EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND YIELD OF BARI BUSH BEAN-2*(Phaseolus vulgaris)*

BY

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REG. No. : 08-03176

A Thesis
Submitted to the Department of Soil Science
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (M.S.)
IN
SOIL SCIENCE

SEMESTER: JULY - DECEMBER, 2009

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF NITROGEN AND POTASSIUM ON THE GROWTH AND YIELD OF BARI BUSH BEAN-2 (Phaseolus vulgaris)"*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE IN SOIL SCIENCE,** embodies the result of a piece of bonafide research work carried out by ***BASUDEB ROY*** Registration No.***08-03176*** under my supervision and my 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 by him.

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Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

All praises are due to the Almighty "GOD" Who helps the author to obey his orders and enabled him to complete this thesis in time.

The author expresses his deepest sense of respect, earmest gratitude, profound regards and immense indebtedness to his reverend teacher and supervisor Professor Dr. Alok Kumar Paul, Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka for his affectionate guidance , kind and invaluable advice, constant encouragement and time to time field visit through out the research period. His patient and cordial instructions in preparation of the thesis are gratefully acknowledged.

The author extends his heartfelt gratitude and profound respect to his Co-supervisor Associate Professor A.T.M.Shamsuddoha, Department of Soil Science, Sher-e-Bangla Agricultural University,Dhaka for his critical suggestions and advice in preparation of this thesis. He is immensely indebted to Associate Professor Dr. Md. Asaduzzaman Khan, Chairman of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207 for providing him the facilities to conduct the experiment.

He expresses his gratitude and profound respect to Professor Dr. Md. Nurul Islam, Associate Professor Mst. Afrose Jahan, Assistant Professor Mohammad Mosharraf Hossain, Assistant Professor Jharna Rani sarker, Assistant Professor Saikat Chowdhury, Assistant Professor Mohammad Issak, Assistant Professor Mohammad saiful Islam bhuiyan of his respective teachers of the Department of Soil Science, Sher-e-Bangla Agricultural University, Dhaka-1207 for their valuable teaching and co-operations in completing the research study.

The author is thankful to Taposh, Hayder, Humayan and all the staff members of the Department of Soil Science for their active co-operation through out the study period. The author owes his whole hearted thanks to all his friends specially Bibek, Sanjoy, for their inspiration, cooperation and accompany during the study period.

The author would like to express his heartfelt gratitude and indebtedness to his beloved parents for their love, prayers, sacrifice, encouragement and moral support which inspired him during the entire study period.

July, 2010 The Author

ABSTRACT

A field experiment was carried out at Sher-e-Bangla Agricultural University Farm during the *Rabi* season of 2008 to investigate the effect of nitrogen and potassium on the growth and yield of BARI Bush Bean-2. The red brown tarrece soil of Tejgaon was silty clay loam in texture having pH 5.6. The experiment was conducted in a RCBD with three replications. The experiment comprises 4 levels of nitrogen from urea (0 kg, 40 kg, 80 kg and 120 kg nitrogen/ha) and 4 levels of potassium from MOP (0 kg, 20 kg, 40 kg and 60 kg potassium /ha). There was combination of sixteen treatments including control (no fertilizer). The results obtained revealed that different levels of nitrogen and potassium showed significant variations on the parameters studied. The treatment $N_{80}K_{40}$ (80 kg nitrogen + 40 kg potassium) gave the highest pod length (11.67 cm), pod diameter (3.13 cm), average single pod weight (5.99 gm), total pod weight per plant (29.07 gm), pod yield per plot (2033.33 gm) and pod yield per hectare (4.96 ton). The highest N, P, K and S content in harvested plant sample (2.92 %, 0.20 %, 2.85 % and 1.04 % respectively) were also obtained with treatment $N_{80}K_{40}$ (80 kg nitrogen + 40 kg potassium). Thus the findings of the experiment suggested that combined use of 80 kg nitrogen + 40 kg potassium produced maximum growth and yield of BARI Bush Bean-2 in red brown terrace soil of the Tejgaon series.

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Introduction

CHAPTER I
INTRODUCTION

BARI Bush bean-2 *(Phaseolus vulgaris)* belongs to the family Leguminosae, and sub-family Papilionaceae. It is an annual herbaceous vegetable crop producing strait or slightly curved pod. In Bangladesh, this crop is known as "Farashi Sheem" (Rashid, 1993). It is also known as french bean, kidney bean, common bean, basic bean, snap bean, raj bean, navy bean, haricot bean, string bean, pole bean, wax bean and bonchi (Duke, 1983; Salunkhe *et al.*, 1987; Tindall, 1988). Bush beans are tender, slender beans with green, rounded pods, 4 to 6 inches (10 to 15 cm) long. The pods are eaten whole, including the immature seeds, when they are still young, juicy and tender. They have a delicate texture and sweet flavor. The part eaten are the pods and the seeds. The seeds of the mature pod are knows as flageolets and can be eaten and used as you would do with peas. They can be called green beans or pole beans. Green beans grow on a vine and are actually pods with little beans inside them. Green beans are a delicious side dish for any meal. They can be found Italian style, Bush style, and simply cut.

Green beans are sold at farmer's markets and grocery stores. Fresh green beans have a sweeter taste than canned. It could be because of the salt that preserves the beans in the can.

Bush bean originated in Central and South America (Swiader *et al.*, 1992). Now it is cultivated in many parts of the tropics, sub-tropics and throughout the temperate region (Purse glove, 1987). Bush bean is grown intensively in five major continental areas: Eastern Africa, north and Central America, South America, Eastern Asia and Western and South Europe. In northeastern plains of India, it is cultivated as a winter crop (AICPIP, 1987). Bush bean and other related species of the genus *Phaseolus* were grown in 27.08 million hectares of the world cropped area, and the production of the pods was about 18.94 million tons with an average yield of 699 Kg/ha (FAO, 2000). In Bangladesh, this crop is grown in Sylhet, Cox's Bazar, Chittagong Hill Tracts and some other parts of the country in very small scale. In recent years, Hortex Foundation, Vegetable Export Center of BRAC and some other organizations facilitated the export of this vegetable of Bangladesh.

Immature pods are marketed fresh, frozen or canned. The dry seeds 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). Green beans are a fat free food that contains vitamins A and C, calcium, iron, and protein. They don't have a lot of carbohydrates which don't adversely affect the blood sugar. It is a good source of vitamin C, carotene and a variety of minerals, some fiber but very little protein; low in calories, as most vegetables. It helps to prevent anemia and diabetes because of their Iron, vitamin C, and vitamin A. It also helps to keep a healthy digestive system because of their fiber content.

It doesn't take long to cook green beans. They can be steamed in a small amount of water or sautéed in some olive oil. Either way, the beans are bright green, crisp, and sweet. Snap beans can be used in stir fry mixtures as well if you desire. Fresh green beans have a bright green color when cooked. Their shape should be maintained during cooking. If you cook them too long, they will wilt and not taste very good.

Boiling and steaming are the preferred methods, and other than these stir-frying or stewing. Boiled or steamed and cold, Bush beans make excellent salads. Beans are usually served with some starch and meat for a complete meal. At Christmas time they take center stage in green bean casseroles. It is a popular dish at the holidays in many countries.

Production of BARI Bush Bean-2 is influenced by many factors. Among them, fertilizer especially nitrogen and potassium, are the most effective and critical input for increasing crop yield (Arya *et al.*, 1999). Nitrogen and potassium content of Bangladesh soil is very low. For that reason, nitrogen and potassium fertilizer should be applied in such a way that minimum is leached or washed out and maximum its utilization for crop production. 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 plant. Furthermore, it helps in uptake of other nutrients from the soil. The vegetative growth and yield of BARI Bush Bean-2 were increased with successive increase in the dose of nitrogen and potassium (Chandra *et al.*, 1987; Tewari and Sing, 2000). BARI Bush Bean-2 can fix atmospheric nitrogen in its root zone, an optimum amount of nitrogen for the whole growth period is necessary to produce maximum yield of good quality zhar sheem but in a small amount relative to other leguminous crops (Habbish and Ishaq, 1974).

The most obvious effect of potassium is on root development, particularly of the lateral and fibrous rootlets that are essential to fix the atmospheric nitrogen in legume crops (Arya and Kalara, 1988). Potassium also affects on seed formation (Buckman and Brady, 1980).

Research findings on response BARI Bush Bean-2 to nitrogen and potassium and their optimum requirement is limited. A judicious amount of nitrogen and potassium is essential to produce maximum and profitable yield of BARI Bush Bean-2. Excessive or under-dose can affect on growth, yield and economic return.

Considering the above prospective, therefore, the present study was undertaken with the following objectives:

1. To assess the response of BARI Bush bean-2 regarding yield and yield contributing Characters to N & K application.
2. To investigate the interaction effect between N & K on the growth and yield of BARI Bush bean-2.
3. To determine the optimum dose of N & K for proper growth and development of BARI Bush bean-2.

Chapter 2
Review of literature

CHAPTER II
REVIEW OF LITERATURE

Bush bean is a popular as well as nutritious vegetable. It is relatively new in Bangladesh. Many research works have been carried out in different parts of the world to study the different aspects on the growth and yield of Bush bean-2. But information on the effect of Nitrogen and Potassium on the growth and yield of Bush bean-2 under Bangladesh conditions is little. Some of the important findings pertinent to the present research work have been reviewed under the following headings.

2.1. Effect of Nitrogen on the growth and yield of Bush bean

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. Further more it helps in uptake of other nutrients from the soil. Both excess and under doses of nitrogen hamper the yield. So for higher yield judicious amount of nitrogen should be applied.

Prajapati *et al*. (2004) conducted a field experiment in Krushinagar, Gujarat, India to study the effect of weed control method and N rate (0, 40, 80 or 120 kg/ha) on the nutrient uptake and yield of *P. vulgaaris* cv.DPR-86-6-4. Among the N rates, 120 kg/ha recorded the highest N, P and K uptake, grain yield, straw yield, protein yield, net return and cost benefit ratio.

Saxena *et al*. (2003) Bushbean (Phaseolus vulgaris) cv. PDR-14 plants were supplied with 0, 60 and 120 kg N and K/ha and 0, 60 and 90 kg P/ha in a field experiment conducted in Kanpur, Uttar Pradesh, India during the rabi seasons of 2000-02. Leaf area index, leaf area distribution and relative growth rate increased with growth stages and increasing rates of N, P and K. Crop yield increased with increasing rates of N and P during both years.

Dhanja *et al*. (2003) carried out an experiment in Baraut, Uttar Pradesh, India to study physiological variations in Bush bean-2 (*Phaseolus vulgaris L.*) as affected by nitrogen. The treatments consisted 3N levels (0, 60 and 120 kg/ha). They found that increasing levels of N up to 120 kg/ha increased dry weight, leaf area index, crop growth rate and relative growth rate, but net assimilation rate increased up to 60 kg N/ha.

