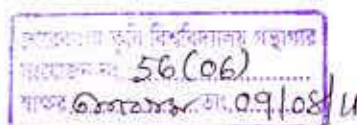


**PERFORMANCE OF NEEM-COATED UREA OVER NORMAL UREA
ON THE GROWTH AND YIELD OF BARI-BUSH BEAN-1**

BY

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CERTIFICATE

This is to certify that the thesis entitled **“Performance of Neem-Coated Urea over Normal Urea on the Growth and Yield of BARI-Bush Bean-1”** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in Soil Science, embodies the result of a piece of bonafide research work carried out by **Chinmayee Adhikari**, Registration number: **08-03201** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Dated:
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The Author

PERFORMANCE OF NEEM-COATED UREA OVER NORMAL UREA ON THE GROWTH AND YIELD OF BARI-BUSH BEAN-1

ABSTRACT

The experiment was conducted in the field of Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from October, 2008 to March, 2009 to find out the performance of Neem-coated urea over normal urea on the growth and yield of BARI Bush bean-1. The experiment consisted of the treatments T_0 : No nitrogen, T_1 : 40 kg N/ha, T_2 : 80 kg N/ha, T_3 : 120 kg N/ha, T_4 : 160 kg N/ha, T_5 : 40 kg N/ha (supplied neem-coated urea), T_6 : 80 kg N/ha (supplied neem-coated urea), T_7 : 120 kg N/ha (supplied neem-coated urea) and T_8 : 160 kg N/ha (supplied neem-coated urea). The tallest plant (13.83 cm, 24.09 cm, 40.04 cm, 46.20 cm and 54.90 cm) at different days interval was recorded from T_7 , while at the same interval the shortest plant (10.27 cm, 19.35 cm, 31.15 cm, 35.66 cm and 44.20 cm) from T_0 . The maximum number of pods per plant (32.05) was obtained from T_7 , while the minimum number (21.03) from T_0 . The highest pods yield (16.28 t/ha) was observed from T_7 , while the lowest yield (11.57 t/ha) from T_0 . Use of neem-coated urea increased pod number per plant significantly at all levels compared to the respective normal urea treatments. However, in terms of pod yield (t/ha) neem-coated urea at the rate of 120 kg N/ha only had significant favorable over normal urea at the same rate. Neem-coated urea failed to have any significant effect on plant height at 55 DAS. The maximum concentration of N (3.85%), P (1.51%), K (1.36%) and S (1.25%) in plant was recorded with T_7 and the minimum concentrations of N (1.21%), P (0.36%), K (0.34%) and S (0.33%) in plant were observed from T_0 . The maximum uptake by stover for N (41.52 kg/ha), P (6.34 kg/ha), K (14.15 kg/ha) and S (8.23 kg/ha) were recorded from T_7 , again the minimum uptake by stover for N (11.04 kg/ha), P (3.00 kg/ha), K (7.44 kg/ha) and S (4.33 kg/ha) were found from T_0 . The maximum uptake by pod for N (65.63 kg/ha), P (17.03 kg/ha), K (36.26 kg/ha) and S (3.18 kg/ha) were obtained from T_7 , while the minimum uptake by pod for N (10.21 kg/ha), P (10.16 kg/ha), K (21.69 kg/ha) and S (2.26 kg/ha) were observed from T_0 . The highest pH (5.57), organic matter (1.45%), total N (0.088%), available P (22.78 ppm), exchangeable K (0.18 me%) and available S (30 ppm) were found from T_4 and the lowest pH (4.06), organic matter (1.01%), total N (0.12%), available P (13.75 ppm), exchangeable K (0.11 me%) and available S (0.17 ppm) were recorded from T_0 .



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CHALTER I

INTRODUCTION



CHAPTER I

INTRODUCTION

Bush bean (*Phaseolus vulgaris* L.) is an important vegetable crop belonging to the family *Leguminosae* and sub-family *Papilionaceae* was originated in the Central and South America (Swiader *et al.*, 1992). It is also known as French bean, Kidney bean, Snap bean, Pinto bean, Green bean, Raj bean, Navy bean, Pole bean, Wax bean, and Bonchi in different countries of the World (Duke, 1983; Salukhe *et al.* 1987; Tindall, 1988). In our country it is known as 'Farashi Seem' (Rashid, 1993). Bush bean is mainly used as green vegetables and its young pods and mature seeds are also used as cooked vegetable.

Bush bean is widely cultivated in the temperate and subtropical regions, and also in many parts of the tropics (Purseglove, 1987). It is intensively grown in five major continental areas: Eastern Africa, North and Central America, South America, Eastern Asia and Western and South Eastern Europe. It is more suitable as a winter crop in the northeastern parts of India (AICPIP, 1987). According to FAO statistics, bush bean including other related species of the genus *Phaseolus* occupied 27.08 million hectares of the World's cropped area, and the production of dry pods was about 18.94 million tons with an average yield of 699 kg ha⁻¹ (FAO, 2000). Brazil is the largest bush bean producing country in the world. In Bangladesh there is no statistics about the area and production of this crop. It is not new crop in our country. It is cultivated in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country in a rather limited scale.

Immature pods are marketed fresh, frozen or canned. The crop also provide hay, silage and green manures. After harvest, plants can be fed to cattle, sheep and

horses. Its edible pods supply protein, carbohydrate, fat, fibre, thiamin, riboflavin, Ca and Fe (Shanmugavelu, 1989) and the seed contains significant amount of thiamin, niacin, folic acid (Rashid, 1993). Recently cultivation of bush bean is gaining popularity in Bangladesh mainly because of its demand as a commodity for export. But the productivity of bush bean at the farmers' field is very low (7-8 q ha⁻¹) and it does not mean the low yield potentiality of this crop. Lack of information about its management practices, poor fertility management, judicious level of fertilizer and exclusively growing local cultivars are the reasons for low potentiality of this crop (Saini and Negi, 1996).

Bush bean shows high yield potential, but unlike other leguminous crops it does not nodulate with the native rhizobia (Ali and Kushwaha, 1987). Therefore, requirement of nitrogenous fertilizers for the crop is of prime importance. Nutrient requirement for different cultivars usually is similar except on poor soils (Adams, 1984). Bush bean cultivation requires ample supply of nitrogen. Nitrogen is necessary for its vegetative growth and development. Fertilizer placement at 10-15 cm depth has promoted growth and development of root and shoot of bush bean (Chaib *et al.*, 1984). However, excessive or under dose of nitrogen can affect the growth and yield. An optimum amount of nitrogen is necessary to produce maximum yield of good quality bush bean. In case of application of the various fertilizer doses, there were significant differences in different yield contributing characters and yield of bush bean (Sa *et al.*, 1982; Tewari and Singh, 2000).

Nitrogen is one of the most essential elements for crop production. It encourages vegetative growth and increases leaf area of plants, which helps in photosynthetic activity. It stimulates root growth and development of the plant. Furthermore, it

helps in uptake of other nutrients from the soil. Both excess and under doses of nitrogen hampered the yield. So for higher yield, judicious amount of nitrogen should be applied. Organic matter is the main source of nitrogen and Bangladesh soil are deficit in organic matter content. Nitrogen content of Bangladesh soil is very low. Nitrogen should be applied in such a way that minimizes leaching loss and maximize its utilization for crop production. Nitrogen is necessary for germination to pod maturity of bush bean. An optimum amount of nitrogen for the whole growth period is necessary to produce maximum yield of good quality bush bean. Neem coated urea are capable to ensure nitrogen requirement with slow releasing nitrogen.

Under the above prospective, therefore, the present study has been designed with the following objectives:

- (i) To investigate the effect of neem-coated urea as a slow release nitrogenous fertilizer on the yield and yield contributing characters of BARI bush bean-1.
- (ii) To compare the performance of neem coated urea over normal urea on the growth and yield of BARI bush bean-1.

CHAPTER II

REVIEW OF LITERATURE



CHAPTER II

REVIEW OF LITERATURE

Bush bean is one of the most important legume vegetables in the world. Researches on various aspects of its production technology have been carried out worldwide. Many research works have been done in different parts of the world to study the effect of the nitrogen on the growth and yield of bush bean. However, studies in this area appear very limited in Bangladesh. For a better understanding and to know the research status on performance of nitrogen of bush bean, the relevant available literature have been reviewed and presented below:

An experiment comprising two varieties (BARI bush bean-1 and BARI bush bean-2), three plant densities (500×10^3 , 333×10^3 , and 250×10^3 plants/ha as maintained by 20×10 , 30×10 , and 40×10 cm spacings, respectively) and three levels of N (0, 60, and 120 kg/ha) was conducted by Moniruzzaman *et al.* (2009) at the Agricultural Research Station, Raikhali in the district of Rangamati during the winter (rabi) seasons of 2004-05 and 2005-06. Application of 120 kg N/ha coupled with the highest plant density (500×10^3 plants/ha) gave the maximum pod yield of 34.3 t/ha and 30.2 t/ha in BARI bush bean-I and BARI bush bean-2, respectively.

A study was conducted by Deshmukh *et al.* (2007) in Maharashtra, India, during the rabi season of 2004-05 to determine the response of French bean cultivars (Arka Komal, Varun, Contender and PDR 14) to different nitrogen rates (0, 50, 100 and 150 kg/ha). Dry pod weight per plant, seed weight per plant, number of

seeds per pod and 100-seed weight were significantly influenced by the nitrogen treatment. Application of 150 and 100 kg N/ha had superior effect on all the yield attributes compared to treatments with 50 and 0 kg N/ha. The 100-seed weight and yield per plant were maximum in Varun followed by Contender, Arka Komal and PDR 14. The number of seeds per pod was significantly higher in Arka Komal and Contender due to their long pods. Less number of seeds per pod were observed in Varun and PDR 14 due to their short pods. Higher dry pod yields were recorded with applications of 150 and 100 kg N/ha. The beneficial effect of nitrogen was observed on seed yield. There was incremental increase in biological yield and straw yield with the application of 150 and 100 kg N/ha.

Mahase *et al.* (2007) conducted an experiment in Nagpur, Maharashtra, India, during the rabi of 2005-06 to study the effects of nitrogen and irrigation levels on French bean (*P. vulgaris* cv. VL-63). In case of nitrogen levels, 105 kg N ha⁻¹ proved significantly superior with respect to yield attributes, yield and water use efficiency than 75 kg N ha⁻¹ and 45 kg N through urea + 45 kg N through FYM, while 90 kg N ha⁻¹ was on a par in terms of yield attributes and yield with 105 kg N ha⁻¹.

The effect of N (0, 60, 90 and 120 kg/ha) and P (0, 45, 60 and 75 kg/ha) on the yield and quality of French bean on vertisols was evaluated by Umap *et al.* (2006) in Maharashtra, India N at 120 kg/ha produced the highest seed yield and stover yield of 14.45 and 17.74 q/ha, which was 50.83 and 53.06% higher than the control, respectively. Many plant species are characterized by pronounced



sensitivity to sole ammonium supply and exhibit growth depression and particularly reduced leaf growth rates. Stress symptoms under sole ammonium supply may be related to perturbation of photosynthetic processes, e.g., low rates of net CO₂ assimilation, low quantum yield, reduced stomatal conductance, and carboxylation capacity. The results of three experiments with French bean plants supplied with an N concentration of 5 mM illustrate significantly lower dry mass and specific leaf area, reduced leaf expansion, and higher chlorophyll and N content of ammonium- compared to nitrate-supplied plants. Light-saturated rates of CO₂ assimilation per unit leaf area were higher under ammonium compared to nitrate supply while no significant effects of N form on quantum yield. It is concluded that ammonium supply had no negative effects on the operation of photosynthetic protein-enzyme complexes.

Kikuti *et al.* (2005) studied the effects of different levels of N (0, 70, 140 and 210 kg ha⁻¹, urea source) and P₂O₅ (0, 100, 200 and 300 kg ha⁻¹) triple super phosphate source) on the bean. The initial and final stands of the plants, grain productivity and the utilization efficiency in response to N and of P₂O₅ treatments were evaluated. The N and K association resulted in small bean plant populations, and the P lessened that effect. The productivity was increased in response to N and P₂O₅ treatments, which varied according to the seasons. The maximum efficiency was obtained with N and P₂O₅ levels higher than those recommend for bean crop.

Bildirici *et al.* (2005) conducted an experiment during 2001 and 2002 to determine the effects of bacterial (*Rhizobium phaseoli*) inoculation, N fertilizers (0, 20, 40,

60 kg N ha⁻¹) and P fertilizer (0, 40, 60, 80 kg P₂O₅ ha⁻¹) on field bean. Nitrogen fertilizer exerted a significant and positive effect on pod number, grain yield and raw protein proportion, whereas no significant effect was observed on seed number pod⁻¹ and 1000-seed weight.

