EFFECT OF PHOSPHORUS, MOLYBDENUM AND *Rhizobium* INOCULATION ON THE GROWTH AND YIELD OF MUNGBEAN

MD. MOKTER HOSSAIN BHUIYAN

DEPARTMENT OF SOIL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

DECEMBER 2006

EFFECT OF PHOSPHORUS, MOLYBDENUM AND *Rhizobium* INOCULATION ON THE GROWTH AND YIELD OF MUNGBEAN

BY

MD. MOKTER HOSSAIN BHUIYAN

REGISTRATION NO. 25271/00377

A Thesis

Submitted to the Faculty of Agriculture.
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

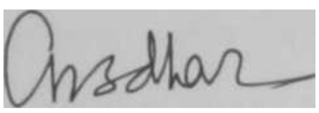
MASTER OF SCIENCE (MS)

IN

SOIL SCIENCE

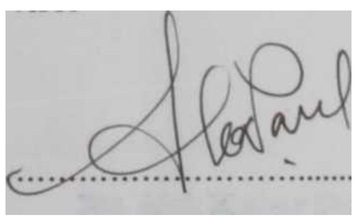
SEMESTER: JULY-DECEMBER, 2006

Approved by:



(Dr. Gopi Nath Chandra Sutradhar)
Associate Professor
Department of Soil Science
SAU, Dhaka-1207
Co-supervisor

(Md. Mukhlesur Rahman)
Chief Scientific Officer Soil
Science Division liARI,
Joydebpur, Gazipur
Supervisor



(Dr. Alok Kumar Paul)
Chairman
Examination Committee

BANGLADESH AGRICULTURAL RESEARCH INSTITUTE
SOIL SCIENCE DIVISION
JOYDEBPUR, GAZIPUR-1701

9252893 9261501

CERTIFICATE

This is to certify that the thesis entitled, 'Effect of phosphorus, molybdenum and Rhizobium inoculation on the growth and yield of mungbean" submitted to the Department of Soil Science, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in SOIL, embodies the result of a piece of bona fide research work carried out by Md. Mokter Hossain Bhuiyan, Registration No. 25271/00377 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 sources of information, as has 6een availed of received during the course of this investigation have Seen duly ac knowledged.

Date: ....

Soil Science Division,
(Bangladesh Agricultural Research Institute
Joydebpur, Gazipur

(Md. Mukhlesur Rahman)
Chief Scientific Officer
Soil Science Division
BARI, Joydebpur, Gazipur
Supervisor

Q

DEDICATED TO
MY
BELOVED PARENTS

ACKNOWLEDGEMENT

All gratefulness is due to the Almighty Allah due Cherisher and Sustainer of the world who enabled me to complete the dissertation works successfully.

I wish to acknowledge with gratitude the appreciation and the contributions of Md. Mukhlesur Rahman, Chief Scientific Officer. Soil Science Division, BARI, Joydebpur Gazipur, for his dynamic, invaluable and immense guidance during the whole period of the research and in preparing this manuscript as a supervisor.

My deepest sense of gratitude and indebtedness are due to the member of my advisory committee, Dr. Gopi Nath Chandra Sutradhar, Department of Soil Science, for taking keen interest in my thesis research, constant inspiration, valuable suggestions and critical review of the manuscript.

It's my great pleasure and privilege to express deep sense of gratitude and sincere regard to the Chairman of my advisory committee Dr. Alok Kumar Paul for his valuable guidance, suggestions and constant encouragement during the whole period of the research and in preparing the manuscript.

Cordial thanks are due to Dr. Md. Nurul Islam, Professor, A.T.M Shamsuddha, Md. Asaduzzaman Khan , Afrose Jahan, Mohammad Mosharraf Hossain, Assistant professors, Mohammad Issak, Jharna Rani Sarker, Saikat Chowdhury, Lecturer, Department of Soil Science, SAU, Dhaka-1207, Dr. Delowara Khanam, Principal Scientific Officer and Khandaker Majedul Hossain, Principle Scientific Officer, Soil Science Division, BARI, Joydebpur, Gazipur and my younger brother Md. Delowar Hossain Bhuiyan for encouraging me in my study and research period, who always gave me their heartiest affection and love. I remain ever grateful to my friends especially Md. Saiful Islam Bhuiyan whose love and inspiration in all the way, brought me here at this stage.

My greatest debt, however, is to my parents who have made lot of sacrifices in many ways for the cause of my study and inspired me all the time.

I like to express my sincere thanks to Mr. Munirul Islam, Scientific Assistant for sincere co-operation in implementing the experiments.

Finally, I want to mention that I am deeply indebted to my well wisher whose sacrifice and encouragement made it possible to complete my degree successfully.

Dated:
Place: Dhaka **The Author**

EFFECT OF PHOSPHORUS, MOLYBDENUM AND *Rhizobium* INOCULATION ON THE GROWTH AND YIELD OF MUNGBEAN

ABSTRACT

A pot experiment was conducted, during *kharifl*2005 at the Soil Science Division, Bangladesh Agricultural Research Institute to study the effect of phosphorus, molybdenum and *Rhizobium* inoculation on the nodulation, growth, yield and yield contributing characters of mungbean (*Vigna radiata)* on a silty clay loam soil. The experiment was laid out in randomized complete block design with four replications. Ten treatments including 8 treatment combinations of 4 levels of P (0, 20, 40. 60 kg/ha) and 2 levels of Mo (1.0, 1.5 kg/ha) having a common *Rhizobium* inoculant. one control with no *Rhizobium* or fertilization and a *Rhizobium* inoculation only were applied. The performance of *Rhizobium* inoculant alone was superior to control in almost all parameters of the crop studied. The maximum stover and grain yield (about 14.6 g/plant) was obtained when plants were fertilized with phosphorus (40 kg/ha), molybdenum (1.0 kg/ha) and *Rhizobium* inoculation. *Rhizobium* inoculation along with phosphorus and molybdenum significantly increased the growth of plants, number of nodules, dry matter production as well as grain yield of mungbean significantly compared to uninoculated control. Nodulation (nodule number/plant) was the highest with 20 kg P/ha and 1.0 kg Mo/ha. However, phosphorus and molybdenum application at the rate of 40 kg P/ha and 1.0 kg Mo/ha progressively and significantly increased dry matter content of shoot and root, yield and yield contributing characters of mungbean. Higher dose of phosphorus (60 kg P/ha) and molybdenum (1.5 kg Mo/ha) decreased grain yield and other parameters. Dry weight of plant tops, seed yield/plant and yield-contributing characters were positively correlated with the number of nodules/plant. From this point of view, dry matter production, nutrient uptake, yield and yield attributes of mungbean combined application of *Rhizobium* inoculant with 40 kg P/ha and 1.0 kg Mo/ha was considered to be the balanced and suitable combination of fertilizer nutrients for achieving the maximum output through cultivation of mungbean in silty clay loam soil.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1
Introduction

CHAPTER 1
INTRODUCTION

Mungbean *(Vigna radiata* L. Wilczek) is one of the major pulse crops grown in Bangladesh. It belongs to the family Leguminosae and sub family Papilionaceae. Mungbean *[Vigna radiata]* is one of the major pulse crops grown principally for its protein rich edible seeds. It is considered as quality pulse for its digestibility and low flatulence. The mungbean yield is very low in our country as compared to other countries of the world (BBS, 1991). Due to its rapid growth and early maturity, mungbean is adapted to multiple cropping systems. Apart from this, it has long been recognized that the use of any legume in crop rotations is one of the principal ways of supplying additional nitrogen for the succeeding non-leguminous crop (Tisdale *cl* a/., 1985).

Knowingly or unknowingly the people of Bangladesh take pulse as the supplement of animal protein. Though the animal proteins are superior to vegetable protein, the protein rich animal products are quite costly and beyond the reach of many of the common people of this country (Gowda and Kaul, 1982). Pulses contain almost double amount of protein as compared to cereals. Pulses can supplement the cereal-based diet to improve the nutritional value of food. These are also best sources of protein for domestic animals. Mungbean *(Vigna radiata* L. Wilezek) is one of the important pulse crops in the country for its high digestibility, good flavor and high protein content. It holds the first position in price, 3rd in protein content and 4lh in both acreage and production in Bangladesh (Anonymous, 1999; Sarker *et at.*, 1982). Hence from the point of nutritional value, mungbean is perhaps the best of all other pulses (Khan *el al*1982). It contains 51% carbohydrate, 26% protein, 3% minerals and 3% viatmins (Kaul, 1982).

Mungbean has a special importance in intensive crop production system of the country for its short growing period (Ahmed *cl al.*, 1978). It requires warm temperature regime. Summer mungbean can tolerate a high temperature but not exceeding 40°C and does well in the temperature range of 30-35°C. In our country, mungbean gives the highest yield under summer planting (Satter and Ahmed, 1995). The successes of growing mungbean in summer have already been made in Bangladesh. One of the biggest advantages of summer pulses is their suitability for early *kharif* period, particularly in the area where low yielding *Aus* is produced. Experiments conducted at BARI indicate that summer pulses are more economical than low yielding *Aus* rice.

Mungbean originated in South Asia (India, Burma, Thailand etc.). Now it is widely grown in India, Pakistan, Bangladesh, Burma, Thailand, Philippines, China and Indonesia. It is also grown in parts of east and central Africa, the West Indies, USA and Australia (Gowda and Kaul, 1982). The production of mungbean has bean steadily decreasing due to reduced acreage, poor management and low yielding local cultivars. Therefore, to meet the situation it is necessary to boost up the production through varietal development and proper management practices as well as summer mungbean cultivation. Fitting them in our usual cropping system and use of seed inoculation with effective *Rhizobium* strains will produce better nodulation, nitrogen fixation, growth and higher yield.

Nitrogen is the most important nutrient element among the major essential elements. It is the most deficient element in Bangladesh soils limiting crop production. For legume, nitrogen is more useful because it is the main component of amino acid as well as protein. Adequate supply of nitrogenous fertilizer is essential for normal growth and yield of a crop. In Bangladesh, most of the lands are deficient in organic matter and nitrogen. To fulfill the demand of nitrogen, usually urea or ammonium sulphates are being used. The price of these fertilizers is very high and often unavailable in the market. For this reason, the poor and marginal farmers cannot afford to supply balanced fertilizers, as a result their crops do not produce expected yield.

imbalanced application of chemical fertilizers is also detrimental to the environment. On the other hand, due to the cultivation of modern varieties of different crops with imbalanced and heavy use of nitrogenous fertilizer soil toxicity is arising and soils of Bangladesh are loosing their fertility and productivity. The use of biological nitrogen fixation (BNF) technology in the form of *Rhizobium* inoculants in grain legumes can be an alternative of expensive fertilizer, particularly for improving the production of food legumes in the country. *Rhizobium* can fix atmospheric nitrogen by symbiosis process with roots of legume crops and makes N available to plants. A field trail showed that *Rhizobium* inoculant and different levels of nitrogen increased nodulation, growth and nitrogen uptake of lentil (Mahmud *et al*1997). Biological nitrogen fixation and seed yield of soybean also significantly increased due to *Rhizobium* inoculant.

Yield increases in mungbean by 10 to 37 percent following *Rhizobium* inoculation have been reported by many researchers (Rajagopalan and Sadasivan, 1964, Maheshwari, 1974, Singh, 1977. Rao, 1980 and Satter and Ahmed, 1992). Singh and Chaubey (1971) reported a profit/cost ratio of 27/1 for inoculation with their most efficient rhizobial strain. An increase of 38 percent in grain yield with inoculation of blackgram was obtained by Reddy *et al.* (1978). An 18 percent increase in nitrogenase activity was reported by Kothari and Saraf (1987) from inoculation of mungbean.

Mungbean, like other legumes has the ability to fix atmospheric nitrogen through partnership with symbiotic nodule bacteria and thus enrich the soil. The nitrogen fixation process is influenced by many factors and phosphorus is one of them. Rhizobial activities and nitrogen fixation is depressed without proper application of phosphorus. The most obvious eftect ol phosphorus is on the plant root system. It promotes early root formation and the formation of lateral, fibrous and healthy roots, which is very important for nodule formation and to fix atmospheric nitrogen and is used by the plants as well as by succeeding crop. Phosphorus had a significant effect on increasing the nitrogen content by legumes (Andrew, 1976). It was reported that application of phosphorus along with *Rhizobium* inoculant influenced nodulation and nitrogen fixation of legume crops (Solaiman and Habibullah, 1990). Leguminous crops meet up their nitrogen requirement through biological nitrogen fixation, which is dependent on proper growth, development and also leghaemoglobin content of the root nodules (Chowdhury *et al.,* 1998). It is supposed that phosphorus is effectively translocated into grain at high rates, since phosphorus is necessary for the production of protein, phospholipid and phytin in mungbean grain (Trung and Yoshida, 1982). Much of the phosphorus applied to the soil in the form of chemical fertilizer is immobilized, fixed in the soil particles and remains unavailable to the crop. Phosphorus applications progressively and significantly increase dry matter production as well as yield and yield contributing characters in mungbean (Satter and Ahmed, 1992).

Molybdenum is indispensable for a variety of plant species especially for legumes forming root nodules becausc it is directly involved in nitrogen fixing enzymes nitrogenase and nitrogen reduction enzyme, nitrate reductase. Molybdenum application can play a vital role in increasing mungbean yield through its effe ct on the plant itself and also on the nitrogen fixation process by *Rhizobium.* On the contrary, deficiency of molybdenum resulted in decreased growth, yield and quality of mungbean as well as low nitrogen fixation through *Rhizobium.* Lewis (1980) and Sharma *et al.,* (1988) observed that molybdenum w'as responsible for the formation of nodule tissue and increase in nitrogen fixation. They also reported that without adequate quantities of molybdenum, nitrogen fixation could not occur and microbial activity was depressed. Grewal *et al.*, (1967) reported that molybdenum has a significant response to fix atmospheric nitrogen and yield of legume crops. Pulses could produce active nodule only when soils were properly supplied with molybdenum (Ahmed. 1982). Numerous experiments were conducted in abroad on mungbean but information on the effect of *Rhizobium* inloculant in combination with phosphorus and molybdenum is scanty in our country. So it is necessary to examine the effects of different levels of those nutrients and assess their best combination in terms of enhanced nitrogen fixation and productivity of mungbean. In view of these points the present study was undertaken to fulfill the following objectives:

1. To determine the effect of phosphorus, molybdenum and *Rhizobium* inoculants on nodulation, growth and yield of mungbean.
2. To know the optimum dose of phosphorus and molybdenum on nodulation, growth and yield with *Rhizobium* inoculation.
3. To determine the relationship between yield contributing characters influenced by *Rhizobium* inoculants.

Chapter 2

Review of literature

CHAPTER 2
REVIEW OF LITERATURE

A number of studies have been undertaken in various aspects related to the mungbean production in different countries of the world but research works on mungbean to *Rhizobium* inoculation in relation to different phosphorus levels on the growth, nodulation and enzymatic activities are limited in Bangladesh.

2.1. Nodulation

2.1.1 Effect of *Rhizobium* inoculant on nodulation

Solaiman *cl al.* (2003) investigated the response of mungbean cultivers. BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5. Bina Moog-2 and BU Mung-1 to *Rhizobium* sp. strains TALI69 and TAL441 and found that bacterial inoculation of the seeds increased nodulation. They obtained highest inoculation from BARI Mung-4 with strain TALI69.

Narendra and Chandra (2003) conducted a field experiment to investigate the effects of combined inoculation of *Rhizobium* strain M-27 (a nitrogen-fixing bacterium) and VAM with different levels of P (0, 25, 50 and 75 kg/ha) on the nodulation of mungbean cv. Pusa Baishakhi. They found that combined inoculation of *Rhizobium* + VAM gave significantly more nodules at 30 and 50 days after sowing (DAS) with phosphorus level 0, 25, 50 and 75 kg/ha than single inoculation with either *Rhizobium* or VAM.

Chatterjee and Bhattacharjee (2002) studied the effects of inoculation with *Rhizobium* sp. on the nodulation of mungbean cv. B-l and found that the plants inoculated with *Rhizobium* strains showed higher nodulation and N content. Navgire *et al.* (2001) conducted a field experiment with mungbean cultivars BM-4, S-8 and BM-86 and these were inoculated with *Rhizobium* strains M-l 1-

85, M-6-84, GR-4 and M-6-65. They recorded the highest mean nodulation (16.66) in S-8, BM-4 and BM-86.

Islam *et al.* (1999) conducted an experiment to study the performance of some bradyrhizobial inoculants on soybean at B1NA experimental farm. Mymensingh. They found that the total nodule numbers were significantly higher in inoculant treatments. All the *Bradyrhizobium* inoculated treatments performed better in nodule formation in soybean.

Taiwo *et al.* (1999) conducted a field experiment in Ibadan, Nigeria, with soybeans cv. TVX 1740-2F and TGX 1448-2E. Seeds were inoculated with *Bradyrhizobium* strains Irj 284A and phosphorus level 0 and 40 kg/ha. Inoculation and P fertilization led to increased nodulation in both cultivators.

Bhuiyan *et al.* (1998) conducted a field experiment at Regional Agricultural Research Station, Ishurdi, Pabna to evaluate the effect of seed inoculation with 4 *Bradyrhizobium* strains on nodulation in soybean. They found that *Bradyrhizobium* inoculation significantly increased nodule number than uninoculated control.

Ghosh and Poi (1998) carried out a pot experiment where soybean, groundnut, kalai *(Vigna mungo),* moog *(Vigna radiata)* and lentil were inoculatcd with *Rhizobium*, *Bacillus polymixa* and *Glomus fasciculatum* in different combinations. They found that nodulation and population of microorganisms in the rhizosphere were the highest from combined inoculation with all three microorganisms.

Das *ct al.* (1997) conducted field trails where *Vigna radiata* cv. Nayagrah local seeds were inoculated with *Rhizobium* and/or VAM culture, which was applied at 15 kg/ha. They observed that number of nodule was increased with dual inoculation compared with uninoculated control.

Uslu *et al.* (1997) conducted a field trail of soybean and inoculated with *Bradyrhizobium japonicum.* They found that nodules per plant were increased by inoculation.

Satter and Ahmed (1995) carried out a field experiment on mungbean *(Vigna radiata* L.) to study the response of inoculation with *Bradyrhizobium* inoculants incorporating with BIN A 403, BINA 407. RCR 3824 and RCR 3825 strains as single and mixed culture. They observed that *Bradyrhizobium* inoculation increased the number of nodules and weight significantly.

Sharma *et al.* (1995) observed that seed inoculation with *Rhizobium* and application of 40 kg P2O5 /ha in chickpea (*Cicer arietinum)* either alone or in combination enhanced nodulation and yield significantly over the uninoculated control.

Thakur and Panwar (1995) conducted a field trail where *Vigna radiata* cv. Pusa-105 and PS -16 were inoculated and they found that inoculation either alone or combined increased plant height compared with no inoculation.

Rahman *et al.* (1994) observed in two field trails that *Rhizobium* (strain RCa- 220) inoculation alone or in presence of phosphate and potash fertilizers significantly increased nodule number and weights and also produced significantly higher grain yield of chickpea than that of other treatments. The grain yield was increased between 37 and 119%. The inoculum was more profitable than other chemical fertilizers considering the cost benefit ratio.

Sarker *et al.* (1993) reported that *Rhizobium* inoculation along with P application and *Rhizobium* inoculation along with *Azotobacter chroococcum* were equally effective in enhancing grain yield of greengram. Combined applications of N and P along with *Rhizobium* inoculation also performed better than other treatments.

Singh and Tilak. (1992) observed that Rhizobium inoculant might increase the nodulation, which ultimately increased the N fixation in soil and thus the yield of cowpea.

Satter and Ahmed (1992) reported that *Bradyrhizobium* inoculation significantly increased the number and weight of nodules of mungbean as compared to uninoculated control.

Haque (1991) studied the performance of some promising strains of lentil Rhizobia under field condition. Rhizobial strains BAU 303 and TAL 638 were performed better in producing higher nodule number and weight, as well as seed yield of lentil. These results and other related studies showed 20 to 60% yield increase in lentil due to different *Rhizobium* inoculants. In other study by Haque (1991) reported that the strain BAU 604 was the best in producing nodule number, shoot weight and seed yield of mungbean. These results showed that seed yield of mungbean was increased upto 20 to 50%.

Solaiman and Habibullah (1990) conducted an experiment to observe the effect of *Rhizobium* inoculation on groundnut and reported that higher nodulation (33.7%) and total dry matter yield (28.10%) was found under inoculation treatment.

Muniruzzaman and Khan (1990) carried out an experiment on lentil and found that inoculation had a great effect on N uptake. Nitrogen contents in inoculated plant shoots recorded by the strains DUM 151, DUM 153 and DUM 155 were 2.5%, 2.9% and 2.6%, respectively.

Rahman (1989) observed significantly higher number of nodules per plant, root and shoot dry weight per plant, 1000 seed weight and grain yield due to inoculation over control in soybean.

Namdeo *et al.* (1988) conducted an experiment on pigeonpea and observed that seed inoculation with 5 *Rhizobium* stain increased nodulation.

Islam *et al.* (1987) found that N content in plant tops increased due to inoculation.

Bhuiya *et al.* (1986) studied the performance of some *Rhizobium* inoculants on blackgram (*Vigna mungo)* and observed that the effective nodulation with all inoculants were reflected in terms of main root and branch root nodule counts relatively higher than uninoculated control.

Poi and Ghosh (1986) carried out an experiment on lentil and chickling pea and found that seed inoculation with *Rhizobium leguminosarum* (strains L25 and L20) increased nodulation and plant N content than other strains.

Khan *et al.* (1985) observed that inoculation of blackgram seed with different *Rhizobium* strains showed highly significant effect on nodulation.

Bhuiya *et al.* (1984a) carried out a field experiment at BAU farm and observed that the inoculation of mungbean gave the higher dry weight of nodules and shoot per plant compared to control. They also reported that large size nodules were produced due to inoculation.

Bhuiyan *et al.* (1984b) found that inoculated treatment of mungbean gave higher dry weight of nodules over control and produced larger size nodules.

Ashraf Zahid *et al.* (1984) found significant increase in nodule number due to inoculation of chickpea.

Raut and Ghosnsiker (1982) found that seed inoculation with *Rhizobium* strain no.24 increased nodulation of 4 chickpea cultivars.

2.1.2 Effect of molybdenum on nodulation

Solaiman (1999a) found increased nitrogenase activity due to seed inoculation along with Mo application in soybean. The highest nitrogenase activity (82.44 H mol C_2H_4/plant/hr) was obtained by inoculant + 1.5 kg Mo/ha.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that the application of Mo (1 kg/ ha) produced 97% and 150% higher nodule number and nodule weight, respectively over control.

Zaman *et al.* (1996) conductcd an experiment on mungbean and observed that application of 2 kg B/ha in combination with 2 kg Mo/ha produced 176% and 229% higher nodules/plant over control in 1989 and 1990, respectively.

Hasan *et al.* (1994) found higher nodule dry weight due to application of 13.3g Mo/feddan in soybean.

