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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 (N_0, N_{40}, N_{60} and N_{80} kg ha^{-1}) were assigned in the main plots and three plant population (P_{30}, P_{35} and P_{40} m^{-2}) in the sub plots. The results revealed that mungbean showed better growth in N_{60} and N_{80} kg ha^{-1} representing higher values of CGR, TDM, LAI and plant height while N_{40} exhibited intermediate growth. Again, growth of mungbean was better in higher plant population (35-40 m^{-2}) representing 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 N_{40} 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 N_{40} 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% (R^2 = 0.78) by this function ($Y = 1540.70+16.069x-0.173x^2$). 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 me 100 g^{-1} soil, available S 20 ppm and available Zn 1.08 ppm) (Mian, 2008). Four nitrogen levels viz., N_0, N_{40}, N_{60} and N_{80} kg ha^{-1} were assigned in the main plots and three plant population viz., P_{30}, P_{35} and P_{40} 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 3×2.4 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 flowing polynomial function generally stated as bellow (Gomez and Gomez, 1984):

$$Y = a+bx-cx^2$$

Where:

Y = Yield of mungbean (dependent variable)

a = Intercept (constant) and b and c are the regression coefficients

x = 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:

$$(N_O) = \frac{-b}{2c}$$

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 (N_{40}, N_{60} and N_{80}) 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 N_{60} and N_{80}. 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 (P_{35} and P_{40}). Higher plant population enhanced tallness of plant due to competition.

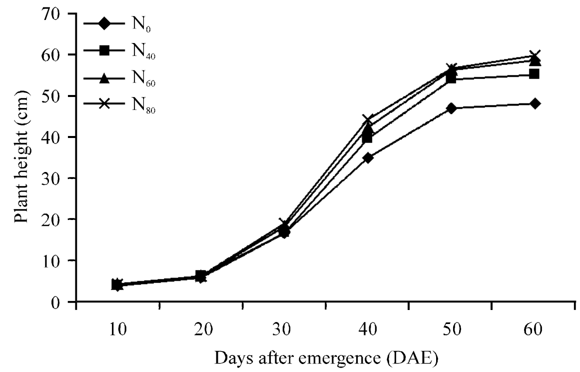

Fig. 1: Changes in plant height of mungbean over time as influenced by N level

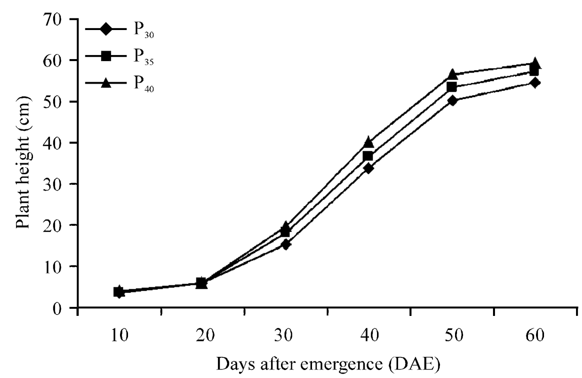

Fig. 2: Changes in plant height of mungbean over time as influenced by plant population

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 N_0, N_{40} and N_{60} but it was very closer between N_{60} and N_{80} (Fig. 3). Higher nitrogen level (N_{60} and N_{80}) 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 (P_{40})