The effects of N (0, 20, 40 and 60 kg ha⁻¹) and P (0, 30, 60 and 90 kg P₂O₅ ha⁻¹) on the seed yield of pea cv. Arkel and french bean [*Phaseolus vulgaris*] were investigated in Uttar Pradesh, India during 2002-03 (Lal, 2004). Nitrogen at 40 kg ha⁻¹ was optimum for obtaining the maximum pea and bean seed yields.

Prajapati *et al.* (2004) conducted an experiment in Sardar Krushinagar, Gujarat, India, to study nutrient uptake and yield of french bean as affected by weed control methods and nitrogen levels (0, 40, 80 and 120 kg ha⁻¹). Among the N rates, 120 kg ha⁻¹ recorded the greatest N uptake (56.70 kg ha⁻¹), P uptake (18.47 kg ha⁻¹), K uptake (37.34 kg ha⁻¹), grain yield (1091.77 kg ha⁻¹), straw yield (1932.35 kg ha⁻¹), protein yield (228.39 kg ha⁻¹), net returns (10816 rupees ha⁻¹), and cost benefit ratio (1: 2.44).

Ram-Gopal *et al.*, (2003) investigated the effects of irrigation (0.5, 0.7 and 0.9 W/CPE) and nitrogen rates (50, 100 and 150 kg ha⁻¹), with or without 5 t farmyard manure (FYM)/ha, on the yield and water use of french bean (*Phaseolus vulgaris*) in a field experiment conducted in Faizabad, Uttar Pradesh, India. Plant height, number of branches plant⁻¹, dry matter plant⁻¹, grain yield, consumptive use of water and water use efficiency increased with increasing irrigation and N rates and with the addition of FYM.

Dhanjal *et al.* (2003) conducted a field experiment in Uttar Pradesh, India. The treatments consisted of 3 french bean (*P. vulgaris*) cultivars (HUR 87, PDR 14 and VL 63), 3 planting densities (250×103 , 333×103 and 500×103 plants ha^{-1}) and 3 N levels (0, 60 and 120 kg ha^{-1}). Leaf area index and crop growth rate were highest at 500×103 plants ha^{-1} , whereas dry weight plant^{-1} , net assimilation rate and relative growth rate in general were the highest at 250×103 plants ha^{-1} . Increasing levels of N up to 120 kg ha^{-1} increased dry weight, leaf area index, crop growth rate and relative growth rate, but net assimilation rate increased up to 60 kg N ha^{-1} only.

A field experiment was conducted by Vishwakarma *et al.* (2002) to determine the response of two french bean (*Phaseolus vulgaris*) cultivars (Holland 84 and PDR 14) to different nitrogen application rates (0, 30, 60, 90 kg ha^{-1}) on sandy loam soil in Varanasi, Uttar Pradesh, India. Both cultivars showed differential performance for growth and yield attributes. Holland 84 was the tallest; whereas PDR 14 recorded the highest dry matter production plant^{-1} as well as pods plant^{-1} , grains pod^{-1} , grains plant^{-1} , pod length and 100-grain weight. The growth, yield attributes and yield (grain and stover) increased with increasing rates of nitrogen up to 90 kg ha^{-1} .

A two-year experiment was conducted during 1995-97 with 5 nitrogen (0, 30, 60, 90 and 120 kg ha^{-1}) and 3 phosphorus levels (0, 30 and $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$) to study their impact on the growth, yield attributes, yield and economics of french bean (cv. PDR 14) under late-sown conditions of eastern Uttar Pradesh, India (Singh

and Verma, 2002). They showed that the highest rates of nitrogen (120 kg ha^{-1}) and phosphorus (60 kg ha^{-1}) resulted in the highest plant height, branches per plant, pods per plant, seeds per pod, 100-seed weight, grain yield (21.19 q ha^{-1} with 120 kg N ha^{-1} ; and 18.68 q ha^{-1} with $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$) and straw yields (29.76 q ha^{-1} with 120 kg N ha^{-1} and 24.76 q ha^{-1} with $60 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$).

Chandel *et al.* (2002) conducted a field experiment to determine the effect of different nitrogen levels (0, 40, 80, 120 kg ha^{-1}) and *Rhizobium* inoculation (control, HURR-3, and Raj-2) on crop yield, nitrogen uptake and crop quality of french bean cv. HUR-137 in Varanasi, Uttar Pradesh, India. The yield components, crop and protein yield significantly increased with increasing nitrogen levels and the highest values were registered with 120 kg N ha^{-1} during both years. *Rhizobium* inoculation increased crop yield over the control. Strain Raj-2 produced significantly higher grain and protein yield compared to HURR-3.

A field experiment was conducted by Farkadeet and Pawar (2002) in Maharashtra, India to determine the effect of N: P fertilizers at 60: 45, 90: 75 and 120: 75 kg/ha on *Phaseolus vulgaris* cultivars. The yield and growth characters increased with increasing N: P fertilizer level and the highest (15.93 q ha^{-1}) were observed at 120: 75 kg/ha.

Rahman (2001) conducted an experiment at Horticulture Farm, Bangladesh Agricultural University, Mymensingh to investigate the influence of nitrogen and plant spacing on French bean. He used four levels of nitrogen viz. 0, 30, 60 and 90 kg N/ha and found that plant height, number of branches per plant, green pod

length, individual pod weight, pods per plant and green pod yield per hectare were significantly influenced by higher dose of nitrogen.

Chaudhuri *et al.* (2001) conducted an experiment in Nagpur, India to study the nutrient management of French bean. They reported that application of nitrogen significantly increased the plant height; pod number and grain yield plant⁻¹ in french bean. They recommended nitrogen fertilizer dose of 90 kg N ha⁻¹.

Rejesh and Singh (2001) carried out a field experiment in India to evaluate the effects of N (80, 160 and 240 kg ha⁻¹) and S (0, 20, 40 and 60 kg ha⁻¹) on the nutrient uptake and grain yield of french bean (*Phaseolus vulgaris* cv. HUR 137). The highest grain yield (2,091 kg/ha) straw yields (3,331 kg ha⁻¹), total N uptake (90.70 kg ha⁻¹) and S uptake (6.58 kg ha⁻¹) was recorded at N level of 240 kg ha⁻¹ and sulphur (S) at 40 kg ha⁻¹ recorded the highest grain yield (1,811 kg ha⁻¹) total N uptake (77.45 kg ha⁻¹) and S uptake (6.06 kg ha⁻¹).

Dhanjal *et al.* (2001) conducted a field experiment in Uttar Pradesh, India to study the effects of crop density (500,000, 333,000, or 250,000 plants ha⁻¹) and N (0, 60, or 120 kg ha⁻¹ applied at sowing) on the yield and yield components of *P. vulgaris* cultivars. The lowest crop density (250,000 plants ha⁻¹) gave the highest values of growth and yield components, except plant height which was the highest under 500,000 plants ha⁻¹. The highest seed and stover yields were recorded under medium crop density (333,000 plants ha⁻¹). The increase in N rate gave a corresponding improvement in yield and yield components.

Prajapati *et al.* (2001) conducted an experiment in Gujarat, India, to determine the effects of weed control methods and N fertilizer application on the physiology of french bean. The highest values of fresh and dry weight per plant, net assimilation rate (NAR), crop growth rate (CGR), relative growth rate (RGR), and grain yield were recorded under weed free conditions. Similarly, most of the physiological parameters, namely fresh and dry matter production per plant, LAI, NAR, RGR, and CGR were significantly high with 120 kg N/ha.

Bassan (2001) studied the Mo application through leaves or in the rows, and side dressing with 4 N levels on a winter bean (*Phaseolus vulgaris*) crop. Inoculation increased plant dry matter weight, but decreased the number of pods plant⁻¹, grains plant⁻¹ and 100-seed weight. N applied at 90 kg ha⁻¹ resulted in high seed production, with or without inoculation. No effect of Mo was observed in any of the treatments. Inoculation did not affect seed germination and field seedling emergence, whereas the treatment without Mo and with 90 kg N ha⁻¹ provided seeds with high germination index.

Tewari and Singh (2000) conducted a field trial in Uttar Pradesh, India to determine the optimum and economical dose of nitrogen (0, 40, 80, 120 or 160 kg N ha⁻¹) and phosphorus (0, 20, 40 or 60 kg P₂O₅ ha⁻¹) for better growth and seed yield of french bean. Plant height, number of branches and length of pod increased with successive increase in the doses of nitrogen as well as phosphorus. Application of 120 kg N ha⁻¹ produced significantly higher number of pods plant⁻¹, weight of seeds plant⁻¹, number of seeds pod⁻¹ and seed yield, whereas 160 kg N



ha⁻¹ significantly reduced seed yield. The highest values on the above yield attributes were recorded with 60 kg P₂O₅ ha⁻¹. The combination of 120 kg N + 60 kg P₂O₅ ha⁻¹ along with 60 kg K₂O ha⁻¹ gave the highest seed yield, net profit and net return per rupee investment.

Teixeira *et al.* (2000) conducted a field experiment to study the effect of sowing density (6, 10, 14 and 18 seeds m⁻²) and N levels (0, 50, 100 and 150 kg N ha⁻¹) on *P. vulgaris*. Grain yield increased with increasing N rates, resulting in increased numbers of pods plant⁻¹, seeds pod⁻¹ and 100-seed weight. This effect, however, was influenced by seasons and sowing densities. An increase in sowing density reduced the number of pods plant⁻¹, and in the absence of N fertilizers increased the grain yield. An increase in sowing density also reduced weed infestation during harvest.

Ghosal *et al.* (2000) conducted a field trial in Bihar, India to study the effect of varying N rates (0, 40, 80, 120, 160 kg N ha⁻¹) and times of application on the growth and yield of french bean. They observed that nitrogen at the rate of 160 kg N ha⁻¹ resulted in significantly highest values for number of pods plant⁻¹, weight of pods plant⁻¹, grain yield and straw yield.

Daba and Haile (2000) reported that *Rhizobium* inoculation and N significantly increased grain yield, nodule number and dry matter yield of french bean. Singh and Singh (2000) carried out a field trial in India with different nitrogen levels (0, 40, 80 or 120 kg N ha⁻¹) on yield and yield components of french bean. They observed that seed yield and 100-seed weight increased with increasing N rate.

Arya *et al.* (1999) conducted an experiment in India to investigate the effect of N, P and K on French bean. They used different doses of NPK combinations. It was concluded that N promoted growth and suggested that 25 kg N ha⁻¹, 75 P₂O₅ kg ha⁻¹ and 50 kg K₂O ha⁻¹ was the best combination in terms of economics and seed yield.

Sushant *et al.* (1998) conducted an experiment in India to investigate the effect of N (0, 50 or 100 kg N ha⁻¹) and P (0, 30 or 60 kg P ha⁻¹) on the yield and water use efficiency of french bean. Yield increased with increasing irrigation and N and P rates. The highest yield was obtained at 100 kg N ha⁻¹ and 60 P₂O₅ kg ha⁻¹. Water use efficiency increased with increasing N and P rates. Interaction of irrigation and N, and N and P was significant for pods plant⁻¹ and seed yield.

In a field experiment during the rainy seasons of 1993/94 and 1994/95 at Rahuri, Maharashtra, India, and *P. vulgaris* cv. Waghya was irrigated at flowering and/or branching and was given 0, 40, 80 or 120 kg N ha⁻¹ (Wani *et al.*, 1998). Yield and yield component values increased with increasing N rate and were highest with irrigation at 75 mm CPE.

Nandan and Prasad (1998) conducted a field trial at Pusa, Bihar to study yield and water use efficiency of *P. vulgaris* cv. Uday and was given 6 irrigation treatment and 3 N treatments (40, 80 or 120 kg N ha⁻¹). Seed yield in the first year was the highest (1.31 t ha⁻¹) when given 3 irrigations at 25, 50 and 75 days after sowing, while in the second year the highest yield of 1.35 t ha⁻¹ was obtained when

irrigating at a 0.8 IW: CPE [irrigation water: cumulative pan evaporation] ratio. Yield and water use efficiency increased with increasing N rate in both years.

In a field trial conducted at India Lakhaoti, Rana *et al.* (1998) found that *Phaseolus vulgaris* seed and straw yields increased significantly with each increment in N rate in both seasons. The mean increase in seed yields with 120 kg N ha⁻¹ compared with 0, 40 and 80 kg N ha⁻¹ was 66.6, 21.7 and 7.0% respectively. Growth and yield parameters generally followed the same trend. Applied P also increased seed yield, and 100 kg P₂O₅ ha⁻¹ gave 39.8 and 7.4% more yield than 0 and 50 kg P₂O₅ ha⁻¹, respectively.

An experiment was carried out in Uttar Pradesh, India by Baboo *et al.* (1998) to study the response of bush bean to applied nitrogen. Seed yield was increased with the increase of nitrogen and it was higher with 120 kg N ha⁻¹. Gajendra and Singh (1998) stated that application of 120kg N ha⁻¹, 90 kg P₂O₅ ha⁻¹ and 45 kg K₂O ha⁻¹ gave higher grain yield of bush bean.