The effect of weed control treatments (hand weeding at 30 and 45 DAS, and 0.75 kg pendimethalin or 0.50 kg fluchloralin/ha, applied singly or in combination with hand weeding at 45 DAS) and N rate (0, 40, 80 or 120 kg/ha) on *Phaseolus vulgaris* cv.DPR-86-6-4 and associated weeds were studied in Sardar Krushinagar, Gujarat, India in 1999. The seed yield of the unweeded crop without N was lower by 51.5 and 18.0% than that of crops treated with pendimethalin + hand weeding and fluchloralin + hand weeding with 120 kg N/ha, respectively. N at 120 kg/ha recorded the highest values of yield and yield components (Prajapati and Patel, 2001).

A field experiment was conducted to determine the effect of different nitrogen levels (0, 40, 80 and 120 kg/ha) and Rhizobium inoculation (control, HURR-3 and Raj-2) on crop yield, nitrogen uptake and crop quality of Bush bean cv. HUR-137 in Varanasi, Uttar Pradesh, India, during 1994-95 and 1995-96. The yield components, crop and protein yield significantly increased with increasing nitrogen levels and the heist values were registered with 120 kg/ha during both years. The nitrogen content and uptake increased with increasing nitrogen levels and highest values were recorded with 120 kg/ha (Chandel *et al*., 2002).

Shaha (2002) conducted an experiment at Horticulture Farm, Bangladesh Agricultural University, Mymensingh to investigate the influence of nitrogen on bush bean viz.0, 50, 100 and 150 kg/ha and found that plant height, number of branches per plant, days required for first flowering, green pod length, pods per plant and green pod yield per hectare were significantly influence by higher dose of nitrogen.

A field experiment was conducted by Vishwakarma *et al.* (2002) in Varanasi, Uttar Pradesh, India in 1997-98 to determine the response of two Bush bean cultivars (Holland 84 and PDR 14) to different nitrogen application rates (0, 30, 60, 90 kg/ha) on sandy loam soil in India during 1996-97 and 1997-98. The growth, yield attributes and yield (grain and stover) increased with increasing rates of nitrogen up to 90 kg/ha. This level of nitrogen also recorded maximum water use efficiency.

A field experiment was conducted by Ramakrishna *et al.* (2002) in Bangalore, Karnataka, India during the kharif season to study dry matter partitioning, nutrient accumulation, and uptake of primary nutrients in Bush bean cultivars Arka Komal and Burpee Stringless. There were 18 treatments consisting of 3 spacing (30 x 15; 30 x 20; and 40 cm) and 3 N rates with constant P and K rates (45:100:75; 60:100:75; and 75:100:75 kg NPK/ha). Dry matter accumulation in various plant parts and in whole plants increased significantly due to cultivars, spacing and fertilizer rates. Arka

Komal recorded significantly higher dry matter accumulation than Burpee Stringless. The NPK uptake ranged from 118.88 to 132.92, 8.29-9.95, and 124.95-138.69 kg/ha, respectively, in varying fertilizer rates. Pods accounted for 70.02-73.23% total N, 88.21-88.64% total P, and 62.32-65.04% total K removed by plant.

Chaudhari *et al.* (2001) studied the nutrient management of Bush bean in Nagpur, India. They reported that application of nitrogen significantly increased the plant height, Pod number and yield per plant in Bush bean.

A field experiment was conducted by Dhanjal *et al.* (2001) in Baraut, Uttar Pradesh, India during the rabi seasin of 1997-98 to study the effect of crop density (500000, 333000 or 250000 plants/ha) and N (0,60,or120 kg/ha applied at sowing) on the yield components of *P. vulgaris* cultivars (HUR 87,PDR 14, and VL 63). They reported that the increase in rate of crop density and nitrogen gave a corresponding improvement in yield and yield components.

An experiment was conducted by Prajapati and Patel (2001) in sardar Krushinagar, Gujarat, India to determine the effect of weed control methods and N fertilizer application on the physiological of Bush bean cv. DPR 86-6-4. They found that fresh and dry matter production per plant, were significantly high with 120 kg N/ha. All the growth parameters were low with 0 kg N/ha.

A field experiment was conducted by Singh *et al.* (2001) during winter 1995-96, on a sandy clay loam soil, at Varanasi, Uttar Pradesh, India to evaluate the effects of N (80, 160, 240 kg/ha) and S (0, 20, 40, 60 kg/ha) on the nutrient uptake and grain yield of Bush bean (*P. vulgaris*) cv. HUR 137. Nitrogen at 140 kg/ha recorded the highest grain (2091 kg/ha) and straw (3331 kg/ha) yields and highest total N (90.70 kg/ha) and S (6.58 kg/ha) uptake.

A field experiment was conducted by Ghosal *et al.* (2000) during winter of 1990-91 and 1991-92 in Bihar, India to evaluate the effects of varying N rates (0, 40, 80,120,160 kg/ha) and times of application (Full basal, ½ as basal+ ½ at branching , ½ as basal + ½ at 50% pod formation,1/3 as basal + 1/3 as branching + 1/3 as 50% pod formation, ¼ as basal + ½ as branching + ¼ at 50% pod formation) on the growth and yield of *P. vulgaris* cv.HUR-15. N at 160 kg/ha gave the highest value for number of pods per plant, weight of unfilled pods per plant, grains per pod, grain weight per plant, 100-grain weight, dry weight per plant and grain and straw yields.

A field experiment was conducted by Vinod et al. (1999) to evaluate the effects of sowing dates (5 and 20 October and 4 and 19 November) and graded rates of nitrogen (0, 50, 100, 150 kg/ha) with reference to growth, fruiting and green pod yield in Bush bean cv. Contender. Plant height at the final stage of observation, number of pods per plant, green pod weight per plant and green pod yield were highest in plants receiving 150 kg N/ha. The interaction of sowing date and N application was significant for characters such number of leaflets per plant, pod length and green pod yield.

Ravi and Prasad (1998) conducted an experiment in Bihar, India during 1991-92 and 1992-93 to study the response of irrigation and nitrogen fertilization on Bush bean (*P. vulgaris*). They observed that plant height, branches per plant, leaves per plant and seed yield were increased due to increased in nitrogen level from 40 to 120 kg N/ha.

Calvache *et al.* (1997) reported that applied N significantly increased seed yield, pod number per plant, seeds per pod and harvest index in Bush bean.

In a field trail in Maharashtra, India Durge *et al.* (1997) studied the effects of nitrogen and irrigation on the yield of Bush bean and found the highest yield with the application of 150 kg N/ha.

2.2. Effect of Potassium on the growth and yield of Bush bean

An experiment was conducted by Kanaujia *et al.* (1999) to investigate the phosphorus and potassium requirement of Bush bean. They used P at 0, 40, 80, 120 kg P_2O_5/ha and K at 0, 30, 60, 90 kg K_2O/ha and observed that highest plant height, number of branches per plant, pod length and growth, number of pods per plant, green pod yield and protein content increased with increasing of K rates up to 60 kg K_2O/ha.

Peralosa *et al.* (1995) conducted an experiment in green house to investigate the nutrition of bean. They used sand culture with Ca: K ratios of 0.25, 0.50, and 1.00. Nitrate uptake and N plant levels and the corresponding concentration in the plants were directly related to the applied Ca: K ratio. Mg uptake decreased as the Ca: K ratio increased. Plant yield was highest with applied Ca: K ratio of 1.00.

2.3 Combined effect of Nitrogen and Potassium on the growth and yield of Bush bean.

Sharma *et al.* (2008) conducted a field experiments in Dhaulakuan, Himachal Pradesh, India, during 2003/04-2004/05 in a ginger-Bush bean (Phaseolus vulgaris) cropping sequence with ginger as the main crop. The treatments comprised pre-sowing application of farmyard manure (FYM) at 5 t/ha, post-sowing mulching with dry straw (cereals/grasses) at 3 t/ha+FYM at 5 t/ha and with partially decomposed FYM at 5 t/ha as hill placement at 2 months after sowing, i.e. after hoeing, and 60 kg N/ha as top dressing in 2 splits (farmers' practice). The negative effect of FYM on rhizome yield as farmers' practice resulted in significantly lower yield than the control or 50 kg N along with adequate and well-decomposed FYM. The highest rhizome yield (160 q/ha) was obtained in treatment with all the nutrients in balanced form, which was statistically at par with the yield in treatment excluding B, Zn, and 20 kg S. Dry matter yield of straw was the highest with 100-75-40-5-1 kg N-K2O-S-Zn-B/ha and was statistically at par with all the combinations of NK, NKS and NKSZn. Application of S, Zn and B along with NPK increased the uptake of N, P, K, Ca and S whereas application of Mo at 1 kg/ha decreased the uptake of all these nutrients. Cu, Mn and Zn uptake remained unaffected with these treatments. Farmers' practice and addition of 40 kg S along with other nutrients resulted in significantly higher decrease in soil pH at 100 days after sowing and harvest stages. In general, as the crop matured, the organic C, available N, P and S status of the soil increased whereas K along with DTPA extractable Cu, Mn, Fe and Zn status of the soil decreased. Pod length, pod girth and straw yield of residual crop-Bush bean were not affected significantly by the treatments, however, the highest number of branches (9.7), pods (27.2) and leaf area per plant (567 cm^2) were recorded in balanced application of nutrients and were statistically superior over the treatments involving N (50-100 kg/ha) or N-K< sub>2</ sub>O (100-25 kg/ha) only.

Prasad *et al.* (2006) conducted a field experiment for two consecutive years (2000 and 2001) at the Feirsa Agricultural University, Ranchi, Jharkhand, India, to determine the effects of intercrop and NPK fertilizer application on the performance of okra (cv. Arka Anamika). Treatments comprised: two intercrops (cowpea and Bush bean) and five fertilizer rates (0, 25, 50, 75 and 100% recommended dose of NPK). The results revealed that intercropping okra with Bush bean did not significantly affect the performance of okra. On the other hand, significantly higher okra equivalent yield and net return were observed with okra + cowpea intercropping (134.61 q/ha and Rs. 27 733.89/ha, respectively). Treatment with 100% recommended dose of fertilizers recorded higher okra equivalent yield (153.16 q/ha) and net returns (Rs. 30 709.91/ha) than the rest of the fertilizer rates. The best performance of okra in terms of yield, number of fruits per plant, fruit weight and plant height were observed with 100% recommended dose of fertilizer. The significantly highest okra equivalent yield (158.98 q/ha) and net returns (Rs. 33 205.17/ha) were obtained with the okra + cowpea intercropping system at 100% recommended dose of fertilizers applied to both crops, which was at par with okra + cowpea at 75% recommended dose of fertilizers applied to both crops.

