INFLUENCE OF RESIDUAL EFFECT OF ORGANIC FERTILIZER AND DIFFERENT DOSES OF CHEMICAL FERTILIZER ON THE YIELD AND SEED QUALITY OF MUNGBEAN

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CERTIFICATE

This is to certify that the thesis entitled **"INFLUENCE OF RESIDUAL EFFECT OF ORGANIC FERTILIZER AND DIFFERET DOSES OF CHEMICAL FERTILIZER ON YIELD AND SEED QUALITY OF MUNGBEAN''** submitted to the Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka-1207 in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **Seed Technology**, embodies the results of a piece of *bona fide* research work carried out by **MD. NUR HASAN**, Registration No. **13-05305**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

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

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INFLUECE OF RESIDUAL EFFECT OF ORGANIC FERTILIZER AND DIFFERENT DOSES OF CHEMICAL FERTILIZER ON THE YIELD AND SEED QUALITY OF MUNGBEAN

ABSTRACT

A pot experiment was conducted at the net house of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from April to June 2018 to investigate the yield performance and seed quality of mungbean as influenced by residual effect of organic fertilizers and different doses of chemical fertilizers. The experiment was laid out in two factors following a Factorial Experiment using Completely Randomized Design (CRD Factorial) with three replications. Factor A. Organic fertilizer-3; viz. O_0=Control, O_1=Cowdung, O_2=Vermicompost and Factor B: Chemical fertilizers-4; viz. F_0=Control, F_1=50% of recommended dose of chemical fertilizers, F_2=75% of recommended dose of chemical fertilizers, F_3=Recommended dose of chemical fertilizers. The result revealed that the residual effect of vermicompost (O_2) showed its superiority by producing the highest mungbean yield (2.03 tha^{-1}) with higher plant height (40.13 cm), dry weight plant^{-1} (12.69 g), pod length (8.65 cm), pods plant^{-1} (33.70), seeds pod^{-1} (12.24) and weight of 1000 seed (40.28 g) in this treatment. On the other hand, recommended dose of chemical fertilizer seems promising in mungbean cultivation as this treatment (F_3) gave the highest seed yield (2.24 tha^{-1}) along with the highest pod length (8.94 cm), pods plant^{-1} (34.49), seeds pod^{-1} (12.51) and 1000 seed weight (40.38 g). Among the interactions, O_2F_3 out yielded other combined treatment by producing highest yield (2.48 tha^{-1}). This interactions produced the tallest plant (43.48 cm), maximum dry weight plant^{-1} (13.71 g), pod length (9.21 cm), pod plant^{-1} (36.31), seeds pod^{-1} (12.88), 1000 seed weight (41.30 g), shelling percentage (71.62%), strover yield (5.52 tha^{-1}), biological yield (8.00 tha^{-1}), harvest index (34.13%), germination percentage (94.33%), speed of germination of seed (10.27), seedling shoot length (22.670 cm), seedling dry weight (0.0430 g) and lowest EC test value (1628.1 µS cm^{-1}). The study clearly indicated that the residual effect of vermicompost as organic fertilizer and the recommended dose of chemical fertilizers and combination of vermicompost and recommended doses of chemical fertilizer might be an option for producing maximum yield and quality seed of mungben.

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LIST OF ACRONYMS

Acronyms	Full word
AEZ	Agro ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Cm	Centimeter
CV	Coefficient of Variation
DAS	Days After Sowing
et al.	And others (*et alibi*)
FAO	Food and Agriculture organization
g	Gram
ha	Hectare
HI	Harvest Index
kg	Kilogram
kg ha^{-1}	kg per hectare
LSD	Least Significant Difference
m^2	Square Meter
MS	Master of Science
no.	Number
%	Percent
pH	Hydrogen ion concentration
$plant^{-1}$	per plant
SAU	Sher-e- Bangla Agricultural University
SRDI	Soil Resources and Development Institute
t ha^{-1}	Ton per hectare
CRD	Completely Randomized Design
EC	Electric conductivity
INM	Integrated Nutrient Management

CHAPTER I

INTRODUCTION

Mungbean is a popular and widely grown pulse in Bangladesh (Islam *et al.*, 2013). Edible grain of mungbean is characterized by good digestibility, flavour, high protein content and absence of any flatulence effects, (Ahmed *et al*., 2001). Its seed contains 24.7% protein, 0.6% fat, 0.9% fiber and 3.7% ash, (Potter and Hotchkiss, 1997) as well as sufficient quantity of calcium, phosphorus and important vitamins. This legume is known to have high nutrient values with excellent source of vegetable protein (seeds and sprouts contain to 28% of proteins). Mungbean is considered as a substitute to animal protein as it forms a balanced diet when used with cereals, (Khan and malik, 2001; Anjum *et al*., 2006).

Mungbean ranks the 3rd in protein content and 4th in acreage production in summer, (BBS, 2017). In Bangladesh, mungbean is grown on an area of 68,000 acres annually and a total production of 37,000 Metric tons with an average seed yield of 766 kg per ha during the year 2015–16, (BBS, 2017) which is very low as compared to other countries of the region. According to FAO a minimum intake of pulse by a human should be 80.0 g per day whereas it is only 38 g per day in Bangladesh, (BBS, 2015). This is mainly because of the fact that the national production of the pulse crops is not sufficient to meet up our national demand. Both the acreage and production of the pulses are decreasing in Bangladesh day by day due to the dominancy of boro rice and wheat in our cropping system.

Quality seed of mungbean is a great lackings for this unsufficient production of mungbean in Bangladesh. Attention has been taken for producing quality seed of mungbean recently. High yielding quality seed can be a great initiative for increasing the production of mungbean. For producing high yield of mungbean, variety plays an important role. So attention should be given to increase yield through the proper selection of high yielding varieties, (Singh *et al*., 2009). With the introduction of high yielding variety Binamoog-8 much attention is being paid to the cultivation of this variety in order to mitigate the alarmingly protein shortage in the diet of our people by cultivating mungbean.

Fertilizer plays an important role in producing high yield of mungbean because different fertilizer have different response on plants growth characters, yield and yield components and seed qualitys. It has a specific response to nitrogen (N), phosphorus (P) and potassium (K). These nutrients play a key role in plant physiological process. Nitrogen, phosphorus and potassium are integral components of all the biochemical compounds that make plant life possible. Nitrogen is an essential nutrient which required for plant growth. Nitrogen is vital as it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e., photosynthesis). Nitrogen is also a major component of amino acids, the building blocks of proteins. Without proteins, plants wither and die. Nitrogen deficiency reduces the number of branches per plant, plant height, stem diameter, pod length, number of nodes. Phosphorus plays a great role in plant physiological processes. It is an essential component of major enzymes which are of great importance in the transformation of energy in carbohydrate metabolism in different types of plants and is closely related in cell division as well as seed development. Potassium is becoming increasingly important in Bangladesh and a good crop response to K is being reported from many parts of the country. Pulse crops showed yield benefits from K application and also improved K supply enhances biological N fixation and protein content of pulse seed, (Srinivasarao *et al*., 2003).

Cow dung manure is a nitrogen rich material and it has economic importance as fertilizer, feed supplement or as energy sources. Cow dung has relatively less N than some other manure, so it can be added directly to the soil without damaging plants. Cow dung manure has been collected and used to supply nitrogen, potassium, phosphorous and calcium to the soil for plant production, (Smith and Wheeler, 1979). Cow dung has a relatively high carbon to the nitrogen ratio.

Vermi-composting is the processing of organic wastes with earthworms. During this process, elements like N, P, K, and Ca present in the waste are released and converted, through microbial activity, into forms more soluble and available to plants than those present in the original waste, (Edwards and Burrows, 1988). It is a great source of micronutrients production. It also develops the soil health too. Thus vermicompost increase the soil fertility, as a result productivity of soil is also increased. Microorganisms and earthworms are important biological organisms helping nature to maintain nutrient flows from one system to another and also minimize environmental degradation, (Moller, 2009).

Integrated management of chemical fertilizers, residual effect of organic fertilizer and high yielding variety like Binamoog-8 may be an important strategy for sustainable crop production and increasing the yield of pulse crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides increasing crop yield and improving available major and minor nutrients, (Rautaray *et al.* 2003). As mungbean is leguminous in nature, mungbean needs low nitrogen but require optimum doses of other major nutrients as recommended. Organic fertilizers act as a great source of multiple nutrients and ability to improve soil characteristics, (Moller, 2009). Organic farming conserves the ecosystem. Management of soil organic matter incorporation as it has great residual effect which has now become a major issue in dealing with the problems of soil fertility and productivity in Bangladesh. Depletion of soil fertility has arisen mainly due to increasing cropping intensity (presently about 190%), increasing use of MVs, soil erosion, sandy soils, and higher decomposition of organic matter due to sub-tropical humid climate. Using of chemical fertilizers will also be quite a limiting factor of agricultural production in future. Because of high energy cost, chemical fertilizers are not available at affordable price to the farmers of Bangladesh. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and intern increase in the usage of organic fertilizer is needed to check the yield and quality levels. On the other hand, use of organic fertilizers alone does not result in remarkable increase in crop yields, due to their low nutrient status, (Subba Rao and Tilak, 1977). Residual effects of increased nutrients and organic matter in soil following manure or vermicompost application on crop yield as well as soil properties can last for several years, (Mugwira, 1979; Wallingford *et al.*, 1975). The residual effects of manure or vermicompost application can maintain crop yield level for several years after manure or compost application ceases since only a fraction of the N and other nutrients in manure or compost become plant available in the first year after application, (Eghball *et al*., 2002). Bodruzzaman *et al*. (2002) found that organic manures had direct and residual effects on crops.

Balance use of chemical fertilizer with organic fertilizer or with its residual effect is important to obtain maximum seed yield. Mungbean yield and quality of seed can be improved by the use of balanced fertilizers, (Aslam *et al.*, 2010). The objective of the research is to find out the best combination of residual effect of organic fertilizer with different doses of chemical fertilizer for better yield and seed quality of mungbean.

Therefore, the present study has been undertaken with the following objectives:

i) To observe the residual effect of cowdung and vermicompost on yield of mungbean ,

ii) To select a suitable dose of chemical fertilizer in presence of residual effect of organic fertilizer on yield of mungbean, and

iii) To select the best combination of organic and inorganic fertilizers on the yield and seed quality of mungbean.

CHAPTER II

REVIEW OF LITERATURE

An attempt has been made to bring out review relating to the "Residual effect of organic fertilizer with different doses of chemical fertilizer on yield and seed quality of mungbean." A brief discussion of the works done in the past by various researchers given in this chapter.

2.1 Residual effect of organic fertilizer on yield and seed quality of mungbean

A field experiment was conducted by Shukia and Tyagi (2009) during 2004-07 in summer season to ascertain the effect of 2 organic inputs, viz enriched compost and vermicompost applied @ 2 tha^{-1}, on selected soil parameters for soil health growth and nodulation of 'PusaRatna' mungbean *vigna radiata* (L.). The beneficial effects were compared not only to soils but also the growth of the crop without organic inputs. Organic matters, like vermicompost and enriched compost enhanced soil physical properties and plant nutrients (N, P and K) at the time of crop establishment and early growth. Incorporation of vermicompost and enriched compost before sowing had a greater beneficial impact, especially on physical properties of soil. The added organic materials, like vermicompost and enriched compost increased germination growth of shoots, roots and enhanced nodulation, the slightly greater benefits were derived with vermicompost as compared to enriched compost. The selected microorganisms used were Rhizobium, a symbiotic nitrogen fixer and phosphate-solubilizing bacteria which helps in solubilization of fixed phosphorus.

Vermicomposting is a process of recycling of organic wastes in an environmentally safe method. Vermicompost is a mixture of worm casts, which is rich source of micro and macronutrients. The worm casts apart from increasing the density of microbes also provide the required nutrients to plants. It contains plant growth promoting substances such as NAA, cytokinins. gibberellins. etc. It also increases the efficacy of added fertilizers in the soil. On an average, vermicompost contains 0.80 to 1.10% N. 0.40 to

0.80% P_20_5 and 0.80 to 0.98% K_2O while 10 to 52 ppm Cu. 186.60 ppm Zn and 930.00 ppm Fe (Giraddi, 2001 and Giraddi *et al.* 2006).

Govindan and Thirumurugan (2005) observed that the application of vermicompost (75%) had significantly recorded higher plant height (84.70 cm), leaf area index (3.40) over press mud (100%N) (78.20cm and 2.70, respectively) in soybean.

Vermicompost contains micro site rich in available carbon and nitrogen (Sudhakar *et al.*, 2002). Worm cast incorporated soils are also rich in water soluble P (Gratt, 1970) and contained two to three times more available nutrients than surrounding soils (Sudhakar *et al*., 2002**)** which encourages better plant growth. Vermicompost suppress parasitic attacks dramatically and also have shown to increase germination rates, growth etc in wide ranges of crops (Arancon *et al*., 2004). Similar results were also reported by application of Vermicompost on seed germination in mung bean by Nagavallemma *et al*. (2004).

Chinnamuthu and Venkatakrishnan (2001) reported that the application of vermicompost @ 2 t per ha recorded significantly higher plant height (147.80 cm) and 100 seed weight (4.14 g) compared to application of FYM @ 5 tha^{-1} (l40.80 cm and 4.06g, respectively) to sunflower.

Raundal and Sabale (2000) conducted a field experiment during 1997-98 in Maharashtra, in India and reported that application of vermicompost to mungbean gave highest nitrogen content (4.15%), protein yields 0.475 tha^{-1} in grain. Karmegam and Daniel (2000) reported that application of vermicompost resulted in significant increase in growth and yield of cowpea.

Sudha and Kapoor (1999) conducted a field experiment and reported that application of vermicompost on mungbean increased the dry matter production of mungbean.

Karmegam *et al.* (1999) conducted an experiment with mungbean and reported that application of vermicompost resulted in significant increase in growth and yield of mungbean.

A field trial was conducted Raundal *et al.* (1999) conducted a field trial with mungbean during kharif season of 1997-98 showed that application of 60 kg P_2O_5 per hectare with vermicompost significantly increased the growth, dry matter and yield of mungbean.

Muneshwar *et al.* (1999) found from their experiment that mungbean plants grown in higher rate of compost were found to be taller than those lower rates.

Appavu and Saravanan (1999) observed that the application of FYM had significantly recorded higher seed yield (738 kg ha^{-1}) than control (500 kg ha^{-1}) in soybean.

Kathiresan *et al*. (1999) observed in soybean that the application of enriched FYM recorded significantly higher number of pods per plant (164), number of seeds per pod (2.30) and test weight of 8.40g. The maximum soybean seed yield of 2031 kg ha^{-1} was obtained by application of enriched FYM, which was 32 % higher over control.

Compost and other agriculture organic wastes are important sources for maintenance of soil productivity. In intensive livestock farming, there is a huge amount of animal excreta being generated. Proper utilization of these wastes can improve soil physical condition and these wastes can improve soil physical condition and environmental quality as well as provide nutrients for plant (Mishra *et al*., 1989).

Aruna and Reddy (1999) reported that the application of vermicompost @ 15 tha^{-1} to soybean recorded significantly higher number of pods per plant (59.00), 100 seed weight(15.80 g), seed yield (1143 kg/ha), seed protein content (41.80%) and seed oil content (24.30%) over the application of FYM @ 5 tha^{-1} + 50 kg N per ha (29.70, 13.9 g, 782 kg/ha, 38.70% and 23.00%, respectively).

2.2 Effect of chemical fertilizer on yield and seed quality of mungbean

N, P, K are considered as the major nutrients in crop production point of view and proper ratio should be maintained among these nutrients to ensure better growth and improved yield. Application of nitrogen and phosphorus increase the number of pods per plant and number of seeds per pod. A balanced ratio of N and K is also important in plant nutrition. Total N uptake and protein synthesis are reduced in K deficient plants. An excess of N in relation to other nutrients, such as P and K can delay crop maturity.

Achakzai *et al.* (2012) found that different nitrogen levels influenced most of the growth attributes of the mungbean. Maximum days to flowering, number of branches per plant, number of leaves per plant, plant height, number of branches per plant, leaf area and grain yield recorded for plants subjected to highest dose of applied N fertilizer at 100 kg ha^{-1}.