Johal and Chahal (1994) found that when viable *Vigna radiata* seeds were surface sterilized and treated with 5 concentrations of Mo (0, 2, 5, 10 or 15 ppm.) as sodium molybdate and then inoculated with *Rhizobium* strain R-2 nodule numbers and dry weight were greatest with 5 ppm. Mo.

Aghatise and Tayo (1994) found significantly higher nodule weight as compared to control plants due to application of Mo. They also reported that application of Mo at the rate of 0, 0.2, 0.4 and 0.8 kg/ha gave 0.001, 0.013,

0. 030 and 0.003g dry weights of nodules in soybean.

Maurya *et al.* (1993) reported that N uptake in soybean increased with Mo application.

Tiwari *et al.* (1989) reported that Mo application improved 75% higher nodule number in chickpea. Verma *et al.* (1988) and Pradhan and Sarkar (1985) found that Mo application increased weight of nodules in chickpea.

Molybdenum is required for increasing nodulation in mungbean (Paricca *et al.*. 1983, Velu and Savithri, 1982). It is essential for symbiotic N fixation. Pulses and legumes can have active nodules only when soils arc adequately supplied with this element.

Franco and Day (1980) found that Mo application significantly increased nodulation, N-fixation and growth of *Phaseolus vulgaris* in Brazil.

2.1.3 Effect of *Rhizobium* inoculant and different fertilizers on nodulation

Chowdhury *et al.* (1998) observed that *Rhizobium* strain RVs-609 along with 50 PiOj + 50 K_20 + 1 Mo +1 B kg/ha increased 295% and 713% higher nodule number and nodule weight, respectively over control.

Bhuiyan *et al.* (1997) conducted an experiment and observed that the application of molybdenum and B, both at the rate of 1 kg/ha along with 50 kg PjOs/ha and 50 kg K_20/ha produced 347% and 440% higher nodule number and nodule weight in chickpea over uninoculated control treatment.

Bhuiyan *et al.* (1996) reported that *Rhizobium* inoculants in presence of P. K, Mo and B fertilizers resulted significant increase in nodule number and nodule weight in groundnut. They also reported that the inoculated plants with Mo and B fertilizers produced significantly higher nodule number and nodule weight compared to uninoculated ones.

Rahman *et al.* (1996) mentioned that *Rhizobium* inoculated (Strain RA11-S92) groundnut plants either alone or in presence of P, K. S and Zn fertilizers produced significantly higher nodule number and nodule weight over control.

Rahman *et al.* (1994) observed that *Rhizobium* inoculant (Strain Rca-220) alone or in presence of phosphate and potash fertilizers significantly increased nodule number, nodule weight in chickpea than other treatments.

Maurya *et al.* (1993) from a pot experiment reported that *Rhizobium* inoculant with Mo in *Vigna mungo* increased nodule number and weight in soybean.

Khanam *et al.* (1993) observed that *Rhizobium* inoculant (Strain Rlc-140) either alone or in combination of phosphate and potash fertilizers significantly increased nodulation of lentil cv. Utfala.

Satter and Ahmed (1992) reported that the phosphorus application upto 60 kg P_20_5/ha on mungbean progressively and significantly increased nodulation, shoot length and weight, grain, hay and total protein yield and grain and hay phosphorus content.

Solaiman *et al.* (1991) studied that higher dose of phosphorus decreased the grain and hay yield and other parameters. Phosphorus application at the rate of 60 kg P_20_5/ha significantly increased nodule number, dry weight of plant tops and yield of groundnut.

Singh and Bajpai (1990) reported that the nodulation of soybean was significantly affected by higher dose of phosphorus. They also reported that highest number and weight of nodules were recorded in 100 kg P_2Os/ha. However, number of nodules and nodule dry weight/plant responded significantly upto 60 kg P_2Os.

Khandaker *et al.* (1985) reported that nodules per plant were increased significantly in Blackgram *(Vigna mungo)* due to P application at 40 days after germination.

Srivastava and Verma (1985) carried out an experiment on field pea and observed that the increased P rate markedly increased P content in shoot of field pea.

Chowdhury (1996) reported that P content in mungbean increased due to inoculation with *Rhizobium.*

2.2. Plant height and root length:

2.2.1 Effect of *Rhizobium* inoculant 011 plant height and root length

Muhammad *et al.* (2004) conducted a field experiment on mungbean cv. NM- 92 under the rainfed conditions with five levels of phosphorus (0, 20. 35, 50. 65, and 80 kg/ha) combined with and without inoculation. They found that the plant height and number of branches per plant were significantly affected with both inoculum and P application. The highest plant height (72.6 cm) was recorded in the plot, which received 35 kg PiOj/ha + *Rhizobium* inoculum.

Podder *et al.* (1999) carried out a field experiment at Brahmaputra Floodplain Soil to evaluate the effect of seed inoculation with 8 bradyrhizobial strains on shoot length of soybean. They reported significantly higher shoot length in the inoculated treatments than the uninoculated control.

Solaiman (1999b) carried out an experiment and found higher plant height and root length of mungbean due to *Bradyrhizobium* inculant over control.

Solaiman *et al.* (1999c) reported that the inoculation of chickpea significantly increased the plant height.

Alam *et al.* (1999) conducted an experiment and obtained higher shoot and root length due to inoculation of *Rhizobium* over control. The strain CC1192 recorded the highest shoot (49.00 cm) and root (26.67 cm) length at flowering stage and also recorded 60% higher plant height and 87% higher root length compared to control.

Chowdhury *et al.* (1998) conducted an experiment on cowpea and observed that inoculum alone increased plant height by 90% more than the control.

Bhuiyan *et al.* (1998) conducted a field experiment at Regional Agricultural Research Station, Ishurdi, Pabna to evaluate the effect of seed inoculation with

4 bradyrhizobial strains viz: RGM-907, RGM-910. RGM-922 and RGM-928 on plant height in soybean. They observed that the soybean plant height was significantly influenced by the *Bradyrhizobium* inoculation. The RGM-922 produced the highest plant height.

Krishnamohan and Rao (1998) conducted a field experiment in Andra Proadesh, India with 4 soybean cultivar seeds inoculated with *BraJyrhizobium japonicum* strains ASB-10, ASB-13 and ASB-15 and found that inoculation with rhizobial strains significantly increased dry matter production over uninoculated.

Das *et al.* (1997) carried out field trials where *Vigna radiata* cv. Nayagrah local seeds were inoculated with *Rhizobium* and/or VAM culture, which was applied at 15 kg/ha. They found that shoot and root lengths were increased with dual interaction compared with uninoculated control.

Dubey (1997) conducted a field experiment on soybean seed inoculation with different strains of *Bradyrhizobium japonicum* and repoited that plant height significantly increased over uninoculated control.

Uslu *et al.* (1997) conducted in a field trail of soybean and inoculated with *Bradyrhizobium japonicum.* They found that plant height was increased due to inoculation.

Aghatise and Tayo (1994) reported that Mo application significantly increased soybean plant height compared with the control plants. At 10 weeks after emergence, application of Mo at the rate ot 0.0, 0.2, 0.4 and 0.8 kg/ha gave 23.1, 24.2, 25.1 and 24.4 cm plant height, respectively.

Sattar and Podder (1994) conducted several field inoculation trails on groundnut and inoculated with local single strain of inoculants and multistrain inoculants. They found that the inoculation with local mixed culture resulted in maximum shoot dry weight at 90 and 120 DAS and pod yield.

Johal and Chahal (1994) showed that *Rhizobium* inoculation increased all growth characteristics compared with the uninoculated treatments.

Sultan (1993) conducted a field experiment on lentil inoculated with *Rhizobium* inoculums and observed that inoculated plants produced significantly tallest plant than uninoculated plants.

Vasilas and Fuhrmann (1993) showed that nodulation of soybean plant by superior strains of *Bradyrhizobium japonicum* increased total shoot weight by 29% over uninoculated control.

Sudhakar *et al.* (1989) conducted an experiment on blackgram and reported that the crop growth was increased due to *Rhizobium* inoculation. They found that inoculation or P application alone increased the protein content in blackgram while their combination increased further *Rhizobium* inoculation to 22.06% higher protein content with 40 kg P_2O_5/ha over control.

Fakir *et al.* (1988) revealed that the biomass production of soybean was the highest with application of inoculum and phosphorus and all the effects were statistically significant over the control. They also reported that the inoculation with N_2 caused tallest plant height in soybean.

Rahman (1988) observed that the *Rhizobium* inoculation either alone or in presence of P and K fertilizers increased nodule number, root and shoot dry weight and grain yield of soybean significantly.

2.2.2 Effect of molybdenum on plant height and root length

Zaman *et al.* (1996) conducted an experiment on mungbean and found the highest plant height (30.29 cm) in plants which received 1 kg Mo/ha. This was 40.69% higher over control. They also reported that the application of Mo (1 kg/ha) produced 44.6% higher root length over control.

2.2.3 Effect of *Rhizobium* inoculant and different fertilizers on plant height and root length

Chovvdhury *et al.* (1998) obtained the tallest plant 64.9 cm, which received inoculum along with Mo and B (both 1kg/ ha) as compared to all other treatments. They also reported that the cowpea plant height was increased by 123% due to the inoculum along with Mo (1 kg/ha) and B (1 kg/ha) over control.

Feng *et al.* (1997) reported that the pea plants inoculated with the bacterial strain grew more vigorously with more branches, effective flowers and increased number of pods.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that the application of Mo (1 kg/ha) with B (2 kg/ha) produced maximum plant height (35.03 cm) as compared to control (21.53 cm). They also reported that the application of Mo (1 kg/ha) either alone or in combination with B (1 or 2 kg/ha) appreciably increased root length of mungbean over the control. They also reported that plant received 1 kg Mo/ha with 2 kg B/ha produced 50.31 and 40.21% higher root length of mungbean over control. Results suggested that Mo at the rate of 1 kg/ha promoted cell division and cell denitrification (Hangstrom, 1968) and B (1 and 2 kg/ha) regulated endogenous auxin levels during root development (Jarvis *et al.*, 1983), which in turn caused root elongation.

Sudhakar *et al.* (1989) conducted an experiment on blackgram and found that *Rhizobium* inoculant increased crop growth rate compared to uninoculated control.

2.3 Plant dry weight:

2.3.1 Effect of *Rhizobium* inoculation on plant dry weight

Solaiman *et al.* (2003) investigated the response of mungbean cultivers BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, Bina Moog-2 and BU Mung-1 to *Rhizobium* sp. strains TALI69 and TAL441 and found that bacterial inoculation of the seeds increased dry matter production. The best characteristics were obtained with BARI Mung-4 inoculated with strain TALI 69.

Khan *el al.* (2002) stated that the effects of phosphorus (50, 75 and 100 kg PiOs/ha) on the grow'th and yield of *Rhizobium* inoculated and uninoculated mungbean were determined in pot experiments and reported that the straw yield increased with increasing rates of P2O5 in *Rhizobium* inoculated. In case of uninoculated mungbean straw yield was also increased with increasing P2O5. But there were significant difference between *Rhizobium* inoculated and uninoculated mungbean.

Eusuf Zai *et al.* (1999) conducted a pot experiment on chickpea and found that *Rhizobium* inoculation increased shoot and root dry weight compared to uninoculated control.

Barakah and Heggo (1998) conducted a pot experiment on soybean (cv. Rillito) in steam sterilized soil in a greenhouse and observed that seed inoculated with *Bradyrhizobium* that had been amended with super phosphate (0.5 g/kg soil) increased soybean shoot and root dry weight compared with uninoculated control. The highest increase in root and shoot were obtained along with *bradyrhizobium* application up to 167% and 400%, respectively.

Mahmud *et al.* (1997) reported that dry weight of shoot and root of lentil significantly increased due to inoculation over control.

Bhuiyan *et al.* (1997) reported that *Rhizobium* inoculants alone significantly increased shoot weight in chickpea.

Vasilas and Fuhrmann (1993) observed that inoculation of soybean plant by superior strains of *Bradyrhizobium japonicum* increased total shoot weight by 29% over uninoculated control.

Hoque and Hashem (1993) observed that the use of *Rhizobium* as bio-fertilizer was remarkably beneficial on shoot weight and total dry matter weight of soybean and groundnut.

Hoque and Hashem (1992) reported that inoculation of soybean seeds with *Bradyrhizobium* inoculum gave higher shoot dry weight over control.

Bhuiyan (1992) reported from a field experiment that *Rhizobium* inoculation increased nodule number, nodule weights, shoot weights and pod yield significantly.

Namdeo *et al.* (1991) conducted a field experiment on pigeon pea and showed that seed inoculation with *Rhizobium* strains produced significantly higher dry matter weight over uninoculated control.

Hoque and Hashem (1992) conducted two field experiments one with soybean and other with groundnut. They observed that inoculation with *Bradyrhizobium* inoculums increased root dry matter during growth stage of the crops.

Muniruzzaman and Khan (1990) carried out an experiment on lentil and found that nodulation, plant dry weight and N uptake increased when inoculated with *Rhizobium.*

Rahman (1989) observed that significantly higher root and shoot dry weight due to inoculation over control in soybean.

Podder *et al.* (1989) in a field experiment with 6 isolates of lentil reported significant increase in grain and hay yield due to *Rhizobium* inoculation. They found 28-42 percent increase in grain yield over uninoculatcd control.

Asghar *et al.* (1988) conducted an experiment on lentil and observed that *Rhizobium* inoculation increased nodule number and root dry weight.

Gill *et al.* (1985) reported that inoculation significantly increased the number of branches/plant, pods/plant, seeds/pod, straw and grain yield and harvest index in mungbean.

2.3.2 Effect of molybdenum on plant dry weight

Aghatise and Tayo (1994) conducted an experiment with soybean in Nigeria and observed that Mo application significantly increased the leaves, stem and nodule and the total dry weight compared with the control. They also reported that the application of 0, 0.2, 0.4 and 0.8 kg Mo/ha produced 0.74, 0.79. 0.85 and 0.65g dry weight of leaves: 0.8. 0.9, 0.93 and 0.79g diy weight of stem and 3.4, 4.2, 4.0 and 3.5g total dry weight respectively.

Wu *et al.*, (1994) observed that total plant dry weight and the dry weight of different organs in soybean were positively correlated with Mo concentration.

Pradhan and Sarkar (1985) found that application of molybdenum increased dry matter weight of stem in horsegram.

Franco and Munns (1981) found higher dry matter weight due to Mo application in bean. They also found significantly higher shoot weight in bean due to Mo application.

2.3.3 Effect of *Rhizobium* inoculant and different fertilizers on plant dry weight

Manpreet *et al.* (2004) conducted a field experiment to investigate the response of P application (0, 20, 40 and 60 kg P_20_5/ha) on mungbean and they observed that the increase in P level showed significant increase in the number of pods per plant, which accounted for significantly higher grain and straw yields at higher levels (40 and 60 kg/ha) compared to lower levels (0 and 20 kg/ha).

Singh and Pareek (2003) conducted a field experiment to investigate the effect of P fertilizer (at 0, 15, 30, 45 and 60 kg P_20_5/ha) on the growth and yield of mungbean cv. RMG 62. They found that the dry matter accumulation, pods/plant, number of seeds/plant and seed yield were highest with P at 45 kg P_2O_s/ha than the other P rates.

Satish *et al.* (2003a) conducted an experiment to investigate the response of mungbean cultivars to different P levels (0, 20, 40 and 60 kg P_2Os/ha). They found that total dry matter above-ground as well as the dry' accumulation in leaves, stems and pods increased with increasing P level up to 60 kg P/ha. The number of branches per plant increased with increasing P rates.

Navgire *et al.* (2001) conducted a field experiment with seeds of mungbean cultivars BM-4, S-8 and BM-86 and these were inoculated with *Rhizobium* strains M-11-85, M6-84, GR-4 and M-6-65 before sowing. They recorded the highest plant biomass(8.29 q/ha) and grain yield (4.79 q/ha) in S-8. BM-4 and BM-86.

Singh *et al.* (2001) studied that the effect of phosphorus (0. 30, 60 and 90 kg P_20_5/ha) application on mungbean biomass and found that maximum dry biomass/plant (24.8 g/plant) was recorded from 60 kg phosphorus followed by 30 kg (24.7 g/plant).

Choudhury and Fujita (1998) conducted an experiment in order to examine the inter-specific difference in low P tolerance in terms of biomass production, photosynthetic rate per unit leaf area (Po) and biological nitrogen fixation. They found that dry matter production increased in all the species with the increasing P levels.

Bhuiyan *et al.* (1996) reported that *Rhizobium* inoculant of groundnut in presence of P. K, Mo and B fertilizer resulted significant increase in shoot dry weight. They found that shoot weight of groundnut increased due to *Rhizobium* inoculant in association with Mo and B.

Bhuiyan *et al.* (1995) observed that inoculation of soybean with *Bradyrhizobium* in presence of P, K, S and Zn gave 66.55% and 80.87% higher shoot dry w'eight of at Joydebpur and Jessore, respectively. They also reported that the inoculation with *Bradyrhizobium* in presence of P, K, S and Zn gave 14% and 72% in higher root dry weight of soybean at Joydebpur and Jessore. respectively.

Surendra *et al.* (1995) carried out an experiment in Uttar Pradesh. India to study the effect of phosphorus on total biomass, grain yield and nitrogen uptake in soybean. They found that seed yield was 2.46 t/ha without applied P and highest (3.34 t/ha) was with 35.2 kg P, which was significantly higher than without P (2.46 t/ha). Plant N uptake, total biomass and soil organic C were also higher with 35.2 kg P ha'^{1}.

Johal and Chahal (1994) showed that *Rhizobium* inoculation increased all growth characteristics of mungbean compared with the uninoculated treatments.

Pangsakul and Jensen (1991) found that phosphorus supply increased top dry matter production at flowering and the dry matter production of seeds, straw, pod shells and roots at late pod filling stage of soybeans. Phosphorus supply did not influence the uptake of fertilizer or soil nitrogen in soybeans, even the root mass was increased upto 60% due to P supply.

Solaiman and Habibullah (1990) stated that *Rhizobium* inoculant of groundnut in presence of P, K and Mo gave significantly higher amount of total dry matter yield at 50% flowering stage of the crop.

Thakuria and Saharia (1990) observed that phosphorus levels significantly influenced the grain yield of summer greengram. The highest plant height, pods/plant and grain yield were recorded with 20 kg P_20_5/ha.

Padma *et al.* (1989) conducted a field in India, and obtained the dry matter production of 62.8 g/plant of French bean with 75 ppm Mo + 2.5 ppm B.
Mishra and Singh (1989) observed that P content of groundnut plant decreased steadily with advancing age stage of plants. The P level at 40 days, however increased significantly over the control at 75 kg P_2Os/ha, though not at 25 kg P_20_5/ha or 50 kg P_20_5/ha. Available P content of the soil increased significantly over control with increasing levels of phosphorus.

Reddy and Gajendragiri (1989) found that application of 40 kg P^Os/ha significantly increased the root biomass, leaf area index, number of pods/plant. 100 kernel weight and pod yield of groundnut. Higher level (80 kg P_20_5/ha) had no advantage over 40 kg P_20_5/ha.

Sairam *et al.* (1989) reported that N-uptake was maximum at 90 kg P_2Os/ha in fodder cowpea cultivator. They also reported that dry matter production recorded at early pod formation stage were markedly increased due to application of phosphorus up to highest level (90 kg P_20_5/ha).

Arya and Kalra (1988) conducted an experiment on summer mungbean variety S-8 and revealed that application of phosphorus had no effect on the growth of summer mungbean; while number of pods/plant, weight ot pods/plant, weight of grains/plant, number of grains/pod, grain yield, dry matter and harvest index were found to be increased with increasing levels of phosphorus upto 50 kg **P_2O_2/ha.**

Ninje and Jagdish Seth (1988) reported that the dry matter yield of whole soybean plant and N, P content and uptake at flowering stages were significantly enhanced with increasing levels of phosphorus. N-content of grain at harvest was, however increased significantly upto 40 kg P_20_5/ha.

Upadhyay *et al.* (1988) reported that leaf area index of soybean increased with P level upto 69 kg P_20_5/ha from 40 days after sowing to reproductive stage. Total dry matter at harvest was maximum with 69 P_20_5/ha, although statistically similar with that of 46 kg P_20_5/ha. The grain and straw yield increased significantly with increasing levels of phosphorus upto 46 kg P_2O_5/ha.

2.4 Yield and yield attributes:

2.4.1 Effect of *Rhizobium* inoculation on yield and yield attributes

Many workers investigated the effect of inoculation on yield of mungbean and other legumes. Some of these are described below:

Muhammad *et al.* (2004) conducted a field experiment on mungbean cv. NM- 92 and observed that both P and inoculum significantly affected grain yield. The highest grain yield (1018 kg/ha) was obtained with 65 kg $P_2$05/ha + inoculum.

Satish *et al.* (2003) conducted a field experiment to investigate the effect of *Rhizobium* sp. on seed inoculation and they found that *Rhizobium* sp. inoculation significantly increased the grain yield.

Chatterjee and Bhattacharjee (2002) studied the effect of inoculation with *Rhizobium* sp. on grain yield of mung bean cv. B-l in field trials and found that the plants inoculated with *Rhizobium* strains showed increased grain yield.

Malik *et al.* (2002) conducted a field experiment on mungbean to observe the effects of seed inoculation with *Rhizobium* on the growth, seed yield and quality of mungbean cv. NM-98. They found that seed inoculation with *Rhizobium* resulted in the highest number of pods per plant (22.47), number of grains per pod (12.06), 100-grain weight (42.27 g), grain yield (1158 kg/ha) and grain protein content (24.61%).

Okereke *et al.* (2000) conducted two field experiments at Akw'a, Nigeria to asses the competitiveness of foreign bradyrhizobia in infecting the promiscuous soybean cultivar TGX 536-02D. Seeds were inoculated w'ith antibiotic mutants of the bradyrhizobial strains before sowing. They observed that inoculation with bradyrhizobial strains resulted highest grain yield of soybean.

Islam *et al.* (1999) studied the performance of some bradyrhizobial inoculants on soybean. There were 8 treatments viz. uninoculated, urea @ 50 kg N/ha, TSP @ 60 kg P_20_5/ha, inoculant RCR 3407, THA 5, TAL 102 and mixed inoculant alone and in combination with TSP. All the *Bradyrhizobium* inoculants performed better in yield of soybean. Grain yield w'as found highest (135.00 kg/ha) in mixed inoculant + TSP and lowest in uninoculated treatments.

Podder *et al.* (1999) conducted a field experiment at Brahmaputra Floodplain soil to evaluate the effect of seed inoculation with eight bradyrhizobial strains on seed yield of soybean. All the bradyrhizobial treatments showed better performance in number of pods/plant, number of seeds/plant. 100 seed weight and seed yield over uninoculated control.

Chowdhury *et al.* (1998) conducted an experiment on cowpea and observed that inoculum alone produced 151%, 78% and 21% more pods/plant, seeds/plant and 1000 grain weight, respectively than the control. They also observed that the plant biomass was increased 265% more due to inoculation than the control. They also found higher seed yield due to inoculation, which was 197% more than the control.