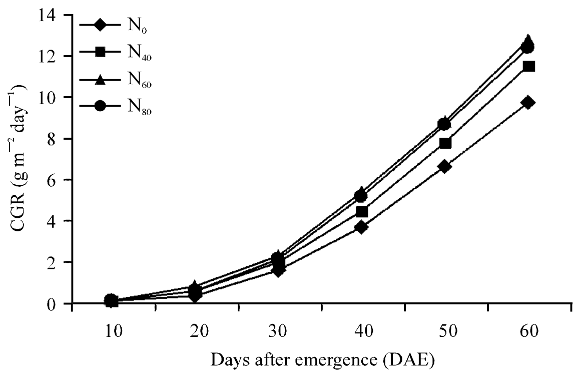

Fig. 3: Changes in CGR of mungbean over time as influenced by N level

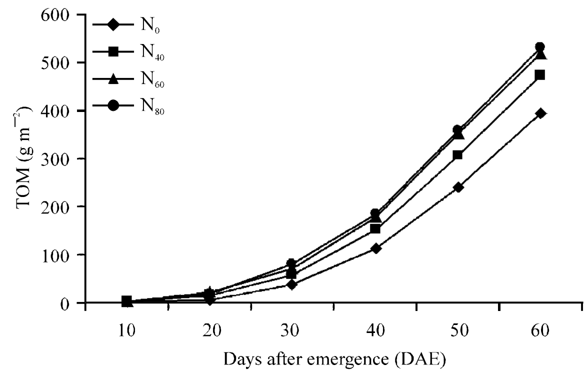

Fig. 5: Changes in TDM of mungbean over time as influenced by N level

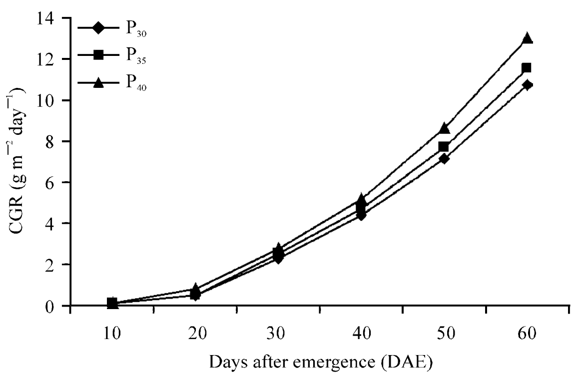

Fig. 4: Changes in CGR of mungbean over time as influenced by plant population

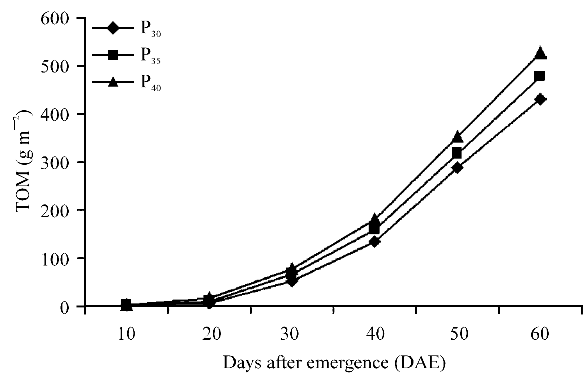

Fig. 6: Changes in TDM of mungbean over time as influenced by plant population

followed by P_{35} while the lowest in P_{30}. 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 squire 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_{40}, N_{60} and N_{80}) over control (N_0) while the differences were more visible after 20 DAE. Increase of TDM over time showed similar trend in N_{60} and N_{80}. Higher TDM in higher nitrogen levels in bushbean was also observed by Islam (2002). TDM was found higher in P_{40} and P_{35} over P_{30} (Fig. 6). More number of individual plants contributed to higher to 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 peaked 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_{40}, N_{60} and N_{80} over N_0 while N_{60} and N_{80} showed closer values to each other (Fig. 7). Higher nitrogen levels (N_{60} and N_{80}) 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_{35} and P_{40}) but lower in P_{30} (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_{35} and P_{40} as compared P_{30}. 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)