A field experiment was conducted by Singh *et al.* (2003) Bush bean (Phaseolus vulgaris) cv. PDR-14 plants were supplied with 0, 60 and 120 kg N and K/ha and 0, 60 and 90 kg P/ha in a field experiment conducted in Kanpur, Uttar Pradesh, India during the rabi seasons of 2000-02. Leaf area index, leaf area distribution and relative growth rate increased with growth stages and increasing rates of N, P and K. Crop yield increased with increasing rates of N and P during both years.

An experiment was conducted by Verma and Singh (2002) during 1994-95, 1995-96 and 1996-97 to work out the productive and economic association of organics and inorganic fertilizer in Bush bean (P. vulgaris) on sandy loam soil of eastern Uttar Pradesh, India. Treatments comprised: 50, 75 or 100% recommended rate of fertilizer (RRF; where 100% RRF=120:60:30 kg NPK/ha), 10 t farmyard manure (FYM)/ha and/or 10 t cane residues. A marked increase in growth, yield attributes and yield was observed due to application of organics, inorganic fertilizer alone and their combinations. Among all treatments, 10 t FYM/ha + 75% RRF recorded the highest net return and benefit: cost ratio.

A field experiment was conducted by Raghavendra and Ali. (2001) in pot culture studies were carried out in a greenhouse to investigate the effect of vermicomposts (at 25 t/ha) derived from 4 green leaves, i.e. cassia (Cassia spectabilis; VC-I), subabul (Leucaena leucocephala; VC-II), neem (Azadirachta indica; VC III) and cashew (VC-IV) in combination with cowdung in 4:1 proportion, on nodulation, nutrient uptake and dry matter yield of Bush bean (Phaseolus vulgaris) cv. Arka Komal. The treatments comprised a control (T1), recommended dose of fertilizer of 62.5:100:75 kg NPK/ha (RDF; T2), VC-I (T3), VC-II (T4), VC-III (T5), VC-IV (T6), VC-I+50% RDF (T7), VC-II+50% RDF (T8), VC-III+50% RDF (T9), VC-IV+50% RDF (T10), VC-I+75% RDF (T11), VC-II+75% RDF (T12), VC-III+75% RDF (T13) and VC-IV+75% RDF (T14). Application of various vermicomposts with or without RDF greatly affected the nodule formation in Bush bean. The mean number of nodules per plant significantly increased in all the treatments when compared to the control. However, with the increase in fertilizer level, the number of nodules decreased. The highest number of nodules (27.10) was recorded in T7. Application of vermicomposts with or without fertilizers significantly increased the uptake of major nutrients in all the treatments over the control. The maximum uptake of N (350.55 mg/pot), P (16.18 mg/pot), K (249.69 mg/pot), Ca (203.45 mg/pot), Mg (91.03 mg/pot) and S (17.91 mg/pot) were recorded in T7. The application of vermicomposts with or without fertilizers had significant effect on dry matter yield of Bush bean. The highest dry matter yield of 8.67 g/pot was recorded in T7.

A field experiment conducted by Chavan *et al.* (2000) in Maharashtra, India during the rabi season of 1990, Bush bean (Phaseolus vulgaris) cultivars Contender, Arka-komal and Waghya sown on 31 December 1989 were supplied with 3 rates of N (0, 25 and 50 kg/ha) and 3 rates of P (0, 25 and 75 kg/ha). Seeds were evaluated for N, P and K contents, total dry matter and protein production. The highest P uptake (6.3 kg/ha) by seeds and straw was recorded in both Waghya and Arka-komal. Waghya recorded the highest total dry matter (17.2 q/ha), seed protein production (128.0 kg/ha) and N and K uptake (31.7 and 12.0 kg/ha, respectively). The highest total P uptake (8.5 kg/ha) was recorded from the highest N rate (50 kg/ha). Total P uptake increased linearly with increase in P rates.

Chapter 3
Materials and Methods

CHAPTER III
MATERIALS AND METHODS

This chapter arranges the materials and methods including a brief description of the experimental site, BARI Bush Bean-2 variety, soil, climate, land preparation, experimental design, treatments, and cultural operations, collection of soil and plant samples etc. and analytical methods used for the experiment. The details of research procedure are described here.

3.1 Description of the experimental site

3.1.1 Location

The research work was conducted in rabi season at Sher-e-Bangla Agricultural University Farm, Sher-e-Bangla Nagar, and Dhaka-1207 during the *rabi* season of November, 2008 to March, 2009. It is located at 90.3350E longitude and 23.774^0 latitude. The specific location of experimental site is presented in Appendix I.

3.1.2 Soil

The soil of the experimental field belongs to the Tejgaon series of AEZ No. 28, Madhupur Tract and has been classified as Shallow Red Brown Terrace Soils in Bangladesh soil classification system. 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 properties. Some physical and chemical characteristics of the initial soil are presented in Table 1.

Table 1. Physical and chemical properties of the initial soil sample

Soil properties	Value
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	28.2
% Silt	41.20
% Clay	30.6
2. Soil texture	Silty Clay
B. Chemical properties	
1. Soil pH	5.6
2. Organic carbon (%)	0.68
3. Organic matter (%)	1.17
4. Total N (%)	0.08
5. C : N ratio	9.75 : 1
6. Available P (mg kg^{-1})	13.42
7. Available K (me100g^{-1})	0.13
8. Available S (mg kg^{-1})	23.74

3.1.3 Climate

The experimental area has sub tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm.

3.2 Description of the BARI Bush Bean-2 variety

BARI Bush Bean-2 is a local, and well adapted variety in our country, a high yielding variety was selected for this experiment. This BARI Bush Bean-2 variety is well recognized and mostly cultivated in different districts of Bangladesh. The germination percentage of the seed was 85.

3.3 Treatments of the experiment

The experiment consists of two factors viz. Nitrogen (N) and Potassium (K). Doses of nitrogen were 0, 40, 80, 120 kg/ha and doses of potassium were 0, 20, 40, and 60 kg/ha. So total numbers of treatment combinations were 16. Details of the treatments are presented below:

T_0 = 0 kg N + 0 kg K ha^{-1} (control)

T_1 = 0 kg N + 20 kg K ha^{-1}

T_2 = 0 kg N + 40 kg K ha^{-1}

T_3 = 0 kg N + 60 kg K ha^{-1}

T_4 = 40 kg N + 0 kg K ha^{-1}

T_5 = 40 kg N + 20 kg K ha^{-1}

T_6 = 40 kg N + 40 kg K ha^{-1}

T_7 = 40 kg N + 60 kg K ha^{-1}

T_8 = 80 kg N + 0 kg K ha^{-1}

T_9 = 80 kg N + 20 kg K ha^{-1}

T_{10} = 80 kg N + 40 kg K ha^{-1}

T_{11} = 80 kg N + 60 kg K ha^{-1}

T_{12} = 120 kg N + 0 kg K ha^{-1}

T_{13} = 120 kg N + 20 kg K ha^{-1}

T_{14} = 120 kg N + 40 kg K ha^{-1}

T_{15} = 120 kg N+ 60 kg K ha^{-1}

Nitrogen was applied as Urea and Potassium was supplied as Muriate of Potash (MOP)

3.4 Design and layout of the experiment

The experiment consisted of 16 treatment combinations and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. An area of 299 m^2 was divided into three equal blocks, representing the replications, each containing 16 plots. Thus, the total numbers of unit plots were 48, each measuring 2.4 m × 1.5 m (3.6 m^2). The treatment combinations of the experiment were assigned at random into 16 plots of each at 3 replications. The distance retained between two plots was 50 cm and between blocks was 50 cm. The layout of the experiment is presented in Figure 2.

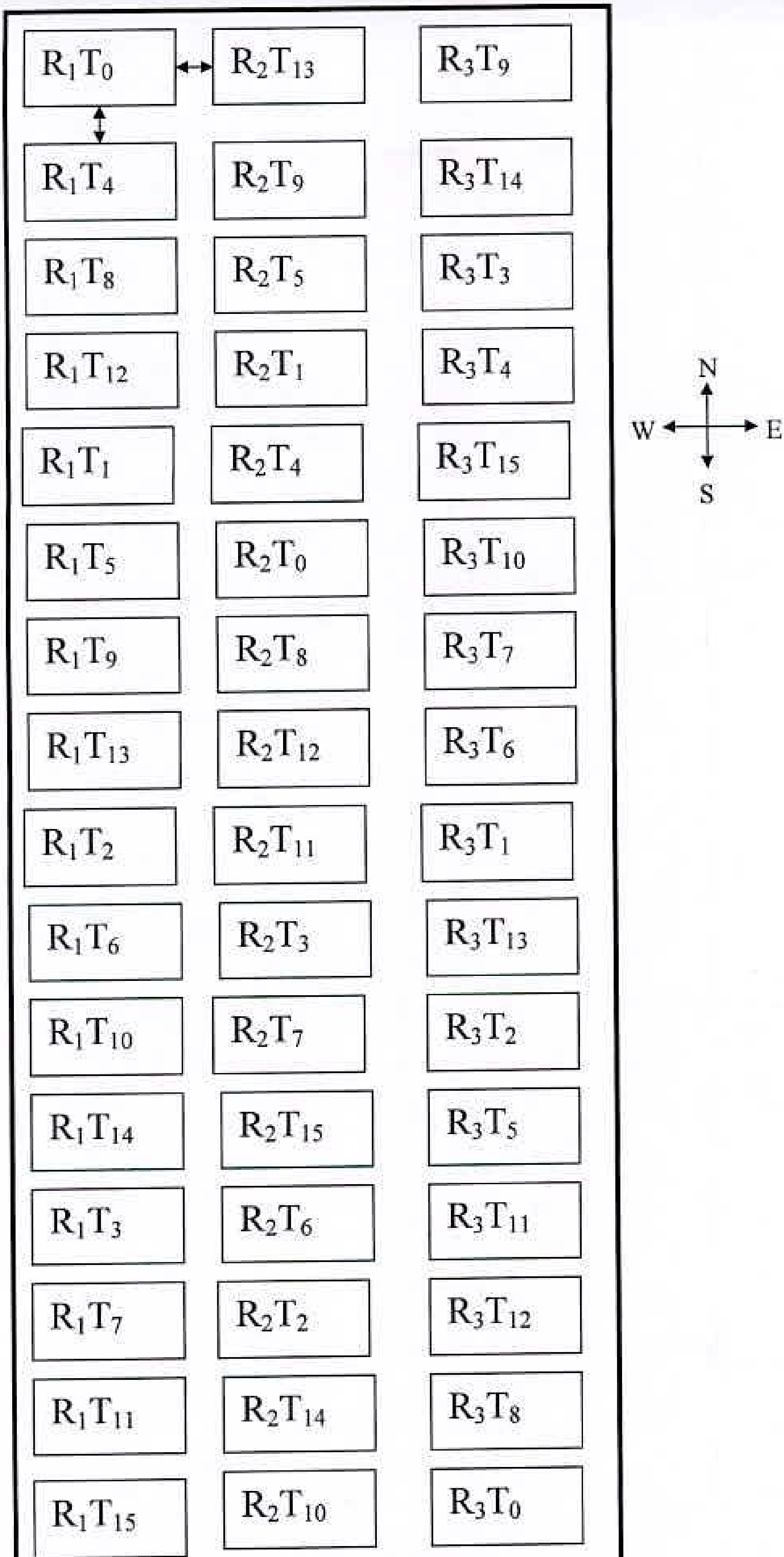

Figure 1. Layout of the experimental field

3.5 Cultivation of BARI Bush Bean-2

3.5.1 Preparation of the field

The plot selected for the experiment was opened by a tractor on the 30th November' 2008, afterwards the land was ploughed and cross-ploughed several times with the help of a power tiller followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soil for transplanting of seed. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the following section (3.4). Irrigation and drainage channels were prepared around the plots.