Calvache *et al.* (1997) found significant increase in seed yield, pod number plant⁻¹, number of seeds pod⁻¹ and harvest index in french bean through increased nitrogen application. Durge *et al.* (1997) stated that the highest yield of french bean (957kg ha⁻¹) was obtained with 150 kg N ha⁻¹.

Furlani *et al.* (1996) conducted an experiment in green house and observed a highly significant correlation between leaf chlorophyll content and leaf N concentration with N application rate. It was concluded that the chlorophyll



content gave accurate assessment of N status in bean plant. Sharma *et al.* (1996) studied the effect of N fertilizer (0, 40, 80 and 120 kg N ha⁻¹) and timing of application on growth and yield of french bean. They observed that increasing level of N significant increase in seed yield, number and weight of pods plant⁻¹ and number of seeds pod⁻¹ upto 120 kg N ha⁻¹. However, in the case of seed yield, pod length and 100 seed weight, variation in 80 and 120 kg N ha⁻¹ were not significant. They also reported that application of N in three equal splits gave higher seed yield attributes in french bean.

Koli *et al.* (1996) conducted an experiment in Maharashtra, India to study the influence of row spacing, plant densities and nitrogen levels on yield of french bean. Results revealed that seed yield was the highest with 60 kg N ha⁻¹ and at the density of 333,333 plants ha⁻¹ (1.41 t) and the row spacing of 30 cm (1.13 t).

Singh *et al.* (1996) investigated the response of french bean to spacing and nitrogen levels. They reported that seed yield increased with up to 120 kg N and 30 × 10 cm spacing. An experiment was conducted by Dahatonde and Nalamwar (1996) at Maharashtra, India to study the effect of nitrogen and irrigation levels on yield and water use of french bean. Seed yields were increased significantly up to 90 kg N ha⁻¹.

A field experiment was conducted by Bagal and Jadhav (1995) to find out the effects of nitrogen and *Rhizobium* on yield and nutrient uptake by french bean. Seeds were inoculated with *Rhizobium phaseoli* or not inoculated and the crop was

given 0, 12.5, 25 or 37.5 kg N ha⁻¹. Seed yield and total P uptake increased up to 25 kg N ha⁻¹, whereas total N and K uptake increased up to 37.5 kg ha⁻¹.

Verma and Saxena (1995) reported the growth and yield of *P. vulgaris*. in response of 0, 60 or 120 kg ha⁻¹ each of N as urea, P₂O₅ as super phosphate and K₂O as muriate of potash. Seed yields were the highest with 120 kg N or 120 kg P₂O₅, but were not significantly affected by K₂O.

Dwivedi *et al.* (1994) conducted a field experiment during the winter seasons of 1990-92 at Agwanpur, Bihar *Phaseolus vulgaris* cv. PDR 14 was sown at inter-row spacing of 30, 45 or 60 cm with an intra-row spacing of 8 cm to give densities of 400000, 286000 and 200000 plants ha⁻¹, respectively, and was given 40, 60, 80 or 100 kg N ha⁻¹. Seed yield was the highest at the density of 400000 plants ha⁻¹ and increased with up to 80 kg N ha⁻¹.

Carranca *et al.* (1993) conducted an experiment on *Phaseolus vulgaris* cv. *Martingal* plants on a heavy alluvial soil supplied with 20, 80, 140 or 200 kg N ha⁻¹. Fertilizer treatment did not significantly influence pod yield, N uptake or crop quality. At the end of the growing cycle nitrate accumulation in the soil was observed at the highest N application rates. The lowest N rate (20 kg ha⁻¹) was sufficient to obtain yields >10 000 kg ha⁻¹ without decreasing the pod quality for deep freezing. Seasonal variations affected yield, pod N content and most quality characteristics with high significance, except for N content in tops and pod alcohol-insoluble solids content.

Negi and Shekhar (1993) conducted a field trial in Himachal Pradesh, India to study the response of French bean genotypes to nitrogen. They used *Phaseolus vulgaris* cv. Katrain 1, Him 1, B₄ and B₆ and 0–90 kg N/ha and observed that seed yield was the highest in B₆ (1.99 t ha⁻¹) and lowest in Katrain 1 (1.45 t ha⁻¹) and it increased with up to 60 kg N ha⁻¹.

Dahatonde *et al.* (1992) carried out an experiment in Akola, India to observe the response of french bean to irrigation regimes and nitrogen levels (0–120 kg N ha⁻¹). They stated that seed yield increased from 0.38 to .92 t ha⁻¹ with the increase in number of irrigation and N application with up to 90 kg ha⁻¹.

Bhatnagar *et al.* (1992) conducted a field trial at Rajasthan, India to find out the effect of nitrogen on french bean during winter. Nitrogen was applied at 20, 40 or 60 kg ha⁻¹. They reported that seed yield and nitrogen uptake in seed increased and crude protein percentage decreased with increasing nitrogen application rate.

Bengtsson (1991) conducted an experiment on bush bean with 0, 30 or 60 kg N ha⁻¹. N fertilizer generally increased seed yield, 1000-seed weight and seed protein content. The number of root nodules was significantly increased by inoculation.

Parthiban and Thamburaj (1991) recorded an increased grain yield with nitrogen fertilization upto 50 kg N ha⁻¹. Number of pods and grain yield plant⁻¹ increased significantly with nitrogen fertilization over the control.

A field experiment was carried out by Srinivas and Naik (1990) at Bangalor, India to investigate the growth, yield and nitrogen uptake by vegetable french bean as

influenced by nitrogen and phosphorus fertilizers. Nitrogen was applied at 0, 40, 80, 120 and 160 kg ha⁻¹ and P₂O₅ at 0, 40 and 80 kg ha⁻¹. They observed that application of nitrogen and phosphorus increased plant growth, nutrient uptake and yield of green pods.

Hegde and Srinivas (1990) worked on the water relation and nutrient in french bean and observed that nitrogen application increased green pod yield, nutrient uptake and water use efficiency but had no marked effect on water relation and canopy temperature. Singh *et al.* (1990) reported that N fertilization and irrigation on french bean increased the number of pods plant⁻¹ and 100 seed weight with increase in nitrogen level.

In a field at Bangalore, India Hegde and Srinivas (1989) worked on the effect of irrigation and nitrogen on growth, yield and water use of french bean. In their trial, the crop received 0, 40, 80 or 120 kg ha⁻¹ of nitrogen. The green pod yield was the greatest (124.3 – 132.3 q ha⁻¹) at the highest N rate. Kucy (1989) noted that addition of nitrogen at 30 mg kg⁻¹ soil had stimulatory effect on plant growth.

Srinivas and Naik (1988) carried out an experiment at Bangalore, India to study the response of vegetable French bean to nitrogen and phosphorus fertilization. Nitrogen was applied at 0, 40, 80, 120 or 160 kg N ha⁻¹. They reported that pod yields were increased with increasing fertilizer rate, from 3927 kg ha⁻¹ at 0 kg ha⁻¹ to 13167 kg ha⁻¹ at 160 kg N ha⁻¹. Ali and Tripathi (1988) worked with an experiment in Uttar Pradesh, India to observe the influence of genotype, nitrogen levels (0 – 60 kg ha⁻¹) and plant population of french bean and noticed that number

of pods plant⁻¹, 100- seed weight, seed yield and seed protein content increased with increasing nitrogen rate.

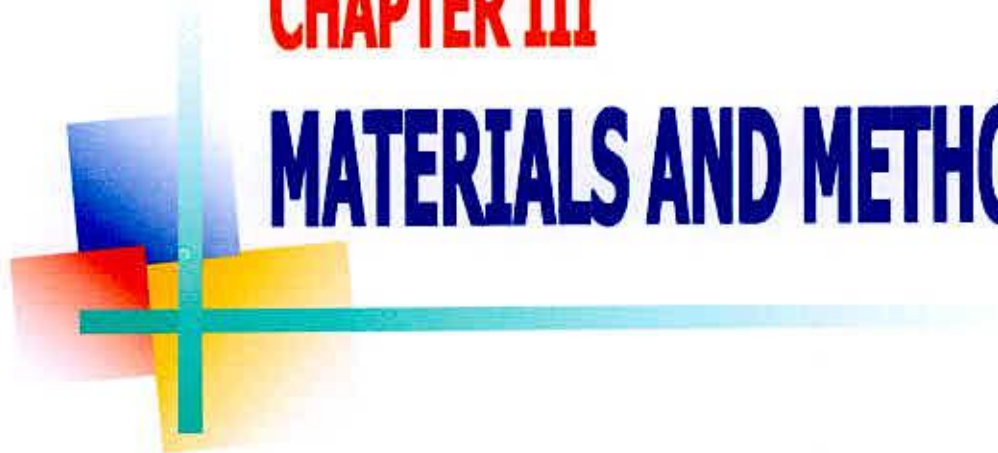
Bhopal and Singh (1987) conducted a field trial in Himachal Pradesh, India to find out the response of french bean to nitrogen and phosphorus fertilizers with french bean grown for green pods. Nitrogen was applied at 0-90 kg ha⁻¹ and P₂O₅ at 0-120 kg ha⁻¹, and a basal dose of K₂O at 50 kg ha⁻¹. The optimum nitrogen: phosphorus dose was 67.3: 79.7 kg ha⁻¹ which gave yields over 210 q ha⁻¹.

In a field trial at Varanasi India, Chandra *et al.* (1987) showed that plant growth and yield (46.19 - 71.59 q ha⁻¹) increased with increasing N (0 - 50 kg ha⁻¹) and with seed inoculation with *Rhizobium*. Kushwaha (1987) conducted an experiment in Uttar Pradesh, India to study the response of french bean to different levels of nitrogen and phosphorus. He used 0, 30, 60, 90 and 120 kg N ha⁻¹ and obtained seed yields of 1.32, 2.05, 2.33, 2.54 and 2.76 t ha⁻¹, respectively. It was reported that yield differences were associated with differences in pod number per plant.

Katoch *et al.* (1983) while working with nitrogen reported that 30 kg N ha⁻¹ increased nodule number and nodule weight plant⁻¹ of french bean.

CHAPTER III

MATERIALS AND METHODS



CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October, 2008 to March, 2009 to find out the performance of Neem-coated urea over normal urea on the growth and yield of BARI bush bean-1. This chapter is presents a brief description of the experimental location, soil, climate, experimental design, treatments, cultural operations, data collection and analysis of different parameters under the following headings-

3.1 Location

The experiment was carried out in the field of Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^{\circ}74'N$ latitude and $90^{\circ}35'E$ longitude and an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone (AEZ- 28), Madhupur Tract and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed for some important physical and chemical parameters. The initial physical and chemical characteristics of the soil are presented in Table 1.

Table 1. Initial characteristics of the soil in the experimental field

1. pH		5.7
2. Particle-size analysis of soil	Sand	29.04
	Silt	41.80
	Clay	29.16
3. Textural Class		Silty Clay Loam
4. Organic matter (%)		0.840
5. Total N (%)		0.0670
6. Phosphorous (ppm)		8.333
7. Potassium (ppm)		25.00

3.3 Climate

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details of the meteorological data related to the temperature, relative humidity and rainfalls during the period of the experiment was collected from the Bangladesh Meteorological Department, Dhaka and presented in Appendix I.

3.4 Planting material

Seeds of BARI bush bean-1 used as a test crop for the study and the seeds of this variety were collected from Bangladesh Agricultural Research Institute, Gazipur. This variety was developed by BARI and exposed for cultivation in the year of 1996 (BARI, 2006). It is a dwarf and bushy type plant and can be easily grown in minimum or shading light.

3.5 Treatment of the Experiment

The experiment was done with the following treatments:

T₀: 0 kg N/ha

T₁: 40 kg N/ha (Supplied by normal urea)

T₂: 80 kg N/ha (Supplied by normal urea)

T₃: 120 kg N/ha (Supplied by normal urea)

T₄: 160 kg N/ha (Supplied by normal urea)

T₅: 40 kg N/ha (Supplied by neem-coated urea)

T₆: 80 kg N/ha (Supplied by neem-coated urea)

T₇: 120 kg N/ha (Supplied by neem-coated urea)

T₈: 160 kg N/ha (Supplied by neem-coated urea)

3.6 Layout of the Experiment

The experiment was laid out in single factors Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the treatments in each plot of each replication. Each replication was divided into 9 plots where 9 treatment combinations were allotted at random. There were 27 unit plots altogether in the experiment. The size of the plot was 2.1 m × 1.5 m. The distance between two replication and two plots were kept 1 m and 50 cm respectively. The layout of the experiment is shown in Figure 1.



