FEASIBILITY OF REDUCING CHEMICAL FERTILIZER BY USING ORGANIC FERTILIZER IN LENTIL

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This is to certify that the thesis entitled "**Feasibility of Reducing Chemical Fertilizer by Using Organic Fertilizer in Lentil**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Md. Muraduzzaman**, Registration number: **15-06951** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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DEDICATED TO

MY

BELOVED PARENTS

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FEASIBILITY OF REDUCING CHEMICAL FERTILIZER BY USING ORGANIC FERTILIZER IN LENTIL

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to March 2016 to study the feasibility of reducing chemical fertilizer by using organic fertilizer in lentil. The experiment comprised of 11 treatments, such as T_0: Control condition; T_1: All chemical fertilizers as recommended dose (RD); T_2: Cowdung as RD + 75% chemical fertilizer as RD; T_3: Cowdung as RD + 50% chemical fertilizer as RD; T_4: Cowdung as RD + 25% chemical fertilizer as RD; T_5: Vermi-compost as RD + 75% chemical fertilizer as RD; T_6: Vermi-compost as RD + 50% chemical fertilizer as RD ; T_7: Vermi-compost as RD + 25% chemical fertilizer as RD; T_8: Poultry Manure as RD + 75% chemical fertilizer as RD and T_9: Poultry Manure as RD + 50% chemical fertilizer as RD and T_{10}: Poultry Manure as RD + 25% chemical fertilizer as RD. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth characters and yield were recorded. Among the treatments, all chemical fertilizers as recommended dose (T_1) was found superior considering all yield contributing characters (grain yield, stover yield) and yield. The treatments T_5 (Vermi-compost as RD + 75% chemical fertilizer as RD) and T_8 (Poultry Manure as RD + 75% chemical fertilizer as RD) also showed statistically similar results in respect of grain yield and most of the yield contributing characters. So, it is possible to reduce the use of chemical fertilizers by combined use of organic and chemical fertilizers without significant yield loss in lentil.

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LIST OF ACRONYMS

%	=	Percent
^0C	=	Degree Centigrade
AEZ	=	Agro-Ecological Zone
BARC	=	Bangladesh Agricultural Research Council
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
cv.	=	Cultivar
DAS	=	Days after sowing
et al.	=	and others
FAO	=	Food and Agriculture Organization
g	=	gram
HI	=	Harvest Index
kg	=	Kilogram
kg/ha	=	Kilogram/hectare
m	=	Meter
Max	=	Maximum
Min	=	Minimum
MP	=	Muriate of Potash
N	=	Nitrogen
No	=	Number
P^H	=	Hydrogen ion concentration
RCBD	=	Randomized Complete Block Design
SAU	=	Sher-e-Bangla Agricultural University
SE	=	Standard Errors
SRDI	=	Soil Resources and Development Institute
TSP	=	Triple Super Phosphate
UN	=	United Nations
UNDP	=	United Nations Development Program
Wt	=	Weight

Chapter I

Introduction

CHAPTER I
INTRODUCTION

Lentil is one of the most important pulse crops in Bangladesh because of their importance as food, feed, and in cropping systems. It contains about twice as much protein as cereals. It also contains amino acid lysine which is generally deficient in food grains (Elias *et al.*, 1986). Its edible grain is characterized by good digestibility, flavor, high protein content and absence of any flatulence effects. Its seed contains protein, fat, fiber and ash as well as sufficient quantity of calcium, phosphorus and important vitamins. Due to its supply of cheaper protein source, it is designated as “poor man’s meat”. Pulses have played an important role in sustaining the productivity of soils in Bangladesh for centuries. They are generally grown without fertilizer since they can meet their nitrogen requirement by symbiotic fixation of atmospheric nitrogen in the soil (Senanayake *et al.*, 1987; Zap; Middleboe *et al.*, 1977). The per capita consumption of pulse in Bangladesh is only 12g/day, which is much lower than WHO recommendation of 45 g/day (Afzal *et al.*, 1999).

Average yield of lentil in Bangladesh is very low, which is primarily due to substandard methods of cultivation, poor crop stand, imbalanced fertilizers application, poor plant protection measures and lack of high yielding varieties. Lentil yield and quality can be improved by the balanced use of fertilizers and also by managing the organic manures properly. Soil and fertilizer management is very complex and dynamic in nature. Integrated management of chemical fertilizers and organic wastes may be an important strategy for sustainable production of crops. Organic materials hold great promise as a source of multiple nutrients and ability to improve soil characteristics. Organic farming preserves the ecosystem. Management of soil organic matter has now become a major issue in dealing with the problems of soil fertility and productivity in Bangladesh. Depletion of soil fertility has arisen due to increase crop cultivation, cropping intensity, increasing soil erosion, and higher decomposition of organic matter due to sub-tropical humid climate. Balance use of fertilizer is important to obtain maximum seed yield. Therefore, the objective of the study is to find the best combination of organic and inorganic fertilizer doses for better yield and quality of lentil.

Lentil is also important in crop diversification in the cropping systems of Bangladesh. The Pulses Research Center of the Bangladesh Agricultural Research Institute (BARI, 2000) has been engaged in lentil research since late-seventies. Lentil seed is a rich source of protein and several essential micronutrients (Fe, Zn, b-carotene) (Bhatty, 1988) and ranks the highest in consumer preference and total consumption (BBS, 2002). Domestic pulse production satisfies less than half of the country's needs. The rest, some 140,000 tones, is imported at a cost of about US$ 32.2 million per annum. Lentil, purchased mostly from Australia, Nepal, Turkey and Canada, accounts for US$17.6 million (MOA, 2002). The resulting high prices have led to widespread protein malnutrition, especially among vulnerable groups, such as rural children and the aged.

Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Application of both chemical and organic fertilizers is needs for the improvement of soil physical properties and quick supply of essential plant nutrients for higher yield. The combined effect of organic manure and inorganic fertilizer on crop yield was also reported by many workers (Davarynejad *et al.*, 2004; Singh and Singh, 2000). Availability of soil P is also enhanced by addition of organic manures, presumably due to chelation of cations by organic acids and other decay products (Mohanty *et al.*, 2006).

Inorganic fertilizers when applied along with FYM, Poultry manure can result in a remarkable increase in the yield (Gosh *et al.*, 2006). However, a major portion of the applied chemical nitrogen fertilizers is lost through leaching, run off, emissions and volatilizations which cause economic losses and serious environmental problems (Singh *et al*., 2006; Abdin *et al*., 2006; Galloway *et al*., 2008; Singh *et al*., 2010). Organic fertilizer viz. farm yard manure (FYM), vermi-compost or other organic manure are used for eco-friendly organic farming, however they are unable to replace chemical fertilizers in terms of crop productivity that because of they are used as combined for better production of any crop. Very few research works have been conducted in our country regarding the effects of cowdung, poultry manure and vermi-compost on lentil yield, quality and nutrient uptake by lentil. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

i. To observe the effect of different combinations of chemical and organic fertilizer on lentil.

ii. To select the best combination of chemical and organic fertilizer on higher yield of lentil, and

iii. To find out the feasibility of reducing chemical fertilizer by using organic fertilizer in lentil.

Chapter II

Review of literature

CHAPTER II
REVIEW OF LITERATURE

The literature pertaining to influence of different organic manures and inorganic fertilizers on growth, seed yield and quality attributes and influence of seed treatment with chemicals and botanicals on seed storability of lentil are presented in this chapter. However, relative information on effect of organic fertilizers on lentil is not adequate, analogies from other crops have also been included to emphasize certain point of view

2.1 Effect of organic fertilizer on growth and yield of Lentil

Haque *et al.* (2001) was conducted a field experiment to study the effect of continued fertilizer, organic manure and lentil residues on soil properties and yield of crops. The grain and stover yield of lentil increased significantly due to treatments over control. For lentil (BARI masur-2) the highest grain yield of 1.06 t ha^{-1} was obtained with inoculums + P_{10} K_{12} S_4 kg ha^{-1} along with residual effect of fertilizer.

Mollah *et al.* (2011) was conducted a field experiment at the Multiplication Testing Site (MLT), Joypurhat sadar upazila with Potato- Lentil -T. *Aman* rice cropping pattern during November/2007 to November/2008 to verify different nutrient management approaches and to determine the economic dose of fertilizer for the said cropping pattern. The treatments were, soil test based fertilizer dose for moderate yield goal, soil test based fertilizer dose for high yield goal, integrated plant nutrient management, farmers' practice, and control. Cowdung was applied at the first crop potato only in the cropping sequence. The varieties for potato, lentil and T. *Aman* rice were Diamant, BARI Mung-6, and BR11, respectively. The results demonstrated that the tuber yield of potato, seed yield of lentil, and grain yield of T. *Aman* rice were significantly influenced by the different treatments. In lentil, the highest seed yield (1384 kg/ha) was also recorded from NPKS for high yield goal with residual cowdung treatment. The results of NPKS application for high yield goal with residual cowdung had a positive effect on seed yield of lentil. So, considering crop productivity, economic return, and soil fertility, integrated plant nutrient management for high yield goal with 5 t/ha cowdung could be recommended for the Potato-Lentil-T *Aman* rice cropping pattern at Joypurhat and similar soils of Level Barind agro-ecological zone for sustainable higher yield.