3.5.2 Rate of common doses of fertilizers and manures

In this experiment fertilizers and manures (except N and K fertilizers) were applied according to the recommendation rate of BARI which was as follows:

Common doses:

Manures/ fertilizers	Dose/ ha
TSP	160 kg
Gypsum	36 kg
Zinc Sulphate	3 kg

3.5.3 Application of fertilizers and manures

The entire quantity of TSP, Gypsum, Zinc Sulphate, MOP (treatment wise) and ¼ N (urea) was applied during the final land preparation as basal dose. The rest of the urea and MOP was applied in three equal installments as top dressing.

3.5.4 Seed sowing

Seeds of BARI Bush Bean-2 were sown 03 December, 2008 following the line to line distance 30 cm, seed to seed distance 10 cm, row to row distance 50 cm and distance retained between two plots was 50 cm. The seeds were sown per hill at a depth of 5 cm and the seeds were covered with pulverized soil just after sowing and gently pressed with hands. Surrounding of the experimental plots, Bush bean seeds were also sown as border crop to reduce border effects.

3.5.5 Intercultural operation

Intercultural operations were done whenever required for getting better growth and development of the plants. So, the plants were always kept under careful observation.

3.5.5. a) Gap fillings

Damaged seedlings were replaced by using healthy plants from the excess plants within one week.

3.5.5. b) Weeding and mulching

Weeding was done three times after transplanting to keep the crop free from weeds and mulching was done by breaking the crust of the soil for easy aeration and to conserve soil moisture when needed, especially after irrigation.

3.5.5. c) Irrigation and drainage

The young seedlings in the field were irrigated just after transplanting. Irrigation was provided by a watering can and or hose pump when needed throughout the growing time mainly after top dressing and after weeding. At this time care was taken so that irrigated water could not pass from one plot to another. During each irrigation, the soil was made saturated with water. After rainfall, excess water was drained when necessary.

3.5.5. d) Protection of plants

Against the soil born pathogen, preventive measure was taken. For the prevention of soil treatment was done with Furadan 3 G @ 20 kg ha^{-1}. Few days after transplanting, some plants were attacked by purple blotch disease caused by *Alternaria porri*. It was controlled by spraying Rovral 50 WP two times at 15 days interval after transplanting.

3.6 Harvesting

According to their attainment of pod maturity showing first harvest was done on 16^{th} February, 2009 and second harvest was done 1^{st} March, 2009.

3.7 Collection of data

Data collection were done from the sample plants on the following parameters at the time of experiment –

3.7.1 Pod length

Five pods were selected randomly from each plot and length of pods was measured using a centimeter scale and the mean value was calculated and expressed in centimeter (cm).

3.7.2 Pod diameter

Five pods were selected randomly from each plot and diameter of pods was measured with the help of slide calipers and the average was taken and expressed in centimeter (cm).

3.7.3 Average single Pod weight

Five pods per plant were randomly selected from each plot treatment wise and average weight of per pod was calculated in gram (gm).

3.7.4 Total pod weight per plant

From each plant total pods were weighed and their average was taken in gram (gm).

3.7.5 Pod yield per plot

Green pod were harvested at regular interval from each unit plot and their weight was recorded. Harvesting was done at different interval and the total pod weights were recorded in each unit plot and expressed in gram (gm).

3.7.6 Pod yield per hectare

The green pod yield per plot was finally converted to yield per hectare and expressed in ton.

3.8 Collection of samples

3.8.1 Soil Sample

The initial soil sample was collected randomly from different spots of the field selected for the experiment at 0-15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post harvest soil samples were collected from each plot at 0-15 cm depth on 5^{th} March, 2008. The samples were air-dried, ground and sieved through a 2 mm (10 meshes) sieve and kept for analysis.

3.8.2 Plant sample

Plant samples were collected from every individual plot for laboratory analysis at the harvesting stage of the crop. Five plants were randomly selected from each plot. Pods and leaves were separated and then samples were dried in the electric oven at 70^0 C for 48 hours. After that the samples were ground in an electric grinding machine and stored for chemical analysis. The plant samples were collected by avoiding the border effect for the highest precision. For this the outer two rows and the outer plants of the middle rows were avoided.

3.9 Post harvest soil sample analysis

The initial and post harvest soil sample were analyzed for both physical and chemical properties. The properties studied included texture, pH, bulk density, particle density, organic carbon, total N, available P, exchangeable K, available S and available N. The soil was analyzed by the following standard methods:

3.9.1 Particle size analysis

Particle size analysis of soil sample was done by hydrometer method as outlined by Day (1965) and the textural class was ascertained using USDA textural triangle.

3.9.2 Soil pH

Soil pH was determined by glass electrode pH meter in soil- water suspension having soil: water ratio of 1: 2.5 as outlined by Jackson (1958).

3.9.3 Organic carbon

Soil organic carbon was determined by wet oxidation method described by Walkley and Black (1935).

3.9.4 Organic matter

The underline 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 organic matter content was determined by multiplying the percent organic carbon with Van Bemmelen factor 1.73 and the result was expressed in percentage (Piper, 1950).

3.9.5 Total nitrogen

Total nitrogen of soil samples were estimated by Micro-Kjeldahl method where soils were digested with 30% H_2O_2 conc. H_2SO_4 and catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Selenium powder in the ratio of 100: 10: 1, respectively). Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 N H_2SO_4 (Bremner and Mulvaney, 1982).

3.9.6 Available Phosphorous

Available phosphorous was extracted from the soil by shaking with 0.5 M $NaHCO_3$ solution of pH 8.5 (Olsen *et al.* 1954). The phosphorous in the extract was then determined by developing blue color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 nm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.9.7 Exchangeable potassium

Exchangeable potassium in the soil sample was extracted with 1N neutral ammonium acetate (NH_4OAC) and the potassium content was determined by flame photometer (Black, 1965).

3.9.8 Available sulphur

Available sulphur was extracted from the soil with Ca $(H_2PO_4)_2.H_2O$. Sulphur in the extract was determined by the turbidimetric method as described by Hunt (1980) using a Spectrophotometer (LKB Novaspec, 4049).

3.10.9 Available Zinc.

Available Zinc was extracted from the soil with sulphuric acid (H_2SO_4). Zinc in the extrated was determined by the tubidimetric method (Murphy and Riley, 1962).

3.10 Chemical analysis of plant sample

3.10.1 Digestion of plant samples with nitric-perchloric acid mixture

An amount of 0.5g of sub-sample was taken into a dry clean 100 ml Kjeldahl flask, 10 ml of di-acid mixture (HNO_3, $HClO_4$ in the ratio of 2:1) was added and kept for few minutes. Then, the flask was heated at a temperature rising slowly to 200°C. Heating was instantly stopped as soon as the dense white fumes of $HClO_4$ occurred and after cooling, 6ml of 6N HCl were added to it. The content of the flask was boiled until they became clear and colorless. This digest was used for determining P, K, S and N.

3.10.2 Phosphorous

Phosphorous in the digest was determined by developing yellow colour by Vanadomolybdate reagent and measuring the yellow colour by spectrophotometer as described in soil analysis section.

3.10.3 Potassium

Five milli-liter of digested 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 determined by flame photometer.

3.10.4 Sulphur

Sulphur content in the digest was determined by turbidimetric method as described by Hunt (1980) using a spectrophotometer

3.10.5 Nitrogen

Plant samples were digested with 30% H_2O_2, conc. H_2SO_4 and a catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Selenium powder in the ratio of 100: 10: 1, respectively) for the determination of total nitrogen by Micro-Kjeldahl method. Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 N H_2SO_4 (Bremner and Mulvaney, 1982).

3.11 Statistical analysis

The data obtained from the experiment were analyzed statistically using MSTAT computer package program to find out the significance of the difference among the treatments. The mean values of all the treatment were calculated and analysis of variances for all the characters was performed by the 'F' (variance ratio) test. The significance of the differences among the pairs of treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 1% and 5% level of probability (Gomez and Gomez, 1984) for the interpretation of results.

Chapter 4

Results and Discussion

RESULTS AND DISCUSSION

The present experiment was conducted to investigate the effect of nitrogen and potassium on the growth and yield of BARI Bush Bean-2. The results obtained from the experiment have been grouped and are presented under the following sub heads.

4.1 Effect of nitrogen on the growth and yield of BARI Bush Bean-2

The effect of nitrogen on pod length, pod diameter, average single pod weight, total pod weight per plant, pod yield per plot and pod yield per hectare of BARI Bush Bean-2 have been presented and discussed below:

4.1.1 Pod Length

Pod length was recorded at the harvest stage of BARI Bush Bean-2 as vegetable and it was observed that there were significant variations in pod length at different levels of Nitrogen application (Table-2). Length of pod increased significantly by the increasing levels of nitrogen up to 80 kg Nha^{-1}. The highest length of green pod was found (11.15 cm) in treatment N_{80} which is statistically identical with N_{40}, N_{120} treatments and the lowest (10.30cm) was found in the plot treated with N_0 treatment. This result is similar with that of Tewari and Singh (2000) and Sharma *et al.* (1996).

4.1.2 Pod diameter

Pod diameter was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in pod diameter at different levels of nitrogen application. Diameter of pod increased significantly by the increasing levels of nitrogen up to 80 kg Nha^{-1}. The highest diameter of pod was found (2.93 cm) in treatment N_{80} which is statistically identical with N_{120} treatment and the lowest (2.73cm) was found in the plot treated with N_0 treatment (Table 2). This result is similar with that of Durge *et al.* (1997).

4.1.3 Average single pod weight

Five pods per plant are randomly selected from each plot treatment wise and average weight of per pod was calculated in gram (gm). A significant influence was observed in respect of average single pod weight at different levels of nitrogen up to 80 kg Nha^{-1}. The highest average single pod weight was found (5.42 gm) in treatment N_{80} which is statistically identical with N_{40}, N_{120} treatments and the lowest (4.78 gm) was found in the control plot (Table 2). Sharma *et al.* (2008) also reported similar result.