Field studies was carried out by Sangakkara *et al.* (2011) for testing the impact of fertilizer K on root development, seed yields, harvest indices, and N-use efficiencies of mungbean, a popular smallholder crops over major and minor seasons. Application of 80 kg K per ha optimized all parameters of growth yields and N-use efficiencies of mungbean in both seasons. Information regarding rates of fertilizer K that optimized N use and yield of mungbean during each of the two tropical monsoonal seasons of South Asia is presented.

Sadeghipour *et al*. (2010) conducted an experiment on green gram at Tehran (Iran) with five levels of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and six levels of phosphorus (0, 30, 60, 90, 120 and 150 kg P_2O_5 ha^{-1}). Results showed that application of N and P fertilizers significantly increased the seed yield of mungbean. The maximum seed yield (224.2 g m^{-2}) was obtained when 90 kg N ha^{-1} and 120 kg P_2O_5 ha^{-1} was applied. This increase in seed yield was mainly due to more number of pods per plant, number of seeds per pod and 1000 seed weight.

Sultana (2006) noticed that plant height of mungbean showed superiority at 30 kg N ha^{-1} followed by 40 kg N ha^{-1}. Nitrogen fertilizer significantly influenced plant height at all growth stages of mungbean. At 20, 35, 50, 65 DAS and harvest the maximum heights were observed in the plants treated with 30 kg N ha^{-1}.

A field experiment was laid out by Oad and Buriro (2005) to determine the effect of different NPK Levels (0-0-0, 10-20-20, 10-30-30, 10-30-40 and 10-40-40 kg/ha) on the growth and yield of mungbean cv. AEM 96 in Tandojam, Pakistan during the spring season of 2004. The different NPK levels significantly affected the crop parameters. The 10-30-30 kg NPK ha^{-1} was the best treatment, recording plant height of 56.3 cm, germination of 90.5% satisfactory plant population of 162, prolonged days taken to maturity of 55.5 long pods of 5.02 cm, seed weight per plant of 10.5 g, seed index of 3.52 g and the highest seed yield of 1.205 kg ha^{-1}. There was no significant change in the crop parameters beyond this level.

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

An experiment was conducted by Slag and Yadav (2004) in Rajasthan, India during 1999-2001 to study the effect of chemical fertilizers on mungbean resulted in increased branches and nodules per plant.

Slag and Yadav (2004) reported that application of chemical fertilizers on mungbean resulted in increased pods per plant.

Rajkhowa *et al*. (2003) carried out a field experiment and reported that application of fertilizers on the performance of mungbean in the summer season on 1988 on the sandy loam soil of Jorhat, Assam, India resulted the highest number of nodules (24.33) per plant.

Malik *et al*. (2003) carried out a field experiment on mungbean (*Vigna radiata* L.) in Pakistan to determine the effect of varying levels of nitrogen (0.25 and 50 kg ha^{-1}) and phosphorus (0, 50. 75 and 100 kg ha^{-1}) on the yield and quality of mungbean (Vigna radiata) cv. NM-98. Although plant population was not affected significantly, various growth and yield components were significantly affectcd by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in the maximum seed yield (1.113 kg/ha). Protein content (25.6%) was maximum in plots treated with 50 kg N + 75 kg P ha^{-1} followed by 25.1% protein content in plots treated at 25 kg N + 75 kg P ha^{-1}. The highest net income (Rs. 21,375) was obtained by applying 25 kg N + 75 kg P ha^{-1}.

Ashraf *et al.* (2003) conducted a field experiment at Faisalabad in Pakistan to observe the effects of seed inoculation of a biofertilizer and NPK application on the performance mungbean cv. NM-98. The treatments consisted of the seed inoculation of Rhizobium phaseoli singly or in combination with 20:50:0, 40:50:0 or 50:50:50 NPK kg ha^{-1}. N (urea), P (single super phosphate) and K (potassium sulphate) were applied during sowing. The tallest plants (69.9 cm) were obtained with seed inoculation + 50:50:0 kg NPK ha^{-1}. Seed inoculation + 50:50:0 or 50:50:50 kg ha^{-1} resulted in the highest number of pods $plant^{-1}$ (29.0. 56.0. 63.9 and 32.6 respectively) and seed yield (1.053, 1.066, 1.075 and 1.072 kg ha^{-1}). Harvest index was highest with seed inoculation in combination with NPK and 40:50:0 (25.23), 50:50:0 (24.70) or 50:50:50 (27.5). Seed inoculation along with NPK at 30:50:0 kg ha^{-1} was optimum for the production of high seed yield by mungbean cv. NM-98.

Panda *et al.* (2003) conducted field experiments in West Bengal, India to evaluate the effects of NK application on the productivity of yambean (*Pachyrhizus erosus*)-pigeonpea (*Cajanus cajan*) intercropping system and its residual effect on the succeeding mungbean (Vigna radiata). Marketable tuber yield of yambean increased linearly with increasing NK levels, with the highest being recorded with NK at 80 kg/ha applied in 2 splits (22.9 tha^{-1} closely followed by 100 kg NK per ha applied in 2 splits (22.4 tha^{-1}). For pigeon pea, the maximum grain (14.38 q/ha), stick (8.08 q/ha) and highest yield (9.96 q/ha) were recorded with 80 kg NK per ha applied in 2 splits. The highest Level of NK (100 kg/ha) applied in 3 splits to yambean-pigeon pea intereropping system registered the maximum grain yield of the succeeding mungbean (9.43 q/ha). which was 33% higher than the untreated control.

Rudreshhappa and Halikatti (2002) explained the effect of N levels (0, 12.5 and 25 kg) on growth, yield and nutrient uptake of green gram in paddy fallows. Application of 12.5 kg N ha^{-1} was recorded to produce significantly higher seed yield. Further increase in N doses (25 kg ha^{-1}) did not significantly increase the yield.

Tariq *et al.* (2001) conducted a field experiment to study the effect of P and K application on growth and yield of green gram on a sandy clay loam soil under irrigated condition of Faisalabad (Pakistan). They indicated that plant height, number of branches per plant, number of pods per plant, number of seeds per pod, 1000-seed weight and seed yields were increased significantly by application of P and K along with nitrogen. Application of P_2O_5 and K_2O each @ 70 kg ha^{-1} along with N application @ 30 kg per ha produced highest grain yield of 876.32 kg ha^{-1}.

Prasad *et al*. (2000) conducted a pot experiment to study the effect of potassium on yield K-uptake by summer mungbean (cv. T-44) and showed that the grain yield increased with potassium application but result was statistically insignificant. Increasing potassium levels significantly increased potassium uptake. Available K in soil after K harvest of crop increased with increasing levels of K.

Suhartatik (1991) observed that NPK fertilizers significantly increased the number of pods per plant of mungbean. He also reported that NPK fertilizers significantly increased the plant height of mungbean.

Sardana and Verma (1987) conducted a field experiment in New Delhi, India in 1983-84. They stated that application of nitrogen, phosphorus and potassium fertilizers resulted in significant increases in plant height of mungbean.

Sardana and Verma (1987) carried out a field experiment in Delhi, India in 1983-84 and stated that application of N, P, K fertilizers resulted in significant increases in 1000- seed weight of mungbean.

Dhingra *et al*. (1998) conducted a field experiment in 1992-94 at Ludhiana, Punjab, India on the combined effects of NPK fertilizers on the productivity of mungbean. They found that mungbean gave positive response to combined application of NPK fertilizers.

Singh and Ahlawat (1998) conducted an experiment and reported that application of phosphorus to mungbean cv. PS 16 increased the number of seeds/pod when grown in a sandy loam soil, low in organic carbon and N, and medium in P and K and with a pH of 7.8.

Samiullah *et al.* (1987) conducted an experiment on fertilizer management and reported that number of pods per plant was highest with the application of 10 kg N + 75 kg P_20_5 + 60 kg K_2O in summer mungbean.

In a field experiment, Yein *et al.* (1981) applied N, P, K fertilizers to mungbean which resulted in increased plant height.

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

2.3 Combined effect between influence of residual effect of organic fertilizer and different doses of chemical fertilizer on yield and seed quality of mungbean

Saravanan *et al.* (2013) observed maximum number of pods and pod length in treatment, which received FYM + 10% RDF of NPK. They also reported that the integrated approach of nutrient management recorded better availability of phosphorus and potassium in fresh and dry seeds of green gram than the individual application.

Meena (2013) conducted a field experiment to find out the effects of organic and inorganic sources of nutrient on growth attributes and dry matter partitioning of green gram in arid western Rajasthan during summer season of 2004. He observed that inorganic source of nutrients as NPK 100% of RDF and organic sources of nutrients like, FYM at 10 tha^{-1} and vermicompost at 5 tha^{-1} significantly enhanced the growth attributes *viz*., plant height at harvest, dry matter accumulation and its partitioning (g $plant^{-1}$) into leaf, stem and pod at 30, 45, 60 DAS and at harvest, dry weight of root nodules (mg $plant^{-1}$) at flower initiation and peak flowering stages of green gram over control and other treatments. He further quoted that increased levels of inorganic and organic sources of nutrients *viz*., NPK at 125% recommended dose, FYM at 10, 15 and 20 t ha^{-1} and vermicompost at 5, 7.5 and 10 t ha^{-1} remained at par each other.

Incorporation of soil amendments (cowdung, vermicompost, compost, biochar, poultry litter etc.) enhanced soil water holding capacity, soil water permeability, saturated hydraulic conductivity (SHC), reduced soil strength, modification in soil bulk density and modified aggregate stability (Peng *et al*., 2011).

Soil amendments increases adsorption properties allowing a greater retention of water and nutrients in the soil solution. The ability to retain a relatively large quantity of water aids plant growth when under water stress. The grain yield and yield components of wheat significantly increased with the application of different organic materials resulting in the compost to be the most superior one (Sarwar, 2005). Irrigating the crop at 60% water holding capacity and applying mineral nitrogen 60kg/fed, with presence of the chicken manure as an organic fertilizer produced the highest wheat yield through two growth seasons (Yassen *et al.,* 2006). Cowdung and vermicompost can be an important tool to increase food security and cropland diversity in areas with severely depleted soils, scarce organic resources, and drought prone areas.

Ghulam *et al.* (2011) reported that different combinations of organic and inorganic fertilizers significantly affected the grain yield of green gram. Maximum grain yield was obtained from the application of DAP at 124 kg ha^{-1} along with 10 t ha^{-1} of poultry litter during both years, while application of DAP at 62 kg ha^{-1} and 10 t ha^{-1} FYM ranked second for grain yield.

Naeem *et al.* (2006) studied the effect of organic manures and inorganic fertilizers on growth and yield of green gram (*Vigna radiata* L.) and reported that grain yield was recorded highest (1104 kg ha^{-1}) with the application of the inorganic fertilizers @ 25:50:50 kg NPK ha^{-1}. Among organic sources, poultry manure @ 3.5 t ha^{-1} was found the best followed by FYM @ 5 t ha^{-1}. The economic analysis revealed maximum net benefit from the treatment, where poultry manure was applied.

Singh *et al.* (2005) studied residual effect of INM in potato-mungbean cropping sequence and reported that highest value of all the yield attributes and grain yield of mungbean was observed with the residual effect of combined application of 100% RDF + FYM @ 15 t ha^{-1}. They also quoted that direct effect of NPK application to mungbean was more pronounced over residual effect. Yield attributes, grain yield and net return improved significantly with each increment of NPK from 50% RDF to 100% RDF. Integrated nutrient management practices brought about significant variation in organic carbon, phosphorous and nitrogen status of soil and non-significant variation in K status at harvest. Highest improvement in soil fertility was observed with application of FYM @15 t ha^{-1} + 100% RDF followed by 100% RDF + biofertilizer + crop residue incorporation.

An experiment was conducted by Slag and Yadav (2004) in Rajasthan, India during 1999-2001 to study the effect of vermicompost (0, 1, 2 and 3 tha^{-1}) and fertilizers (0, 50 and 100% recommended dose) on mungbean (*Vigna radiata*) yield. Significant increase in seed yield was observed by the application of vermicompost up to 2 tha^{-1} owing to increased secondary branches per plant, pods per plant. Increased in secondary branches and nodules per plant which resulted in improved yield attributes and seed yield over the control. Application of vermicompost (2 tha^{-1}) along with 50% recommended dose of fertilizers (10 kg N and 8.7 kg P ha^{-1}) was found to be the optimum dose for mughean grown on sandy-loam soil.

Rautaray *et al.* (2003) reported that high dependency on the increased use of chemical fertilizers and associated hazards put back attention on organic sources, which are effective in promoting health and productivity of the soil. Combined use of chemical fertilizer with organic fertilizer may be an important strategy for sustainable production of crops. This may not only improve the efficiency of chemical fertilizers along with their minimal use in crop production besides increasing crop yield and improving available major and minor nutrients.

Rajkhowa *et al.* (2003) investigated that application of vermicompost alone or in combination with fertilizers on the performance of mungbean in the summer season on 1988 on the sandy loam soil of Jorhat, Assam, India. The treatment included: a control; 100% fertilizers (N at 15 kg/ha + P at 35 kg/ha; 100% CFs + VC at 2.5 tha^{-1}; 75% fertilize + VC; 50% fertilizer + VC; VC alone. They observed that combination of vermicompost with fertilizers (50% fertilizers + VC) resulted the highest numbers of nodules per plant (24.33).

A field experiment was conducted by Abraham and Lal (2003) and showed that the effects of NPK fertilizers (100 and 33% of recommended dose), vermicompost in combination with inorganic fertilizers showed synergistic effects on the growth and yield of mungbean.

An experiment was conducted by Rajkhoha *et al.* (2002) Jorhat, Assam, in India (1998) showed that application of vermicompost (at 2.5 tha^{-1}) in combination with fertilizers (recommended rate, N:P at 15:35 kg/ha and 50 and 25% of the recommended) on mungbean showed that application of VC at 2.5 tha^{-1} + recommended fertilizer rate resulted the highest yield which was closed to the yield obtained with the combination of VC with 50°/o recommended fertilizer rate.

A field experiment was conducted by Satish Kumar *et al*. (2003) revealed that application of vermicompost at 2.5 and 5 t ha^{-1} and 3 levels of chemical fertilizers 75% recommended dose of fertilizers N:P at 20:40 kg/ha on the performance of mungbean cv. Asha significantly increased the grain yield. Vermicompost at 5 tha^{-1} produced higher grain yield. Vermicompost application at both levels resulted in higher yield. Yield increased with increasing fertilizer rate up to 125% recommended dose of fertilizers.

An experiment was carried out by Bhuiyan *et al.* (2003) at the Bangladesh Agricultural University (BAU) Farm, Mymensingh from rabi season of 1999 to kharif II season of 2002 in the Old Brahmaputra Floodplain Soils (AEZ 9) of Bangladesh to investigate the effect of integrated use of organic and inorganic fertilizers on yield and nutrient uptake of T. Aus rice and mungbean in the Wheat-T. Aus/ mungbean-T. Aman cropping pattern. The results showed that application of organic manure along with chemical fertilizers resulted in markedly higher uptake of nutrients. The application of NPKS (HYG) fertilizers remarkably increased the crop yield. The lowest grain yield and the lowest nutrient uptake were noted in control plots receiving no fertilizer or manure.

Bharne *et al.* (2003) reported that total N, P and K contents increased after decomposition of composts in an experiment on summer mung.

A field experiment was conducted by Kumar *et al.* (2003) during 2001-02 on the sandy loam soil of Haryana, India to investigate the effect of *Rhizobiun sp*. seed inoculation. FYM (farmyard manure) at 5 tha^{-1} vermicompost at 2.5 tha^{-1} and 5 tha^{-1} and 4 levels of fertilizers (control, no chemical fertilizer; 75% recommended dose of fertilizer, RDF; 100% RDF, N:P at 20:40 kg/ha and 125% RDF) on the performance of mungbean cv. Asha. *Rhizobium sp.* inoculation significantly increased the grain yield. Increasing RDF levels up to 100% also increased grain yield. Vermicompost at 5 tha^{-1} produced 16.5 and 9.5% higher grain yield compared to FYM at 5 tha^{-1} and vermicompost at 2.5 tha^{-1}, respectively in 2002. However. The organic amendment did not affect the grain per pod in 2001 and the 1000-grain weight in both years. The interaction of the different treatments was significant in 2002. Vermicompost application at both levels resulted in higher yield compared to FYM. Yield increased with increasing fertilizer rate up to 125% RDF when applied with FYM but yield was higher under the treatment 100% RDF + vermicompost (both rates).