Bhuiyan *et al.* (1998) stated that *Rhizobium* seed inoculation with 1 kg Mo/ha and 1 kg B/ha increased nodule number, nodule and shoot weight and seed yield compared with the control in soybean. Seed yield was 107% and 148% higher in two consecutive growth seasons.

Gupta *et al.* (1998) conducted a field experiment with chickpea and observed that seed yields w'ere higher with inoculation and 40 kg P_20_5/ha and produced the highest seed yield of 1.06 t/ha.

Paul (1998) conducted a field experiment where mungbean cv. PS-16 seed was inoculated singly with 5 *Rhizobium* strains and exposed to 3 water regimes and found that seed yield was not increased by inoculation under excess water or normal irrigation conditions. But under water stress conditions seed yield was increased by inoculation, particularly with strains N11 and D4.

Poonam and Khurana (1997) conducted a field experiment with summer mungbean variety SML and observed that single strain and multistrain *Rhizobium* inoculants increased the grain yield by 10.4% and 19.3% over uninoculated control, respectively.

Bhuiyan et al. (1997) conducted an experiment on chickpea and observed that Rhizobium inoculant without any chemical fertilizers produced 64%, 31% and 63% higher seed yield over uninoculated control during 1992-93. 1993-94 and 1994-95, respectively.

Saraf *et al.* (1997) recorded that seed yield was higher with inoculation than without (1.03 vz.0.88) inoculation and seed yield was highest with 60 kg P_20_5/ha (1.24 t/ha) in chickpea.

Sharma and Khurana (1997) studied the effectiveness of single and multistrain inoculants in field experiment with summer mungbean variety SML32 and found that grain yield was superior in multistrain inoculants. On an average, single strain and multistrain *Rhizobium* inoculants increased the grain yield by 10.4% and 19.3%, respectively over uninoculated control.

Gupta and Namdeo (1996) observed in a field experiment with chickpea that seed inoculation increased seed yield by 9.6-27%.

Konde and Deshmaukh (1996) observed that plant dry weight and other yield components w'ere generally increased by inoculant in chickpea.

Shukla and Dixit (1996) conducted a field experiment where greengram cv. Pusha Baiskhi seed was inoculated with *Rhizobium* shown in rows 20, 30 or 40 cm apart w'ith 0-60 kg $P_2 05$/ha.They found that seed inoculation increased seed yield.

Satter and Ahmed (1995) conducted a field experiment at BARI farm Rajbari, Dinajpur with mungbean inoculated with *Bradyrhizobium* and reported significant increase in hay and total protein yield.

Satter *et al.* (1995) carried out a greenhouse trial on chickpea inoculated with two local isolates of *Bradyrhizobium*, either alone or as mixed culture. They observed that inoculation significantly increased N accumulation and seed yield.

Roy *et al.* (1995) reported that inoculum alone increased seed yield by 22% more than the control in gram.

Shah *et al.* (1994) observed in chickpea that the number of nodules/plant and seed yield increased significantly with *Rhizobium* strains.

Sarker *et al.* (1993) reported that *Rhizobium* inoculation along with P application and *Rhizobium* inoculation along with *Azotobacter chroococcum* were equally effective in enhancing grain yield of greengram.

Sarker *et al.* (1993) conducted a field experiment to study the effect of nitrogen, phosphorus and bacterial inoculation on yield and its components of summer green gram (*Phaseolus radiatus* L.). *Rhizobium* inoculation along with *Azotobacter chroococcum* was equally effective in enhancing grain yield of green gram.

Hoque and Hashem (1992) observed that inoculation of soybean seeds with *Bradyrhizobium* inoculum gave highest nodule weight, shoot dry weight and stover yield.

Satter and Ahmed (1992) reported that *Bradyrhizobium* inoculation gave better yield performances of mungbean at 60 kg P_2O_5/ha.

Satter and Ahmed (1992) reported that *Bradyrhizobium* inoculant significantly increased grain and hay yields of mungbean as compared to uninoculated control.

Yadav and Mandal (1992) reported that the number and DW of nodules and seed yield were higher with inoculation of chickpea.

2.4.2 Effect of molybdenum on yield and yield attributes

Kliemann *et al.* (2002) conducted an experiment on productivity of soybean as a function of the application of cobalt and molybdenum and they found that cobalt and molybdenum did not increase the yield of soybean.

Hazra and Tripathi (1998) observed that Mo application at the rate of 1.5 kg/ha to Berseem increased forage and seed yield in calcareous soil.

Sfredo *et al.* (1997) found that Mo significantly increased seed yield up to 0.48 t/ha.

Zaman *et al.* (1996) conducted an experiment on mungbean and observed that 1000 seed weight increased by 34.42% over control due to application of Mo (2 kg/ha).

Aghatise and Tayo (1994) observed that application of Mo at the rate of 0.2 and 0.4 kg/ha increased seed dry weight of soybean by 29 and 10%, respectively compared with the control. They also reported that application of Mo at the rate of 0.2 and 0.4 kg/ha gave significantly higher dry weight of pods, i.e. 2.9 and 2.5g, respectively. They also observed that Mo application significantly increased dry matter accumulation in pod and husk compared with the control throughout the period of pod development.

Amadi (1994) conducted a field experiment in Baghdad to investigate the influence of five levels of molybdenum (0, 0.16, 0.36, 0.48 and 0.64 k/ha as ammonium molybdate) on the growth of soybean in the alkaline soil of Iraq (pH range 7.6 to 7.9). The results indicated a significant increase in weight of seeds/plant and total crop yield, the plant height, protein and oil percentage but not significantly.

Ibupoto and Kotechi (1994) observed that the application of Mo or Mo + B to soybean increased the number of seeds/plant, DW and seed yield.

Maurya *et al.* (1993) reported from a pot experiment that *Rhizobium* inoculation with Mo in *Vigna mungo* increased nodule number and weight. 1000 seed weight and N uptake.

Gupta and Narayanan (1992) reported that the pod r:jmber, seed number and weight and shoot dry weight showed significantly higher values on exposure to 2mg Mo/kg soil.

Sharma (1992) conducted an experiment to see the response of soybean to micronutrients in acidic soil and observed that application of Mo (1.5 kg ammonium molybdate/ha) gave 26.2% higher seed yield than control.

Bertie *et al.* (1991) reported that application of Mo (0.5 kg/ha) increased average yield (270 kg/ha) of soybean.

Yanni (1992) observed that seed yields of chickpea, lentil and *Lupinus albus* were generally the highest due to Mo application (3 ppm).

Singh *et al.* (1992) reported that application of molybdenum at the rate of 1 kg/ha increased the grain yield of chickpea significantly. Further increase in Mo level had no effect on the yield. Results are in fair agreement with those of Tiwari *et al.* (1989).

Sarkar and Banik (1991) conducted an experiment in Calcutta, India on green gram and observed that Mo application significantly increased pods/plant, seeds/pod, 1000 seed weight, seed yield and straw yield. They also reported that application of Mo at the rate of 0.10 and 0.25 kg/ha gave 11.45 and 11.76 kg/ha straw yield and 19.25 and 20.18 pods/plant, respectively.

Anwar (1989) conducted a field experiment at BJRI farm, Fridpur in Calcareous Dark Grey Floodplain Soil with mungbean *(Vigna radiata* L.). He observed that the application of Mo had significant effect on grain yield and Mo content in straw and grain.

Kalia and Sharma (1989) observed that soybean yield was increased by 46% over control due to the application of 1.0 kg Mo/ha.

2.4.3 Effect of *Rhizobium* inoculation and different fertilizers on yield and yield attributes

Satish *et al.* (2003) conducted an experiment to investigate the response of mungbean cultivars to different P levels (0, 20, 40 and 60 kg INOs/ha). I hey found that P at 40 and 60 kg/ha increased the number of pods/plant, grain yield and grains per pod over the control and P at 20 kg/ha.

Malik *et al.* (2003) conducted a study to determine the effect of varying levels of phosphorus (0, 50, 75 and 100 kg ha-1) on the yield and quality of mungbean *(Vigna radiata)* cv. NM-98. They observed that different levels of phosphorus significantly affected various growth and yield components of mungbean. Fertilizer application with 75 kg P/ha resulted maximum seed yield (1112.96 kg/ha).

Landge *et al.* (2002) conducted a field experiment and observed a progressive increase in yield and yield contributing characters of soybean with the application of P fertilizer in combination with *Rhizobium.*

Malik *et al.* (2002) conducted a field experiment on mungbean to observe the effects of phosphorus application (0, 30, 50, 90 and 110 kg/ha) on the growth, seed yield and quality of mungbean cv. NM-98. They found that application of 70 kg P/ha resulted in the highest number of pods per plant (22.47), number of grains per pod (12.06), 100-grain weight (42.27 g), grain yield (1158 kg/ha).

Sharma *et al.* (2002) carried out a field experiment to know the effect of different levels and sources of phosphorus under the influence of farm yard manure on growth determinants and productivity of soybean (*Glycine max* L Merrill) and observed that P @ 60 kg ha"^{1} produced better yield, dry matter and yield components compared to 30 kg ha'^{1}.

Thirumurugan *et al.* (2002) conducted a field experiment to study the influence of zinc, phosphorus and phosphobacteria on seed quality of soybean. The highest protein content due to P application were obtained with 60 kg/ha + phosphobacteria @ 2 kg/ha. Phosphorus treatments had no significant effect on oil content in seed.

Singh *et al.* (2001) studied that the effect of phosphorus (0, 30. 60 and 90 kg P_20_5/ha) application on mungbean grain yield was maximum when plants were treated with P @ 30 kg/ha (4.3 g/plant) and minimum with P 0 kg/ha (1.2 g/plant).

Yadev and Jakhar (2001) conducted a field study on mungbean with P fertilizer application (0, 20, 40 and 60 kg P_2O_s ha$'^{1}$) and found that the grain and straw yields were significantly higher with 60 kg P_20_5 ha$'^{1}$ (0.75 and 2.13 t ha^{1}).

Mishra *et al.* (1998) observed in a field study on mungbean *{Vigna radiata*) cv. K-851 with phosphorus levels 0, 25 or 50 kg P_20_5/ha and found the highest seed yield of 714 kg/ha with 50 kg P_20_5/ha.

Mohan and Rao (1997) observed that the seed yield and number of pods/plant generally increased with increasing rate of Mo (0.50 kg/ha) and P (90 kg P_20_5/ha).

Soni and Gupta (1997) found that mungbean with P fertilizer levels of 0, 20 or 40 kg/ha increased mungbean yield. The protein content of mungbean was also increased with increasing P rates.

Rahman *et al.* (1996) observed that *Rhizobium* inoculant (Strain RAH-892) with groundnut either alone on in combination of P, K. S and Zn fertilizers produced significantly higher seed yield over control.

Patro and Sahoo (1994) carried out a field experiment on mungbean cv. Dhauli and PDM 54 with 0, 15, 30, 45 or 60 kg P_20_5/ha gave seed yields of 706. 974. 1049, 1234 and 1254 kg/ha, respectively.

Vara *et al.* (1994) observed in a field experiment on soybean cv. Gujrat soybean-1 that the application of 40, 60 or 80 kg P_2Os/ha produced 1199. 1255, 1282 kg/ha seed yield, respectively.

Siag *et al.* (1992) reported that in a field trial on mungbean, seed yield increased with up to 60 kg P_2O_s/ha .P application increased consumptive water use and water use efficiency.

Singh *et al.* (1991) cited the results that seed yields of mungbean cv. PS 16. PDM 62, PDM 54 and Pusa 105 grown in the rainy season averaged 1.09, 1.19.

1.46 and 2.24 t/ha, respectively. Mean yields were 1.21, 1.46. 1.79 and 1.52 t/ha with 0, 30, 60 and 90 kg P_20_5/ha, respectively. Highest seed yield 1.79 t/ha was recorded with 60 kg P_20_5/ha. Yield differences were mainly associated with differences in number of pod/palnt.

Jana *et al.* (1990) reported that phosphorus application resulted significant increase in number of pods/plant, number of seeds/pod and 100-kernel weight of groundnut. Phosphorus also increased significantly pod and seed yield as compared to control.

Parihar (1990) reported that the phosphorus application had remarkable influence on seed yield of chickpea. Increasing levels of phosphorus significantly increased the number of pods/plant, number of grains/plant and 1000 seed weight.

Reddy *et al.* (1990) reported that phosphorus application in soybean significantly increased N-uptake with successive increments of phosphorus levels from 0 to 90 kg P_20_5/ha. No appreciable difference in N uptake at harvest was recorded between 90 kg and 60 kg P_20_5/ha. Both at 60 DAS and at harvest highest phosphorus uptake was recorded at highest level of phosphorus (90 kg P_2O_5/ha) and it was significantly superior to all other levels. Application of 90 kg P_20_5/ha resulted in highest grain yield (16.5 q/ha). but it was similar to 60 kg P_20_5/ha.

Singh and Bajpai (1990) reported that grain yield of soybean increased significantly with increasing phosphorus levels upto 60 kg P_20_5/ha. The response in respect of per kg of applied phosphorus to grain yield (8.2 kg grain/kg P_2O_s/ha) was highest upto 60 kg P_2O_s/ha, with a further addition of 40 kg P_20_5/ha the grain yield per kg of phosphorus (3.5 kg grain/ kg P_20_5/ha) declined.

Yadav *et al.* (1990) P application significantly increased the grain yield, though the effect was not significant on plant height, branches and dry weight/plant of pea.

Javia *et al.* (1989) reported that the application of phosphorus responded upto the higher level of 50 kg P_20_5/ha. Higher yield at this level could be ascribed to higher number of developing pods/plant and 1000 grain weight of gram. They also reported that the protein content of gram was affected by phosphorus application.

Chauhan *et al.* (1988) observed that the application of 17.6 kg P_20_5/ha increased average pod yield from 2.55 to 2.98 t/ha; further increase in P rates gave no additional yield.

Dwivedi *et al.* (1988) reported with 10 mungo cultivars/lines that the application of 40 kg P_20_5/ha increased seed yield, which was statistically significant with 60 kg P_2O_5/ha.

Paikera *et al.* (1988) reported that the application of higher doses of phosphatic fertilizer increased the percentage of fertile pods of soybean.

Shaktawat (1988) reported that application of 60 kg P_20_5/ha increased the grain yield of cowpea by 6.9 and 49.4 % over 30 kg P_20_5/ha and control, respectively. However, there was no remarkable response beyond 30 kg P_2O_s/ha.

Chapter 3

Materials and Methods

CHAPTER 3
MATERIALS AND METHODS

Materials and methods of the experiment that were used to study the effect of phosphorus, molybdenum and *Rhizobium* inoculation on the growth, yield and quality of mungbean were described in this chapter.

A pot experiment was carried out at the Soil Science Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during *kharif* season, 2005 using mungbean variety BARI Mung -5. The physicochemical analysis of soils and chemical analysis of plants were carried out in the laboratory of the Soil Science Division.

3.1 Soil

The soil used in this experiment belongs to Kodda series, under Madhupur tract (AEZ 28). Four soil samples were collected from bulk volume of soil. The soil was air dried, crushed and passed through a 2 mm seive. Initial physical and chemical properties of the soil are given in Table 1.

Tablel. Physical and chemical properties of initial soil

Soil properties	Analytical value
Sand (%)	18.40
Silt (%)	45.60
Clay (%)	36.00
Texture	Silty clay loam
pH (Soil water ratio 1:2.5)	5.6
Organic carbon (%)	1.067
Total-N (%)	0.097
C:N Ratio	11.00

Total-P (ppm)	1 1.00
Ca (meq/100 g dry soil)	6.3
Mg (meq/100 g dry soil)	1.8
Na (meq/100 g dry soil)	3.02
K (meq/100 g dry soil)	0.13

3.2 Crop

Mungbean (Var. BARI Mung-5) was used for the experiment. The seeds of mungbean were collected from the Agronomy Division, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The seeds were healthy, vigorous, w'ell matured and free from other seeds, weeds and extraneous materials. The germination percentage of the seeds was 85.

3.3 Preparation of pot soil

Each pot was filled with 12 kg of soil. Basal doses of nitrogen (N) and potassium (K) were applied to the soil at the rate of 30 kg N/ha (in the form of Urea) and 60 kg K_20/ha (in the form MP), respectively. N and K doses were applied to the upper half of the soil in the pots seven days before sowing. Four levels of phosphorus (0, 20, 40 and 60 kg P/ha) and two levels of molybdenum (1.0 and 1.5 kg Mo/ha) were applied to the pots according to the treatment combinations. Phosphorus as Triple Super Phosphate and Mo as Ammonium molybdate were applied 5 cm below the seed level two days before sowing.

3.4 Source of inoculum

The study was carried out with the *Rhizobium* inoculant containing the strains BARI RVr-2005. The strains were collected from the Soil Science Division. Bangladesh Agricultural Research Institute (BARI), Joydebpur. Gazipur.

3.5 Preparation of inoculum

Rhizobium inoculants were prepared in the Soil Science Laboratory usin" the broth culture. *Rhizobium* inoculants BARI RVr-2005 were used from the stock culture of the laboratory. Yeast extract mannitol medium was prepared in a 1 L beaker. The medium contained the following constituents

K_2HPO_4	0.5g
$MgS0_4.7H_20$	0.2g
NaCl	0.2g
$CaCl_2.6H_20$	0.2g
$FeCl_3.6H_20$	O.Olg
Mannitol	10.0g
Yeast extract	0.4g
Distilled H_20	1 litre

The pH was adjusted to 7.0 with 0.1 N 1IC1 solutions with the help of a pH meter. The medium was then dispensed in 50 ml amount into 100 ml Erlenmeyer flasks. The liquid medium was sterilized at 121° C for 15 minutes. The medium was cooled at room temperature. After cooling the medium a small portion of *Rhizobium* culture was aseptically transferred from slant to the liquid YEM medium in the flask with the help of a sterile needle. Duplicate 50 ml aliquots of the medium in 100 ml Erlenmeyer flasks w ere inoculated w ith a dilution of culture of *Rhizobium* from the logarithmic phase of growth to give a final viable *Rhizobium* concentration of approximately 1 X 10 ' cells/ml of test medium. The flasks were then kept in the incubator shaker at 25° C at 100 rpm to enhance rhizobial growth and observed for turbidity upto 7 days. Growth rates of the strain were determined following visual observation of turbidity. Diluted broth culture of the strain was mixed together in equal proportion before inoculating the peat.

For preparing the inoculant 100 g of dried and well ground peat was autoclaved at 121°C for one hour and was inoculated with a diluted mixed rhizobial culture. Thirty (30) ml of broth culture was aseptically injected to a polyethylene packct containing 100 g peat with the help of a sterile syringe and was mixed thoroughly. Peat was moist (0.3 bar tension) after inoculation but not saturated. The packet was labeled with the name of inoculants and date and was incubated at 25°C for two weeks. After incubation the number of rhizobia/g in peat inoculant was determined through enumeration by drop plate method (Vincent. 1970).

3.6 Determination of *Rhizobium* population in peat inoculant

1 g of inoculant was dissolved in a vial containing 9 ml of ringer solution to give a dilution of 10^{-1}. The vial was shaken well without splashing the contents to the top of the vial and transferred 1 ml suspension with a sterilized pipette from vial No.2 to give a 10^{-2} dilution. Again shaken and transferred 1 ml of suspension from vial No.2 to vial No.3 to give a 10^{-3} dilution. In the same way 8 fold dilution was made.

0. 2 ml suspension was taken by sterilized pipette and was added to duplicate plate containing sterile yeast mannitol agar (YMA) media and the suspension was spread to agar media with the help of sterile glass rod and then it was covered. Plates were incubated for 3 days at 25°C. Colonies developed were counted on duplicate plates. Rhizobial population of the inoculant was 4.86 X 10 cell/g. All operations were done in a clean bench.

3.7 Experimental Design

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Each replication consisted of 10 treatment combination. The total no. of individual pot was forty. The capacity of each pot w as 15 k”. Four levels of phosphorus and two levels of molybdenum were applied to the pots. *Rhizobium* inoculum was applied w ith all the treatments exccpt control.

3.8 Treatments

There were 10 treatments combination which are shown below -

1. Control [T|]
2. *Rhizobium* (R) [T2]
3. 0 kg P/ha + 1 kg Mo/ha + *Rhizobium* (R) [T3]
4. 20 kg P/ha + 1 kg Mo/ha + *Rhizobium* (R) [T_4J
5. 40 kg P/ha + 1 kg Mo/ha + *Rhizobium* (R) [T_5]
6. 60 kg P/ha + 1 kg Mo/ha + *Rhizobium* (R) [$T_{(>}$]
7. 0 kg P/ha +1.5 kg Mo/ha + *Rhizobium* (R) [T_7]
8. 20 kg P/ha + 1.5 kg Mo/ha + *Rhizobium* (R) [T_8J
9. 40 kg P/ha + 1.5 kg Mo/ha + *Rhizobium* (R) [T_9]

10.60 kg P/ha + 1.5 kg Mo/ha + *Rhizobium* (R) [T_{i0}]

3.9 Fertilizer application

Total amount of Urea, Muriate of potash was applied to the upper half of the pot soil seven days before sowing. Four levels ofTSP and two levels of Ammonium molybdate were applied to the pots according to the treatment combinations as a source of phosphorus and molybdenum. TSP and Ammonium molybdate were applied 5 cm below the seed level two days before of sowing.

3.10 Inoculation of seeds and sowing

Mungbean seeds were taken in vinyl bags and then gum arabic solution was added to the seeds to make them sticky. Prepared peat inoculant was used for inoculating seeds. The seeds were mixed with the peat inoculant thoroughly without the control treatments. After inoculation, the seeds were air dried by spreading on a newspaper placed on the table. Eight (8) seeds were sown in each pot on March 12, 2005 in the evening.

3.11 Germination of seeds

Germination of seeds started from 2'ul day of sowing. On the 3rd day the percentage of germination was more than 80% and on the 5lh day nearly all plants came out of the soil.

3.12 Collection of soil samples

Soil samples were taken from each pot after each sampling. The composite soils was mixed thoroughly and divided into four equal parts and one part was cleaned from plant root, stone and other discrete materials and stored. Samples were air dried and were prepared for analysis.

3.13 Intercultural operation

Five healthy plants per pot were retained after the formation of First trifoliate leaf. All the intercultural operation like weeding, irrigation, mulching etc. was performed as and when necessary. Fusarium wilt control measures were taken by 5 sprays with knowin @ lg/litre water during the initial growth period. For controlling insect pest Ripcord 100 EC @ 1 ml/litre water was sprayed.