4.1.4 Total pod weight per plant

Statistically significant variation was recorded for different levels of nitrogen in terms of total pod weight per plant (Table 2). The highest total pod weight per plant was observed (25.63 gm) in treatment N_{80} which is statistically identical with N_{40}, N_{120} treatments and the lowest (22.85) was found in the zero treated plot. This result is similar with that of Sharma *et al.* (1996).

4.1.5 Pod yield per plot

The effect of nitrogen on pod yield per plot showed a statistically significant difference at harvesting stage of BARI Bush Bean-2. Pod yield per plot increased significantly by the increasing levels of nitrogen up to 80 kg Nha^{-1}. The highest pod yield per plot was found (1789.58 gm) in treatment N_{80} which is statistically identical with N_{40} treatment and statistically followed N_{120}. The lowest (1454.17 gm) was found in the plot treated with control (Table 2). This result is similar with that of Durge *et al.* (1997).

4.1.6 Pod yield per hectare

Pod yield per hectare was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in pod yield per hectare at different levels of nitrogen application. Pod yield per hectare increased significantly by the increasing levels of nitrogen up to a certaining dose. The highest pod yield per hectare was found (4.37 ton) in treatment N_{80} which is statistically identical with N_{40} treatment and statistically followed N_{120}. The lowest (3.55 ton) was found in the plot treated with control (Table 2). Durge *et al.* (1997) also reported similar result.

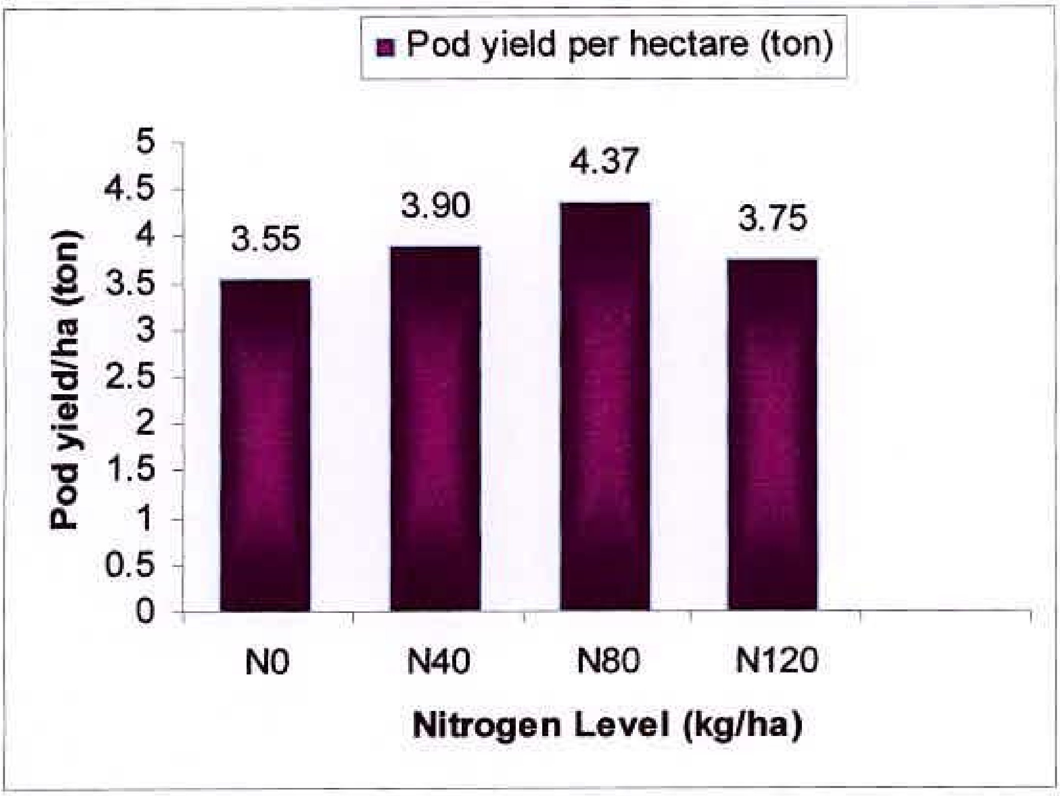

Fig.- 2: Effect of Nitrogen on pod yield per hectare of BARI Bush Bean-2

Table 2. Effect of nitrogen on the growth and yield of BARI Bush Bean-2

Treatment	Pod length (cm)	Pod diameter (cm)	Average single pod weight (gm)	Total pod weight per plant (gm)	Pod yield per plot (gm)	Pod yield per hectare (ton)
N_0	**10.30 b**	**2.73 c**	**4.78 b**	**22.85 c**	**1454.17 c**	**3.55 c**
N_{40}	10.55 ab	2.74 b	5.17 ab	24.42 ab	1600.00 ab	3.90 ab
N_{80}	**11.15 a**	**2.93 a**	**5.42 a**	**25.63 a**	**1789.58 a**	**4.37 a**
N_{120}	10.90 ab	2.90 ab	5.00 ab	24.99 ab	1537.50 b	3.750 b
CV (%)	7.28	7.47	10.48	7.01	15.43	15.41
Level of significance	*	*	*	*	*	*

* = Significant at 5% level,
NS = Not significant, CV= Co-efficient of variation

4.2 Effect of potassium on the growth and yield of BARI Bush Bean-2

The effect of potassium on pod length, pod diameter, average pod weight, total pod weight per plant, pod yield per plot and pod yield per hectare of BARI Bush bean-2 have been presented and discussed below:

4.2.1 Pod Length

Pod length was recorded at the harvest stage of BARI Bush Bean-2 as vegetable and it was observed that there were significant variations in pod length at different levels of potassium application up to a certaining dose. The highest length of green pod was found (10.90 cm) in treatment K_{40} which is statistically identical with N_{20}, N_{80} treatments and the lowest result (10.40) was found in the plot treated with control (Table 3).

4.2.2 Pod diameter

Pod diameter was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in Pod diameter at different levels of potassium application up to a certaining dose. Diameter of Pod increased significantly by the increasing levels of potassium. The highest diameter of Pod was found (2.95 cm) in treatment K_{40} which is statistically identical with N_{20} treatment and the lowest (2.66 cm) was found in the plot treated with control (Table 3).

4.2.3 Average single pod weight

Average single pod weight was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in Single pod weight per plant at different levels of potassium application. Average single pod weight significantly increased by the increasing levels of potassium up to a certaining dose. The highest Single pod weight per plant was found (5.49 gm) in treatment K_{40} which is statistically identical with N_{20} treatment and the lowest (4.35 gm) was found in the plot treated with control (Table 3).

4.2.4 Total pod weight per plant

Total pod weight per plant was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in Total pod weight per plant at different levels of potassium application. The highest Total pod weight per plant was found (25.37 gm) in treatment K_{40} which is statistically identical with N_{20} treatment and the lowest (23.29 gm) was found in the plot treated with control (Table 3).

4.2.5 Pod yield per plot

Pod yield per plot was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in pod yield per plot at different levels of potassium application. Pod yield per plot increased significantly by the increasing levels of potassium. The highest pod yield per plot was found (1795.83 gm) in treatment K_{40} which is statistically identical with N_{20}, treatment and statistically followed K_{60}. The lowest (1466.67 gm) was found in the plot treated with control (Table 3).

4.2.6 Pod yield per hectare

Pod yield per hectare was recorded at the harvest stage of BARI Bush Bean-2 and it was observed that there were significant variations in pod yield per hectare at different levels of potassium application. The highest pod yield per hectare was found (4.38 ton) in treatment K_{40} which is statistically identical with N_{20} treatment and statistically followed $K_{60.}$ The lowest (3.02 ton) was found in the plot treated with control (Table 3). This result is similar with that of Kanaujia *et al.* (1999).