Rupa *et al.* (2014) was conducted an experiment at Sher-e-Bangla Agricultural University farm during the period from February to April 2012 to study the effect of organic and inorganic fertilizers on growth and yield of mungbean (BARI Mung 5). The experiment was followed by Randomized Completely Block Design with three replications. During the experiment following treatments were incorporated T_0; Control, T_1; 10 tha^{-1} Cowdung (Recommended dose), T_2; 10 tha^{-1} Cowdung + 25 % of recommended dose of inorganic fertilizer, T_3; 10 tha^{-1} Cowdung + 50% of recommended dose of inorganic fertilizer, T_4; 10 tha^{-1} + 75% of recommended dose of inorganic fertilizer, T_5; 10 tha^{-1} Vermicompost (Recommended dose), T_6; 10 tha^{-1} Vermicompost + 25% of recommended dose of inorganic fertilizer, T_7; 10 tha^{-1} Vermicompost + 50 % of recommended dose of inorganic fertilizer, T_8; 10 tha^{-1} Vermicompost + 75 % of recommended dose of inorganic fertilizer, T_9; 100 % Inorganic fertilizer. Maximum numbers of pods/plant (25.6), seeds/pod (12.1), seeds/plant (312.6), seed yield/plant (14.6 g), 1000-seed weight (35.6g), seed yield (1127.5 kg/ha), N content in seeds (3.39%), P content in seeds (0.35%) and K content in seeds (2.25%) was found from T_8 treatment while lowest was found from T_0.

Khalilzadeh *et al.* (2012) was done the study to determine the effect of foliar spraying of Bio-organic fertilizers and urea on root and vegetative growth of mung bean (Vigna radiata L.) in a greenhouse condition. The experiment was conducted with four replications in Randomized Complete Design with ten treatments (Urea, Nitroxin, Amino acid, Green hum, Biocrop L-45, Nutriman N24 and Mas Raiz, cattle manure, water and control). Results showed that all traits were significantly affected by treatments except the number of second roots. Foliar application of urea and organic manure substantially improved the plant height, leaf area, shoot and root dry weights, root and shoot length, volume and number of roots. Similarly shoot and leave number and nodules root were also improved by the foliar spraying of Green hum and Amino acid, respectively. While the lowest nodules root was observed in plants treated by nutriman N24 and urea. This improved growth of mainly due to nutrient availability in bio-organic fertilizer and uptake by plants.

Salahin *et al.* (2011) was conducted a field experiment for three consecutive years to observe the effect of tillage and integrated nutrient management on soil physical properties and yield under tomato-mungbean- T. aman cropping pattern during 2007-08, 2008-09 and 2009-10 at BARI, Gazipur. There were nine treatment combinations comprising three tillage practices i.e. T_1: tillage up to 8 cm depth, T_2: tillage up to 12 cm depth and T_3: tillage up to 20 cm depth and three levels of fertilizers i.e. F_1: recommended dose of chemical fertilizers only, F_2: cowdung @ 5 t ha^{-1} + (Recommended dose of chemical fertilizers-nutrients from cow dung) and F_3: native fertility (no fertilizer used) were tested in a split-plot design with three replications. Soil bulk density, particle density, porosity and field capacity were not significantly affected by tillage and organic and inorganic fertilizers but soil moisture significantly influenced by both treatments. The crop yields were significantly influenced by different treatment combinations of organic and inorganic fertilization but not by tillage practices. The combined effect of tillage and organic and inorganic fertilizers was non-significant in all aspects.

An experiment was carried out by Bhuiyan *et al.* (2011) 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 lentil in the Wheat-T. Aus/ Lentil-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.

Phanphruek *et al.* (2006) was conducted a field experiment in Pak Chong soil series at Lop Buri field crops experiment station in 2004 to investigate the effect of chicken manure and nitrogen fertilizer in sweet corn-lentil cropping system under no-tillage system. The experimental design was a split plot with 5 replications. Main plot consisted of 2 soil preparations: conventional tillage and no-tillage. Subplot were nitrogen fertilizer and chicken manure (CM) applied for sweet corn (1st crop) which were 3 rates of nitrogen: 0, 10, 20 kgN/rai and CM 500 kg/rai + 5 kgN/rai, CM 500 kg/rai + 10 kgN/rai and CM 1000 kg/rai+5 kgN/rai. Nitrogen 20 kgN/rai produce highest yield (1515 kg/rai) significantly difference from the plot applied with 10 kgN/rai and treatment CM 500 kg/rai+5kgN/rai. However no significantly difference in corn yield as the effect of treatment CM 500 kg/rai+10 kgN/rai, CM 1000 kg/rai + 5 kgN/rai and 20 kgN/rai were observed. For lentil (2nd crop) the result showed that CM residual effect significantly increased growth and seed weight.

Saleem *et al.* (2010) conducted an experiment of bio-economic efficiency of maize - legumes based intercropping systems under different fertility treatments and its effects on subsequent wheat crop were evaluated at National Agriculture Research Center (NARC) Islamabad Pakistan. Higher CGR, NAR values were recorded of maize with half PM + half PK + inoculation. Wheat grain yield improved by 12 % and 11 % sown after mashbean and lentil treated with PK (80:60 kg ha^{-1}) + Rhizobium inoculation respectively. In similar fashion, wheat grain yield increased by 20 % after 15 t ha^{-1} poultry manure and 15 % wheat grain yield was improved with poultry manure @ 7.5 t ha^{-1} + PK (40:30 kg ha-1) + inoculation. In maize higher crop growth rate (CGR) and net assimilation rate (NAR) were registered in poultry manure plots 7.5 t ha^{-1} + PK (40:30 kg ha^{-1}) + inoculation treatment. Same variables increased the pH, NPK and organic matter in soil. Maize + lentil with NPK (120:80:60 kg ha-1) gave the highest net benefit of Rs. 68720.75 ha-1 without wheat in succession and Rs. 96543.95 ha-1 with wheat in succession, respectively. According to partial budget analysis highest net benefit of Rs.148069.92 ha-1 was accrued in maize + lentil – wheat sequence with half poultry manure + half PK + inoculation.

Rahman *et al.* (2014). was conducted an experiment to investigate the effect of different nutrients application on common bean at experimental field, Department of Botany, Hazara University, Mansehra during 2012-13 in Randomized Complete Block Design with three replicates and four treatments i.e. control (H_2O spray alone), poultry manure, DAP (Di-ammonium Phosphate) and foliar spray of (NPK 20:20:20). The results showed that foliar spray of NPK significantly increased number of pods $plant^{-1}$, number of seeds pod^{-1}, number of seeds $plant^{-1}$, biomass and grain yield.

2.2 Effect of chemical fertilizers on growth and yield of Lentil

Malik *et al.* (2003) carried out a field experiment on bean 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 bean cv. NM-98. Although plant population was not affected significantly, various growth and yield components were significantly affected by varying levels of nitrogen and phosphorus. A fertilizer combination of 25 kg N + 75 kg P ha^{-1} resulted in the maximum seed yield (1,113 kg ha^{-1}). 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}.

Srinivas and Shaik (2002) conducted field experiment during the kharif seasons to study the effects of N (0, 20, 40 and 60 kg ha^{-1}) and P (0, 25, 50 and 75 kg ha^{-1}) along with seed inoculation with *Rhizobium* culture on the growth and yield components of greengram. Plant height generally increased with increasing rates of P and with increasing rates of N up to 40 kg ha^{-1} followed by decrease with further increase in N. Number of seeds pod^{-1}, 1000-seed weight, seed and haulm yields generally increased. Seed inoculation with *Rhizobium* resulted in higher values for the parameters measured relative to the control. The interaction effects between N and P were not significant for the number of pods $plant^{-1}$, pod length, seed and haulm yield.

Patel *et al*. (2003) conducted a field experiment in Gujrat, India during the summer seasons of 1995 to 1998 on sandy loam soils to determine the suitable sowing date, and nitrogen and phosphorus requirements of summer lentil (cv. GM3). Treatments comprised: all the 27 combinations of three sowing dates: 15 February, 1 March and 15 March; three nitrogen rates: 10, 20 and 30 kg N ha^{-1};

and three phosphorus rates: 20, 40 and 60 P ha^{-1}. Results indicated that sowing lentil on 1 March recorded significantly higher grain yields, 37 and 16% higher than those of early (15 February) or late-sown crops (15 March), respectively. Application of 10 kg N ha^{-1} recorded significantly higher grain yield over the control. Treatment with 40 kg P ha^{-1} produced 15 and 18% higher grain yields than treatments with 20 and 60 kg P ha^{-1}, respectively. The highest net return of Rs. 18,240 ha^{-1} was recorded from lentil sown on 1 March and treated with 20 kg N ha^{-1} and 40 kg P ha^{-1}.

