of the Monsi and Saeki (1953).

$$I = I_0 \, e^{-KL}$$

$$\text{Or} = \frac{I}{I_0} e^{-KL}$$

$$\text{Or Ln} = \left(\frac{I}{I_0}\right) = ^{-KL}$$

$$K = \left\{ \text{Ln}\left(\frac{I}{I_0}\right) \right\} / L$$

where:

K = Light extinction co-efficient

I = Light intensity on a particular depth in the canopy profile.

$I_0$ = Light intensity at the top of the canopy

L = Cumulative LAI from the point to the top of the crop canopy.

**Dry matter accumulation and distribution:** Plant samples were taken at 3 stages pre flowering, pod filling and mature stage; 10 plants per sampled were used for dry matter accumulation and partitioning. The above ground portion of the plants was partitioned into stem. Leaf, petiole and reproductive organs and oven dried at 70°C for 72 h.

**Statistical analysis:** The data collected on different parameters were statistically analyzed with the help of MSTAT program. The differences between the treatment means were compared by Least Significant Differences (LSD) test at 5% level of significance after performing ANOVA.

## RESULTS AND DISCUSSION

**Dry matter production and distribution:** Accumulation of total dry matter increased progressively over time attaining the highest amount at physiological maturity (Fig. 1a and b). In the beginning of the growth cycle, the differences in TDM between the varieties due to fertilizer

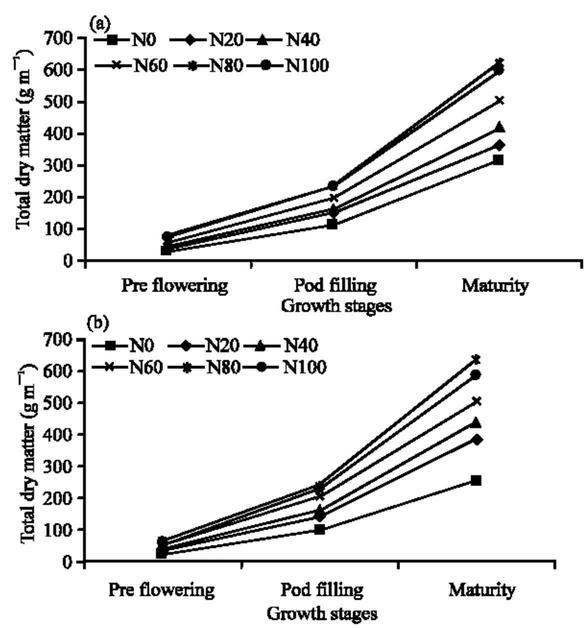


Fig. 1: Total dry matter of two blackgram varieties as influenced by different levels of N fertilizer at different growth stages (a) BARI mash-3 and (b) BINA mash-1