Treatment	Plant height (cm)	Branches plant^{-1}	Pods pod^{-1}	Seeds pod^{-1}	1000-seed wt. (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Nitrogen (N)							
N_0	55.64^{c}	3.71	23.94^{b}	10.26^{ab}	36.79^{c}	1761^{b}	2430^{b}
N_{40}	58.38^{b}	3.84	29.98^{a}	10.41^{a}	37.70^{a}	1908^{a}	2698^{ab}
N_{60}	61.12^{a}	3.96	26.35^{b}	10.37^{b}	37.19^{b}	1789^{b}	3072^{a}
N_{80}	62.15^{a}	4.10	25.29^{b}	10.04^{b}	37.22^{b}	1751^{b}	3111^{a}
CV%	7.62	11.13	16.98	9.61	7.52	17.27	18.75
Plant population (P)							
P_{30}	57.33^{c}	4.15^{a}	30.04^{a}	10.46^{a}	37.51^{a}	1619^{c}	2525^{c}
P_{35}	59.96^{b}	3.84^{b}	24.88^{b}	10.04^{b}	38.01^{a}	1835^{b}	2926^{b}
P_{40}	60.67^{a}	3.64^{b}	24.26^{b}	10.08^{b}	36.17^{b}	1919^{a}	3082^{a}
CV (%)	6.19	10.25	15.33	9.94	6.19	9.48	11.16
Interaction (N×P)							
N_0 P_{30}	53.40^{c}	3.67^{cde}	26.12^{bc}	10.69^{a}	39.86^{a}	1544^{c}	2135^{g}
N_0P_{35}	56.09^{ef}	3.72^{e}	22.59^{c}	10.40^{ab}	38.78^{ab}	1722^{b}	2651^{ef}
N_0P_{40}	56.77^{e}	3.67^{de}	23.12^{c}	9.70^{c}	36.18^{cde}	1839^{b}	2654^{ef}
$N_{40}P_{30}$	55.23^{f}	4.49^{a}	31.55^{ab}	10.35^{ab}	37.52^{a-e}	1816^{ab}	2470^{f}
$N_{40}P_{35}$	59.36^{d}	3.65^{cde}	24.20^{c}	9.45^{c}	37.69^{a-d}	1886^{a}	2781^{cde}
$N_{40}P_{40}$	60.58^{c}	3.65^{cde}	23.30^{c}	10.44^{ab}	36.63^{b-e}	1963^{a}	2964de
$N_{60}P_{30}$	58.95^{d}	4.22^{ab}	34.99^{a}	10.98^{a}	36.22^{cde}	1527^{c}	2743^{def}
$N_{60}P_{35}$	61.26^{c}	3.78^{bc}	28.62^{bc}	10.67^{a}	36.45^{b-e}	1838^{ab}	3051^{bc}
$N_{60}P_{40}$	63.16^{b}	3.75^{cde}	26.35^{bc}	9.97^{bc}	35.67^{de}	1906^{a}	3538^{a}
$N_{80}P_{30}$	59.02^{d}	4.12b^{cd}	28.04^{bc}	10.45^{ab}	38.18^{abc}	1560^{c}	2951^{cd}
$N_{80}P_{35}$	62.71^{b}	3.88^{cde}	24.93c	9.95^{bc}	38.18^{abc}	1886^{a}	3143^{bc}
$N_{80}P_{40}$	64.71^{a}	3.60^{de}	22.92^{c}	9.43^{c}	35.21^{e}	1785^{b}	3322^{ab}
CV (%)	6.19	10.25	15.33	9.94	6.19	9.48	11.16

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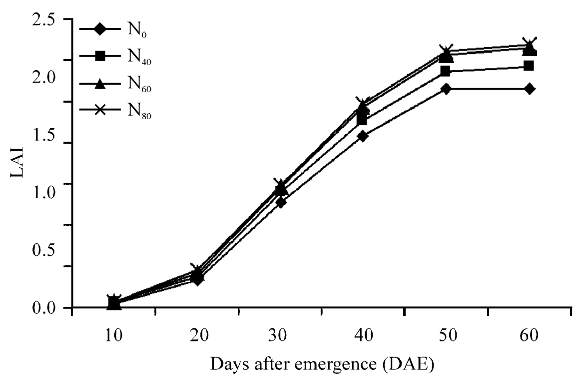

Fig. 7: Changes in LAI of mungbean over time as influenced by N level

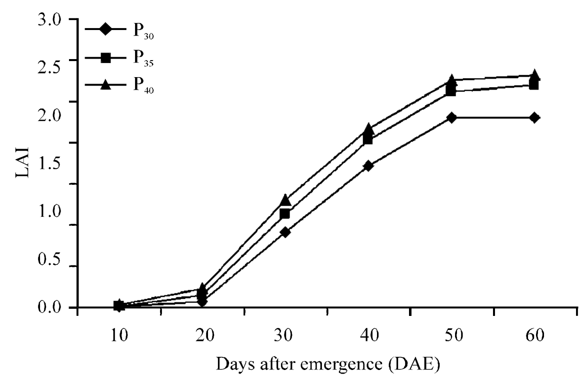

Fig. 8: Changes in LAI of mungbean over time as influenced by plant population

Yield components and yield of mungbean

Effect of nitrogen level: Plant height was the highest (61.12-62.15 cm) in N_{60} and N_{80} followed by N_{40} 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_{40} (29.98) over other nitrogen levels (23.94-26.35). The results revealed that higher nitrogen levels (N_{60} and N_{80}) failed to produce more number of pods plant^{-1} over N_{40}. 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_{40} 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_{40} followed by N_{60} and N_{80} while the lowest in N_0. Seed yield was the highest in N_{40} (1908 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_{80} (3111 kg ha^{-1}) which was statistically identical to N_{40} and N_{60} 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).

