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Mohammad Naim Jalali
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Anil K Choudhary
Division of Agronomy, Indian Agricultural Research Institute, New Delhi, India

Mohammad Qayom Mangle
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Mohammad Amin Omari
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Habibullah Hamayon
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Said Rahim Ghafari
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Anchal Dass
Division of Agronomy, Indian Agricultural Research Institute, New Delhi, India

Correspondence
Mohammad Naim Jalali
Department of Agronomy, Faculty of Plant Sciences, Afghanistan National Agricultural Science and Technology University (ANASTU), Kandahar, Afghanistan

Respons of different nitrogen levels on growth and yield of mungbean (*Vigna radiata* L. Wilczek) in semi-arid region of Kandahar Afghanistan

Mohammad Naim Jalali, Anil K Choudhary, Mohammad Qayom Mangle, Mohammad Amin Omari, Habibullah Hamayon, Said Rahim Ghafari and Anchal Dass

Abstract
An experiment was conducted at the Experimental Farm of (ANASTU), Kandahar during 2015 to study the effect of varying nitrogen levels on growth and yield of mungbean (*Vigna radiata* L. Wilczek) in semi-arid region of Kandahar, Afghanistan. Experimental treatments comprised of seven N levels (0, 10, 20, 30, 40, 50, 60 kg N ha^{-1}). The experiment was laid-out in a RCB design with three replications. The results indicated that nitrogen levels with a few expectations significantly influenced the growth parameters and yield characteristics of mungbean. The maximum plant height and net assimilation rate was recorded when nitrogen was applied @ 60 kg N ha^{-1} while the lowest were found in control treatment. The highest leaf area surface, leaf area index, total dry matter $plant^{-1}$, number of primary branches $plant^{-1}$, root dry weight, root length, root nodule count at maximum flowering, crop growth rate and relative growth rate were recorded from the plots supplied with N @ 40 kg ha^{-1}. Total number of pods $plant^{-1}$, pod length, number of grains pod^{-1}, number of grains $plant^{-1}$, grains weight $plant^{-1}$ were significantly highest with treatment 30 kg N ha^{-1}, but 1000-grains weight had non-significant influence due to N levels. Grain, straw and biological yield were found significantly higher (1.96, 5.29, 7.25 t ha^{-1}) in treatment 30 kg N ha^{-1}. Significantly lowest grain, straw and biological yields were recorded in control treatment. Harvest index was non-significant with maximum harvest index (27.7%) in treatment 20 kg N ha^{-1} and the lowest (24.3%) in control.

Keywords: Growth behavior of mungbean, yield attributes and yield

1. Introduction
Mungbean [*Vigna radiata* (L.) wilczek] is an important short duration pulse crop of the south Asian countries like India, Pakistan and Afghanistan. According to Vavilov (1926), the mungbean is a native of India and central Asia. It is rich in protein (24%) with excellent digestibility as compared to urdbean and soybean (Sarwar *et al.*, 2004) [20]. Mungbean is also known as greengram, mung, moong, moog, munggo, golden gram and green soya (Panwar and Srivastava, 2012) [16]. Greengram is one of the most important, short-season, summer growing legumes, grown widely throughout the tropics and subtropics (Thomas *et al.*, 2004) [21].
It is reported to be drought tolerant and can be cultivated in areas of low rainfall. Generally, mungbean is sown in warm region of the country like Kunduz, Helmand, Kandahar, Nangarhar, Baghlan, Laghman, Takhar, Kapisa etc. It is commonly cultivated as summer crop in Afghanistan, but in some region of the country it is also sown in spring season (USAID, 2007) [23]. It is also used as fodder crop and green manure crop (Pooniya *et al.*, 2015) [17]. The reports showed that the Afghanistan climate is more suitable for mungbean cultivation, but the productivity of mungbean is very low in the nation. Thus, government of Afghanistan spends huge foreign currency for pulse imports to feed its population. There are several reasons for low yield of mungbean in Afghanistan including non-availability of high yielding genotypes, sub-optimal fertilizer application, poor crop management, poor crop stand, imbalanced nutrition, and poor plant protection measures etc. Above all, the efficient fertilizer management is the important factor that greatly affects the growth attributes and yield of this crop.