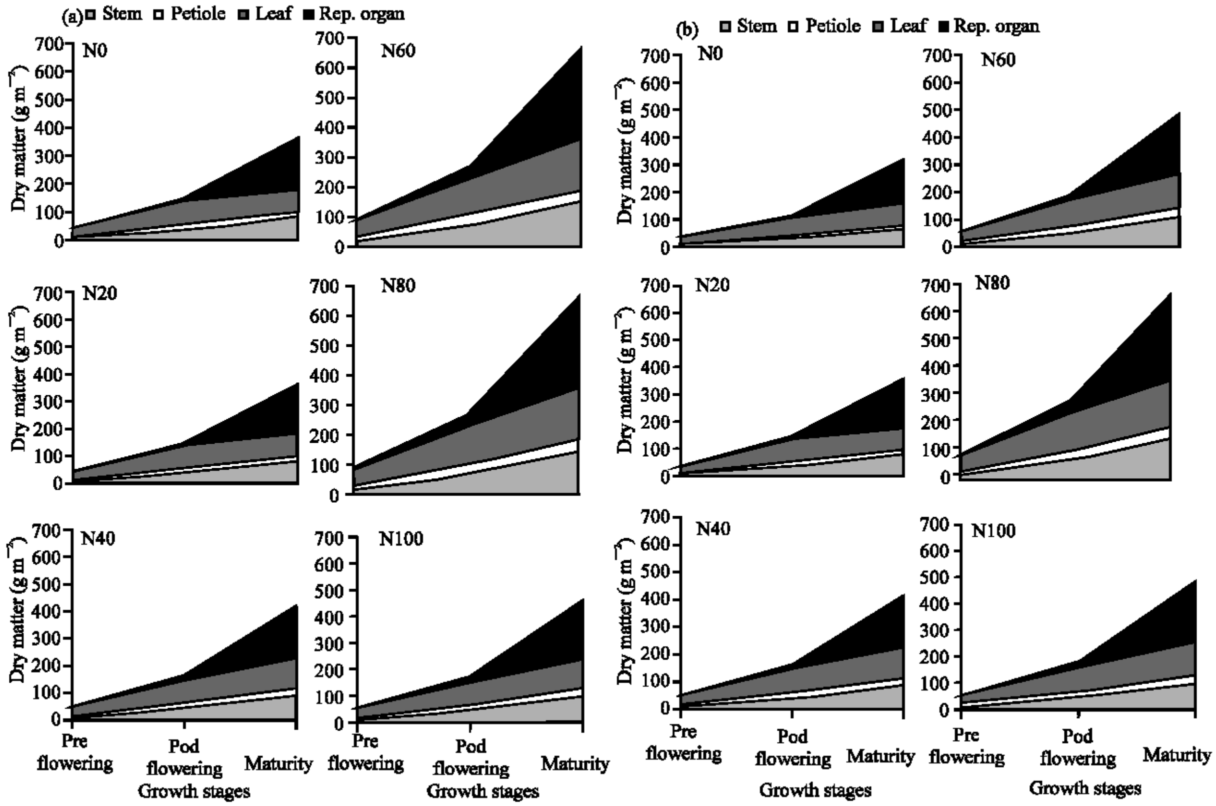


Fig. 2a: Dry matter distribution of (a) BARI mash-3 (b) BINA mash-1 as affected by different N levels at different growth stages

N application was less conspicuous but over the time the differences widened. A rapid growth rate followed after pod filling stage persisted till maturity in both the blackgram varieties. Highest rate of TDM production was observed from pod filling to maturity stage irrespective of varieties and N levels. Increased TDM production at this growth phase might be due to increased photosynthetic rate resulting in higher leaf area and thereby increased TDM production. The treatment with 80 kg N $ha^{-1}$ was found superior to other treatments in production and accumulation of DM, which was statistically similar with that of 100 kg N $ha^{-1}$. Leelavathi *et al.* (1991) reported that different levels of nitrogen showed significant differences in dry matter yield of mungbean upto a certain level (60 kg N $ha^{-1}$). Accumulation of dry matter and its distribution into different plant components is an important consideration in achieving desirable economic yield from crop plants (Singh and Yadav, 1989). There were significant variation in dry matter distribution in leaves, petiole, stem and reproductive organs (Fig. 2a and b). The treatment with 80 kg N $ha^{-1}$ was found superior to other treatments in accumulation of DM in these components. Leaf and stem dry weight continued to increase until mature stage then decreased irrespective of N treatments. Decreasing leaf and stem dry weight may be due to remobilization of assimilates towards grain. Similar trend was observed in edible poded pea (Ferdous, 2001) and in mungbean (Biswas and Hamid, 1989). In terms of TDM production BARI mash-3 always showed better performance than BINA mash-1, this might be due to greater variation in pod yield, irrespective of N levels.

**Canopy structure:** The canopy structure of two blackgram varieties varied markedly due to N levels at pod filling stage. Although the variation of canopy height among the treatments was not large enough but the pattern of foliage display and component wise dry matter distribution varied markedly. BINA mash-1 showed no variation in canopy height due to N treatment whereas BARI mash-3 showed higher canopy height (above 40 cm) at higher N levels. The pattern of foliage display of two blackgram varieties under six N treatments varied widely over the crop canopies (Table 1) However, there was greater trend of clustering of most of the leaves in the middle strata. Larger leaf area in the middle strata due to higher N in mungbean was also observed by Akhtaruzzaman (1998). At pod filling stage, maximum leaf area of BARI mash-3 was 5505.18 $cm^2$ in 0-10 cm stratum, 7640 $cm^2$ at 10-20 cm stratum, 8963.29 $cm^2$ at 20-30 cm stratum and 6843.62 $cm^2$ at 30-40 cm stratum treated with 80 kg N $ha^{-1}$. The similar trend was found in BINA mash-1 at pod filling stage. On the other hand, BARI mash-3 only showed partial leaf area above 40 cm canopy height with higher doses of N whereas no leaf area was observed in BINA mash-1. The maximum leaf area (8963.29 $cm^2$) was obtained in BARI mash-3 plants received 80 kg N $ha^{-1}$ at 20-30 cm stratum among the blackgram cultivars (Table 1). N levels influenced leaf dry mass production at different stratum like as leaf area. Maximum leaf dry mass was obtained where plant treated with 80 kg N $ha^{-1}$ at 20-30 cm stratum in both the cultivars. This might be due to higher leaf area distribution in this stratum (Table 1). With the increasing N levels leaf area and leaf dry mass increased. However, after 80 kg N $ha^{-1}$ leaf dry mass slightly decreased at all the canopy stratum.

Regardless of the treatment differences, dry mass of storage organs (petiole) increased with the decreasing of canopy height. Petiole dry mass increased with increasing N levels and canopy height (Table 1). Both BARI mash-3 and BINA mash-1 showed maximum petiole dry mass in 10-20 cm stratum when plants treated with 80 kg N $ha^{-1}$ (Table 1). BINA mash-1 showed maximum petiole dry mass compared to BARI mash-3 with this treatment. Irrespective of variety and N treatments stem dry weight (g $m^{-2}$) increased with the decreasing canopy height (Table 1). Maximum stem dry weight was recorded in 0-10 cm strata at pod filling stage and stem dry weight gradually decreased with the increasing canopy height. The maximum stem dry weight was lied in 0-10 cm stratum because of the presence of its branches in this layer. Both the varieties showed maximum stem dry weight when treated with 80 kg N $ha^{-1}$. In comparison, BINA mash-1 had higher stem dry weight than BARI mash-3 at all the N levels.

The distribution of maximum pod dry matter was mostly in 10-20 cm stratum on both the varieties (Table 1). With the increasing canopy height pod dry weight was decreased. Irrespective of N levels and cultivars, pod dry weight was increased with the increasing N levels. Maximum pod dry weight was obtained where plants treated with 80 kg N $ha^{-1}$. BARI mash-3 had higher pod dry weight than BINA mash-1 at all the N treatments. At pod filling stage, contribution of reproductive organs increased with the subsequent

Table 1: Variation in leaves, petiole, stem and reproduction organ distribution within canopy of two blackgram varieties as affected by different levels of nitrogen fertilizers at pod filling stage

| | | Canopy height (cm) | | | | |
|---|---|---|---|---|---|---|
| Variety | N level (kg $ha^{-1}$) | 0-10 | 10-20 | 20-30 | 30-40 | 40 above |
| **Leaf area ($cm^2$)** | | | | | | |
| BARI mash-3 | 0 | 1396.92 | 6436.18 | 6720.78 | 1608.51 | |
| | 20 | 1461.69 | 6468.63 | 7016.81 | 2522.45 | |
| | 40 | 1913.93 | 6500.30 | 7475.96 | 4308.99 | |
| | 60 | 2133.59 | 6550.77 | 8116.42 | 6485.51 | |
| | 80 | 5505.18 | 7640.00 | 8963.29 | 6843.62 | 85.66 |
| | 100 | 3876.65 | 7629.10 | 8580.30 | 6796.33 | 214.06 |
| BINA mash-1 | 0 | 3534.06 | 5559.90 | 7017.70 | 248.94 | |
| | 20 | 4634.51 | 6106.60 | 7969.57 | 783.75 | |
| | 40 | 5251.91 | 6315.85 | 8019.15 | 898.10 | |
| | 60 | 5520.22 | 6392.63 | 8449.65 | 1299.55 | |
| | 80 | 5806.00 | 6924.69 | 8645.52 | 4083.98 | |
| | 100 | 5752.09 | 6647.88 | 8508.09 | 1633.03 | |
| **Leaf day weight (g $cm^{-2}$)** | | | | | | |
| BARI mash-3 | 0 | 7.44 | 32.62 | 38.40 | 8.60 | - |
| | 20 | 7.69 | 34.91 | 38.46 | 14.21 | - |
| | 40 | 9.23 | 35.37 | 38.79 | 17.28 | - |
| | 60 | 9.89 | 37.97 | 38.88 | 31.73 | - |
| | 80 | 26.56 | 38.97 | 43.06 | 37.27 | 0.55 |
| | 100 | 10.12 | 38.25 | 42.50 | 33.86 | 1.40 |
| BINA mash-1 | 0 | 14.18 | 28.71 | 32.26 | 1.36 | - |
| | 20 | 18.37 | 31.14 | 34.98 | 4.50 | - |
| | 40 | 21.04 | 31.37 | 38.69 | 4.88 | - |
| | 60 | 22.85 | 33.22 | 39.53 | 7.15 | - |
| | 80 | 25.76 | 39.19 | 43.17 | 21.05 | - |
| | 100 | 23.09 | 35.60 | 43.07 | 7.36 | - |

Table 1: Continued

| | | Canopy height (cm) | | | | |
|---|---|---|---|---|---|---|
| Variety | N level (kg ha$^{-1}$) | 0-10 | 10-20 | 20-30 | 30-40 | 40 above |
| **Petiole dry weight (g cm$^{-2}$)** | | | | | | |
| BARI mash-3 | 0 | 3.46 | 7.78 | 1.98 | 0.25 | |
| | 20 | 3.99 | 9.01 | 2.82 | 0.25 | |
| | 40 | 4.57 | 9.17 | 2.90 | 0.26 | |
| | 60 | 4.82 | 9.29 | 3.14 | 0.86 | |
| | 80 | 6.46 | 9.70 | 4.82 | 3.00 | |
| | 100 | 4.83 | 9.30 | 3.27 | 1.85 | |
| BINA mash-1 | 0 | 5.92 | 8.07 | 3.01 | - | |
| | 20 | 5.95 | 9.59 | 3.26 | - | |
| | 40 | 7.79 | 9.86 | 3.43 | 0.13 | |
| | 60 | 8.05 | 10.56 | 4.32 | 0.45 | |
| | 80 | 8.83 | 11.47 | 6.49 | 1.63 | |
| | 100 | 8.65 | 10.85 | 4.82 | - | |
| **Stem dry weight (g m$^{-2}$)** | | | | | | |
| BARI mash-3 | 0 | 17.42 | 5.81 | 0.23 | - | |
| | 20 | 18.34 | 7.25 | 0.45 | - | |
| | 40 | 18.69 | 8.06 | 0.75 | - | |
| | 60 | 19.72 | 10.36 | 1.89 | 0.20 | |
| | 80 | 25.62 | 13.88 | 6.96 | 2.34 | |
| | 100 | 20.87 | 13.06 | 2.36 | 0.20 | |
| BINA mash-1 | 0 | 19.97 | 5.70 | 1.02 | - | |
| | 20 | 21.21 | 5.70 | 1.19 | - | |
| | 40 | 21.26 | 7.66 | 1.89 | - | |
| | 60 | 26.19 | 8.55 | 1.98 | - | |
| | 80 | 32.49 | 11.43 | 5.34 | 1.02 | |
| | 100 | 27.70 | 8.72 | 2.58 | - | |
| **Reproductive organ dry weight (g m$^{-2}$)** | | | | | | |
| BARI mash-3 | 0 | 1.49 | 2.70 | - | | |
| | 20 | 1.73 | 5.66 | - | - | |
| | 40 | 1.87 | 6.03 | 0.09 | - | |
| | 60 | 3.12 | 6.18 | 1.18 | - | |
| | 80 | 3.50 | 15.95 | 2.10 | 0.73 | |
| | 100 | 3.17 | 7.75 | 1.84 | - | |
| BINA mash-1 | 0 | 0.45 | 0.89 | - | - | |
| | 20 | 0.90 | 0.95 | - | - | |
| | 40 | 0.94 | 1.00 | - | - | |
| | 60 | 1.02 | 1.35 | - | - | |
| | 80 | 2.58 | 2.81 | 2.06 | - | |
| | 100 | 1.66 | 2.58 | 0.45 | - | |