Sharma *et al*. (2001) carried out a field experiment on mungbean cv. Pusa Baisakhi which was fertilized with various levels of nitrogen (0, 10 and 20 kg N ha^{-1}) and phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) under mid-hill conditions in Himachal Pradesh, India during the kharif seasons of 1998 and 1999. The highest levels of N and P_2O_5 applications resulted in the average maximum test weight, biological and grain yields, harvest index and seed protein content.

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 lentil 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} (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 the 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 lentil cv. NM-98.

Sangakhara (2003) carried out a field experiment in Sri Lanka in 1999 to determine the impact of effective microorganisms (EM) on N dynamics in a cereal (maize cv. Ruwan)-legume (mungbean) cropping system, using ^{15}N labeled maize or mungbean residues. EM increased the ^{15}N concentrations of maize at the V8 growth stage indicating better use of applied nutrients from organic matter. The uptake of ^{15}N was greater from mungbean residues rather than from maize. EM also increased biological N fixation. The synergistic effects of EM in organic systems were evident from this field study.

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^{-1} applied in 2 splits (22.9 t ha^{-1}) closely followed by 100 kg NK ha^{-1} applied in 2 splits (22.4 t ha^{-1}). For pigeonpea, the maximum grain (14.38 q ha^{-1}), stick (8.08 q ha^{-1}) and bhusa yield (9.96 q ha^{-1}) were recorded with 80 kg NK ha^{-1} applied in 2 splits. The highest level of NK (100 kg ha^{-1}) applied in 3 splits to yambean-pigeonpea intercropping system registered the maximum grain yield of the succeeding mungbean (9.43 q ha^{-1}), which was 33% higher than the untreated control.

Hayat *et al*. (2004) conducted a field experiment during kharif 2000 in Rawalpindi, Pakistan to find out the effect of N and *Rhizobium* sp. inoculation on the yield, N uptake and economics of mungbean (cultivars NM 92 and NCM 209). The treatments were: control; 500 g *Rhizobium* inoculum, 30, 60 and 90 kg N ha^{-1} and inoculum combined with N at 30, 60 and 90 kg ha^{-1}. N content was higher in nodules of NM 92 than NCM 209. The highest N content in nodules (2.80%) was obtained with inoculation + 30 kg N ha^{-1}. NCM 209 had higher N shoot content (2.13%) than NM 92 (1.87%). The highest shoot N content was obtained with inoculation + 30 kg N ha^{-1}. The highest soil N content was obtained with inoculation + 90 kg N ha^{-1}. NCM 209 produced higher yield than NM 92. The maximum economic yield for NM 92 and NCM 209 (768 and 910 kg ha^{-1}, respectively) was obtained with inoculation + 90 kg N ha^{-1}. The maximum biological yield (4,889 kg ha^{-1}) was obtained in NCM 209 with inoculation + 30 kg N ha^{-1}. NCM 209 showed higher biological yield than NM 92. The highest harvest index of 18.45% was obtained with inoculation + 30 kg N ha^{-1}. The maximum net income (Rs. 18,329 and Rs. 13,003 ha^{-1}) in NCM 209 and NM 92 was obtained with inoculation alone and inoculation + 30 kg N ha^{-1}, respectively. The highest benefit: cost ratio was obtained in NCM 209 with the inoculation treatment alone.

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^{-1}) on the growth and yield of lentil 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.

Rana and Choudhary (2006) conducted a field experiment during 2000 and 2001 in New Delhi, India to evaluate the relative moisture utilization by maize grown as sole crop or in maize-lentil intercropping system. Total grain production in terms of maize equivalent was higher in maize (75 cm) + two rows of lentil. Total N uptake and water use efficiency were also highest in maize (75 cm) + two rows of lentil. All parameters increased with increasing concentration of N up to 120 kg ha^{-1}.

Tickoo *et al.* (2006) carried out a field experiment in Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal which were sown at 22.5 and 30 m spacing and supplied with 36-46 and 58-46 kg NP ha^{-1}. Cultivar Pusa Vishal recorded higher biological and grain yield (3.66 and 1.63 t ha^{-1}, respectively) compared to cv. Pusa 105. Differences in the values of the parameters examined. NP rates had no significant effects on both the biological and grain yield of the crop. Row spacing at 22.5 cm resulted in higher grain yields in both crops.

Sultana *et al*. (2009) conducted a field experiment during the period from March 2007 to June 2007 at Sher-e-Bangla Agricultural University, Dhaka with nitrogen and weed management in mungbean where nitrogen (0, 20 kg ha^{-1} at vegetative, 20 kg N ha^{-1} at vegetative and flowering) and weeding (no weeding, one weeding at vegetative, two weeding at vegetative and flowering) was done. Result showed that application of 20 kg N ha basal showed significantly higher values of all growth parameters like number of leaflet (24.3 at 20 DAS and 24.3 at 40 DAS), leaf area (23.3 cm^2 at 20 DAS and 102.2 cm^2 at 40 DAS), Leaf dry weight (0.30, 6.99 and 10.61 g at 10, 17 and 24 DAS, respectively) and shoot dry weight (2.76 and 4.69 g at 17 and 24 DAS, respectively). This treatment also produced significantly more number of branches (1.67), pods $plant^{-1}$ (17.8) and seed yield (1,982 kg ha^{-1}).

Yaqub *et al*. (2010) carried out pattern based experiment at Pakistan to evaluate the induction of short-duration (maturity period, 55-70 days) mungbean [*Vigna radiata* (L.) Wilczek] as a grain legume in the pre-rice niche of the rice-wheat annual double cropping system and found that induction of a short-duration grain legume in the rice-wheat system appears to be more attractive as it offers short-term additional benefits to farmers and is equally beneficial in sustaining the productivity of rice-wheat system over time. The mungbean crop (grown without mineral N fertilizer) produced 1,166 kg ha^{-1} of grain in addition to 4,461 kg ha^{-1} of the manure biomass (containing 52 kg N ha^{-1}) that was ploughed under before planting rice with urea-N applied in the range of 0-160 kg N ha^{-1}. Averaged across urea-N treatments, manuring significantly increased the number of tillers $plant^{-1}$ (11% increases), rice grain yield (6% increase), grain N content (4% increase) and grain N uptake (9% increase). Significant residual effects of manuring were observed on the subsequent wheat crop showing higher grain yield (21% increases), grain N uptake (29% increase) and straw yield (15% increase). The results suggested the feasibility of including mungbean in the pre-rice niche to improve the productivity of the annual rice-wheat double cropping system.

Kayani *et al*. (2010) conducted experiment to investigate the impact of legume on the oncoming wheat crop. Lentil was planted during Kharif 2007. The wheat variety Inqalab-91 was sown before and after the lentil plantation during Rabi 2006-07 and 2007. Twelve different treatments were applied having different doses of N and P but Farm Yard Manure (FYM) remained constant. Six parameters were selected to investigate the potential effects of the legume viz., soil physico-chemical properties, plant height, spike length, number of grains $spike^{-1}$, 1000 grains weight and yield $plot^{-1}$. The results showed significant increase in plant height, spike length, number of grains/spike, 1000-grains weight and yield/plot after cropping lentil. The yield was obtained at an increase of 26.90% after lentil application. Based on results, cereal legume crop rotation is highly recommended.

A field experiment was conducted by Mohammad *et al*. (2010) to study the effect of crop residues and tillage practices on BNF, WUE and yield of mungbean (*Vigna radiata* (L.) Wilczek) under semi-arid rainfed conditions at the Livestock Research Station, Surezai, Peshawar in North West Frontier Province (NWFP) of Pakistan. The experiment comprised of two tillage i) conventional tillage (T1) and ii) no-tillage (T0) and two residues i) wheat crop residues retained (+) and ii) wheat crop residues removed (-) treatments. Basal doses of N @ 20: P @ 60 kg ha^{-1} was applied to mungbean at sowing time in the form of urea and single super phosphate respectively. Labeled urea having 5% N-15 atom excess was applied @ 20 kg N ha^{-1} as aqueous solution in micro plots ($1m^2$) in each treatment plot to assess BNF by mungbean. Similarly, maize and sorghum were grown as reference crops and were fertilized with N-15 labeled urea as aqueous solution having 1% N-15 atom excess @ 90 kg N ha^{-1}. The results obtained showed that mungbean yield (grain/straw) and WUE were improved in no-tillage treatment as compared to tillage treatment. Maximum mungbean grain yield (1224 kg ha^{-1}) and WUE (6.61 kg ha^{-1} mm^{-1}) were obtained in no-tillage (+ residues) treatment. The N concentration in mungbean straw and grain was not significantly influenced by tillage or crop residue treatments. The amount of fertilizer-N taken up by straw and grain of mungbean was higher under no-tillage with residues-retained treatment but the differences were not significant. The major proportion of N (60.03 to 76.51%) was derived by mungbean crop from atmospheric N-2 fixation, the remaining (19.6 to 35.91%) was taken up from the soil and a small proportion (3.89 to 5.89%) was derived from the applied fertilizer in different treatments. The maximum amount of N fixed by mungbean (82.59 kg ha^{-1}) was derived in no-tillage with wheat residue-retained treatment. By using sorghum as reference crop, the biological nitrogen fixed by mungbean ranged from 37.00 to 82.59 kg ha^{-1} whereas with maize as a reference crop, it ranged from 34.74 to 70.78 kg ha^{-1} under different treatments. In comparison, non-fixing (reference) crops of sorghum and maize derived upto 16.6 and 15.5% of their nitrogen from the labeled fertilizer, respectively. These results suggested that crop productivity, BNF and WUE in the rainfed environment can be improved with minimum tillage and crop residues retention.