(Bending *et al.* (2002) reported that crop residues and soil organic matter both could affect the diversity of soil microbial community and increase the crop growth and yield. Combined use of nutrient may be one of the solutions to increase mungbean production as well as reducing cost of production and make the best use of locally available resources like animal dung, urine, crop residues etc. The use of organic matter as a low cost supplement to the artificial fertilizers may help decreasing the cost of production.

Satyanarayana et al. (2002) conducted a field experiment on irrigated lowland rice and reported that integrated use of organic and inorganic fertilizers guarantee improved soil health and fertility.

Rajkhowa *et al.* (2002) reported that the application of 100 percent RDF along with vermicompost @ 2.5 tha^{-1} recorded significantly higher plant height (52.7 cm), number of pods per plant (12.67), seeds per pod (12.00), 100 seed weight (4.6 g), seed yield (5.35 q ha^{-1}), seed yield (5.4 q ha^{-1}) and it was on par with the application of 75% or 50% RDF + vermicompost (2.5 tha^{-1}) over control in mungbean.

Kumari and Ushakumari (2002) in field experiment studied on the effect of enriched vermicompost on the yield and uptake of nutrients by cowpea. The results indicated that enriched vermicompost @ 20 t ha^{-1} produced 28% yield increment over application of FYM + 30 kg P_2O_5 ha^{-1} and 21% yield increase over application of vermicompost + 30 kg P_2O_5 ha^{-1}. The enriched vermicompost treatment also showed its superiority over other treatments for the uptake of N, P and K.

Malligawad *et al.* (2000) conducted an experiment on groundnut and revealed that application of RDF (25:75:25 kg NPK kg/ha) ± vermicompost @ 1 tha^{-1} recorded significantly higher pod yield (3389 kg/ha) compared to FYM @ 4 tha^{-1} + 50% RDF (3232 kg/ha). RDF alone (3148 kg/ha) and no NPK application (2742 kg/ha).

Srikanth *et al.* (1999) conducted experiment to prepare compost from city and industrial waste (involving press mud). Thy used rock phosphate and microbial inoculants to improve the quality of the compost in terms of N and P. They observed that addition of microbial culture with rock phosphate hastened the process of decomposition. They also reported that industrial compost involving press mud showed superiority in respect to NPK contents and the enriched compost of these wastes showed superiority with respect to nutrient contents compared to un-enriched compost.

A field trial was conducted by Reddy *et al*. (1998) during kharif season of 1997-98 showed that application of 60 kg P_20_5 per hectare through phospho-vermicompost significantly increased the growth, dry matter and yield of pea.

Reddy *et al.* (1998) conducted a field experiment and reported that application of vermicompost (5 tha^{-1}) along with recommended N, P and K fertilizers resulted in significant high yield of mungbean.

Patil (1998) conducted an experiment and reported that in groundnut the maximum pod yield (30.04 q/ha) was recorded with the application of vermicompost @2.50 tha^{-1} + fly ash (@ 30 tha^{-1} + RDF whereas the lowest pod yield (20.66 q/ha) was recorded with the application of RDF alone.

Combined use of nitrogenous fertilizers and organic sources of nitrogen sustained the higher availability of N, P and K. More (1994) observed that the treatment compost at the rate of 25 tha^{-1} plus PM at the rate of 20 tha^{-1} + was best for increasing yields of rice and wheat. This treatment decreased the soil pH and increased the organic matter content and availability of N. P and K in soil.

Kale *et al.* (1994) observed that the application of vermicompost @ 47 tha^{-1} + 50% RDF recorded significantly higher value of growth yield components and yield of sunflower compared to FYM @ 5 tha^{-1} + RDF.

Pawar *et al*. (1995) reported that the application of vermicompost @2.50 tha^{-1} along with 100 per cent RDF recorded significantly higher seed yield (74.80 q/ha). However,in situ vermiculture and application of 50 per cent RDF recorded a yield equivalent to that with 100 percent RDF. They further observed that the application of vermicompost @ 2.50

tha^{-1} along with 50 percent RDF recorded seed yield on par with 100 percent RDF in maize.

Aruna and Narsareddy (1999) reported that the application of organic manures @ 15 tha^{-1} + 50:0:0 kg NPK ha^{-1} recorded significantly higher pods per plant (56), 100 seed weight (15.7 g), seed yield (1127 kg ha^{-1}), seed protein content (42.1%) and seed protein content (24.4%) over the application of organic manures @ 5 t ha^{-1} + 50:0:0 kg NPK ha^{-1} (32.9, 12.8g, 792 kg ha^{-1}, 39.3% and 23.1%, respectively) in soybean.

Farmyard manure (FYM) refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. Good quality FYM is more valuable organic manure. The long term manurial studies conducted at many places have revealed the superiority of integrated nutrient supply system in sustaining crop productivity in comparison to chemical fertilizer alone (Gaur, 1991). On an average well decomposed FYM contains 0.5 percent N, 0.2 percent P_2O_5 and 0.5 percent K_2O. It has been estimated that a ton of FYM would supply 3.6 kg nitrogen + 1.9 kg phosphorus + 1.8 kg potassium (Gaur *et al*., 1992). FYM promotes seed germination and root growth of the crop plants by improving the water holding capacity and aeration of the soil.

Sharma and Dixit (1987) conducted a field experiment and reported that the application of FYM @ 6 t ha^{-1} + NPK @ 10:40:0 kg ha^{-1} recorded significantly higher plant height (73.3 cm), higher number of seeds per plant (128), 100 seed weight (111.7 g) and seed yield (20.2 q ha^{-1}) as compared to the application of NPK @ 10:40:0 kg ha^{-1} (64.6 cm, 104.7, 100.8 g, 16.5 q ha^{-1}) in soybean.

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted in the net house of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from April 2018 to June 2018. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

The experiment was conducted in the net house of the department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, under the Agro-Ecological Zone of Madhupur Tract (AEZ-28). The land area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season (October-March). The details are presented in Appendix II.

3.3 Soil

Soil of the experimental area belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The experimental area was flat having available irrigation and drainage system. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depths were collected from the pots. The samples were collected in two times at before wheat cultivation and after wheat cultivation. The analyses were done by Soil

Resources and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Planting material

Seeds of Binamoog-8 were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh. Binamoog-8 is a summer mungbean variety released in 2010. This variety is a high yielding, short durated and early maturing variety. Plant height 35-40 cm. It takes 64-67 days for harvesting. It is obtained from seeds of MB-149 which were irradiated with 400 Gy dose of gamma ray. Maximum grain yield is about 2.2 tha^{-1} (av. 1.8 tha^{-1}). Seed is medium size with green shiny color. Seed contains higher protein (23%). Plants are short and tolerant to yellow mosaic virus (YMV) disease. This variety is suitable for cultivation in pulse growing areas of Bangladesh.

3.5 Experiment details

The experiment was conducted after the cultivation of wheat. Cowdung and vermicompost was applied in the pot @ 10 and 5 tha^{-1} respectively during wheat cultivation. After cultivation of wheat, mungbean was grown in that pot. During mungbean cultivation, previous organic manures applied pots were used to evaluate their residual effect (Appendix IV) in such a way where treatments were arranged as mentioned in the section 3.6.

3.6 Treatments

The following treatments were included in this experiment:

Factor A: Residual effect of organic fertilizers - 3 levels

i. O_0 = Control (No organic fertilizer)
ii. O_1 = Cowdung
iii. O_2 = Vermicompost

Factor B: Chemical fertilizer doses - 4 levels

i. F_0 = Control (No chemical fertilizer)
ii. F_1 = 50% of recommended dose of chemical fertilizer (RDF)
iii. F_2 = 75% of recommended dose of chemical fertilizer (RDF)
iv. F_3 = Recommended dose of chemical fertilizer (RDF)

N.B. The rate of cowdung, vermicompost and chemical fertilizer were mentioned in section 3.8.3.

3.7 Experimental design

The experiment was laid out in Factorial Experiment using Completely Randomized Design (CRD Factorial) with three replications. Three extra replication were sown in the experiment from where growth data were taken. There were 36 × 2 pots all together in the experiment. Organic fertilizers were arranged in the main plots and chemical fertilizers in the sub plots (Appendix V).

3.8 Conduction of the experiment

3.8.1 Seed collection

Seeds of Binamoog-8 were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh.

3.8.2 Preparation of pot

During wheat cultivation, the soil was collected from the experimental pot. The collected soil was sun dried, crushed and sieved properly. The soil and organic fertilizers were mixed well before placing the soils into the pots. For mungbean, amounts of fertilizers were mixed with the soil as per treatment of the experiment. Each pot was filled up with 18 kg soil. The size of the individual pot was 22 cm in diameter and 25 cm in height.

3.8.3 Fertilizer dose and method of application

Urea, TSP, MP, Gypsum, Zinc and Molybdenum were applied @ 30, 70, 35, 50, 3 and 1 kg per hectare, respectively for mungbean cultivation. All the fertilizers were mixed with with soil in full dose as per the treatment before mungbean seed sowing. Cowdung and vermicompost were applied in the pot @ 10 and 5 tha^{-1} for wheat cultivation. The residual effect of this two organic fertilizer was considered in the mungbean cultivation.

3.8.4 Seed sowing

Seeds were sown in the pot on 4 April, 2018. Eight seeds were used in each pot.

3.9 Intercultural operation

3.9.1 Gap filling and thinning

After seed sowing, continuous observation was done to observe the condition of the pot and seedlings. Strong observation and monitoring was made for thinning to maintain seedlings spacing requirement. Thinning was done to maintain spacing of the plants. No gap filling was needed. After 10 days after sowing 2 healthy seedlings were kept in each pot and others were thinned out from the experimental pots. But growth data were taken from the plants of the extra pots.

3.9.2 Weeding

Weeding was done as as when necessary to keep the pot weed free.

3.9.3 Irrigation

There was huge rainfall during the whole period of growth and till final harvest. However, irrigation were done as as when necessary to keep the pot moisten.

3.9.4 Plant protection measure

Just after sowing, some ants attacked the crop. Sevin powder was used in this regard. At early stage of growth few virus vectors (jassid) infested the young plants and at later stage of growth pod borer (*Maruca testulalis*) attacked the plant. Hairy caterpillar and pod borer were effectively controlled by the application of Diazinon 50 EC and Ripcord @ 1 L ha-1 on the time of 50% pod formation stage.

3.9.5 General observation of the experimental pots

Regular strict monitoring and evaluation was done for the observing of weed infestation,insect and pest attack and disease infestation . When weed infestation, insect and pest attack and disease infestation were found, an immediate remedy was taken to solve the problem.

3.9.6 Harvesting and processing

On different dates based on pods maturity the crop (pods) were harvested by hand picking. Harvesting of pods were done in three steps-first at 50% maturity, second at 25% maturity and third at rest of the pods maturity. The crop was finally harvested at maturity on 9th June, 2018. Seeds of the pods were separated and dried in the sun and then weighted. The seed weight was converted as seed yield plant^{-1} and seed yield tha^{-1}. After collecting of pods, the plants were cut down at the ground level and then the plants of each pot was bundled separately with tag mark indicating the respective treatment and brought to the threshing floor for drying. The bundles were dried in sunshine for 3–4 days and weighted in an electric balance. Then the stover weight was converted into tha^{-1}.

3.10 Data collection

Data collections from the experiment of crop were done under the following heads:

A. Growth characters data

i) Plant height (cm) (at 15, 30, 45 DAS and at harvest)

ii) Dry weight of plant (g) (at 15, 30, 45 DAS and at harvest)

B. Yield contributing characters data

iii) Pods plant^{-1}(no.)

iv) Pod length (cm)

v) Seeds pod^{-1}(no.)

vi) 1000 seed weight (g)

vii) Shelling percent (%)

C. Yield parameters data

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

ix) Stover yield (t ha^{-1})

x) Biological yield (t ha^{-1})

xi) Harvest index (%)

D. Seed quality parameter

The pot wise sun-dried seeds were used for quality assessment. The seeds were set for standard germination test in laboratory and the following data were recorded.

xii) Germination percentage (%)

xiii) Speed of germination

xiv) Seedlings shoot length (cm)

xv) Dry weight of seedlings (g)

xvi) Electric conductivity (EC) test

3.11 Procedures of recording data

A brief outline of the data recording procedure is given below:

3.11.1 Plant height

Plant height was measured at 15 days interval starting from 15 days after sowing (DAS) and continued up to harvest. Two plants were used for collecting plant height data from each pot. The height of the plants were measured from the ground level to the tip of the plant at 15, 30, 45 days after sowing (DAS) and at harvest. The collected data were finally averaged.

3.11.2 Dry weight of plant

The dry weight of plant was measured at 15 days interval starting from 15 days after sowing (DAS) and continued up to harvest. Two plants were selected randomly from each pot from the extra replicated pots. The dry weight of the plants was measured at 15, 30, 45 days after sowing (DAS) and at harvest. The selected two plants of each pot were dried by oven and weight data were taken by electric balance every time. The collected data were finally averaged and expressed as dry weight per plant.

3.11.3 Pods plant^{-1}

The number of pods were counted from the two plants of each pot and the average value was recorded as pods plant^{-1}.

3.11.4 Pod length

The pod length (cm) was measured with a meter scale from the randomly selected 10 pods of each pot and the average value was recorded as pod length per pod.

3.11.5 Seeds per pod

The number of seeds were counted from each randomly selected 20 pods and averaged them and then expressed as number of seeds pod^{-1}.

3.11.6 1000 seed weight (g)

One hundred (100) seeds from each pot were randomly selected and weighed by an electric balance after sun dried and then the weight was multiplied with 10 to convert as 1000 seed weight (g).

3.11.7 Shelling percentage

The weight of 20 pods and the grains of 20 pods were taken from each treatment and the mean results were recorded. Shelling percentage was calculated by the following formulae:

$$\text{Shelling percentage (\%)} = \frac{\text{Weight of seeds (g)}}{\text{Weight of pods (g)}} \times 100$$

3.11.8 Seed yield

Seeds harvested from all the two plants of each pot was sun dried and weighed carefully. The dry weight of the sun dried grain of the respective pot was recorded, and then divided by 2 for yield per plant. Then from the ideal spacing of Binamoog-8, number of plants of 1 ha was counted. Number of plants of 1 ha was multiplied by the yield per plant for obtaining the yield of 1 ha area and then calculated yield was converted into t ha^{-1} for each pot. The weight of seed was adjusted at 14% moisture content.

3.11.9 Stover yield

After separation of seeds from plant, the stover obtained from two plants of each pot was sun dried and weighed carefully. The dry weight of stover of the respective pot was recorded, and then divided by 2 for stover $plant^{-1}$. Then from the ideal spacing of Binamoog-8, number of plants of 1 ha was counted. Number of plants of 1 ha was multiplied by the stover yield per plant for obtaining the stover yield of 1 ha area and then calculated stover yield was converted into tha^{-1} for each pot.

3.11.10 Biological yield

Grain yield and straw yield were all together regarded as biological yield and calculated with the following formula:

Biological yield (t/ha) = Grain yield (t/ha) + Stover yield (t/ha)

3.11.11 Harvest index

Harvest index was calculated by using the following formula-

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (tha}^{-1}\text{)}}{\text{Biological yield (tha}^{-1}\text{)}} \times 100$$

3.11.12 Germination percentage (%)

Seeds obtained from each treatment were placed in petridish with sand media. There were 25 seeds in each petridish where replicated thrice. The number of sprouted and germinated seeds were counted daily commencing. Germination was recorded at 24 hrs interval and continued upto 6 days. The germination rate was calculated using the following formula-

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of total seeds set for germination}} \times 100.$$

3.11.13 Speed of germination

Speed of germination was calculated for each treatment by the following formula : (Czabator, 1962).