Nitrogen constituents one of the major essential plant nutrients and the successful crop production depends mainly upon the availability of nitrogen in adequate amounts. Nitrogen is perhaps the single most important factor limiting the crop yields. One of the probable reasons for low yield of grain legumes in general is the high requirement of nitrogen for the formation and development of prominent grains (Alberada and Bower, 1983) [2]. Mungbean requires a large amount of nutrients in 2-3 phases (Trung and Yoshida, 1985) [22]. Mungbean needs much more N at reproductive stage than it does in the vegetative stage. In a study, Mitra *et al.* (1988) [13] reported that a moderate yielding mungbean crop requires as much as 27.86 mg N g^{-1} photosynthetic during the first 20 days of the pod and seed development. On the other hand, nitrogen deficiency reduces the number of branches per plant, plant height, stem diameter and pod length (Mainul *et al.*, 2014) [10]. Nitrogen deficiency reduces early vigor and the crop yield reduces accordingly.

The nitrogen is most useful for pulse crops because it is a major component of proteins. Moreover, research studies have revealed that mungbean yield and quality could be improved by the use of balanced fertilizers especially nitrogen (Aslam *et al*., 2010) [5]. Moreover, there is an exigency in the country to increase the mungbean yield through proper soil fertility management practices especially N.

2. Materials and Methods

The present field experiment was laid-out in Tarnak Research Farm at Afghanistan National Agricultural Science & Technology University (ANASTU), Kandahar, Afghanistan during the summer season of 2015. The geographical position of Kandahar is situated in southern part of Afghanistan and falls between latitude ranging from 31°30'N to longitude 65°50' E with altitude 1010 m above mean sea level. Its climate is semi-arid to subtropical with extreme cold and hot situations.

In order to determine the physical and chemical properties of the experimental soil, the soil samples were collected randomly from whole field at 0–20 cm depth. The samples of all the places were mixed together to form a composite sample for mechanical and chemical analysis. Mechanical analysis of the soil was carried-out using hydrometer method. Textures class was determined using USDA textural triangle. The pH value of each soil series was also determined using calibrated pH meter in saturated soil paste (1:2 soils: water ratio).

The experiment was laid out in Randomized Block Design (RBD) with seven treatments *viz*, (N_0, N_{10}, N_{20}, N_{30}, N_{40}, N_{50} and N_{60} ha^{-1}) while each treatment was replicated trice.

The data recorded on various parameters were subjected to statistical analysis, following analysis of variance technique as described by Gomez and Gomez (1984) and were tested at 5% level of significance to interpret the significant differences. The significance of treatment effects were tested with the help of F-test and significant difference of two treatments mean was tested by CD at P=0.05. All these calculations were carried out with the degree of freedom (df) as difference.

3. Results and Discussion

3.1 growth parameters of mungbean

Data pertaining to growth parameters of mungbean under different nitrogen (N) levels is presented in Table 3.1. In general, plant height at 30 DAS, the mungbean crop showed a significant and consistent increase in plant height with the increase in N levels from (N_0) to N @ 60 kg ha^{-1}. Similarly, plant height showed a gradual increase from 30 to 90 DAS, and thereafter there was no increase in plant height upto maturity of the mungbean crop. At 30 DAS, N @ 60 kg ha^{-1} produced significantly taller plants thought it remained statistically at par with T_6 (N @ 50 kg ha^{-1}) which was followed by N_{40}, N_{30}, N_{20}, N_{10}, N_0, respectively. At 60 DAS, N @ 60 kg ha^{-1} produced significantly taller plants, thought it remained statistically at par with N_{50}, N_{40}, N_{30} and N_{20}, however it differed significantly with N_{10} and N_0 both producing shorter plants. At 90 DAS and at harvest, N @ 50 and 60 kg ha^{-1} produced plants of same height and higher over other N levels but both remained statistically at par with N_{40} and N_{30}. In general, control treatment produced significantly shorter plants at all the observational stages. These results confirm the findings of Quah and Jaafar (1994) [18] and Mian and Hossain (2014) [12], who reported that application of nitrogen @ 50 and 60 kg ha^{-1} significantly increased the plant height, respectively. Mian (2008) [11] also described similar results.

The increase in nitrogen levels from control to N @ 60 kg ha^{-1} resulted in significant and consistent increase in leaf area surface per plant. However, N_{60}, N_{50}, N_{40} remained statistically at par with N @ 60 kg ha^{-1} at each stage of observation. Effect of nitrogen levels on LAS was non-significant at 60 DAS. The highest LAS (1231 cm^{-2} $plant^{-1}$) at 60 DAS were observed when N was applied @ 40 kg N ha^{-1}. The results showed that the leaf area surface at 90 DAS was significantly different among the treatments with highest leaf area surface (1537 $cm^{-2}plant^{-1}$) in treatment 40 kg N ha^{-1} which was at par 10, 20, 30, 50 and 60 kg N ha^{-1}. In general, lowest leaf area surface (1230 cm^{-2} $plant^{-1}$) was recorded in control treatment at all the observational stages. These results confirm the findings of Mondal *et al.* (2010) [14] and Khalilzadeh *et al.* (2012) [9] who reported that N application improves the leaf area.

Leaf area index (LAI) of mungbean increased significantly due to nitrogen application. Application of nitrogen influenced the leaf area index at 30 DAS significantly over control with maximum leaf area index (1.47) with 60 kg N ha^{-1} which was statistically at par with 10, 30, 40 and 50 kg N ha^{-1} and significant with control and 20 kg N ha^{-1}. At 60 DAS, N application had non-significant effect on LAI. At 90 DAS, application of 40 kg N ha^{-1} gave highest LAI of 5.12 which remained statistically at par with all applied N doses except control. In general, control treatment produced significantly lowest LAI at all the observational stages.

These results are similar to findings of Khalilzadeh *et al.* (2012) [9]. Results revealed that DMA was non-significantly affected by N fertilization at 30 DAS. However at 60 DAS, the highest dry matter accumulation was seen when N was applied @ 40 kg ha^{-1} which was significantly different with the treatments *viz*. 0, 10, 20 and 60 kg N ha^{-1}, but it was statistically at par with the treatments when N was applied @ 30 and 50 kg N ha^{-1}. At 90 DAS, the maximum dry matter accumulation was recorded when N was applied @ 40 kg ha^{-1} which was significantly different than the treatments *viz*. control and 10 kg N ha^{-1}. In general, control treatment produced significantly lowest DMA at all the observational stages (Table 3.1). Similar results were found by Asaduzzaman *et al.*, (2008) [4] and Mian and Hossain (2014) [12].

Effect of different nitrogen levels on growth indices of mungbean is presented in Table 3.2. Results revealed that absolute growth rate was not affected significantly by N fertilization at 30–60, and 60–90 DAS, however, the highest absolute growth rate was seen when N was applied @ 40 kg ha^{-1} and lowest in control. The results confirm the finding of Mondal *et al.* (2010) [14] who reported that N application showed superiority in absolute growth rate. Results revealed that the maximum (0.29 g plant^{-1} day^{-1}) crop growth rate (CGR) at 30–60 DAS was seen when N was applied @ 40 kg ha^{-1} which was significantly higher over treatments when N was applied @ 0, 10, 20 and @ 60 kg N ha^{-1}. However, at 60–90 DAS, the maximum CGR was recorded when N was applied @ 40 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0 and 10 kg N ha^{-1}. The crop growth rate in a unit area of canopy cover at any instant time is defined as the increase of plant material per unit of time (Radford 1967) [19]. Results revealed that relative growth rate was non-significantly affected by N fertilization at 30–60 DAS. However at 60–90 DAS, the highest relative growth rate (0.026 g g^{-1} day^{-1}) was seen when N was applied @ 60 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0, 10, 20, 30, 40 and 50 kg N ha^{-1}. These results confirm the finding of Hunt (1978). Results revealed that maximum net assimilation rate (0.00038 g cm^{-2} day^{-1}) at 30–60 DAS was seen when N was applied @ 40 kg ha^{-1} which was significantly higher over treatments when N was applied @ 0, 10, 20 and 60 kg N ha^{-1}, but it was statistically at par with the treatment when N was applied @ 30 and 40 kg N ha^{-1}. However at 60-90 DAS, the highest net assimilation rate (0.00023g.cm^{-2} day^{-1}) was seen when N was applied @ 60 kg ha^{-1} with no significant differences among all the treatments.

Data pertaining to number of leaves plant^{-1} recorded at various stages of crop growth as influenced by different nitrogen levels is presented in Table 3.3. It was revealed that growth parameters were non-significantly affected by N fertilization at 30 DAS. However, the number of leaves plant^{-1} was significantly affected by N fertilization at 60 DAS. Though at 90 DAS, the highest number of leaves plant^{-1} (90) was seen when N was applied @ 40 kg ha^{-1} which was significantly higher over treatments when N was applied @ 10 N ha^{-1}, but it was statistically at par with the treatments when N was applied @ 20, 30, 50 and @ 60 kg N ha^{-1}, respectively. In general, control treatment produced significantly lowest number of leaves plant^{-1} at 60 and 90 DAS. Asaduzzaman (2006) [4] also showed significant increase in plant height and number of leaves plant^{-1} of mungbean up to 30 kg N ha^{-1}.

It was revealed that number of primary branches plant^{-1} at 30 DAS was maximum (2.7) when N was applied @ 30 kg ha^{-1} which was significantly higher over the treatments *viz.* 0, 10 and 20 kg N ha^{-1}. However, the number of primary branches plant^{-1} was not affected significantly by the N fertilization at 60 and 90 DAS. In general, control treatment produced significantly lowest number of branches plant^{-1} at 30 and 60 DAS. These results are in accordance with Achakzai *et al.* (2012) reported that application of 100 kg N ha^{-1} significantly increased the number of branches per plant.

Results revealed that root dry weight (RDW) at 60 DAS, the highest root dry weight plant^{-1} was seen when N was applied @ 40 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0, 10, 20, 50 and 60 kg N ha^{-1}. At 90 DAS, the maximum root dry weight plant^{-1} was seen when N was applied @ 40 and 50 kg ha^{-1} which were significantly higher over the treatments when N was applied @ 0 and 10 kg N ha^{-1}, but statistically at par with the treatments *viz.* 20, 30, 40, 50 and 60 kg N ha^{-1}. Khalilzadeh *et al.* (2012) [9] who showed that foliar application of urea and organic manure substantially improved the root length. Application of nitrogen @ 30 kg ha^{-1} also resulted in gradual increase then gradual decrease in the root nodule count plant^{-1} in mungbean. The results revealed that the highest root length plant^{-1} (10.7 cm) was seen when N was applied @ 50 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0, 10 and 20 kg N ha^{-1}, but statistically at par with the treatments where N was applied @ 30, 40 and 60 kg N ha^{-1}. However at 60 DAS, it was revealed that the root length plant^{-1} was non-significantly affected by N fertilization. At 90 DAS, the results revealed that the highest root length plant^{-1} was seen when N was applied @ 50 kg ha^{-1} but it was statistically at par with the treatments where N was applied @ 10, 20, 30, 40 and 60 kg N ha^{-1}.

3.2 Effect of different N levels on yield attributes and yield of mungbean

Effect of N levels on yield attributes of mungbean is presented in Table 3.4 and their results are interpreted as hereunder:

Data revealed that number of pods plant^{-1}, pod length (cm) and number of grains pod^{-1} and grains wt. plant^{-1} was affected significantly by the N fertilization. The highest number of grains plant^{-1} (248.7 g) was seen when N was applied @ 30 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0 and 10 kg N ha^{-1}, but it was statistically at par with the treatments when N was applied @ 20, 40, 50 and 60 kg N ha^{-1}. It was also revealed that the 1000–seed weight (g) was not affected significantly by the N fertilization. Zabir (2015) [25] who reported that application of nitrogen @ 40 kg ha^{-1} significantly increased the number of seeds per pod. Result revealed that highest seed yield was obtained when N was applied @ 30 kg ha^{-1} which was significantly higher over the treatments where N was applied @ 0, 10, 50 and 60 kg N ha^{-1}, but it was statistically at par with the treatment when N was applied @ 20 and 40 kg N ha^{-1} Similarly, Kamithi and Akuja (2009) also found that the highest grain yield was 2.57 and 2.35 t grains ha^{-1} under 20 and 40 kg N ha^{-1}, respectively.

Result revealed that the straw yield was highest when N was applied @ 30 kg ha^{-1} which was significantly higher over the treatments when N was applied @ 0, 10 and 60 kg N ha^{-1}, but at the same time statistically at par with the treatments when N was applied @ 20, 40 and 50 kg N ha^{-1}. These findings corroborate the results of Zabir (2015) [25] who reported that application of 45 kg N ha^{-1} produced greater seed yield and straw yield thereafter it decreased. Result revealed that highest biological yield was obtained when N was applied @ 30 kg ha^{-1} which was significantly higher over the treatments when N was applied 0, 10, 50 and 60 kg N ha^{-1}, but, it was statistically at par with the treatments when N was applied 20 and 40 kg N ha^{-1}. The outcomes of the present study confirm the finding of Mian and Hossain (2014) [12] who reported that N application @ 40 kg ha^{-1} significantly increased the seed and biological yield in mungbean. Data on harvest index (%) revealed a non-significant effect of N fertilization. The highest harvest index (27.7) was found when N was applied @ 40 kg N ha^{-1} and minimum in control plots. Harvest index (%) decreased with the application of higher nitrogen levels, quite similar to the findings of Mozumder (1998) [15] who revealed that nitrogen produced negative effect on harvest index.

Table 3.1: Effect of different nitrogen levels on plant height of mungbean**.**

Treatment	Plant height (cm)			Leaf area (cm^2 plant^{-1})			LAI			Dry matter accumulation (g plant^{-1})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: Control	12.2	32.8	40.3	282	918	1230	0.94	3.06	4.10	0.62	4.82	11.93
T_2 : N @ 10 kg ha^{-1}	13.8	36.3	44.7	385	1167	1451	1.28	3.89	4.84	0.68	7.13	14.00
T_3 : N @ 20 kg ha^{-1}	15.8	38.9	49.0	405	1207	1492	1.35	4.02	4.97	0.70	8.00	16.30
T_4 : N @ 30 kg ha^{-1}	17.1	40.1	51.3	411	1210	1533	1.37	4.03	5.11	0.75	8.76	17.32
T_5 : N @ 40 kg ha^{-1}	16.1	41.3	52.3	423	1231	1537	1.41	4.10	5.12	0.77	9.39	18.63
T_6 : N @ 50 kg ha^{-1}	17.8	41.0	52.7	437	1205	1499	1.46	4.02	5.00	0.72	9.12	17.58
T_7 : N @ 60 kg ha^{-1}	18.1	41.8	52.7	440	1149	1467	1.47	3.83	4.89	0.70	7.75	16.76
SE(m) ±	0.55	1.20	1.19	22.7	82.6	40.7	0.08	0.28	0.14	0.05	0.33	0.98
CD (P=0.05)	1.68	3.69	3.66	69.9	NS**	125.4	0.23	NS	0.42	NS	1.03	3.01

DAS*= Days after sowing
NS**= Non-significant

Table 3.2: Effect of different nitrogen levels on plant growth indices of mungbean.

Treatment	Plant growth indices							
	AGR (cm day^{-1})		CGR (g plant^{-1} day^{-1})		RGR (g g^{-1} day^{-1})		NAR (g cm^{-2} day^{-1})	
	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS	30-60 DAS	60-90 DAS
T_1: Control	0.69	0.25	0.14	0.24	0.069	0.030	0.00027	0.00023
T_2 : N @ 10 kg ha^{-1}	0.75	0.28	0.21	0.23	0.078	0.022	0.00031	0.00018
T_3 : N @ 20 kg ha^{-1}	0.77	0.34	0.24	0.28	0.081	0.024	0.00033	0.00021
T_4 : N @ 30 kg ha^{-1}	0.77	0.37	0.27	0.29	0.082	0.022	0.00036	0.00021
T_5 : N @ 40 kg ha^{-1}	0.81	0.37	0.29	0.31	0.084	0.023	0.00038	0.00022
T_6 : N @ 50 kg ha^{-1}	0.79	0.37	0.28	0.28	0.085	0.022	0.00037	0.00021
T_7 : N @ 60 kg ha^{-1}	0.79	0.37	0.24	0.30	0.080	0.026	0.00032	0.00023
SE(m) ±	0.04	0.04	0.01	0.03	0.002	0.002	0.00001	0.00002
CD (P=0.05)	NS	NS	0.03	NS	0.007	NS	0.00004	NS

Table 3.3: Effect of different nitrogen levels on plant height of mungbean.

Treatment	Number of leaves plant^{-1}			Number of primary branches plant^{-1}			Root dry weight (g plant^{-1})			Root length (cm)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Control	5.9	33.0	62.7	1.5	2.4	4.0	0.13	0.43	0.87	7.7	15.0	14.7
10 N kg ha^{-1}	6.8	41.3	81.3	1.7	3.5	4.9	0.15	0.51	1.04	8.3	15.7	16.7
20 N kg ha^{-1}	7.3	42.0	88.7	2.2	4.0	5.1	0.17	0.91	1.15	8.7	15.5	18.3
30 N kg ha^{-1}	8.0	43.7	89.0	2.7	4.1	5.3	0.18	1.08	1.27	9.3	15.5	18.8
40 N kg ha^{-1}	8.2	44.7	90.0	2.6	4.2	5.5	0.18	1.10	1.39	10.3	16.8	19.7
50 N kg ha^{-1}	7.1	42.0	89.3	2.6	4.4	5.5	0.14	0.91	1.39	10.7	17.1	19.2
60 N kg ha^{-1}	7.6	41.0	83.0	2.6	4.3	5.4	0.14	0.91	1.38	10.0	16.2	18.3
SE(m) ±	0.64	1.38	2.51	0.10	0.23	0.37	0.01	0.06	0.11	0.56	0.90	0.96
CD (P=0.05)	NS	4.27	7.74	0.30	0.70	NS	0.02	0.17	0.35	1.74	NS	2.95

DAS*= Days after sowing, NS**= Non-significant

Table 3.4: Effect of different nitrogen levels on yield attributes and productivity and harvest index of mungbean.

Treatment	Yield attributes									
	Number of pods plant^{-1}	Pod length (cm)	Number of grains pod^{-1}	Number of grains plant^{-1}	Grain weight plant^{-1} (g)	1000-grain Weight (g)	Seed yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1: Control	21.3	6.3	6.0	223.4	6.7	37.7	0.98	3.04	4.02	
T_2 : N @ 10 kg ha^{-1}	29.3	7.3	7.2	232.3	8.0	43.3	1.48	4.29	5.77	24.3
T_3 : N @ 20 kg ha^{-1}	30.6	8.0	8.7	241.3	9.1	46.3	1.89	4.94	6.82	25.9
T_4 : N @ 30 kg ha^{-1}	32.3	8.3	8.8	248.7	9.2	47.3	1.96	5.29	7.25	27.7
T_5 : N @ 40 kg ha^{-1}	32.0	8.3	8.7	248.1	8.7	46.3	1.87	4.93	6.80	27.0
T_6 : N @ 50 kg ha^{-1}	28.3	7.7	8.3	244.7	7.8	44.7	1.62	4.52	6.14	27.5
T_7 : N @ 60 kg ha^{-1}	27.2	7.5	7.0	241.4	6.2	43.0	1.39	4.31	5.70	26.5
SE(m) ±	1.66	0.30	0.53	3.61	0.58	2.34	0.10	0.28	0.32	24.4
CD (P=0.05)	5.11	0.91	1.64	11.12	1.79	NS	0.32	0.87	0.98	1.65

4. Conclusions

The following conclusions have been drawn from the present investigation:

- Among different nitrogen levels, application of nitrogen @ 30 kg N ha^{-1} was found to be most effective which exhibited significantly higher growth, yield attributes and productivity in terms of grain, straw and biological yield.
- The economic optimum dose of nitrogen for mungbean (var. Mai-2008) was estimated as 33.47 kg N ha^{-1}.

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