3.14 Plant sampling

Plant samples were collected randomly from each pot carefully at 50% flowering stage with the help of a shuble so that no nodule was left in the soil. The roots were then carefully washed with clean water and finally ringed with distilled water. The nodules from the root of each plant were separated, collected and counted. Then number of roots plant'[1], nodulation data and shoot length, fresh weight of shoot, root and nodules were recorded. The plant samples were oven dried at 65°C for 48 hours. The oven dry weight of plants (roots, shoots) and nodules were recorded. After determination of dry weight of the samples, these were put in a dessicator for further analysis. Oven dried shoot were grinded in a grinder (Neiko sample mill, Model-Tl 200) for their chemical analysis.

3.15 Data collection

Data were collected on the following parameters at 50% flowering stage:

1. Plant height
2. Leaf number
3. Nodule number
4. Number of branches per plant
5. Root length
6. Root weight
7. Shoot weight
8. Pod length
9. Number of pods per plant
10. Number of seeds per pod
11. 100 grain weight
12. Grain yield per plant
13. Stover yield per plant

3.16 Harvesting

The crop was harvested at full maturity. Harvesting was done in two picking within the 20th of May, 2005. From each pot selected plant was collected and then plants were harvested and tied with rope separately and tagged and brought to the threshing floor.

3.17 Threshing and processing

The harvested plant materials were allowed to dry in the sun for 3 days. After drying, threshing and processing were done pot wise carefully. The processed grain and stover were again dried in the sun for 3 days. Grain and stover yields were recorded pot wise, which were then converted into yield in gm per plant.

3.18 Statistical analysis

The recorded data on various plant yield characteristics were statistically analyzed to find out the significance of variation resulting from the experimental treatments. For this purpose, analysis of variance was worked out for each plant and yield characters. The differences between treatment means were compared by least significance difference (LSD) test at 5% level of significance.

3.19 Measurement of Soil Initial Parameters

3.19.1 Soil Texture: The texture of the soil samples was determined by hydrometer method (Bouyoucos, 1927).

3.19.2 Soil pH : Soil pFl was measured by pH meter (Horiba.Model No. M-8L) fitted with glass electrode using a soil- water ratio of 1:2.5.

3.19.3 Total Nitrogen : Total N in soil was determined by Kjeldahl method (Bremner. 1965) using $CuS0_4$ and $KtS0_4$ mixture (1:9) as catalyst.

3.19.4 Organic Carbon: Organic Carbon of the soil was determined by wet digestion method (Tyurin, 1980).

3.19.5 Total Phosphorus: Total phosphorus of soil was determinedn by 'Perchloric acid digestion method.

3.20 Analytical Methods for Total N and P (%) in Plant Samples:

3.20.1 Total Nitrogen : Salicylic acid modified Kjehldahl method following sulphuric acid digestion and then colorimetric assay (Cataldo *et al.*, 1974)

3.20.2 Total P : Perchloric acid digestion and assay method for mineral elements following nitric acid digestion and then vanamobdate was added for cholorimetric assay (Yamakawa. 1992**).**

Chapter 4

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter includes the presentation of experimental results along with discussion in relation to the effect of phosphorus, molybdenum and *Rhizobium* inoculation on the growth, yield and quality of mungbean. Different agronomic parameters as well as yield and yield contributing characters of mungbean are shown in the tables 2 to 1 1 and figures 1 to 15.

4.1 Plant height

The effects of phosphorus, molybdenum and *Rhizobium* inoculant on the plant height of mungbean was found to be positive and significant. The plant height of mungbean ranged from 30.13 to 44.95 cm (Table 2). The highest plant height 44.95 cm was found with 40 kg P plus 1.0 kg Mo/ha and *Rhizobium* inoculant, which was statistically higher than other treatments. The lowest value 30.13 cm was recorded with the control treatment. *Rhizobium* inoculant alone gave higher plant height (32.12 m) than the control. Plant height increased with the increasing level of phosphorus up to 40 kg. Similar trend was also observed with molybdenum being highest with 1.0 kg/ha. But phosphorus with excess molybdenum also reduces crop growth. Chemical and biologically fixed N is the most dominating factor influencing the plant height. Muhammad *et al.* (2004) reported that the highest plant height (72.6 cm) was recorded in plot receiving 35 kg P_20_5/ha + *Rhizobium* inoculum on mungbean. Aghatise and Tayo (1994) reported that Mo application significantly increased plant height of soybean compared with control.

4.2 Root length

The effect of different treatments on root length of mungbean was found significant (Table 2). The root length ranged from 6.52 to 11.90 cm. Plants receiving phosphorus, molybdenum with *Rhizobium* inoculant gave higher root length. The highest root length 1 1.90 cm was found with P 60 kg/ha and Mo 1.0 kg/ha, which showed 82% higher root length over uninoculated control. *Rhizobium* inoculant alone also gave 30% higher root length over uninoculated control. Similar results were also reported by Solaiman (1999b) and *Zaman et al.* (1996).

Table 2. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on plant height, root length and nodule number of mungbean

Treatment	Plant height (cm)	Root length (cm)	Nodule number/plant
Control (T|)	30.13 g	6.52 e	6.75 f
Rhizobiuni(R)(T 2)	32.12 f	8.54 d	11.25 d
P0+M01 o$^+$R (T_3)	33.40 def	9.45 cd	11.75 c
P20+M01 0+R (T_4)	34.58 d	8.87 cd	13.00 b
P40+M01 o+R(T_5)	44.95 a	11.84 a	13.50a
Pfco+Moi.o+ R (T_6)	37.49 c	11.90 a	13.00 b
P0+M015+ R (T_7)	32.87 ef	8.70 d	1 1.75 c
P_{20}+Mo| 5+ R (T_8)	33.79 de	9.71 be	13.00 b
P40+M01 *$+R* ($T_9$)	41.32 b	10.52 b	11.75 c
P_{60}-+-MO| 5+ R (T10)	36.33 c	11.72 a	11.00 e
LSD (0.05)	1.299	0.893	0.247
CV%	2.5	6.3	1.5 !

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

4.3 Nodulation

Inoculation had a significant positive effect on the formation of nodules. Seed inoculation with *Rhizobium* markedly increased nodule number as compared to that of the non-inoculated plants of mungbean (Table 2 and Fig. 1). These results are in agreement with Sarker *el al.* (1993) and Chowdhury *et al.* (1998). They reported that phosphorus application at the rate of 60 kg P_2O_s/ha significantly increased nodulation. Phosphorus application promotes early root formation and the formation of lateral fibrous and healthy roots. Individual effect of P application was pronounced in this study. Among the phosphorus levels, P at the rate of 40 kg/ha and 60 kg/ha, respectively along with 1.0 kg Mo/ha produced significant number of nodules (13.50 and 13.00/plant) at flowering stage. However, mean data showed that the highest nodule/plant was observed with P_2o (Table 4 and Fig. 2). Khandaker *et al.* (1985) reported that nodules per plant were increased significantly in blackgram *(Vigna mungo)* due to P application at 40 days after germination. Similar results were reported by Satter and Ahmed (1992). Plant receiving *Rhizobium* inoculation alone or w ith different levels of phosphorus and molybdenum produced higher number of nodules over uninoculated control. The number of nodules ranged from 6.75 to 13.50 per plant and the increasing trend was recorded upto 40 kg P plus 1.0 kg Mo/ha along with *Rhizobium* inoculation. Sharma *el al.* (1995) reported that seed inoculation with *Rhizobium* and application of 40 kg P_2Os/ha in chickpea *(Cicer arietinum)* either alone or in combination enhanced nodulation over uninoculated control. Rahman *et al.* (1994) also reported the similar result. Chowdhury *et al.* (1998) found that 50 kg P_20_5/ha with other fertilizers increased 245% nodule number over control. Khanam *el al.* (1993) also found the similar results in lentil.

The effect of molybdenum alone on total number of nodule per plant was significant (Table 5). From the experiment it was clear that. 1.0 kg Mo/ha produced significantly higher number of nodules per plant than 1.5 kg Mo/ha.

The higher number of nodule 12.81 was obtained with 1.0 kg Mo/ha and the number of nodule decreased significantly (1 1.88) with 1.5 kg Mo/ha (Fig. 2). Zaman *et al.* (1996) observed that application of molybdenum *(a)* 1.0 kg/ha produced 97% higher nodule number over control. Tiwari *el al.* (1989) also reported that molybdenum application gave 75% higher nodule number in chickpea. Chowdhury *et al.* (1998) observed similar trend on mungbean.

T1 T2 T3 T4 T5 T6 T7 T8 T9 T10

Treatment

Fig.1 Effect of phosphorus,molybdenum and *Rhizobium* inoculation on nodule number per plant at flowering stage of mungbean

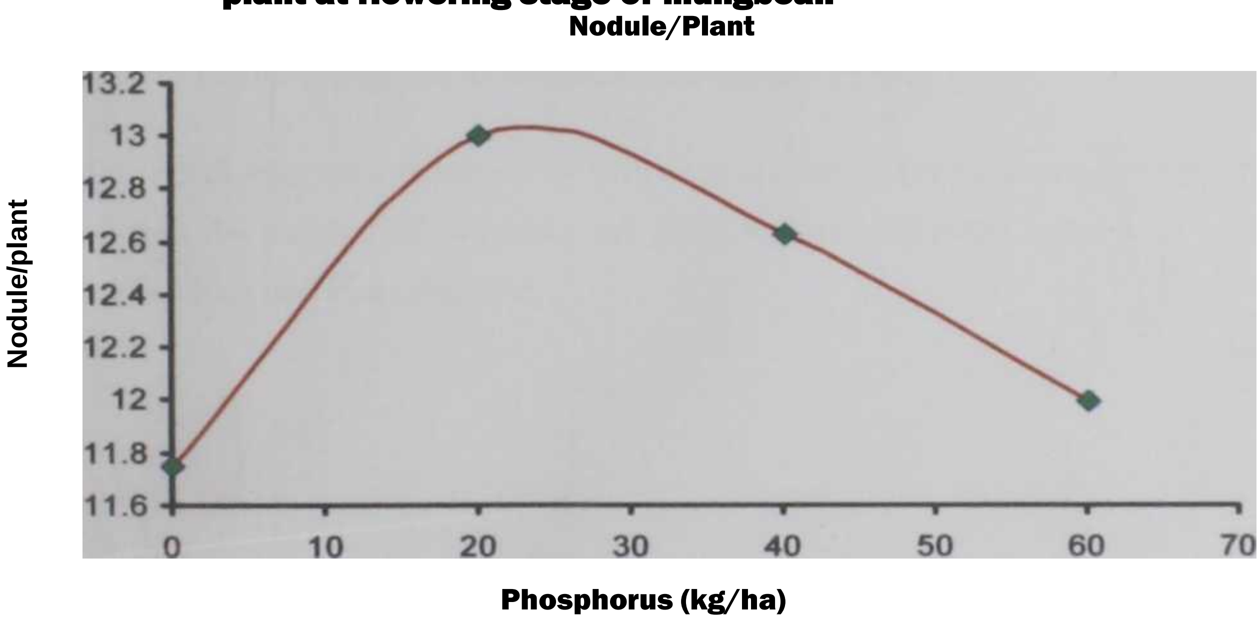


Fig. 2 Effect of phosphorus application on number of nodules per plant of mungbean

4.4 Number of leaves per plant

Inoculated plants produced significantly higher number of leaves with phosphorus and molybdenum (Table 3). Highest number of leaves (22.84) was found with P & Mo level 40 & 1.0 kg/ha, which was statistically significant with control treatment (19.27). However, inoculation alone ($T_:$). or inoculation plus molybdenum (T_3) failed to increase leaves no/plant significantly.

It was found that inoculated plants produced higher number of leaves compared to uninoculated plants (19.27). Similar result was also reported by Reddy and Gajendragiri (1989) in groundnut plants.

4.5 Number of branches per plant

The significant effect of phosphorus, molybdenum and *Rhizobium* inoculant on branches of mungbean were found (Table 3). It was found that the inoculated plants with phosphorus, molybdenum and *Rhizobium* inoculant had higher number of branches per plant at harvest stage of the crop. The highest number of branches per plant was 5.58 w'ith T_5, but statistically similar w ith $T_{(,}$. T<, and $T|_0$ treatments. The lowest number of branches 4.40 was obtained in control treatment. It was observed that the higher number of branches was produced by inoculated plants compared to uninoculated control (Table 3).

Similar result was also observed by Gill *el al.* (1985). Muhammad *et al.* (2004) found that the number of branches per plant was significantly influenced with both inoculum and P application.

f able 3. Effect of phosphorus, molybdenum and *Rhizobium* inoculant, on leaf, branch, shoot and root dry matter (g/plant) of mungbean at flowering stage

Treatment	Leaves no./ plant	Branches no./ plant	Shoot wt./plant (g)	Root wt./plant (g)
Control (T|)	19.27 d	4.40 d	1.55 h	0.25 f
Rhizobium(R)(T_2)	19.54 d	4.67 cd	2.22 g	0.28 c
P_0+Moi (T_3)	19.70 d	4.80 bed	2.41 ef	0.31 d
P_2o+MO| o+ R (T_4)	21.37 be	4.92 be	2.46 e	0.35 be
P_{40}+MO| (T_5)	22.84 a	5.58 a	3.29 a	0.40 a
P_{60}+Moi *O*+*R* (T_6)	22.90 a	5.54 a	2.94 b	0.38 ab
P_0+Moi 5+ R (T_7)	19.70 d	4.77 bed	2.39 f	0.30 de
P_{20}+Mo, $_5$+ R (T_8)	20.71 c	4.88 be	2.42 ef	0.34 c
P_{40}+MO| $_5$+*R* (T_9)	21.52 b	5.17 ab	2.77 c	0.37 be
P_{60}+Moi 5+ R (T1o)	22.72 a	5.15 ab	2.68 d	0.36 be
LSD (0.05)	0.734	0.399	0.052	0.028
CV%	2.4	5.5	1.4	5.9

Table 4. Effect of phosphorus on number of nodule, stover yield and seed yield of mungbean

Phosphorus levels (kg/ha)	No. of nodules/plant	Stover yield/plant (g)	Seed yield/plant (g)
0	11.75 d	25.78 c	10.15 d
20	13.00 a	26.01 b	1 1.00 c
40	12.63 b	26.38 a	14.00 a
60	12.00 c	26.13 b	12.62 b
LSD (0.05)	0.166	0.15	0.269
CV (%)	0.9	0.4	1.6

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

Table 5. Effect of molybdenum on number of nodule, stover yield and seed yield per plant of mungbean

Molybdenum (kg/ha)	No. of nodule/plant	Stover yield/plant (g)	Seed yield/plant (g)
1.0	12.81 a	26.17 a	12.34 a
1.5	11.88 b	25.98 b	1 1.58 b
LSD (0.05)	0.166	0.15	0.269
CV (%)	0.9	0.4	1.6

4.6 Dry weight of shoot

Significant etlect of phosphorus, molybdenum and *Rhizobium* inoculant on shoot dry weight of mungbean was observed (Table 3). The highest shoot dry w'eight (3.29 g/plant) was recorded in P_{40}+Mo, $_{0}$+*R* at flowering stage, which was significantly higher than other treatments. At flow'ering stage treatments T_3, T_4 and T_8 were statistically similar. Molybdenum 1.0 kg/ha performed better than higher dose (Table 3). The lowest dry weight of shoot was recorded in control treatment. *Rhizobium* inoculation increased dry weight of shoot significantly over control.

Eusuf Zai *el al.* (1999) showed that *Rhizobium* inoculant significantly increased shoot dry weight of chickpea compared to uninoculated control. Pradhan and Sarkar (1985) found that application of Mo increased dry weight of stem in horsegram. Franco and Munns (1981) also reported higher shoot dry weight due to application of Mo in bean. Hoque and Hashem (1993) stated that *Rhizobium* as biofertilizer was remarkably beneficial on shoot weight and total dry weight of soybean and groundnut. Mahmud *et al.* (1997) reported that weight of shoot in lentil significantly increased due to inoculation compared to control. Dry weight of shoot remarkably increased in inoculated mungbean over control as reported by Solaiman (1999b).

4.7 Dry weight of root

The effect of phosphorus, molybdenum and *Rhizobium* inoculant significantly increased dry weight of root of mungbean compared to control (Table 3). *Rhizobium* inoculant alone and fertilizers along w'ith inoculum produced significantly higher dry weight of root over control. Addition of Mo upto 1.0 kg/ha along with *Rhizobium* inoculant and phosphorus upto 40 kg/ha produced higher dry weight of root and then reduced gradually. Study show'ed that dry weight of root positively correlated with total number of nodules (Table 1 1).

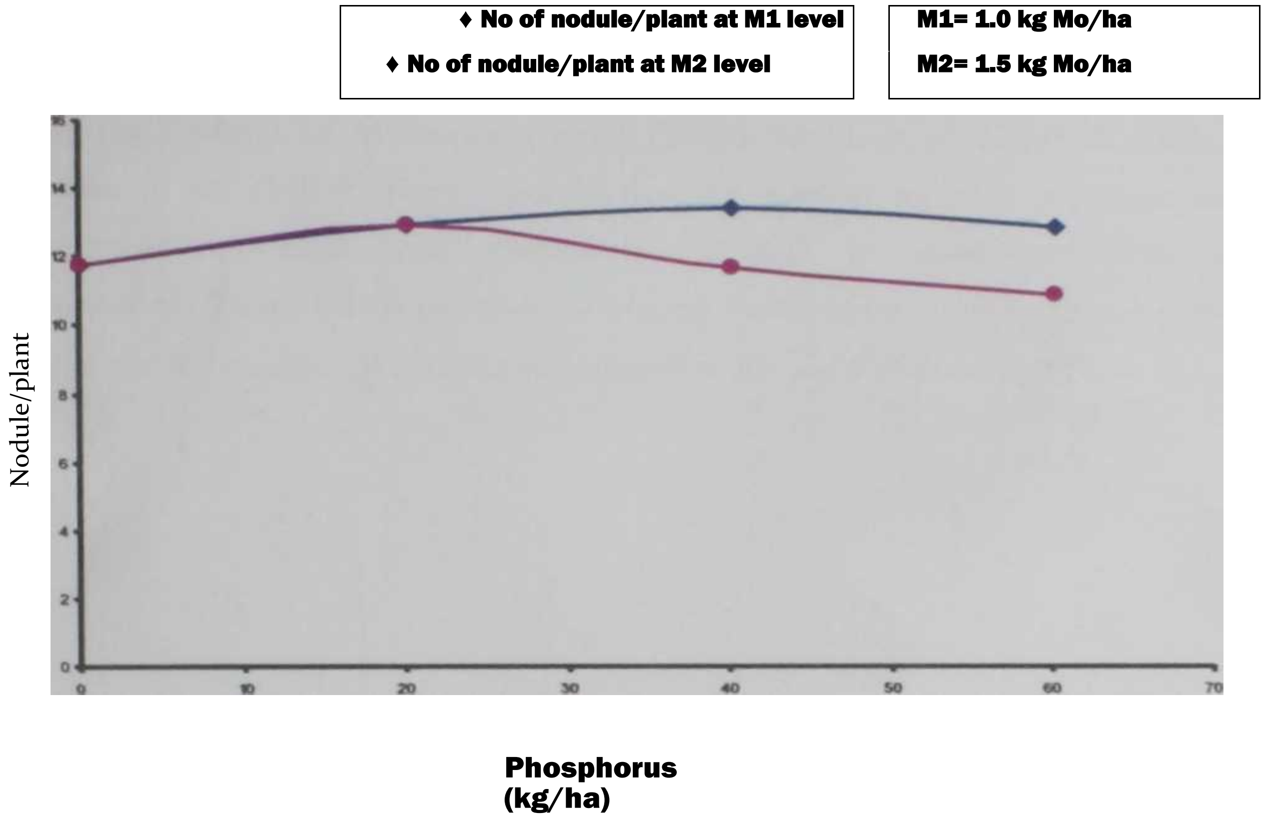
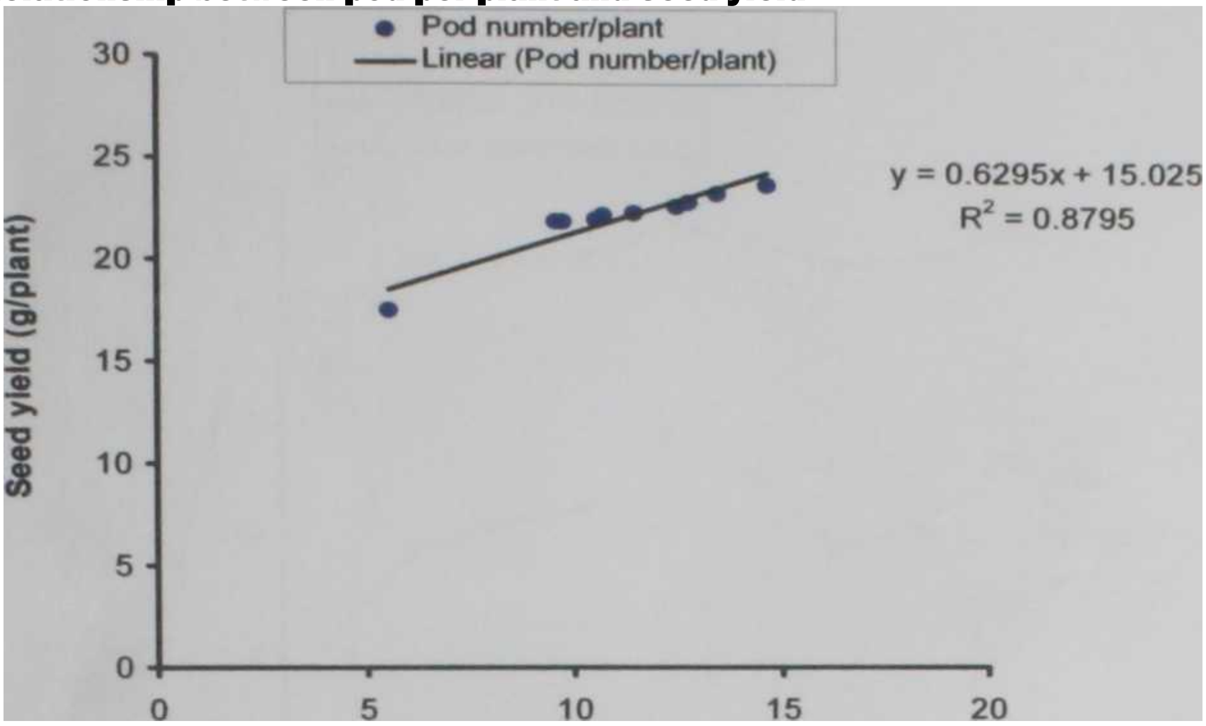


Fig. 3 Interaction effect of phosphorus and molybdenum on number of nodule per plant of mungbean

4.8 No of pods per plant

Effect of *Rhizobium* inoculant along with phosphorus and molybdenum significantly increased the number of pod per plant (Table 6). The highest number of pod (23.65) was found with the treatment T_s, which was significantly higher than other treatments and statistically similar with the treatment T_9. The treatment containing *Rhizobium* inoculant alone produced 20% higher number of pod/plant over control. These results are in agreement with the findings of Muhammad *cl al.* (2004), Malik *cl al.* (2002 & 2003). Podder *cl al.* (1999). They reported that the number of pods per plant of mungbean increased with *Rhizobuim* inoculant in association with P application. There was a positive correlation between the number of pods per plant and the number of nodules and mature seeds yield of the crop (Table 1 1).

