Nitrogen Level and Physiological Basis of Yield of Mungbean at Varying Plant Population in High Ganges River Flood Plain Soil of Bangladesh

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Abstract: A field experiment was conducted at the Regional Agricultural Research Station of Bangladesh Agricultural Research Institute, Jessore during early kharif season of 2009 and 2010 to observe the effect of nitrogen on the physiological basis of yield of mungbean at varying plant population. In the experiment, four nitrogen levels (N10, N20, N80, and N100 kg ha⁻¹) were assigned in the main plots and three plant population (P30, P50, and P70 m⁻²) in the sub plots. The results revealed that mungbean showed better growth in N80 and N100 kg ha⁻¹ representing higher values of CO₂, TDM, LAI and plant height while N10 exhibited intermediate growth. Again, growth of mungbean was better in higher plant population (35-40 m⁻²) showing higher values of growth parameters. Seed yield of mungbean was obtained the highest (1908 kg ha⁻¹) associated with the highest No. of pods plant⁻¹ (29.98), seeds pod⁻¹ (10.41) and 1000-seed weight (37.70 g) in N30 kg ha⁻¹. Further, seed yield of mungbean was the highest (1919 kg ha⁻¹) in plant population of 40 m⁻². In interaction, seed yield was the highest (1963 kg ha⁻¹) in N30 kg ha⁻¹ with plant population of 40 m⁻². The effect of applied nitrogen on the seed yield of mungbean can be explained 78% (R² = 0.78) by this function (Y = 1.540.7016.069x⁻⁰.⁰₁₇₃x²). The optimum nitrogen level was 46 kg ha⁻¹ by using the developed functional model and then the predicted seed yield of mungbean would be 1944 kg ha⁻¹.

Key words: Growth, yield, nitrogen, population, mungbean, functional model

INTRODUCTION

Yield of a crop is realized by the interaction of genotype and the growth environment (Mian et al., 2002). Better crop growth related to physiological process contributed to good yield formation (Hamid et al., 1991). Yield is the function of dry matter accumulation whose partitioning contributes to seed yield formation. Proper growth of plant resulting sufficient dry matter accumulation significantly realizes better yield. Nitrogen involves in many important biochemical process of amino acids, protein, enzymes, nucleic acids and chlorophyll (Pandey and Sinha, 1986). Nitrogen involves in many physiological processes in the plant system and enhances growth of plant. Nitrogen accumulation in plant contributes to biomass production and seed yield of grain legume. Nitrogen accumulation in grain encourages seed development and ultimately contributes to better yield formation. Although, mungbean as a legume plant can fix atmospheric nitrogen responses to applied nitrogen for better growth and yield realization (Ayub et al., 1999). Furthermore, plant population determines the degree of inter plant competition influencing the growth of individual plant as well as total dry matter production per unit area. Although, lower plant population rather than optimal encourages growth of individual plant but reduces the total dry matter production per unit area. On the contrary, over plant population limits the availability of growth resources retarding growth of individual plants. Plant population pertaining to dry matter production depends on soil characteristics and environment of a specific location. Thus nitrogen and plant population influence the growth and yield formation of mungbean. Therefore, optimum nitrogen level and plant population is very important for proper growth and physiological behaviour for better realization of yield. Hence, the study was undertaken to estimate the optimum level of nitrogen and understanding of physiological basis of yield of mungbean at varying plant population.

MATERIALS AND METHODS

Materials: An experiment was conducted at Regional Agricultural Research Station of Bangladesh Agricultural Research Institute, Jessore during early kharif season of 2009 and 2010. The experimental site belongs to High Ganges River Flood Plain Soil (Agro-Ecological Zone-11) of Bangladesh. The texture of the soil was sandy loam with medium to low nutrient status (organic matter 1.28%, total N 0.098%, available P 14.80 ppm, exchangeable K

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0.15 cm 100 g⁻¹ soil, available S 20 ppm and available
Zn 1.08 ppm) (Mian, 2008). Four nitrogen levels viz., N₀,
N₄₀, N₆₀ and N₈₀ kg ha⁻¹ were assigned in the main plots
and three plant population viz., P₁₀, P₃₀, and P₅₀ m⁻² in the
sub plots. BARI Mungbean-6 was sown on 3 March
2009 and 2010.