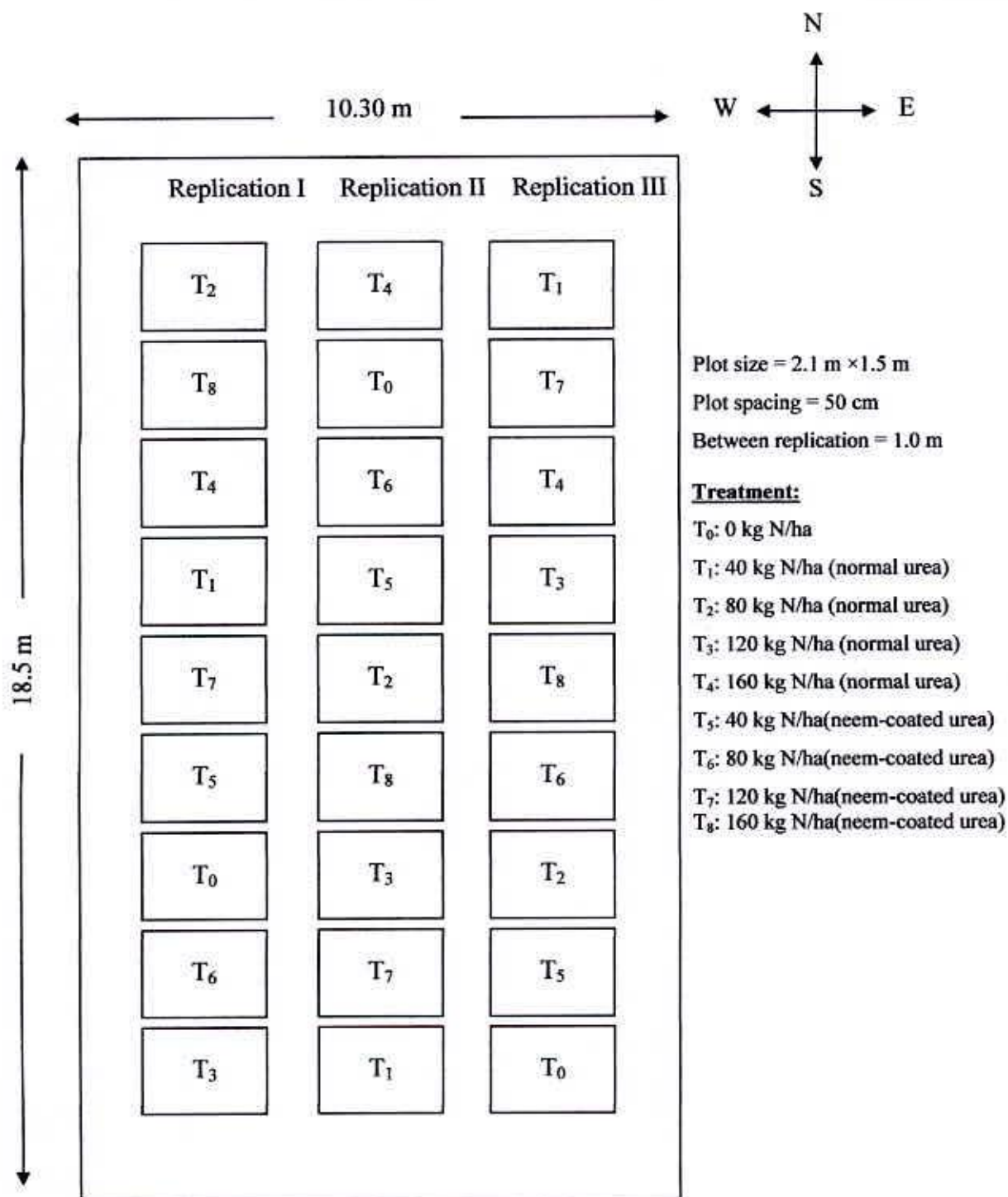


Figure 1. Layout of the experimental field

3.7 Land preparation

The experimental field was first opened on October 24, 2008 with the help of a power tiller and prepared by three successive ploughings and cross-ploughings. Each ploughing was followed by laddering to have a desirable fine tilth. The visible larger clods were hammered to break into small pieces. All kinds of weeds and residues of previous crop were removed from the field. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.8 Fertilizer application

Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of cowdung, TSP, MP, total zinc and sulfur was applied as basal dose at the time of land preparation. Total amount of Neem-coated urea was applied in one installment and normal Urea (as per treatment) was applied in two installments at 15 and 30 days after seed sowing.

Table 2. Dose and method of application of fertilizers in bush bean field

Fertilizers and Manures	Dose/ha	Application (%)		
		Basal	15 DAS	30 DAS
Cowdung	10 tonnes	100	--	--
Urea	As per treatment	--	50	50
TSP	150 kg	100	--	--
MP	150 kg	100	--	--
Zinc	2 kg	100	--	--
Sulphur	10 kg	100	--	--

Source: BARI, 2006

3.9 Sowing of seeds

The seeds of BARI bush bean-1 were sown on 10 November 2008 in rows with maintaining of spacing of 30 cm × 15 cm.

3.10 Intercultural operation

3.10.1 Irrigation

Light over-head irrigation was provided with a watering can to the plots immediately after germination of seedlings. Irrigation also provided at 10 and 25 days after seed sowing.

3.10.2 Gap Filling

Dead, injured and week seedlings were replaced by healthy one from the stock kept on the border line of the experimental plot. Those seedlings were re-transplanted with a big mass of soil with roots to minimize transplanting shock. Replacement was done with healthy seedling having balls of earth that were also sowing at same date on border line. The transplanted seedlings give out with shading and watering for 3 days continued for the establishment of seedlings.

3.10.3 Weeding

Weeding was done two times at 10 and, 25 days after seed sowing followed by irrigation in the plots considering the optimum time for removal weed.

3.10.4 Plant Protection

The crop was protected from the attack of insect-pest by spraying Malathion. The insecticide application were made fortnightly as a matter of routine work from seedling emergence to the end of harvest.

3.11 Harvesting

The pod was harvested depending upon the attaining good sized and the harvesting was done manually. Enough care was taken during harvesting.

3.12 Data collection

The data were collected from the inner rows of plants of each treatment to avoid the border effect. In each unit plot, 10 plants were selected at random for data collection. Data were collected in respect of the plant growth characters and yield of bush bean. Data on plant height, number of branches per plant, number of leaves per plant were counted at 15, 25, 35, 45 and 55 days after sowing (DAS). Data were recorded on the following parameters-

3.12.1 Plant height

The height of plant was recorded in centimeter (cm) at 15, 25, 35, 45 and 55 DAS by using a meter scale. The height was measured from the ground level to the tip of the leaf of an individual plant. Mean value of ten selected plants was calculated for each unit plot.

3.12.2 Number of branches per plant

Number of branches per plant was counted and the data were recorded from randomly selected 10 plants at 15, 25, 35, 45 and 55 DAS and mean value was counted.

3.12.3 Number of leaves per plant

Number of leaves per plant was counted and the data were recorded from randomly selected 10 plants at 15, 25, 35, 45 and 55 DAS and mean value was counted.

3.12.4 Days to first flowering

The number of days from sowing to first flower opening was recorded from 10 randomly selected plants.

3.12.5 Number of flowers per plant

From 10 randomly selected plants from each unit plot numbers of flowers were counted and their mean values were recorded.

3.12.6 Number of pods per plant

From 10 randomly selected plants from each unit plot numbers of pods were counted and their mean values were recorded.

3.12.7 Number of seeds per green pod

From 10 randomly selected pods from each unit plot numbers of seeds were counted and their mean values were recorded.

3.12.8 Length of green pod (cm)

The pods from each of 10 randomly selected plant were measured using centimeter scale and the mean value was calculated and was expressed in cm.

3.12.9 Diameter of green pod (cm)

Diameter of green pod from 10 randomly selected plants from each unit plot was measured in cm with the help of slide calipers and their average was taken and was expressed in cm.

3.12.10 Length of root (cm)

The roots from each randomly selected plant were measured using centimeter scale and the mean value was calculated and was expressed in cm.

3.12.11 Dry matter content of plant (%)

One hundred and fifty grams (g) fresh weight of plant was taken from 10 randomly selected plants from each experimental plot. This 150 g plant was cut with a fine knife, there after, dried under room condition and kept in an oven at

70⁰c for drying for 72 hours until the constant weight was reached. The percentage of plant dry matter was calculated by the following formula-

$$\text{Dry matter content of plant (\%)} = \frac{\text{Dry weight of plant}}{\text{Fresh weight of plant}} \times 100$$

3.12.12 Dry matter content of pod (%)

One hundred and fifty gram of fresh weight of pod was taken from 10 randomly selected pods of each experimental plot. This 150 g pod was cut with a fine knife, there after, dried under room condition and kept in an oven at 70⁰C for drying for 72 hours until the constant weight was reached. The percent pod dry matter content was calculated by the following formula-

$$\text{Dry matter content of pod (\%)} = \frac{\text{Dry weight of pod}}{\text{Fresh weight of pod}} \times 100$$

3.12.13 Weight of fresh pods per plant (g)

Pods from 10 randomly selected plants were weighed and their average was taken in gram (g).

3.12.14 Pod yield per plant

Green pod were harvested at regular from each plant and their weight was recorded. Harvesting was done at different interval and the total pod weights were recorded from 10 plants and average for each plant was expressed in kilogram (kg).

3.12.15 Pod yield per plot

Green pod were harvested at regular from each plot and their weight was recorded. Harvesting was done at different interval and the total pod weights were recorded from each plot. The green pod yield per plot was finally converted to yield per hectare and expressed in ton (t).

3.13 Chemical analysis of plant and pod samples

3.13.1 Collection of samples

Plant and pod samples were collected and dried. The samples were finely ground by using a Wiley-Mill with stainless contact points to pass through a 60-mesh sieve. The samples were stored in plastic vial for analyses of N, P, K and S.

3.13.2 Preparation of samples

The plant and pod samples were dried in an oven at 70⁰C for 72 hours and then ground by a grinding machine to pass through a 20-mesh sieve. The seed and stover samples were analyzed for determination of N, P, K and S concentrations. The methods of analysis were as follows:

3.13.3 Digestion of plant and pod samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.2 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K₂SO₄:CuSO₄.5H₂O: Se in the ratio of 100: 10: 1), and 5 ml conc. H₂SO₄ were added. The flasks were heated at 120⁰C and added 2.5 ml 30% H₂O₂ then heating was continued at 180 ⁰C



until the digests became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4 .

3.13.4 Determination of P, K and S from plant and pod samples

3.13.4.1 Digestion of plant and pod samples with nitric-perchloric acid for P, K and S

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3 : HClO_4 in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated slowly and the temperature was raised to 200°C . Heating was stopped when the dense white fumes of HClO_4 occurred. The content of the flask were boiled until they became clean and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest.

3.13.4.2 Phosphorus

Phosphorus in the digest was determined by developing yellow color by vanadomolybdate reagent and measuring the yellow color by spectrophotometer as described in soil analysis section.

3.13.4.3 Potassium

Five milli-liter of digest sample for the plant were taken and diluted to 50 ml volume to make desired concentration so that the absorbance of sample were

measured within the range of standard solutions. The absorbances were measured by flame photometer.

3.13.4.4 Sulphur

Sulphur content in the disest was determined by turbidimetric method as described by Hunt (1984) using a spectrophotometer.

3.14 Nutrient Uptake

After chemical analysis of plant and pods the nutrient contents were calculated and from the value of nutrient contents, nutrient uptakes were also calculated by following formula:

$$\text{Nutrient uptake (kg/ha)} = \text{Nutrient content (\%)} \times \text{Yield (kg/ha)}$$

3.15 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.16 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P, K, and S contents. The soil samples were analyzed by the following standard methods as follows:

3.16.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1973).

3.16.2 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. The content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.16.3 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4 : $CuSO_4 \cdot 5H_2O$: Se in the ratio of 100: 10: 1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated to $200^{\circ}C$ and added 3 ml H_2O_2 and then heating at $360^{\circ}C$ was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al.*, 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which was placed under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Added sufficient amount of 10 N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink. The amount of N was calculated using the following formula:

$$\% \text{ N} = (\text{T}-\text{B}) \times \text{N} \times 0.014 \times 100 / \text{S}$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.16.4 Available phosphorus

Available P was extracted from the soil with 0.5 M NaHCO_3 solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated by the standard P curve (Page *et al.*, 1982).

3.16.5 Exchangeable potassium

Exchangeable K was determined by 1 N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al.* 1982).

3.16.6 Available sulphur

Available S content was determined by extracting the soil with CaCl_2 (0.15%) solution as described by (Page *et al.*, 1982). The extractable S was determined by developing turbidity by adding acid seed solution (20 ppm S as K_2SO_4 in 6N HCl) and BaCl_2 crystals. The intensity of turbidity was measured by spectrophotometer at 420 nm wavelengths.