Relationship between pod per plant and seed yield



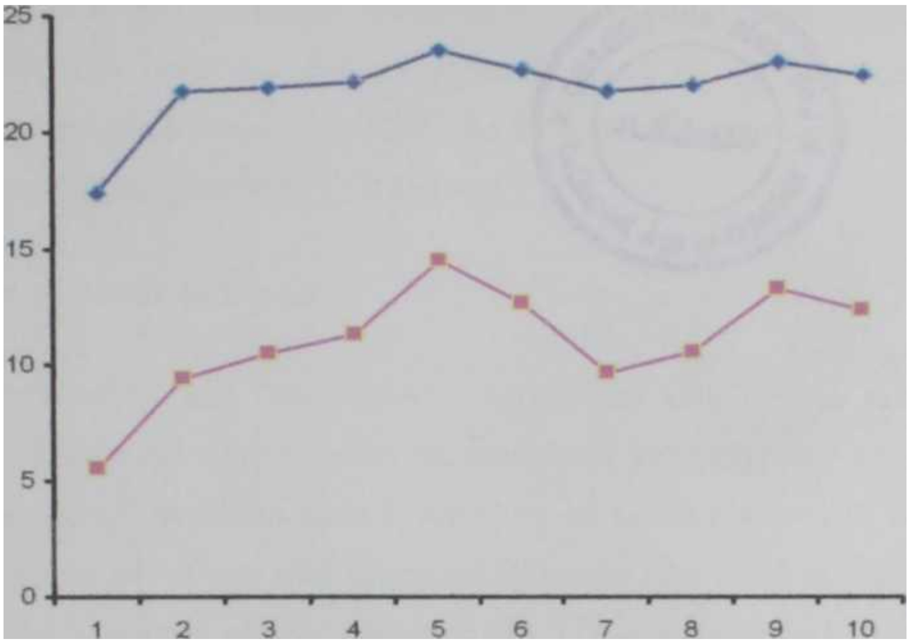
Pods per plant

Fig. 4 Relationship between number of pod per plant and seed yield of mungbean

Fig. 4 showed that there was a positive correlation (R^2 = 0.8795) between pods per plant and seed yield. The relationship is described by yield response function y= 0.6295x + 15.025 where y indicates seed yield, which varied with pods per plant levels x.

Number of pods/plant

—■—Seed yield/plant (gm)



Treatment

Fig. 5 Effect of phosphorus, molybdenum and *Rhizobium* inoculation on pod per plant and seed yield of mungbean

4.10 Pod Length

Pod length due to the application of phosphorus, molybdenum and *Rhizobium* inoculation is presented in Table 6. Pod length varied significantly over control. The highest pod length 10.93 cm was obtained with the treatment T> where phosphorus was applied at 40 kg/ha along with 1.0 kg Mo/ha and *Rhizobium*. The lowest pod length 8.32 cm was found with control. Except control, statistically no variations were observed among other treatments. Again, no effect was observed due to different levels of Mo application. In treatment T_5 pod length increased to 32% and 27% over control and *Rhizobium* inoculated treatment, respectively (Table 6).

4.11 Number of seeds per pod

Rhizobium inoculant, P and Mo played a significant role on the number of seeds per pod. Data regarding number of seeds/pod are presented in Table 6. Number of seeds/pod increased upto P levels at 40 kg/ha along with Mo level upto 1.5 kg/ha, but no effect was observed between Mo level at 1.0 and 1.5 kg/ha. The highest number of seeds per pod (11.71) was found in P at 40 kg/ha along with 1.0 kg Mo/ha and *Rhizobium* but statistically similar with P level at 60 kg and Mo level at 1.5 kg/ha. The lowest number of seeds per pod (8.68) was found in uninoculated control. It was observed that *Rhizobium* inoculant in association with P and Mo led to increase the number of seeds per pod of mungbean. Similar results were also reported by Landge *et al.* (2002) and Jana *et al.* (1990). In the present study, number of seeds per pod had a positive correlation with seed yield/plant (Table 11 and Fig. 10).

Table 6. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on pod length, pod/plant, seeds/pod and 100 seed weight of mungbean

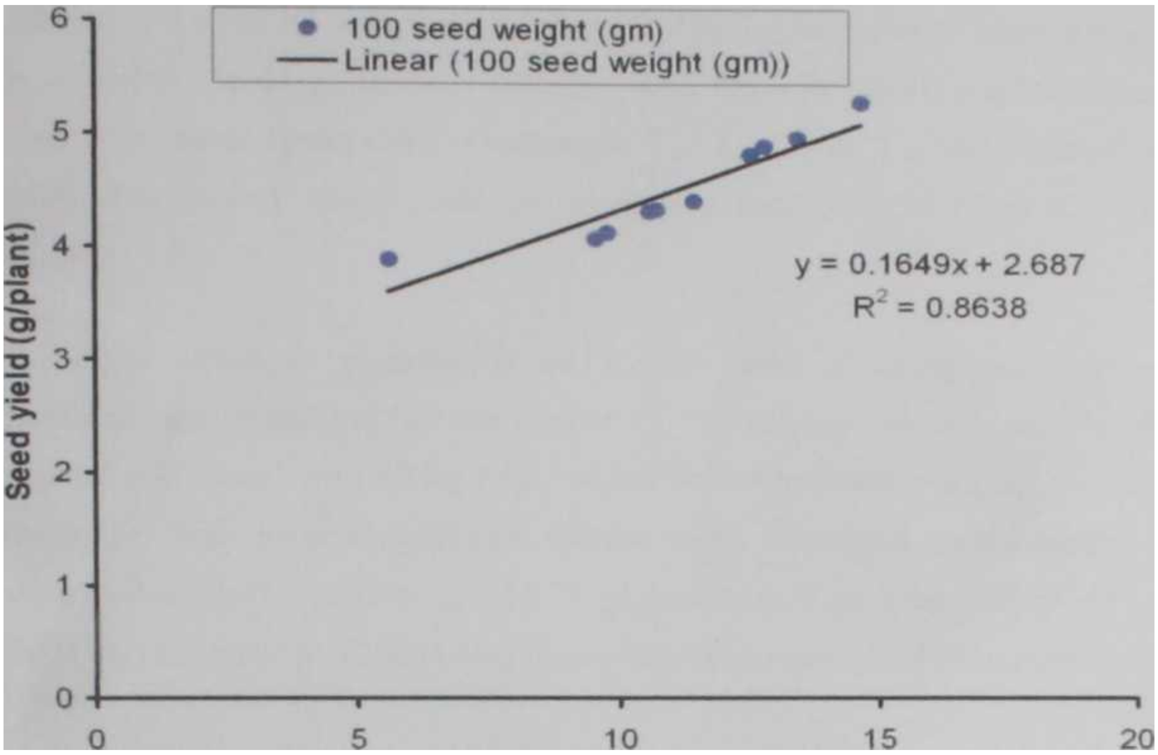
Treatment	Pod length (cm)	Pods/plant	Number of seeds/pod	100 seed weight (g)
Control (T_t)	8.32 b	17.46 e	8.64 e	3.90 d
Rhizobium(R)(T_2)	8.54 ab	21.85 d	10.82 d	4.08 d
Po+Mo! $_0$+*R* (T_3)	10.43 ab	22.00 d	11.07 cd	4.32 cd
P_2o+Moi o+ *R* (T_4)	10.75 ab	22.25 cd	11.29 be	4.41 bed
P_{40}+Moi (T_5)	10.93 a	23.65 a	11.71 a	5.28 a
P_{60}+Moi.$_0$ *R* (T_6)	10.84 ab	22.85 be	11.47 ab	4.90 ab
P_0+MO| 5+ *R* (T7)	10.32 ab	21.86 d	10.82 d	4.13 d
P_2o+Moi.5+ *R* (T_8)	10.55 ab	22.20 ed	11.09 cd	4.34 cd
P_{40}+Moi *s*+*R* (T_9)	10.75 ab	23.19 ab	11.62 ab	4.97 a
P_{60}-t-Mo! 5+ *R* (T|$_0$)	10.79 ab	22.65 bed	11.40 abc	4.81 abc
LSD (0.05)	2.235	0.714	0.309	0.507
CV%	15.1	2.2	1.9	7.7

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

4.12 100 seed weigh

Rhizobium inoculant along with P and Mo significantly increased 100 seed weight compared to control (Table 6). Treatments with *Rhizobium* inoculant along with Mo @ 1.0 and 1.5 kg/ha and P @ 40 and 60 kg/ha were statistically similar and recorded higher 100 seed weight compared to *Rhizobium* inoculant alone. Statistically similar effect was observed between the treatment with or without inoculum (Table 6). The highest 100 seed weight (5.28 gm) was recorded with the treatment T_5 (P_{40} + Moi $_0$ + R). This finding is in agreement with Solaiman (1999b). Sarker *et al.* (1993) reported that *Rhizobium* inoculant along with P increased 100 seed weight of green gram in a pot experiment. Zaman *el al.* (1996) observed that 100 seed weight was increased to 34.42% over control due to application of Mo. Malik *et al.* (2002) reported that seed inoculation with *Rhizobium* significantly increased 100 grain weight (42.27 g) of mungbean. Similar results were observed by Podder *et al.* (1999) and Chowdhury *et al.* (1998). There was a highly positive correlation between 100 seed weight with seed yield/plant (Table 11 and Fig-9)

Relationship between 100 seed weight and seed yield



100 seed weight (g)

Fig. 6 Relationship between 100 seed weight and seed yield of mungbean

Fig. 6 showed that there was a positive correlation (R~ = 0.8638) between 100 seed weight and seed yield. The relationship is described by yield response function y= 0.1649x + 2.687 where y indicates seed yield, which varied with 100 seed weight levels x.

4.14 Stover yield per plant

Phosphorus, molybdenum and *Rhizobium* inoculation influenced significant on the stover yield of mungbean (Table 7). The highest stover yield per plant was recorded (26.67 g) in P_{40} + Moi $_0$ + R at harvest, which was statistically higher over other treatments. Treatments T_4, T_6, T_9 & $T_{,0}$ were statistically similar. The lowest stover yield per plant was recorded (20.75 g) in control treatment.

The single effect of phosphorus on stover yield of mungbean was also influenced significantly at harvest (Table 4). The highest stover yield (26.38 g) per plant was found with 40 kg P/ha, which w'as significantly higher than other treatments. With increasing P rate, stover yield decreased significantly. The lowest stover yield was recorded 25.78 g/plant with 0 kg P/ha. Manpreet *et al.* (2004) and Singh *et al.* (2001) also observed the similar trend in mungbean.

Again the single effect of molybdenum on mungbean stover yield w'as also influenced significantly (Table 5). The stover yield (26.17 g/plant) with 1.0 kg Mo/ha, was significantly higher than the stover yield (25.98 g/plant) recorded with 1.5 kg Mo/ha. Wu *et al.* (1994) reported that plant dry weight and the dry weight of different organs in soybean were positively correlated with Mo concentration.

The highest stover yield per plant 26.67 g was recorded w'ith P^o + Mo| $_0$ kg/ha (Table 7). The lowest stover yield (20.75g) was recorded in the control. Considering interaction between phosphorus and molybdenum, the highest yield was recorded with 40 kg P and 1.0 kg Mo/ha (Fig. 8). In this treatment it was observed that stover yield was increased to 28.53% over control (Table 7). Sharma (1992) reported the same results with soybean.

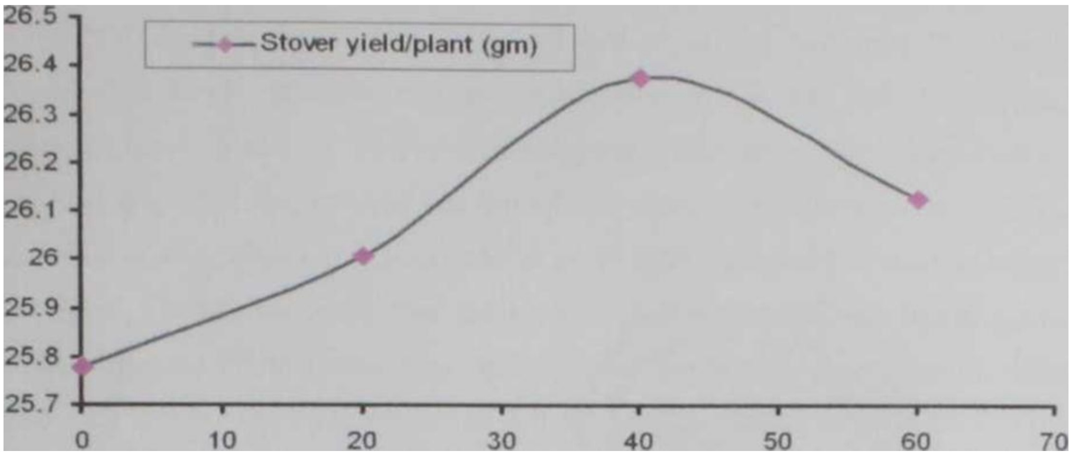


Fig. 7 Effect of phosphorus application on stover yield of mungbean

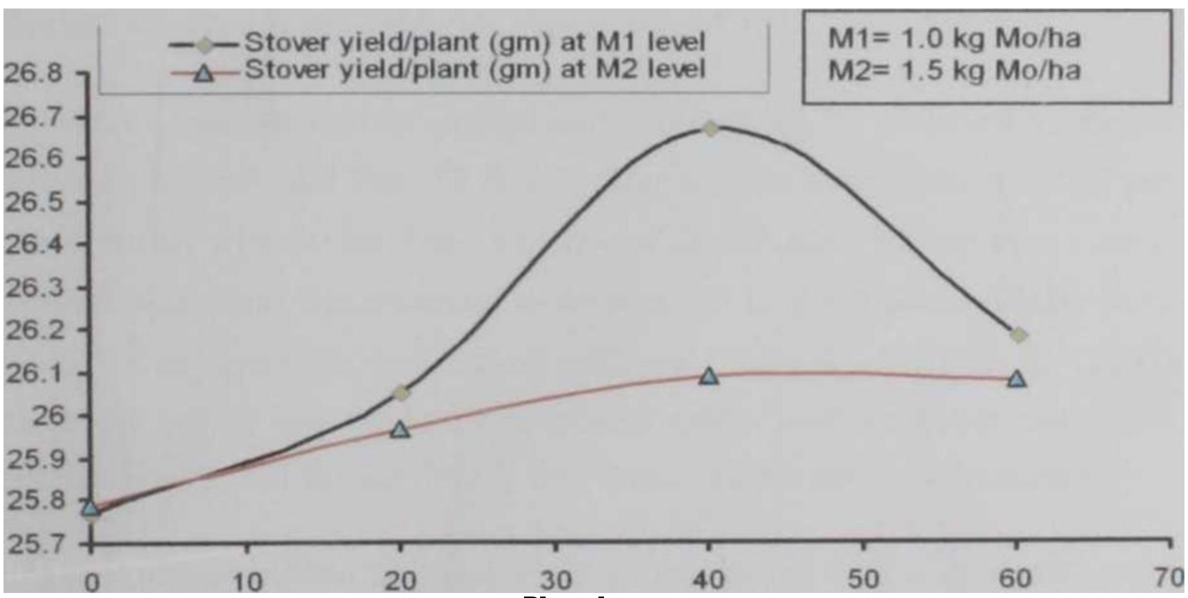


Fig 8. Interaction effect of phosphorus and molybdenum on stover yield of mungbean

4.15 Seed yield per plant

Seed yield per plant of mungbean is presented in Table 7. *Rhizobium* inoculant significantly increased seed yield per plant compared to control (Tabic 7). The treatment inoculated with *Rhizobium* along with 1.0 kg Mo and 40 kg P/ha produced the highest seed yield (14.61 g) per plant. In treatment T_5 plants receiving *Rhizobium,* phosphorus and molybdenum @ 40 and 1.0 kg/ha, respectively gave yield of 162% higher grain yield over the uninoculated control (T|) and 53% higher over the *Rhizobium* alone ($T_;$). Evans *et al.* (1993), Muhammad *et al.*, (2004) and Solaiman *et al.* (1999) reported the similar trend. Verma *et al.* (1988) reported that seed yield increased with Mo application. Kalia and Sharma (1989) observed that soybean yield was increased by 46% over control due to the application of 1.0 kg Mo/ha. Satish *et al.* (2003) also observed that P at 40 and 60 kg/ha increased mungbean grain yield over control. Same results were observed by Lange *et al.(2002)* in soybean, Malik *et al.* (2003) and Singh *et al.* (2001) in mungbean.

Seed yield per plant of mungbean showed positive correlation with number of nodule per plant, number of pod per plant, number of seed per pod and 100 seed weight of mungbean (Table 11, Fig. 9, 10 and 11).

Seed yield of mungbean was significantly influenced by different levels of phosphorus (Table 4 and Fig. 12 & 13). The highest seed yield (14.00g) per plant was found with 40 kg P/ha, which was significantly higher than others. The lowest seed yield was recorded in control (10.15 g per plant). Phosphorus at 60 kg P/ha produced the 2nd highest seed yield (12.62g). Satish *et al.* (2003) found that P at 40 and 60 kg/ha increased grain yield over the control in mungbean. Yadev and Jakhar (2001) also found similar result on mungbean.

Again main effect of Mo on seed yield of mungbean was also significantly influenced (Table 5). The highest seed yield (12.34 g/plant) was found with 1.0

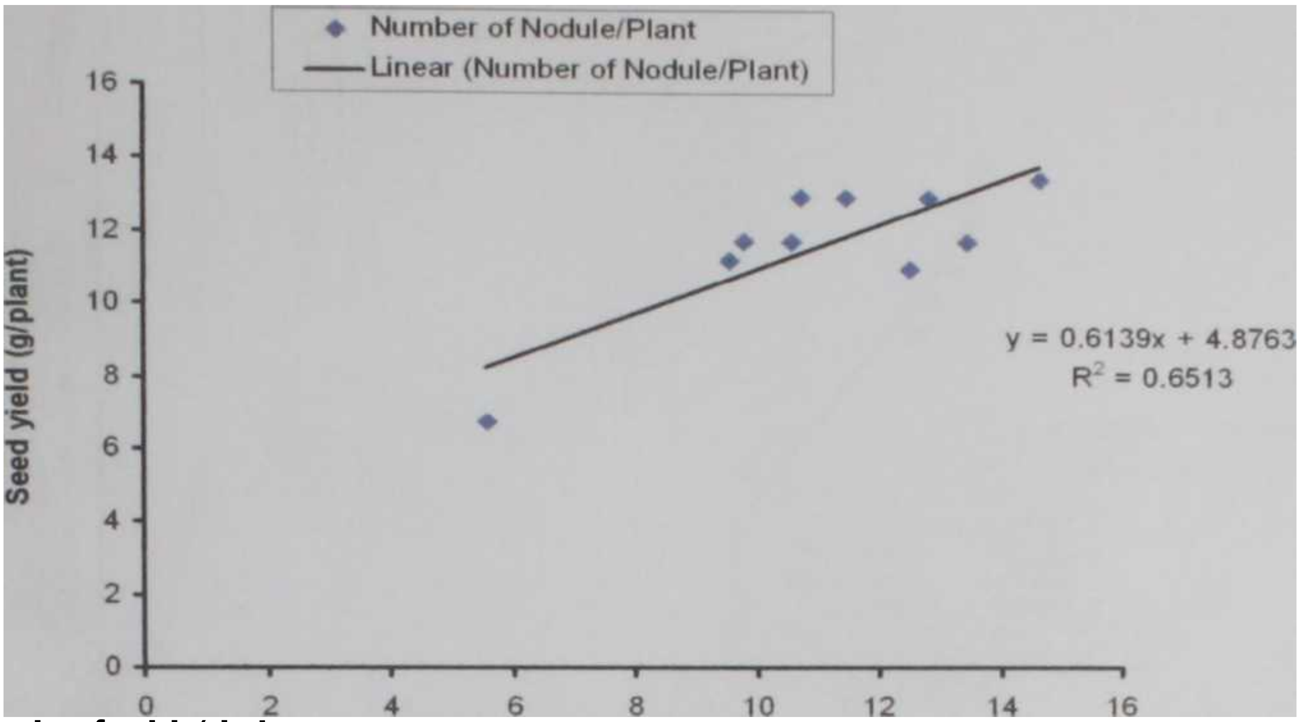
kg Mo/ha and the lowest (11.58 g/plant) was recorded with 1.5 kg/ha. Sfredo *et al.* (1997), Ibupoto and Kotechi (1994) also found same results on soybean. Interaction effect of phosphorus and molybdenum also significantly influenced the seed yield of mungbean and are presented in Fig. 13. The highest seed yield per plant was recorded with $P_{4()}$ + Moi $_{()}$ kg/ha. The lowest seed yield per plant was recorded with P_0 + Moi 5 kg/ha. Sharma (1992) found the similar result on soybean.

Table 7. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on yield of mungbean

Treatment	Stover yield/plant (g)	Increase over control (%)	Seed yield/plant (g)	Increase over control (%)
Control (T|)	20.75 e		5.56 h	-
Rhi:obium(R)(T2)	25.79 d	24.29	9.53 g	71.40
P_o+Moi o+ *R* (T_3)	25.77 d	24.19	10.54 f	89.57
P_2o+MO! o+ *R* (T_4)	26.05 be	25.54	11.43 e	105.58
P4o+Mo1 *o*+*R* (T_5)	26.67 a	28.53	14.61 a	162.77
P_6o+Mo_t *o*+*R* (T_6)	26.18 b	26.17	12.77 c	129.68
P_o+MO| 5+ *R* (T_7)	25.79 d	24.29	9.74 g	75.18
P20+M01 5+ *R* (T_8)	25.97 c	25.16	10.68 f	92.08
P4o+Mo15+ *R* (T_9)	26.09 be	25.74	13.40 b	141.00
P_{6o}+MOI 5+ *R* (T1o)	26.08 be	25.69	12.48 d	124.46
LSD (0.05)	0.146	-	0.264	
CV%	0.4		1.6	—

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

Relationship between nodule number and seed yield



Number of nodule/plant

Fig. 9 Relationship between nodule number and seed yield of mungbean

Fig. 9 showed that there was a positive correlation (R‘ = 0.6513) between number of nodule per plant and seed yield. The relationship is described by yield response function y= 0.6139x + 4.8763 where y indicates seed yield, which varied with number of nodule per plant levels x.