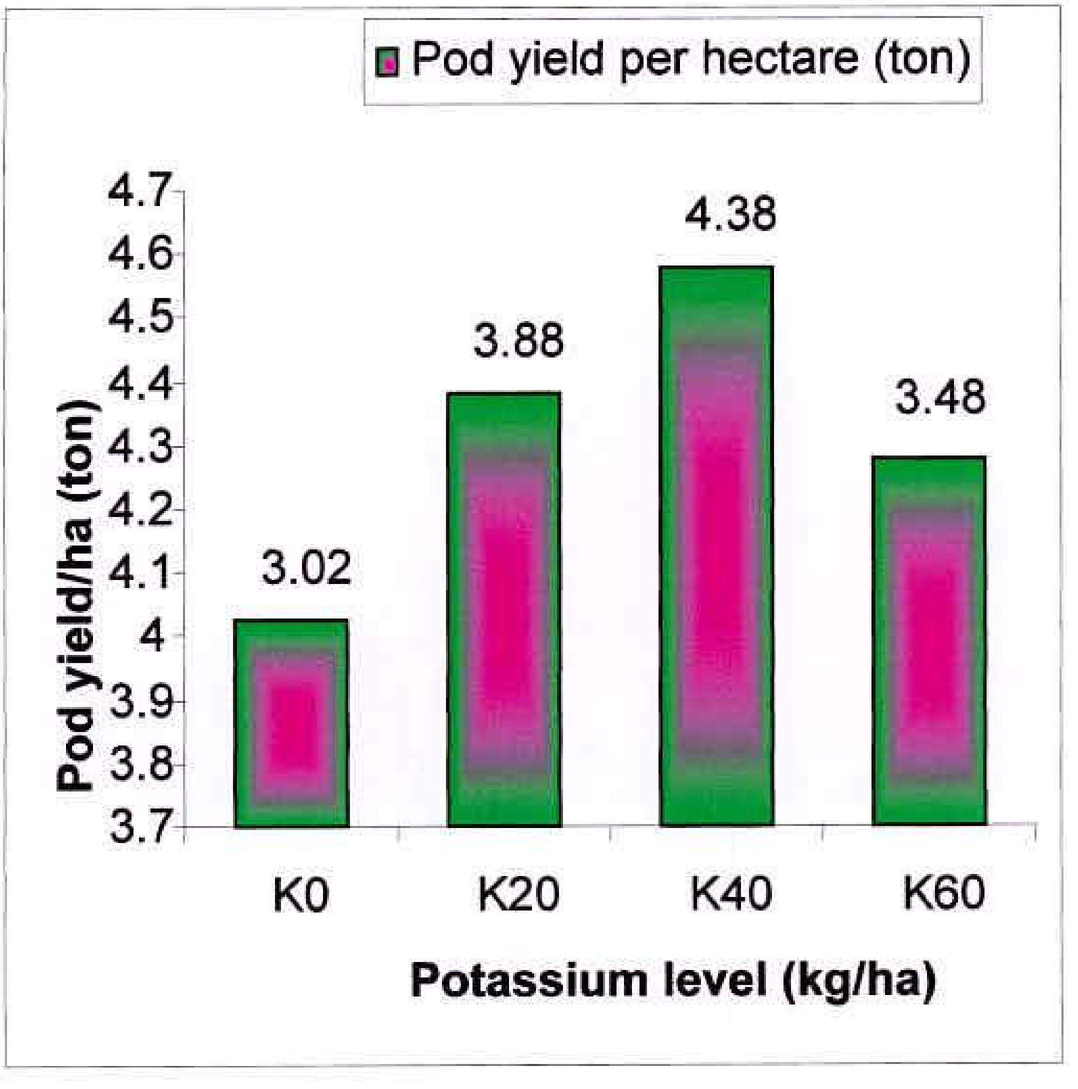

Fig.-3: Effect of Potassium on pod yield per hectare of BARI Bush Bean-2

Table 3. Effect of Potassium on the growth and yield of BARI Bush Bean-2

Treatment	Pod length (cm)	Pod diameter (cm)	Average single pod weight (gm)	Total pod weight per plant (gm)	Pod yield per plot (gm)	Pod yield per hectare (ton)
K_0	**10.52 b**	**2.66 c**	**4.35 c**	**23.29 c**	**1466.67 c**	**3.02 c**
K_{20}	10.80 ab	2.92 ab	5.40 ab	24.87 ab	1650.00 ab	3.88 ab
K_{40}	**10.90 a**	**2.95 a**	**5.49 a**	**25.37 a**	**1795.83 a**	**4.38 a**
K_{60}	10.60 ab	2.77 b	4.74 b	24.37 b	1568.75 b	3.48 b
CV (%)	7.28	7.47	10.48	7.01	15.43	15.41
Level of significance	*	*	*	*	*	*

* = Significant at 5% level,
NS = Not significant, CV= Co-efficient of variation

4.3 Interaction effect of nitrogen and potassium on the growth and yield of BARI Bush Bean-2

The interaction effect of nitrogen and potassium treatments on pod length, pod diameter; average single pod weight, total pod weight per plant, pod yield per plot and pod yield per hectare of BARI Bush Bean-2 have been presented and discussed below:

4.3.1 Pod Length

The interaction effect of nitrogen and potassium on the length of pod was found to be significant (Table 4). The highest length of pod was found (11.6 7 cm) under treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatments T_1 (0 kg N + 20 kg K ha $^{-1}$), T_2 (0 kg N + 40 kg K ha $^{-1}$), T_3 (0 kg N + 60 kg K ha $^{-1}$), T_4 (40 kg N + 80 kg K ha $^{-1}$), T_5 (40 kg N + 20 kg K ha $^{-1}$), T_6 (40 kg N + 40 kg K ha $^{-1}$), T_7 (40 kg N + 60 kg K ha $^{-1}$), T_8 (80 kg N + 0 kg K ha $^{-1}$), T_9 (80 kg N + 20 kg K ha $^{-1}$), T_{11} (80 kg N + 60 kg K ha $^{-1}$), T_{12} (120 kg N + 0 kg K ha $^{-1}$), T_{13} (120 kg N + 20 kg K ha $^{-1}$), T_{14} (120 kg N + 40 kg K ha $^{-1}$) and T_{15} (120 kg N + 60 kg K ha $^{-1}$) and the lowest length of pod was found (9.90 cm) under the treatment interaction T_0 (0 kg N + 0 kg K ha^{-1}). This result is similar with that of Sharma *et al.* (2008).

4.3.2 Pod diameter

The interaction effect of nitrogen and potassium on the Pod diameter was found to be significant .The highest diameter of pod was found (3.13 cm) treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatment interaction T_1 (0 kg N + 20 kg K ha $^{-1}$), T_3 (0 kg N + 60 kg K ha $^{-1}$),

T_5 (40 kg N + 20 kg K ha $^{-1}$), T_6 (40 kg N + 40 kg K ha $^{-1}$), T_8 (80 kg N + 0 kg K ha $^{-1}$), T_9 (80 kg N + 20 kg K ha $^{-1}$), T_{11} (80 kg N + 60 kg K ha $^{-1}$), T_{12} (120 kg N + 0 kg K ha $^{-1}$), T_{13} (120 kg N + 20 kg K ha $^{-1}$), T_{14} (120 kg N + 40 kg K ha $^{-1}$) and T_{15} (120 kg N + 60 kg K ha $^{-1}$). The lowest diameter of pod was found (2.10 cm) under control treatment interaction (Table 4). This result is similar with that of Sharma *et al.* (2008).

4.3.3 Average single pod weight

The interaction effect of nitrogen and potassium on the average single pod weight was found to be significant (Table 4). The highest average single pod weight was found (5.99 gm) treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatment interaction T_1 (0 kg N + 20 kg K ha $^{-1}$), T_2 (0 kg N + 40 kg K ha $^{-1}$), T_5 (40 kg N + 20 kg K ha $^{-1}$), T_6 (40 kg N + 40 kg K ha $^{-1}$), T_8 (80 kg N + 0 kg K ha $^{-1}$), T_9 (80 kg N + 20 kg K ha $^{-1}$), T_{13} (120 kg N + 20 kg K ha $^{-1}$) and T_{15} (120 kg N + 60 kg K ha $^{-1}$). The lowest average single pod weight was found (4.15 gm) under control treatment interaction. This result is similar with that of Sharma *et al.* (2008).

4.3.4 Total pod weight per plant

The interaction effect of nitrogen and potassium on the total pod weight per plant was found to be significant. The highest total pod weight per plant was found (29.07 gm) treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatment interaction T_6 (40 kg N + 40 kg K ha $^{-1}$), T8 (80 kg N + 0 kg K ha $^{-1}$) and T_{14} (120 kg N + 40 kg K ha $^{-1}$). The lowest total pod weight per plant was found (21.30 gm) under control treatment interaction (Table 4).

4.3.5 Pod yield per plot

The interaction effect of nitrogen and potassium on the pod yield per plot was found to be significant (Table 4). The highest pod yield per plot was found (2033.33 gm) treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatment interaction T_0 (0 kg N + 0 kg K ha $^{-1}$), T_3 (0 kg N + 60 kg K ha $^{-1}$), T_6 (40 kg N + 40 kg K ha $^{-1}$), T_7 (40 kg N + 60 kg K ha $^{-1}$), T_8 (80 kg N + 0 kg K ha $^{-1}$), T_{11} (80 kg N + 60 kg K ha $^{-1}$), T_{12} (120 kg N + 0 kg K ha $^{-1}$) and T_{13} (120 kg N + 20 kg K ha $^{-1}$) and which is statistically followed T_2 (0 kg N + 40 kg K ha $^{-1}$), T_4 (40 kg N + 0 kg K ha $^{-1}$), T_5 (40 kg N + 20 kg K ha $^{-1}$), T_9 (80 kg N + 20 kg K ha $^{-1}$), T_{14} (120 kg N + 40 kg K ha $^{-1}$), T_{15} (120 kg N + 60 kg K ha $^{-1}$). The lowest pod yield per plot was found (883.33 gm) under treatment interaction T_1 (0 kg N + 20 kg K ha $^{-1}$).

4.3.6 Pod yield per hectare

The interaction effect of nitrogen and potassium on the Pod yield per hectare was found to be significant. The highest length of pod Pod was found (4.96 ton) treatment interaction T_{10} (80 kg N + 40 kg K ha $^{-1}$) which is statistically identical with treatment interaction T_1 (0 kg N + 20 kg K ha $^{-1}$), T_3 (0 kg N + 60 kg K ha $^{-1}$), T_6 (40 kg N + 40 kg K ha $^{-1}$), T_7 (40 kg N + 60 kg K ha $^{-1}$), T_8 (80 kg N + 0 kg K ha $^{-1}$), T_{11} (80 kg N + 60 kg K ha $^{-1}$), T_{12} (120 kg N + 0 kg K ha $^{-1}$) and T_{13} (120 kg N + 20 kg K ha $^{-1}$) and which is statistically followed T_2 (0 kg N + 40 kg

K ha $^{-1}$), T_4 (40 kg N + 0 kg K ha $^{-1}$), T_5 (40 kg N + 20 kg K ha $^{-1}$), T_9 (80 kg N + 20 kg K ha $^{-1}$), T_{14} (120 kg N + 40 kg K ha $^{-1}$), T_{15} (120 kg N + 60 kg K ha $^{-1}$). The lowest length of pod Pod was found (2.16 ton) under control treatment interaction (Table 4). This result is similar with that of Sharma *et al.* (2008).

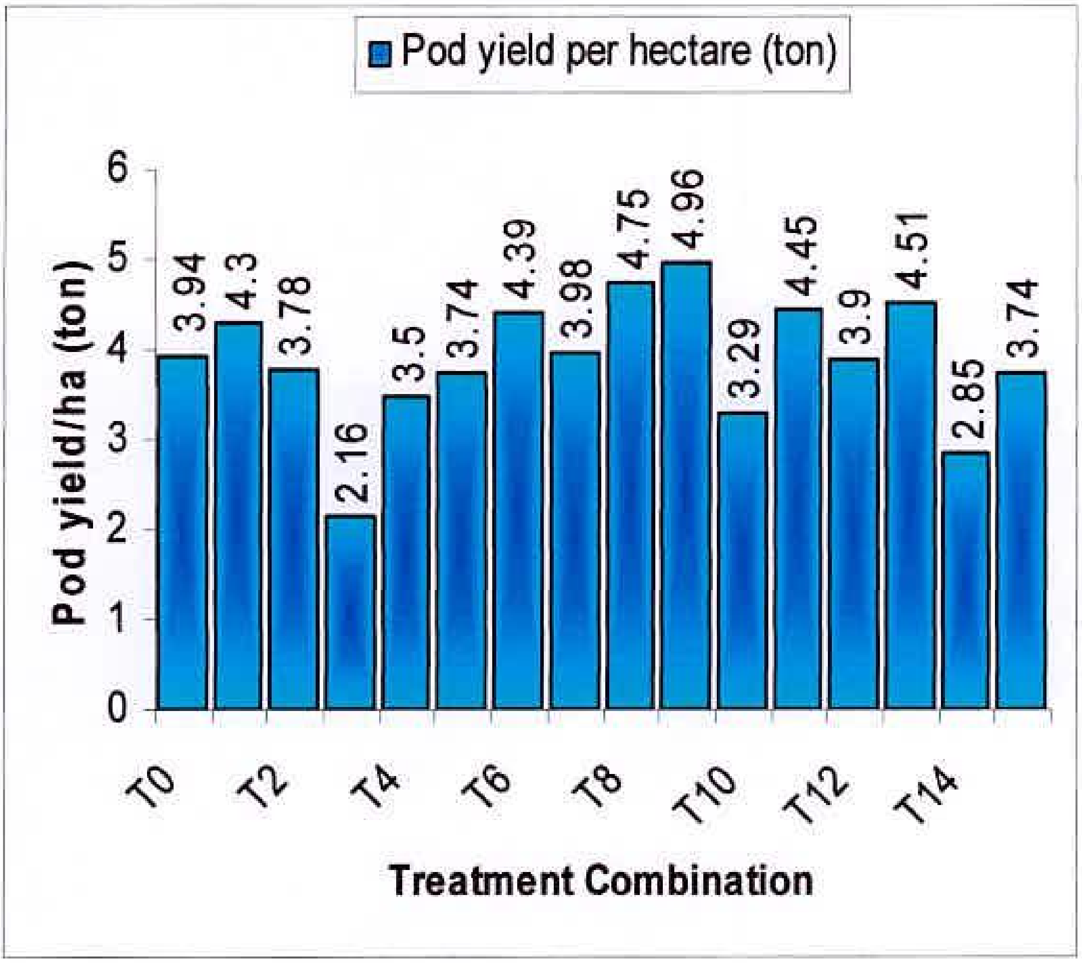

Fig.- 4: Interaction effect of Nitrogen and Potassium on pod yield per hectare of BARI Bush Bean-2