3.17 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was done by the 'F' (variance ratio) test. The mean differences were evaluated by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability (Gomez and Gomez, 1984).

CHAPTRE IV

RESULTS AND DISCUSSION



CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the performance of Neem-coated urea over normal urea on the growth and yield of BARI Bush bean-1. Data on yield contributing characters, yield, nutrient concentration and uptake by plant and pods, nutrient status of post harvest soil was recorded and the analyses of variance (ANOVA) of the data are presented in Appendix II-IX. The results have been discussed and possible interpretations given under the following headings:

4.1 Yield contributing characters and yield of bush bean

4.1.1 Plant height

Plant height of bush bean showed significant variation due to neem-coated urea over normal urea at 15, 25, 35, 45 and 55 DAS (Table 3). The tallest plant (13.83 cm, 24.09 cm, 40.04 cm, 46.20 cm and 54.90 cm respectively) was recorded from T₇ (120 kg N/ha from neem-coated urea) which was statistically identical (13.40 cm, 23.61 cm, 39.78 cm, 45.81 cm and 53.00 cm) with T₄ (160 kg N/ha), while at the same DAS the shortest plant (10.27 cm, 19.35 cm, 31.15 cm, 35.66 cm and 44.20 cm) from T₀ which was closely followed (10.60 cm, 20.76 cm, 34.99 cm, 39.91 cm and 51.45 cm) by T₂ (40 kg N/ha). From the data it was revealed that all the treatments produced taller plants compared to the control. The increase in plant height both in normal and neem-coated might be associated with stimulating effect of nitrogen on various physiological process including cell division and cell elongation. Mahase *et al.* (2007), Vishwakarma *et al.* (2002), Farkadeet and Pawar (2002) also reported similar results from their earlier experiment using N.

Table 3. Performance of neem-coated urea and normal urea on plant height of bush bean

Treatment	Plant height (cm) at				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T ₀	10.27 e	19.35 e	31.15 d	35.66 c	44.20 b
T ₁	10.60 de	20.76 de	34.99 c	39.91 b	51.45 a
T ₂	10.50 de	22.02 c	35.52 c	40.43 b	52.03 a
T ₃	11.67 c	22.77 bc	35.65 c	43.77 a	52.00 a
T ₄	13.40 a	23.61 ab	39.78 a	45.81 a	53.00 a
T ₅	11.12 cd	21.80 cd	37.73 b	40.95 b	52.35 a
T ₆	11.47 c	22.70 bc	38.51 ab	44.01 a	53.25 a
T ₇	13.83 a	24.09 a	40.04 a	46.20 a	54.90 a
T ₈	12.77 b	22.87 abc	39.76 a	44.58 a	54.00 a
LSD _(0.05)	0.610	1.183	1.790	2.726	3.808
Level of significance	0.05	0.01	0.01	0.01	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha(neem-coated urea)

T₈: 160 kg N/ha(neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha(neem-coated urea)

4.1.2 Number of branches per plant

Significant variation was recorded for number of branches per plant of bush bean due to neem-coated urea over normal urea at 15, 25, 35, 45 and 55 DAS (Table 4). The maximum number of branches per plant (2.10, 7.25, 8.77, 11.87 and 14.25) was obtained from T₇ (120 kg N/ha neem-coated urea) which was statistically followed (1.83, 6.10, 8.43, 11.70 and 14.13) by T₄ (160 kg N/ha), again at the same DAS the minimum number (1.20, 4.05, 7.30, 10.50 and 11.69) from T₀ (control) which was closely followed (1.25, 4.35, 7.37, 10.57 and 12.32) by T₂ (40 kg N/ha). From the data it was found that all the treatments produced significantly highest number of branches per plant compared to the control condition. Rahman (2001) found that number of branches per plant was significantly influenced by higher dose of nitrogen.

4.1.3 Number of leaves per plant

Neem-coated urea over normal urea showed statistically significant variation for number of leaves per plant of bush bean at 15, 25, 35, 45 and 55 DAS (Table 5). The maximum number of leaves per plant (4.00, 10.00, 19.35, 24.35 and 28.33) was found from T₇ (120 kg N/ha neem-coated urea) which was statistically identical (3.67, 9.72, 19.32, 24.05 and 26.67) with T₄ (160 kg N/ha), whereas at the same DAS the minimum number (2.33, 7.33, 13.60, 18.49 and 22.67) from T₀ (control) which was closely followed (2.67, 8.00, 15.58, 18.94 and 23.33) by T₂ (40 kg N/ha). Nitrogen fertilizer ensured maximum number of leaves per plant through highest vegetative growth. Similar findings also reported by Prajapati *et al.* (2004), and Tewari and Singh (2000).

Table 4. Performance of neem-coated urea and normal urea on number of branches per plant of bush bean

Treatment	Number of branches per plant (cm) at				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T ₀	1.20 f	4.05 f	7.30 d	10.50 d	11.69 e
T ₁	1.25 f	4.35 ef	7.37 d	10.57 d	12.32 d
T ₂	1.43 e	4.45 ef	7.70 cd	10.97 cd	12.69 cd
T ₃	1.65 cd	5.50 bcd	8.00 bc	11.37 abc	13.02 bc
T ₄	1.83 b	6.10 b	8.43 ab	11.70 a	14.13 a
T ₅	1.55 de	4.85 de	7.90 c	11.30 abc	12.60 cd
T ₆	1.70 bcd	5.20 cd	8.10 bc	11.07 bcd	12.70 cd
T ₇	2.10 a	7.25 a	8.77 a	11.87 a	14.25 a
T ₈	1.82 bc	5.85 bc	8.37 ab	11.63 ab	13.30 b
LSD _(0.05)	0.164	0.668	0.413	0.545	0.539
Level of significance	0.01	0.05	0.05	0.01	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha (neem-coated urea)

T₈: 160 kg N/ha (neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)

Table 5. Performance of neem-coated urea and normal urea on number of leaves per plant of bush bean

Treatment	Number of leaves per plant (cm) at				
	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
T ₀	2.33 d	7.33 e	13.60 d	18.49 c	22.67 d
T ₁	2.67 cd	8.00 de	15.58 bc	18.94 c	23.33 cd
T ₂	3.00 bcd	8.33 cd	16.15 b	20.85 b	23.67 cd
T ₃	3.05 bcd	9.00 bc	18.30 a	20.94 b	24.00 bcd
T ₄	3.67 ab	9.72 ab	19.32 a	24.05 a	26.67 ab
T ₅	3.33 abc	9.00 bc	17.75 a	23.36 a	25.67 abc
T ₆	2.67 cd	9.00 bc	14.13 cd	22.60 a	25.33 bcd
T ₇	4.00 a	10.00 a	19.35 a	24.35 a	28.33 a
T ₈	3.67 ab	9.67 ab	18.48 a	23.53 a	26.00 abc
LSD _(0.05)	0.857	0.677	1.582	1.647	2.570
Level of significance	0.01	0.01	0.01	0.05	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha(neem-coated urea)

T₈: 160 kg N/ha(neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

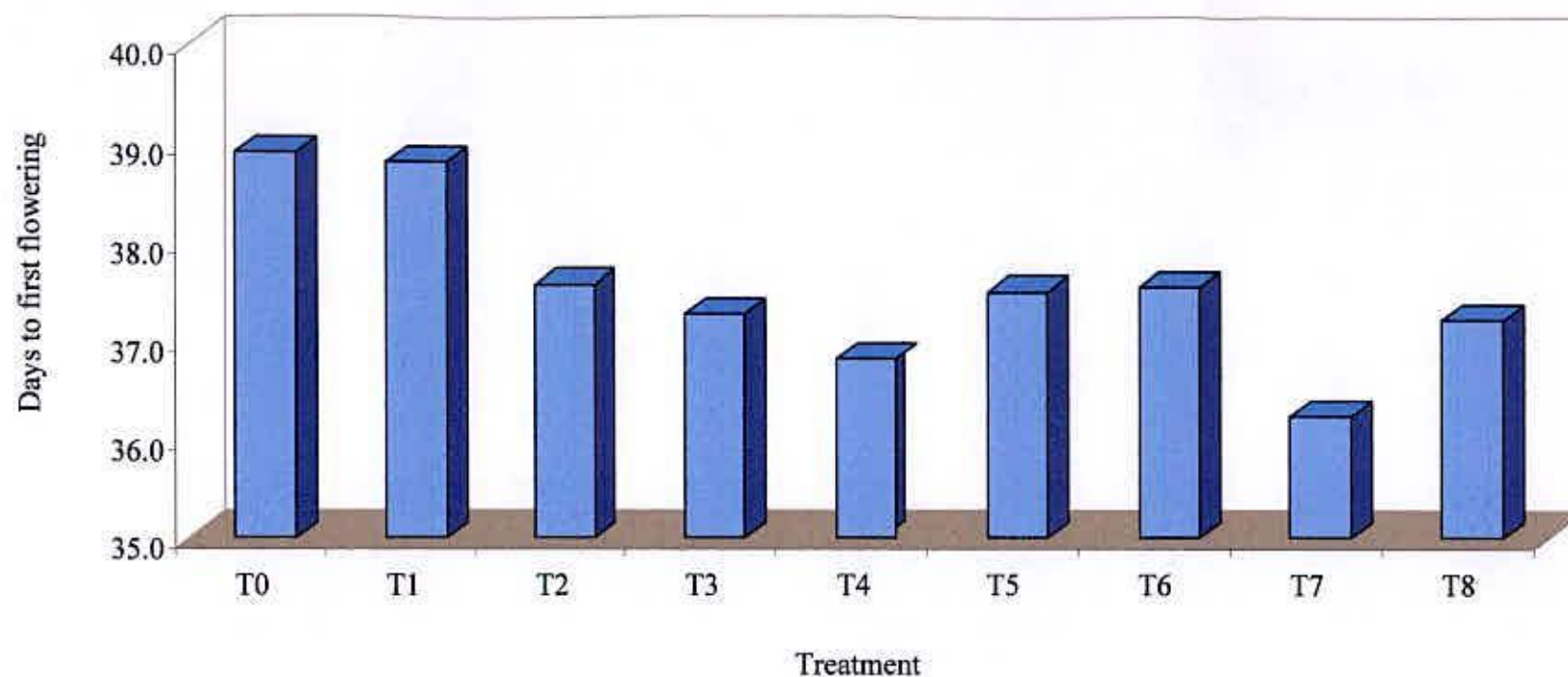
T₇: 120 kg N/ha(neem-coated urea)

4.1.4 Days to first flowering

Days to first flowering of bush bean showed statistically significant differences due to neem-coated urea over normal urea (Figure 2). The minimum days for first flowering (36.23) was observed from T₇ (120 kg N/ha neem-coated urea) which was statistically identical (36.82) with T₄ (160 kg N/ha) and closely followed (37.20 and 37.26) by T₈ (160 kg neem-coated N/ha) and T₃ (80 kg N/ha) again, the maximum days (38.91) from T₀ (control) which was statistically similar (38.81) with T₂ (40 kg N/ha). Optimum level of nitrogen ensured reproductive growth plant through optimum vegetative growth. Bush bean cultivation requires ample supply of nitrogen. Nitrogen is necessary for its vegetative growth and development as well as attaining reproductive growth. Nitrogen fertilizer placement at optimum form depth has promoted growth and development as well as flower initiation of bush bean (Chaib *et al.*, 1984).

4.1.5 Number of flowers per plant

Statistically significant variation was recorded in terms of number of flowers per plant of bush bean due to neem-coated urea over normal urea (Table 6). The maximum number of flowers per plant (56.60) was recorded from T₇ (120 kg N/ha neem-coated urea) which was statistically identical (56.40) with T₄ (160 kg N/ha) and closely followed (55.63 and 55.67) by T₈ (160 kg neem-coated N/ha) and T₆ (80 kg neem-coated N/ha). On the other hand, the minimum number (46.37) from T₀ (control) which was closely followed (53.43 and 54.13) with T₁ (40 kg N/ha) and T₂ (80 kg N/ha). Similar findings also reported by Prajapati *et al.* (2004), Dhanjal *et al.* (2001) and Tewari and Singh (2000).