Relationship between seeds per pod and seed yield

Seed/pod

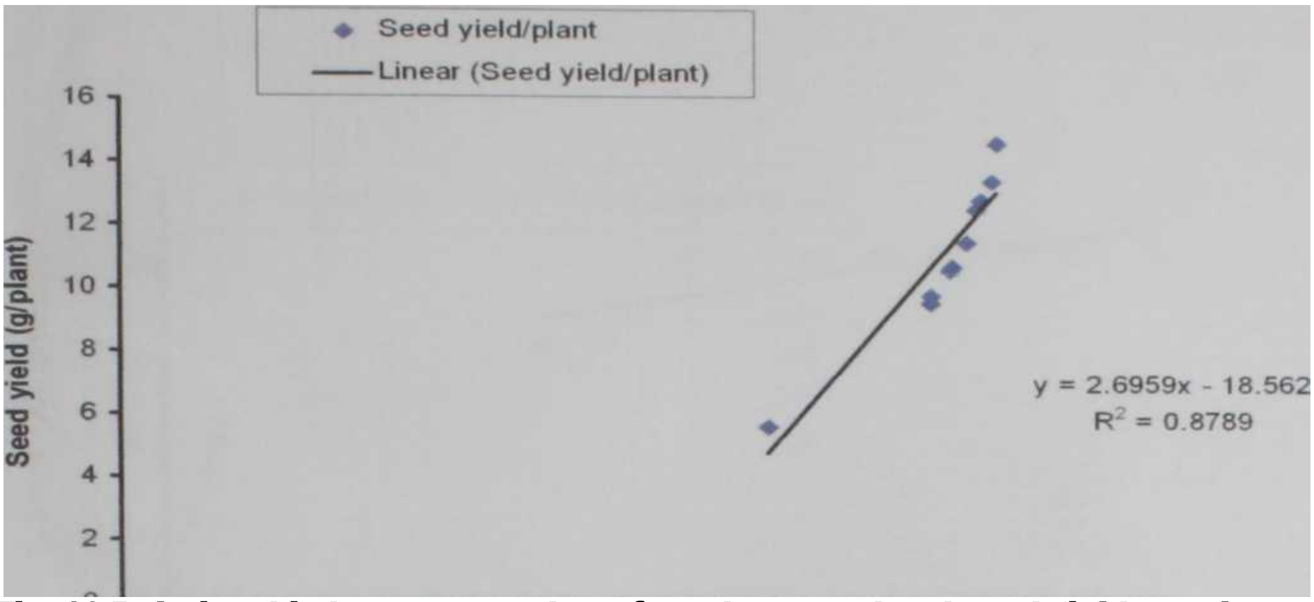
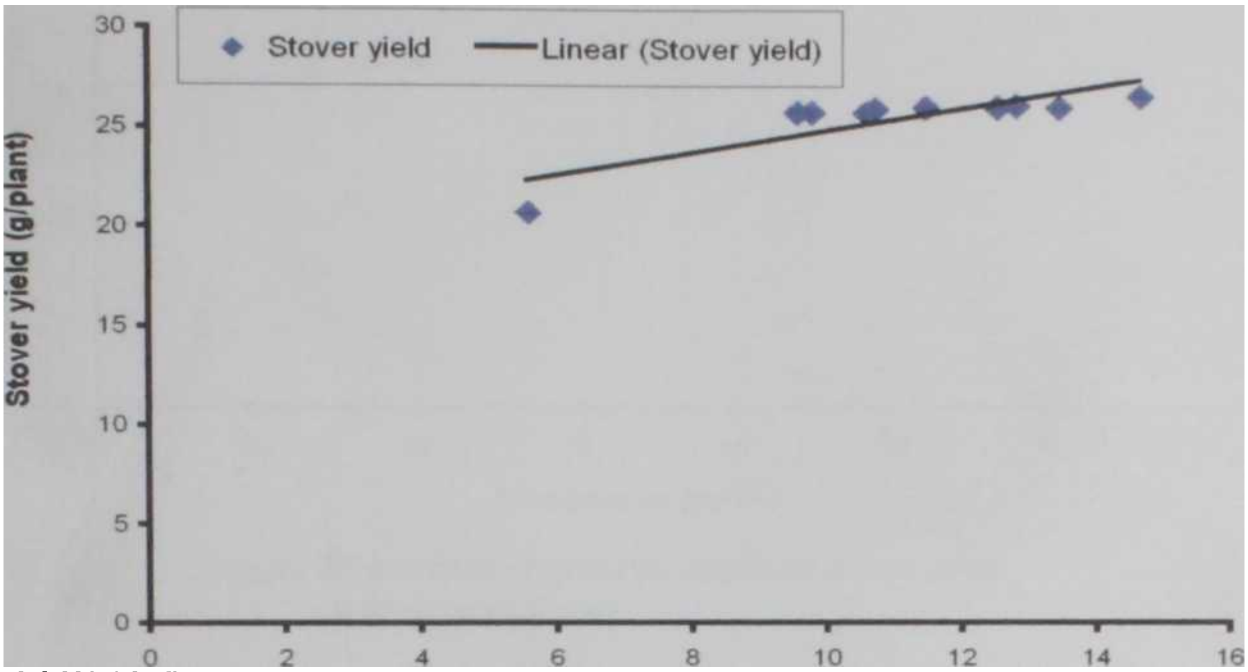


Fig. 10 Relationship between number of seeds per pod and seed yield per plant of mungbean

Fig. 10 showed that there was a positive correlation (R~ = 0.8789) between seeds per pod and seed yield The relationship is described by yield response function y= 2.6959x - 18.562 where y indicates seed yield, which varied with the seeds per pod levels x.

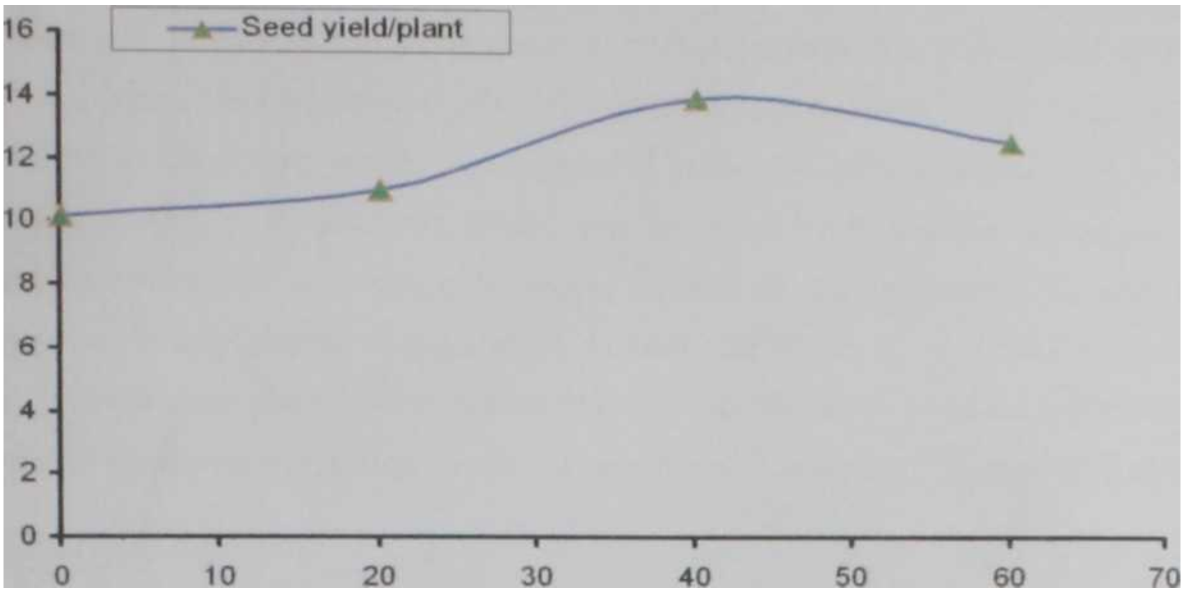
Relationship between seed and stover yield



Seed yield (g/plant)

Fig. 11 Relationship between seed and stover yield of mungbean

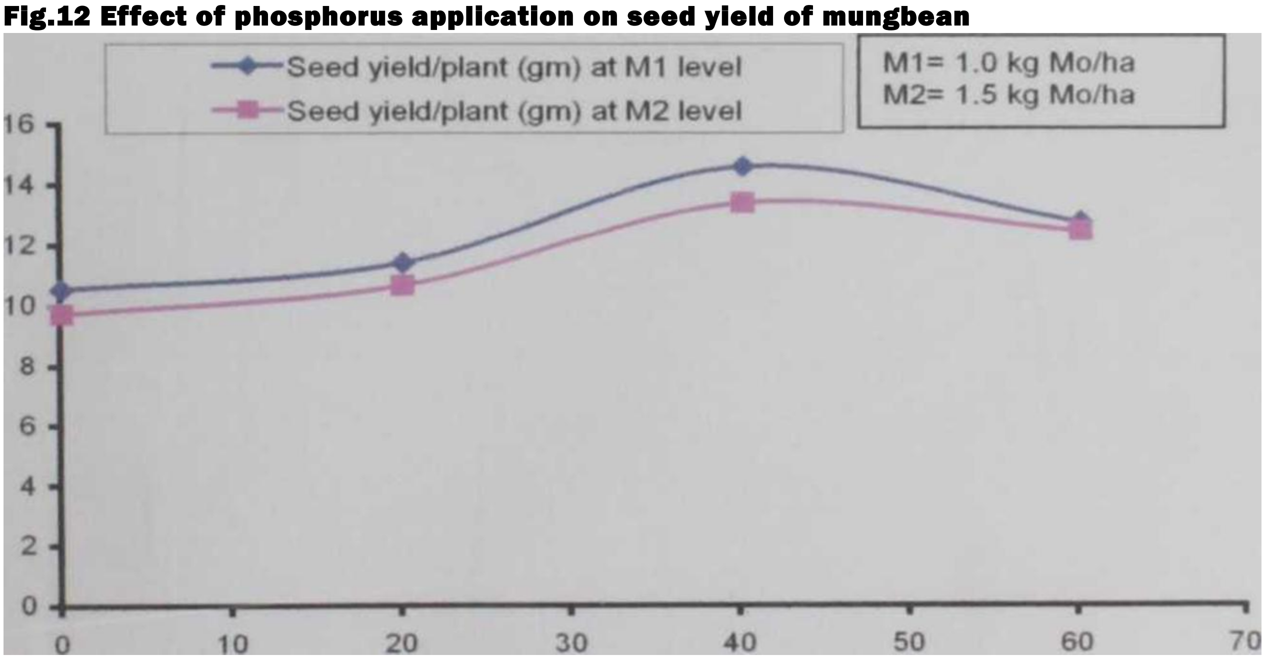
Fig. I I showed that there was a positive correlation (R^2= 0.8213) between grain yield and stover yield. The relationship is described by yield response function y= 0.1457x + 24.341 where y indicates straw yield, which varied with the grain yield levels x.



Phosphorus (kg/ha)

Fig.12 Effect of phosphorus application on seed yield of mungbean

Seed yield/plant Seed yield/plant (g)



Phosphorus level

Fig. 13 Interaction effect of phosphorus and molybdenum on seed yield of mungbean

4.19 Nitrogen content in shoot

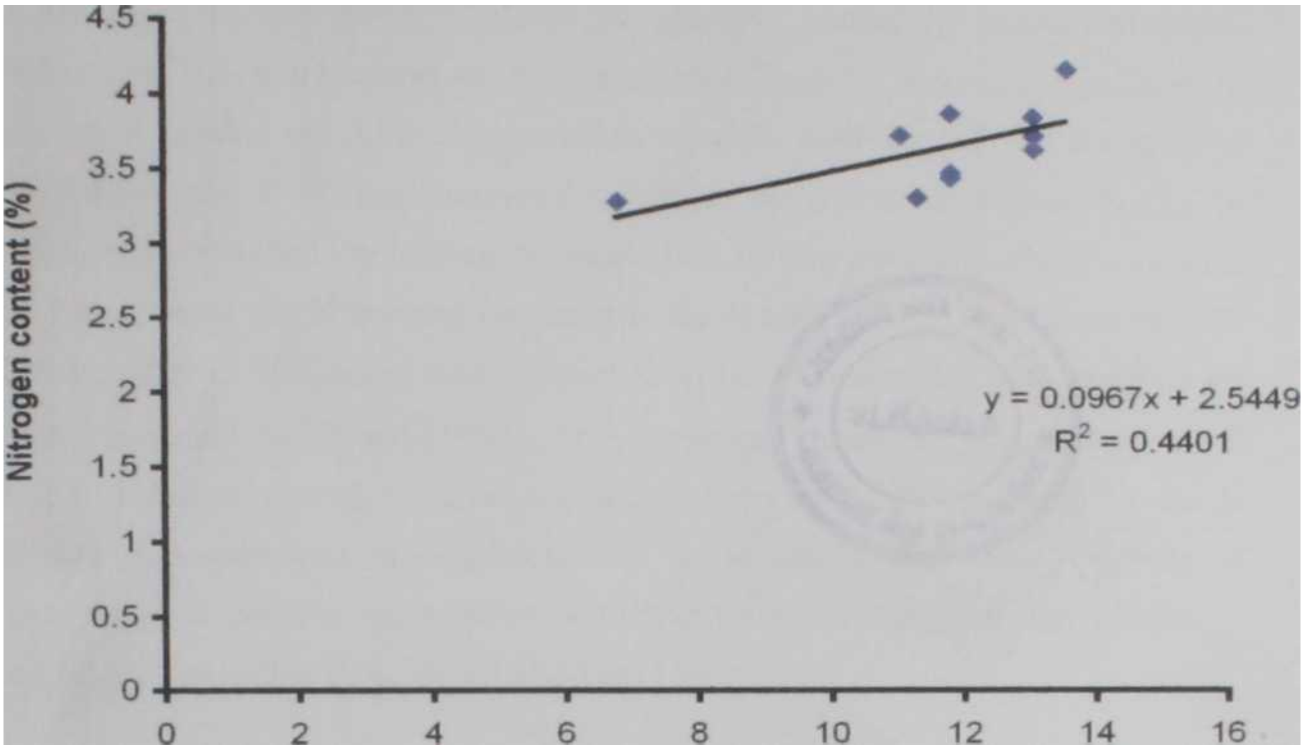
I able 8 shows nitrogen content in shoot at harvest and significantly influenced by *Rhizobium* inoculant, P and Mo fertilization. All the treatments significantly increased N accumulation compared to control except the treatment, which received *Rhizobium* inoculum only. Nitrogen content in shoot varied from 3.20 to 4.20% at harvesting stage. The highest N content 4.20% was recorded in Ts

i. e. (P_4o + MO| 0 + *Rhizobium),* which was followed by *Rhizobium* inoculant in combination with P_{40} + Moi $_5$. Nitrogen content in the treatments T_6 and T.) were statistically similar. Singh *et al.* (1992) and Islam *et al.* (1987 reported that N content in plant tops increase due to inoculation. A positive correlation was also observed in relation to nodule number and N content in seed (Fig. 14).

Relationship between nodule number and nitrogen content in shoot

♦ Nitrogen content (%)

---- Linear (Nitrogen content (%))



Nodule/palnt

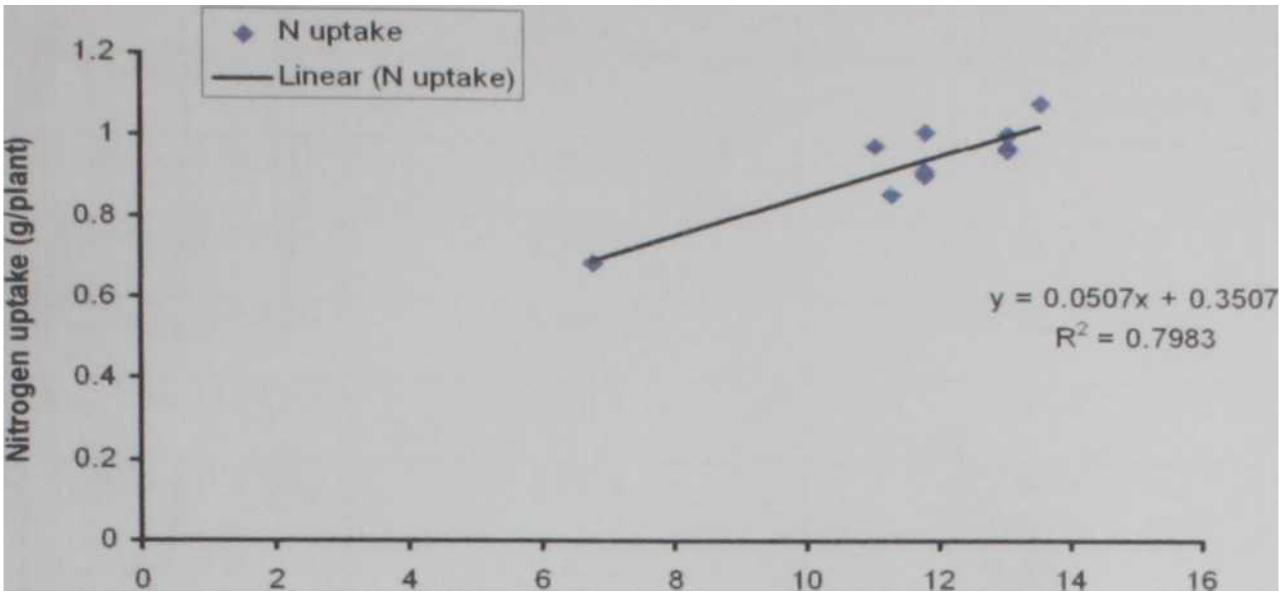
Fig. 14 Relationship between nodule number and nitogen content in shoot of mungbean

Fig. 14 showed that there was a positive correlation (R~ = 0.4401) between nodule number per plant and nitrogen (%) content in shoot. The relationship is described by yield response function y= 0.0967x + 2.5449 where y indicates nitrogen content in shoot, which varied with the nodule number per plant x.

4.21 Nitrogen uptake by shoot

The effect of phosphorus, molybdenum and *Rhizobium* on N uptake by the shoot is presented in 1 able 8. Application of P, Mo and *Rhizobium* inoculation had significant and positive effect on nitrogen uptake by mungben shoot. *Rhizobium* inoculant alone or in combination with P recorded significantly higher N uptake by shoot compared to control. Addition of Mo along with *Rhizobium* and P further increased N uptake by shoot. Treatment T_5 (P_{40} + Mo_1o + R) recorded the highest N uptake of 1.09 mg/plant and above this level of P decreased the N content but statistically similar (Table 8).At treatment T_5 uptake of N is 58% more over control. Similar of result was also reported by Muniruzzaman and Khan (1990). They observed increased N uptake by lentil due to inoculation with *Rhizobium* strains. Maurya *et al.* (1993) reported that N uptake increased with Mo application in blackgram. In this study N uptake by shoot had a positive correlation with the total number and dry weight of nodules of mungbean (Table 1 1 and Fig. 15).

Relationship between nodule number and nitrogen uptake by shoot



Nodule/paint

Fig. 15 Relationship between nodule number and nitrogen content in shoot of mungbean

Fig. 15 showed that there was a positive correlation (R~ = 0.7983) between nodule number per plant and nitrogen uptake by shoot. The relationship is described by yield response function y= 0.0507x + 0.3507 where y indicates nitrogen uptake by shoot, which varied with the nodule number per plant x.

Table 8. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on nitrogen content and uptake by shoot at harvest of mungbean

Treatment	Nitrogen content in shoot (%)	Nitrogen uptake by shoot (mg/plant)
Control (T|)	3.20 f	0.69 f
Rhizobiwn(R){T **{)**	3.33 e	0.86 e
P_0+Mo, 0+/? (T_3)	3.50 d	0.92 d
P20+M01 *o*+*R* (T_4)	3.66 c	0.98 c
P_{40}+Moi *0*+*R* (T_5)	4.20 a	1.09 a
P_{60}+MO(0+/? (T_6)	3.88 b	1.01 b
P_0+Moi 5+/? (T_7)	3.47 d	0.91 d
P_2o+Moi *S*+*R* (T_8)	3.75 c	0.97 c
P_{40}+MO| 5+/? (Tg)	3.90 b	1.02 b
P60^{+}M0| 5+/? (T|$_0$)	3.75 c	0.98 c
LSD (0.05)	0.112	0.032
CV%	2.07	2.29

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

4.23 Phosphorus content in mungbean shoot

Phosphorus content and uptake in mungbean shoot at harvest are presented in Table 9. Significant ettect was observed due to the application of phosphorus, molybdenum and *Rhizobium* inoculation. Treatment T_5, showed the highest P content in mungbean stover w'hich was statistically different with other treatments but similar with T_6 and T_9. The lowest (0.265%) P was found in control but statistically identical with inoculant treatment (Table 9). No variation was observed due to the application of different levels of Mo. The highest amount of P content was observed in T_5 (0.365%), which was 38% more over control treatment. This finding is in agreement with Srivastava and Venna (1985) w'ho carried out an experiment and observed that increased P rates markedly increased P contents in shoot of field pea. Chowdhury (1996) reported that P content increased due to inoculation with *Rhizobium.* Phosphorus content in shoot had a positive correlation with the number and dry weight of nodules at all the growth stages (Table 9).

4.24 Phosphorus uptake by mungbean shoot

The influence of phosphorus, molybdenum and *Rhizobium* inoculant. on P uptake by mungbean shoot was found significant at harvest (Table 9). Both the P content and weight of shoot directly influenced P uptake. Therefore the values of P uptake increased with the increase of shoot weight and rate of P application. Phosphorus uptake at harvest was higher favored by the addition of *Rhizobium* inoculant with P and Mo. The highest P uptake (91.88 mg/plant) was found with the treatment T_6, which was statistically significant with control but no variation, was found with treatment T_6 and $T_{!0}$. *Rhizobium* inoculant alone led to uptake 34% higher P over control treatment. These findings are in agreement with the Srivastava and varma (1985). They reported the similar observation in P uptake.

Table 9. hffect of phosphorus, molybdenum and *Rhizobium* inoculation on phosphorus content and uptake by shoot at harv est of mun^hcan

Treatment	Phosphorus content in shoot (%)	Phosphorus uptake by shoot (mg/plant)
Control (T|)	0.265 c	55.00 c
Rhizobium(R)(T 2)	0.268 c	73.84 b
Po+Mo. o+*R* (T_3)	0.300 b	73.91 b
P20+Mo,,+i? (T_4)	0.308 b	81.10 b
P40+M01 (T_5)	0.365 a	90.69 a
P60$^+$M0i *o*$^+$*R* (T_6)	0.355 a	91.88 a
P_0+Moi.5+/? (T_7)	0.305 b	80.99 ab
P_2o+MO| 5+/? (T_8)	0.308 b	82.25 ab
P40+M015+/? (T_9)	0.358 a	82.73 ab
P_{60}+MO| *s*+*R* (T_{10})	0.315 b	91.64 a
LSD (0.05)	0.021	11.83
CV%	4.55	10.14

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

4.25 Potassium content in mungbean shoot

Potassium content in shoot influenced by phosphorus, molybdenum and *Rhizobium* inoculation and the data are presented in Table 10. All the treatments significantly increased K accumulation compared to control. Potassium content in shoot varied from 2.51 to 2.88% at harvest (Table 10). In treatment T_5 potassium content was 2.88%, which was 14.74% more over control. The treatments T5, T_6, T_9, $T|_0$ were statistically similar. On the other hand, no variations were observed among the treatments T_7, T_x and T_4. No variation was found between inoculation and without inoculation with *Rhizobium.*

4.26 Potassium uptake by mungbean shoot

The effect of *Rhizobium,* P and Mo on K uptake by mungbean shoot is presented in Table 10. Accumulation of potassium (K) was significantly influence by application of P, Mo and *Rhizobium* inoculation. Significantly higher uptake was found with T_5 but statistically similar with T_6 and T_9. Treatment T_5 uptake 45% more K than the control.