Table 4. Interaction effect of Nitrogen and Potassium on the growth and yield of BARI Bush Bean-2

Treatment combinations (A×B)	Pod length (cm)	Pod diameter (cm)	Average single pod weight (gm)	Total pod weight per plant (gm)	Pod yield per plot (gm)	Pod yield per hectare (ton)
T_0	**9.90 c**	**2.10 e**	**4.15 d**	**21.30 f**	1616.67 a-e	**2.16 f**
T_1	10.43 ab	2.83 a-c	4.97 a-d	21.80 ef	**883.33 f**	4.31 abcd
T_2	10.27 ab	2.67 b-d	5.18 a-d	23.73 c-f	1550.00 b-e	3.78 bcde
T_3	10.57 ab	2.90 a-c	4.83 b-d	22.03 ef	1766.67 a-d	3.93 abcde
T_4	10.57 ab	2.63 cd	4.92 b-d	25.40 b-d	1433.33 c-e	3.50 cde
T_5	10.73 ab	3.00 a-c	5.46 a-c	24.33 b-f	1533.33 b-e	3.74 bcde
T_6	10.94 ab	2.93 a-c	5.83 ab	26.63 a-c	1800.00 a-d	4.39 abcd
T_7	9.97 b	2.33 de	4.48 cd	23.83 c-f	1633.33 a-e	3.98 abcde
T_8	10.71 ab	2.97 a-c	5.28 a-c	27.40 ab	1950.00 ab	4.75 ab
T_9	11.17 ab	3.07 ab	5.77 ab	23.77 c-f	1350.00 de	3.29 de
T_{10}	**11.67 a**	**3.13 a**	**5.99 a**	**29.07 a**	**2033.33 a**	**4.96 a**
T_{11}	11.00 ab	2.90 a-c	4.64 cd	22.30 d-f	1825.00 a-d	4.45 abcd
T_{12}	11.03 ab	2.93 a-c	4.66 cd	24.53 b-f	1600.00 a-e	3.90 abcde
T_{13}	11.20 ab	2.90 a-c	5.40 a-c	26.27 a-c	1850.00 a-c	4.51 abc
T_{14}	10.73 ab	2.93 a-c	4.95 b-d	25.33 b-e	1166.67 ef	2.85 ef
T_{15}	10.70 ab	2.93 a-c	5.01 a-d	23.83 c-f	1533.33 b-e	3.74 bcde
CV (%)	7.28	7.47	10.48	7.01	15.43	15.4
Level of significance	*	NS	NS	*	*	*

* = Significant at 5% level, NS = Not significant, CV= Co-efficient of variation

4.4 Nutrient status of soil after harvest of BARI Bush Bean-2 as affected by Nitrogen and Potassium

4.4.1 Soil pH

The pH value of initial soil sample was 5.6 (Table-1). The result showed that on the treatment effect on the pH value of the post harvest soil sample compared to initial soil sample. The lowest pH value was observed 4.87 in T_{13} treatment interaction and the highest pH value was observed 6.05 in T_{14} treatment interaction (Table 5).

4.4.2 Organic Matter (%)

Organic matter content varied due to application of different levels of fertilizers. The lowest (0.86 %) organic matter content of soil was observed in T_{11} treatment interaction and the highest (1.16 %) organic matter content of soil was observed in T_{15} treatment interaction (Table 5).

4.4.3 Total nitrogen content (%)

The total nitrogen content of initial soil was 0.08 %. The lowest (0.05 %) total nitrogen content of soil was observed in $N_{80}K_0$ treatment combination and the highest (0.08 %) total nitrogen content of soil was observed $N_{40}K_{40}$ treatments (Table 5).

4.4.4 Available phosphorous content of soil (mg kg^{-1})

Combined effect of nitrogen and potassium showed a significant effect in respect of phosphorous content in the post harvest soil sample. The highest (19.41) phosphorous content was observed in T_{10} treatment and the lowest (14.95) phosphorous content was observed in T_{12} treatment (Table 5).

4.4.5 Exchangeable potassium content of soil (m.eq / 100 g)

Combined effect of nitrogen and potassium showed a significant effect in respect of potassium content in the post harvest soil sample. The lowest 0.12 potassium content was observed in T_0 treatment and whereas the highest 0.26 potassium content of soil was observed in T_{15} treatment (Table 5).

4.4.6 Sulphur content of soil (ms / kg)

Combined effect of nitrogen and potassium showed a significant effect in respect of sulphur content in the post harvest soil sample. The lowest sulphur content of soil was observed 15.73 control treatments and the highest sulphur content of soil was observed 26.47 in T_6 treatment (Table 5).

4.4.7 Zinc content of soil (mg kg^{-1})

Combined effect of nitrogen and potassium showed a significant effect in respect of zinc content in the post harvest soil sample. The lowest zinc content of soil was observed 2.48 in T_0 treatment and the highest zinc content of soil was observed 4.42 in T_6 treatment (Table 5).

Table 5. Interaction effect of Nitrogen and Potassium on the soil pH, Organic matter, total N, available P, K, S and Zn in the soil after harvest of BARI Bush Bean-2

Treatment combination (A×B)	Soil pH	Organic Matter (%)	Total N (%)	Available P ($mg\ kg^{-1}$)	Exchangeable K (m.eq / 100 gm)	Available S (m.eq / 100 gm)	Available Zn ($mg\ kg^{-1}$)
T_0	5.30 bc	0.96 b-d	**0.04 c**	16.34 cd	**0.12 d**	**15.73 d**	**2.48 f**
T_1	5.09 b-d	1.11 ab	0.08 b	16.51 b-d	0.16 a-d	18.19 a-c	2.95 de
T_2	4.93 cd	1.05 bc	0.08 b	17.72 a-c	0.17 a-c	21.43 bc	3.88 cd
T_3	5.01 cd	0.93 b-d	0.05 bc	16.26 cd	0.25 ab	19.59 a-c	2.95 de
T_4	5 cd	1.10 ab	0.10 ab	16.64 b-d	0.13 cd	17.27 b-d	2.61 gh
T_5	5.02 cd	1.04 bc	0.07 bc	15.73 cd	0.17 a-c	19.87 a-c	3.00 de
T_6	5.21 bc	0.98 b-d	0.06 bc	16.35 cd	0.13 b-d	**26.47 a**	**4.42 a**
T_7	5.15 b-d	.98 b-d	0.07 bc	16.98 bc	0.24 ab	25.33 ab	3.27 e
T_8	5.21 bc	1.06 bc	0.07 bc	15.83 cd	0.13 a-c	18.35 a-c	2.54 d-f
T_9	5.49 ab	0.90 b-d	0.08 b	19.03 ab	0.14 a-c	20.77 a-c	3.68 d
T_{10}	5.50 ab	1.01 bc	**0.12 a**	**19.41 a**	0.23 ab	23.27 ab	4.30 ab
T_{11}	5.21 bc	**0.86 d**	0.06 bc	16.20 cd	0.23 ab	18.37 a-c	3.73 d
T_{12}	5.51 ab	0.98 b-d	0.07 bc	**14.95 d**	0.16 a-d	17.27 b-d	2.86 de
T_{13}	**4.87 d**	0.91 b-d	0.07 bc	17.71 a-c	0.17 a-c	19.53 bc	3.70 cd
T_{14}	**6.05 a**	1.05 bc	0.07 bc	16.89 b-d	0.22 ab	21.47 bc	3.68 cd
T_{15}	5.69 ab	**1.16 a**	0.07 bc	18.05 b	**0.26 a**	24.25 ab	4.10 bc
Level of significance	**	*	NS	*	*	**	**
CV (%)	9.47	9.43	20.39	7.07	14.90	5.41	4.47

* = Significant at 5% level, ** = Significant at 1% level
NS = Not significant, CV= Co-efficient of variation

4.5 Nutrient status of plant of BARI Bush Bean-2 as affected by Nitrogen and Potassium

4.5.1 Total nitrogen content of plant (%)

Combined effect of nitrogen and potassium showed a significant effect in respect of total nitrogen content in the plant sample. The highest total nitrogen content was observed (2.92) in T_{14} treatment and the lowest total nitrogen content was observed (2.00) in control treatment (Table 6).

4.5.2 Total phosphorous content of plant (mg kg^{-1})

Combined effect of nitrogen and potassium showed a significant effect in respect of total phosphorous content in the plant sample. The highest total phosphorous content was observed (2.20) in T_{10} treatment and the lowest total phosphorous content was observed (0.09) in control treatment (Table 6).

4.5.3 Total potassium content of plant (m.eq / 100 gm)

Combined effect of nitrogen and potassium showed a significant effect in respect of total potassium content in the plant sample. The highest total potassium content was observed (2.85) in T_{10} treatment and the lowest total potassium content was observed (1.55) in control treatment (Table 6).

4.5.4 Total sulphur content of plant (m.eq / 100 gm)

Combined effect of nitrogen and potassium showed a significant effect in respect of total sulphur content in the plant sample. The highest total sulphur content was observed (1.04) in T_{10} treatment and the lowest total sulphur content was observed (0.43) in control treatment (Table 6).

4.5.5 Total zinc content of plant (m. eq / 100 gm)

Combined effect of nitrogen and potassium showed a significant effect in respect of total zinc content in the plant sample. The highest total zinc content was observed (0.85) in T_{10} treatment and the lowest total zinc content was observed (0.14) in control treatment (Table 6).