Speed of germination = $\frac{n1}{d1} + \frac{n2}{d2} + \frac{n3}{d3}$ + ------ + $\frac{n6}{d6}$

Where, n = number of germinated seeds, d = Number of days.

3.11.14 Seedlings shoot length

Randomly selected 10 seedlings of 10 days from each treatment were collected and cotyledons were removed from them and shoot was measured with a meter scale and the average value was recorded as shoot length per seedling.

3.11.15 Dry weight of seedling

10 seedlings were selected randomly from each treatment. After drying by oven, the dry weight of the seedlings were measured by electric balance . The collected data were finally averaged and expressed as dry weight per seedling.

3.11.16 Electric conductivity (EC) test

Assessment of seed vigor has long been an important tool of seed quality control programs and electrical conductivity test is one of the methods for assessment of seed vigor. Electrical conductivity (EC) test was done using EC meter (Model-CM-30-ET) and for this 50 g seed were soaked in 100 ml water for 24h before collecting the data.

3.12 Statistical analysis

The data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance (ANOVA) was done following the computer package Statistix10 program. The mean differences among the treatments were adjusted by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

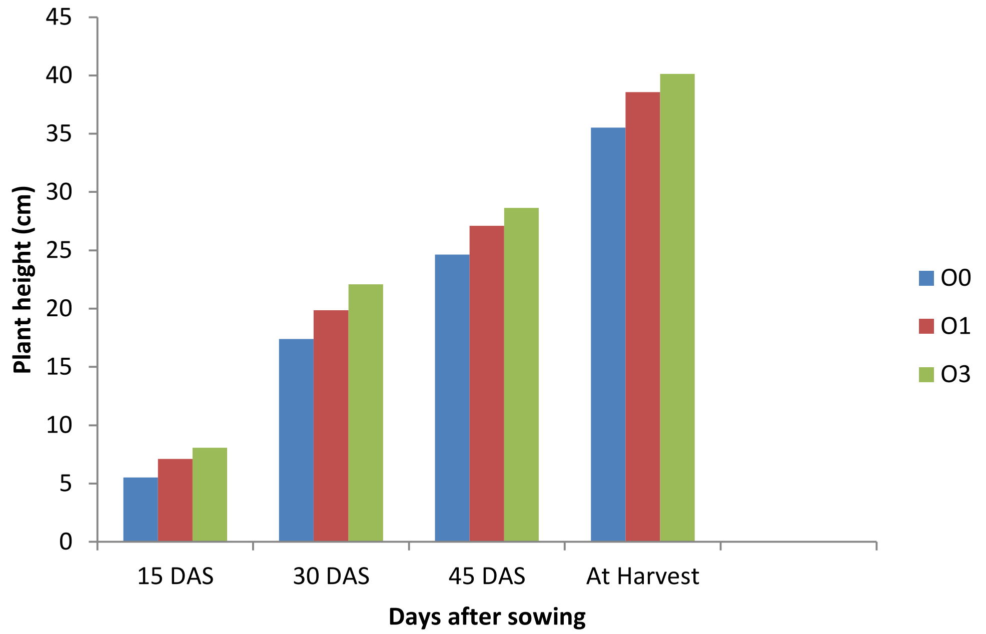
RESULTS AND DISCUSSION

The present experiment was conducted to observe the residual effect of organic fertilizer with different doses of chemical fertilizer on the yield and seed quality of mungbean. Data on different growth and yield parameters of mungbean were recorded. All the growth characters, yield attributing characters, yield and seed quality data were statistically analyzed and the results are presented and discussed with the help of either table or graphs. In order to understand the effect of treatments, the data have also been given in appendix tables for reference.

4.1 Growth characters

4.1.1 Plant height

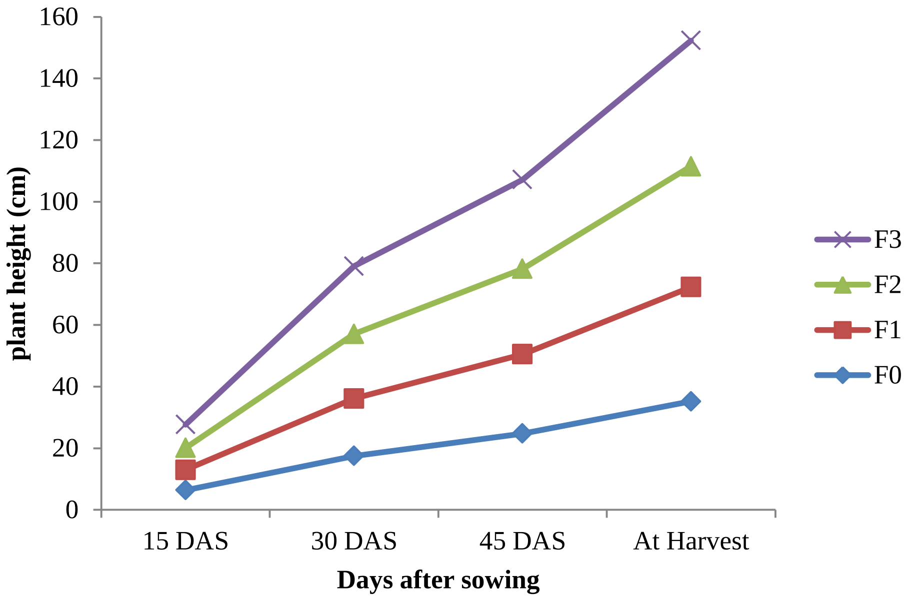
The plant heights of mungbean were significantly influenced by residual effect of organic fertilizers at 15, 30, 45 DAS and at harvest (Fig. 1 and Appendix VI). The figure revealed that plant height showed a gradual increase in trend with the advances of growth stages irrespective organic fertilizer treatment. However, at 15, 30, 45 DAS and at harvest the treatment O_2 (vermicompost) produced the tallest plant (8.08, 22.08, 28.63 and 40.13 cm respectively) and the treatment O_0 (control) produced the shortest plant (5.52, 17.39, 24.64 and 35.52 cm respectively). This results confirms the reports of Rekha et al. (2017) who reported that vermicompost can be exploited as a potent biofertilizer. The reasons behind obtaining higher plant height might be due to the contribution vermicompost application. The above result obtained in the study was in conformity with the results of Karmegam *et al.* (1999) who reported that application of vermicompost resulted in significant increase in plant height of mungbean.



O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost

Fig. 1 Residual effect of of organic fertilizer on plant height of mungbean at different days after sowing ($LSD_{(0.05)}$ = 0.53, 0.72, 1.20 and 1.40 at 15, 30, 45 DAS and harvest respectively).

Significant variation were observed on the plant height of mungbean at 15, 30, 45 DAS and at harvest because of different chemical fertilizer doses (Fig. 2 and Appendix VI). It can be inferred from the figure that irrespective fertilizer doses plant height increased sharply with the advancement of growth stages. The height increase was found at harvest. The F_3 (RDF) treatment showed its superiority in producing tallest plant at all sampling dates and F_0 (control) treatment showed the shortest plant. At 15, 30, 45 DAS and at harvest the treatment F_3 produced the tallest plant (7.53, 22.02, 28.95 and 40.82 cm respectively) and the treatment F_0 produced shortest plant (6.38, 17.47, 24.75 and 35.17 cm respectively). Sardana and Verma (1987) reported that with increasing fertilizer levels the height of mungbean increased significantly.



F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 2 Effect of different doses of chemical fertilizer on plant height of mungbean at different days after sowing ($LSD_{(0.05)}$ = 0.62, 0.83, 1.38 and 1.62 at 15, 30, 45 DAS and harvest respectively).

Interaction effect of residual effect of organic fertilizers and different doses of chemical fertilizer showed significant variation on plant height at 15, 30, 45 DAS and at harvest (Table 1 and Appendix VI). At 15 DAS, the highest plant height (8.78 cm) was observed from the treatment O_2F_3 which was statistically similar with O_2F_2 (8.46 cm) and 0_1F_3 (7.86 cm) and the lowest plant height (4.93 cm) was observed from the treatment O_0F_0 which was statistically similar with O_0F_1 (5.27 cm), O_0F_2 (5.92 cm) and O_0F_3 (5.96 cm). At 30 DAS, the highest plant height (24.13 cm) was observed from the treatment O_2F_3 and the lowest plant height (15.17 cm) was observed from the treatment O_0F_0. At 45 DAS, the highest plant height (30.61 cm) was observed from the O_2F_3 treatment and the lowest plant height (22.58 cm) was observeds from the O_0F_0 treatment. At harvest, the highest plant height (43.48 cm) was observed from the O_2F_3 treatment and the lowest plant height (33.28 cm) was observed from the O_0F_0 treatment. This result was in agreement with that of Abrabam and Lal (2003) reported that the effect of vermicompost in combination with inorganic fertilizers showed synergistic effect on the growth of mungbean.

Table 1. Interaction effect of residual value of organic fertilizer with different doses of chemical fertilizer on plant height of mungbean at different days after sowing

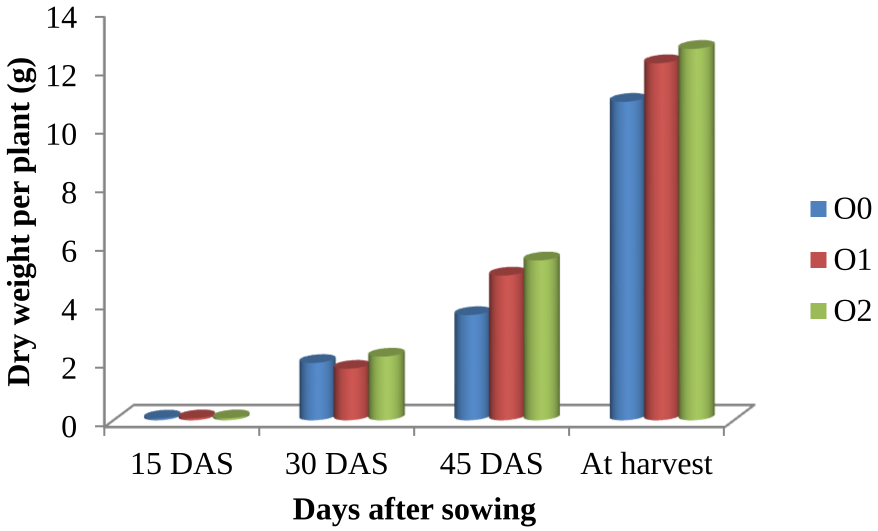
Treatment combination	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	At Harvest
O_0F_0	4.93 f	15.17 g	22.58 g	33.28 f
O_0F_1	5.27 f	16.95 f	23.92 fg	34.70 ef
O_0F_2	5.92 ef	18.17 ef	25.47 d-f	36.45 c-e
O_0F_3	5.96 d-f	19.28 de	26.58 c-e	37.65 cd
O_1F_0	6.80 c-e	17.43 f	24.92 e-g	35.91 d-f
O_1F_1	6.84 c-e	18.20 ef	25.77 c-f	37.96 cd
O_1F_2	7.00 cd	21.11 c	28.03 bc	39.05 bc
O_1F_3	7.86 a-c	22.67 b	29.67 ab	41.34 ab
O_2F_0	7.42 bc	19.81 cd	26.75 c-e	36.33 c-e
O_2F_1	7.67 bc	20.83 c	27.50 b-d	38.74 bc
O_2F_2	8.46 ab	23.56 ab	29.67 ab	42.00 a
O_2F_3	8.78 a	24.13 a	30.61 a	43.48 a
LSD (0.05)	**1.07**	**1.44**	**2.39**	**2.81**
CV (%)	**9.11**	**4.30**	**5.28**	**4.35**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost; F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

4.1.2 Plant dry weight

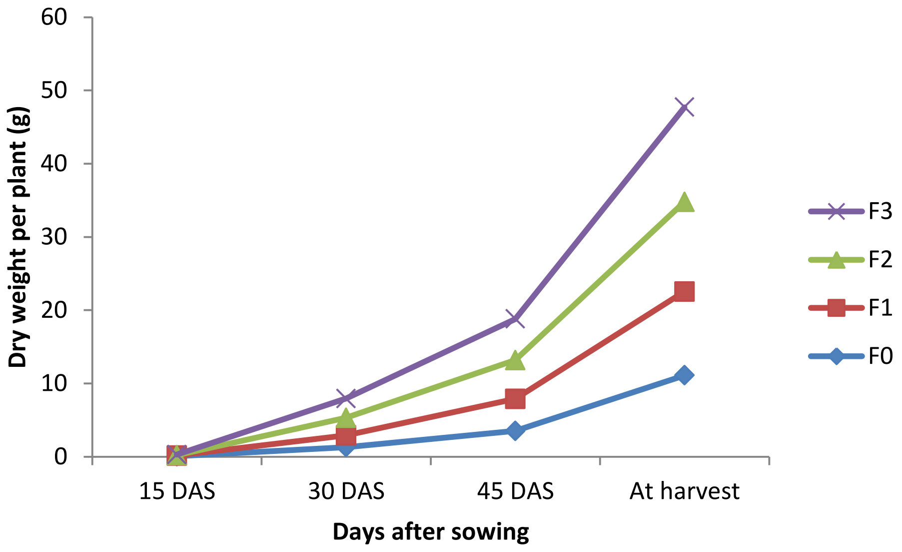
Effects of dry weight of plant in mungbean due to residual effect of organic fertilizer have been presented in Fig. 3 (Appendix VII). The figure showed a steady increasing trend with the advances of growth stages and the maximum increase was recorded at harvest stage, irrespective of organic fertilizer treatments. Vermicompost treatment (O_2) showed the maximum dry weight for all sampling dates followed by cowdung (O_1) and the lowest dry weight was found with O_0 (control) treatment. At 15, 30, 45 DAS and at harvest the treatment O_2 produced the highest dry weight of plant (0.07, 2.20, 5.50 and 12.69 g respectively). In case of 15, 45 DAS and at harvest, the lowest dry weight of plant are produced by the treatment O_0 (0.06, 3.63 and 10.89 g respectively) and in case of 30 DAS the lowest dry weight of plant is produced by O_1 treatment (1.78 g). Karmegam *et al.* (1999) found that vermicompost resulted total dry matter increased.



O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

Fig. 3 Residual effect of organic fertilizer on plant dry weight at different days after sowing of mungbean ($LSD_{(0.05)}$ = 4.051E-03, 0.15, 0.35 and 0.61 at 15, 30, 45 DAS and harvest, respectively).

Results of dry weight plant^{-1} due to different doses of chemical fertilizers have been presented in (Fig. 4 and Appendix VII). It can be inferred from the figure that irrespective fertilizer fertilizer doses, dry weight plant^{-1} increased gradually with the advances of growth stages. The rate of increase was much higher in later stage (45 DAS to at harvest) than early stage (15-45 DAS). It can be also inferred that F_3 (RDF) treatment was found superior than other doses for all sampling dates in producing dry weight plant^{-1}.



F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 4 Effect of chemical fertilizer on plant dry weight at different days after sowing of mungbean ($LSD_{(0.05)}$ = 4.68, 0.18, 0.40 and 0.70 at 15, 30, 45 DAS and at harvest respectively).

Significant variation was found in combined effect of residual effect of organic fertilizers and different doses of chemical fertilizer on plant dry weight at 15, 30, 45 DAS and at harvest (Table 2 and Appendix VII). At 15 DAS, the highest plant dry weight (0.07 g) was observed from the treatment O_2F_3 and the lowest plant dry weight (0.05 g) was observed from the treatment O_0F_2 which was statistically similar with O_0F_3 (0.06 g). At 45 DAS, the highest plant dry weight (2.83 g) was observed from the treatment O_2F_3 and the lowest plant dry weight (1.19 g) was observed from the treatment O_0F_0. At 45 DAS, the highest plant dry weight (6.87 g) was observed from the O_2F_3 treatment and the lowest plant dry weight (3.06 g) was observed from the O_0F_0 treatment. At harvest, the highest plant dry weight (13.71 g) was observed from the O_2F_3 treatment and the lowest plant dry weight (10.22 g) was observed from the O_0F_0 treatment. It was observed that application of recommended doses of chemical fertilizer with residual effect of vermicompost showed the highest dry matter of plant (O_2F_3 treatment). Channaveerswani (2005) reported that combined application of vermicompost @ 2.5 t per ha + RDF (25:50:50 kg NPK per ha) + copper ore tailing recorded higher seedling dry weight in groundnut. Kale *et al.* (1994) found that the application of vermicompost @ 5 t per ha + 50% RDF recorded significantly higher value of growth yield components and yield of sunflower compared to FYM @ 5 t per ha + RDF.