Table 10. Effect of phosphorus, molybdenum and *Rhizobium* inoculation on potassium contcnt and uptake by shoot at harvest of mungbean

Treatment	Potassium content in shoot (%)	Potassium uptake by shoot (mg/plant)
Control (Ti)	2.51 d	0.520 f
Rhizobium(R)(T_2)	2.51 d	0.645 e
P_0+Mo, o+R (T_3)	2.64 c	0.702 d
P20+M01 o+R (T_4)	2.72 b	0.700 d
P_{40}+MO| o+R (T_5)	2.88 a	0.754 a
P_{60}+Moi o+R (T_6)	2.84 a	0.735 ab
P_0+Moi 5+R (T_7)	2.67 b	0.696 d
P_2o+MO| 5+R (T_g)	2.69 b	0.71 1 cd
P_{40}+Moi 5+R (T_9)	2.87 a	0.745 ab
P_{60}+MO| 5+R (Ti_0)	2.82 a	0.730 be
LSD (0.05)	0.079	0.021
CV%	1.91	2.16

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.

Table 11. Relationship between different crop characters of mungbean

Parameter	Correlation of coefficient (r value)
1 Number of nodules vs dry weight of shoot	0.81
I Number of nodules vs dry weight of root	0.75
1 Number of nodules vs | Nitrogen content in shoot	0.44
I Number of nodules vs P content in shoot	0.64
I Number of nodules vs Nitrogen uptake by shoot	0.69
1 Number of nodules vs seed yield/plant	0.81
i Number of branches vs I pods/plant	0.78
j Husk yield vs seed yield/plant	0.85
Number of nodules vs stover j yield	0.92
j Number of nodules vs plant ! height	0.55
j Number of pods /plant vs seed yield/plant	0.94
Number of seeds/pod vs seed yield/plant	0.94
! 100 seed weight vs seed yield/plant	0.93
n =40	r value P_{oo5}= 0.367 P_{o}.oi= 0.470

CHAPTER 5
Summary and Conclusion

CHAPTER 5
SUMMARY AND CONCLUSION

A pot experiment was carried out during *kharif* season of 2005 with mungbean variety BARI Mung-5, laid out in randomized complete block design with four replications on silty' clay loam (Kodda series) soil at the Soil Science Division. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. All the treatments were inoculated with *Rhizobium* strains (BARI RVr-2005) except control. There were 4 levels of phosphorus e.g. 0, 20. 40. 60 kg P/ha and 2 levels of molybdenum e.g. 1.0 and 1.5 kg Mo/ha. The objectives of this study were to determine the effect of phosphorus, molybdenum and *Rhizobium* inoculants on nodulation, growth and yield of summer mungbean and to know' the optimum dose of phosphorus and molybdenum on nodulation. grow'th and yield with *Rhizobium* inoculation. Another objective was to determine the relationship between yield and yield contributing characters influenced by *Rhizobium* inoculants.

The highest plant height, number of leaves, branches per plant, root length were produced by the inoculated plants with phosphorus and molybdenum application at the rate of 40 kg and 1.0 kg/ha. respectively. The number of nodules was also significantly higher in the same treatment combination.

The effect of phosphorus, molybdenum and *Rhizobium* inoculation was significant on nodulation of mungbean plants. The individual effect of phosphorus and molybdenum had also a significant influence on producing higher number of nodules per plant. It was also found that inoculated plants produced higher number of nodules compared to uninoculated control. The highest nodule number per plant was observed with 40 and 1.0 kg/ha phosphorus and molybdenum, respectively. Higher dose of molybdenum (1.5 kg Mo/ha) did not increase nodule number.

The highest dry weight ol mungbean shoot was recorded with the treatment + Moi $_0$+ R and statistically ditterent from the other treatments. Similar results were found in root dry weight. I he highest root dry weight was found with the treatment P_{60} + Mo, $_0$+ R.

Phosphorus, molybdenum and *Rhizobium* inoculation had significant effect on stover yield of mungbean. Increase in stover yield with phosphorus, molybdenum and *Rhizobium* inoculation at 40 kg P/ha, was 28.53% higher over control. The interaction effect between phosphorus and molybdenum was highly significant. Significantly highest stover yield of 26.67 gm/plant was- obtained with phosphorus and molybdenum application at the rate of 40 and 1.0 kg/ha, respectively. It was 28.53 and 3.49 % higher over both control and *Rhizobium* inoculation, respectively.

Phosphorus, molybdenum and *Rhizobium* inoculation had significant effect on yield and yield contributing characters of mungbean. Increase in seed yield with phosphorus, molybdenum and *Rhizobium* inoculation at 40 kg/ha P and Mo, respectively, which was 61.94 % higher over control. Number of pod per plant, seed per pod. pod length and 100 seed weight were found higher in P and Mo level at 40 and 1.0 kg/ha, respectively with *Rhizobium* inoculation over other and uninoculated plants.

The interaction effect between phosphorus and molybdenum was highly significant. Significantly highest seed yield 14.61 (g/plant) was obtained by phosphorus and molybdenum application at the rate of 40 kg P/ha,which was 162 and 53.31% higher over control and *Rhizobium* inoculation alone, respectively.

Maximum nitrogen content (4.20%) in shoot was recorded by the application of 40 and 1.0 kg/ha phosphorus and molybdenum, respectively and *Rhizobium* inoculation. The highest amount of nitrogen uptake by shoot was also recorded in T_5 treatment. Maximum phosphorus contents in shoot was recorded with 40 kg I/ha. 1.0 kg Mo/ha and *Rhizobium* inoculation. The highest phosphorus uptake by shoot was also recorded in treatment T_s.

In the present investigation the following conclusions may be drawn:

1. *Rhizobium* inoculation had shown positive effect on nodulation. growth and yield of mungbean.
2. Application of phosphorus upto 20 kg/ha increased nodulation and upto 40 kg/ha progressively enhanced growth, yield and yield contributing characters of mungbean.
3. Application of molybdenum upto 1.0 kg/ha significantly enhanced nodulation, growth, yield and yield contributing parameters and at 1.5 kg/ha Mo these parameters decreased significantly.
4. The present study also showed that *Rhizobium* inoculation with phosphorus and molybdenum fertilization gave better yield and was maximum with 40 kg P and 1.0 kg Mo/ha.
5. There is enough scope to explore and exploit the production of mungbean in Bangladesh through using *Rhizobium* technology along with phosphorus and molybdenum @ 40 and 1.0 kg/ha. respectively.

REFERENCES

REFERENCES

Aghatise, V.O. and T O Tayo. (1994) Response of soybean to molybdenum application in Nigeria. *Indian J. Agric. Sci.*, 64 (4): 597-603.

Ahmed, Z U , M A Q Shaikh, A.I. Khan and A K Kaul (1978). Evaluation of local, exotic and mutant germplasm of mungbean for varietal characters and yield in Bangladesh. SABRAO ***J.*** 10: 48

Ahmed, S. (1982). Crops response to applied molybdefnum in Brahmaputra Floodplain Soil of Bangladesh. ***Bangladesh J. Soil Sci.,*** 18: 36-41.

Alam, M.J., A R M Solaiman, A.J M S Karim and M T Hossain (1999) Potential of ***Rhizobium*** strains on nodulation, nitrogen fixation, crop growth and dry matter production of chickpea *Bangladesh .1 .Microbiol.* **16** (2): 107-114.

Anonymous (1999). Statistical Yearbook of Bangladesh Bangladesh Bureau of Statistics, Govt. Peoples Republic of Bangladesh, Dhaka p. 137.

Andrew, C S.(1976). Nutritional restraints of legume-symbiosis. In: Exploiting the legum***e-Rhizobium*** symbiosis in Tropical Agriculture Edited by J.M. Vincent. Univ. of Hawaii, College of Trop Agric. Misc Bull 1145.

^A.nwar, H. (1989). Effect of phosphorus and molybdenum on the yield of and uptake by mungbean (***Vigna radiata*** L). M. Sc. Ag. Thesis, Deptt. of Soil Science, Faculty of Agriculture, BAU, Mymensingh.

Amadi, T H (1994) The response of soybean to the molybdenum at the condition of calcareous soil in Iraq. ***IraqJ. Argil. Sci.*** 25(1): 18-24

Arya, M.P.S and G.S. Kalra (1988) Effect of phosphorus doses on the growth, yield and quality of summer mung *(Vigna radiata* L Wilczek) and soil nitrogen. *Indian J. Agril. Research*, 22(1): 23-30.

Asghar, A B, B Roider Khan and J H Keating. (1988). Effect of inoculation and phosphate fertilizer on lentil under rainfed conditions in upland Baluchistan *Lens News* 15 (1): 29-33.

Ashraf Zahid, M., M.C. Saxena, and M V. Murinda (1984). Effect of fertilizer and *Rhizobium* application on nodulation and seed yield of chickpea cv. IL.C. 480. INC. II: 39-41.

Bangladesh Bureau of Statistics.(1991). Statistical Year Book of Bangladesh Govt, of the Peoples Republic of Bangladesh, Dhaka.

Barakha, F.N and A.M. Heggo, (1998). Moisture stress, bradyrhizobia, vesicular arbuscular mycorhiza and p-fertilizers effects on soybean results nutrient content and phosphatase activity under calcareous soil *Ann. of Agril. Sci. Cairo.* 3 (2): 461-475.

^Bertie, M M Vrataric and V Vukadinovic. (1991) Three-year Investigation of foliar application of micronutrients and side dressing treatment with nitrogen in soybean. Crop Sci. 21: 9-14

Bhuiyan, M A , D. Khanam, MHH Rahman and A.K.M Hossain (1997) Influence of *Rhizobium* inoculum, molybdenum and boron on chickpea in Grey Terrace Soil of Bangladesh. *Ann. Bangladesh Agric.*, 7(2): 119- 126.

Bhuiyan, MAH., D Khanam, M H H Rahman, A K Rahman and M R Khatun.(1996). Effect of molybdenum, boron and *Rhizobium* inoculation on nodulation and yield of groundnut *Bangladesh J. Agril. Res.* 21 (1): 64-74.

Bhuiyan, M.A., D Khanam, MHH Rahman and A KM Hossain (1997) Influence of *Rhizobium* inoculum, molybdenum and boron on chickpea in Grey Terrace Soil of Bangladesh *Ann. Bangladesh Agric*, 7(2): 1 19- 126.

Bhuiyan, M A H , D Khanam, MHH Rahman, M Z Islam, A K M Hossain and A.K M.S. Hoque.(1995). Growth, yield and economic performance of soybean at two agro-ecological zones of Bangladesh as influenced by *Bradyrhizobium* and fertilizer application./4m?. *Bangladesh Agric.* 5(1): 55-59.

Bhuiya, Z H , M R Islam, ABM Alam, and M S Hoque (1984a) Effectivity test of different strains of *Rhizobium* on Mashkalai *(Phaseolus mungo* L.) Proc. 9th Ann Bangladesh Sci Conf BAAS, Sec I Abst No 38 pp 21-22.

Bhuiya, Z.H., M.S. Hoque and M H Matin (1984b) Field trail at BAU Farm on the effect of *Rhizobium* inoculation on mungbean 1[51] Ann. Report on B.N.F. under irrigated and rainfed condition pp 11-14

Bhuiya, Z.H., M R Islam, M.J. Uddin, and M.S. Hoque (1986) Performance of some *Rhizobium* inoculants on blackgram (*Vigna mungo) Bangladesh J. Agric.* II (4): 55-63.

Bhuiyan, A T M. (1992) Response of groundnut (*Arachis hypogaea* L) to *Rhizobium* inoculum as affected by plant genotypes. M Sc.Ag Thesis, Dept, of Soil Science, Faculty of Agriculture, BAU, Mymensingh

Bhuiyan, M A H , D Khanam, M M Rahman, and M M Ali (1998) Variation in the symbiotic effectiveness of *Bradyrhizobium* strains of soybean *Bangladesh J. Microbiol* 15: 25-30.

Bouyoucos, G J. (1927) The hydrometer as new method for mechanical analysis of soils. Soil Sci. 23 343-353.

Bremner, JM (1965) Total Nitrogen In " Methods of Soil analysis Vol 2". (C A. Black ed.) pp. 1179-1237 American Society of Agronomy. Madison.

Cataldo, D.A., L.E. Schrader and V.L Young. (1974). Analysis by digestion and colorimetric assay of total nitrate in plant tissues. *Crop Sci.* 14 854- 856.

Chatterjee, A and P Bhattacharjee (2002) Influence of combined inoculation with *Rhizobium* and phosphobactena on mungbean in field *Journal of Mycopat ho logical Research* 40:2, 201-203.

Chauhan, Y S , V.K Jain, M P Khandekar and P C Jain (1988) Response of groundnut *{Arachis hypoaea)* varieties to phosphorus application *Indian J. Agril. Sciences.* 58(5): 359-361.

Chowdhury M I and K Fujita (1998). Comparison of phosphorus deficiency effects on the growth parameters of mashbean, mungbean, and soybean. *Soil Science and Plant Nutrition* 44: 1, 19-30.

Chowdhury, M U., M H. Ullah, M A Afzal, D Khanam and S M Nabi (1998) Growth, nodulation and yield of cowpea as affected by *Rhizobium* inoculation and micronutrients in the hilly region *Bangladesh J. Agril. Res.,* 23(2): 195-203.

Chowdhury, M M (1996) Response of mungbean *[Vigna radiata* (L) Wilczek] to *Rhizobium* inoculation and phosphorus application. M.S. (Soil Science) Thesis, Institute of Postgraduate Studies in Agriculture. Gazipur, Bangladesh

Das, P.K., P.N. Sahoo and M.K. Jena. (1997). Effect of VA-mycorrhiza and *Rhizobium* inoculation on nutrient uptake. *Environment and Ecol.* 15: 830-833.

Dubey, S.K. (1997). Compatibility among different strains of *Bradyrhizobium japonicum* and soybean cultivars in relation to nodulation, growth and yield. *Annals of Agril. Res.* 18: 152-156.

Dwivedi, G.K., V.P. Singh and M. Dwivedi. (1988). Effect of phosphorus and sulfur on yield potential and nutritional quality of blackgram (*Vigna mungo* L. Hepper). *Annals of Agricultural Research.* 9(1): 6-12.

Eusuf Zai, A.K.E., A.R.M. Solaiman and J.U. Ahmed. (1999). Response of some chickpea varieties to *Rhizobium* inoculation in respect of nodulation, biological nitrogen fixation and dry matter yield. *Bangladesh J. Microbiol.* 16(2): 135-144.

Evans, J.,C. Wallace, N. Dobrowolski, 1. Pritchard and B. Sullivan. (1993). Requirement of field pea (*Pisum sativum*) for inoculation with *Rhizobium* and lime pelleting in soils of Western Australia. *Aust. J. Exp. Agric.* 33(6): 767-773.

Fakir. M.S. A., A. A.A. Mushi and S.M.M. Alam. (1988). Effects of *Rhizobium* inoculum, nitrogen and phosphorus on yield contributing characters of soybean. *Bangladesh J. Agric. Sci.* 15 (2): 211-215.

Feng, Y., C. Pan, D. Wang, Y. Li and C. Wei. (1997). Isolation of nodule bacteria from *Pisum sativum* and application of nitragine from the isolate. *J. Trop. Sub Tro. Bot.* 5(2): 47-53.

Franco,A.A. and D.N. Munns. (1981). Response of *Phaseolus vulgaris* L. to molybdenum under acid conditions. *Soil Sci. Soc. Amer. J.*, 45: 1145- 1148.

Franco, A.A. and J.M. Day. (1980). Effect of lime and molybdenum on nodulation and nitrogen fixation of *Phaseolus vulgaris* L. in acid soils of Brazil. *Turrialba.* 30(1): 99-105.

Ghosh, G. and S.C. Poi. (1998). Response of *Rhizobium*, Phosphate solubilizing bacteria and mycorhizal organisms on some legume crops. *Environment and Ecol.* 16: 607-610.

Gill, M.A., A. Naimat, and M.M. Nayyer. (1985). Relative effect of phosphorus combined with potash and *Rhizobium phaseoli* on the yield of *Vigna radiata* (mung). *J. Agril. Res.*, Pakistan. 23 279-282.

Gowda, C.L.L. and A.K. Kaul.(1982). Pulses in Bangladesh, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp. 119-427.

Grewal, J.S., N.S. Randhawa and D.R. Bhumbla. (1967). Effect of molybdenum on the nitrogen fixation by legume crops. *J. Res. Punjab Agricultural University.* 4: 315.

Gupta, S.C. and S.L. Namdeo. (1996). Effect of *Rhizobium* strains on symbiotic
1
strains and grain yield of chickpea. *Indian J. Pulses Res.* 9(1): 94-95.

Gupta, G. and R. Narayanan. (1992). Nitrogen fixation in soybean treated with nitrogen dioxide and molybdenum. *J. Environ. Quality.* 21(1): 46-49.

Gupta. S.C., N. Sukhlal, K.K. Paliwal and S. Namdeo, (1998). Effect of P levels and microbial inoculants on symbiotic strains, N and P uptake, quality and yield of rainfed chickpea (*Cicer arietinum* L.). European conf. on grain legumes. Valladolid, Spain. 14-19 November, 418-419.

Hangstrom, G.M. (1968). Micronutrients a close look at molybdenum. J Fer. Soln., 26-33.

Hazra, C.R. and S B. Tripathi. (1998). Effect of secondary micronutrient on yield and quality of forages. Fertilizer News. New Delhi 110001, India 43(1); 77-82.

Hoque, M.S. and M.A. Hashem. (1993). Field evaluation of *Rhizobium* bio- fertilizer at different location in Bangladesh. BAU. Res. Prog. 7: 1-9.

Hoque M.S. and M.A. Hashem. (1992). Performance of some promising strains of soybean and groundnut under field condition. Proc. BAU. Res. Prog. 6: 112-119.

Hoque, M.S. (1991). Collection and characterization of *Rhizobium* bacteria and there effectiveness on some important food legume crops. Proc. BAU. Res. Prog. 5: 91-97.

lbupoto,A.A. and A. Kotecki. (1994). The effect of soil application of nitrogen fertilizer and foliar application of trace elements on development and yield of soybean. *Pakistan J.*

Agron. 20(2): 153-159.

Islam. M.Z., A.K. Podder, M.A. Satter, and M B. Hossain. (1999). Performance studies of some single and mixed culture *Bradyrhizobium* inoculants on nodulation, dry matter production and yield of soybean. *Bangladesh J. Environ. Sci.* 25 (5): 90-93.

Islam, A.B., M.S. Hoque and Z.H. Bhuiya. (1987). Effect of different *Rhizobium* inoculants on soybean. *Bangladesh J. Agric.*, 12(2): 129-137.

Jana. P.K.. S. Ghatak, A. Barik. B.C. Biswas, G. Sounda and A.K. Mukherjee. (1990). Response of summer groundnut to phosphorus and potassium. *Indian J. Agron. 16: 60-63.*

Jarvis. B.C., A.H.N. Ali and A.I. Shabeed. (1983). Response of soybean to *Rhizobium* inoculatuion and NPK fertilizer. *Crop Res.*, 1(1): 102-108.

Javia, J.J., R.P.S. Ahlawat, J.C. Patel, B.B. Kaneria and D.A. Tank. (1989). **Response of** gram to irrigation under vaiying levels of nitrogen and **phosphorus.** *Indian J. Agron.* **35(4):439-44i**

Johal, R.K. and V.P.S. Chahal. (1994). Effect of *Rhizobium* inoculation and molybdenum on N-fixation and growth characteristics of mungbean (*Vigna radiata* L.). *Indian Journal of Ecology.* 21:2, 160-162.

Kalia, B.D. and C.M. Sharma. (1989). Effect of micronutrients on yield of soybean. *Ind. J. Agron.* 33(2): 199-200.

Kaul, A.K. (1982). Pulses in Bangladesh. BARC, Fanngate, Dhaka, p.27.

Khan, M.A., M. Aslam, S. Tariq and I.A. Mahmood. (2002). Response of phosphorus application on growth and yield of inoculated and uninoculated mungbean *(Vigna radiata). International Journal of Agriculture and Biology.* 4: 4, 523-524.

Khanam, D., M.H.H. Rahman, M.A.H. Bhuiyan, A.K.M. Hossain and A.F.M. Rahman. (1993). Effect of rhizobial inoculation and chemical fertilizers on the growth and yield of lentil at two agroecological zones of Bangladesh. *Bangladesh J. Agril. Res.* 18(2): 196-200.

Khan, A.R., Z.H. Bhuiya and M.Q. Islam. (1985). Effectivity test of different strains of *Rhizobium* on blackgram. Pro. 4th Ann. Conf. Bangladesh Soc. Microbial. Feb. 7-8, Dhaka, Abst. 26: 15.

Khan, M.R.T.. M.A.Q. Saikh and P C. Dutta. (1982). Nutritional quality characters in pulse. Proc. Natl. Workshop on pulses, Aug 18-19, 1981. BARI, Joydebpur, Dhaka, pp. 199-206.

Khandakar. U.R., D.A. Shinde, V.S. Kandalkak, NR Jamley and N.K. Jain. (1985). Growth, nodulation and yield of rainfed blackgram (*Vigna* *ungo* L. Hepper) as influenced by phosphate and sulphur application in vertisol. *Indian J. Plant Physiol.* XXVIII(4): 318-322.

^Kliemann, A., A.M.C. Costro, and F.F. Dliveira. (2002). Productivity of soybeans as a function of the application of cobalt and molybdenum. *Madras Agril. J.* 7(1): 59-65.

Konde, V.B. and R.B. Deshmukh. (1996). Response of Chickpea varieties to *Rhizobium* and/or V AM inoculation. *J. Maharashtra Agril. Univ.* 21 (2): 304-306.

Kothari, S.K. and C.S. Saraf. (1987). Nitrate reduction in relation to nitrogenase activity in summer mung *(Vigna radiata)* as influenced by bacterial inoculation and phosphorus application. Current Science.56: 833-836.

Krishnamohan, K. and L.M. Rao. (1998). Effect of *Bradyrhizoium japonicum* strains and N on growth, N_2 fixation and yield of soybean genotypes during monsoon and post monsoon season. *J. of Res. ANGRAU.* 26: 28- 32.

Landge, S.K., S.U. Kakade, P.D. Thakare., A.P. Karunakar and D.J. Jiotode. (2002). Response of soybean to nitrogen and phosphorus. *Pakistan J. Crop Sci.* 3(3): 653-655.