Table 6. Effect of combined use of nitrogen and potassium on the nutrient Concentrations in plant of BARI Bush Bean-2

Treatment combinations (A×B)	Concentrations				
	Total N	Total P	Total K	Total S	Total Zn
T_0	**2 e**	**0.09 d**	**1.55 d**	**0.43 d**	**0.14 e**
T_1	2.26 c	0.15 a-c	2.01 a-c	0.64 cd	0.17 de
T_2	2.48 b	0.11 b	2.72 ab	0.77 c	0.63 c
T_3	2.58 b	0.17 a-c	2.23 b	0.92 b	0.60 c
T_4	2.11 cd	0.11 b	1.62 b	0.49 cd	0.21 de
T_5	2.5 b	0.14 b	2.09 a-c	0.8 c	0.29 d
T_6	2.85 ab	0.18 ab	2.82 ab	0.98 b	0.73 b
T_7	2.86 ab	0.18 ab	2.57 b	0.98 b	**0.85 a**
T_8	2.07 d	0.13 b	1.71 ab	0.83 c	0.38 d
T_9	2.44 bc	0.17 a-c	2.38 b	0.88 c	0.31 d
T_{10}	**2.92 a**	**0.2 a**	**2.85 a**	**1.04 a**	0.75 b
T_{11}	2.74 ab	0.18 ab	2.83 ab	0.99 b	0.56 c
T_{12}	2.07 d	0.17 a-c	1.60 cd	0.49 cd	0.82 ab
T_{13}	2.69 ab	0.18 ab	2.51 b	0.93 b	0.61 c
T_{14}	2.67 ab	0.18 ab	2.83 ab	1.00 ab	0.73 b
T_{15}	2.78 ab	0.16 a-c	2.12 bc	0.52 cd	0.70 b
Level of significance	*	**	**	**	**
CV(%)	5.12	19.20	3.53	6.67	7.92

* = Significant at 5% level, ** = Significant at 1% level
NS = Not significant, CV= Co-efficient of variation

Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The present experiment was carried out at Sher-e-Bangla Agricultural University Farm (Tejgaon series under AEZ No. 28), Dhaka-1207 during the *Rabi* season of 2009 to investigate the effect of nitrogen and potassium on the growth and yield contributing parameters of BARI Bush Bean-2. The soil was silty loam in texture having pH 5.6 and organic matter (1.17%). There were sixteen treatments of the experiment viz. T_0 (control), T_1 (0 kg Nitrogen + 20 kg Potassium ha^{-1}), T_2 (0 kg Nitrogen + 40 kg Potassium ha^{-1}), T_3 (0 kg Nitrogen + 60 Potassium ha^{-1}), T_4 (40 kg Nitrogen + 0 kg Potassium ha^{-1}), T_5 (40 kg Nitrogen + 20 kg Potassium ha^{-1}), T_6 (40 kg Nitrogen + 40 kg Potassium ha^{-1}), T_7 (40 kg Nitrogen + 60 kg Potassium ha^{-1}), T_8 (80 kg Nitrogen + 0 kg Potassium ha^{-1}), T_9 (80 kg Nitrogen + 20 kg Potassium ha^{-1}), T_{10} (80 kg Nitrogen + 40 kg Potassium ha^{-1}), T_{11} (80 kg Nitrogen + 60 kg Potassium ha^{-1}), T_{12} (120 kg Nitrogen + 0 kg Potassium ha^{-1}), T_{13} (120 kg Nitrogen + 20 kg Potassium ha^{-1}), T_{14} (120 kg Nitrogen + 40 kg Potassium ha^{-1}) and T_{15} (120 kg Nitrogen + 60 kg Potassium ha^{-1}). The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

The data were collected plot wise for pod length, pod diameter, single pod weight per plant, and total pod weight per plant, pod yield per plot and pod yield per hectare. The post harvest soil samples were analyzed for pH, organic matter and N, P, K, S and Zn contents. The collected data on different parameters were statistically analyzed following F-test and the mean comparison was made by DMRT at 5% level. The salient results of the experiment are stated below:

The combined effect of nitrogen and potassium on the length of pod was found to be significant. The highest length of pod pod was found (11.67 cm) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest length of pod Pod was found (9.90 cm) from the treatment combination of control treatment.

The combined effect of nitrogen and potassium on the pod diameter was found to be significant. The highest diameter of pod was found (3.13 cm) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest diameter of pod Pod was found (2.10 cm) from the treatment combination of control treatment.

The combined effect of nitrogen and potassium on the average single pod weight was found to be significant. The highest single pod weight per plant was found (5.99 gm) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest single pod weight per plant was found (4.15 gm) from the treatment combination of control treatment.

The combined effect of nitrogen and potassium on the total pod weight per plant was found to be significant. The highest total pod weight per plant was found (29.07 gm) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest total pod weight per plant was found (21.30 gm) from the treatment combination of control treatment.

The combined effect of nitrogen and potassium on the pod yield per plot was found to be significant. The highest pod yield per plot was found (2033.33 gm) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest pod yield per plot was found (883.33 gm) from the treatment combination of 0 $kgNha^{-1}$ and 20 kg Kha^{-1}.

The combined effect of nitrogen and potassium on the pod yield per hectare was found to be significant. The highest length of pod Pod was found (4.96 ton) from the treatment combination of 80 $kgNha^{-1}$ and 40 kg Kha^{-1}. The lowest pod yield per hectare was found (2.16 ton) from the treatment combination of control.

The soil properties such as organic matter content, total nitrogen, available phosphorus, potassium were increased after the harvest of crop compared to the nutrient status of the initial soil.

The ultimate findings of this experiment which was on the growth and yield of BARI Bush Bean-2 were found to be greatly increased in all parameters of the study. The results of the study also indicate that 80 kg N and 40 kg K showed better performance in the major parameters i.e pod length, pod diameter, average single pod weight, total pod weight per plant, pod yield per plot and pod yield per hectare. This treatment appears to be very promising. The findings of the study also emphasizes on doing further research on the other production side of BARI Bush Bean-2 for the farmers of the country.

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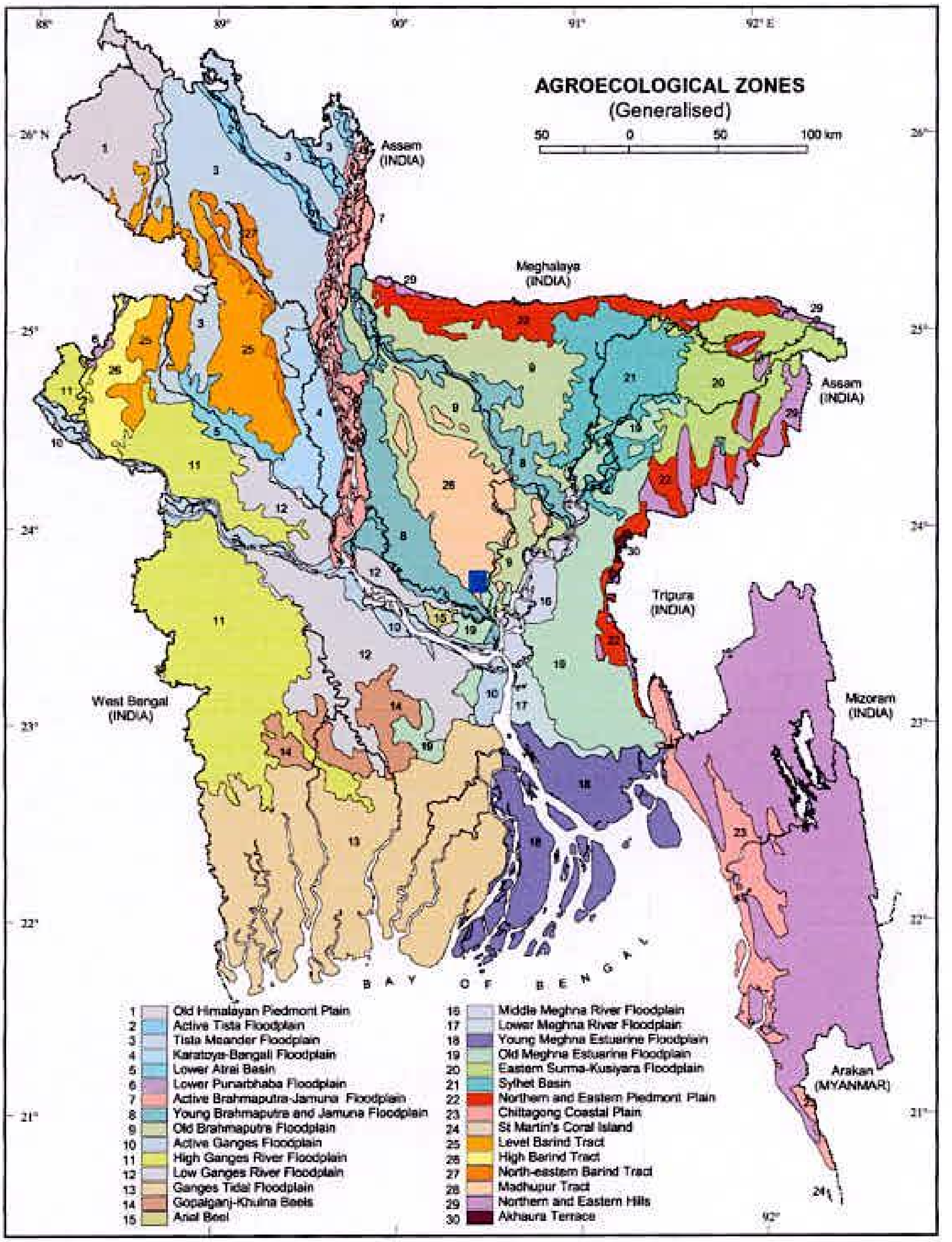
Appendices

APPENDICES

Appendix I.



■ **Location of the experimental site**

Map showing the experimental site under the study

Appendix II. Monthly record of air temperature (°C), relative humidity (%), rainfall (mm) and sunshine hours during the period of experiment (November, 2008 to March, 2009).

Months	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)	Sunshine (hrs.)
	Max.	Min.	Average			
November	29.52	18.99	24.25	56.20	2.3	6.50
December	25.91	13.55	19.73	45.79	2.61	6.79
January	24.38	13.32	18.85	50.29	2.54	7.12
February	24.63	13.79	19.21	48.54	3.06	7.39
March	25.1	15.49	20.29	50.10	4.01	8.10

Source: Bangladesh Meteorological Department (Climate and weather division) Agargaon, Dhaka – 1212.

Appendix III. LIST OF ABBRIVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
BCR	=	Benefit Cost Ratio
cm	=	Centimeter
^{0}C	=	Degree Centigrade
DAS	=	Days after sowing
et al.	=	and others *(at elli)*
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^{H}	=	Hydrogen ion conc.
RCBD	=	Randomized Complete Block Design
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent