INFLUENCE OF NITROGEN AND NAPHTHALENE ACETIC ACID ON THE YIELD OF SUMMER MUNGBEAN (*Vigna radiata* (L.) Wilczek) cv. BARI mung-3

BY

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CERTIFICATE

This is to certify that the thesis entitled, "Influence of nitrogen and naphthalene acetic acid on the yield of summer mungbean (*Vigna radiata* (L.) Wilczek) cv. BARI mung-3" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRONOMY,** embodies the result of a piece of bonafide research work carried out by **Md. Rokonuzzaman,** Registration No. 23852/00130 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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Dated: 27-12-2005

Dhaka, Bangladesh

Dedicated to

My

Beloved Parents & Brothers

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The Author

REFERENCE ONLY

INFLUENCE OF NITROGEN AND NAPHTHALENE ACETIC ACID ON THE YIELD OF SUMMER MUNGBEAN (*Vigna radiata* (L.) Wilczek) cv. BARI mung-3

ABSTRACT

An experiment was carried out in experimental field of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka to investigate the effect of nitrogen and naphthalene acetic acid (NAA) on growth, yield contributing characters and yield of summer mungbean (cv. BARI mung-3) during summer season of 2005. Four levels of nitrogen viz. 0, 20, 40 and 60 kg N $ha^{-1}$and three concentrations of NAA viz. 0, 25 and 50 ppm were used as experimental variables. The experiment was laid out in randomized complete block design with three replications. Results revealed that nitrogen and NAA interacted significantly on most of the growth; yield parameters and yield of mungbean. Plant height, number of leaves, total dry weight of plant, number of flowers, number of pods per plant, 1000 seed weight and seed yield increased significantly by 20 kg N ha^{-1} in combination with 25 ppm of NAA.

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LIST OF ABBRIVIATIONS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
FAO	=	Food and Agriculture Organization
ppm	=	parts per million
TDM	=	Total Dry Matter
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAS	=	Days After Sowing
g	=	gram(s)
Kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
HI	=	Harvest Index
No.	=	Number
wt.	=	Weight
DMRT	=	Duncan's Multiple Range Test
LSD	=	Least Significant Difference
^{0}C	=	Degree Centigrade
NS	=	Not Significant
mm	=	millimeter
Max.	=	Maximum
Min.	=	Minimum
%	=	Percent
cv.	=	Cultivar(s)
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance
h	=	hour
meq	=	miliequivalent
µg	=	microgram

শেরেবাংলা কৃষি বিশ্ববিদ্যালয় গ্রন্থাগার শেরেবাংলা নগর, ঢাকা-১২০৭

Chapter 1
Introduction

শেরেবাংলা কৃষি বিশ্ববিদ্যালয় গ্রন্থাগার
সংযোজন নং ....
স্বাক্ষর.......... তাং..........

Chapter 1

INTRODUCTION

Pulse crops belong to grain legume. Bangladesh grows various types pulse crops among them lentil, cowpea, blackgram, mungbean, field pea and grass pea are important. These crops provide valuable protein in our human diet. Pulse protein is rich in lysine that is deficient in rice. According to FAO (1999) recommendation, a minimum intake of pulse by a human should be 80 g/day, where as it is 7.92 g in Bangladesh (BBS, 2002). This is because of fact that national production of the pulses is not adequate to meet our national demand. Both the acreage and production of the pulses are decreasing in Bangladesh day by day due to the inception of wheat and boro rice in our cropping system with irrigation facilities. At present, the area under pulse crop is 0.406 million hectare with a production of 0.322 million tonne (BBS, 2005), where mungbean is cultivated in the area of 0.108 million ha with production of 0.03 million tonne (BBS, 2005).

Among the pulse crops, mungbean has a special importance in intensive crop production system of the country for its short growing period (Ahmed *et al.*, 1978). In Bangladesh, it can be grown in late winter and summer season. Summer mungbean can tolerate a high temperature exceeding 40^0C and grows well in the temperature range of 30 - 35 ^{0}C. There are evidences in India, mungbean gives higher yield under summer planting than winter season (Sing and Yadav, 1978). This crop is also reported to be drought tolerant and can also be cultivated in areas of low rainfall, but also grows well in areas with 750 - 900 mm rainfall (Kay, 1979). So, cultivation of mungbean in the summer season could be an effective effort to increase pulse production in Bangladesh. Such effort may also help to save the foreign exchange for importing mungbean grain from abroad (Gowda and Kaul, 1982).

In Bangladesh mungbean ranks third in acreage and production but ranks first in market price. Mungbean grain contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamins (Khan, 1981; Kaul, 1982). The green plants can also be used as animal feed and the residues as manure. The crop is potentially useful in improving cropping system as it can be grown as a catch crop due to its rapid growth and early maturing characteristics. It can also fix atmospheric nitrogen through the symbiotic relationship between the host mungbean roots and soil bacteria and thus improves soil fertility.

The average yield of mungbean is 0.69 t ha^{-1} (BBS, 2005).There are many reasons of lower yield of mungbean of which use of inadequate nitrogen is the most important one. For the pulse crops, nitrogen is most useful because it is the main component of protein. Adequate supply of nitrogen is essential for growth and yield enhancement of the crop. In Bangladesh, most of the lands are deficient in organic matter and nitrogen (BARC, 1997). Besides nitrogen, application of growth regulators seems to be another approach to enhance mungbean productivity (Nickell, 1982). The growth regulators Naphthalene acetic acid (NAA) can play significant role in increasing physiological processes and yield of mungbean.

Considering the above facts, the present work was conducted under nitrogen and naphthalene acetic acid (NAA) managements on summer mungbean with following objectives:

i) to observe the growth and yield of summer mungbean under different nitrogen levels,

ii) to evaluate the effect of naphthalene acetic acid (NAA) on growth, yield and yield attributes of summer mungbean,

iii) to find out the proper dose of nitrogen fertilizer and naphthalene acetic acid (NAA) for achieving higher yield.

Chapter 2

Review of literature

CHAPTER 2

REVIEW OF LITERATURE

An attempt has been made in this chapter to present a brief review of research in relation to nitrogen requirements and NAA effects in different pulse crops. It is an established fact that plant growth regulators are substances, which affect the growth and developments of plants significantly (Nickell, 1982). In recent years, many scientists are engaged to change the pattern of growth and development of plants for long time to achieve higher yield benefit. Among different growth regulators, naphthalene acetic acid has been found to have considerable effect on the growth, yield and yield contributing characters of different pulse crops along with mungbean. In Bangladesh, pulse crops are generally grown without fertilizer or manures. However, there is evidence that the yield of pulse can be increased substantially by using fertilizers. Pulses, although fix nitrogen from atmosphere, it is evident that nitrogen application become helpful to increase the yield. However, there are controversies regarding the rates of nitrogen (Patel, *et al.* 1984 and Ardesana, *et al.* 1993). Furthermore, literature revealed that nitrogen and NAA interact each other to increase pulse yield (Jain, *et al.* 1995). Available literatures have been reviewed in this regard and presented below.

2.1 Effects of different fertilizers on mungbean

2.1 .1 Plant height

In a field experiment, Yein *et al.* (1981) applied nitrogen in combination with phosphorus fertilizer to mungbean. They revealed that application of N fertilizer along with P increased plant height.

Yein (1982) carried out a field trial in Assam of India on mungbean and reported that application of various levels of nitrogen and phosphorous significantly increased the plant height.

Trung and Yoshida (1983) conducted a field trail on mungbean in nutrient-rich soil, involving 0 -100 ppm N as treatments. They observed that maximum plant height at all the stages of plant were obtained by the application of 25 ppm N.

Sardana and Verma (1987) carried out a study in New Delhi, India in 1983 - 84. They found that application of nitrogen, phosphorus and potassium fertilizers in combination resulted in significant increase in plant height of mungbean.

Hamid (1988) conducted a field experiment to investigate the effect of Nitrogen and carbon on the growth and yield performance of mungbean (*Vigna radiate* (L.) Wilczek). He found that the plant height of mungbean cv. Mubarik was found to be increased by nitrogen.

Shuhartatik (1991) in a study observed that increased application of NPK fertilizers significantly increased the plant height of mungbean.

Quah and Jaafar (1994) found that plant height of mungbean was significantly increased by the application of nitrogen fertilizer at 50 kg ha^{-1}.

2.1.2 Number of leaves

Srivastava and Verma (1982) showed that N application at the rate of 15 kg N ha^{-1} increased the number of green leaves, branches and dry matter accumulation in mungbean plants.

2.1.3 Number and weight of nodules

Bachchhav *et al.* (1994) conducted a field experiment on a clay soil during the summer season with mungbean (*Vigna radiata*) cv. Phule-M. They observed that root nodule weight per plant was highest with 30 kg N ha^{-1}.

Inthong (1987) observed that the application of 15 kg N $ha^{-1}$to mungbean increased nodule production and enhanced nitrogen fixation while further higher rates (30, 60 and 90 kg N ha^{-1}) suppressed it.

Carrying out a field experiment to examine different levels of nitrogen on mungbean, Patel *et al.* (1984) reported that the highest nodules per plant was obtained with 10 kg N ha^{-1} compared to 20 and 30 kg N ha^{-1}.

2.1.4 Total dry matter

The total dry matter production is the integration of daily dry matter production over the entire growth period. The accumulation and pattern of dry matter distribution is controlled by the rate of photosynthesis, respiration and environmental conditions (Evans, 1975). Total dry matter production of a crop is also dependent on the source and its activities; the process of mineral uptake and senescence of leaves.

Yein (1982) carried out a field trial on mungbean in Assam of India and reported that combined application of nitrogen and phosphorus significantly increased the dry weight of the plants.

Raju and Varma (1984) carried out a field experiment during summer season of 1979 and 1980 to study the response of mungbean var. Pusa Baishaki to varying levels of nitrogen (15, 30, 45 and 60 kg N ha^{-1}) in the presence and absence of seed inoculation with *Rhizobium*. They found that maximum dry matter weight per plant was obtained by the application of 15 kg N ha^{-1}inoculated with *Rhizobium*.

Agbenin *et al.* (1991) carried out an experiment under glass house condition and found that nitrogen application significantly increased the dry matter yield of mungbean. In another study, Leelavati *et al.* (1991) using different levels of nitrogen found a significant increase in dry matter production of mungbean with 60 kg N ha^{-1}.

Chowdhury and Rosario (1992) studied the effect of 0, 30, 60 or 90 kg N ha^{-1} levels on the rate of growth and yield performance of mungbean at los Banos, Philippines in 1988. They observed that N above the rate of 30 kg ha^{-1}reduced the dry matter yield.

Santos *et al.* (1993) carried out an experiment on mungbean cv. Berken which was grown in pots in podzolic soil with 7 levels of N (0, 25, 50, 100, 200, 400 and 500 kg ha^{-1}). They noted that application of N up to 200 kg ha^{-1} increased the total dry matter and with use of higher rates decreased, the total dry matter decreased.

Yakadri *et al.* (2002) studied the effect of nitrogen (20, 40 and 60 kg ha^{-1}) and phosphorus (40 and 60 kg ha^{-1}) on crop growth and yield of greengram (cv.ML-267). Application of nitrogen at 20 kg $ha^{-1}$and phosphorus at 60 kg ha^{-1} resulted in the significant increase in leaf area ratios indicating better partitioning of leaf dry matter.

2.1.5 Number of flowers

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 in 2001. They observed that number of flowers per plant was found to be significantly higher by varying levels of nitrogen and phosphorus.

2.1.6 Number of pods

In an experiment, Yein *et al.* (1981) applied nitrogen and phosphorus fertilizers to mungbean and reported that combined application of nitrogen and phosphorus fertilizers increased the number of pods per plant.

Salimullah *et al.* (1987) also reported that the number of pods per plant was highest with the application of 10 kg N along with 75 kg P_2O_5 $ha^{-1}$and 60 kg K_2O ha^{-1} in summer mungbean.

Patel and Parmer (1986) conducted an experiment on the response of greengram to varying levels of nitrogen and phosphorus. They observed that increasing N application to rainfed mungbean (cv. Gujrat-1) from 0 to 45 kg ha^{-1} increased the number of pods per plant.

A field trial was carried out by Sardana and Verma (1987) in New Delhi, India. In that trial, they observed that application of nitrogen in combination with phosphorus and potassium fertilizers resulted the significant increase in number of pods per plant.

Sarkar and Banik (1991) reported that application of 10 kg N ha^{-1} to mungbean resulted in appreciable improvement in the number of pods per plant while compared with no nitrogen.

Suhartatik (1991) observed that N, P and K fertilizers in combination significantly increased the number of pods per plant.

Tank *et al.* (1992) reported that mungbean fertilized with 20 kg N ha^{-1} along with 40 kg P_2O_5 ha^{-1}significantly increased the number of pods per plant.

In trials, on clay soils during the summer season. Patel *et al.* (1984) studied the effect of N (0, 10, 20 and 30 kg N ha^{-1}) and that of the P (0, 10, 20, 40, 60 and 80 P_2O_5 ha^{-1}) on the growth and seed yield of mungbean. In that experiment, it was found that application of 30 kg N ha^{-1}along with 40 kg P_2O_5 ha^{-1} significantly increased the number of pods per plant.

Srinivas *et al.* (2002) examined the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and phosphorus (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield of mungbean. They observed that the number of pods per plant was increased with the increasing rates of N up to 40 kg/ha followed by a decrease with further increase in N.

2.1.7 Pod length

Srinivas *et al.* (2002) studied the effect of nitrogen (0, 20, 40 and 60 kg ha^{-1}) and phosphorus (0, 25, 50 and 75 kg ha^{-1}) on the growth and yield components of mungbean. They observed that pod length was increased with the increasing rates of N up to 40 kg ha^{-1}which was followed by a decrease with further increase.

Malik *et al.* (2003) studied the effect of varying levels of nitrogen and phosphorus on mungbean cv. NM-98. It was reported that pod length was significantly affected by both nitrogen and phosphorus application.

2.1.8 Number of seeds per pod

Malik *et al.* (2003) investigated the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phophorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98 during 2001. It was found that number of seeds per pod was significantly affected by varying levels of nitrogen and phosphorus.

2.1.9 1000 seed weight

Patel *et al.* (1984) studied the effect of 0, 10, 20 and 30 kg N ha^{-1} and 0, 20, 40, 60 and 80 kg P_2O_5 ha^{-1}on the growth and seed yield of mungbean during summer season. They observed that application of 40 kg P_20_5 ha^{-1} along with 20 kg N ha^{-1}significantly increased the 1000 seed weight of mungbean.

Sardana and Verma (1987) carried out an experiment on mungbean. They stated that application of nitogen, phosphorus and potassium fertilizers combinedly resulted in significant increases in 1000 seed weight of mungbean.

A field experiment was conducted by Sarkar and Banik (1991) to evaluate the effect of varing rates of N on mungbean. Results revealed that application of 10 kg N ha^{-1} resulted in the appreciable improvement in different yield attributes along with 1000 seed weight over the control (no application).

Trung and Yoshida (1983) set up an experiment on mungbean, spraying 0 - 100 ppm N in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. Results showed that 1000 seed weight was the highest with 100 ppm N of all forms.

Bali *et al.* (1991) conducted a field trail in kharif seasons on silty clay loam soil. They revealed that seed yield, 1000-seed weight and LAI were increased with up to 40 kg N and 60 kg P_2O_5 ha^{-1}.

Quah and Jaafar (1994) noted that 1000 seed weight of mungbean was increased significantly by the application of nitrogen at 50 kg ha^{-1}.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on the yield and yield components of mungbean at the Agronomic Research

Station, Farooqabad in Pakistan during the year of 2000 and 2001. They revealed that various yield components like 1000 grain weight were affected significantly fertilizer (50 - 50 - 0 NPK kg ha^{-1}) application.

Srinivas *et al.* (2002) conducted an experiment on the performance of mungbean at different levels of nitrogen and phosphorus. Different rates of N (0, 25, and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) were tested. They observed that 1000 seed weight was generally increased with increasing rates of P along with increasing rates of N up to 40 kg ha^{-1} which was than followed by a decrease with further increase in N.

2.1.10 Seed yield

Werakonphanit *et al.* (1979) stated that mungbean showed no significant differences in response to different fertilizer levels. NPK levels of 0 - 0 - 0, 3 - 0 - 0 and 3 - 9 - 0 gave seed yield of 156, 168 and 175 kg ha^{-1} respectively. From the results of that study, it was concluded that the fertilizer application in mungbean was not necessary.

Yien *et al.* (1981) applied N and P fertilizers to study their relative contributions towards increasing the seed yield of mungbean. Their studies showed that N along with P fertilizers increased the seed yield.

Yien (1982) conducted a field trials in Assam, India, on mungbean and found out that 10 kg N in combination with 20 kg P ha^{-1} resulted in significant increases in the seed yield. An experiment was conducted by Trung and Yoshida (1983) using 0 -100 ppm N as treatments in the form of ammonium nitrate or 10 or 100 ppm N as urea, sodium nitrate, ammonium nitrate or ammonium sulphate. They found that seed yield of mungbean increased with the increase in N up to 50 ppm.

Raju and Varma (1984) reported that seed inoculation and/or application of 15 - 60 kg N ha^{-1} significantly increased seed yields of mungbean.

Results of an experiment, conducted by Sardana and Verma (1987) in Delhi, India, revealed that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increases in seed yield of mungbean.

Pongkao and Inthong (1988) applied N at the rate of 0 - 60 kg ha^{-1}, and reported that application of 15 kg N ha^{-1} was found to be superior giving 23 % higher seed yield over the control. However although not significantly, 60 kg N ha^{-1} tended to produce the highest yield.

Arya and Kalra (1988) reported that application of N at the rate of 50 kg ha^{-1} along with P (50 kg ha^{-1}) increased mungbean yield.

Results from field experiments conducted by Mahadkar and Saraf (1988) during summer season showed that the application of N with P and K at 20 :2 :5 kg ha^{-1} gave higher seed yield.

A field experiment was conducted by Sarkar and Banik (1991) to study the effect of N in combination with P. Results showed that application of N along with P significantly increased the seed yield of mungbean. The higher yield was found the application of N and P up to 10 and 60 kg ha^{-1}, respectively. However, the maximum seed yield was obtained with the combination of 20 kg N and 60 kg P_2O_5 ha^{-1}.

Leelavathi *et al.* (1991) showed significant increase seed yield of mungbean by using N up to 60 kg N ha^{-1}. While in another study Sarkar and Banik (1991) reported, that seed yield of mungbean increased significantly using N up to 10 kg ha^{-1}.

Chowdhury and Rosario (1992) had undertaken a study to evaluate the effects of 0, 30, 60 or 90 kg N ha^{-1}on the growth and yield performance of mungbean at Las Banos, Philippines in 1988. They noted that applied N at the levels above 30 kg /ha reduced the seed yield.

Patel *et al.* (1992) conducted a field trial to evaluate the response of mungbean to sulphur fertilizaton under different levels of nitrogen and phosphorus. Greengram cv. Gujrarat 2 and K 851 were given 10 kg N + 20 kg P ha^{-1}or triple these rates and 0, 10, 20 or 30 kg sulphur ha^{-1}as gypsum. Seed yield was 1.20 and 1.24 t ha^{-1}in Gujrarat 2 and K 851, respectively and was increased with the increase of fertilizer up to 20 kg N + 40 kg Pha^{-1}.

Phimsirkul (1992) conducted a field trial on mungbean variety, U- Thong I grown in different soils under varying N levels. Results revealed that there was no effect of N fertilizer when mungbean was grown in Mab Bon soil. However, seed yield of mungbean was increased when the crop received N at 3 kg/rai.

Tank *et al.* (1992) found that mungbean fertilized with 20 kg N along with up to the level of 40 kg P_2O_5 ha^{-1}increased seed yield significantly over the unfertilized control.

Ardesna *et al.* (1993) conducted a field experiment on clay soil during the rainy season of 1990 to study the response of mungbean to nitrogen, phosphorus and Rhizobium inoculation. They observed that seed yield increased with the application of nitrogen fertilizer up to 20 kg N ha^{-1} in combination with phosphorus fertilizer up to 40 kg P_2O_5 and inoculation with Rhizobium.

Sing *et al.* (1993) examined the effects of varying levels of N on mungbean cv. MH-85-61. They found that nitrogen application at the rate of 30 kg ha^{-1} increased seed yield. Application of 30 kg N resulted in the highest seed yield in all legumes.

Bachchhav *et al.* (1994) conducted a field experiment during the summer season on greengram cv. Phule-M. They observed that among nitrogen fertilizers rates (0-45 kg ha^{1}) seed yield increased with up to 30 kg N (1.65 ton ha^{-1}).

In a field experiment on clay soil during kharif season of 1990, Badole and Umale (1994) observed that the seed yield of mungbean cv. TAP was increased by N and P application. Application of 50% of the recommended N and P rate gave the highest yield of 1.17 to N ha^{-1}.

Yadav *et al.* (1994) conducted a field experiment on sandy loam soil during the kharif (monsoon) season of 1986 at Hisar, Hariana, India, with mungbean cv. k851. Treatments 0, 50 or 100% of the recommended N and P fertilizers (20 kg N as Urea and 40 kg P_2O_5 ha^{-1} as single super phosphate) were tested. They found that mungbean receiving the recommended dose gave the highest seed yield.

Kaneria and Patel (1995) conducted a field experiment on a Vertisol in Gujarat, India with mungbean cv. K 581 using 0 or 20 kg N ha^{-1} levels. They found that application of 20 kg N ha^{-1} significantly increased the seed yield (1.14 to N ha^{-1}) when compared with that of control (1.08 to N ha^{-1}).

In a field experiment conducted by Satyanarayanamma *et al.* (1996), five mungbean cultivars were sprayed with 2% urea at pre-flowering, flowering, pod development or at all the combinations or at combination of two of three growth stages. They reported that spraying urea at flowering and pod development stages produced the highest seed yield.

Khanam *et al.* (1996) reported that the use of recommended dose of NPK plus compost increased the seed yield of mungbean by 83 - 87%.

Karle and Pawar (1998) examined the effect of varying levels of N and P fertilizers on summer mungbean. They reported that mungbean produced higher yield with the combination application of 15 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1}.

A field experiment was carried out by Sharma and Sharma (1999) during summer seasons at Golaghat, Assam, India. Mungbean was grown using farmers' practices (no fertilizer) or using different combinations of fertilizer application (10 kg N + 35 kg P_2O_5 ha^{-1}). Seed yield was 0.40 to N ha^{-1} with farmers' practices, while the highest yield was obtained by the fertilizer application (0.77 t ha^{-1}).

Mandal and Sikder (1999) conducted a greenhouse pot experiment on mungbean cv. BARI Mung-5 under different N rates. They noted that the yield increased significantly with N application.

Mahboob and Asghar (2002) studied the effect of seed inoculation at different nitrogen levels on mungbean at the Agronomic Research Station, Farooqabad in Pakistan. They revealed that seed inoculation + 50 - 50 - 0 NPK kg ha^{-1} exhibited superior performance in respect seed yield (955 kg ha^{-1}).

Malik *et al.* (2003) conducted an experiment to determine the effect of varying levels of nitrogen (0, 25 and 50 kg ha^{-1}) and phosphorus (0, 50, 75 and 100 kg ha^{-1}) on the yield and quality of mungbean cv. NM-98.Growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in the maximum seed yield (1112.96 kg ha^{-1}).

Mozumder *et al.* (2003) conducted an experiment to study the effect of Rhizobium at different nitrogen levels viz. 0, 20, 40, 60 and 80 kg N ha^{-1} on Binamoog-2. It was reported that increase of nitrogen fertilizer increased seed yield up to 40 kg N ha^{-1}. Highest seed yield (1607 kg ha^{-1}) was obtained when 40 kg N ha^{-1} was applied with *Bradyrhizobium* inoculation. Mahmoud and Gad (1988) also observed that applied N up to a certain level increased the seed yield of mungbean.

Rajender *et al.* (2003) investigated the effects of N (0, 10, 20 and 30 kg ha^{-1}) and P (0, 20, 40 and 60 kg ha^{-1}) fertilizer rates on mungbean genotypes MH 85-111 and T44. Grain yield increased with increasing N rates up to 20 kg ha^{-1}. Further increase in N rate did not affect yield.

Nadeem *et al.* (2004) studied the response of mungbean cv. NM - 98 to seed inoculation and different levels of fertilizer (0 - 0, 15 - 30, 30 - 60 and 45 - 90 kg N- P_2O_5 ha^{-1}) under field conditions. Results showed that the application of fertilizer significantly increased the seed yield and the maximum seed yield was obtained when 30 N ha^{-1} was applied.

2.1.11 Harvest index

Harvest index is the ratio of economic yield to the biological yield reflected by the translocation of assimilates to the grain.

Mozumdar *et al.* (2003) observed in a field experiment at the Bangladesh Agricultural University, Mymensingh. He tested five levels nitrogen (0, 20, 40, 60 and 80 kg N ha^{-1}) and two varieties of summer mungbean viz., Binamoog-2 and Kanti. The results revealed that nitrogen application had negative effect on the harvest index.

2.2 Effect of naphthalene acetic acid on mungbean and other grain legume crops

2.2.1 Plant height

Kelaiya *et al.* (1991) conducted an experiment with four growth regulators, such as, CCC (chlormequat), NAA, GA_3, and triacontanol and sprayed at 25, 50 and 75 days after sowing (DAS) on groundnut. In that experiment, they observed that where NAA was found to be most effective one in increasing the plant height.

Lakshmamma and Rao (1996a) conducted a field experiment during the rabi season at Rajendranagar, Andhra Pradesh. Blackgram was sprayed with 0, 5, 10 or 20 ppm NAA at 50% flowering stage. They found that application of NAA increased plant height of blackgram.

2.2.2 Number of leaves per plant

Singh *et al.* (1982) conducted an experiment on groundnut to determine the effect of NAA. They observed that two foliar spray of 100-ppm planofix (NAA) to groundnut at 40 and 50 days after sowing increased the number of leaves per plant.

Reddy and Shah (1984) reported that application of planofix (NAA) at the rate of 50 ppm to significantly produced the higher number of leaves in groundnut

Mahla *et al.* (1999) reported that spraying 20 ppm NAA on blackgram had greater effect in increasing the number of branches.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three mungbean cultivars and two levels of NAA (20 and 40 ppm). NAA sprayed at 30 days after sowing and at flowering stages and both the concentrations of NAA significantly increased the number of leaves.

2.2.3 Total dry mater per plant

Kelaiya *et al.* (1991) reported that groundnuts when sprayed with 40 ppm of NAA at 25 and 50 DAS increased plant dry weight. Application of 10 or 20 ppm planofix (NAA) on groundnut cv. DH3-30 increased the dry matter production when compared to the untreated control (Nawalagatti *et al.* 1991).

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied by spraying at 30 days after sowing and at flowering stage. Both sprays of NAA significantly increased the total dry matter production.

2.2.4 Number of flowers

The number of flower per plant is an important reproductive character that contributes much towards yield. There are evidence that this component is influenced by different concentrations of NAA.

Chellappa and Karicaratharaju (1973) studied the effect of soaking groundnuts seed in 5 or 10 ppm solution of NAA for 12 or 24 hours. They found that seeds treated with 5 ppm NAA for 12 hours resulted in the highest number of flowers.

Subbian and Chamy (1984) conducted that in a field trial with 2 foliar applications of 0, 20 or 40 ppm of NAA on summer mungbean. The numbers of flowers were increased with increasing NAA rate.

Lee (1990) found that soaking of groundnut seeds in solutions of 0, 50, and 100 ppm of GA_3 before sowing produced plants with greater number of flowers than those of the control.

Upadhyay (1994) conducted a field experiment at Faizabad, Uttar Pradesh. Chickpea cv. K-850 was treated with 10, 20 or 30 ppm of NAA at bud initiation and pod formation stages. It was reported that growth regulator increased the number of flowers.

Arora *et al.* (1998) reported that NAA applied at 50% flowering stage to chickpea increased the number of flowers as compared with the untreated ones. Flowering and fruiting were also reported to be increased by foliar spraying with NAA on groundnut (Manikandan and Hakim, 1999).

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three mungbean cultivars and two levels of NAA (20 and 40 ppm). Both concentrations of NAA significantly increased the number of flowers.

2.2.5 Number of pods per plant

Studies have showed that external application of planofix (NAA) reduced the premature abscissions of flowers, young pods and thus increased the number of pods and consequently the yield of groundnut (Mani and Raja, 1976).

A foliar application of 40 ppm NAA on groundnut increased the number of pods per plant and eventually the pod yield (Gupta and Singh, 1982).

Subbian and Chamy (1984) carried out a field trial in summer with 2 foliar applications of 0, 20 or 40 ppm NAA to greengram. They found increased number of pods per plant with increasing NAA rate.

Venkaten Warlu *et al.* (1984) pointed out that both in rabi and kharif seasons, spraying NAA with various concentrations at 30 and 50 days after sowing increased the number of pods per plant in groundnut.

Sharma *et al.* (1989) conducted a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. Results revealed that the NAA application increased the number of pods per plant. Kalita *et al.* (1995) also reported that the regulatory effect of NAA on number of pod of mungbean.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three summer mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied at 30 days after sowing and also at the flowering stage. Two sprays of NAA at 20 or 40 ppm significantly increased the number of pods per plant.

2.2.6 Pod length

Das and Prasad (2003) studied on three summer mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied by spraying at 30 days after sowing and at flowering stage. Both sprays of NAA at 20 or 40 ppm concentration significantly increased the pod length.

2.2.7 Number of seeds per pod

Sharma *et al*. (1989) conducted a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. Results revealed that the NAA application increased the number of seeds per pod.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied by spraying at 30 days after sowing and at flowering stage. Both sprays of NAA significantly increased the number of seeds per pod of summer mungbean.

2.2.8 1000 seed weight

Venkaten Warlu *et al*. (1984) pointed out that both in rabi and in kharif seasons application of NAA at various concentrations sprayed at 30 and 50 days after sowing increased 1000 seed weight in groundnut.

Sharma *et al*. (1989) conducted a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. Results revealed that the NAA application increased

1000 seed weight. Kelaiya *et al.* (1991) also stated that spraying with 40 ppm of NAA on groundnut cv. GG2 increased 1000 seed weight.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three summer mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied by spraying at 30 days after sowing and at flowering stage. Both sprays of NAA at 20 or 40 ppm concentrations significantly increased 1000 grain weight.

2.2.9 Seed yield

Subbian and Chamy (1982) mentioned that two foliar sprays of 40-ppm planofix (NNA) when applied to summer mungbean at the flower initiation stage and 15 days later significantly increased the seed yield.

Subbian and Chamy (1984) reported that in a field trial with 2 foliar applications of 0, 20 or 40 ppm NAA to summer mungbean increased seed yield from 0.8 to 1.2 t ha^{-1} with increasing NAA concentrations.

Bai *et al*. (1987) investigated the effect of growth regulators (NAA and GA) on the yield performance of mungbean. They found that 25 ppm of NAA and 50 ppm of GA increased the yield of mungbean when compared with control.

Gurpreet *et al.* (1988) mentioned that grain yield was increased from 0.71 to 0.78 t ha^{1} with applications of NAA in mungbean.

Kalita (1989) reported that applying a foliar spray at the rate of 50 ppm of NAA in mungbean increased seed yield from 0.64 to 0.88 t ha^{-1}.Sharma *et al.* (1989) conducted a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. Results revealed that the NAA application increased the seed yield.

Subbin *et al.* (1989) performed two foliar sprays with 20 or 40-ppm planofix (NAA) in blackgram at the flower initiation stage and 15 days later in summer season found that seed yield of 1.46 t ha^{-1} was obtained by using 40 ppm NAA, compared 0.95 t ha^{-1}, when no growth regulator was used.

Jaiswal and Bhambil (1989) conducted a field experiment to determine the effect of growth regulators on mungbean. It was observed that GA_3 and NAA resulted in the reduction of yield and yield components. Rahman *et al.* (1989) in a pot experiment on grasspea showed that foliar application of 50 ml/liter of GA_3 increased seed yield.

Sharma *et al.* (1989) reported from the result of a field trial with foliar applications of NAA at anthesis and 10 days later on mungbean. It was found that the NAA treated plants gave higher seed yield of 795 - 849 kg ha^{-1}compared with 611-694 kg of without NAA.

Kandagal *et al.* (1990) observed that a foliar application of 50 ppm of NAA at flowering stage of mungbean gave seed yields of 0.66 t/ha compared with 0.55 t/ha with the untreated control.

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Chaplot *et al.* (1992) reported increases in seed yield of mungbean due to NAA application by 5.7 - 21 %.

Baghel and Yadav (1994) revealed that blackgram when sprayed with 0 - 30 ppm of NAA, seed yield was generally increased and was highest with 30 ppm concentration.

Kalita and Dey (1994) observed that greengram when sprayed with different concentrations of phosphorus alone or in combination with 50 or 100 ppm of NAA improved yields and yield components.

Upadhyay (1994) conducted a field experiment at Faizabad, Uttar Pradesh, with chickpeas cv. K-850. The plants were treated with 10, 20 or 30 ppm of NAA at the bud initiation and pod formation growth stages. Seed yield was generally increased by the growth regulator and it was highest with 20 ppm.

Lakshmamma and Rao (1996b) conducted a field experiment at Rajendranagar in Andhra Pradesh during rabi season. They found that blackgram when sprayed with 20 ppm of NAA at 50 % flowering stage decreased flower drop and increased seed yield.

Das and Prasad (2003) conducted a study on sandy clay loam soil in New Delhi, India, during summer 1999. The treatments comprised of three summer mungbean cultivars and two levels of NAA (20 and 40 ppm) which were applied by spraying at 30 days after sowing and at flowering stage. Both sprays of NAA at 20 or 40 ppm significantly increased the grain yield.

2.3 Interaction effect of different fertilizers and NAA on summer mungbean and grain legume crops

Kalita *et al.* (1995) conducted a field experiment at the Assam Agricultural University, Joarhat, on a sandy clay loam soil during 1993-94 to investigate the influence of foliar application of phosphorous and naphthalene acetic acid (NAA) on mungbean cv. AAU-34. The treatment combination of 3 % P_2O_5 + 100 ppm NAA resulted in the greatest seed yield and harvest index (0.79 kg $ha^{-1}$and 28.76 %, respectively) which were reported to be associated with a greater number of pods per plant and seeds per pod.

Jain *et al.* (1995) carried out a field experiment at Jabalpur, Madhya Pradesh, India. In that study, the effect of nitrogen (40, 60 or 80 kg N ha^{-1}) and foliar application of NAA (0, 15, 30 or 45 ppm NAA) were examined in cowpea. NAA was applied at the start of flowering and found that seed yield was highest with the treatment combination of 40 kg N+ 45 ppm NAA.

Mahla *et al.* (1999) conducted a field experiment on clay loam soil at Udaipur, Rajasthan in kharif season. The plants of blackgram was given 0 - 60 kg P_2O_5 $ha^{-1}$and sprayed with 2 ppm mixtalol (triacontanol) and/or 20 ppm NAA. They found that seed yield and dry matter production were best with the combined application of the growth regulator and phosphorus.

Ganiger *et al.* (2003) investigated the effect of foliar spray with different NAA concentrations (250 and 500 ppm) and urea (2%) on the growth and yield of cowpea cv. C-152. Application of growth regulators at 250 ppm and urea increased the growth and yield of cowpea.

Chapter 3

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

In this chapter, the details of different materials used and methodology followed during the experimental period are described.

3.1 Experimental site

The research work was carried out at the experimental field of Agronomy Department of Sher-e- Bangla Agricultural University, Dhaka during the period from March 2005 to May 2005. The field was located at the southeast part of the main academic building. The soil of the experimental plots belonged to the agro ecological zone Madhupur Tract (AEZ-28).

3.2 Soil

A soil sample from 0 -15 cm depth was collected from experimental field. The physio-chemical properties of the soil are presented in Appendix 1.

3.3 Climate

The experimental area is under the subtropical climate. Usually the rainfall was heavy during Kharif season and scanty in Rabi season. The atmospheric temperatures increased as the growing period proceeded towards Kharif season. The weather conditions of crop growth period such as monthly mean rainfall (mm), mean temperature (^{o}C), sunshine hours and humidity (%) are presented in Appendix 2.

3.4 Planting material

The variety of mungbean used for the present study was BARI mung-3. The seeds of this variety were collected from the Pulse Research Centre of Bangladesh Agricultural Research Institute (BARI), Gazipur. Before sowing, the seeds were tested for germination in the laboratory and the percentage of germination was found to be over 90%. The important characteristics of these varieties are mentioned below:

BARI mung-3 (Progoti)

Plants are of average 50 -55 cm height. Leaves are darker green .The variety is moderately resistant to cercospora leaf spot and yellow mosaic virus. Maximum pod yield is 1 - 1.1 ton per ha. Seeds contain 19 - 25% protein.

3.5 Land preparation

The land was first opened with the tractor drawn disc plough. Ploughed soil was then brought into desirable fine tilth by 4 operations of ploughing and harrowing with country plough and ladder. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 22 February and 28 February 2005, respectively. Experimental land was divided into unit plots following the design of experiment. The plots were spaded one day before planting and the basal dose of fertilizers was incorporated thoroughly before planting.

3.6 Fertilizer application

Urea, triple super phosphate (TSP) and muriate of potash (MP) were used as source of nitrogen, phosphorus and potassium respectively. Urea was applied as per treatments illustrated later. The rate of TSP and MP was 125 kg and 67 kg ha^{-1} respectively.

3.7 Treatments of the experiment

The experiment was two factorials with four levels of nitrogen and three levels of NAA.

Factor A : Nitrogen levels

The following nitrogen levels were imposed in the experiment;

N_0	:	0 kg N ha^{-1} (control)
N_{20}	:	20 kg N ha^{-1}
N_{40}	:	40 kg N ha^{-1}
N_{60}	:	60 kg N ha^{-1}

Factor B : NAA levels

The following NAA levels were imposed in the experiment

G_0	:	0 ppm
G_{25}	:	25 ppm
G_{50}	:	50 ppm

Combining two factors, 12 treatments combination were obtained;

N_0G_0	$N_{40}G_0$
N_0G_{25}	$N_{40}G_{25}$
N_0G_{50}	$N_{40}G_{50}$
$N_{20}G_0$	$N_{60}G_0$
$N_{20}G_{25}$	$N_{60}G_{25}$
$N_{20}G_{50}$	$N_{60}G_{50}$

3.8 Experimental design and lay out

The experiment was laid out in a Randomized Complete Block Design (factorial). Each treatment was replicated three times. The size of a unit plot was 3.3 m x 2.5 m. The distance between two adjacent replications (block) was 1m and row-to-row distance was 0.5 m. The inter block and inter row spaces were used as footpath and irrigation/ drainage channels.

3.9 Germination test

Germination test was performed before sowing the seeds in the field using petridishes . Three layers of filter paper were placed on petridishes and the filter papers were softened with water. Seeds were distributed at random in four petridishes. Each petridish contained 100 seeds. Germination percentage was calculated by using the following formula:

$$\text{Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds taken for germination}} \times 100$$

3.10 Sowing of seeds in the field

The seeds of mungbean were sown in rows made by hand plough on March 3, 2005. The seeds were sown in solid rows in the furrows having a depth of 2-3 cm from the soil surface. Row to row distance was 30 cm.

3.11 Intercultural operations

3.11.1 Irrigation and weeding

Two irrigations were done during the life cycle. The crop field was weeded twice; first weeding was done at 25 DAS (Days after sowing) and second weeding at 40 DAS. Demarcation boundaries and drainage channels were also kept weed free.

3.11.2 Protection against insect and pest

At early stage of growth, few worms (*Agrotis ipsilon*) and virus vectors (Jassid) attacked the young plants. To control these pests, Dimacron 50 EC was sprayed at the rate of 1litre per ha.

3.12 Preparation and application of plant growth regulator (NAA)

The NAA solution of 25 and 50 ppm concentrations were prepared by dissolving 25 and 50 mg of NAA in 1 litre of distilled water respectively. NAA was applied in the form of fine foliar sprays. The spraying was done at 25 DAS with the help of a hand sprayer until all leaves were completely covered.

3.13 Crop sampling and data collection

The first crop sampling was done at 30 DAS and it was continued at an interval of ten days, viz. 40, 50, 60, 70 and 80 DAS. At each harvest, five plants were selected randomly from each plot. The selected plants of each plot were cut carefully at the soil surface level. The heights, number of leaves, flowers, pods and nodules were recorded separately. The components were oven dried at $60^{0}C$ for 72 hours to record constant dry weights. Total dry matter was determined by recording the dry weight of each portion of the plants.

3.14 Harvest and post harvest operations

Harvesting was done when 90% of the pods became brown to black in color. The matured pods were collected by hand picking from a pre demarcated area of 1 m^2 at the centre of each plot. After harvesting, the samples were sun dried.

3.15 Data collection

The data on the following parameters of five plants were recorded at each harvest.

1) Plant height (cm)
2) Number of leaves per plants
3) Number of nodules per plant
4) Total dry matter production per plant (g)
5) Number of flowers per plants
6) Number of pods per plants
7) Length of pod (cm)
8) Number of seeds per pod
9) 1000 seed weight
10) Seed yield (kg ha^{-1})
11) Harvest index (%)

3.16 Procedure of data collection

3.16.1 Plant height

The heights of five plants were measured with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.16.2 Number of leaves per plant

The leaves (trifoliate) were separated from each sampled plant and counted.

3.16.3 Number of nodules per plant

Number of total nodules of five plants from each plot was noted and the mean number was expressed on per plant basis.

3.16.4 Total dry matter production per plant

The parts of the plants were separated, then dried in oven and weight was taken carefully. The sum of the plant parts constituted the total dry matter of a single plant.

3.16.5 Number of flowers per plant

Number of total flowers of five plants from each plot was counted and the mean number was expressed on per plant basis.

3.16.6 Number of pods per plant

Number of total pods of five plants from each plot was counted and the mean number was expressed on per plant basis

3.16.7 Length of pod

Length of ten pods (randomly selected) from each plot was measured with a meter scale and the mean length was expressed in cm.

3.16.8 Numbers of seeds per pod

The number of grain in each pod was also recorded from ten randomly selected pods at the harvest.

3.16.9 Weight of 1000 seeds

One thousand cleaned dried seeds were counted randomly from each harvest sample and weighed by using a digital electric balance and the mean weight was expressed in gram.

3.16.10 Seed yield (t ha^{-1})

Weight of seed of the demarcated area (1 $m^{2)}$ at the centre of each plot was taken and then converted to the yield in t ha^{-1}.

3.16.11 Harvest index (%)

The harvest index was calculated on the ratio of grain yield to biological yield and expressed in terms of percentage. It was calculated by using the following formula (Donald and Hamblim, 1976).

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.17 Analysis of data

The data collected on different parameters were statistically analyzed to obtain the level of significance using the MSTAT-computer package program developed by Russel (1986). 5% level of significance (Gomez and Gomez, 1984) was used to compare the mean differences among the treatments. The analysis of variance of the data on different parameters has been presented in (Appendix 3).

Chapter 4

Results and Discussion

Chapter 4

RESULTS AND DISCUSSION

Present experiment was conducted with different levels of nitrogenous fertilizer and NAA to study their effects on summer mungbean. The results regarding the effect of nitrogen and NAA and their interactions on different growth and yield parameters are presented and discussed in this chapter.

4.1 Plant height

Results of plant height have been presented in Fig. 1, Fig. 2 and Table 1. From the figures, it is seen that plant height increased gradually up to 80 DAS. Irrespective of treatment differences, plant height of mungbean ranged from 26.96 - 29.31 cm, 34.60 - 51.83 cm, 39.33 - 52.30 cm, 40.90 - 54.00 cm, 45.00 - 56.50 cm and 46.25 - 58.50 cm at 30, 40, 50, 60, 70 and 80 DAS respectively.

4.1.1 Effect of nitrogen

At all the growth stages, the plant height was found to be increased with the increasing rate of N fertilizer up to 40 kg ha^{-1} and thereafter, it decreased (Fig. 1). The maximum plant height was observed with the plants treated with 40 kg N ha^{-1} (N_{40}) and minimum with the control (0 kg N ha^{-1}). The response was a bit inconsistent at 30 DAS. However, with increasing nitrogen, plant height was found to be increased. Similar findings were found by Trung and Yoshida (1983), and also by Quah and Jaafar (1994). They found that plant height of mungbean was significantly increased by nitrogen fertilizer. The increment of plant height treated with 40 kg N ha^{-1} was possibly due to maximum N assimilation and utilization in plants.

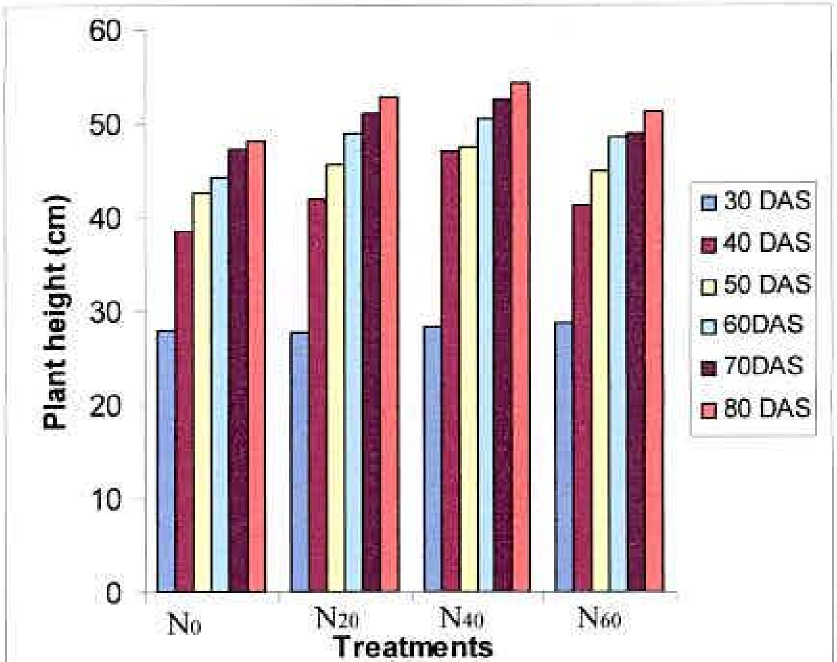


Fig. 1 Effect of nitrogen treatments on plant height of summer mungbean

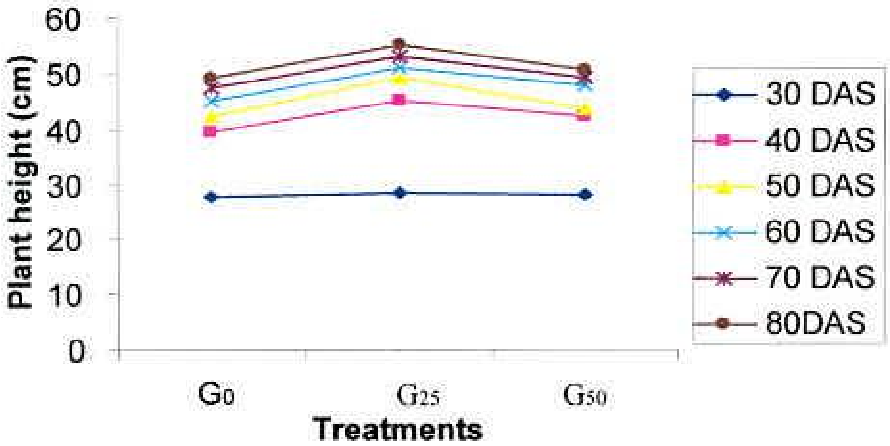


Fig. 2 Effect of NAA treatments on plant height of summer mungbean at different growth stages

4.1.2 Effect of NAA

The effect of NAA on plant height has been presented in Fig. 2. From the figure, it is seen that there was a significant effect of NAA on plant height. The plant height was higher with G_{25} (25 ppm of NAA) and lower with the control. There was a significant difference between the plant height of G_{25} with those of other two treatments except at 30 DAS. This finding agrees well with those of some other scientists. Lakshmamma and Rao (1966a) reported that plant height of blackgram increased with NAA application. Kelaiya *et al.* (1991) reported that among four growth regulators such as CCC, NAA, GA_3 and triacontanol, NAA was the most effective to increase the plant height of groundnut.

4.1.3 Interaction effect of nitrogen (N) & NAA (G) treatments

At each growth stage, plant height increased with the increase of N rate and NAA concentrations in the combination treatments (Table 1). At 30 DAS, the control showed lowest height and $N_{40}G_{25}$ showed the highest plant height. Most other treatments did not show significant difference in this respect. This was obvious, as NAA was applied at 25 DAS and so, main effect was mainly due to the differences in nitrogen levels. However, from 40 DAS and onwards, the interaction effect was found to be significantly pronounced.

At 40 DAS, $N_{40}G_{25}$ showed the highest plant height, which was significantly higher than other treatments. $N_{40}G_{50}$ had the second highest plant height which was also significantly higher than other treatments except $N_{40}G_{25}$. Treatments $N_{20}G_{25}$, $N_{60}G_{25}$ and $N_{40}G_0$ showed statistically similar plant heights, which were significantly lower than those of $N_{40}G_{25}$ and $N_{40}G_{50}$, but significantly higher than others. Treatments excluding the above-mentioned ones showed intermediate values, but produced plants, which had significantly longer than that of the control.

Table 1 Interaction effect of nitrogen & NAA treatments on plant height of summer mungbean at different growth stages

Treatments	**Plant height (cm)**					
	30 DAS	**40 DAS**	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**
N_0G_0	26.96	34.60	39.33	40.90	45.00	46.25
N_0G_{25}	28.77	41.40	46.60	48.00	50.50	51.50
N_0G_{50}	27.79	39.60	42.00	44.00	46.00	46.50
$N_{20}G_0$	27.27	41.00	41.33	45.00	48.20	50.00
$N_{20}G_{25}$	28.06	45.00	51.83	53.00	55.00	57.20
$N_{20}G_{50}$	27.47	40.00	43.66	49.10	50.00	51.00
$N_{40}G_0$	27.65	42.60	44.60	47.00	48.60	50.50
$N_{40}G_{25}$	29.12	51.83	52.30	54.00	56.50	58.50
$N_{40}G_{50}$	27.91	48.16	44.33	50.00	52.33	53.50
$N_{60}G_0$	28.79	39.60	44.33	47.64	48.00	50.00
$N_{60}G_{25}$	28.31	42.33	45.66	49.33	50.00	53.00
$N_{60}G_{50}$	29.31	41.60	45.00	48.28	49.00	51.00
LSD.05%	**1.741**	**2.599**	**2.523**	**2.335**	**2.746**	**3.396**
CV%	3.66%	3.63%	3.30%	4.87%	3.25%	3.89%

DAS = Days after sowing

At 50 DAS, $N_{40}G_{25}$ and $N_{20}G_{25}$ showed identical but significantly higher plant height than others. N_0G_{25}, $N_{40}G_{50}$, $N_{40}G_0$ and all the combination treatments at N_{60} levels showed statistically similar plant height, which was significantly lower than those of $N_{20}G_{25}$ and

$N_{40}G_{25}$, $N_{20}G_0$ and control had significantly lower plant heights than those of all other treatments.

At 60 DAS, again $N_{40}G_{25}$ and $N_{20}G_{25}$ showed significantly higher plant height than others. N_0G_{25}, $N_{20}G_{50}$, $N_{40}G_{50}$ and the combination treatments of all NAA concentrations with N_{60} levels showed significantly lower plant height than $N_{20}G_{25}$ and $N_{40}G_{25}$ but higher than others. Rest of the treatments showed intermediate values of plant height, which were significantly higher than that of the control.

At 70 DAS, $N_{40}G_{25}$ and $N_{20}G_{25}$ treatments were identical but had significantly higher plant height than others. $N_{40}G_{50}$ treatment gave third highest plant height which was not significantly different than $N_{20}G_{25}$.Treatments of N_0G_{25}, $N_{60}G_{25}$, $N_{40}G_{50}$ and $N_{20}G_{50}$ showed statistically similar plant heights which however, were significantly lower than those of $N_{20}G_{25}$ and $N_{40}G_{25}$. Treatments N_0G_{25}, $N_{20}G_0$, $N_{20}G_{50}$, $N_{40}G_0$ and all the combination treatments at N_{60} levels showed statistically similar plant heights, which were significantly higher than those of N_0G_{50} and control. N_0G_{50} and control had significantly lower plant height than those of all other treatments.

At 80 DAS, $N_{20}G_{25}$ and $N_{40}G_{25}$ treatments gave similar plant height, which were significantly higher than those of other treatments. Rest other treatments showed intermediate values, which produced significantly taller plants than those of N_0G_{50} and control.

4.2 Number of leaves per plant

Results of number of leaves per plant have been presented in Fig. 3, Fig. 4 and Table 2. From the figures and Table, it is seen that number of leaves per plant was significantly affected by the treatments. Irrespective of treatment differences, number of leaves per plant of mungbean ranged from 6.20 - 7.80, 6.21 - 7.88, 6.22 - 8.55, 6.55 - 9.44, 6.77 - 8.99 and 4.00 - 8.88 at 30, 40, 50, 60, 70 and 80 DAS respectively.

4.2.1 Effect of nitrogen

At all the growth stages number of leaves per plant was found to be increased with the increasing rate of N fertilizer up to 40 kg ha^{-1} (N_{40}) and thereafter, it decreased at all date of observations (Fig. 3). The highest number of leaves per plant was observed with 40 kg N ha^{-1} (N_{40}) at 60 DAS. This was significantly different from other treatments and the lowest number of leaves per plant was obtained with control. This result is supported by Srivastava and Verma (1982). They found that nitrogen application increased the number of leaves per plant.

4.2.2 Effect of NAA

The effect of NAA on number of leaves per plant has been presented in Fig. 4. From the figure, it is seen that there was a significant effect of NAA on number of leaves per plant at all date of observations. The highest number of leaves per plant was produced with 25 ppm of NAA (G_{25}) at 60 DAS, which were significantly different from the other treatments, and the lowest number of leaves per plant was obtained from control. Present

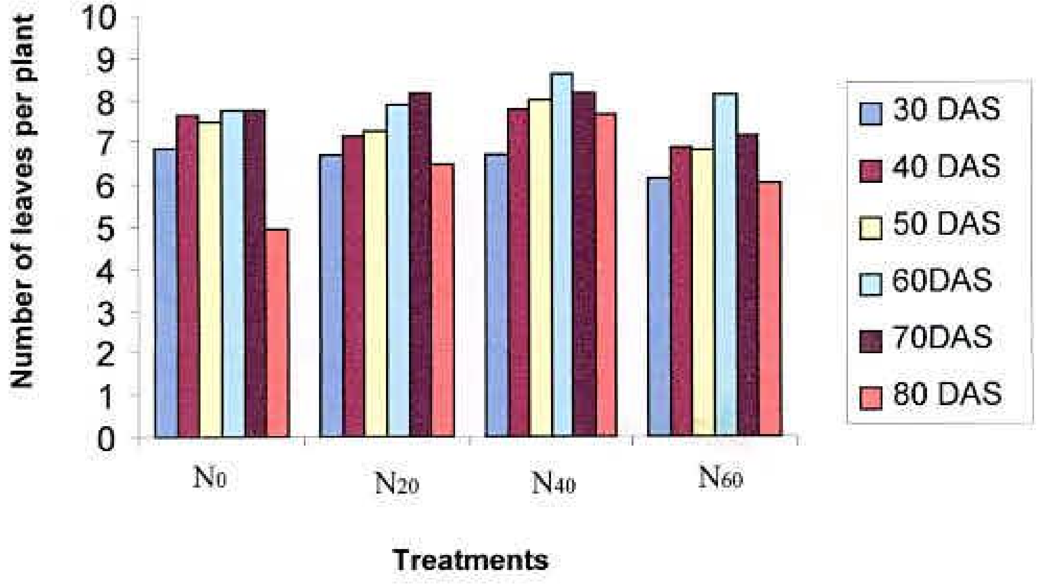


Fig. 3 Effect of nitrogen treatments (N) on number of leaves of summer mungbean at different growth stages

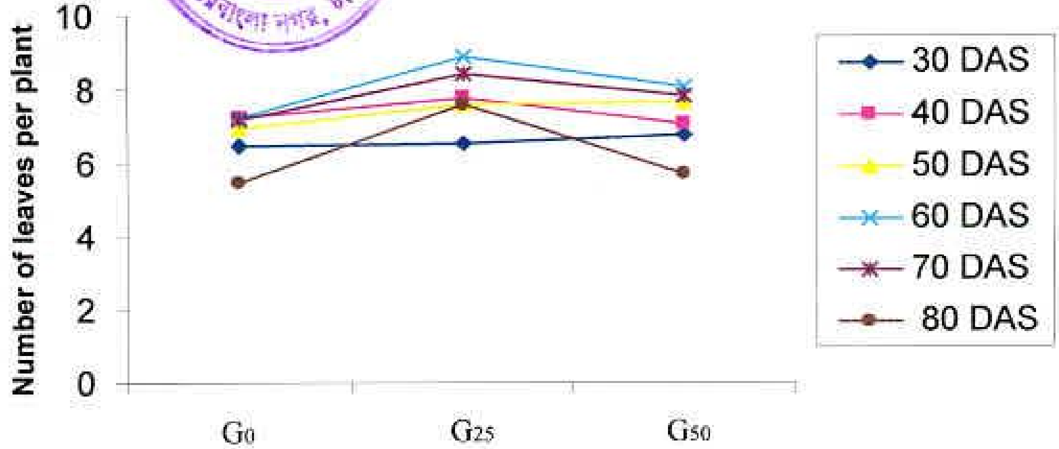


Fig. 4 Effect of NAA treatments (G) on number of leaves of summer mungbean at different growth stages

result agreed with that of Mahla *et al.* (1999) who stated that 20 ppm of NAA on mungbean had greater effect to increase number of leaves.

4.2.3 Interaction effect of nitrogen (N) & NAA (G) treatments

Interaction effects of nitrogen and NAA were found to be significant in respect of number of leaves per plant of mungbean at all dates of observations (Table 2).

From the Table 2, it is seen that at 30 DAS, N_0G_{50} showed the highest number of leaves per plant, which was significantly different from other treatments. $N_{40}G_{25}$ had the second highest number of leaves per plant, which was not significantly different from $N_{20}G_{50}$ and $N_{20}G_0$. Rest other treatments showed intermediate values. At 40 DAS, $N_{40}G_{25}$ and N_0G_{25}produced the highest number of leaves per plant which was not significantly different than most of the treatments.

At 50 DAS, $N_{40}G_{25}$ showed the highest number of leaves per plant, which was identical to $N_{20}G_{50}$. Rest of the treatments gave intermediate values. At 60 DAS, $N_{40}G_{25}$ also showed the highest number of leaves but that was statistically similar as was found in $N_{60}G_{25}$. $N_{20}G_0$ showed the lowest number of leaves but that was identical to control.

At 70 DAS, $N_{40}G_{25}$ showed the highest number of leaves per plant, but this was statistically similar to $N_{40}G_{50,}$ $N_{20}G_{50,}$ $N_{20}G_{25,}$ and N_0G_{25} treatments. The treatment $N_{60}G_0$ showed the lowest value, which was not significantly different from $N_{20}G_0$, $N_{40}G_0$ and

Table 2 Interaction effect of nitrogen & NAA treatments on number of leaves per plant of summer mungbean at different growth stages

Treatments	Number of leaves per plant					
	30 DAS	**40DAS**	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**
N_0G_0	6.330	7.440	7.220	6.990	7.110	4.220
N_0G_{25}	6.460	7.880	7.550	8.550	8.100	6.550
N_0G_{50}	7.800	7.660	7.660	7.660	7.990	4.000
$N_{20}G_0$	6.930	6.990	6.660	6.550	7.550	5.990
$N_{20}G_{25}$	6.200	7.770	6.880	8.550	8.500	7.330
$N_{20}G_{50}$	6.860	6.660	8.210	8.440	8.330	6.000
$N_{40}G_0$	6.600	7.660	7.660	8.100	7.330	6.110
$N_{40}G_{25}$	7.260	7.880	8.550	9.440	8.990	8.880
$N_{40}G_{50}$	6.260	7.660	7.770	8.210	8.11	7.880
$N_{60}G_0$	6.000	6.880	6.220	7.330	6.660	5.550
$N_{60}G_{25}$	6.200	7.440	7.330	9.100	7.990	7.550
$N_{60}G_{50}$	6.200	6.210	6.900	7.880	6.770	4.990
LSD.05%	**0.5355**	**0.4043**	**0.6470**	**0.4849**	**0.8174**	**0.7924**
CV%	4.81%	4.26%	5.17%	3.54%	6.20%	7.48%

DAS= Days after sowing.

control. Rest other treatments showed intermediate values. At 80 DAS, $N_{40}G_{25}$ also showed significantly the highest number of leaves per plant among the treatments. Treatment $N_{40}G_{50}$ gave the second highest number, which, however, was not significantly different from $N_{60}G_{25}$ and $N_{20}G_{25}$. Rest other treatments showed intermediate values. N_0G_{50} treatment showed lower number, which did not have significantly variation with the control.

4.3 Number of nodules per plant

Results of number of nodules per plant are presented in Fig. 5, Fig. 6 and Table 3. From the figures and Table, it is seen that number of nodules per plant was significantly affected by the treatments. Irrespective of treatment differences, number of nodules per plant of mungbean ranged from 3.20 - 9.50, 9.44 - 17.22, 8.33 - 23.55, 7.55 - 16.66, 1.10 - 6.66 and 0.00 - 1.44 at 30, 40, 50, 60, 70 and 80 DAS respectively.

4.3.1 Effect of nitrogen

At all the growth stages number nodules per plant was found to be significant increased with the increasing rate of N fertilizer up to 20 kg ha^{-1} (N_{20}) and thereafter, it decreased at all date of observations (Fig. 5). The highest number of nodules per plant was observed in 20 kg N ha^{-1} (N_{20}) at 50 DAS. After 50 DAS, the nodule numbers gradually decreased up to harvest. The lowest number of nodules per plant was observed at 60 kg N ha^{-1} (N_{60}) and control. This result is partially supported by Inthong (1987), who stated that the application of N increased the nodule production up to 15 kg N ha^{-1}and thereafter decreased.

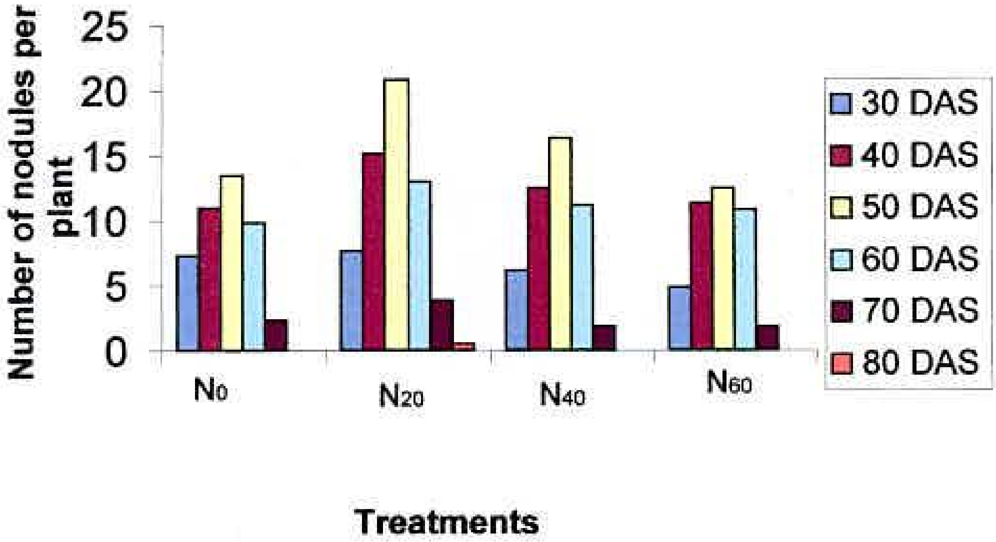


Fig. 5 Effect of nitrogen treatments (N) on number of nodules of summer mungbean

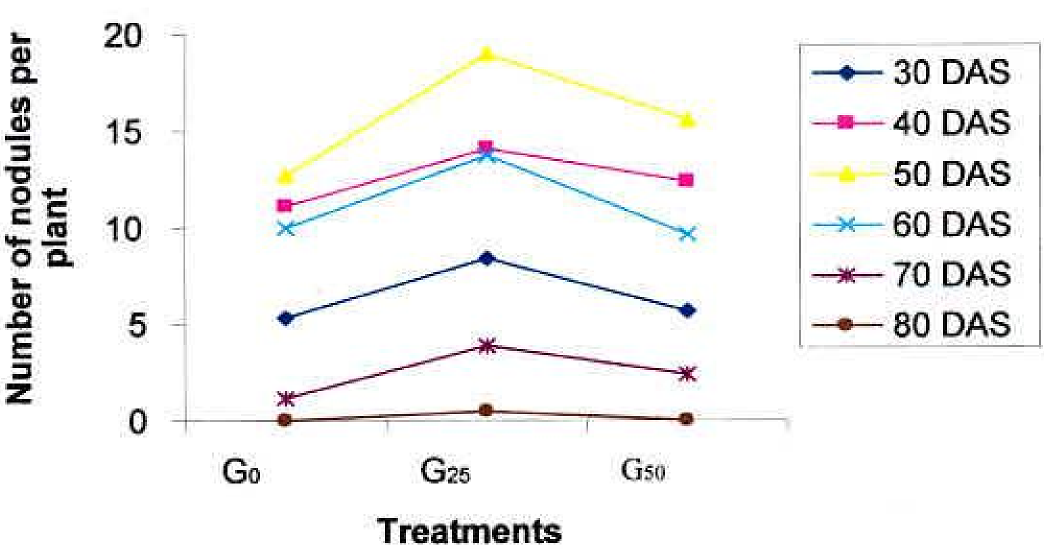


FIG. 6 Effect of NAA treatments (G) on number of nodules of summer mungbean

4.3.2 Effect of NAA

From the figure 6, it is seen that the application of NAA significantly increased the number of nodules per plant. The highest number of nodules per plant was produced with 25 ppm NAA (G_1), which was significantly different than other treatments in all growth stages. The lowest number of nodules per plant was obtained with control.

4.3.3 Interaction effect of nitrogen (N) & NAA (G) treatments

From the Table 3, it is seen that at 30 DAS, $N_{40}G_{25}$ showed the highest number of nodules per plant, which was not significantly different than $N_{20}G_{25}$. $N_{20}G_0$ had the third highest number of nodules per plant, which was not significantly different than N_0G_{25}. Rest other treatments and control showed intermediate values but $N_{60}G_0$ showed the lower number of nodules per plant.

At 40 DAS, $N_{20}G_{25}$ produced the highest number of nodules per plant, which was significantly different from rest of the treatments. $N_{60}G_0$ showed the lower number of nodules per plant but that was not significantly different from that of the control. Rest other treatments along with control showed intermediate values.

At 50 DAS, $N_{20}G_{25}$ gave the highest number of nodules per plant, which was significantly different than other treatments. $N_{20}G_{50}$ showed the second highest number of nodules per plant. Treatments excluding above-mentioned ones showed intermediate values, but produced significantly higher number of nodules per plant than that of control and $N_{60}G_{50}$.

Table 3 Interaction effect of nitrogen and NAA treatments on number of nodules per plant of summer mungbean at different growth stages

Treatments	Number of nodules per plant					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
N_0G_0	6.600	9.880	10.89	7.550	1.770	0.0000
N_0G_{25}	8.100	12.77	15.99	11.77	3.000	0.0000
N_0G_{50}	7.270	10.33	13.44	9.990	2.220	0.0000
$N_{20}G_0$	8.330	13.77	17.66	14.00	0.9700	0.0000
$N_{20}G_{25}$	9.130	17.22	23.55	16.66	6.660	1.440
$N_{20}G_{50}$	5.530	14.55	21.22	8.330	4.110	0.1100
$N_{40}G_0$	3.200	11.33	13.99	7.660	1.030	0.0000
$N_{40}G_{25}$	9.500	13.44	18.66	15.33	2.330	0.2200
$N_{40}G_{50}$	5.670	12.88	16.22	10.44	2.100	0.0000
$N_{60}G_0$	3.060	9.440	8.330	8.220	0.8800	0.0000
$N_{60}G_{25}$	7.060	12.77	17.88	14.11	3.660	0.2200
$N_{60}G_{50}$	4.400	11.78	11.44	10.00	1.100	0.0000
LSD.05%	**0.3786**	**0.8243**	**1.276**	**1.110**	**0.3861**	**0.1931**
CV%	3.44%	3.89%	4.78%	5.87%	9.15%	9.42%

DAS = Days after sowing.

At 60 DAS, $N_{20}G_{25}$ treatment also gave highest number of nodules per plant, which was significantly different than other treatments. $N_{40}G_{25}$ showed the second highest number of nodules per plant. After 50 DAS, the rate of nodules per plant decreased. Treatments excluding above-mentioned ones showed intermediate values. Control showed lower values but there was no significant variation with $N_{20}G_{50}$, $N_{40}G_0$ and $N_{60}G_0$.

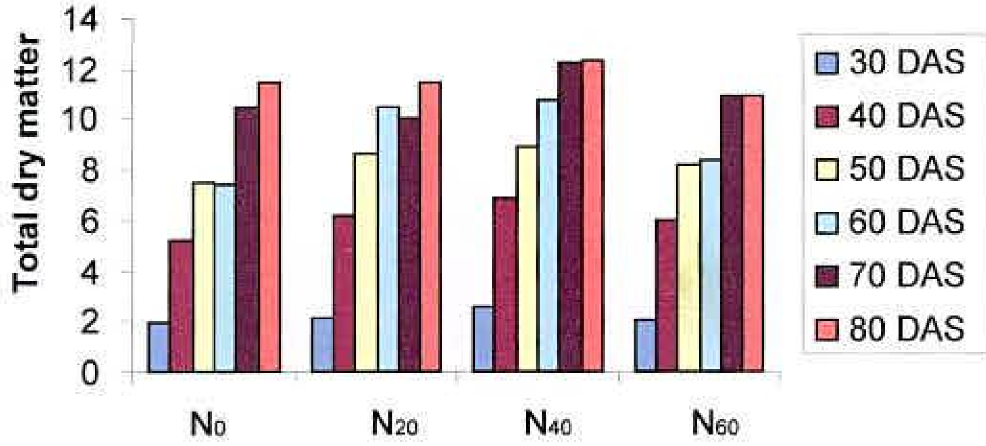
At 70 DAS, $N_{20}G_{25}$ showed the highest number of nodules per plant, which had significant effect on number of nodules per plant compared to other treatments. At 80 DAS, $N_{20}G_{25}$ also showed the highest number of nodules per plant, which was not statistically similar to other treatments. Rest of other treatments showed no nodules per plant.

4.4 Total dry matter per plant

Data of total dry matter are presented Fig.7, Fig. 8 and Table 4. From the figures and table, it is seen that there was a significant effect of treatments on total dry matter. It was also found that total dry matter gradually increased up to 80 DAS. Irrespective of treatments differences, the total dry matter of mungbean ranged from 1.70 - 3.12 g, 4.150 - 7.167 g, 7.22 - 9.483 g, 6.697 - 11.88 g, 9.067 - 13.80 g and 13.49 - 10.03 g at 30, 40, 50, 60, 70 and 80 DAS respectively.

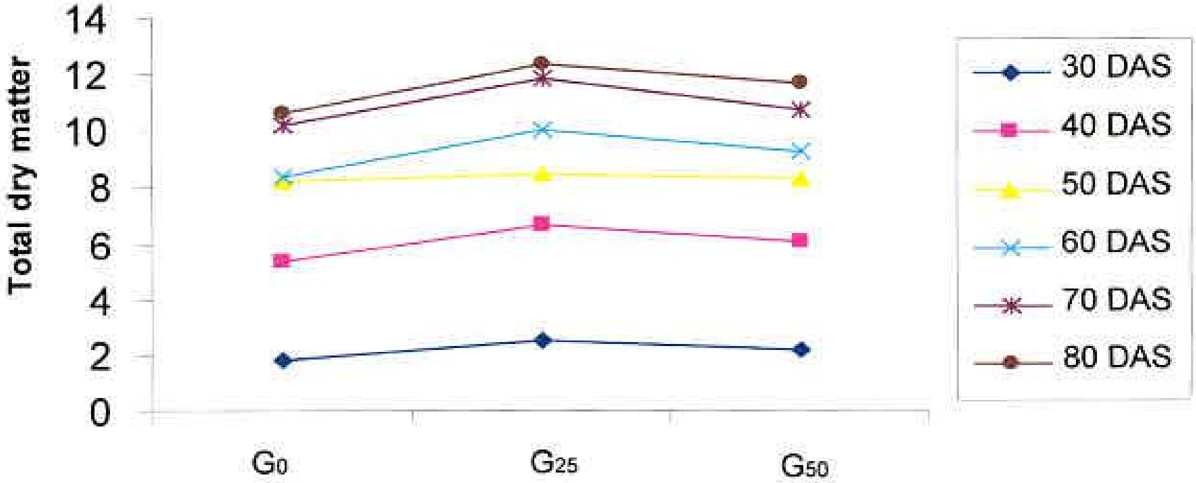
4.4.1 Effect of nitrogen

From the result it was found that the total dry matter increased with the increasing rate of N fertilizer up to 40 kg ha^{-1} (N_{40}) and thereafter, it decreased at all date of observations (Fig.7). It was also seen that total dry matter accumulation was comparatively lower in early stage of crop growth. At 80 DAS, total dry matter per plant was the highest with 40 kg N ha^{-1} (N_{40}) and the lowest with control. Agbenin *et al.* (1991) reported that applied



Treatments

Fig. 7 Effect of nitrogen treatments (N) on total dry matter of summer mungbean



Treatments

Fig. 8 Effect of NAA treatments (G) on total dry matter of summer mungbean

nitrogen significantly increased the dry matter yield of mungbean over control. Leelavati *et al.* (1991) found that nitrogen application showed significant increase in dry matter yield of mungbean up to 60 kg N ha^{-1}. Santos *et al.* (1993) also found that application of nitrogen as NH_4NO_3 up to 200 kg ha^{-1}increased the total dry matter of mungbean and with higher rates the dry matter decreased.

4.4.2 Effect of NAA

Effect of NAA on total dry matter has been presented in Fig. 8. From the figure, it is seen that the total dry matter was higher in 25 ppm of NAA (G_{25}) at all date of observation and lower with control. Das and Prasad (2003) while testing three mungbean cultivars under two levels of NAA (20 and 40 ppm), they found that both the concentrations of NAA significantly increased the total dry matter production. Kelaiya *et al.* (1991) also reported that groundnuts when sprayed with 40 ppm NAA at 25 and 50 DAS, plant dry weight was increased.

4.4.3 Interaction effect of nitrogen (N) & NAA (G) treatments

From the Table 4, it is seen that the total dry matter was lower at early stage of mungbean plants. At 30 DAS, $N_{40}G_{25}$ showed the highest total dry matter and control showed the lowest. The treatment $N_{40}G_{50}$ produced the second highest dry matter which was identical to $N_{20}G_{25}$. Rest other treatments showed intermediate values, but the control showed identical total dry matter to N_0G_{50}, $N_{20}G_0$ and $N_{60}G_0$ treatments.

Table 4 Interaction effect of nitrogen and NAA treatments on total dry matter of summer mungbean at different growth stages

Treatments	Total dry matter per plant (g)					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
N_0G_0	1.700	4.150	7.220	6.697	10.25	10.03
N_0G_{25}	2.200	6.216	7.673	8.066	10.77	12.24
N_0G_{50}	1.861	5.163	7.626	7.367	10.36	11.95
$N_{20}G_0$	1.824	5.130	9.047	10.03	9.067	10.95
$N_{20}G_{25}$	2.480	6.830	8.100	11.32	11.51	11.93
$N_{20}G_{50}$	2.057	6.513	8.770	9.233	9.473	11.43
$N_{40}G_0$	2.068	6.640	8.503	10.99	11.12	11.30
$N_{40}G_{25}$	3.120	7.167	9.483	11.88	13.80	13.49
$N_{40}G_{50}$	2.580	6.820	8.800	10.22	11.90	12.24
$N_{60}G_0$	1.776	5.590	7.940	7.700	10.47	10.17
$N_{60}G_{25}$	2.250	6.503	8.610	8.960	11.30	11.61
$N_{60}G_{50}$	2.008	5.800	8.043	8.353	10.97	10.97
LSD. 05%	**0.2074**	**0.7043**	**0.6752**	**0.5487**	**0.7535**	**0.8928**
CV%	5.63%	6.88%	4.79%	3.50%	4.08%	4.57%

DAS = Days after sowing.

At 40 DAS, $N_{40}G_{25}$ showed the highest total dry matter, but that was not significantly higher than those of $N_{20}G_{25}$, $N_{20}G_{50}$, $N_{40}G_{50}$, $N_{40}G_0$ and $N_{60}G_{25}$. Treatments excluding above-mentioned ones showed intermediate values, but produced significantly higher dry mater than that of control.

At 50 DAS, $N_{40}G_{25}$ also showed the highest total dry matter, which was not significantly higher than those of $N_{20}G_0$, $N_{20}G_{50}$ and $N_{40}G_{50}$. Control showed the lowest total dry matter. $N_{20}G_0$ had the second highest total dry matter, which was not significantly different when compared than those of $N_{20}G_{50}$, $N_{40}G_0$, $N_{60}G_{25}$ and $N_{40}G_{50}$. Treatments excluding above-mentioned ones showed intermediate values and produced significantly higher total dry matter than those of all treatments combination with N_0 and $N_{60}G_0$.

At 60 and 70 DAS, $N_{40}G_{25}$ showed the highest total dry matter, which was significantly higher than other treatments. Rest of the treatments showed intermediate values, but produced significantly higher dry matter than that of control at 60 DAS but at 70 DAS $N_{20}G_0$ showed the lowest value. However, at 80 DAS, $N_{40}G_{25}$ also produced higher total dry matter, which, however, was not significantly different than other treatments. Rest of the treatments produced significantly higher total dry matter than those of $N_{20}G_0$, $N_{60}G_0$, $N_{60}G_{50}$ and control.

From the above results, it can be summarized that at most of the growth stages, $N_{40}G_{25}$ showed highest total dry matter per plant, which was also significantly higher than most of other treatments. Such observation was also observed by Mahla *et al.* (1999) who tested blackgram under 2-ppm mixtalol (triacontanol) and/or 20 ppm of NAA with P_2O_5 (0 - 60 kg ha^{-1}). They showed that total dry matter production was highest with combination of both treatments.

4.5 Number of flowers per plant

Results of number of flowers per plant have been presented in Fig. 9, Fig. 10 and Table 5. From the figures and table, we can see that the number of flowers per plant was higher at 40 DAS and thereafter it decreased. Irrespective of treatment differences, number of flowers per plant ranged from 2.77 - 6.55, 0.40 - 1.77, 0.39 -3.44, 0.33 - 2.44, and 0.55 - 2.77 at 40, 50, 60, 70 and 80 DAS respectively.

4.5.1 Effect of nitrogen

Number of flowers per plant was found to be increased with the increasing rate of N fertilizer up to 40 kg ha^{-1} (N) and thereafter, it decreased (Fig. 9). The highest number of flowers was observed with the treatment 40 kg N ha^{-1} (N_{40}) at 40 DAS. This treatment always showed significantly more flowers than other treatments at all growth stages. The control showed the lowest. At each stage with increasing nitrogen, number of flowers per plant was found to be increased up to 40 kg N ha^{-1} (N_{40}). In this study, the number of flowers per plant was significantly affected by different doses of nitrogen levels. This finding agrees well with that of Malik *et al.* (2003) who found that numbers of flowers per plant were affected significantly by the application of nitrogen and phosphorus.

4.5.2 Effect of NAA

The effect of NAA on number of flowers per plant has been presented in Fig. 10. From the figure, it is seen that there was a significant effect of NAA on number of flowers. The highest number of flowers was found at 40 DAS with 25 ppm of NAA (G_{25}), which was significantly different among the other treatments at all growth stages.

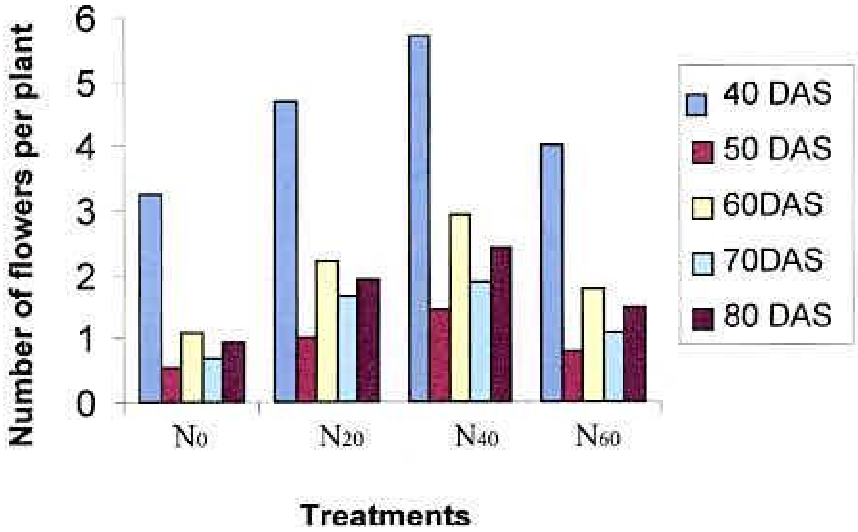


Fig. 9 Effect of N treatments (N) on number of flowers per plant of summer mungbean

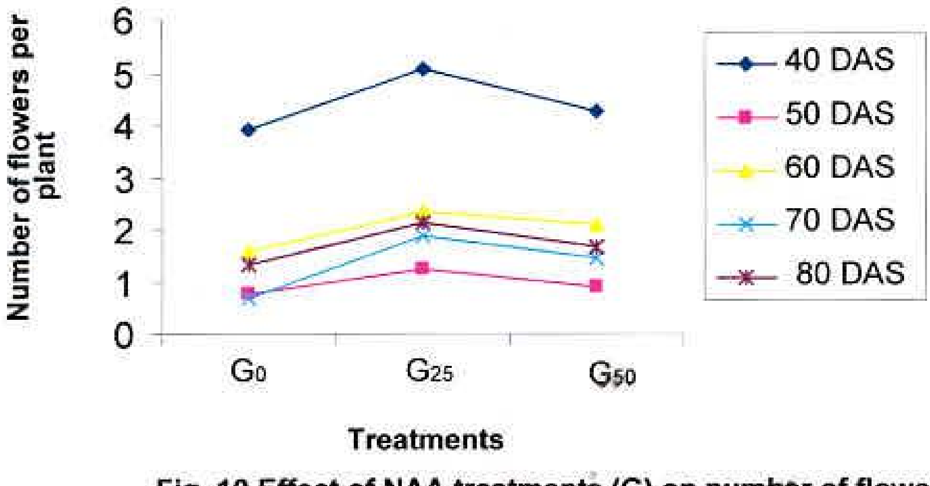


Fig. 10 Effect of NAA treatments (G) on number of flowers per plant of summer mungbean

Control always showed the lowest number of flowers. Similar result was found by Das and Prasad (2003) who stated that 20 ppm of NAA had produced significantly higher number of flowers of mungbean.

4.5.3 Interaction effect of nitrogen (N) & NAA (G) treatments

At 40 DAS, $N_{40}G_{25}$ showed significantly higher number of flowers per plant than others. Treatment $N_{40}G_{50}$ gave the second highest number of flowers per plant which although was not significantly different from $N_{20}G_{25}$ and $N_{40}G_0$ treatments. $N_{20}G_0$, $N_{60}G_{25}$ and $N_{20}G_{50}$ showed statistically similar number of flowers, which were significantly lower than those of the previously mentioned treatments. Rest treatments showed intermediate values producing significantly more flowers than those of N_0G_{50} and control.

At 50 DAS, $N_{40}G_{25}$ gave highest number of flowers per plant, which was significantly higher than those of other treatments. $N_{40}G_{50}$ and $N_{20}G_{25}$ showed statistically similar number of flowers per plant but those were significantly lower than that of $N_{40}G_{25}$. $N_{40}G_0$ showed significantly lower number of flowers than those of $N_{20}G_{25}$, $N_{40}G_{50}$ and $N_{40}G_{25}$. Rest other treatments showed intermediate values. Control and N_0G_{50} showed significantly lower number of flowers than those of all other treatments (Table 5).

At 60 DAS, $N_{40}G_{25}$ treatment gave the highest number of flowers per plant, which was significantly higher than other treatments. $N_{40}G_{50}$ produced the second highest number of flowers, which was higher than other treatments except $N_{40}G_{25}$. Control had significantly lower number of flowers than those of all other treatments.

Table 5 Interaction effect of nitrogen and NAA treatments on number of flowers per plant of summer mungbean

Treatments	Number of flowers per plant				
	40 DAS	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**
N_0G_0	2.770	0.4000	0.3900	1.550	0.5500
N_0G_{25}	3.990	0.7700	1.490	0.9900	1.650
N_0G_{50}	3.000	0.4400	1.400	0.9900	0.6600
$N_{20}G_0$	4.210	0.7700	2.100	1.330	1.660
$N_{20}G_{25}$	5.320	1.440	2.350	1.550	2.100
$N_{20}G_{50}$	4.550	0.8800	2.200	0.3300	1.950
$N_{40}G_0$	5.100	1.220	2.220	0.6600	1.990
$N_{40}G_{25}$	6.550	1.770	3.440	2.440	2.770
$N_{40}G_{50}$	5.440	1.400	3.100	0.440	2.550
$N_{60}G_0$	3.550	0.7000	1.550	2.330	1.110
$N_{60}G_{25}$	4.440	0.9000	2.150	2.440	1.980
$N_{60}G_{50}$	4.100	0.7800	1.660	0.8800	1.400
LSD .05%	**0.3257**	**0.1312**	**0.2142**	**0.1312**	**0.1515**
CV%	4.37%	7.92%	6.30%	5.80%	5.28%

DAS= Days after sowing

At 70 DAS, $N_{40}G_{25}$ and $N_{60}G_{25}$ treatments gave higher number of flowers per plant, which were not significantly different from $N_{60}G_0$ treatment. N_0G_0 and $N_{20}G_{25}$ showed statistically similar number of flowers. $N_{20}G_0$ treatment gave lower number of flowers per plant than above the mentioned treatments. N_0G_{25}, N_0G_{50} and $N_{60}G_{50}$ treatments showed statistically similar number of flowers per plant, but those had significantly lower number of flowers than those of the previously mentioned treatments.

At 80 DAS, $N_{40}G_{25}$ gave higher number of flowers per plant, which was significantly higher than other treatments. $N_{40}G_{50}$ produced second highest number of flowers per plant, which was higher than other treatments except $N_{40}G_{25}$. Treatments $N_{60}G_{25}$, $N_{20}G_{25}$, $N_{20}G_{25}$ and $N_{40}G_0$ showed statistically similar number of flowers which although were significantly lower than those of the above mentioned treatments. Rest other treatments showed intermediate values. Control and N_0G_{50} showed significantly lower number of flowers per plant than those of all other treatments.

4.6 Number of pods per plant

Results of number of pods per plant have been presented in Fig. 11, Fig. 12 and Table 6. From the figures and table, we find that number of pods per plant increased gradually up to 80 DAS. Irrespective of treatment differences, number of pods per plant of mungbean ranged from 6.88 - 13.22, 11.22 - 17.55, 19.77 - 33.88, 20.5 - 26.88, and 27.12 - 37.44 at 40, 50, 60, 70 and 80 DAS respectively.

4.6.1 Effect of nitrogen

At all the growth stages number of pods per plant was found to be increased with the increasing rate of N fertilizer up to 40 kg ha^{-1} (N_{40}) and thereafter, it decreased at all date of observations (Fig. 11). The maximum number of pods per plant was obtained from the plants treated with 40 kg N ha^{-1} (N_{40}) at 80 DAS which were significantly different from those of other treatments .The lowest number of pods per plant was obtained with control. This finding was strongly supported by Sarkar and Banik (1992) and partially supported by Patel and Parmar (1986). They stated that application of N increased the number of pods per plant.

4.6.2 Effect of NAA

The effect of NAA on number of pods per plant has been presented in Fig. 12. From the figure, it is seen that there was a significant effect of NAA on number of pods per plant. The highest number of pods per plant was produced with 25 ppm of NAA (G_{25}), which was significantly different from the other treatments at all growth stages. The lowest number of pods per plant was obtained from the control. This finding is strongly supported by Das and Prasad (2003), Venkaten Warlu *et al.* (1984) and Subbian and Chamy (1984). They stated that NAA at 20 ppm significantly increased the number of pods per plant of summer mungbean.

4.6.3 Interaction effect of nitrogen (N) & NAA (G) treatments

Interaction effects between nitrogen levels and NAA levels were found to be significant in respect of number of pods per plant (Table 6) at all dates of observations. At 40 DAS, $N_{40}G_{25}$ treatment gave highest number of pods per plant, which was not significantly

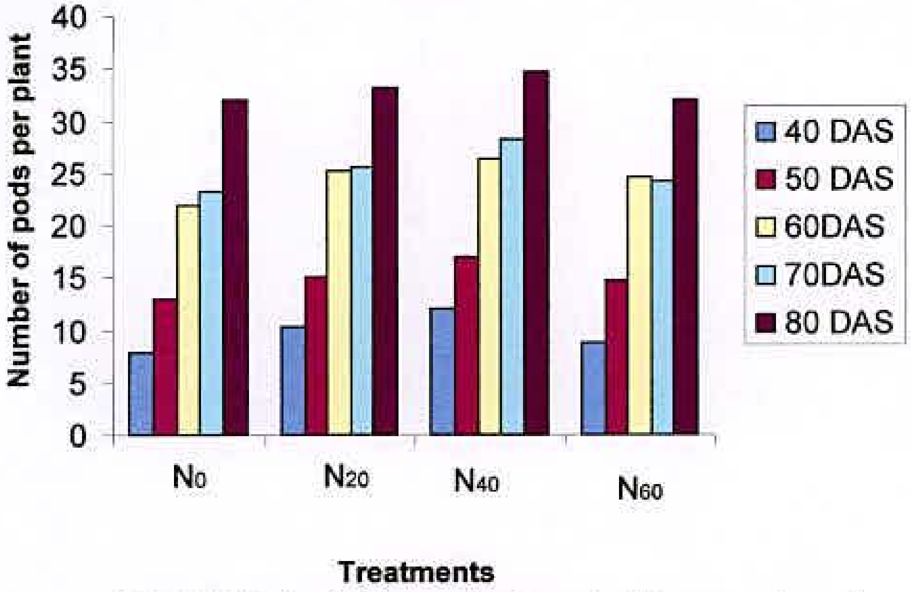


Fig.11 Effect of nitrogen treatments (N) on number of pods of summer mungbean

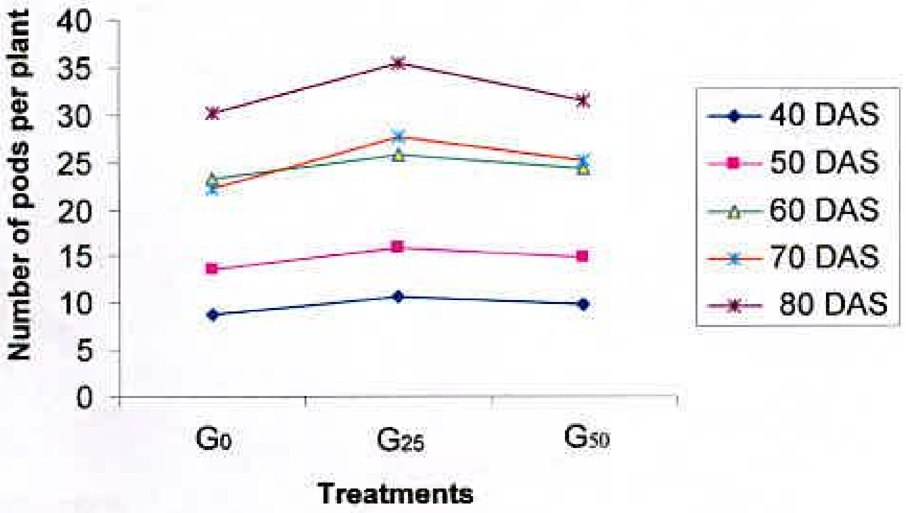


Fig. 12 Effect of NAA treatments (G) on number of pod of summer mungbean

different from $N_{40}G_{50}$. $N_{20}G_{50}$ and $N_{20}G_{25}$ treatments gave statistically similar number of pods per plant. Rest of the treatments showed intermediate values but the control showed significantly lower number of pods per plant than those of all other treatments.

At 50 DAS, $N_{40}G_{25}$ treatment gave highest number of pods per plant, which was not significantly different from $N_{20}G_{25}$ and $N_{40}G_{50}$ treatments. $N_{60}G_{25}$, and $N_{40}G_{0}$ showed identical number of pods per plant, which were not significantly different from $N_{20}G_{25}$ and $N_{40}G_{50}$ but had significantly lower number of pods per plant than that of $N_{40}G_{25}$. Treatments excluding above-mentioned ones showed intermediate values, but produced significantly higher number of pods per plant than that of control.

At 60 DAS, $N_{40}G_{25}$ showed the highest number of pods per plant, which was not significantly different than most of other treatments. $N_{0}G_{50}$ and control showed significantly lower number of pods per plant.

At 70 DAS, $N_{40}G_{25}$ showed the highest number of pods per plant, which was significantly higher than other treatments. $N_{20}G_{25}$ had the second highest number of pods per plant, which was not significantly different from $N_{60}G_{25}$. Treatments $N_{60}G_{25}$, $N_{40}G_{50}$, $N_{0}G_{25}$ and $N_{20}G_{50}$ showed identical number of pods per plant, which were significantly lower than those of $N_{40}G_{25}$ and $N_{20}G_{25}$ except $N_{60}G_{25}$, but were significantly higher than those of others. The control produced significantly lower number of pods per plant than rest of the treatments.

Table 6 Interaction effect of nitrogen and NAA treatments on number of pods of summer mungbean at different growth stages

Treatments	**Number of pods per plant**				
	40 DAS	**50 DAS**	**60 DAS**	**70 DAS**	**80 DAS**
N_0G_0	6.880	11.22	20.50	19.77	27.12
N_0G_{25}	8.660	14.11	24.00	25.55	33.00
N_0G_{50}	7.990	13.33	21.39	24.10	28.60
$N_{20}G_0$	9.800	13.33	24.10	22.65	31.25
$N_{20}G_{25}$	11.00	17.00	26.40	27.77	36.00
$N_{20}G_{50}$	10.22	14.88	25.10	25.90	32.00
$N_{40}G_0$	10.13	16.10	25.10	24.44	32.66
$N_{40}G_{25}$	13.22	17.55	26.88	33.88	37.44
$N_{40}G_{50}$	12.88	17.00	26.66	26.10	33.77
$N_{60}G_0$	8.000	13.94	23.61	21.60	29.99
$N_{60}G_{25}$	9.990	16.10	25.95	27.00	35.10
$N_{60}G_{50}$	8.390	14.14	24.00	24.10	31.10
LSD .05%	**0.8243**	**1.142**	**1.961**	**1.525**	**1.668**
CV%	4.998%	4.53%	4.73%	3.57 %	3.05%

DAS = Days after sowing.

At 80 DAS, $N_{40}G_{25}$ showed the highest number of pods per plant, which was not significantly different from $N_{20}G_{25}$. $N_{20}G_{25}$ had the second highest number of pods per plant, which was not significantly different from $N_{60}G_{25}$. The control and N_0G_{50} showed significantly lower number of pods per plant than those of all other treatments.

From the critical observation of this table, we can find that at most of the growth stages, N_2G_1 showed more number of pods, which was not, however, significantly higher than N_1G_1 treatment at the later stages. Ganiger *et al.* (2003) and Jain *et al.* (1995) also found similar results, which support and strengthen this finding.

4.7 Pod length (cm)

The results of pod length have been presented in Table 7 and 8. From the result, it is easily observed that treatments did not have any significant effect on pod length. Pod length of mungbean ranged from 6.00 - 6.41cm.

4.8 Number of seeds per pod

Results of number of seeds per pod have been presented in Table 7 and Table 8. From the Table 8, it is seen that number of seeds per pod was not significantly affected by nitrogen levels but there were significant effects of NAA and interaction treatments. Irrespective of treatment differences, number of seeds per pod of mungbean ranged from 8.00 - 9.33.

4.8.1 Effect of nitrogen

Effect of nitrogen on number of seeds per pod of mungbean has been presented in Table 7. From table it was observed that there was not significantly difference due to the application of nitrogen. But produced more seeds than control. This finding was slightly supported by Malik *et al* (2003) who stated that application of N increased the number of seeds per pods.

4.8. 2 Effect of NAA

From the Table 7, it was observed that the application of NAA significantly affected the number of seeds per pod. Significantly, the highest number of seeds per pod (9.070) was produced with 25 ppm of NAA (G_{25}) and the lowest (8.24) was obtained from the plants treated with control. This finding is supported by Das and Prasad (2003) they found that application of NAA at 20 ppm increased number of seeds per pod .

4.8.3 Interaction effect of nitrogen (N) and NAA (G) treatments

Results of number of seeds per pod have been presented in Table 8. From the Table, it is seen that number of seeds per pod was significantly affected by the interaction of nitrogen and NAA levels. Treatment $N_{40}G_{25}$ showed the highest number of seeds per pod which was not significantly different than those of $N_{60}G_{25}$, $N_{20}G_{25}$ and N_0G_{25}. Control showed the lowest. Rest other treatments produced significantly higher number of seeds per pod than those of $N_{40}G_0$, $N_{40}G_{50}$, $N_{60}G_0$ and control. There is evidence that NAA when used in combination with fertilizer (s), affected seed production. Kalita (1989) reported that combined application of P and NAA significantly increased the number of seeds per pod in greengram.

4.9 1000 seed weight

The results of 1000 seed weight have been presented in Table 7 and Table 8. From the table 8, it is seen that 1000 seed weight was significantly affected by nitrogen and NAA levels. Irrespective of treatment differences, 1000 seed weight of mungbean ranged from 27.00 - 30.10 g.

4.9.1 Effect of nitrogen

Significantly the highest 1000 seed weight (29.06) was observed with 40 kg N ha^{-1} (N_{40}) which, however, was not significantly different from 20 kg N ha^{-1} (N_{20}). But that was significantly higher than the other treatments. The lowest 1000 seed weight (27.40) was found with control. This result was in agreement with the findings of Trung and Yoshida, 1983; Sarkar and Banik, 1992; Quah and Jaafar, 1994; and Sardana and Verma, 1987) who reported that 1000 seed weight increased with the increasing rates of N up to 40 kg ha^{-1}.

4.9.2 Effect of NAA

The effect of NAA on 1000 seed weight has been presented in Table 7. From the table it can be observed that 1000 seed weight varied significantly due to the application of different concentrations of NAA. The highest 1000 seed weight (28.93) was observed with 25 ppm of NAA (G_{25}) which was significantly different than the other treatment. The lowest 1000 seed weight (27.45) was found with control. Das and Prasad (2003) observed that 1000 seed weight was increased with spraying 20 ppm of NAA on summer mungbean.

4.9.3 Interaction effect of nitrogen (N) and NAA (G) treatments

Results of 1000 seed weight have been presented in Table 8. From the Table, it is seen that 1000 seed weight was significantly affected by the interaction of nitrogen and NAA levels. It was also observed that $N_{40}G_{25}$ showed the highest 1000 seed weight, however that was not significantly different than those of $N_{40}G_{50}$, $N_{60}G_{25}$ and $N_{20}G_{25}$. The control showed the lowest value which, however, was not significantly lower than most of the treatments. Das and Prasad (2003) observed that combined effect of N and NAA significantly increased 1000 seed weight.

4.10 Yield

Results of yield have been presented in Table 7 and Table 8. From the tables, it is seen that seed yield was significantly affected by nitrogen and NAA levels. Irrespective of treatment differences, yield of mungbean ranged from 1.05 - 1.54 t ha^{-1}.

4.10.1 Effect of nitrogen

Results showed that application of nitrogen significantly influenced the seed yield. The maximum yield (1.39 t ha^{-1}) was obtained from the plants treated with 40 kg N ha^{-1} (N_{40}), which was significantly different than other treatments (Table 7). The lowest yield (1.237) was obtained with control. This result agreed well with the findings of Mozumder *et al.* (2003) who stated that application of 40 kg N ha^{-1}resulted in the highest seed yield. Singh *et al.* (1993) and Bachchhav *et al.* (1994) found that application of 30 kg N ha^{-1}resulted in the highest seed yield of mungbean.

4.10.2 Effect of NAA

Seed yield ha^{-1} varied significantly due to the application of different concentrations of NAA (Table 7). The maximum yield (1.417 t ha^{-1}) was obtained from the plants treated with 25 ppm of NAA (G_1) which was significantly higher than other treatments. The lowest yield (1.112 t ha^{-1}) was obtained with control (G_0). This result is supported by Bai *et al.* (1987) who observed that application at 25 ppm of NAA on mungbean increased seed yield. Das and Prasad (2003) and Upadhyay (1994) also reported a lower dose of NAA to be the best in increasing yield. They found that spraying 20 ppm of NAA on mungbean increased seed yield when compared to control.

Table 7 Effect of nitrogen (N) and NAA (G) on pod length, number of seeds per pod, 1000 seed weight, yield t ha^{-1} and HI of summer mungbean

Treatments	Pod length (cm)	Number of seeds/pod	1000 grain weight (g)	Yield t ha^{-1}	Harvest index (%)
N_0	6.107	8.533	27.40	1.237	40.50
N_{20}	6.197	8.703	28.35	1.317	32.73
N_{40}	6.193	8.563	29.06	1.397	29.51
N_{60}	6.20	8.733	28.08	1.243	27.71
LSD.05	**NS**	**NS**	**0.7164**	**0.06183**	**2.529**
CV %	3.46%	3.40%	2.60%	4.73%	7.93%
G_0	6.193	8.243	27.45	1.112	33.55
G_{25}	6.082	9.070	28.93	1.417	32.41
G_{50}	6.247	8.587	28.29	1.335	31.87
LSD.05	**NS**	**0.2483**	**0.6240**	**0.05335**	**NS**
CV %	3.46%	3.40%	2.60%	4.73%	7.93%

4.10.3 Interaction effect of nitrogen (N) and NAA (G) treatments

Interaction effects of nitrogen and NAA levels were found to be significant in respect of seed yield of mungbean (Table 8). From the table it can also be found that

$N_{40}G_{25}$although, showed the highest seed yield, that was not significantly different than that of $N_{20}G_{25}$. $N_{20}G_0$, $N_{60}G_0$ and control showed significantly lower seed yields than others.

Table 8 Interaction effect nitrogen (N) and NAA (G) on pod length, number of seeds per pod, 1000 seed weight, yield and harvest index of summer mungbean

Treatments	**Pod length (cm)**	**Number of seeds per pod**	**1000 seed wt. (g)**	**Yield t ha^{-1}**	**Harvest index (%)**
N_0G_0	6.270	8.000	27.00	1.060	41.11
N_0G_{25}	6.000	8.850	27.90	1.400	37.70
N_0G_{50}	6.050	8.750	27.29	1.250	42.68
$N_{20}G_0$	6.230	8.570	27.65	1.100	33.80
$N_{20}G_{25}$	6.060	8.920	29.20	1.450	32.52
$N_{20}G_{50}$	6.300	8.620	28.20	1.400	31.87
$N_{40}G_0$	6.150	8.030	28.07	1.240	30.87
$N_{40}G_{25}$	6.200	9.330	30.10	1.540	30.28
$N_{40}G_{50}$	6.230	8.330	29.00	1.410	27.37
$N_{60}G_0$	6.120	8.37	27.07	1.050	28.43
$N_{60}G_{25}$	6.070	9.180	28.90	1.400	29.16
$N_{60}G_{50}$	6.410	8.650	28.28	1.280	25.58
LSD .05%	**NS**	**0.4966**	**1.241**	**0.1071**	**4.380**
CV%	3.46%	3.40%	2.60%	4.73%	7.93 %

From the above results, it can be summarized that, $N_{40}G_{25}$ showed the highest seed yield which was significantly higher than most of other treatments except $N_{20}G_{25}$. Jain *et al.* (1995) also reported the similar result. They found that seed was highest with the treatment combination of 40 kg N ha^{-1}+ 45 ppm NAA.

4. 11 Harvest index (HI)

The results of harvest index have been presented in Table 7 and 8. From the result, it is easily observed that there was a significant affect of nitrogen on the harvest index. But, the effect of NAA was not found to be significant. Irrespective of treatment differences, harvest index of mungbean ranged from 25.55- 42.68 %.

4. 11.1 Effect of nitrogen

The harvest index was found to be significantly decreased with N application. This negative relationship of HI and N agree to the finding of Mozumder (2003), who stated that HI (%) was decreased with the increase of nitrogen fertilizer. Significantly, the highest harvest index (40.50%) was observed with control. Treatments N_{40} (40 kg N ha^{-1}) and N_{60} (60 kg N ha^{-1}) showed identical HI.

4.11.2 Effect of NAA

Harvest index did not vary significantly due to the application of NAA (Table 7). The highest Harvest index (33.55%) was observed with control. Like N, NAA application also decreased the harvest index.

4.11.3 Interaction effect of nitrogen (N) and NAA (G) treatments

Interaction effect of nitrogen and NAA levels were found to be significant in respect of harvest index of mungbean (Table 8). From the table it can be found that N_0G_{50} showed the highest harvest index however, that was not significantly different than that of the control. Other treatments showed lower harvest index than those of N_0G_{50} and the control. The interaction effect of fertilizer with NAA was previously reported to be significant. Kalita *et al.* (1995) who found that treatment combination of 3% P_2O_5+100 ppm of NAA resulted in the greatest harvest index.

From the results of this chapter, it was seen that the most of the growth and yield parameters of this study were enhanced by the application of N and NAA.

From the results, it was also observed that, both N and NAA affected these parameters individually, as well as when their combination or interactions were considered. Among all the N doses, N_{40} (40 kg N ha^{-1}) performed best in respect of all parameters, except number of nodules per plant, number of seeds per pod, pod length and harvest index. Likewise, among the NAA concentrations, G_{25} (25 ppm of NAA) gave significantly higher values of all the parameters except pod length and harvest index. The interaction treatment $N_{40}G_{25}$ was found to be identical to $N_{20}G_{25}$ showing significantly higher values of all most growth and yield parameters except pod length and harvest index. But number of nodules per plant was highest only $N_{20}G_{25}$. However, it was found that the treatments N_{40}, G_{25}, $N_{40}G_{25}$ and $N_{20}G_{25}$ produced significantly higher seed yield ha^{-1}, number of pods per plant and 1000 seed weight. In other words, it may be said that these four treatments gave higher yields, which were due to increase in number of pods per plant and 1000 seed weight. So, from these findings it may be concluded that for achieving higher seed yields, either application of nitrogen (N) at the rate 40 kg ha^{-1} (N_{40}), or naphthalene acetic acid (NAA) at concentration of 25 ppm (G_{25}) or combination of nitrogen and NAA at the above said rate or concentration; or combination at 20 kg N ha^{-1} with 25 ppm NAA can be used. If the performances of these four treatments are compared, it can be observed that the two combination treatments $N_{20}G_{25}$ and $N_{40}G_{25}$ produced higher seed yields. But there was no significant difference between $N_{20}G_{25}$ and $N_{40}G_{25}$. So, in this respect, the use of nitrogen at the rate of 20 kg ha^{-1} (N_{20}) along with 25 ppm of NAA (G_{25}) seemed to be more profitable.

So, it may be suggested that mungbean can be grown using nitrogen at 20 kg ha^{-1} along with NAA at 25 ppm concentration. However, this study was performed in the soils and Agro-Climatic conditions of Sher-e-Bangla Agicultaral University farm and so this finding may not agree to the different soils and Agro-Climatic conditions of other locations or regions. So to assess the optimum rates/concentration of nitrogen and NAA to achieve higher yield of mungbean, further studies should be undertaken on a priority basis at other locations of Bangladesh.

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Chapter 5

Summary and conclusion

CHAPTER 5

CONCLUSION

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the influence of nitrogen and naphthalene acetic acid (NAA) on the yield of summer mungbean (*Vigna radiate* (L.) Wilczek) cv. BARI mung-3 during the period from March 2005 to May 2005. The experiment comprised of two different factors such as (1) four levels of nitrogen viz. N_0 (control), N_{20} (20 kg N ha^{-1}), N_{40} (40 kg N ha^{-1}) and N_{60} (60 kg N ha^{-1}) and (2) three levels of NAA viz. G_0 (no NAA), G_{25} (25 ppm of NAA) and G_{50} (50 ppm of NAA).

The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 12 treatment combinations. The experimental plot was fertilized at the rate of 125 kg Triple Super Phosphate and 67 kg Muriate of Potash per hectare. Mungbean seed of cv. BARI mung-3 (Progoti) were sown on 3rd March 2005 and harvested on 30 May 2005. Data on different growth and yield parameters were recorded and analyzed statistically.

Results showed that the effect of nitrogen was significant in respect of various plant characters including yield and yield attributes. Plant heights of mungbean were influenced significantly by the application of nitrogen fertilizers and NAA at all dates of observations. Plant height was always highest with 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}) and the lowest with control. Plant height was significantly higher with the interaction effect of $N_{40}G_{25}$.

Number of leaves per plant of mungbean was also influenced significantly by the application of nitrogen and NAA at all dates of observations. Highest number of leaves were observed with 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}) and lowest with control. Significantly, higher number of leaves per plant was present with the interaction effect of nitrogen fertilizers and NAA application at 60 DAS when applied N at 40 kg ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}) respectively.

The number of nodules per plant responded significantly to nitrogen application. It continued increasing up to 50 DAS and there after it decreased. Significantly more nodules was found at 50 DAS with 20 kg N ha^{-1} (N_{20}) and 25 ppm of NAA (G_{25}). The combination treatment 20 kg N ha^{-1} (N_{20}) and 25 ppm of NAA showed the highest number of nodules per plant at 50 DAS.

Experimental results showed that total dry matter was significantly affected by different levels of nitrogen fertilizers and NAA at all dates of observations. Significantly higher total dry matter was recorded with 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}) when individually factor was considered, while the lowest was obtained with control. Significantly higher total dry matters were present with the interaction treatment of nitrogen at 40 kg ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}).

Nitrogen fertilizers and NAA also significantly influenced the numbers of flowers. The more number of flowers was found at 40 DAS. The highest number of flowers was observed with 40 kg N ha^{-1} (N_{40}) and the lowest with control. Application of 25 ppm of

NAA (G_{25}) resulted that the highest number of flowers while control showed the lowest. Significantly, higher numbers of flowers were found with the combination treatment of N_{40} and G_{25}.

The number of pods per plant was also significantly influenced by nitrogen and NAA application. More number of pods was found at 80 DAS with 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}). However, the combined application of N at the rate of 20 - 40 kg ha^{-1} ($N_{20} - N_{40}$) and NAA concentration of 25 ppm (G_{25}) showed the highest number of pods per plant.

The pod length was not found to be significantly affected by the application of nitrogen and NAA and also their interaction.

Nitrogen fertilizers did not show any significant effect on number of seeds per pod but NAA had significant effect on this parameter. The highest number of seeds per pod was observed with 25 ppm of NAA (G_{25}) and the lowest with control. The combination treatment $N_{40}G_{25}$ showed more number of seeds per pod.

1000 seed weight was significantly affected by the application of nitrogen and NAA. The highest 1000 seed weight was recorded with 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}) and lowest with control. Higher 1000 seed weight was recorded with the interaction effect of $N_{40}G_{25}$ and $N_{20}G_{25}$ treatments.

Effect of nitrogen was significant in terms of yield. Significantly higher yield was produced with the application of 40 kg N ha^{-1} (N_{40}). NAA application also showed significant effect on the yield of mungbean. Significantly higher amount of yield was found with the interaction effect of 20 or 40 kg N ha^{-1} (N_{20}or N_{40}) with 25 ppm of NAA (G_{25}).

Harvest index was affected significantly by nitrogen. Highest harvest index was found in control but in case of NAA application, there was no significant effect. But Significant effect was found with the interaction of nitrogen and NAA.

From the above results, it may be concluded that both the treatments had significant effect on growth and most yield contributing characters of BARI mung -3. The plant height, number of leaves, total dry weight of plant, number of flowers, number of pods per plant, number of seeds per pod, 1000 seed weight, seed yield were enhanced significantly by 40 kg N ha^{-1} (N_{40}) and 25 ppm of NAA (G_{25}). With combined application of both, highest yield was obtained with 20 or 40 kg N ha^{-1} (N_{20} or N_{40}) and 25 ppm of NAA (G_{25}) application. So, It may be concluded that significantly higher yield of mungbean was achieved using 20 kg N ha^{-1} (N_{20}) along with 25 ppm of NAA (G_{25}).

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APPENDICES

Appendix 1. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0 - 15 cm depth).

Mechanical composition:

Particle size constitution

Sand	:	40%
Silt	:	40%
Clay	:	20%

Texture : Loamy

Chemical composition:

Soil characters	Value
Organic matter	1.44 %
Potassium	0.15 meq/100 g soil
Calcium	3.60 meq/100 g soil
Magnesium	1.00 meq/100 g soil
Total nitrogen	0.072
Phosphorus	22.08 μg/g soil
Sulphur	25.98 μg/g soil
Boron	0.48 μg/g soil
Copper	3.54 μg/g soil
Iron	262.6 μg/g soil
Manganese	164 μg/g soil
Zinc	3.32 μg/g soil

Source: Soil Resources Development Institute (SRDI), Khamarbari, Dhaka

Appendix 2. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March 2005 to May 2005.

Year	Month	Air temperature (^0C)			Relative humidity (%)	Rainfall (mm)	Sunshine (h)
		Maximum	Minimum	Mean			
2005	March	32.20	21.80	27.00	66.69	66.70	155.0
	April	34.44	23.96	29.20	68.08	90.01	253.0
	May	33.23	24.11	28.67	96.13	297.9	96.0

Source: Bangladesh Meteorological Department (Climate division), Dhaka-1212.

Appendix 3. Analysis of Variance on different parameters of summer mungbean

Appendix 3.1 Analysis of Variance on plant height of summer mungbean

Sources of variation	DF	Mean square					
		Plant height (cm)					
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	10.146	11.083	6.583	10.083	10.083	18.750
Factor-A (N- level)	3	2.481^{NS}	128.676**	30.625**	61.088**	48.835**	60.926**
Factor-B (NAA level)	2	2.416^{NS}	97.136**	150.670**	106.516**	95.594**	113.588**
Interaction (AxB)	6	1.050^{NS}	10.628**	14.628**	6.262*	5.751^{NS}	4.788^{NS}
Error	22	1.050	2.356	2.220	1.902	2.629	4.023
Total	35	-	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

DF = Degrees of fredom

Appendix 3. 2. Analysis of Variance on number of flowers of mungbean

Sources of variation	Degrees of freedom	Mean square				
		Number of flowers				
		40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	0.090	0.200	0.085	0.036	0.032
Factor-A (N- level)	3	9.653**	1.395**	5.282**	2.651**	3.548**
Factor-B (NAA level)	2	4.281**	0.660**	1.950**	4.460**	1.938**
Interaction (AxB)	6	0.094*	0.039**	0.237**	0.305**	0.129**
Error	22	0.037	0.006	0.016	0.006	0.008
Total	35	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

Appendix 3. 3 Analysis of Variance on number of pods per plant of Summer mungbean

Sources of variation	Degrees of freedom	Mean square				
		Number of pods per plant				
		40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	1.841	3.00	6.083	2.250	5.333
Factor-A (N- level)	3	30.934**	24.137**	41.453**	29.574**	40.491**
Factor-B (NAA level)	2	12.283**	19.419**	124.525**	18.765**	87.390**
Interaction (AxB)	6	1.068**	1.117^{NS}	6.989**	0.898NS	0.227^{NS}
Error	22	0.237	0.455	0.811	1.341	0.970
Total	35	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

Appendix 3.4 Analysis of Variance on number of leaves per plant of summer mungbean

Sources of variation	Degrees of freedom	Mean square					
		Number of leaves per plant					
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	0.186	0.130^{NS}	0.227^{NS}	0.403*	0.336^{NS}	0.692^{NS}
Factor-A (N- level)	3	0.907**	1.631**	2.159**	1.283**	1.991**	11.192**
Factor-B (NAA level)	2	0.332^{NS}	1.542**	1.759**	8.345**	4.559**	15.948**
Interaction (AxB)	6	0.986**	0.255**	0.709**	0.469**	0.266^{NS}	1.053**
Error	22	0.100	0.057	0.146	0.082	0.233	0.219
Total	35	-	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

Appendix 3.5 Analysis of Variance on number of nodules per plant of summer mungbean

Sources of variation	Degrees of freedom	Mean square					
		Number of nodules per plant					
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	0.301	2.521	1.750	3.521	0.051	0.015
Factor-A (N- level)	3	14.784**	32.469**	124.408**	16.356**	8.617**	0.503**
Factor-B (NAA level)	2	35.104**	26.167**	119.498**	62.623**	22.784**	0.835**
Interaction (AxB)	6	6.659**	1.088**	4.650**	25.920**	3.785**	0.396**
Error	22	0.050	0.237	0.568	0.430	0.052	0.013
Total	35	-	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

Appendix 3.6 Analysis of Variance on total dry matter per plant of summer mungbean

Sources of variation	Degrees of freedom	Mean square					
		TDM/per plant					
		30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS
Replication	2	0.068	1.147	0.653	0.422	0.875	0.563
Factor-A (N- level)	3	0.796**	4.391**	3.448**	24.350**	8.583**	3.193**
Factor-B (NAA level)	2	1.359**	5.090**	0.251 NS	8.098**	8.385**	8.873**
Interaction (AxB)	6	0.056*	0.488*	0.598*	0.411*	1.071**	1.014 NS
Error	22	0.015	0.173	0.159	0.105	0.198	0.278
Total	35	-	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

Appendix 3.7 Analysis of Variance on number of seeds per pod, 1000 grain wt., Yield, pod length and harvest index (HI)

Sources of variation	Degree of freedom	Mean square				
		No. seeds per pod	1000 grain wt.	Yield	Pod length	Harvest index
Replication	2	0.653	2.261	0.015	0.216	7.364
Factor-A (N- level)	3	0.089^{NS}	4.240**	0.051**	0.018^{NS}	287.151**
Factor-B (NAA level)	2	2.073**	7.473**	0.349**	0.085^{NS}	8.812^{NS}
Interaction (AxB)	6	0.193^{NS}	0.236^{NS}	0.003^{NS}	0.043^{NS}	11.610^{NS}
Error	22	0.086	0.537	0.004	0.046	6.691
Total	35	-	-	-	-	-

** = Significant at 1% level

* = Significant at 5% level

NS = Non Significant

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