Methods: The experiment was laid out in a split plot
design with 3 replications. The unit plot size was 3 x 2.4 m.
Nutrients, 25-25 kg ha⁻¹ of P and K were applied as basal.
Two irrigations were done at 28-30 March and 14-16 April
of 2009 and 2010. Two weeding was done at 12 and
24 DAE for the crop. Ten plants were sampled randomly
at 10 days intervals after emergence for assessing growth
parameters like plant height, leaf area, CGR and Total Dry
Matter (TDM) of mungbean. Plant samples were taken
excluding the harvesting area for measuring yield and
yield components. Pod harvesting was started from
8-10 May of 2009 and 2010. Yield components and yield
were also recorded at the maturity of crop and analyzed
statistically. Optimum level of nitrogen was estimated
using the following polynomial function generally stated as
bellow (Gomez and Gomez, 1984):

\[ Y = a + bx - cx^2 \]

Where:
\[ Y = \text{Yield of mungbean (dependent variable)} \]
\[ a = \text{Intercept (constant) and b and c are the} \]
\[ x = \text{Applied nitrogen level (independent variable)} \]

From the function, optimum level of nitrogen for
mungbean can be determined as follows (Gomez and
Gomez, 1984).

Optimum level of nitrogen for maximum yield of
mungbean:

\[ (N_{opt}) = \frac{-b}{2c} \]

Yield was also predicted against the optimum nitrogen
level through developed functional model.

RESULTS AND DISCUSSION

Plant height: Plant height was higher in all nitrogen levels
(N₀, N₄₀ and N₆₀) while lower in control (Fig. 1). The
differences of plant height were more evident after
30 DAE. The increase of plant height showed more or less
similar trend in N₀, and N₆₀. The highest plant height was
noticed at 60 DAE irrespective of nitrogen levels. Similar
results also have been described by Mian (2008). Changes
of plant height over time were noticed among the plant
populations (Fig. 2). Plant height showed higher values in
higher plant density. This was possibly happened due
to more inter plant competition at higher plant densities
(P₃₀ and P₅₀). Higher plant population enhanced tallness
of plant due to competition.

Crop growth rate (CGR): Crop growth rate (CGR) of
mungbean was influenced by nitrogen level (Fig. 3). It was
clearly evident after 20 DAE among the nutrient levels.
The CGR gradually increased up to 30 DAE and afterwards it advanced rapidly with the time. Differences
of CGR were more visible among N₀, N₄₀ and N₆₀ but it was
very closer between N₆₀ and N₈₀ (Fig. 3). Higher nitrogen
level (N₆₀ and N₈₀) showed higher CGR as compared to
other levels. Higher nitrogen level exerted more growth of
plant. Variation of CGR due to nutrient level was also
reported by Mian (2008). Again, variation of CGR was
noticed among the plant population (Fig. 4). Higher values
of CGR was shown in higher plant population (P₅₀)
followed by $P_{35}$ while the lowest in $P_{10}$. However, the differences of CGR among the plant population were clearly evident at later growth stages. Higher plant population showed higher CGR due to more dry matter accumulation per unit area ($m^2$). The results are in agreement with the findings of Hamidullah (2000).

**Total dry matter (TDM):** Dry matter accumulation per square meter increased slowly over time up to 30 DAE, then it increased sharply and reached at the peak at 60 ADE irrespective of nitrogen levels (Fig. 5). TDM was higher in all nitrogen levels ($N_{10}$, $N_{30}$ and $N_{60}$) over control ($N_{0}$) while the differences were more visible after 20 DAE. Increase of TDM over time showed similar trend in $N_{10}$ and $N_{30}$. Higher TDM in higher nitrogen levels in bushbean was also observed by Islam (2002). TDM was found higher in $P_{30}$ and $P_{50}$ over $P_{10}$ (Fig. 6). More number of individual plants contributed to higher dry matter accumulation per unit area ($m^2$) at higher population of mungbean. The differences of TDM were more distinct at later growth stages. TDM gradually increased with the advancement of time up to 30 DAE, then it increased rapidly and reached at the peak at 60 DAE. The results have been supported by the findings of Mian (2008).

**Leaf area index (LAI):** Variation of LAI was observed among the nitrogen levels but it was clearly evident after 20 DAE (Fig. 7). LAI showed higher values in $N_{10}$, $N_{30}$ and $N_{60}$ over $N_{0}$ while $N_{10}$ and $N_{60}$ showed closer values to each other (Fig. 7). Higher nitrogen levels ($N_{10}$ and $N_{60}$) gave higher LAI values indicating more photosynthetic area for higher dry matter accumulation in the plants. The results have been supported by the findings of Hamidullah (2000) and Islam (2002). Again, LAI was higher in higher plant population ($P_{30}$ and $P_{50}$) but lower in $P_{10}$ (Fig. 8). LAI increased sharply after 20 DAE up to 50 DAE but it was relatively stable at both of 50 and 60 DAE irrespective of plant populations. Leaf area of more number of individual plants contributed to exhibit higher LAI due to higher population density in $P_{30}$ and $P_{50}$ as compared to $P_{10}$. Higher LAI in higher plant density was also observed by Hamidullah (2000).
Table 1: Yield components and yield of mungbean as influenced by nitrogen and plant population (Pooled average of 2007 and 2008)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Branches plant(^{-1})</th>
<th>Pods plant(^{-1})</th>
<th>Seeds pod(^{-1})</th>
<th>1000 -seed wt. (g)</th>
<th>Seed yield (kg ha(^{-1}))</th>
<th>Straw yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>N(_0)</td>
<td>55.64(^{a})</td>
<td>3.71</td>
<td>23.94(^{ab})</td>
<td>10.26(^{a})</td>
<td>36.79(^{a})</td>
<td>1761(^{a})</td>
<td>2430(^{a})</td>
</tr>
<tr>
<td>N(_1)</td>
<td>58.38(^{a})</td>
<td>3.84</td>
<td>29.98(^{abc})</td>
<td>10.41(^{a})</td>
<td>37.70(^{b})</td>
<td>1508(^{b})</td>
<td>2638(^{b})</td>
</tr>
<tr>
<td>N(_2)</td>
<td>61.12(^{a})</td>
<td>3.96</td>
<td>26.35(^{abc})</td>
<td>10.73(^{ab})</td>
<td>37.79(^{ab})</td>
<td>1789(^{ab})</td>
<td>3672(^{b})</td>
</tr>
<tr>
<td>N(_3)</td>
<td>62.15(^{a})</td>
<td>4.10</td>
<td>25.20(^{bc})</td>
<td>10.60(^{b})</td>
<td>37.22(^{b})</td>
<td>1751(^{b})</td>
<td>3111(^{b})</td>
</tr>
<tr>
<td>CV (%a)</td>
<td>7.62</td>
<td>11.13</td>
<td>16.98</td>
<td>9.61</td>
<td>7.52</td>
<td>17.27</td>
<td>18.75</td>
</tr>
</tbody>
</table>

**Plant population (P)**

| P\(_2\) | 57.33\(^{a}\) | 4.15\(^{a}\) | 30.04\(^{a}\) | 10.40\(^{a}\) | 37.51\(^{a}\) | 1619\(^{a}\) | 2525\(^{a}\) |
| P\(_3\) | 59.90\(^{a}\) | 3.84\(^{a}\) | 24.88\(^{ab}\) | 10.64\(^{b}\) | 38.04\(^{b}\) | 1835\(^{b}\) | 2926\(^{b}\) |
| P\(_4\) | 60.67\(^{a}\) | 3.64\(^{a}\) | 24.26\(^{bc}\) | 10.84\(^{c}\) | 36.17\(^{b}\) | 1919\(^{b}\) | 3082\(^{b}\) |

**Interaction (N x P)**

| N\(_0\) P\(_2\) | 53.40\(^{a}\) | 3.67\(^{a}\) | 26.12\(^{a}\) | 10.69\(^{a}\) | 39.89\(^{a}\) | 1544\(^{a}\) | 2153\(^{a}\) |
| N\(_0\) P\(_3\) | 56.09\(^{a}\) | 3.72\(^{a}\) | 22.59\(^{a}\) | 10.46\(^{b}\) | 38.78\(^{a}\) | 1722\(^{a}\) | 2505\(^{a}\) |
| N\(_0\) P\(_4\) | 56.77\(^{a}\) | 3.67\(^{a}\) | 23.12\(^{a}\) | 9.70\(^{c}\) | 36.18\(^{a}\) | 1835\(^{a}\) | 2676\(^{a}\) |
| N\(_0\) P\(_5\) | 55.29\(^{a}\) | 4.40\(^{a}\) | 31.55\(^{a}\) | 10.35\(^{b}\) | 37.52\(^{a}\) | 1816\(^{a}\) | 2479\(^{a}\) |
| N\(_0\) P\(_6\) | 59.36\(^{a}\) | 3.65\(^{a}\) | 24.20\(^{a}\) | 9.45\(^{c}\) | 37.69\(^{a}\) | 1886\(^{a}\) | 2781\(^{a}\) |
| N\(_0\) P\(_7\) | 60.58\(^{a}\) | 3.45\(^{a}\) | 23.30\(^{a}\) | 10.44\(^{b}\) | 36.63\(^{a}\) | 1963\(^{a}\) | 2946\(^{a}\) |
| N\(_0\) P\(_8\) | 58.95\(^{a}\) | 4.22\(^{a}\) | 34.90\(^{a}\) | 10.98\(^{b}\) | 36.22\(^{a}\) | 1527\(^{a}\) | 2374\(^{a}\) |
| N\(_0\) P\(_9\) | 61.26\(^{a}\) | 3.78\(^{a}\) | 28.62\(^{a}\) | 10.67\(^{c}\) | 36.45\(^{a}\) | 1888\(^{a}\) | 3051\(^{a}\) |
| N\(_0\) P\(_10\) | 63.10\(^{a}\) | 3.75\(^{a}\) | 26.35\(^{a}\) | 9.97\(^{c}\) | 35.67\(^{a}\) | 1506\(^{a}\) | 2330\(^{a}\) |
| N\(_0\) P\(_11\) | 59.02\(^{a}\) | 4.12\(^{a}\) | 28.04\(^{a}\) | 10.45\(^{b}\) | 38.18\(^{a}\) | 1560\(^{a}\) | 2591\(^{a}\) |
| N\(_0\) P\(_12\) | 62.71\(^{a}\) | 3.88\(^{a}\) | 24.93\(^{a}\) | 9.95\(^{c}\) | 38.18\(^{a}\) | 1886\(^{a}\) | 3145\(^{a}\) |
| N\(_0\) P\(_13\) | 64.71\(^{a}\) | 3.60\(^{a}\) | 22.92\(^{a}\) | 9.43\(^{c}\) | 35.21\(^{a}\) | 1785\(^{a}\) | 3322\(^{a}\) |

CV (%a) 6.19 10.25 15.33 9.94 6.19 9.48 11.16

Same letter (a) within the column do not differ significantly.

Fig. 7: Changes in LAI of mungbean over time as influenced by N level

**Yield components and yield of mungbean**

**Effect of nitrogen level:** Plant height was the highest (61.12-62.15 cm) in N\(_0\) and N\(_1\) followed by N\(_2\) while the lowest (55.64 cm) in control (N\(_0\)) (Table 1). Branches plant\(^{-1}\) were not significant among the nitrogen levels. Pods plant\(^{-1}\) showed the highest value in N\(_0\) (29.98) over other nitrogen levels (23.94-26.35). The results revealed that higher nitrogen levels (N\(_0\) and N\(_1\)) failed to produce more number of pods plant\(^{-1}\) over N\(_0\). The reason behind that was higher nitrogen level exerted vigorous growth (Fig. 3 and 5) and retarded pod formation. Similar results also have been reported by BARI (2005) and Mian (2008). Seeds pod\(^{-1}\) was the highest in N\(_0\) which was statistically similar to N\(_0\) while other nitrogen levels showed lower number of seeds pod\(^{-1}\). Higher nitrogen level encouraged crop growth (Fig. 3 and Fig. 5) but diminished seed development resulting lower number of filled seeds pod\(^{-1}\) (Table 1). The results are in agreement with the observations of Mian (2008). The weight of 1000-seed was the highest in N\(_0\) followed by N\(_0\) and N\(_0\) while the lowest in N\(_0\). Seed yield was the highest in N\(_0\) (1508 kg ha\(^{-1}\)) as compared to other nitrogen levels (1751-1789 kg ha\(^{-1}\) of seed yield). The highest straw yield was noticed in N\(_0\) (3111 kg ha\(^{-1}\)) which was statistically identical to N\(_0\) and N\(_0\) but with the lowest in N\(_0\) (2430 kg ha\(^{-1}\)). Higher straw yield in higher nitrogen levels was caused by higher crop growth (Fig. 3). The results have been supported by Islam (2002).