Field study was carried by 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 maize and mungbean, two popular smallholder crops over major and minor seasons. Application of 120 kg K ha^{-1} optimized all parameters of maize in the major wet season, whereas the requirement was 80 kg K ha^{-1} in the minor season. Optimal growth yields and N-use efficiencies of mungbean was with 80 kg K ha^{-1} in both seasons. Information regarding rates of fertilizer K that optimized N use and yield of maize and mungbean during each of the two tropical monsoonal seasons of South Asia is presented.

2.3 Combined effect of organic and chemical fertilizers on growth and yield of Lentil

A field investigation was carried out by Aslam *et al.* (2010) in Pakistan to evaluate the effect of organic and inorganic sources of phosphorous on the growth and yield of lentil. FYM, poultry manure and chemical fertilizer were accumulated at various concentrations to formulate different treatments. Analysis of data revealed significant differences with respect to plant height, number of plants m^{-2}, leaf area (cm^{2}), root length (cm), number of pod bearing branches plant $^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, pod size (cm), number of seeds plant $^{-1}$, 1000 seed weight (g), biological yield (Kg ha^{-1}), seed yield (Kg ha^{-1}), harvest index (%) and grain protein contents (%) indicating primacy of integration of the two sources in having improved lentil productivity.

Effects of organic and inorganic fertilizers on lentil yield under arid climate were studied by Abbas *et al.* (2011) at adaptive research farm Karor and at farmer's field during two kharif seasons of 2006 and 2007. In these experiments different combinations of organic and inorganic fertilizers were used for comparison. Experiments were laid in randomized complete block design with seven treatments.

Senaratne, R. and D. S. Ratnasinghe. 1993, a promising variety of lentil for arid climate was used as a test variety. The results revealed that different combinations of organic and inorganic fertilizers significantly affected the pod number plant^{-1}, seed number pod^{-1} and grain yield. Maximum grain yield was obtained from the application of DAP at 124 Kg along with 10 tons ha^{-1} of poultry litter during both years, while application of DAP at 62 Kg and 10 tons of FYM ha^{-1} ranked second for grain yield.

Rajkhowa *et al*. (2002) reported that the application of 100 per cent RDF along with vermicompost @ 2.5 t per ha 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 t/ha) over control in mungbean.

Naeem *et al.* (2006) was carried a field experiment out to determine the effect of organic manures and inorganic fertilizers on growth and yield of mungbean (Vigna radiata L.). Experiment comprised of two varieties (NM-98 & M-1) and four fertility levels as NPK @ 25 -50 kg ha^{-1}, poultry manure @ 3.5 t ha^{-1}, FYM @ 5 t ha^{-1} and Bio-fertilizer @ 8 g kg^{-1} seed. NPK fertilizers and organic manures were applied at the time of seed bed preparation. Wheat grain yield was recorded highest (1104 kg ha^{-1}) with the application of the inorganic fertilizers (NPK @ 25

-50 -50 kg ha^{-1}). Among organic nutrient a source, poultry manure @ 3.5 t ha^{-1} was found the best followed by FYM @ 5 t ha^{-1}. Both varieties were equal in grain yield. Numbers of pods, number of seeds per pod, 1000 grain weight were also almost higher in inorganic fertilizer treatment. The economic analysis revealed maximum net benefit from the treatment, where poultry manure was applied.

Shen *et al.* (2001) was conducted a pot experiment to investigate the effects of organic materials on the alleviation of Al toxicity in acid red soil Crop production in red soil areas may be limited by Al toxicity. A possible alternative to ameliorate Al toxicity is the application of such organic manure as crop straw and animal manure. Ground wheat straw, pig manure or $CaCO_3$ were mixed with the soil and incubated, at 85% of water holding capacity and 25°C, for 8 weeks. Growth of mungbean seedling was improved substantially by the application of organic material or $CaCO_3$. Pig manure or wheat straw was more effective in ameliorating Al toxicity than was $CaCO_3$. Mungbean plants receiving pig manure or wheat straw contained relatively high concentrations of P, Ca and K in their leaves. It is suggested that the beneficial effect of organic manure on mungbean is likely due to decreasing concentrations of monomeric inorganic Al concentrations in soil solution and improvement of mineral nutrition.

Ahmad *et al.* (2014) was the study describes the optimizing organic and inorganic fertilizers recommendations for wheat-sorghum and wheat-mung bean crop rotations under rainfed conditions. Five different treatments including T_0 as Control, T_1 with farmyard Manure (FYM) at 30 tons ha^{-1}, T_2 include NPK at120-80-60 at kg ha^{-1}, T_3 using poultry manure at 20 tons ha^{-1}, T_4 included compost (Press mud) at 12.5 tons ha^{-1} and in T_5, Inoculation by Phosphorus mobilizing microorganisms at 2.5 packets ha^{-1} was used only for wheat while, sorghum and mungbean were planted on the residual nutrients. Net benefits for the poultry manure were highest mainly due to high wheat yield and marginal rate of return are also high. The results were also confirmed using residual analysis.

Crop productivity of maize-legume intercropping system for yield and yield attributes were evaluated by Saleem *et al.* (2011) under different fertility treatments at National Agriculture Research Center (NARC), Islamabad, Pakistan during 2007 and 2008 using complete randomized strip block design replicated thrice. Three cropping systems were kept in vertical blocks and five fertility treatments were placed in horizontal blocks. According to results of the study it was revealed that half poultry manure + half PK+ inoculation gave maximum maize grain yield of 4830.95 kg ha^{-1} and biological yield of 15330.29 kg ha^{-1} respectively, while cropping systems did not have an affect on grain and biological yields of maize to the significant extent. On the basis of agronomic as well as economic performance of maize + mashbean intercropping, it was well evident that combined use of organic, biofertilizers and chemical fertilizers was proved to be more productive and remunerative and can be recommended for maize growers to elevate income.

Chapter III

Materials and Methods

CHAPTER III
MATERIALS AND METHODS

A field experiment was conducted at the research field of Agronomy Department, Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 28, 2015 to March 5, 2016. The materials and methods of this experiment are presented in this chapter under the following headings-

3.1 Experimental site

The present piece of research work was conducted in the field of Agronomy Department, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is 23°74'N latitude and 90°35'E longitude with an elevation of 8.2 meter from sea level(Appendix I).

3.2 Weather condition of the experimental site

The climate of the experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were presented in (Appendix III).The average maximum and minimum temperature were varied from 28.1^{o}C to 34.8^{o}C and 11.1^{o}C to 18.0^{o}C, respectively.The relative humidity varied from 55% to 79%. The month November was experienced with maximum total rainfall (227mm).

3.3 Characteristics of soil

The soil of the experimental area was loamy belonging to the Madhupur Tract under AEZ 28. The soil of the experimental plots were clay loam, land was medium high with medium fertility level. The organic matter and nitrogen status of the soil was poor. The P^{H} varied from 6.00-6.63(Appendix II).

3.4.Planting material

The seeds of BARI Masur-7 were used as experimental material and collected from Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The seeds were healthy, vigorous, well matured and free from other crop seeds and inert materials.

3.5 Experimental treatments

The experiment was a fertilizer trial and it comprised the following 11 treatments.

T_0: Control (without organic & inorganic fertilizer)

T_1: All chemical fertilizers as recommended dose (RD)

T_2: Cowdung as RD + 75% chemical fertilizers as RD

T_3: Cowdung as RD + 50% chemical fertilizers as RD

T_4: Cowdung as RD + 25% chemical fertilizers as RD

T_5: Vermi-compost as RD + 75% chemical fertilizers as RD

T_6: Vermi-compost as RD + 50% chemical fertilizers as RD

T_7: Vermi-compost as RD + 25% chemical fertilizers as RD

T_8: Poultry manure as RD + 75% chemical fertilizers as RD

T_9: Poultry manure as RD + 50% chemical fertilizers as RD

T_{10}: Poultry manure as RD + 25% chemical fertilizers as RD

3.6 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications (Appendix IV). An area of 14m × 35mwas divided into three equal blocks. Each block was divided into 11 plots where 11 treatments were allotted randomly. There were 33 unit plots in the experiment. The size of the each unit plot was 3.5 m × 2 m. The space between two blocks and two plots were 1 m and 0.5 m, respectively. Plant to plant and row to row distances were maintained 10cm and 30 cm, respectively.

3.7 Land preparation

The land of the experimental site was first opened in November 17, 2015 with power tiller. Later on, the land was ploughed and cross-ploughed three times followed by laddering to obtain the desired tilth. The corners of the land were spaded and larger clods were broken into smaller pieces after ploughing and laddering all the stubbles and uprooted weeds were removed from the field. Thus the plots were made ready for sowing.

3.8 Fertilizer application

Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP) and Boric acid were used as a source of nitrogen, phosphorous, potassium and boron respectively. Manures and fertilizers that were applied to the experimental plot presented in Table 1. The total amount of Cowdung, Vermi-compost, Poultry manure, Urea, TSP, MoP and Boric Acid was applied as basal dose at the time of land preparation.

Table 1. Dose of fertilizers in lentil field (Anon., 1999)

Fertilizers and Manures	**Dose/ha**
Cowdung	10 tones
Vermi-compost	2 tones
Poultry manure	2 tones
Urea	50 kg
TSP	90 kg
MoP	40 kg
Boric Acid	10 kg

3.9 Seed sowing

Seeds @35 kg ha^{-1} were sown on November 28, 2015. Seeds were treated with Bavistin before sowing the seeds to control the seed borne diseases. The seeds were sown in rows in the furrows having a depth of 2-3 cm. Line to line distance was 30cm and plant to plant distance was 10 cm.

3.10 Intercultural operations

3.10.1 Thinning

Seeds were germinated five days after sowing (DAS). Thinning Seeds was done two times; first thinning was done at 10 DAS and second was done at 15 DAS maintained 10 cm between plants to obtain proper plant population in each plot.

3.10.2 Weeding

Weeding was done twice; first weeding was done at 20 DAS and second weeding was done at 45 DAS.

3.10.3 Irrigation

Three irrigations were given as plants required. First irrigation was given immediate after thinning at 15 DAS and second and third irrigations were applied at 45 and 65 DAS.

3.10.4 Crop protection

At seedling stage, fungal disease (root rot) was observed in the field and some plants were died. For prevention of disease, Bavistin was sprayed. At vegetative stage, aphid (*Aphis craccivora*) attacked the young plants and at latter stage of growth, pod borer (*Maruca testulalis*) attacked the plants. For aphid control, Ripcord 2 ml L^{-1} water and for pod borer Dimacron 50 EC at the rate of 3 ml L^{-1} was sprayed, respectively.

3.11 Crop sampling and data collection

Ten plants from each treatment were randomly selected and marked with tag for recording plant characters data. The data of plant characters were recorded from 20 days of sowing till harvest at 20 days interval. Yield and yield contributing parameters were recorded from the central part of the plots.

3.12 Harvesting and threshing

Crop was harvested when 80% (approximately) of the pods became brown to black in color. The matured crops was harvested and tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.13 Drying and weighing

The seeds and stovers thus collected were dried in the sun for couple of days. Dried seeds and stovers of each plot was weighed and subsequently converted into kg ha^{-1} basis.

3.14 Collection of data

A.Growth and phonological parameters

i.Plant height (cm) (20 days interval starting from 20 DAS)

ii.No. of primary branches $plant^{-1}$ (20 days interval starting from 20 DAS)

iii. Dry weight $plant^{-1}$(g) (30,60,90 DAS and at harvest)

iv.Days to emergence(80%)

v.Days to flowering(50%)

vi.Days to pod maturity(80%)

vii.Crop Growth Rate(CGR)

viii.Relative Growth Rate(RGR)

B. Yield contributing characters

i.Pods $plant^{-1}$(no.)

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

iii.Weight of 1000 seeds (g)

iv.Shelling percentage(%)

C. Yield and harvest Index

i.Seed yield (kg ha^{-1})

ii.Stover yield (kg ha^{-1})

iii.Biological yield (kg ha^{-1})

iv.Harvest index(%)

3.15 Procedure of data collection

3.15.1 Plant height (cm)

Plant height of 10 randomly selected plants was measured with a meter scale from the ground level to the tip of the plants and the mean height was expressed in cm. Data were recorded from the inner rows of each plot starting from 20 DAS at 20 days interval up to harvest.

3.15.2 Primary branches $plant^{-1}$(no.)

Branches were counted from selected plants starting from 40 DAS at 20days interval up to harvest. The total branches of 10 plants were averaged to have number of branches $plant^{-1}$.

3.15.3 Dry matter $plant^{-1}$(g)

Five sample plants from each plot were collected and gently washed with tap water, thereafter soaked with paper towel. The sample was oven dried at 70^{0}C for 72 hours. Then oven-dried samples were transferred into a desiccators and allowed to cool down to room temperature, thereafter dry weight of plants was taken and expressed in gram. Above ground dry matter $plant^{-1}$ was recorded at 30, 60, 90 DAS and harvest.

3.15.4 Days to emergence(80%)

Days to 80% seedling were germination by counting the number of days required. 80% emergence was measured on the basis of physical appearance.

3.15.5 Days to flowering(50%)

Days to 50% flowering were measured by counting the number of days required to start flower initiation in each plot.

3.15.6 Days to pod maturity(80%)

Days to 80% pod maturity were measured by counting the number of days required to attain maturity of 80% pods. Maturity was measured on the basis of brown colour of leaves and stem and dark grey colour of pods.

3.15.7 Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{A} \times \frac{W_2 - W_1}{T_2 - T_1} \quad g\ m^{-2} day^{-1}$$

Where,

A = Area (m^2)

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

3.15.8 Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{LnW_2 - LnW_1}{T_2 - T_1} \quad (g\ g^{-1} day^{-1})$$

Where,

W_1 = Total dry weight at previous sampling date (T_1)

W_2 = Total dry weight at current sampling date (time T_2)

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Logarithm

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

Total pods of selected plants from each plot were counted and the mean numbers were expressed as podsplant^{-1} basis. Data were recorded as the average of 10 plants selected at random from the inner rows of each plot.

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

Seeds pod^{-1} was recorded randomly from selected plants at the time of harvest. Data were recorded as the average of 10 pods selected at random from the inner rows of each plot.

3.15.11 Weight of 1000 seeds (g)

One thousand cleaned, dried seeds were counted from each harvested sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.15.12 Shelling percentage (%)

Shelling percentage is a ratio calculated from per hectare grain and biological weight that were obtained from each unit plot and expressed in percentage.

3.15.13 Seed yield (kg ha^{-1})

The seeds collected from central 3 m^2 (3 m×1 m) square meter area of each plot were sun dried properly. The weight of seeds was taken and converted the yield in kg ha^{-1}.

3.15.14 Stover yield (kg ha^{-1})

The Stover collected from central 3 m^2 (3 m×1 m) square meter area of each plot was sun dried properly. The weight of stover was taken and converted the yield in kg ha^{-1}.

3.15.15 Biological yield (kg ha^{-1})

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.15.16 Harvest index(%)

Harvest index was calculated from per hectare grain and straw yield that were obtained from each unit plot and expressed in percentage.

$$HI = \frac{\text{Economic yield (grain weight)}}{\text{Biological yield (total dry weight)}} \times 100$$

3.15.17 Statistical analysis

The data obtained from experiment on various parameters were statistically analyzed in R computer package program by Randomized Complete Block Design (RCBD) (Russel, 1986). The mean values for all the parameters were calculate and the analysis of variance for the characters was accomplished by Least Significant Differences (LSD) test at 5 % levels of probability (Gomez and Gomez, 1984).

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the feasibility of reducing chemical fertilizer by organic fertilizer in lentil production. Data on different growth, yield contributing characters and yield of lentil were recorded. The results have been presented and discussed with the help of Tables and Graphs and possible interpretations given under the following headings:

4.1 Growth and phonological parameters of lentil

4.1.1 Plant height (cm)

Plant height is an important morphological character that acts as a potent indicator of availability of growth resources in its vicinity. Plant height varied significantly at 30, 50, 70 and 90 DAS, and at harvest for different chemical and organic fertilizer and their combinations under the present trial (Table 2). At 20 DAS, the tallest plant (7.74cm) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD),T_8(poultry manure as RD + 75% chemical fertilizers as RD), T_6(vermi-compost as RD + 50% chemical fertilizers as RD), T_2(cowdung as RD + 75% chemical fertilizers as RD). The shortest plant (4.13cm) was found in T_0,control (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_4(cowdung as RD + 25% chemical fertilizers as RD), T_3(cowdung as RD + 50% chemical fertilizers as RD).

At 40 DAS, maximum plant height (11.03cm) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD),T_8(poultry manure as RD + 75% chemical fertilizers as RD), T_2(cowdung as RD + 75% chemical fertilizers as

RD), T_6(vermi-compost as RD + 50% chemical fertilizers as RD). The shortest plant (10.34cm) was found in T_0, (without Organic & Inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_7(vermi- compost as RD + 25% chemical fertilizers as RD), T_9(poultry manure as RD + 50% chemical fertilizers as RD).

At 60 DAS, maximum plant height (15.82 cm) was observed in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD),T_8 (poultry manure as RD + 75% chemical fertilizers as RD), T_2(cowdung as RD + 75% chemical fertilizers as RD), T_6(vermi-compost as RD + 50% chemical fertilizers as RD). The shortest plant (15.97cm) was observed in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_4(cowdung as RD + 25% chemical fertilizers as RD), T_7(vermi-compost as RD + 25% chemical fertilizers as RD).

At 80 DAS, maximum plant height (35.52cm) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD),T_8(poultry manure as RD + 75% chemical fertilizers as RD), T_6(vermi-compost as RD + 50% chemical fertilizers as RD),T_2(cowdung as RD + 75% chemical fertilizers as RD). The shortest plant (21.43cm) was found in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_4(cowdung as RD + 25% chemical fertilizers as RD), T_7(vermi-compost as RD + 25% chemical fertilizers as RD).

At Harvest, maximum plant height (35.54 cm) was observed in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD),T_8(poultry manure as RD +

75% chemical fertilizers as RD), T_2(cowdung as RD + 75% chemical fertilizers as RD), T_6(vermi-compost as RD + 50% chemical fertilizers as RD). The shortest plant (21.37cm) was observed in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_9(poultry manure as RD + 50% chemical fertilizers as RD),T_4(cowdung as RD + 25% chemical fertilizers as RD).

Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative growth of the lentil and the ultimate results were the longest plant. Combination of cow dung, FYM and chemical fertilizers in different recommended doses also created a favorable condition for the growth and development of lentil plant for that combination of cow dung, FYM and chemical fertilizers in different recommended doses also gave the similar results. 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.

Table 2. Effect of chemical and organic fertilizers and their combinations on plant height of lentil

Treatment	Plant height(cm)				
	20 DAS	**40 DAS**	**60 DAS**	**80 DAS**	**Harvest**
T_0	4.13 d	10.34 e	15.97 e	21.43 d	21.37 d
T_1	7.74 a	17.13 a	23.29 a	35.52 a	35.54 a
T_2	6.51 bc	14.80 bc	20.00 bc	28.43 bc	28.63 bc
T_3	6.33bc	14.53 b-d	19.l0 cd	28.20 bc	28.50 c
T_4	5.65c	12.86 cd	18.07 cd	26.94 c	26.73 c
T_5	7.27 ab	15.80 ab	21.83 ab	33.37 ab	33.23 ab
T_6	6.47 bc	14.63 b-d	19.23 cd	28.63 bc	28.60 bc
T_7	6.23 bc	13.81 b-d	18.73 cd	26.97 c	28.64 bc
T_8	7.20 ab	15.77 ab	21.70 ab	33.29 ab	33.20 ab
T_9	6.27 bc	14.43 b-d	18.93 cd	27.26 c	26.80 c
T_{10}	5.36 c	12.51 de	18.00 d	26.84 c	26.67 c
LSD(0.05)	1.21	2.28	1.94	5.39	4.65
CV (%)	11.29	9.39	5.84	10.98	9.44

T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

4.1.2 Primary branches plant^{-1} (no.)

Significant differences was recorded for the application of organic and inorganic fertilizers in terms of primary branches plant^{-1} of lentil at 20, 40, 60, 80 DAS and harvest (Table 3). At 20 DAS, the highest number of branches plant^{-1} (0.93) was recorded in T_1(all chemical fertilizers as recommended does) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_7(vermi-compost as RD + 25% chemical fertilizers as RD).The lowest number of branches plant^{-1} (0.13) was recorded in T_0,(without organic & inorganic fertilizer).

At 40 DAS, the highest number of branches plant^{-1} (8.07) was found in T_7(vermi-compost as RD + 25% chemical fertilizers as RD). The lowest number of branches plant^{-1} (1.77) was found in T_0, (without organic & inorganic fertilizer).

At 60 DAS, the highest number of branches plant^{-1} (9.00) was found in T_1(All chemical fertilizers as recommended dose) which was statistically similar with T_5 (vermi-compost as RD + 75% chemical fertilizers as RD) and T_8 (poultry manure as RD + 75% chemical fertilizers as RD). The lowest number of branches plant^{-1} (4.10) was found in T_0, (without organic & inorganic fertilizer) treatment.

At 80 DAS, the highest number of branches plant^{-1} (13.20) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD) and T_8(poultry manure as RD + 75% chemical fertilizers as RD) treatments. The lowest number of branches plant^{-1} (6.10) was found in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD) treatments.

At Harvest, the highest number of branches plant^{-1} (13.33) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_8(poultry manure as RD + 75% chemical fertilizers as RD) 12.53 and 12.50 respectively. The lowest number of branches plant^{-1} (6.47) was found in T_0,(without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD).

Combination of organic (vermi-compost as RD + 75% chemical fertilizer as RD and poultry manure as RD + 75% chemical fertilizer as RD and inorganic fertilizers significantly increased among the treatment combination. As organic fertilizers help to improve the soil condition and inorganic fertilizers assure quick availability of essential nutrients, the combination of two proved better than single use of the each. Aslam *et al.* (2010) reported that combined application of FYM and chemical fertilizer recorded higher number of pod bearing branches plant $^{-1}$ in mungbean.

Table 3. Effect of chemical and organic fertilizers and their combinations on primary branch plant^{-1} of lentil

Treatments	Primary branch plant^{-1} (no.)				
	20 DAS	40 DAS	60 DAS	80 DAS	Harvest
T_0	0.13 d	1.77 d	4.10 e	6.10 e	6.47 d
T_1	0.93 a	5.13 a	9.00 a	13.20 a	13.33 a
T_2	0.53 bc	3.37 bc	7.07 b-d	9.33 b-d	10.10 bc
T_3	0.47 b-d	3.20 c	6.93 cd	9.03 b-d	9.70 c
T_4	0.37 cd	2.03 cd	6.43 d	8.77 d	9.47 c
T_5	0.80 ab	4.67 ab	8.27 ab	11.33 ab	12.53 ab
T_6	0.50 b-d	3.30 bc	7.00 b-d	9.30 b-d	9.97 bc
T_7	0.80 ab	8.07 cd	6.50 d	8.83 cd	9.57 c
T_8	0.40 cd	4.63 ab	8.23 a-c	11.27 a-c	12.50 ab
T_9	0.43 b-d	3.10 c	6.60 d	8.90 b-d	9.63 c
T_{10}	0.33 cd	2.00 cd	6.30 d	8.70 d	9.00 cd
LSD(0.05)	0.38	1.38	1.32	2.49	2.68
CV (%)	42.62	25.92	6.30	15.35	15.41

T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

4.1.3 Dry matter plant^{-1}(g)

The dry matter production per plant was very slow at early growth stages 60 DAS then it increased upto harvest. However, dry matter production exerted significant difference due to different fertilizer application(Table 4). At 30 DAS, the highest above ground dry matter plant^{-1} (0.42g) of lentil was found in T_1(All chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_8(poultry manure as RD + 75% chemical fertilizers as RD) 0.38 and 0.36 g respectively. The lowest dry matter plant^{-1} of lentil (0.13g) was found in T_0, (without organic &inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_7(vermi-compost as RD + 25% chemical fertilizers as RD).

At 60 DAS, the highest above ground dry matter plant^{-1} of lentil (0.77g) was found in T_1(all chemical fertilizers as recommended dose) which was followed by T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_8(poultry manure as RD + 75% chemical fertilizers as RD), T_2(cowdung as RD + 75% chemical fertilizers as RD). The lowest dry matter plant^{-1} of lentil (0.21g) was found in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_4 (cowdung as RD + 25% chemical fertilizers as RD) treatment.

At 90 DAS, the highest dry matter plant^{-1} of lentil (4.67g) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_8(poultry manure as RD + 75% chemical fertilizers as RD). The lowest above ground dry matter plant^{-1} of lentil (1.24g) was found in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD).

At Harvest, the highest above ground dry matter plant^{-1} of lentil (4.89g) was found in T_1(all chemical fertilizers as recommended dose) which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD), T_8(poultry manure as RD + 75% chemical fertilizers as RD) T_2(cowdung as RD + 75% chemical fertilizers as RD). The lowest above ground dry matter plant^{-1} of lentil (1.30g) was found in T_0, (without organic & inorganic fertilizer) which was statistically similar with T_{10}(poultry manure as RD + 25% chemical fertilizers as RD), T_4(cowdung as RD + 25% chemical fertilizers as RD) and T_7(vermi-compost as RD + 25% chemical fertilizers as RD). Similar results found Agarwal *et al.* (1995) observed that organic fertilizers improved dry weight per plant of maize.

Table 4. Effect of chemical and organic fertilizers and their combinations on dry matter plant^{-1}of lentil

Treatments	Dry weight per plant(g)			
	30 DAS	60 DAS	90 DAS	At Harvest
T_0	0.13 g	0.21 g	1.24 e	1.30 f
T_1	0.42 a	0.77 a	4.67 a	4.89 a
T_2	0.33 bcd	0.66 bc	3.34 bc	3.62 bc
T_3	0.31 cde	0.56 d	2.13 de	2.90 cd
T_4	0.25 ef	0.29 f	1.63 de	1.68 ef
T_5	0.38 ab	0.73 ab	4.45 ab	4.31 ab
T_6	0.32 bcd	0.64 c	2.59 cd	3.21 c
T_7	0.29 de	0.44 e	1.63 de	1.85 ef
T_8	0.36 abc	0.72 ab	4.15 ab	4.29 ab
T_9	0.30 cde	0.60 cd	1.88 de	2.28 de
T_{10}	0.20 f	0.24 fg	1.36 e	1.61 ef
LSD(0.05)	0.07	0.07	1.13	0.83
CV (%)	13.18	8.05	25.16	16.75

T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

4.1.4 Days to emergence(80%)

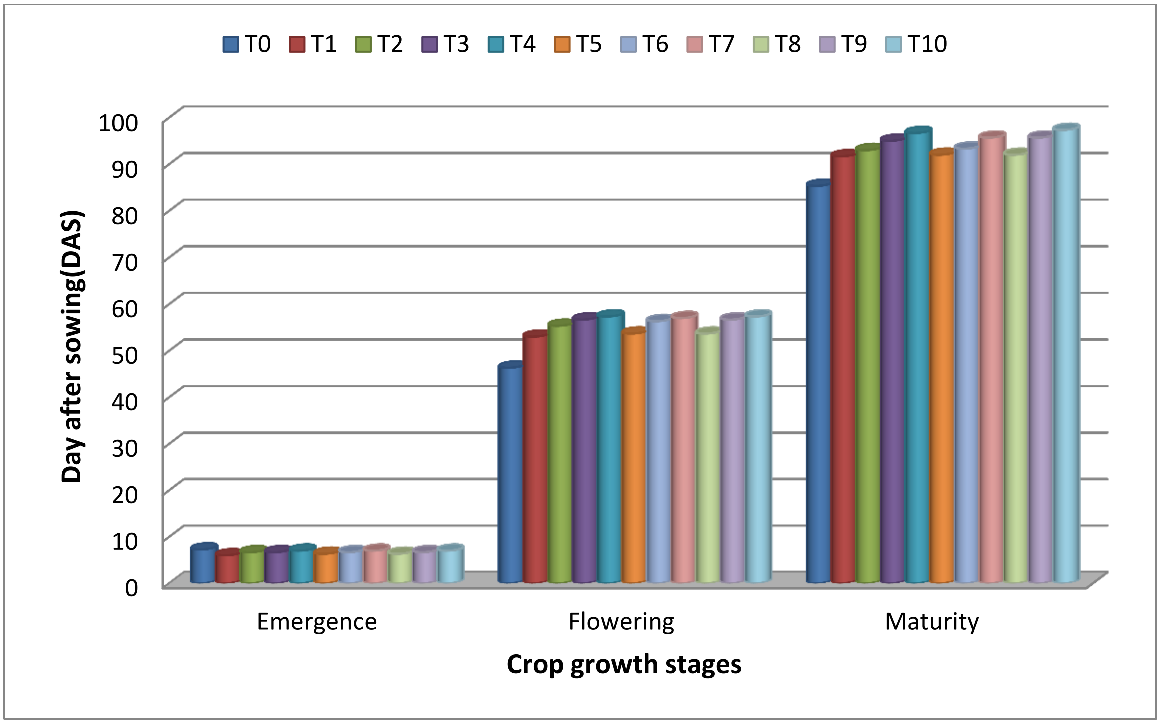
Statistically significant variation was recorded for days to emergence for different chemical and organic fertilizers, and their combinations treatments (Figure 1). Delayed emergence (8 DAS) was found in T_0 (without organic & inorganic fertilizer) treatment and emergence was earliest (6 days) in T_1, (all chemical fertilizers as recommended dose). Similar observation was also reported combined fertilizers recommended dose.

4.1.5 Days to flowering (50%)

Days to flowering showed statistically significant variation for different chemical and organic fertilizers, and their combinations (Figure 1). Delayed flowering (59 DAS) was found in T_0, (without organic & inorganic fertilizer) treatment and flowering was earliest (53 DAS) in T_1,(all chemical fertilizers as recommended dose).

4.1.6 Days to maturity (80%)

There was a marked difference among the different chemical and organic fertilizers, and their combinations on the days to maturity (Figure 1). Delayed maturity (99 DAS) was found in T_0, (without organic & inorganic fertilizer) treatment and maturity was earliest (91 DAS) in T_1, (all chemical fertilizers as recommended dose). Similar observation was also reported by Hassan (2005), Akbar *et al.* (2002) and Ali *et al.* (1999).



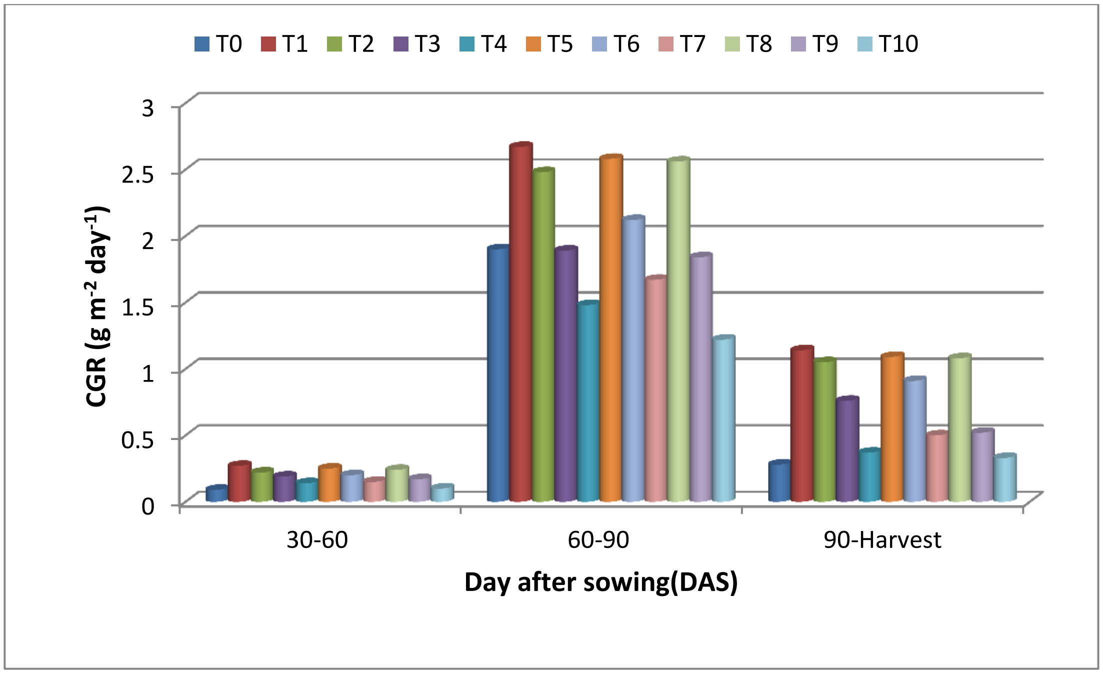
T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

Figure 1. Effect of chemical and organic fertilizers and their combinations on days to emergence, days to flowering and days to maturity of lentil ($LSD_{0.05}$=0.81, 1.96 and 2.16 respectively)

4.1.7 Crop Growth Rate (CGR)

Crop Growth Rate (CGR) varied significantly for different chemical and organic fertilizers and their combinations at 30-60 DAS, 60-90 DAS and 90-harvest (Figure 2). At 30-60 DAS, the highest CGR (0.27g m^{-2} day^{-1}) was found in T_1, while the lowest CGR (0.09 g m^{-2} day^{-1}) was recorded in T_0. At 60-90 DAS, the highest CGR (2.67 g m^{-2} day^{-1}) was found in T_1, while the lowest CGR was recorded in T_{10}. At 90-harvest, the highest CGR was found in T_1 (1.14 g m^{-2} day^{-1}), while the lowest CGR (1.22 g m^{-2} day^{-1}) was recorded in T_0 (0.28 g m^{-2} day^{-1}) (Figure 2). Combination of cowdung, Vermi-compost and Poultry manure at 75%

RD with chemical fertilizers created a favorable condition for the growth and development of lentil plant which ultimately increases the CGR. Similar results was also reported by Abbas (2005) and Haque and Hamid (1998).