Table 2. Combined effect of residual value of organic fertilizer with different doses of chemical fertilizer on plant dry weight at different days after sowing

Treatment combination	Plant dry weight (g)			
	15 DAS	**30 DAS**	**45 DAS**	**At Harvest**
O_0F_0	0.06 bc	1.19 d	3.06 h	10.22 f
O_0F_1	0.07 ab	1.75 c	3.65 gh	10.41 ef
O_0F_2	0.05 d	2.24 b	4.12 fg	11.04 d-f
O_0F_3	0.06 cd	2.73 a	3.67 gh	11.89 cd
O_1F_0	0.06 bc	1.33 d	3.55 gh	11.46 c-e
O_1F_1	0.07 ab	1.23 d	4.41 ef	11.60 c-e
O_1F_2	0.07 b	2.20 b	5.62 cd	12.57 a-c
O_1F_3	0.07 a	2.34 b	6.34 ab	13.18 ab
O_2F_0	0.07 ab	1.40 d	3.90 fg	11.62 c-e
O_2F_1	0.07 ab	1.82 c	5.08 de	12.27 bc
O_2F_2	0.06 bc	2.73 a	6.13 bc	13.16 ab
O_2F_3	0.07 a	2.83 a	6.87 a	13.71 a
LSD (0.05)	**8.103e-03**	**0.3075**	**0.6971**	**1.2119**
CV (%)	**7.22**	**9.16**	**8.76**	**6.00**

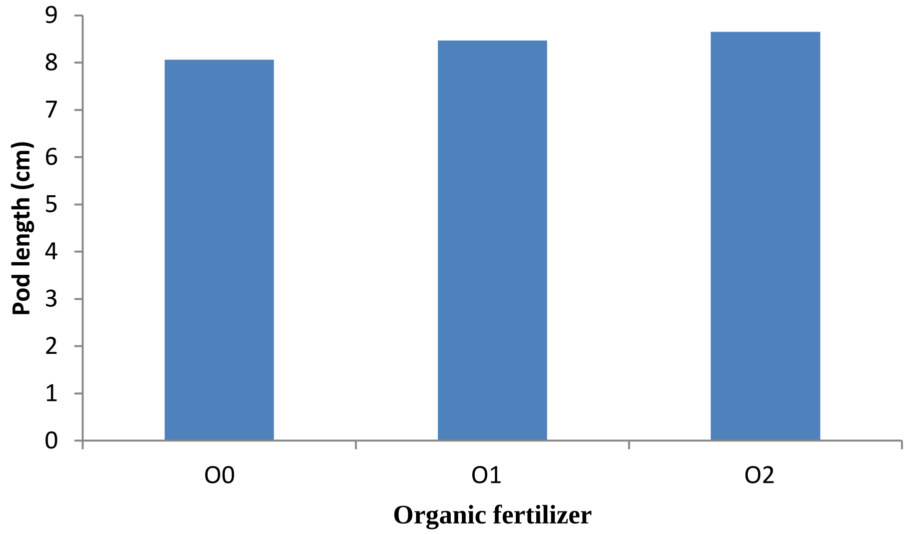
In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost; F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

4.2 Yield contributing characters

4.2.1 Pod length

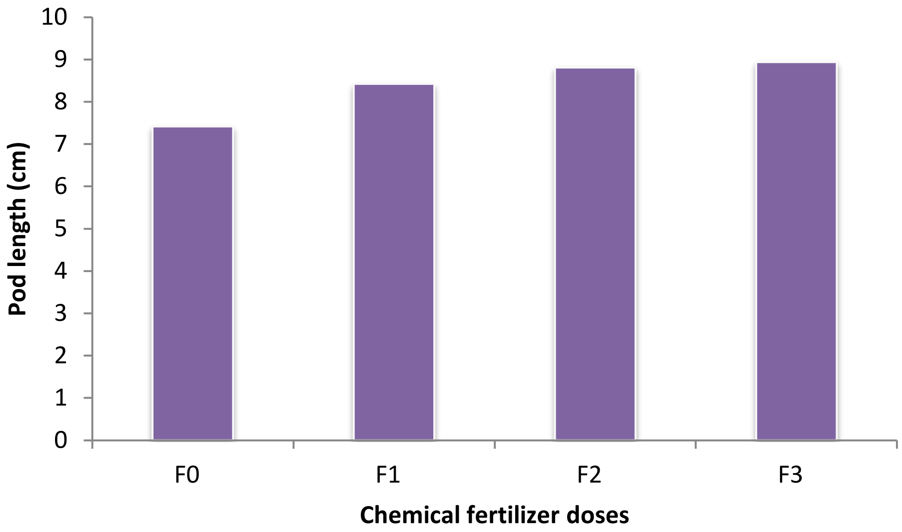
There observed a significant variation on pod length of mungbean due to residual effect of organic fertilizer (Fig. 5 and Appendix VIII). The data expresses that O_2 (Vermicompost) treatment was found superior in producing pod length (8.65 cm) than other treatments and the inferior treatment was O_0 (control) in producing pod length (8.06 cm) of mungbean.



O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

Fig. 5 Residual effect of organic fertilizer on pod length of mungbean ($LSD_{(0.05)}$ = 0.42)

Significant variation was observed in the length of pod of mungbean when different levels of fertilizer were applied (Fig. 6 and Appendix VIII). The highest length of pod (8.94 cm) was recorded in F_3 treatment which was statistically at par with F_2 treatment (8.81 cm). On the other hand, the lowest length of pod (7.42 cm) was recorded with F_0 (control) treatment. Azadi *et al.* (2013) also found that the highest pod length was obtained from higher fertilizer dose upto a certain limit which correlates with the present findings.



F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 6 Effect of chemical fertilizer on pod length per pod of mungbean ($LSD_{(0.05)}$ = 0.49)

Combined effect of organic fertilizer residue and chemical fertilizer exerted significant effect on pod length (Table 3 and Appendix VIII). All combined treatments gave significantly higher pod length over control except O_1F_0 and O_2F_0. The highest length of pod (9.21 cm) was observed in the treatment combination of O_2F_3 which was statistically similar with similar with O_2F_2, O_2F_1, O_1F_1, O_1F_2, O_1F_3, O_0F_2 and O_0F_3. On the other hand, the lowest length of pod (7.02 cm) was recorded with O_0F_0 treatment which was statistically at par with O_1F_0 and O_2F_0 combination. Similar result also reported by Sharma *et at* (1997) which supports the present findings.

Table 3 Combined effect of residual value of organic fertilizer with different doses of chemical fertilizer on yield contributes of mungbean

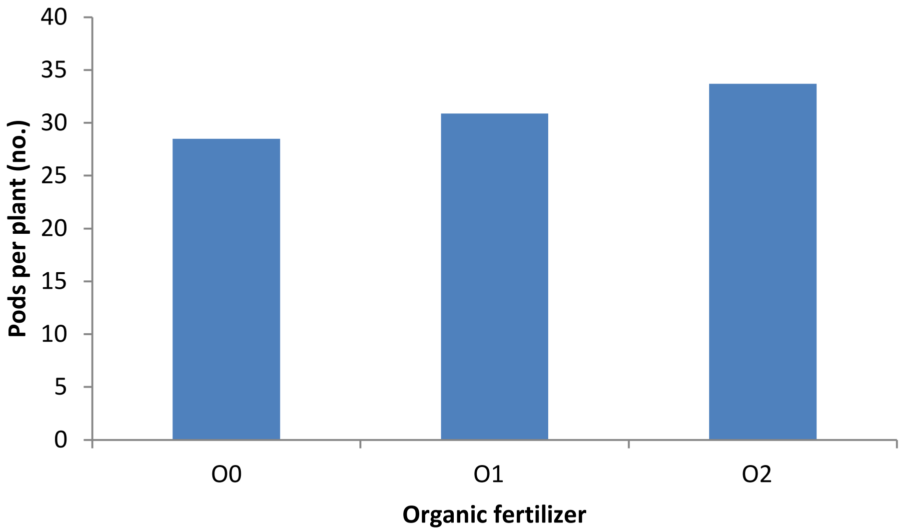
Treatment combination	Pod length (cm)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	1000 seed weight (g)	Shelling percent (%)
O_0F_0	7.02 e	23.18 g	10.61 e	37.07 c	67.57 b
O_0F_1	8.07 b-d	24.97 g	10.93 de	38.08 bc	68.07 ab
O_0F_2	8.60 a-c	32.27 cd	11.81 b-d	38.87 a-c	69.81 ab
O_0F_3	8.57 a-c	33.58 bc	12.01 a-c	39.08 a-c	70.20 ab
O_1F_0	7.45 de	28.70 f	11.13 c-e	38.46 bc	68.54 ab
O_1F_1	8.53 a-c	29.75 ef	11.73 b-d	38.87 a-c	69.61 ab
O_1F_2	8.85 ab	31.48 c-e	12.47 ab	39.46 a-c	70.94 ab
O_1F_3	9.05 a	33.58 bc	12.63 ab	40.77 ab	71.27 ab
O_2F_0	7.78 c-e	30.60 d-f	11.43 c-e	39.16 a-c	69.11 ab
O_2F_1	8.65 ab	32.58 cd	11.97 a-c	39.95 ab	70.11 ab
O_2F_2	8.97 a	35.31 ab	12.67 ab	40.72 ab	71.29 ab
O_2F_3	9.21 a	36.31 a	12.88 a	41.30 a	71.62 a
LSD (0.05)	**0.85**	**2.50**	**0.99**	**2.74**	**3.97**
CV (%)	**5.98**	**4.76**	**4.94**	**4.12**	**3.36**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost; F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

4.2.2 Pods plant^{-1}

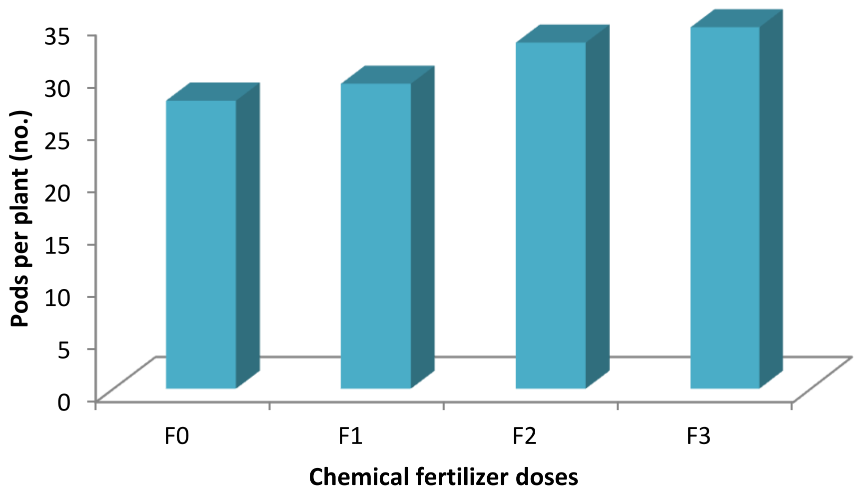
Statistically significant difference was found for number of pods plant^{-1} of mungbean due to residual effect of organic fertilizer (Fig. 7 and Appendix VIII). The highest number of pod plant^{-1} (33.70) was recorded from O_2 treatment, whereas, the lowest (28.50) was observed from O_0 treatment. It was observed that number of pod plant^{-1} increased with the residual effect of vermicompost and cowdung over control. Reddy *et al.* (1998) found that application of vermicompost and chemical fertilizer increased the number of pod per plant in mungbean.



O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

Fig. 7 Residual effect of organic fertilizer on number of pod per plant of mungbean ($LSD_{(0.05)}$ = 1.25)

The number of pod $plant^{-1}$ was significantly influenced by different doses of recommended chemical fertilizer (Fig. 8 and Appendix VIII). The figure shows that the highest number of pod $plant^{-1}$ (34.49) was obtained from F_3 treatment. On the other hand the lowest number of pod $plant^{-1}$ (27.49) was obtained from F_0 treatment. It was observed that number of pod $plant^{-1}$ increased gradually with the increase of fertilizer doses. This might be due to higher availability of N and P_2O_5 and their uptake that progressively increase photosynthesis and other physiological function of plant resulting in higher pod $plant^{-1}$.



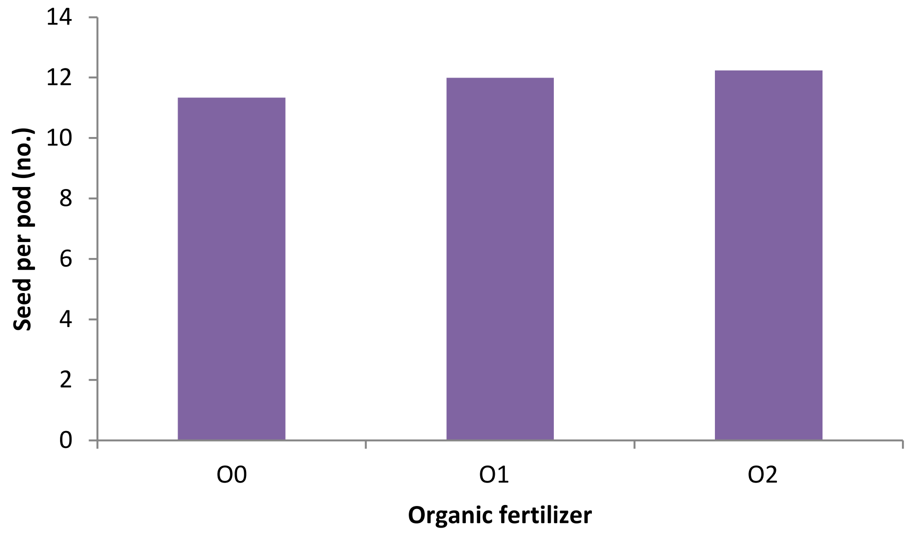
F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 8 Effect of chemical fertilizer on number of pod per plant of mungbean ($LSD_{(0.05)}$ = 1.44)

Number of pod plant^{-1} was significantly affected by the combination of effect of organic fertilizer residue and chemical fertilizer which is shown at (Table 3 and Appendix VIII). Residual effect of vermicompost with recommended dose of chemical fertilizer (O_2F_3) scored the maximum number of pod plant^{-1} (36.31) which was statistically at par with O_2F_2 (35.31) and minimum number of pod plant^{-1} (23.18) was recorded at no organic fertilizer residual effect with no use of chemical fertilizer combination (O_0F_0) which was statistically similar with O_0F_1 (24.97).

4.2.3 Seed pod^{-1}

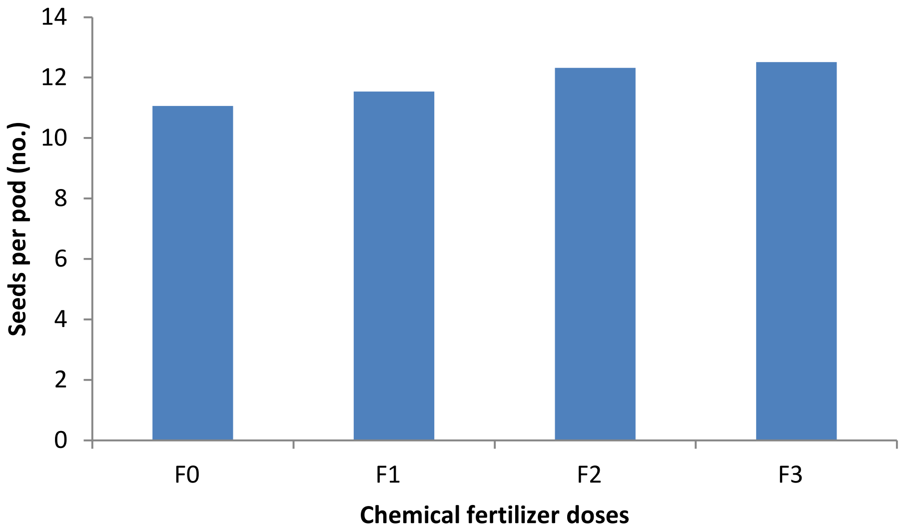
Number of seeds per pod of mungbean differed significantly due to residual effect of organic fertilizer (Fig. 9 and Appendix VIII). It was observed maximum number of seed per pod was (12.24) in O_2 (vermicompost) treatment which was statistically similar with O_1 (cowdung) treatment (11.99). The number of seeds per pod was found minimum (11.34) in O_0 treatment. It revealed that vermicompost have the greatest effect on seeds per pod of mungbean.



O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

Fig. 9 Residual effect of organic fertilizer on number of seed per pod of mungbean ($LSD_{(0.05)}$ = 0.50)

A critical analysis of mean data (Fig. 10 and Appendix VIII) revealed that different doses of chemical fertilizer had significant influence on seed per pod value. Seed per pod value increased with the increase of chemical fertilizer doses. Maximum seed per pod value (12.51) was recorded from F_3 treatment which was statistically at par with F_2 treatment (12.32). Minimum seed per pod value (11.06) was recorded at F_0 treatment which was stastically similar with F_1 treatment (11.54).



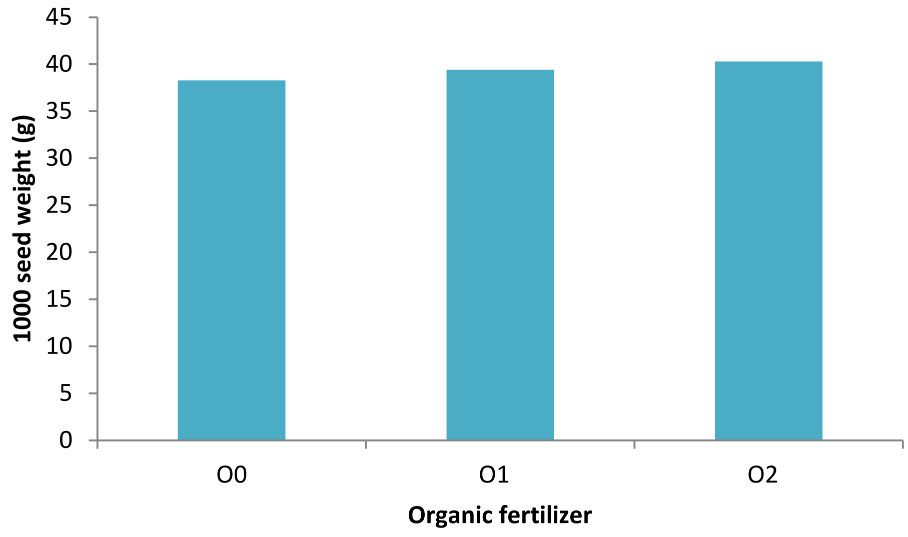
F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 10 Effect of chemical fertilizer on number of seed per pod of mungbean
($LSD_{(0.05)}$ = 0.57)

Interaction effect between residual effect of organic fertilizers and different doses of chemical fertilizer exerted significant effect on number of seeds per pod (Table 3 and Appendix VIII). The highest number of seed per pod (12.89) was observed from the O_2F_3 treatment which was statistically at par with the combine effect of O_2F_2, O_1F_3, O_1F_2, O_0F_3 and O_2F_1 (12.67, 12.63, 12.47, 12.01 and 11.97, respectively). The lowest number of seed per pod (10.61) was observed from the O_0F_0 treatment which was statistically similar with O_0F_1, O_1F_0 and O_2F_0 combination (10.93, 11.13 and 11.43, respectively).

4.2.4 1000 seed weight

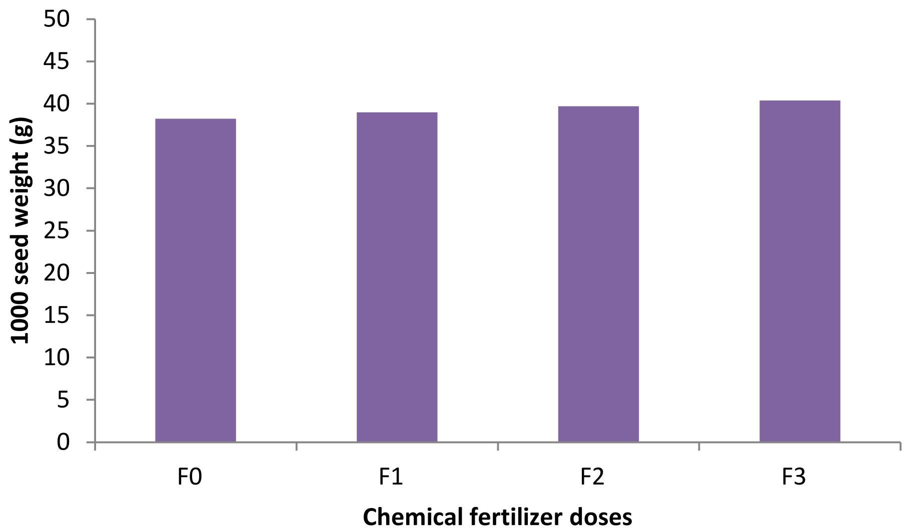
Significant variation was observed on weight of 1000 seed of mungbean due to residual effect of different organic fertilizers (Fig. 11 and Appendix VIII). The treatment O_2 produced the highest weight of 1000 seed (40.28 g) which was at par with O_1 treatment (39.39 g) and the O_0 produced the lowest 1000 seed weight (38.28 g). Raundal *et al.* (1999) also found similar result that vermicompost resulted increase in the weight of 1000 seed.



O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost

Fig. 11 Residual effect of organic fertilizer on 1000 seed weight of mungbean ($LSD_{(0.05)}$ = 1.37)

Significant variation was observed in 1000 seed weight of mungbean when different levels of fertilizer were applied (Fig. 12 and Appendix VIII). The figure shows that weight of 1000 seed of mungbean showed an increase trend with the increase of fertilizer level and highest increase was found with highest fertilizer dose (F_3). However, maximum weight of 1000 seed of mungbean (40.38 g) was recorded in F_3 treatment which was statistically at par with F_2 and F_1 treatment (39.68 and 38.97 g, respectively). On the other hand, minimum weight of 1000 seed of mungbean (38.23 g) was recorded with F_0 treatment which was statistically at par with F_1 and F_2 (38.97 and 39.68 g, respectively)



F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Fig. 12 Effect of chemical fertilizer on 1000 seed weight of mungbean ($LSD_{(0.05)}$ = 1.58)

The combined effect of different integration of organic fertilizer residue and different doses of chemical fertilizer showed statistically significant variation for 1000 seed weight of mungbean (Table 3 and Appendix VIII). The result revealed that the highest 1000 seed weight was observed in O_2F_3 (41.30 g) which was similar with all the combination except O_1F_0, O_0F_1 and O_0F_0 (38.46, 38.08 and 37.07, respectively) and the lowest 1000 seed weight (37.07 g) was recorded in O_0F_0 treatment. It is clearly observed that the application of vermicompost with different levels of chemical fertilizer showed better performance in producing 1000-seed weight of mungbean.

4.2.5 Shelling percent

Residual effect of organic fertilizer non-significantly affected the shelling percentage of mungbean (Table 4 and Appendix VIII). Numerically, the highest shelling percentage (70.54%) was calculated from vermicompost (O_2) treatment and that of lowest (68.91%) was found from control (O_0) treatment.

Table 4. Residual effect organic fertilizer on shelling percentage of mungbean

Organic fertilizer	**Shelling percentage**
O_0	68.91
O_1	70.09
O_2	70.54
LSD (5%)	**NS**
CV (%)	**3.36**

NS-Non-significant

O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost

Application of different doses of chemical fertilizer showed significant variation for shelling percentage of mungbean (%) (Table 5 and Appendix VIII). Recommended dose of chemical fertilizer (F_3) showed the highest shelling percentage (71.03%) which was statistically similar with F_2 and F_1 treatments (70.68 and 69.26%, respectively) and the lowest shelling percentage (68.40%) observed due to no application of chemical fertilizer in F_0 treatment.

Table 5 Effect chemical fertilizer on shelling percentage of mungbean

Fertilizer doses	Shelling percentage
F_0	68.40 b
F_1	69.26 ab
F_2	70.68 ab
F_3	71.03 a
LSD (5%)	**2.30**
CV (%)	**3.36**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Combined effect between residual effect of organic fertilizers and different doses of chemical fertilizer showed significant effect on shelling percentage (Table 3 and Appendix VIII). The highest shelling percentage (71.62%) was observed in O_2F_3 treatment which was statistically similar with all the combination except O_0F_0.The lowest shelling percentage (67.57%) was observed in O_0F_0 treatment which was statistically at par with all the combination except O_2F_3.

4.3 Yield parameter

4.3.1 Seed yield

It was noticed that statistically significant differences were found for seed yield of mungbean due to residual effect of organic fertilizer (Table 6 and Appendix IX). The result revealed O_2 treatment (vermicompost) showed the highest seed yield (2.03 tha^{-1}) which was 9.14 and 23.78% higher yield than O_1 (cowdung) and O_0 (control) treatments, respectively. On the other hand, O_0 (control) treatment gave the lowest yield (1.64 tha^{-1}).

It was observed that statistically significant differences were found for seed yield of mungbean due to different doses of chemical fertilizer (Table 7 and Appendix IX). It can be said from the table that seed yield increased gradually with the increase of fertilizer doses. The maximum seed yield (2.24 tha^{-1}) was recorded from F_3 treatment. On the contrary the minimum seed yield (1.48 tha^{-1}) was recorded from F_0 treatment. The result revealed that F_3 treatment out yielded over F_2, F_1 and F_0 by producing 15.46, 30.99 and 51.35% higher yield, respectively. The result is in agreement with the findings of Sadeghipour *et al.* (2010), who found that the maximum seed yield was obtained at higher fertilizer level.

Combined effect of residual effect of organic fertilizers and different doses of chemical fertilizer showed significant variation in seed yield of mungbean (Table 8 and Appendix IX). The highest seed yield (2.48 tha^{-1}) was recorded from the combination of O_2F_3 treatment which was statistically similar with O_1F_3 (2.33 tha^{-1}). The lowest yield (1.38 tha^{-1}) was recorded from the combination of O_0F_0 treatment which was statistically at par with O_1F_0 (1.50 tha^{-1}). Similar trends of result were reported by Raundal *et al. (1999)* and Satish *et al.* (1999). Combination of organic and inorganic fertilizers was found better by Channaveerswami (2005) in groundnut and Rajkhowa *et al.* (2002) in green gram than only inorganic fertilizers.

4.3.2 Stover yield

Stover yield was significantly influenced by the residual effect of organic fertilizer (Table 6 and Appendix IX). O_2 (vermicompost) treatment gave the highest stover yield of mungbean (4.86 tha^{-1}) and the lowest stover yield (3.64 tha^{-1}) was observed in O_0 (control) treatment.

Stover yield of mungbean varied significantly due to different doses of chemical fertilizer application (Table 7 and Appendix IX). Maximum stover yield (4.78 tha^{-1}) was observed from F_3 (RDF) treatment while minimum stover yield (3.90 tha^{-1}) from F_0 (control) which was statistically similar with F_1 (50% of RDF) treatment (4.17 tha^{-1}).

Combined effect between residual effects of organic fertilizers and different doses of chemical fertilizer showed significant effect on strover yield of mungbean (Table 8 and Appendix IX). All combined treatments gave significantly higher stover yield over control except O_0F_2 and O_0F_3. The highest strover yield (5.52 tha^{-1}) was observed in the O_2F_3 treatment combination which was statistically at par with O_2F_2 and O_1F_3 treatment (5.20 and 5.06 tha^{-1}, respectively). The lowest strove yield (3.25 t/ha) was observed in the O_0F_2 treatment combination which at par with O_0F_0 and O_0F_3 (3.67 and 3.77 tha^{-1}, respectively). Similar result was observed by Bharne *et al* (2003).

4.3.3 Biological yield

Significant variation was observed on biological yield of mungbean due to residual effect of organic fertilizers (Table 6 and Appendix IX). It was observed from the data that biological yield increased over control due to residual effect of organic fertilizers. Among the organic fertilizers, O_2 (vermicompost) showed the maximum yield (6.89 tha^{-1}. On the other hand, the minimum yield (5.28 tha^{-1}) was observed in the O_0 (control) treatment.

The effect of different doses of chemical fertilizer on biological yield of mungbean was also significant (Table 7 and Appendix IX). It was found from the table that biological yield increased gradually with the increase of fertilizer doses. The maximum biological yield (7.03 tha^{-1}) was produced from F_3 (RDF) treatment. On the other hand, the minimum (5.38 tha^{-1}) was observed in F_0 treatment. Sardana and Verma (1987) stated that the application of nitrogen, phosphorus and potassium fertilizers in combination resulted in the significant increase in biological yield of mungbean which supports the present findings.

Combined effects of residual effect of organic fertilizers and different doses of chemical fertilizer had significant effect on biological yield of mungbean (Table 8 and Appendix IX). The maximum biological yield (8.00 tha^{-1}) was observed in the treatment combination of O_2F_3 which was statistically similar with O_2F_2 and O_1F_3 treatment (7.42 and 7.39 tha^{-1}, respectively). On the other hand, the minimum biological yield (4.91 tha^{-1}) was recorded with O_0F_2 treatment combination which was statistically at par with O_0F_0, O_1F_0 and O_0F_1 treatment (5.05, 5.40 and 5.46 tha^{-1}, respectively). It can be explained from the table that biological yield increased with the residual effect of organic fertilizers with different doses of chemical fertilizer. This might be due to higher availability of nutrients that came from the combination of residual effect of organic fertilizers with different doses of chemical fertilizer that progressively increase the biological yield of the mungbean.

4.3.4 Harvest index

Significant difference was observed due to the residual effect of organic fertilizers on harvest index of mungbean (Table 6 and Appendix IX). Numerically, the highest harvest index (31.27%) was found in O_2 (vermicompost) treatment and lowet harvest index (29.37%) was obtained from the O_0 (control) treatment which was statistically at par with O_1 (cowdung) (29.67%).

Table 6. Residual effect organic fertilizer on yield and harvest index of mungbean

Organic fertilizer	Seed yield (tha^{-1})	Stover yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
O_0	1.64 c	3.64 c	5.28 c	29.37 b
O_1	1.86 b	4.41 b	6.27 b	29.67 b
O_2	2.03 a	4.86 a	6.89 a	31.27 a
LSD (5%)	**0.08**	**0.28**	**0.31**	**1.57**
CV (%)	**4.90**	**7.82**	**6.00**	**6.15**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

Harvest index was significantly influenced by different doses of chemical fertilizer application (Table 7 and Appendix IX). From the present study table showed that the highest harvest index (32.25%) was recorded in F_3 which was statistically at par with F_2 (31.20%). and the lowest harvest index (27.62%) was achieved by F_0 treatment which was statistically similar with F_1 (29.34%).

Table 7. Effect chemical fertilizer on yield and harvest index of mungbean

Fertilizer doses	Seed yield (tha^{-1})	Stover yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
F_0	1.48 d	3.90 c	5.38 d	27.62 b
F_1	1.71 c	4.17 bc	5.88 c	29.34 b
F_2	1.94 b	4.35 b	6.30 b	31.20 a
F_3	2.24 a	4.78 a	7.03 a	32.25 a
LSD (5%)	**0.09**	**0.33**	**0.36**	**1.81**
CV (%)	**4.90**	**7.82**	**6.00**	**6.15**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

Combined effect of residual effect of organic fertilizers and different doses of chemical fertilizer showed significant effect on harvest index of mungbean (Table 8 and Appendix IX). The highest harvest index (34.13%) was observed in the O_2F_3 treatment which was statistically similar with O_2F_2 and O_1F_3 treatment (34.05 and 31.64%, respectively). The lowest harvest index (27.37%) was observed in O_2F_0 treatment which was statistically at par with O_0F_0, O_1F_0, O_0F_1, O_2F_1, O_1F_1, O_1F_2 and O_0F_2 treatment (27.66, 27.83, 28.93, 29.52, 29.58, 29.64 and 29.91%, respectively).

Table 8. Combined effect of residual value of organic fertilizer with different doses of chemical fertilizer on yield and harvest index of mungbean

Treatment	Seed yield (tha^{-1})	Stover yield (tha^{-1})	Biological yield (tha^{-1})	Harvest index (%)
O_0F_0	1.38 f	3.67 de	5.05 d	27.66 d
O_0F_1	1.60 de	3.87 d	5.46 cd	28.93 cd
O_0F_2	1.67 d	3.25 e	4.92 d	29.91 cd
O_0F_3	1.92 c	3.77 de	5.69 c	30.99 bc
O_1F_0	1.50 ef	3.90 d	5.40 cd	27.83 d
O_1F_1	1.68 d	4.05 cd	5.73 c	29.58 cd
O_1F_2	1.94 c	4.62 bc	6.56 b	29.64 cd
O_1F_3	2.33 ab	5.06 ab	7.39 a	31.64 a-c
O_2F_0	1.57 de	4.13 cd	5.70 c	27.37 d
O_2F_1	1.86 c	4.58 bc	6.44 b	29.52 cd
O_2F_2	2.22 b	5.20 a	7.42 a	34.05 ab
O_2F_3	2.48 a	5.52 a	8.00 a	34.13 a
LSD (0.05)	**0.15**	**0.57**	**0.62**	**3.13**
CV (%)	**4.90**	**7.82**	**6.00**	**6.15**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost; F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

4.4 Seed quality parameter

4.4.1 Germination percentage

It is revealed that the nutrient management by organic fertilizer residue treatments showed significant effect on germination percentage on mungbean seed (Table 9 and Appendix X). The germination percentage value was significantly highest in treatment O_2 (89.50%) and it was statistically similar with O_1 (86.11%). The lowest value of germination percentage (83.92%) was recorded under control O_0 which was statistically similar with O_1 (86.11%).

Significant variation was observed on the germination percentage of mungbean when different doses of chemical fertilizer were applied (Table 10 and Appendix X). Maximum germination percentage of mungbean (91.98%) was recorded in F_3 treatment which was statistically similar with F_2 (89.27%). The minimum germination percentage of mungbean (79.22%) was recorded in the F_0 treatment.

The combined effect of different integration of organic fertilizer residual effect and different doses of chemical fertilizers expressed statistically significant variation for germination percentage of mungbean (Table 11 and Appendix X). The highest germination percentage (94.33%) of mungbean was observed in O_2F_3 treatment which was statistically at par with O_2F_2, O_1F_3, O_2F_1, O_1F_2 and O_0F_3 treatment (92.33, 92.27, 91.00, 90.15 and 89.34%, respectively) where the lowest germination percentage (78%) was observed in O_0F_0 treatment which was statistically at par with O_1F_0, O_2F_0, O_1F_1, O_0F_1 and O_0F_2 treatment (79.33, 80.33, 82.67, 83.00 and 85.33%, respectively).

4.4.2 Speed of germination

A significant difference was found in speed of germination due to residual effect of organic fertilizer (Table 9 and Appendix X). The highest speed of germination (9.54) was recorded from the O_2 treatment. The lowest speed of germination (8.62) was found from the O_0 treatment which was at par with O_1 treatment (8.95).

Speed of germination was significantly influenced by different doses of fertilizer application of (Table 10 and Appendix X). The data presented in the table showed an increasing trend on the value of speed of germination with the increases of fertilizer rate. This might be due to higher availability of fertilizer and their uptake that progressively increase the speed of germination of the plant. The maximum speed of germination (9.74) was recorded from treatment F_3 which was at par with F_1 treatment (9.38) whereas, the minimum (8.05) was found in F_0 treatment.

Combined effect between residual effect of organic fertilizer and different doses of chemical fertilizer showed significant effect on the value of speed of germination (Table 11 and Appendix X). The maximum speed of germination of mungbean (10.27) was observed in the O_2F_3 treatment which was statistically similar with O_2F_2, O_2F_1, O_1F_3, O_1F_2 and O_0F_3 and the minimum speed of germination (7.86) was observed in the O_0F_0 treatment which was statistically similar with O_0F_1, O_1F_0, O_1F_1, and O_2F_0.

4.4.3 Seedling shoot length

It was revealed that residual effect of organic fertilizer had significant effect on the seedling shoot length of Mungbean (Table 9 and Appendix X). The highest seedling shoot length (21.33 cm) was observed in the treatment O_2. On the other hand, the lowest seedling shoot length (18.83 cm) was recorded with O_0 treatment which was statistically similar with O_1 (cowdung) treatment (19.73).

Significant variation was found in the seedling shoot length of mungbean when different doses of chemical fertilizers were applied (Table 10 and Appendix X).The maximum seedling shoot length (21.62 cm) was recorded in F_3 treatment which was statistically similar with F_2 treatment (20.45 cm). On the other hand, the minimum seedling shoot length (18.47 cm) was recorded with F_0 treatment.

A significant effect was found by the combination between residual effect of organic fertilizer with different doses of chemical fertilizer on the seedling shoot length of mungbean (Table 11 and Appendix X). The maximum seedling shoot length of mungbean (22.67 cm) was obtained from the treatment combination of O_2F_3 which was statistically at par with O_2F_2, O_1F_3, O_2F_1, O_0F_3 and O_1F_2 treatment (21.73, 21.36, 20.93, 20.83 and 20.27 cm, respectively).On the other hand, the minimum seedling shoot length of Mungbean (17.25) was obtained from the treatment combination O_0F_0.

4.4.4 Dry weight of seedling

A significant difference was observed in the dry weight of seedlings due to residual effect of organic fertilizer (Table 9 and Appendix X). It was observed from the table that dry weight of seedlings increased with the cowdung and vermicompost over control. The highest dry weight of seedlings (0.034 g) was recorded from the O_2 treatment whereas, the lowest dry weight of seedlings (0.031 g) was found in O_0 treatment.

It was revealed that significant difference was found in dry weight of seedlings of mungbean due to different doses of chemical fertilizer (Table 10 and Appendix X). The data presented in the table showed an increasing trend with the increases of chemical fertilizer dose increase. The highest dry weight of seedlings (0.037 g) was recorded from F_3 treatment. The lowest dry weight of seedlings (0.031 g) was found from F_0 treatment.

The interaction effect of residual effect of organic fertilizer and different doses of chemical fertilizer on the seedling shoot length of mungbean was significant on dry weight of seedling (Table 11 and Appendix X). The highest dry weight of seedling (0.043 g) was recorded from the combination O_2F_3 treatment . On the contrary, the lowest dry weight of seedling (0.023 g) was recorded with O_0F_1 treatment combination.

4.4.5 Electric conductivity (EC) test

Electric conductivity test value of seed of mungbean differed significantly due to the different varieties (Table 9 and Appendix X). Lowest value of the EC test indicate highest vigor of seed of any crops. Electric conductivity test value of seed of mungbean was found minimum (1978.4 mS cm^{-1}) in O_2 treatment. The value of electric conductivity test of seed of mungbean was observed maximum (2326.3 mS cm^{-1}) in O_0 treatment.

Table 9. Residual effect organic fertilizer on on seed quality parameters of mungbean of Mungbean

Organic fertilizer	Germination percentage	Speed of germination	Seedling shoot length (cm)	Dry weight of seedling (g)	Electric conductivity (mS cm^{-1})
O_0	83.92 b	8.62 b	18.83 b	0.031 b	2326.3 a
O_1	86.11 ab	8.95 b	19.73 b	0.034 a	2047.1 b
O_2	89.50 a	9.53 a	21.33 a	0.034 a	1978.4 b
LSD (5%)	**3.67**	**0.56**	**1.22**	**1.55**	**113.73**
CV (%)	**5.01**	**7.25**	**7.20**	**5.50**	**6.34**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung , O_2 = Vermicompost

A significant difference was observed in electric conductivity test value due to different doses of chemical fertilizer (Table 10 and Appendix X). The highest EC test value (2807.4 mS cm^{-1}) was recorded from treatment F_0 whereas, the minimum (1697.6 mS cm^{-1}) was found in F_3 treatment.

Table 10. Effect chemical fertilizer on on seed quality parameters of mungbean of mungbean

Fertilizer doses	Germination percentage	Speed of germination	Seedlings shoot length	Dry weight of seedling (g)	Electric conductivity (mS cm^{-1})
F_0	79.22 c	8.05 c	18.47 c	0.033 b	2807.4 a
F_1	85.56 b	8.97 b	19.30 bc	0.031 c	2125.2 b
F_2	89.27 ab	9.38 ab	20.45 ab	0.032 bc	1838.7 c
F_3	91.98 a	9.74 a	21.62 a	0.037 a	1697.6 d
LSD (5%)	**4.24**	**0.64**	**1.22**	**1.546E-03**	**113.73**
CV (%)	**5.01**	**7.25**	**7.20**	**5.50**	**6.34**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

The combined effect of residual effect of organic fertilizer and different doses of chemical fertilizer was significant on EC test value of mungbean (Table 11 and Appendix X). The highest EC test value of mungbean (3126.7 mS cm^{-1}) was recorded from the combination O_0F_0 treatment. On the other hand, the lowest EC test value of mungbean (1628.1 mS cm^{-1}) was recorded with treatment O_2F_3.

Table 11. Combined effect of residual value of organic fertilizer with different doses of chemical fertilizer on seed quality parameters of mungbean

Treatment	Germination percentage (%)	Speed of germination	Seedlings shoot length (cm)	Dry weight of seedling (g)	Electric conductivity (mS cm^{-1})
O_0F_0	78.00 e	7.86 e	17.25 e	0.033 b	3126.7 a
O_0F_1	83.00 c-e	8.40 c-e	17.87 de	0.023 c	2339.3 c
O_0F_2	85.33 b-e	9.05 b-d	19.35 b-e	0.034 b	2013.1 d
O_0F_3	89.34 abcd	9.17 a-c	20.83 a-c	0.034 b	1826.1 de
O_1F_0	79.33 e	8.02 de	18.18 de	0.033 b	2743.3 b
O_1F_1	82.67 de	8.75 b-e	19.09 c-e	0.036 b	2049.0 d
O_1F_2	90.15 a-c	9.25 a-c	20.27 a-d	0.036 b	1757.3 e
O_1F_3	92.27 ab	9.78 ab	21.36 a-c	0.033 b	1638.7 e
O_2F_0	80.33 e	8.27 c-e	19.99 b-d	0.034 b	2552.3 bc
O_2F_1	91.00 ab	9.75 ab	20.93 a-c	0.035 b	1987.3 d
O_2F_2	92.33 ab	9.85 ab	21.73 ab	0.026 c	1745.7 e
O_2F_3	94.33 a	10.27 a	22.67 a	0.043 a	1628.1 e
LSD (0.05)	**7.34**	**1.11**	**2.43**	**3.09**	**227.45**
CV (%)	**5.01**	**7.25**	**7.20**	**5.50**	**6.34**

In a column means with having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability.

O_0 = Control, O_1 = Cowdung, O_2 = Vermicompost; F_0 = Control, F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3 = Recommended dose of chemical fertilizer

CHAPTER V

SUMMARY AND CONCLUSION

The pot experiment was conducted at the net house of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka during the period from April 2018 to June 2018 to study the residual effect of organic fertilizer and different doses of chemical fertilizer on yield and seed quality of mungbean. The experimental area belongs to the Agro-Ecological Zone (AEZ) of "The Modhupur Tract"(AEZ-28). The land area is situated at 23°41′N latitude and 90°22′E longitude at an altitude of 8.6 meter above sea level. The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in kharif season (April-September) and less rainfall associated with moderately low temperature during the rabi season. Soil of the experimental area belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. The land was above flood level and sufficient sunshine was available during the experimental period. The experiment consisted of two factors. Factor A: organic fertilizer management(3 levels); O_0 = Control, O_1 = Cowdung ,O_2 = Vermicompost. Factor B: chemical fertilizer doses (4 levels); F_0 = Control,F_1 = 50% of recommended dose of chemical fertilizer, F_2 = 75% of recommended dose of chemical fertilizer, F_3= Recommended dose of chemical fertilizer. The data were compiled and tabulated in proper form and were subjected to statistical analysis. Analysis of variance (ANOVA) was done following the computer package Statistix10 program. The mean differences among the treatments were adjusted by least significant difference (LSD) test at 5% level of significance. The variety Binamoog-8 was used in this experiment as the test crop. The experiment was laid out in two factors Factorial Experiment using Completely Randomized Design (CRD Factorial) with three replications.

Different growth characters, yield contributing characters, yield and seed quality parameters were significantly influenced by residual effect of different organic fertilizer. The tallest plant (40.13 cm) was obtained from O_2, while the shortest plant (35.52 cm) was obtained from O_0 treatment at harvest. The maximum and minimum dry weight per plant (12.69 g) and (10.89 g) was obtained from treatment O_2 and O_0 treatment, respectively at harvest. The highest and lowest length of pod (8.65 cm) and (8.06 cm) was recorded in O_2 and O_0 treatment, respectively. The highest and lowest pods plant^{-1} (33.70 and 28.50), seeds per pod (12.24 and 11.34), 1000 seed weight (40.282 g and 38.28 g) was recorded in O_2 and O_0 treatment, respectively. The maximum and minimum shelling percentage (70.54%) and (68.91%) was recorded in O_2 and O_0 treatment, respectively. The highest and lowest seed yield (2.03 tha^{-1} and 1.64 tha^{-1}), stover yield (4.86 tha^{-1} and 3.64 tha^{-1}), biological yield (6.89 tha^{-1} and 5.28 tha^{-1}), harvest index (31.27% and 29.37%) was recorded in O_2 and O_0 treatment, respectively. The highest and lowest germination percent (89.50% and 83.92%), speed of germination (9.54 and 8.62), seedling shoot length (21.33 cm and 18.83 cm), dry weight of seedling (0.034 g and 0.031 g) was recorded in O_2 and O_0 treatment, respectively. The highest and lowest EC test value (2326.3 mS cm^{-1} and 1978.4 mS cm^{-1}) was found in O_0 and O_2 treatment, respectively.

Different growth characters, yield contributing characters, yield and seed quality parameters were significantly influenced by different doses of chemical fertilizer. The tallest plant (40.82 cm) was obtained from F_3, while the shortest plant (35.17 cm) was obtained from F_0 treatment at harvest. The maximum and minimum dry weight per plant (12.93 g) and (11.10 g) was obtained from treatment F_3 and F_0 treatment, respectively at harvest. The highest and lowest length of pod (8.94 cm) and (7.42 cm) was recorded in F_3 and F_0 treatment, respectively. The highest pods per plant (34.49) were obtained from F_3 treatment while the lowest pods per plant (27.49) were obtained from F_0 treatment. The highest and lowest seeds per pod (12.51 and 11.06), 1000 seed weight (40.38 g and 38.23 g) was recorded in F_3 and F_0 treatment, respectively. The maximum and minimum shelling percentage (71.03%) and (68.40%) was recorded in F_3 and F_0 treatment, respectively. The highest and lowest seed yield (2.24 tha^{-1} and 1.48 tha^{-1}), stover yield (4.78 tha^{-1} and 3.90 tha^{-1}), biological yield (7.03 tha^{-1} and 5.38 tha^{-1}), harvest index (32.25% and 27.62%) was recorded in F_3 and F_0 treatment, respectively. The highest and lowest germination percent (91.98% and 79.22%), speed of germination (9.74 and 8.05), seedling shoot length (21.62 cm and 18.47 cm), dry weight of seedling (0.037 g and 0.031 g) was recorded in F_3 and F_0 treatment, respectively. The highest and lowest EC test value (2807.4 mS cm^{-1} and 1697.6 mS cm^{-1}) was found in F_0 and F_3 treatment, respectively.

Different growth characters, yield contributing characters, yield and seed quality parameters were significantly influenced by residual effect of organic fertilizer and different doses of chemical fertilizer. The tallest plant (43.48 cm) was obtained from O_2F_3, treatment combination while the shortest plant (33.28 cm) was obtained from O_0F_0 treatment combination at harvest. The maximum and minimum dry weight per plant (13.710 g) and (10.22 g) was obtained from treatment O_2F_3 treatment combination and O_0F_0 treatment combination, respectively at harvest. The highest and lowest length of pod pod^{-1} (9.21 cm) and (7.02 cm) was recorded in O_2F_3 treatment combination and O_0F_0 treatment combination, respectively. The highest pods per plant (36.31) were obtained from O_2F_3 treatment combination while the lowest pods per plant (23.18) were obtained from O_0F_0 treatment combination. The highest and lowest seeds per pod (12.88 and 10.61), 1000 seed weight (41.30 g and 37.07 g) was recorded in O_2F_3 and O_0F_0 treatment combination, respectively. The maximum and minimum shelling percentage (71.62%) and (67.57%) was recorded in O_2F_3 and O_0F_0 treatment, respectively. The highest and lowest seed yield (2.48 tha^{-1} and 1.37 tha^{-1}) was recorded in O_2F_3 and O_0F_0 treatment, respectively. The highest and lowest stover yield (5.52 tha^{-1} and 3.25 tha^{-1}), biological yield (8.00 tha^{-1} and 4.92 tha^{-1}) was recorded in O_2F_3 and O_0F_2 treatment, respectively. The highest and lowest harvest index (34.13% and 27.37%) was recorded in O_2F_3 and O_2F_0 treatment, respectively. The highest and lowest germination percent (94.33% and 78%), speed of germination (10.27 and 7.86), seedling shoot length (22.67 cm and 17.25 cm), dry weight of seedling (0.0343 g and 0.0233 g) was recorded in O_2F_3 and O_0F_0 treatment, respectively. The highest and lowest EC test value (3126.7 mS cm^{-1} and 1628.1 mS cm^{-1}) was found in O_0F_0 and O_2F_3 treatment, respectively.

Based on the experimental results, it may be concluded that-

i) Residual effect of vermicompost had a great positive effect on yield contributing characters, yield and seed quality in mungbean,

ii) Chemical fertilizers at recommended dose seems to be suitable for higher yield and quality seed production of mungbean, and

iii) The combined application of vermicompost as residual effect with recommended dose of chemical fertilizers may be recommended for seed production of mungbean.

RECOMMENDATION

The study was undertaken at the environment of Sher-e-Bangla Agricultural University which may not be similar to those of the rural farmer's field environment. Moreover, the soil condition and nutritional status of the Sher-e-Bangla Agricultural University is different from the farmer's field. So, results obtained from this study may not be applicable in the farmer's field. To optimize the obtained technology in this study, the trial must be repeated on-farm in the farmer's field at different ecological regions of Bangladesh.

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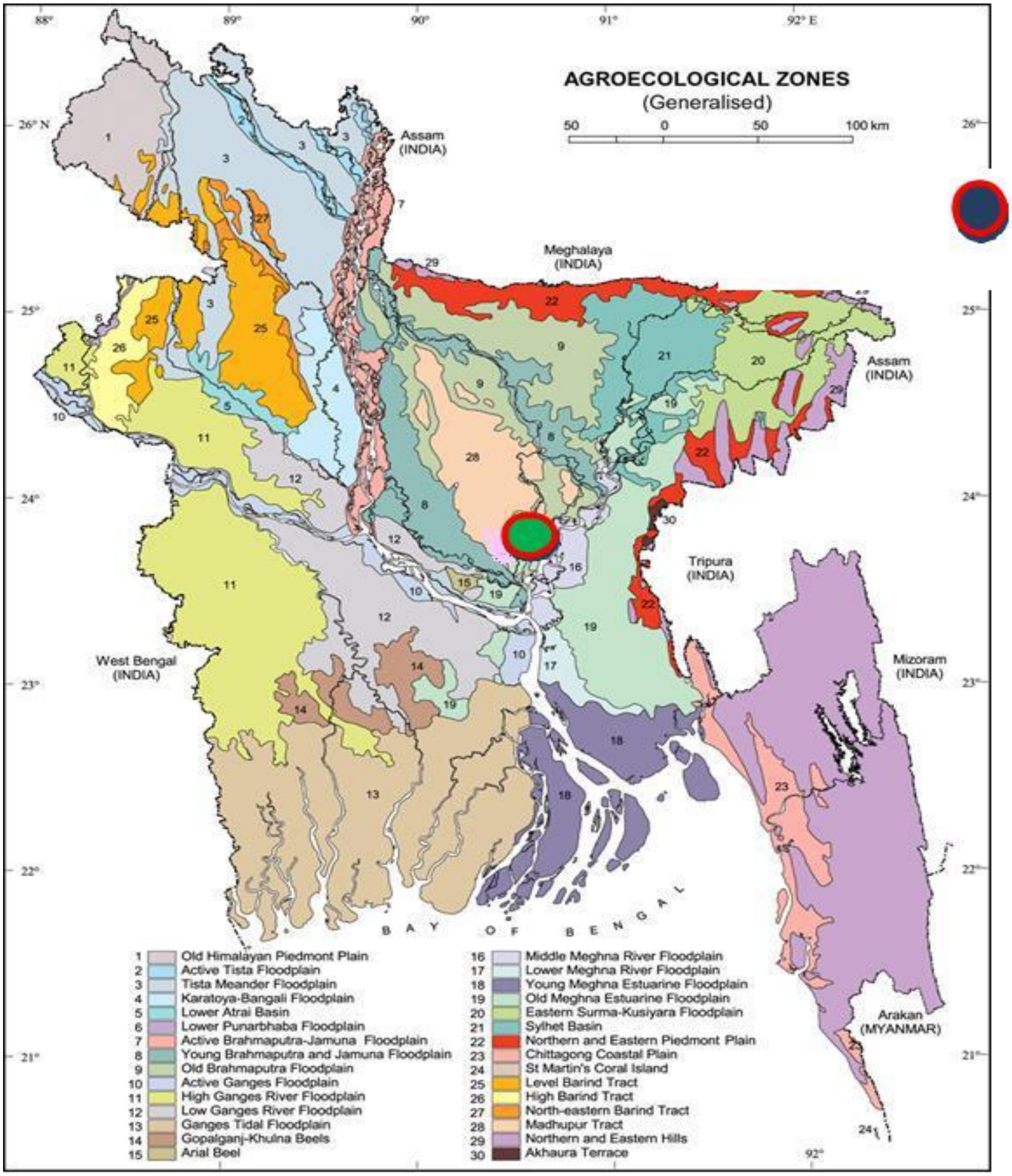
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Monthly meteorological information during the period from March to June, 2018

Year	Month	Air temperature (^{0}C)		Relative Humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2108	March	33.83	15.20	55.96	65
	April	34.92	17.51	67.43	48
	May	33.91	18.60	58.63	137
	June	30.49	21.80	71.53	286

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix III. Morphological characteristics of the experimental field

Morphology	Characteristics
Location	SAU Farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ- 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Terrace
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

Source: Soil Research and Development Institute, Farmgate, Dhaka

Appendix IV. Soil analysis result of the experimental pot in wheat-mungbean-T.aman rice cropping pattern

Treatment	P^H	Organic matter (%)	Total nitrogen (%)	Potassium (100 g soil)	Phosphorus µg/g (ppm)	Sulpher µg/g (ppm)	Boron µg/g (ppm)	Zinc µg/g (ppm)
Initial soil	5.9	2.08	0.104	0.34	60.75	7.54	0.30	13.72
After cultivation of wheat								
Control	6.7	2.62	0.131	1.80	113.96	5.50	0.17	14.56
Cowdung	6.7	2.76	0.138	0.49	93.13	5.94	0.60	18.42
Vermicompost	6.5	2.49	0.125	0.39	84.85	14.21	0.08	17.54

Source: Soil Resource Development Institute (SRDI), Farmgate,Dhaka

R1	R2	R3
O_0F_0	O_0F_0	O_0F_0
O_0F_1	O_0F_1	O_0F_1
O_0F_2	O_0F_2	O_0F_2
O_0F_3	O_0F_3	O_0F_3
O_1F_0	O_1F_0	O_1F_0
O_1F_1	O_1F_1	O_1F_1
O_1F_2	O_1F_2	O_1F_2
O_1F_3	O_1F_3	O_1F_3
O_2F_0	O_2F_0	O_2F_0
O_2F_1	O_2F_1	O_2F_1
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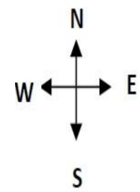
O_2F_3	O_2F_3	O_2F_3



O_0 = Control,
O_1 = Cowdung
O_2 = Vermicompost

F_0 = Control,
F_1 = 50% of RDF,
F_2 = 75% of RDF,
F_3 = 100% RDF

Unit Pot area = 0.1297 m^2

Row to row distance = 30.48 cm

Plant to plant spacing = 7.62 cm

Appendix V: Pot arrangement of the Factorial Experiment using Completely Randomized Design (CRD Factorial)

Appendix VI. Analysis of variance of the data on plant height at different days after sowing of mungbean as influenced by organic fertilizer residue,chemical fertilizer and also their combination

Source of variation	Degrees of freedom	Mean square			
		Plant height			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	2.41	2.83	10.88	6.67
Factor A	2	20.12*	66.04*	48.73*	66.17*
Factor B	3	2.45*	38.99*	32.52*	54.17*
A × B	6	0.15	0.76	0.26	1.70
Error	22	0.30	0.72	1.99	2.75

*Significant at 5% level

Appendix VII. Analysis of variance of the data on plant dry weight at different days after sowing of mungbean as influenced by organic fertilizer residue,chemical fertilizer and also their combination

Source of variation	Degrees of freedom	Mean square			
		Plant dry weight			
		15 DAS	30 DAS	45 DAS	At harvest
Replication	2	2.837E-04	0.17	2.03	9.90
Factor A	2	2.566E-04*	0.53*	11.20*	10.40*
Factor B	3	1.172E-04*	3.57*	8.22*	6.13*
A × B	6	7.389E-05*	0.09*	0.99*	0.08
Error	22	2.290E-05	0.03	0.17	0.51

*Significant at 5% level

Appendix VIII. Analysis of variance of the data on yield contributing parameters of mungbean as influenced by organic fertilizer residue,chemical fertilizer and also their combination

Sources of variation	Degrees of Freedom	Mean square of yield contributing parameters				
		Length of pod (cm)	pod/plant (No.)	Seeds/pod (No.)	1000 seed weight	Shelling percentage
Replication	2	7.20	57.25	10.96	43.64	1069.44
Factor A	2	1.09*	81.32*	2.58*	12.13*	8.45
Factor B	3	4.29*	96.49*	4.11*	7.73	13.54
A × B	6	0.02	9.12*	0.01	0.20	0.08
Error	22	0.25	2.18	0.34	2.62	5.50

*Significant at 5% level

Appendix IX: Analysis of variance of the data on yield parameters of mungbean as influenced by organic fertilizer residue,chemical fertilizer and also their combination

Sources of variation	Degrees of Freedom	Mean square of yield contributing parameters			
		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.40	4.01	6.87	12.32
Factor A	2	0.46*	4.58*	7.91*	12.44*
Factor B	3	0.96*	1.24*	4.36*	37.76*
A × B	6	0.03	0.50*	0.78*	4.89
Error	22	0.01	0.11	0.14	3.42

*Significant at 5% level

Appendix X Analysis of variance of the data on seed quality parameters of mungbean as influenced by organic fertilizer residue,chemical fertilizer and also their combination

Sources of variation	Degrees of Freedom	Mean square of yield contributing parameters				
		Germination percentage (%)	Speed of germination	Seedlings shoot length (cm)	Dry weight of seedlings (g)	Electric conductivity (EC) value
Replication	2	564.30	12.33	26.35	8.100E-05	1020241
Factor A	2	94.86*	2.57*	19.29*	4.225E-05*	407501*
Factor B	3	274.77*	4.78*	16.95*	5.256E-05*	2190330*
A × B	6	11.11	0.15	0.21	9.258E-05*	20302
Error	22	18.78	0.43	2.06	3.333E-06	18043

*Significant at 5% level

PLATES

Plate 1. Experimental view in the net house

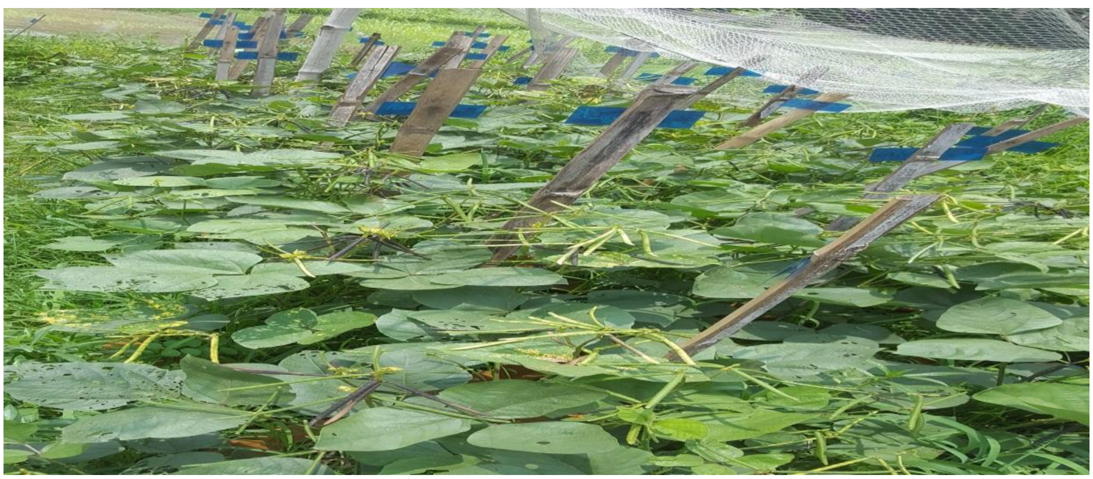


Plate 2. Crop in pod filling stage

Plate 3. Mature pods

Plate 4. Harvesting of mature pods

Plate 5. Germination test in the laboratory

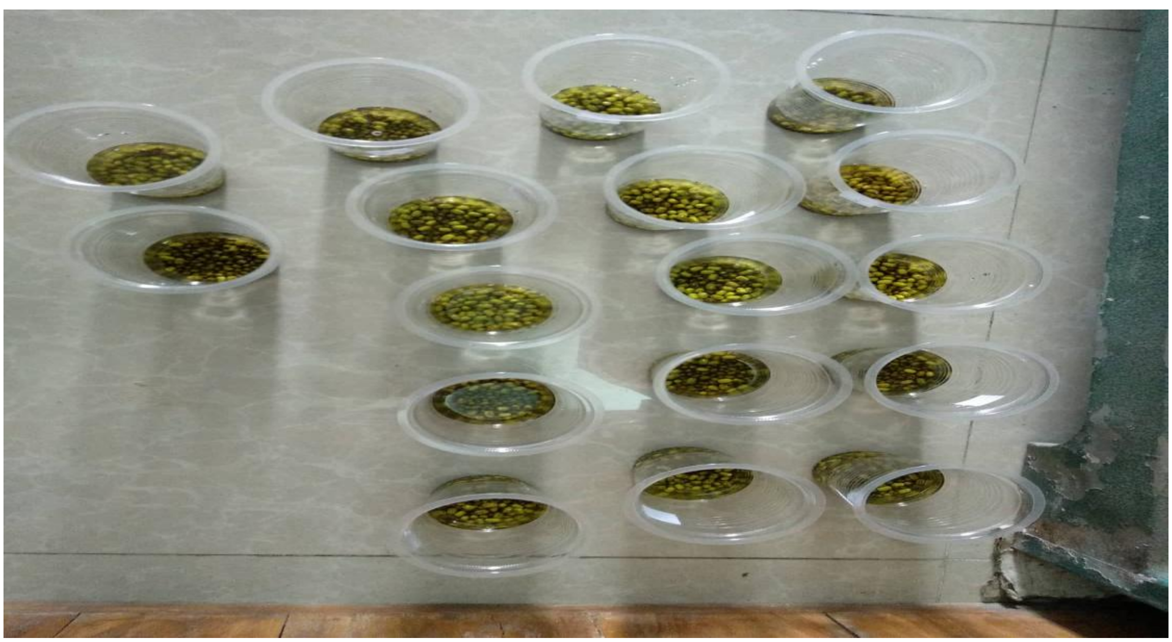


Plate 6. View of the EC test