decrease of leaves and petiole dry weight in both the varieties of blackgram. However, contribution of reproductive organs towards total dry matter was better under 80 kg N ha$^{-1}$ than other N levels. Irrespective of N levels BINA mash-1 always produced lower pod dry weight than BARI mash-3. This might be due to the fact that the contribution of petiole to total dry matter was higher in BINA mash-1 than in BARI mash-3. Higher petiole dry weight in BINA mash-1 might led to increase leaf angle which made the canopy less efficient in light interception (Hamid *et al*., 1990).

**Light Transmission Ration (LTR) and Light extinction coefficient (K):** Distribution of radiation over the leaf surface of the community is an important factor in determining the conversion of solar energy to chemical energy and thus for dry matter production (Tripathi and Singh, 1989). There was a great deal of variation in light transmission due to differences in variety and nitrogen levels (Fig. 3a and b). Better light interception (about 97%) by the crop canopy was associated with large leaf surface availability for photosynthesis as evident by the higher leaf dry weight. The relationship between foliage coverage and fractional radiation interception was reduced using the absorbed radiation and the leaf area index for each layer of the canopy. Within the canopy LTR (%) diminished at a linear rate with increasing LAI (Fig. 3a and b). This clearly indicates that with the increasing LAI, LTR decreased. This result agreed with the results of Akhtaruzzaman (1998) in mungbean. They found that the interception of PPFD by the crop canopies was closely related to the leaf area index. The relationship between LTR and LAI was influenced by the application of N fertilizers. Highly significant $R^2$ value indicated that the linear relationship were able to describe the relationships.

Light extinction coefficient (K) values of the two blackgram varieties were found widely varied across the