Mahmud, M.S., A R M. Solaiman. M.S. Hoque and M.A. Hashem. (1997). Influence of *Rhizobium* inoculant and nitrogen on nodulation, growth and N uptake of lentil. *Ann. Bangladesh Agric.* 7(2): 139-143.

Maheshwari, S.K. (1974). Response of greengram *(Phaseolus aureus)* to inoculum and levels of N and P with their economics. JNKVV Research Journal. 8:157-158.

Malik, M.A., S. Hussain, E. A. Warraich, Habib and S.UUah. (2002). Effect of seed inoculation and phosphorus application on growth, seed yield and quality of mungbean *(Vigna radiata* L.) cv. NM-98. *International Journal of Agriculture and Biology.* 4: 4, 515- 516

Mahk,M.A., M.F. Saleem, Ali Asghar and Mahmood Ijaz. (2003). Effect of nitrogen and phosphorus application on growth, yield and quality of mungbean *{Vigna radiata* L.). *Pakistan Journal of Agricultural Sciences.* 40(3/4): 133-136.

Manpreet, S., H.S. Sekhon and S. Jagrup.(2004). Response of summer mungbean *(Vigna radiata* L. Wilczek) genotypes to different phosphorus levels. *Environment and Ecology.* 22(1): 13-17.

Maurya, B.R., K. Kishor and P C. Ram. (1993). Effects of iron and molybdenum on soybean. J. Maharastra Agri. Univ. 18(1): 128.

Mishra, J.P., A. Masood and M. Ali. (1998). Phosphorus and molybdenum management in summer mungbean. *Indian Journal of Pulses Research.* 11: 1, 100-102.

Mishra, S.N. and A.P. Singh. (1989). Studies on sulphur and phosphorus availability and uptake by groundnut. Legume Research. 12(4): 160-164.

Maurya, B.R., K. Kishor and PC. Ram. (1993). Effect of iron and molybdenum on urd bean. J. Maharastra Agril. Univ. 18(1): 128. (Cited from, Soils and Fertilizers Abst. 57(9):76J>.

Mohan, K.K. and L.M. Rao. (1997). Effect of phosphorus and molybdenum on growth, nitrogen fixation and yield of soybean. *J. Res. ANGRAU.* 25(4): 77-80.

Moniruzzaman. S. **and** S.l. Khan. (.990). Symb.ofc effectiveness and **nodulation and** potential of Streptomycin and Spectmomyc.n resistance mutants some indegenous *Rhizobium* isolates. *Bangladesh J. Microbiol.* 7 (1): 19-23.

Muhammad, D., A H. Gurmam and K. Matiullah. (2004). Effect of phosphorus and *Rhizobium* inocualtion on the yield and yield components of mungbean under the rainfed conditions of D.l. Khan. *Sarhad Journal of Agricultural.* 20(4): 575-582.

Namdeo, S. L., K.S. Banger and S.C. Gupta. (1991). Response of pigeonpea *(Cajanus cajan* L. Mills P.) Cultivars to *Rhizobium* Strains. *Ind. J. Agron.* 36(1): 29-31.

Namdeo, S.L., S.C. Gupta and K.S. Bangar. (1988). Response of pigeonpea varieties to *Rhizobium* strains. *Indian J. Pulses Res.* 1 (2): 102-105.

Narendra, Kumar and R. Chandra. (2003). *Rhizobium* and VAM inoculation effect on mungbean (*Vigna radiata)* with varying phosphorus levels. *Legume Research.* 26(4): 284-287.

Navgire, K.D., V.V. Datar. B.V. Asewar and A.L. Dahiwal. (2001). Response of mungbean cultivars to different *Rhizobium* strains under rainfed conditions. *Annals of Plant Physiology.* 15(2): 134-137.

Ninje. P.M and J. Seth. (1988). Effect of phosphorus and farmyard manure on nutrient uptake by soybean. *Indian J. Agron.* 33(3): 139-142.

Okereke. G.U., C.C. Onochie, A.U. Onokwo, E. Onyeagba, and G O. Elejindu (2000). Response of introduced *Bradyrhizobium* strains infecting a promiscuous soybean cultivar. *World J. of Microbiol, and Biotech.* 16:

43-48.

Padma. M., S.A Reddy and R.S. Babu. (1989). Effect of foliar sprays of molybdenum and boron on vegetative growth and dry matter production of french bean *(Phaseolus vulgaris* L). ./. *Res. Hyderabad*, India. 17:1, 87-89.

Paikera, A. and S.N. Mishra. (1988). Response of soybean varieties to nitrogen and phosphorus. *Indian J. Agron.* 33(3): 320-322.

Pangsakul, P. and E.S. Jensen. (1991). Dinitrogen fixation and soil N uptake by soybean as affected by phosphorus availability. *Journal of plant Nutrition.* 14(8): 809-823.

Paricca, P.C., N.C. Sahoo and M. Kar. (1983). Significance of molybdenum and applied nitrogen on the chemical composition and seed yield of green gram *(Vigna radiata* L.). *Ind. J. Plant Physiol.* 26(3): 305-313.

Parihar, S.S. (1990). Yield and water of chickpea *(Cicer arietinum)* as influenced by irrigation and phosphorus. *Indian J. Agron.* 35(3): 251- 257.

Patro, H. and P.N. Sahoo .(1994). Response of mungbean genotypes to phosphorus. *Indian Journal of Pulses Research.1*: 2, 191 -192.

Paul. S. (1998). Symbiosis between mungbean and Rhizobia: influence of water stress. *Indian J. Plant Physiol.*, 3: 11-16.

Podder. A.K., M B. Hossasin, M.C. Chanda, M.Z. Islam. N. Mondal. and M. Rahman. (1999). Selection of effective bradyrhizobial strains for soybean cultivation for environmental management of Brahmaputra Floodplain Soil. *Bangladesh J. Environ. Sci.* Vol. 5, 56-60.

Podder. A.K.. M.A. Satter and G. Marshed. (1989). Performance studies of some isolated native rhizobial inocualtion on the production of lentil with or Without nitrogenous fertilizer. Proc. 6'h Natl. Bot. Conf. Jan. 18- 19. Abst. No. 43. p.24.

Poi, S.C. and Ghosh.(1986). Response of lentil *{Lens esculanta)* and chickling pea *(Lathyrus sativus)* to inoculation with different strains of *Rhizobium* leguminosarum. *Environ, and Ed.* 4 (4):630-632.

Poonam, S. and A.S. Khurana. (1997). Effect of single and multistrain *Rhizobium* inoculants on biological nitrogen fixation in summer mungbean, *Vigna radiata* (L.) Wilczek. Research and Development Reporter. 14: 1-2, 8-11.

Pradhan. A C. and A.K. Sarkar. (1985). Effect of micronutrients on the horsegram (Kulthi) in lateric acid soils of west Bengal. Seeds and Farms. 11(4-5): 17-22.

Rahman, M.H.H., M.Z. Islam. M.A.H. Bhuiyan, D. khanam, A.K.M. Hossain and A.F.M. Rahman. (1994). Effect of Rhizobial inoculum with and without chemical fertilizers on chickpea in Halaquepts. *Bangladesh J. Agric. Sci.* 21(2): 273-277.

Rahman. M.M., M.A.H. Bhuiyan and A.K.M. Hossain. (1996). Response of groundnut to bacterial fertilizer under nutrient management. Annual Research Report on Soil Mangement . Soil Sci. Div. BARI, pp. 203-206.

Rahman. M.H.H. (1988). Response of soybean *{Glycine max* L. Merril) to *Rhizobium* inoculation and urea-N application. An M.Sc(Ag) Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Rahman, Q.M. (1989). Response of soybean *{Glycine max* L. Merril) to *Rhizobium* inoculation and fertilizer application. M.Sc.(Ag). Thesis, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Ratagopalan, N. and T.S. Sadasivan. (1964). Some aspects of root nodulation **in tropical legumes. Current Science. 33: 197-202**

Rao, N.S.S. (1980). Role of bacteria in crop production. Indian Farming. 30(7):71, 73 & 75.

Raut, R.S. and G.R. Ghonsiker. (1982). Inoculation trails in chickpea Madhya Pradesh. INC. 6: 24-25.

Reddy, P.R., A.A. Zaheda and L.M. Rao. (1978). Influence of basal dose of nitrogen and Rhizobial inoculation on yield and nitrogen uptake in blackgram *{Phaseolus mungo* L.). *Indian J. Agron.* 35(3): 311-313.

Reddy, T.R., M. Rao and K.R. Rao. (1990). Response of soybean *(Glycine max* L. Merril) to nitrogen and phosphorus. *Indian J. Plant Physiology.* 35(3): 311-313.

Roy, S.K., S.ML. Rahman and A.B.M.Salauddiun. (1995). Effect of *Rhizobium* inoculation and nitrogen on nodulation, growth and seed yield of gram *(Cicer arietinum). Indian j. Agric. Sci.* 65(12): 853-857.

Sairam. R.K., P.S. Tomas, A S. Harika and T.K. Ganguly. (1989). Effect of phosphorus levels and inoculation with *Rhizobium* on nodulation, leghaemoglobin content and nitrogen uptake in fodder cowpea. Legume Research. 12(1): 27-30.

Saraf, C.S., B.G. Shivakumar and R.R. Patil. (1997). Effect of phosphorus, sulphur and seed inoculation on the performance of chickpea *(Cicer arietinum). Indian J. Agron.* 4 (22): 323-328.

Sarker, R.K., S. Karmaker and A. Chakraborty. (1993). Response of summer greengram *(Phaseolus radiata)* to nitrogen, phosphorus application and bacterial inoculation. *Indian J. Agron.* 38 (4): 578-581.

Sarkar, R.K. and P Banik. (1991). Response of greengram to nitrogen, phosphorus and molybdenum. *Ind. J. Agron.* 36(1): 91-94

Sarker, R.K., S. Karmakar and A.Chakraborty. (1982). Response of summer greengram (*Phaseolus radiata)* to nitrogen, phosphorus application and bacterial inoculation. *Indian J. Agron.* 38(4): 578-581.

Satish, K., R.C. Singh and V.S. Kadian. (2003a). Response of mungbean genotypes to phosphorus application. *Indian Journal of Pulses Research.* 16(1): 65-66.

Satish, K., R.C. Singh and V.S. Kadian. (2003b). Performance of mungbean as influenced by seed inoculation with *Rhizobium* and levels of organic and inorganic sources of nutrients. *Indian Journal of Pulses Research.* 16(1): 67-68.

Satter, M.A. and S.U. Ahmed. (1995). Response of mungbean (*Vigna radiata*
f
L. Wilczek) to inoculation with *Bradyrhizobium* as affected by phosphorus levels. Proc. Int. Cong. Coom. IV. pp. 419-423.

Satter. M.A. and A.K. Podder. (1994). Single strain vs. multistrain inoculation: Field response of groundnut to *Bradyrhizobium* strain under different agro-ecological region of Bangladesh. Extended Synopsis 15th Inter. Cong. Soil Sci. Poster, Commission III, Symposium l i b , July 10-16 held at Acapulco, Mexico. Vol. 4b.

Satter. M.A.. M.A. Quader, and S K A. Danso. (1995). Nodulation. N_2 fixation and yield of chickpea as influenced by host cultivar and *Bradyrhizobium japomcum* strain differences. *Soil Biol. Biochem.* 27 (4/5): 725-727.

Satter. M.A. and S.U., Ahmed. (1992). Response of mungbean *(Vigna radiata* L.Wilczedk) to inoculation with *Bradyrhizobium* as affected by
phosphorus levels. Proc. Commission IV Conference. Bangladesh. 1-3

December, 1992. Pp.419-423.

Sfredo, G.J., C.M. Borkerf, A.L. Nepomuceno, and M.C.N. De. Oliveiva. (1997). Effectiveness of products containing trace elements applied to the seed on yield and protein content of soybean seed. Eficacia de products contendo micronutrients. Field crop Abst. 24(4): 237.

Shah, S.H., D.F. Khan, and M.S. Madani. (1994). Effect of different rhizobial strains on the performance of two chickpea cultivars under field conditions. *Sarhad J. Agric.* 10 (1): 103-107.

Shaktawat, M.S. (1988). Response of cowpea to phosphorus and *Rhizobium* inoculation. *Indian J. Agron.* 33(3): 341-342.

Sharma, S.C., A.K. Vyas and M.S. Shaktawnt. (2002). Effect of levels and sources of phosphorus under the influence of farm yard manure on growth determinants and periodicity of soybean (*Glycin max* L.) *Indian J. Crop. Sci.* 36(2): 123-127.

Sharma, P. and A S. Khurana.(1997). Effect of single and multistrain *Rhizobium* inoculants on Biological Nitrogen fixation in summer mungbean (*Vigna radiata* L. Wilczek) Research and Development Report. 14: 8-11.

Sharma, R.D.. R.P. Pareck and R.Chandra. (1995). Residual effect of phosphate and *Rhizobium* inoculation in chickpea on succeeding maize and fodder sorghum. *J. Indian. Soc. Soil Sci.* 43 (4): 600-603.

Sharma, M S , M.S. Upadhyay and S.S. Tomar. (1988). Water use efficiency of some rainfed crop on a Vertisol as influenced by soil micronutrients and straw mulching. *Ind. J. Soil Sci.*, 33. 387-390.

Sharma, C M and R.S Minhas. (1986). Effect of levels and sources of phosphorus under the influence of farm yard manure on growth determinants and periodicity of soybean (*Glycine max* L). *Indian J. Crop Sci.* 36(2): 123-127

^ Sharma, U.C. (1992). Response of soybean (*Glycine max* L.) to micronutrients in acidic soil of Nagaland *Indian J. Hill farming* .5 (1) 75-76.

Shukla, S.K. and R S Dixit (1996). Effect of Rhizobium inoculation, plant population and phosphorus on the growth and yield of summer greengram (.*Phaseolus radiatus). Indian J. of Agron.* 41: 611-615.

Siag, R. K., B.L.Verma, S.K Sharma, Ved Singh and V.Singh. (1992).Effect of irrigation and levels of phosphorus on yields and water use of mungbean. *Indian Journal of Pulses Research* 5: 1, 84-85

Singh,B. and R.G. Pareek (2003). Effect of phosphorus and biofertilizers on growth and yield of mungbean. *Indian Journal of Pulses Research* 16(1): 31-33.

Singh, B.R., B. Khadelwel and B Singh. (1992). Effect of manganese and molybdenum fertilization with *Rhizobium* inoculation on the yield and protein content of cowpea *J. Ind. Soc. Soil Sci.,* 40(4): 738-741

Singh, A.K., R. Humuman and H Ram (2001). Effect of phosphorus and zinc fertilization on growth and quality of mungbean (Vigna radiata). *Journal of Interacademicia* 5: 3, 314-317

Singh, M and K.V.B R Tilak (1992). Inoculation of sorghum (*Sorghum biocolor)* with *Glomus vesiforme* under field conditions. Trop Agric. 69 (4): 323-326.

Singh, D , Mukand Singh and M Singh (1991) Response of mungbean to phosphorus. *Indian Journal of Pulses Research.* 4:1,113-114

Singh, V.K. and R.P. Bajpai (1990). Effect of phosphorus and potash on the growth and yield of rainfed soybean. *Indian J. Agron.* 35(3): 310-311

Singh, S.D. (1977). Effect of Rhizobia inoculation on nodulation and yield of moong (*Vigna radiata* L. Wilczek). Annals of the Arid Zone. 16: 79-84

Singh, P. and S.D. Chaubey. (1971). Inoculation a cheap source of nitrogen to legumes.

Indian Farming. 20(10): 33-34.

Solaiman, A.R.M., D. Hossain and M.M. Haque. (2003). Response of mungbean to *Rhizobium* inoculation in respect of nodulation, nitrogenase activity, dry matter yield and nitrogen uptake. *Korean Journal of Crop Science.* 48(5):355-360.

Solaiman, A R M . , M.A. satter, A.F.M.S. Islam and M.A. Khan. (1991). Response of *Rhizobium* inoculated groundnut (*Arachis hypogaea* L.) to nitrogen and phosphorus application under field conditions. *Bangladesh J. Soil Sci.* 22(1 &2): 51-58.

Solaiman, A R M. and A.K.M. Habibullah. (1990). Response of groundnut to *Rhizobium* inoculation. *Bangladesh J. Soil Sci.* 21 (1): 42-46.

Solaiman A R M . (1999a). Effects of *Bradyrhizobium japomcum* inoculation and molybdenum on soybean. *Bangladesh J. Bot.* 28(2): 181-183.

Solaiman, A R M. (1999b). Response of mungbean to *Bradyrhizobium sp. {Vigna)* inoculation with and without phosphorus and potassium fertilization. *Bangladesh J. Sci. Res.* 17(2). 125-132.

Solaiman, A R M. (1999c). Nitrogenase activity, yield iJid yield contributing characters of chickpea as influenced by *Rhizobium* inoculant in presence and absence of nitrogen. *Bangladesh J. Sci. Tech.* 1(1): 141-144.

Soni. K.C. and S.C.Gupta (1999). Effect of irrigation schedule and phosphorus on yield, quality and water-use efficiency of summer mungbean *(Phaseolus radiatus). Indian Journal of Agronomy.* 44: 1, 130-133.

Srivastava. S.N.L. and S.C. Varma. (1985). Effect of nitrogen, phosphorus and molybdenum fertilization on growth, nodulation and residual fertility in field pea. *Ind. J. Agril. Res.* 19(3): 131-137.

Sudhakar, P., G. B. Singh, and L.M. Rao. (1989). Effect of *Rhizobium* and phosphorus on the growth and yield of blackgram *(Phaseolus mungo). Indian J. Agric. Sci.* 59 (6): 402-404.

Sultan, M.M. (1993). lnfuence of *Rhizobium* inoculant and urea nitrogen on the yield and yield contributing characters of lentil *(Lens culinaris* Medik). An M.Sc. (Ag) Thesis, Deptt. of Soil Science, Faculty of Agriculture, BAU, Mymensingh.

Surendra, S., A.S.Chandel and S.C. Saxena. (1995). Effect of phosphorus on total biomass, grain yield and nitrogen uptake in soybean. *Indian J. Agric. Sci.* (6): 431-432.

Taiwo. L.B., F.C. Nworgu and O.B. Adarayo. (1999). Effect of *Bradyrhizobium* inoculation and phosphorus fertilization on the growth, nitrogen fixation and the yield of promiscuously nodulation soybean *(Glycine max* L. Merr.) in a Tropical Soil. *Crop Res. Hisar.* 18(2): 169-
177.

Thakuria, K. and P. Sahana. (1990). Response of green gram gmotypes to plant density and phosphorus levels in summer. *Indian J. Agron.* 35(4): 416-
417.

Thakur, A.K., and J.D.S. Panwar. (1995). Effect of *Rhizobium-V*AM interactions on growth and yield in mungbean *[Vigna radiata* (L) Wilczek] under field conditions. *Indian Journal of plant Physiolosy.* 38(1): 62-65.

Thirumurugan, V., S. Vijayabaskaran and A. REngaduri. (2002). Influence of zinc, phosphorus and phosphobacteria on seed quality of soybean. *Indian J. Agron.* 3(2): 461-462.

1 rung, B.C. and S. Yoshida. (1982). Nutrient uptake and its distribution patterns in mungbean. *Japan J. Prop. Agri.* 26(3): 121-129.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. (1985). Soil Fertility and Fertilizer. 4th edn., Macmillan Publishing Company, New York, p.l 12.

Tiwari, B.N., K.K. Lehri and A.N. Pathak. (1989). *Rhizobium* inoculation of legumes as influenced by phosphorus and molybdenum fertilization. *J. Ind. Soc. Soil Sci.* 37: 712-716.

Tyurin, I.V. (1980). Tyurin’s method. In “Analytical Methods of Nutrients in Soils.” Japanese Society Soil Science and Plant Nutrition, pp: 120-124. Yokendo Co. Tokyo.

Upadhyay, A.P., M R. Deshmukh, R.P. Rajput and S.C. Deshmukh. (1988). Effect of sources, levels and methods of phosphorus application on plant productivity and yield of soybean. *Indian J. Agron.* 33(1): 14-18.

Uslu, N., Aytac and E. Esendal. (1997). Effect of inoculation, sowing data and imbition duration on some agronomic characters and seed yield of soybeans (*Glycine max* L.). *Turkish J. Agril. Forestry.* 21: 451-456.

Vara, J.A., M.M. Modhwadia, J.C. Patel and V.D. Khanpara. (1994). Response of soybean (*Glycine max)* to nitrogen, phosphorus and *Rhizobium* inoculation. *Indian J. Agron.* 39(4): 678-680.

Vasilas, B.L. and J.J. Fuhrmann. (1993). Field response of soybean to increase nitrogen fixation. *Crop Sci.* (USA). 33: 785-787.

Vclu, G. and P. Savithri. (1982). Molybdenum requirement for enhancing the yield of blackgram and greengram. *Madras Agril. J.* 70:629-630.

Verma, L.P., P.C. Ram and B.R. Maurya. (1988). Response of chickpea to phosphorus and molybdenum in alluvium of Eastern Uttar pradesh. Intl. Chickpea Newsletter. 18:31-33.

Vincent, J.M. (1970). A Manual for the Practical Study of the Root Nodule Bacteria, IBP Hand Book No. 15, Blackwell Scientific Publications, Oxford.

Wu, M., C. Xiao, M. C. Wu and C.Z. Ziao. (1994). A study of molybdenum in soybeans. *Soybean Sci.* 13(3): 245-251.

Yadev, B.L. and S.R. Jakhar. (2001). Effect of tillage and phosphorus fertilization on yield and water expense efficiency of rainfed mungbean. *Journal of the Indian Society of Soil Science.* 49: 1, 193-194.

Yadav, K. and K. Mandal.(1992). Effect of rhizobial strains of different origin on the nodulation, nitrogenase activity and grain yield of chickpea *(Cicer arietinum* L.). *Journal of Research Birsa Agricultural University.* 4(2): 167-168.

Yadav, R.P., D.V.S. Chauhan, and K.S. Yadav. (1990). Effect of phosphorus, row spacing and irrigation on yield of pea. *Indian J. Agron.* 35(3): 333- 335.

Yamakawa, T. (1992). Laboratory Methods for Soil Science and Plant Nutrition. Part 2. Methods of Plant Analysis. J1CA-IPSA project, pp. 6- 14.

Yanni, Y.G. (1992). Performance of chickpea, lentil and lupin nodulated with indigenous or inoculated rhizobia micropartners under nitrogen, boron, cobalt and molybdenum fertilization schedules. *World J. Micro. Biotech.* 8(6): 607-613. [Cited from Sols and Fertilizers Abst. 57(1-3): 115,1994],

Zaman, A.K.M.M., M.S. Alam. B. Roy and A H. Beg. (1996). Effect of B and Mo application on mungbean. *Bangladesh J. Agril. Res.* 21(1): 118-124.

*The figures in a column having common letter(s) do not differ significantly at *5%* level of significance.

*The figures in a column having common letter(s) do not differ significantly at 5% level of significance.