T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha (neem-coated urea)

T₈: 160 kg N/ha (neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)

Figure 2. Performance of neem-coated urea and normal urea on days to first flowering of bush bean

Table 6. Performance of neem-coated urea and normal urea on yield contributing characters of bush bean

Treatment	Number of flowers per plant	Number of pods per plant	Length of green pod (cm)	Diameter of green pod (mm)
T ₀	46.37 e	21.03 d	11.83 e	10.33 e
T ₁	53.43 d	26.91 c	13.07 d	10.67 de
T ₂	54.13 d	27.51 bc	13.47 c	11.00 cde
T ₃	55.20 c	27.47 bc	13.60 bc	11.33 bcd
T ₄	56.40 ab	31.69 a	14.17 a	12.00 ab
T ₅	55.33 c	29.65 ab	13.67 bc	11.00 cde
T ₆	55.67 bc	30.36 a	13.73 bc	11.33 bcd
T ₇	56.60 a	32.05 a	14.27 a	12.67 a
T ₈	55.63 bc	31.67 a	13.90 ab	11.67 bc
LSD _(0.05)	0.812	2.313	0.391	0.789
Level of significance	0.01	0.01	0.01	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha (neem-coated urea)

T₈: 160 kg N/ha (neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)

4.1.6 Number of pods per plant

Number of pods per plant of bush bean showed significant variation due to neem-coated urea over normal urea (Table 6). The maximum number of pods per plant (32.05) was obtained from T₇ (120 kg N/ha neem-coated urea) which was statistically identical (31.69, 31.67, 30.36 and 29.65) with T₄ (160 kg N/ha), T₈ (160 kg N/ha from neem-coated urea), T₆ (80 kg N/ha from neem-coated urea) and T₅ (40 kg N/ha from neem-coated urea) while, the minimum number (21.03) from T₀ (control) which was closely followed (26.91, 27.47 and 27.51) by T₁ (40 kg N/ha), T₃ (120 kg N/ha) and T₂ (80 kg N/ha). Nitrogen should be applied in such a way that minimum is leached or washed out and maximum is utilized for crop production. Rahman (2001) found that pods per plant were significantly influenced by higher dose of nitrogen.

4.1.7 Number of seeds per green pod

The effect of Neem-coated urea over normal urea varied significantly for number of seeds per green pod of bush bean (Figure 3). The maximum number of seeds per green pod (5.60) was found from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (5.33, 5.18 and 5.15) with T₄ (160 kg N/ha), T₈ (160 kg N/ha, neem-coated urea) and T₆ (80 kg N/ha, neem-coated urea) whereas, the minimum number (3.95) from T₀ (control) which was statistically identical (4.21) with T₁ (40 kg N/ha). An optimum amount of nitrogen for the whole growth period is necessary for bush bean cultivation. Neem coated urea are capable to ensure nitrogen requirement with slow releasing nitrogen. Similar findings also reported by Umap *et al.* (2006) and Tewari and Singh (2000).

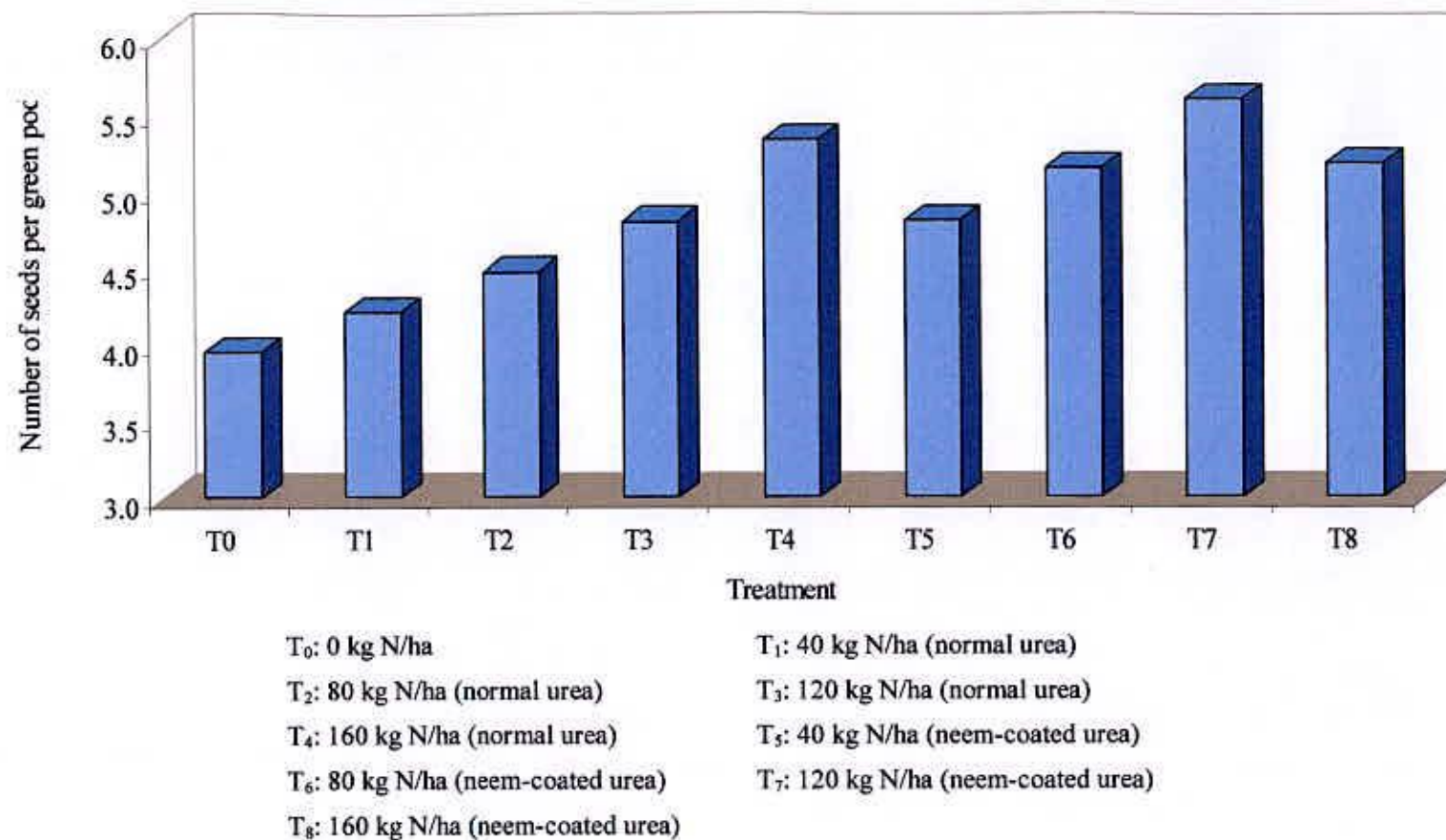


Figure 3. Performance of neem-coated urea over normal urea on number of seeds per green pod of bush bean

4.1.8 Length of green pod

Length of green pod showed significant variation due to neem-coated urea over normal urea (Table 6). The longest pod (14.27 cm) was observed from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (14.17 cm and 13.90 cm) with T₄ (160 kg N/ha) and T₈ (160 kg N/ha, neem-coated urea) and closely followed (13.73 cm, 13.67 cm and 13.60 cm) by T₆ (80 kg N/ha, neem-coated urea), T₅ (40 kg N/ha, neem-coated urea) and T₃ (120 kg N/ha) consequently, the shortest pod (11.83 cm) from T₀ (control) which was closely followed (13.07 cm) by T₁ (40 kg N/ha). Rahman (2001) found that green pod length were significantly influenced by higher dose of nitrogen.

4.1.9 Diameter of green pod

Statistically significant variation was recorded for diameter of green pod due to neem-coated urea over normal urea (Table 6). The highest diameter of green pod (12.67 mm) was recorded from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (12.00 mm) with T₄ (160 kg N/ha) and closely followed (11.67 mm and 11.33 mm) by and T₈ (160 kg N/ha neem-coated urea), T₆ (80 kg N/ha, neem-coated urea) and T₃ (120 kg N/ha) whereas, the lowest diameter of pod (10.33 mm) from T₀ (control) which was statistically identical (10.67 mm, 11.00 mm) by T₁ (40 kg N/ha), T₂ (80 kg N/ha) and T₅ (40 kg N/ha, neem-coated urea).

4.1.10 Length of roots

Length of roots showed statistically significant differences due to neem-coated urea over normal urea (Figure 4). The longest roots (18.16 cm) was found from T₇



(120 kg neem-coated N/ha) which was statistically identical (17.86 cm, 17.17 cm and 16.41 cm) with T₄ (160 kg N/ha), T₆ (80 kg neem-coated N/ha) and T₈ (160 kg neem-coated N/ha) and closely followed (15.82 cm) by and T₅ (40 kg neem-coated N/ha). On the other hand, the shortest roots (10.30 cm) was recorded from T₀ (control) which was closely followed (12.75 cm, 13.14 cm and 13.23 cm) by T₁ (40 kg N/ha), T₂ (80 kg N/ha) and T₃ (120 kg N/ha). Similar findings also reported by Umap *et al.* (2006), Prajapati *et al.* (2004), Dhanjal *et al.* (2001) and Tewari and Singh (2000).

4.1.11 Dry matter content in plant

Dry matter content in plant showed significant variation due to neem-coated urea over normal urea (Table 7). The highest dry matter in plant (11.40%) was obtained from T₇ (120 kg N/ha, neem-coated urea) which was closely followed (10.00% and 9.20%) by T₄ (160 kg N/ha) and T₈ (160 kg neem-coated N/ha), while the lowest dry matter content in plant (5.20%) from T₀ (control) which was statistically identical (6.20%) with T₁ (40 kg N/ha).

4.1.12 Dry matter content in pod

Statistically significant variation was recorded for dry matter content in pod due to neem-coated urea over normal urea (Table 7). The highest dry matter in pod (12.40%) was observed from T₇ (120 kg neem-coated N/ha) which was closely followed (11.80% and 11.20%) by T₄ (160 kg N/ha) and T₈ (160 kg neem-coated N/ha), again the lowest dry matter content in pod (6.60%) was recorded from T₀ (control) which was statistically identical (7.13%) with T₁ (40 kg N/ha).

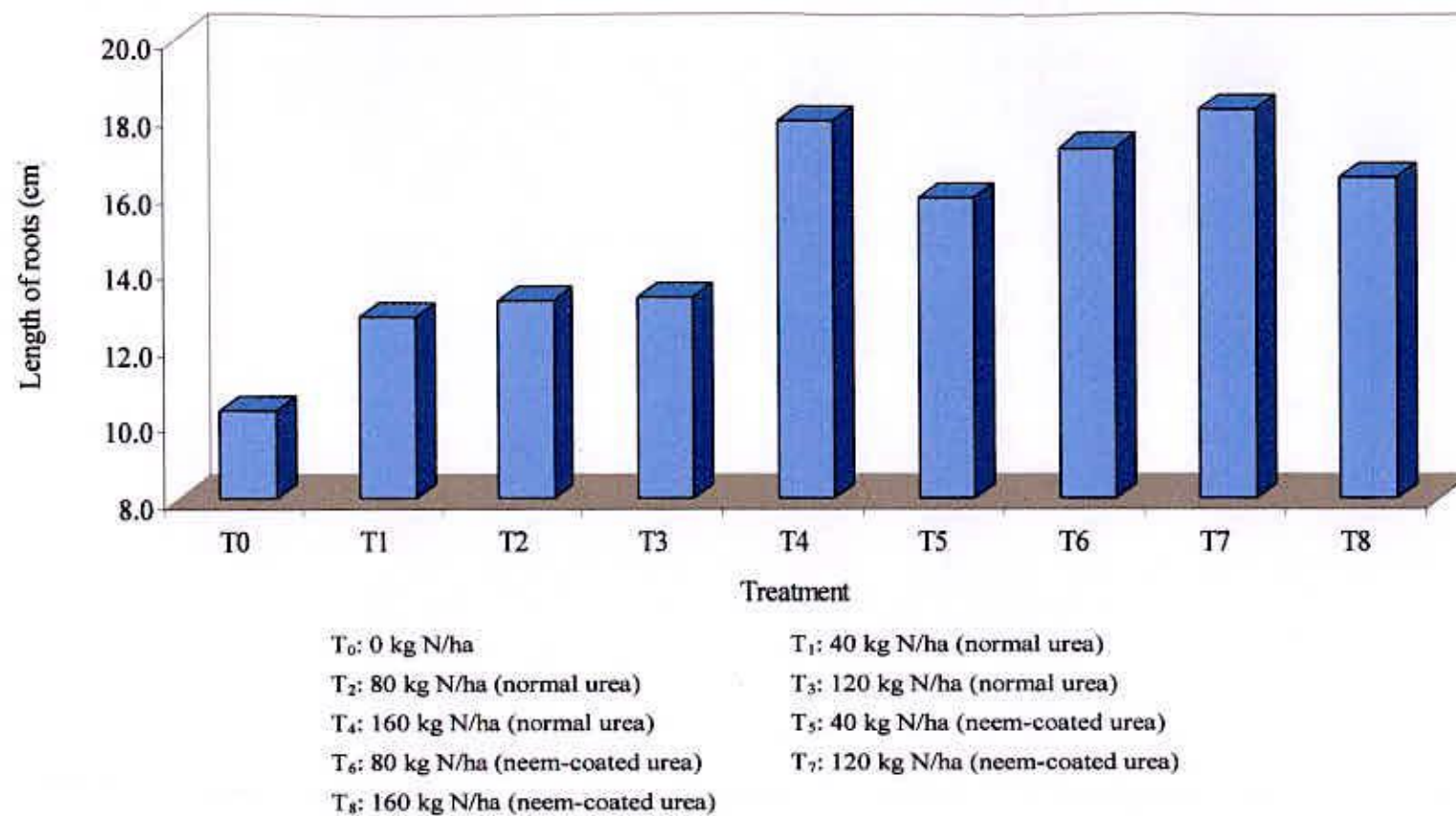


Figure 4. Performance of neem-coated urea over normal urea on length of roots of bush bean

Table 7. Performance of neem-coated urea and normal urea on yield contributing characters and yield of bush bean

Treatment	Dry matter content of plant (%)	Dry matter content of pod (%)	Pod weight per plant (g)	Pod yield (t/ha)
T ₀	5.20 g	6.60 e	214.33 d	11.57 c
T ₁	6.20 fg	7.13 e	256.24 c	14.40 b
T ₂	6.80 ef	8.60 d	265.62 c	14.62 b
T ₃	7.80 de	9.00 d	289.00 b	14.90 b
T ₄	10.00 b	11.80 b	303.54 ab	16.01 a
T ₅	7.40 de	8.80 d	286.93 b	14.85 b
T ₆	8.40 cd	10.60 c	290.62 ab	14.94 b
T ₇	11.40 a	12.40 a	311.83 a	16.28 a
T ₈	9.20 bc	11.20 bc	293.06 ab	15.00 b
LSD _(0.05)	1.009	1.049	19.87	0.617
Level of significance	0.01	0.05	0.01	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha(neem-coated urea)

T₈: 160 kg N/ha(neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)

4.1.13 Weight of individual pod

Neem-coated urea, normal urea produced significant variation in terms of weight of individual pod (Figure 5). The highest weight of individual pod (7.47 g) was recorded from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (7.19 g, 7.01 g) with T₄ (160 kg N/ha), T₆ (80 kg N/ha neem-coated urea) and T₈ (160 kg N/ha neem-coated urea) and closely followed (6.68 g and 6.67 g) by T₅ (40 kg N/ha neem-coated urea) and T₃ (120 kg N/ha), while the lowest weight (5.42 g) from T₀ (control) which was closely followed (6.05 g and 6.36 g) by T₁ (40 kg N/ha) and T₂ (80 kg N/ha). Rahman (2001) found that individual pod weight were significantly influenced by higher dose of nitrogen.

4.1.14 Pods weight per plant

Pods weight per plant showed statistically significant differences due to neem-coated urea over normal urea (Table 7). The highest weight of pods per plant (311.83 g) was found from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (303.54 g, 293.06 g and 290.62 g) with T₄ (160 kg N/ha), T₈ (160 kg N/ha, neem-coated urea) and T₆ (80 kg N/ha, neem-coated urea) and closely followed (289.00 g and 286.93 g) by T₃ (120 kg N/ha) and T₅ (40 kg N/ha, neem-coated urea), whereas the lowest weight (214.33 g) from T₀ (control) which was closely followed (256.24 g and 265.62 g) by T₁ (40 kg N/ha) and T₂ (80 kg N/ha). An optimum amount of nitrogen for the whole growth period is necessary to produce maximum yield of good quality bush bean. Neem coated urea are capable to ensure nitrogen requirement with slow releasing nitrogen.

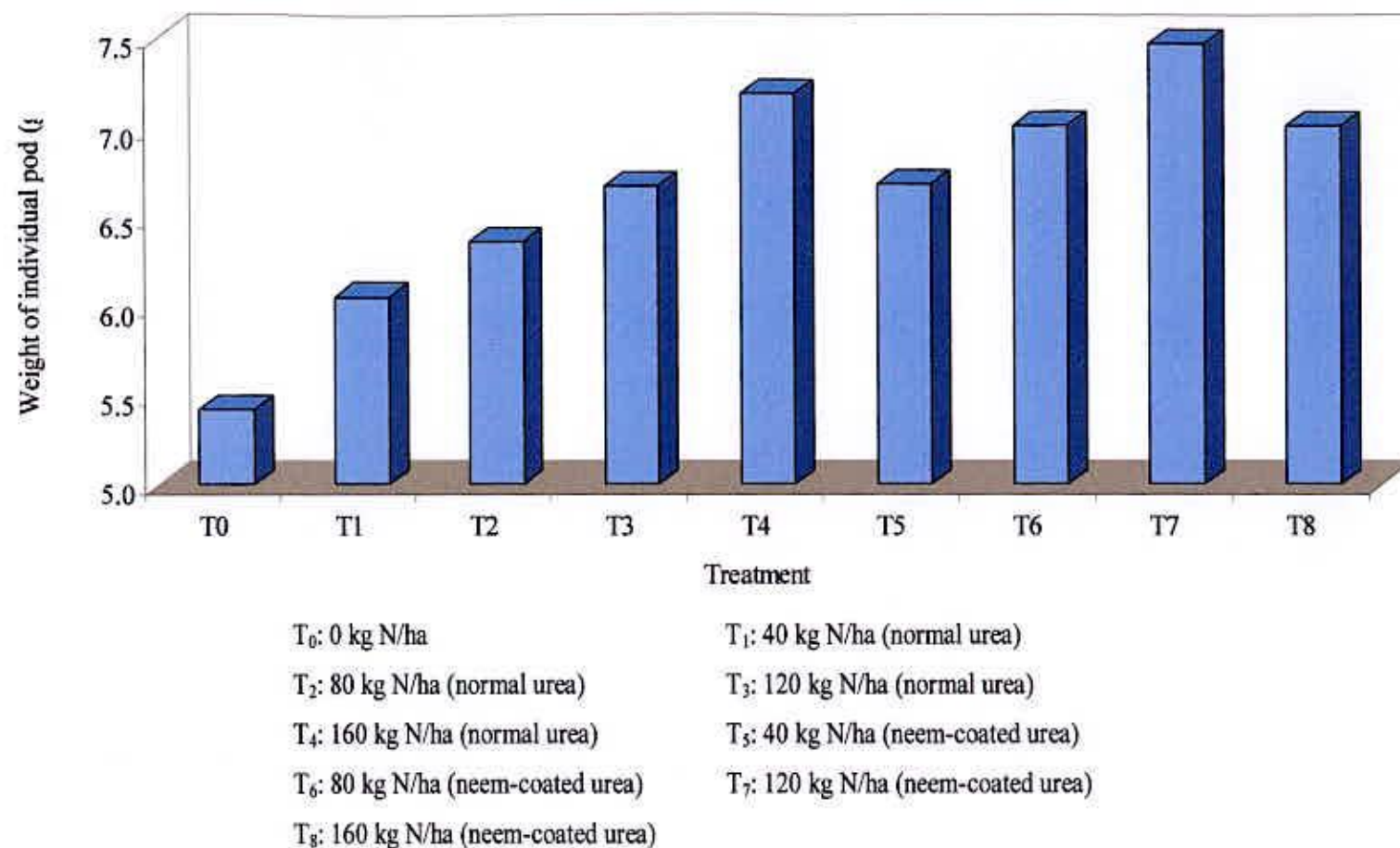


Figure 5. Performance of neem-coated urea over normal urea on weight of individual pod of bush bean

4.1.15 Pods yield per hectare

Statistically significant variation was recorded for pods yield per hectare due to neem-coated urea over normal urea (Table 7). The highest pods yield (16.28 ton) was observed from T₇ (120 kg N/ha, neem-coated urea) which was statistically identical (16.01 ton) with T₄ (160 kg N/ha) at the same dose of N, neem-coated urea produced significantly higher pod yield compare to normal urea up to 120 kg N/ha was equivalent to 160 kg N/ha normal urea while the lowest weight (11.57 ton) was recorded from T₀ (control). Rahman (2001) found that green pod yield per hectare were significantly influenced by the application of higher dose of nitrogen. Similar findings also reported earlier by Umap *et al.* (2006), Prajapati *et al.* (2004) and Tewari and Singh (2000).

4.2 NPKS concentrations in plant and pod

4.2.1 NPKS concentrations in plant

Significant variations were recorded of NPKS concentrations in bush bean plant due to neem-coated urea over normal urea (Table 8). The maximum concentration of N (3.85%), P (1.509%), K (1.357%) and S (1.246%) in plant was recorded with T₇ (120 kg N/ha, neem-coated urea). On the other hand the minimum concentrations of N (1.21%), P (0.360%), K (0.345%) and S (0.327%) in plant were observed from T₀ (control).

Table 8. Performance of neem-coated urea and normal urea on N, P, K and S concentrations in plant and pods of bush bean

Treatment	Concentration (%) in plant				Concentration (%) in pods			
	N	P	K	S	N	P	K	S
T ₀	1.21 g	0.360 e	0.345 g	0.327 e	2.02 e	0.345 c	0.403 e	0.276 e
T ₁	2.65 f	0.525 gh	0.372 fg	0.446 e	4.16 cd	0.413 b	0.421 d	0.328 d
T ₂	2.97 cde	0.718 ef	0.467 f	0.681 d	4.27 cd	0.425 b	0.430 d	0.326 d
T ₃	3.01 cd	0.836 de	0.716 d	0.716 d	4.74 bcd	0.434 b	0.450 c	0.341 bcd
T ₄	3.64 ab	1.231 b	1.067 b	1.220 a	5.00 b	0.456 b	0.481 a	0.359 ab
T ₅	2.84 def	0.662 fg	0.583 e	0.658 d	4.19 d	0.422 b	0.463 abc	0.332 cd
T ₆	3.21 c	0.968 cd	0.730 d	0.849 c	4.59 bcd	0.446 b	0.458 bc	0.349 bc
T ₇	3.85 a	1.509 a	1.357 a	1.246 a	5.58 a	0.535 a	0.482 a	0.370 a
T ₈	3.52 b	1.078 c	0.885 c	1.074 b	4.76 bc	0.438 b	0.470 ab	0.350 bc
LSD _(0.05)	0.271	0.144	0.109	0.133	0.491	0.054	0.017	0.017
Level of significance	0.01	0.01	0.05	0.01	0.01	0.05	0.01	0.05

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha (neem-coated urea)

T₈: 160 kg N/ha (neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)

4.2.2 NPKS concentration in pod

Significant variations were observed for NPKS concentrations in bush bean due to neem-coated urea over normal urea (Table 8). The maximum concentrations of N (5.58%), P (0.535%), K (0.482%) and S (0.370%) in pod were obtained from T₇ (120 kg N/ha, neem-coated urea), whereas the minimum concentrations of N (2.02%), P (0.345%), K (0.403%) and S (0.276%) in pod were found from T₀ (control).

4.3 NPKS uptake by stover and pod

4.3.1 NPKS uptake by stover

Significant variations were recorded for NPKS uptake by bush bean due to neem-coated urea over normal urea (Table 9). The maximum uptake by plant for N (41.52 kg/ha), P (6.34 kg/ha), K (14.15 kg/ha) and S (8.23 kg/ha) were recorded from T₇ (120 kg N/ha, neem-coated urea), again the minimum uptake by plant for N (11.04 kg/ha), P (3.00 kg/ha), K (7.44 kg/ha) and S (4.33 kg/ha) were found from T₀ (control).

4.3.2 NPKS uptake by pod

Statistically significant variations were recorded for NPKS uptake by bush bean due to neem-coated urea over normal urea (Table 9). The maximum uptake by pod for N (65.63 kg/ha), P (17.03 kg/ha), K (36.26 kg/ha) and S (3.18 kg/ha) were obtained from T₇ (120 kg N/ha, neem-coated urea), while the minimum uptake by pod for N (10.21 kg/ha), P (10.16 kg/ha), K (21.69 kg/ha) and S (2.26 kg/ha) were observed from T₀ (control).

Table 9. Performance of neem-coated urea and normal urea on N, P, K and S uptake by plant and pods of bush bean

Treatment	Uptake by plant (kg/ha)				Uptake by pod (kg/ha)			
	N	P	K	S	N	P	K	S
T ₀	11.04 i	3.00 h	7.44 h	4.33 e	10.21 g	10.16 f	21.69 g	2.26 e
T ₁	14.28 h	3.71 g	9.19 g	4.93 de	14.02 f	10.61 ef	23.97 fg	2.41 de
T ₂	24.89 g	3.96 fg	9.66 fg	5.04 cde	24.81 e	11.90 de	25.32 ef	2.69 cd
T ₃	28.52 ef	4.75 de	10.57 ef	5.64 bcd	44.78 c	13.59 bc	26.88 de	2.76 bcd
T ₄	39.08 ab	5.97 ab	12.98 b	7.86 a	52.31 b	16.52 a	33.07 b	3.16 ab
T ₅	15.94 h	4.36 ef	11.03 de	5.77 bcd	14.21 f	13.04 cd	29.85 c	2.81 abcd
T ₆	34.39 cd	5.14 cd	11.73 cd	6.08 bc	33.35 d	13.22 cd	29.44 cd	2.96 abc
T ₇	41.52 a	6.34 a	14.15 a	8.23 a	65.63 a	17.03 a	36.26 a	3.18 a
T ₈	36.94 bc	5.64 bc	12.76 bc	6.63 b	53.09 b	14.64 b	30.68 bc	3.14 ab
LSD _(0.05)	3.245	0.491	1.045	1.002	5.141	1.301	2.765	0.372
Level of significance	0.01	0.05	0.05	0.05	0.01	0.05	0.05	0.05

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha(neem-coated urea)

T₈: 160 kg N/ha(neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha(neem-coated urea)

4.4 Post harvest soil

Significant variations were recorded for pH, organic matter, total N, available P, exchangeable K and available S due to neem-coated urea over normal urea (Table 10). The highest pH (5.57), organic matter (1.45%), total N (0.088%), available P (22.78 ppm), exchangeable K (0.18 me%) and available S (0.30 ppm) were found from T₄ (160 kg N/ha supplied by normal urea) and the lowest pH (4.06), organic matter (1.01%), total N (0.12%), available P (13.75 ppm), exchangeable K (0.11 me%) and available S (0.17 ppm) were recorded from T₀ (control).



Table 10. Performance of neem-coated urea and normal urea on the post harvest soil

Treatment	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
T ₀	4.06 d	1.01 e	0.065 g	13.75 f	0.11 e	17 g
T ₁	4.17 cd	1.05 de	0.071 f	16.13 e	0.12 de	20 f
T ₂	4.40 cd	1.10 cde	0.077 ef	16.66 de	0.13 d	22 e
T ₃	4.35 cd	1.05 de	0.081 cd	17.88 cd	0.13 d	24 de
T ₄	5.57 a	1.45 a	0.088 a	22.78 a	0.18 a	30 a
T ₅	4.55 bcd	1.09 cde	0.082 de	17.08 cde	0.13 d	23 e
T ₆	4.78 abcd	1.21 bcd	0.080 cd	18.17 cd	0.15 bc	25 cd
T ₇	5.34 ab	1.33 ab	0.083 b	20.54 b	0.16 b	27 b
T ₈	4.96 abc	1.24 bc	0.0834 bc	18.47 c	0.14 cd	27 b
LSD _(0.05)	0.765	0.144	0.054	1.510	0.017	0.017
Level of significance	0.05	0.05	0.01	0.05	0.05	0.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T₀: 0 kg N/ha

T₂: 80 kg N/ha (normal urea)

T₄: 160 kg N/ha (normal urea)

T₆: 80 kg N/ha (neem-coated urea)

T₈: 160 kg N/ha (neem-coated urea)

T₁: 40 kg N/ha (normal urea)

T₃: 120 kg N/ha (normal urea)

T₅: 40 kg N/ha (neem-coated urea)

T₇: 120 kg N/ha (neem-coated urea)



CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted in the field of Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh during the period from October, 2008 to March, 2009 to find out the performance of Neem-coated urea over normal urea on the growth and yield of BARI bush bean-1. The experiment considered the treatments of T_0 : 0 kg N/ha, T_1 : 40 kg N/ha, T_2 : 80 kg N/ha, T_3 : 120 kg N/ha, T_4 : 160 kg N/ha, T_5 : 40 kg N/ha (neem-coated urea), T_6 : 80 kg N/ha (neem-coated urea), T_7 : 120 kg N/ha (neem-coated urea) and T_8 : 160 kg N/ha (neem-coated urea). Data on yield contributing characters, yield, nutrient concentration in plant and pods, uptake by plant and pod, nutrients status of post harvest soil was recorded.

The tallest plant (13.83 cm, 24.09 cm, 40.04 cm, 46.20 cm and 54.90 cm) was recorded from T_7 , while at the same DAS the shortest plant (10.27 cm, 19.35 cm, 31.15 cm, 35.66 cm and 44.20 cm) from T_0 . The maximum number of branches per plant (2.10, 7.25, 8.77, 11.87 and 14.25) was obtained from T_7 , again at the same DAS the minimum number (1.20, 4.05, 7.30, 10.50 and 11.69) from T_0 . The maximum number of leaves per plant (4.00, 10.00, 19.35, 24.35 and 28.33) was found from T_7 , whereas at the same DAS the minimum number (2.33, 7.33, 13.60, 18.49 and 22.67) from T_0 . The minimum days for first flowering (36.23) were observed from T_7 again, the maximum days (38.91) from T_0 . The maximum number of flowers per plant (56.60) was recorded from T_7 and the minimum number (46.37) from T_0 .

The maximum number of pods per plant (32.05) was obtained from T₇ while, the minimum number (21.03) from T₀. The maximum number of seeds per green pod (5.60) was found from T₇ whereas, the minimum number (3.95) from T₀. The longest pod (14.27 cm) was observed from T₇ consequently, the shortest pod (11.83 cm) from T₀. The highest diameter of green pod (12.67 mm) was recorded from T₇ whereas, the lowest diameter of pod (10.33 mm) from T₀. The longest root (18.16 cm) was found from T₇ and the shortest (10.30 cm) was recorded from T₀. The highest dry matter in plant (11.40%) was obtained from T₇, while the lowest dry matter content in plant (5.20%) from T₀. The highest dry matter in pod (12.40%) was observed from T₇, again the lowest dry matter content in pod (6.60%) was recorded from T₀. The highest weight of individual pod (7.47 g) was recorded from T₇, while the lowest weight (5.42 g) from T₀. The highest weight of pods per plant (311 g) was found from T₇, whereas the lowest weight (214.33 g) from T₀. The highest pods yield (16.28 ton) was observed from T₇, while the lowest weight (11.57 ton) from T₀.

The maximum concentration of N (3.85%), P (1.509%), K (1.357%) and S (1.246%) in plant was recorded with T₇ and the minimum concentrations of N (1.21%), P (0.360%), K (0.345%) and S (0.327%) in plant were observed from T₀. The maximum concentrations of N (5.58%), P (0.535%), K (0.482%) and S (0.370%) in pod were obtained from T₇, whereas the minimum concentrations of N (2.02%), P (0.345%), K (0.403%) and S (0.276%) in pod were found from T₀. The maximum uptake by plant for N (41.52 kg/ha), P (6.34 kg/ha), K (14.15 kg/ha) and S (8.23 kg/ha) were recorded from T₇, again the minimum uptake by plant for N

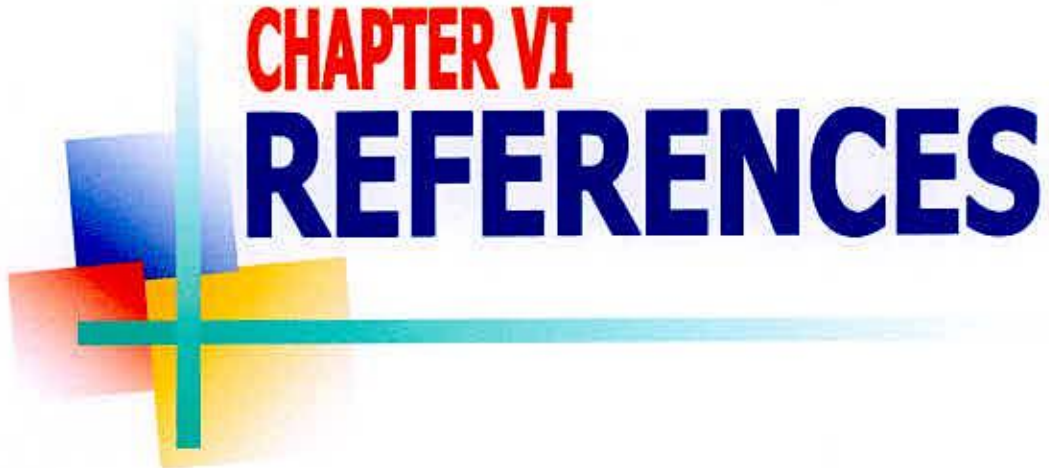
(11.04 kg/ha), P (3.00 kg/ha), K (7.44 kg/ha) and S (4.33 kg/ha) were found from T_0 . The maximum uptake by pod for N (65.63 kg/ha), P (17.03 kg/ha), K (36.26 kg/ha) and S (3.18 kg/ha) were obtained from T_7 , while the minimum uptake by pod for N (10.21 kg/ha), P (10.16 kg/ha), K (21.69 kg/ha) and S (2.26 kg/ha) were observed from T_0 . The highest pH (5.57), organic matter (1.45%), total N (0.088%), available P (22.78 ppm), exchangeable K (0.18 me%) and available S (30 ppm) were found from T_4 and the lowest pH (4.06), organic matter (1.01%), total N (0.12%), available P (13.75 ppm), exchangeable K (0.11 me%) and available S (0.17 ppm) were recorded from T_0 .

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Neem coated Urea is very much useful for successful production of bush bean and which increase the nitrogen use efficiency by crops.
2. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability;
3. Neem coated Urea with organic manure may be used for the further study.

CHAPTER VI

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APPENDICES



APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2008 to March 2009

Month	*Air temperature (°C)		*Relative humidity (%)	*Rainfall (mm) (total)
	Maximum	Minimum		
October, 2008	26.03	18.22	81	34
November, 2008	25.82	16.04	78	00
December, 2008	22.4	13.5	74	00
January, 2009	24.5	12.4	68	00
February, 2009	27.1	16.7	67	30
March, 2009	31.4	19.6	54	11

* Monthly average,

* Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka - 1212

Appendix II. Analysis of variance of the data on plant height of bush bean as influenced by neem-coated urea and normal urea

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.477	0.031	1.293	3.136	2.566
Treatment	8	26.337**	51.217**	55.589**	115.873**	164.124**
Error	16	1.009	1.153	2.985	4.091	3.278

** Significant at 0.01 level of probability

Appendix III. Analysis of variance of the data on number of branches per plant of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square				
		Number of branches per plant (cm) at (cm) at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.087	0.058	0.378	0.576	0.089
Treatment	8	2.317**	1.334*	1.405*	3.130**	6.442**
Error	16	0.188	0.374	0.334	0.246	0.599

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square				
		Number of leaves per plant (cm) at				
		15 DAS	25 DAS	35 DAS	45 DAS	55 DAS
Replication	2	0.036	0.001	0.143	0.013	0.036
Treatment	8	3.429**	4.487**	3.759**	0.477*	6.677**
Error	16	0.112	0.048	0.073	0.083	0.059

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on yield contributing characters of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square					
		Days to 1 st flowering	Number of flowers per plant	Number of pods per plant	Number of seeds per green pod	Length of green pod (cm)	Diameter of green pod (mm)
Replication	2	5.250	0.741	0.002	0.732	0.014	0.0001
Treatment	8	34.324**	80.247**	0.246**	16.210**	0.163**	0.146**
Error	16	9.139	7.849	0.089	2.121	0.023	0.034

** Significant at 0.01 level of probability



Appendix VI. Analysis of variance of the data on yield contributing characters and yield of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square					
		Length of roots (cm)	Dry matter content of plant (%)	Dry matter content of pod (%)	Weight of individual pod (g)	Pod weight per plant (g)	Pod yield (t/ha)
Replication	2	0.670	0.020	0.115	0.001	0.025	0.063
Treatment	8	47.274**	2.237**	2.905*	73.057**	2.348**	11.868**
Error	16	8.243	0.037	0.214	13.535	0.068	0.428

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on N, P, K and S concentrations in plant and pods of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square							
		Concentration (%) in plant				Concentration (%) in pods			
		N	P	K	S	N	P	K	S
Replication	2	0.162	0.0001	0.0001	0.002	0.005	0.002	0.003	0.121
Treatment	8	0.583**	0.005**	0.0001*	0.003**	0.627**	0.106*	0.817**	1.871*
Error	16	0.082	0.001	0.0001	0.0001	0.007	0.004	0.006	0.231

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on N, P, K and S uptake by plant and pods of bush bean as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square							
		Uptake by plant (kg/ha)				Uptake by pod (kg/ha)			
		N	P	K	S	N	P	K	S
Replication	2	0.065	0.163	0.294	0.451	6.202	0.755	4.420	0.005
Treatment	8	5.781**	1.914*	1.335*	2.564*	151.423**	2.698*	6.276*	0.158*
Error	16	0.082	0.371	0.341	0.932	8.981	0.575	2.599	0.047

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on the post harvest soil as influenced by neem-coated urea over normal urea

Source of variation	Degrees of freedom	Mean square					
		pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me %)	Available S (ppm)
Replication	2	0.0001	0.004	0.246	0.001	3.023	0.001
Treatment	8	0.077*	0.065*	19.412**	0.016*	11.190*	4.487**
Error	16	0.019	0.017	8.193	0.005	3.356	0.048

** Significant at 0.01 level of probability,

* Significant at 0.05 level of probability

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