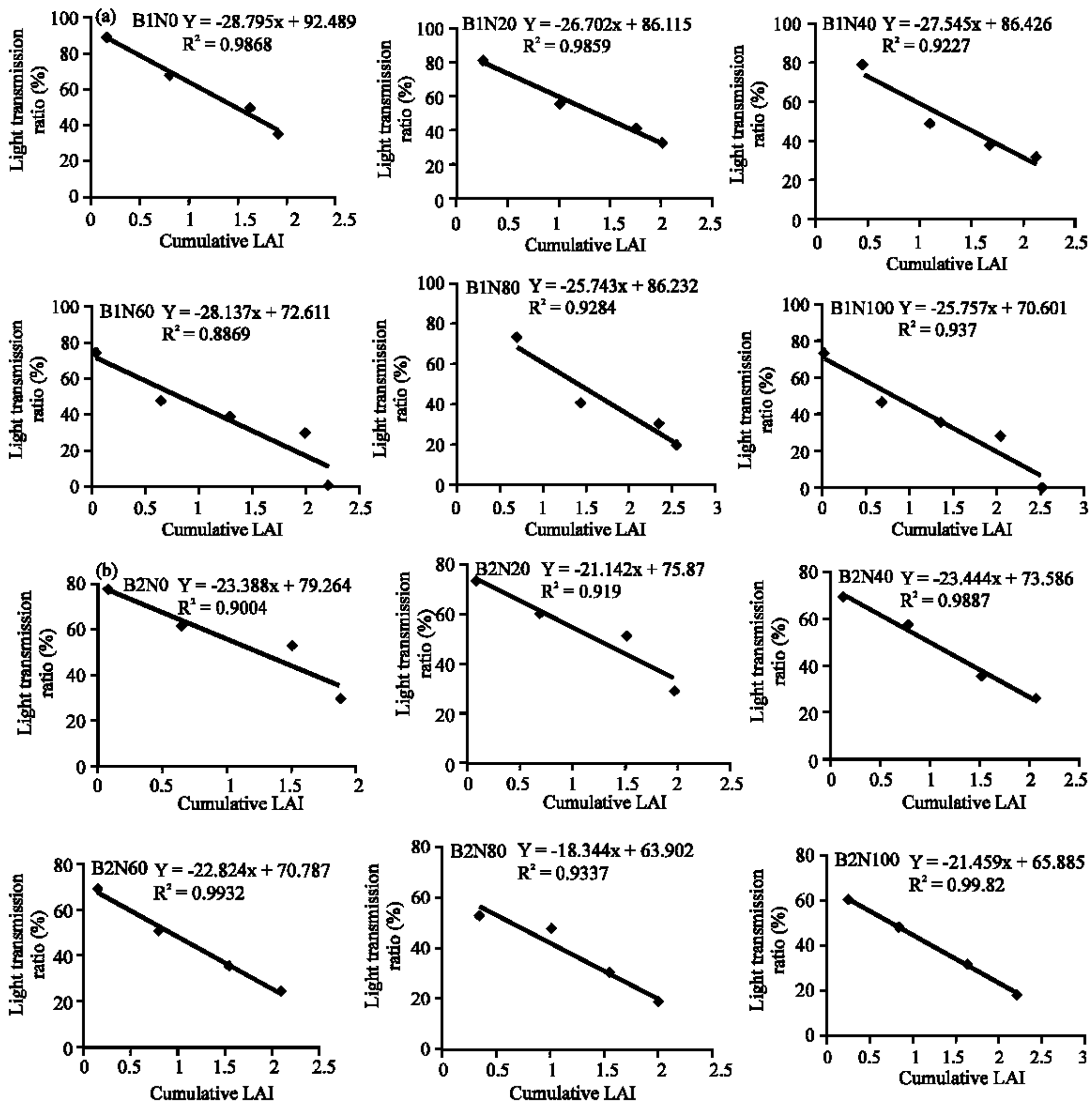


Fig. 3: Functional relationship between cumulative leaf area index at different height and light transmission ratio (LTR %) as affected by different levels of N at pod filling stages of (a) BARI mash-3 and (b) BINA mash-1

Table 2: Variation in light extinction co-efficient (K value) as affected by different levels of nitrogen and varieties at pod filling stage

| | | Canopy height (cm) | | | |
|---|---|---|---|---|---|
| Variety | N level (kg ha$^{-1}$) | 0-10 | 10-20 | 20-30 | 30-40 |
| BARI mash-3 | 0 | 1.97 | 1.52 | 0.59 | 0.37 |
| | 20 | 1.47 | 1.04 | 0.46 | 0.33 |
| | 40 | 1.17 | 0.70 | 0.38 | 0.31 |
| | 60 | 0.94 | 0.56 | 0.37 | 0.30 |
| | 80 | 0.62 | 0.49 | 0.36 | 0.18 |
| | 100 | 0.79 | 0.53 | 0.36 | 0.18 |
| BINA mash-1 | 0 | 2.85 | 2.63 | 0.80 | 0.50 |
| | 20 | 2.76 | 1.91 | 0.77 | 0.42 |
| | 40 | 2.23 | 1.59 | 0.59 | 0.29 |
| | 60 | 2.15 | 1.49 | 0.55 | 0.25 |
| | 80 | 1.48 | 1.00 | 0.44 | 0.17 |
| | 100 | 1.66 | 1.19 | 0.53 | 0.20 |

N levels. The K value ranged between 0.17 to 2.85 depending on the canopy height and treatment variations (Table 2). Lower K value was obtained from 80 kg N ha$^{-1}$ treated plants and higher K value was from those plants where, N was not applied ($N_0$). These K values may be comparable with the values of (0.49) Islam *et al.* (1994) and Akhtaruzzaman (1998) in mungbean grown in optimum and different N and P combinations. The K values indicated that light distribution within the canopy of BARI mash-3 was better than BINA mash-1 in all the nitrogen levels. Irrespective of varieties and N levels the highest K values were always observed at bottom layers of the varieties, which was decreased with the increased canopy height. Higher K values at bottom stratum of BINA mash-1 indicated its capability of interception of less light than the BARI mash-3.

The findings of this study will helps to furnish the information on the nature of combination among dry matter production, canopy structure and light transmission with different nitrogen levels to choose a suitable selection criteria for predicting the yield of blackgram.

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