Fig. 8: Changes in LAI of mungbean over time as influenced by plant population
Effect of plant population: Plant population had significant effect on plant height showing the highest value in P25 (60.67 cm) followed by P35 (59.96 cm) but the lowest in P15 (Table 1). Branches plant⁻¹ (4.15), pods plant⁻¹ (30.04) and seeds pod⁻¹ (10.46) were the highest in P35 while other plant populations exhibited the lower values of these characters. Lower plant population enhanced these characters due to lower inter plant competition. Higher number of pods plant⁻¹ and seeds pod⁻¹ in higher plant population of mungbean were also observed by Singh et al., (2011). The weight of 1000-seed was the highest in P35 (38.01 g) and P35 (37.51 g) but the lowest in P5 (36.17 g). The highest seed yield was obtained from P40 (1919 kg ha⁻¹) followed by P35 whereas the lowest in P5. Higher plant population contributed to higher seed yield although having the inferior yield components of mungbean. The results have been supported by the finding of Singh et al., (2011). Similar trend was also noticed in straw yield while it was the highest in P35 (3082 kg ha⁻¹) and the lowest in P5 (2525 kg ha⁻¹) (Table 1). Higher plant population per unit area (m²) resulted in higher CGR (Fig. 4) producing higher straw yield.

Effect of interaction of nitrogen level and plant population: Plant height was the highest (64.71 cm) in N30P30 followed by N10P10, and N50P40 while the lowest in N40P20 (Table 1). Branches plant⁻¹ was the highest (4.22-4.49) in N60P50 and N50P50 followed by N30P30 (4.12) and N50P30 (3.78) but the lowest in N5P30 (3.67). Merely, similar trend was followed in the case of pods plant⁻¹ when the highest value (31.55-34.99) was in N60P30 and N40P30. Seeds pod⁻¹ was the highest (10.98) in N60P30 which was identical to N50P30, N50P30, N30P30, N30P10, N50P30 and N50P30. The weight of 1000-seed was the highest in N30P30 (39.86 g) which was statistically similar to N50P30, N10P10, N50P10, N60P40, and N60P30, N50P30, N60P30 while N10P40 gave the lowest value (35.21 g). Seed yield was the highest (1963 kg ha⁻¹) in N60P40 which was identical to N50P30, N60P20, N60P30, N60P50, N50P40, and N50P30, whenever producing the lowest in N5P30, N5P20, N50P50, and N5P50. The straw yield was the highest (3322-3538 kg ha⁻¹) in N50P4, and N50P40, while the lowest in N5P30. Higher nitrogen levels with higher plant population produced higher straw yield. The results have been supported by the findings of Mian (2008).

Functional relationship of applied nitrogen and seed yield: Functional relationship between applied nitrogen and seed yield of mungbean showed a second degree polynomial function (Fig. 9). The effect of applied nitrogen on the seed yield of mungbean can be explained

\[ Y = 1540.7 + 16.069x - 0.173x^2 \]

\[ R^2 = 0.78 \]

Fig. 9: Functional relationship between applied nitrogen and seed yield of mungbean

78% (R² = 0.78) by this function (Y = 1540.70+16.069x-0.173x²). The function indicated that seed yield of mungbean can be increased 16.069 kg ha⁻¹ with the increase of 1 kg ha⁻¹ of nitrogen application. The optimum nitrogen level was 46 kg ha⁻¹ by using the developed functional model and then the predicted seed yield of mungbean would be 1944 kg ha⁻¹. Similar functional relationship has been explained in mustard by Mian et al., (2011).

CONCLUSION

Nitrogen 40 kg ha⁻¹ with plant population of 40 m⁻² were suitable for higher yield of mungbean at Jessore region in High Ganges River Flood Plain soil of Bangladesh. The optimum nitrogen level would be 46 kg ha⁻¹ by using the developed functional model and then the predicted seed yield of mungbean would be 1944 kg ha⁻¹.

REFERENCES