Effect of plant population: Plant population had significant effect on plant height showing the highest value in P_{40} (60.67 cm) followed by P_{35} (59.96 cm) but the lowest in P_{30} (Table 1). Branches plant^{-1} (4.15), pods plant^{-1} (30.04) and seeds pod^{-1} (10.46) were the highest in P_{30} while other plant populations exhibited the lower values of those 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 P_{35} (38. 01 g) and P_{30} (37.51 g) but the lowest in P_{40} (36.17 g). The highest seed yield was obtained from P_{40} (1919 kg ha^{-1}) followed by P_{35} whereas the lowest in P_{30}. 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 P_{40} (3082 kg ha^{-1}) and the lowest in P_{30} (2525 kg ha^{-1}) (Table 1). Higher plant population per unit area (m^2) 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 $N_{80}P_{40}$ followed by $N_{80}P_{35}$ and $N_{60}P_{40}$ while the lowest in $N_{40}P_{30}$ (Table 1). Branches plant^{-1} was the highest (4.22-4.49) in $N_{40}P_{30}$ and $N_{60}P_{30}$ followed by $N_{80}P_{30}$ (4.12) and $N_{60}P_{35}$ (3.78) but the lowest in N_0P_{30} (3.67). Merely, similar trend was followed in the case of pods plant^{-1} when the highest value (31.55-34.99) was in $N_{60}P_{30}$ and $N_{40}P_{30}$. Seeds pod^{-1} was the highest (10.98) in $N_{60}P_{30}$ which was identical to N_0P_{30}, N_0P_{35}, $N_{40}P_{30}$, $N_{40}P_{40}$, $N_{60}P_{35}$ and $N_{80}P_{30}$. The weight of 1000-seed was the highest in N_0P_{30} (39.86 g) which was statistically similar to N_0P_{35}, $N_{40}P_{30}$, $N_{40}P_{35}$, $N_{80}P_{30}$ and $N_{80}P_{35}$ while $N_{80}P_{40}$ gave the lowest value (35.21 g). Seed yield was the highest (1963 kg ha^{-1}) in $N_{40}P_{40}$ which was identical to $N_{40}P_{30}$, $N_{40}P_{35}$, $N_{60}P_{35}$, $N_{60}P_{40}$ and $N_{80}P_{35}$ whenever producing the lowest in N_0P_{30}, $N_{60}P_{30}$ and $N_{80}P_{30}$. The straw yield was the highest (3322-3538 kg ha^{-1}) in $N_{80}P4_0$ and $N_{60}P_{40}$ while the lowest in N_0P_{30}. 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

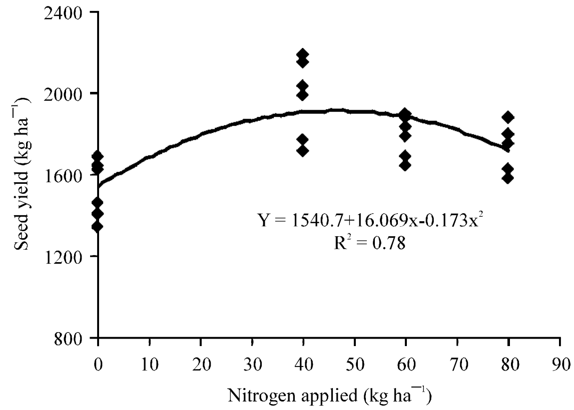

Fig. 9: Functional relationship between applied nitrogen and seed yield of mungbean

78% (R^2 = 0.78) by this function (Y = 1540.70+16.069x-0.173x^2). 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}.

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