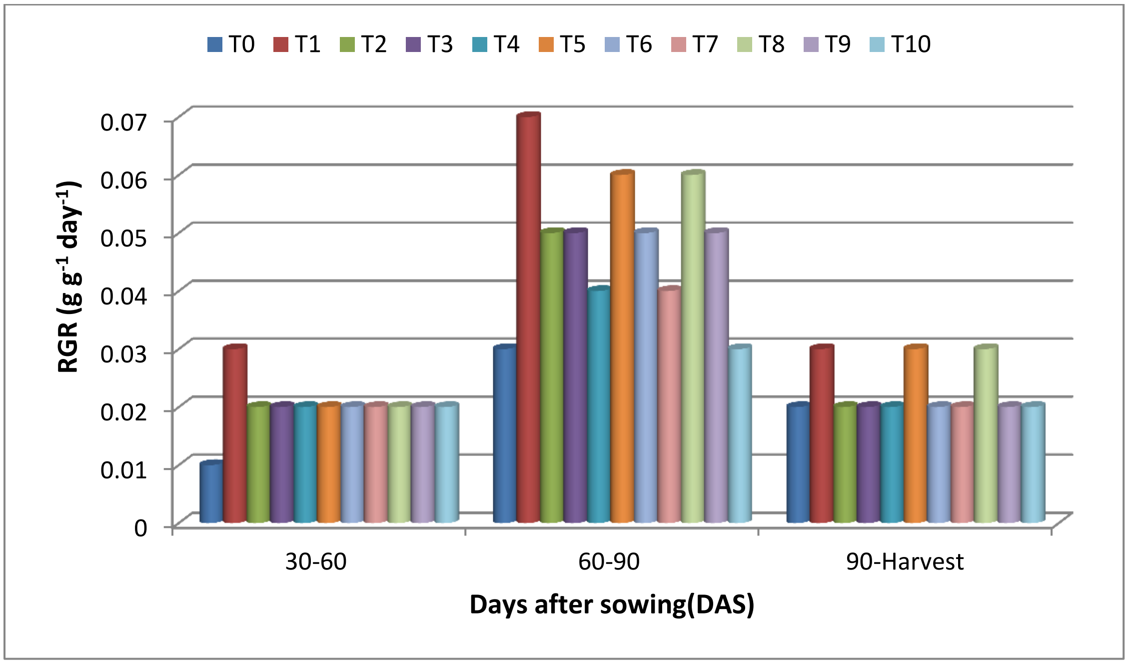


T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

Figure 2. Effect of chemical and organic fertilizers and their combinations oncrop growth rate (CGR) of lentil(LSD$_{0.05}$=0.02, 0.13 and 0.08 respectively)

4.1.8 Relative Growth Rate (RGR)

Relative Growth Rate (RGR) showed significant variation for different chemical and organic fertilizers and their combinations at 30-60 DAS, 60-90 DAS and 90-Harvest (Figure 3). At 30-60 DAS, the highest RGR (0.03 g g^{-1} day^{-1}) was found in T_1, which was statistically similar with all treatment except to the lowest RGR was recorded in T_0treatment (0.01 g g^{-1} day^{-1}). At 60-90 DAS, the highest RGR (0.07 g g^{-1} day^{-1}) was found in T_1 and the lowest RGR (0.03 g g^{-1} day^{-1}) was recorded in T_0& T_{10}. At 90-at harvest, the highest RGR was found in $T_{1,}T_5$ and T_8 (0.03 g g^{-1} day^{-1}) and the lowest RGR was recorded in T_0, T_{10} and T_9 (0.02 g g^{-1} day^{-1}).



T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

Figure 3. Effect of chemical and organic fertilizers and their combinations on relative growth rate (RGR) of lentil($LSD_{0.05}$=0.01, 0.01 and 0.02 respectively)

4.2 Yield contributing characters of lentil

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

Number of pods plant^{-1} is one of the most important yield contributing characters in lentil. The number of pods plant^{-1} was significantly affected by organic and inorganic fertilizers application(Table 5). Results revealed that the highest number of pods plant^{-1} (104.67) was recorded at T_1 treatment (all chemical fertilizers as recommended dose), which was statistically similar with T_5 (101.23) vermi-compost as RD + 75% chemical fertilizers as RD and T_8 (99.07) poultry manure as RD + 75% chemical fertilizers as RD. The lowest number of pods plant^{-1} (41.83) was recorded from T_0, (without organic & inorganic fertilizer) treatment. The result revealed with the findings of Abbas *et al.* (2011) who reported that application of DAP at 124 Kg along with 10 tons ha^{-1} of poultry litter yielded maximum pod yield plant^{-1} in mungbean.

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

Organic and inorganic fertilizers management significantly influence the number of seeds pod^{-1}(Table 5).Results showed that the highest seeds pod^{-1}(1.87) was recordedat was recorded at T_1 treatment (All chemical fertilizers as recommended dose), which was statistically similar with T_5 (1.83) vermi-compost as RD + 75% chemical fertilizers as RD, T_8 (1.80) poultry manure as RD + 75% chemical fertilizers as RD. T_0, (without organic & inorganic fertilizer) showed the lowest seeds pod^{-1}(1.43) which was statistically at part with T_0. Aslam *et al.* (2010) reported that combined application of cowdung, vermi- compost, poultry manure and chemical fertilizer recorded higher number of seeds pod^{-1} that indicating primacy of integration of the two sources in having improved mungbean productivity.

4.2.3 Weight of 1000 seeds(g)

Statistically significant variation was recorded for weight of 1000 seeds of lentil due to the application of organic, inorganic fertilizers and their different combinations (Table 5).Weight of 1000 seed varied due to different chemical and organic fertilizers, and their combinations treatments. Hassan (2005), Akbar *et al.* (2002) and Ali *et al.* (1999) observed that combinations of organic and inorganic fertilizers application increased weight of 1000 seeds. The highest weight of 1000 seeds was recorded from T_1 (19.95 g), which was statistically similar with T_5 and T_8 treatments and the lowest weight (14.86 g) was recorded from T_0 treatment.

4.2.4 Shelling percentage(%)

Shelling percentage varied significantly due to different chemical and organic fertilizers, and their combinations. The highest shelling percentage was recorded from T_0 (80.33) and the lowest shelling percentage was recorded from T_1 (74.67) (Table 5). Results revealed that reduction of recommended chemical fertilizer, the shelling percentage was reduced. The similar result was found by El-Kholy *et al.* (2005).

Table 5. Effect of chemical and organic fertilizers and their combinations onpod plant^{-1}, seed pod$^{-1,}$ 1000 seed weight and shelling percentage of lentil

Treatments	Pod plant^{-1}(no.)	Seed pod^{-1}(no.)	1000 Seed weight (g)	Shelling %
T_0	41.83 f	1.43 f	14.86 e	80.33 a
T_1	104.67 a	1.87 a	19.95 a	74.67 d
T_2	93.93 bc	1.73 bc	18.33 bc	76.33 b-d
T_3	89.53 c	1.67 cd	18.17 b-d	75.67 cd
T_4	54.47 e	1.57 de	17.44 cd	78.00 a-c
T_5	101.23 ab	1.83 ab	19.63 ab	75.00 d
T_6	91.27 c	1.73 bc	18.24 bc	75.33 d
T_7	63.73 d	1.60 de	17.91 cd	76.00 cd
T_8	99.07 ab	1.80 ab	19.63 ab	75.00 d
T_9	88.03 c	1.63 c-e	17.95 cd	77.00 b-d
T_{10}	51.57 e	1.53 ef	16.74 d	78.67 ab
LSD(0.05)	7.47	0.12	1.49	2.43
CV (%)	5.49	4.07	4.83	1.86

T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

4.3Yield and harvest index

4.3.1 Seed yield (kg ha^{-1})

Statistically significant variation was recorded in the seed yield ha^{-1} for different chemical and organic fertilizers, and their combinations (Table 6). The highest yield (1838.67kg ha^{-1}) was obtained from T_1 (all chemical fertilizers as recommended dose), which was statistically similar with T_5(vermi-compost as RD + 75% chemical fertilizers as RD) and T_8(poultry manure as RD + 75% chemical fertilizers as RD), respectively for 1761.67kg ha^{-1} and 1740kg ha^{-1}. On the other hand, the lowest yield was found in T_0(498.33kg ha^{-1}),control that means without organic & inorganic fertilizer. Ahmed and Hossain (1992) reported that chemical and organic fertilizer, the major essential plant nutrient, plays an important role in producing higher seed yield of lentil. The result was consistence with the findings of Baron *et al.* (1995) who reported positive influence of the addition of organic matter notonly on soil properties but also on the mineral nutrient of plants and yield. This result also collaborate with the findings of Khan *et al.* (2009). Hassan (2005), Sharma and Subehia (2003), Sahoo and Panda (1999) and Ali *etal*. (1999).

4.3.2 Stover yield (kg ha^{-1})

Different chemical and organic fertilizers and their combinations exerted significant variation on stover yield per hectare of lentil (Table 6). The highest stover yield (2287.60kg ha^{-1}) was observed in T_1 which was statistically at per with T_5 and T_8 (2233.33 and 2226.67 kg ha^{-1}, respectively). Again the lowest yield (718.40kg ha^{-1}) was recorded from T_0. Vadivel *etal.* (2001) reported that application of enriched combination of organic and inorganic fertilizers@ 250 kg ha^{-1}increased thestover yield of lentil.

4.3.3 Biological yield (kg ha^{-1})

Significant variation was recorded in biological yield of lentil for different chemical and organic fertilizers, and their combinations (Table 6). The highest biological yield (4126.27kg ha^{-1}) was found in T_1 and that of the lowest 1216.73kg ha^{-1} from T_0. Application of all chemical fertilizer in recommended doses ensured the essential macro and micro nutrients for the vegetative and reproductive growth of lentil and the ultimate results were the highest seed and stover yield as well as maximum biological yield. Combination of cowdung, Vermi-compost, poultry manure and chemical fertilizers in different recommended doses also created a favorable condition for the growth and development of lentil plant for that combination of cowdung, vermi-compost, poultry manure and different chemical fertilizers also gave the similar results. Similar findings also reported by Khan *et* *al.* (2009), Hassan (2005) , Akbar *et al.* (2002), Vadivel *et al.* (2001) and Ali *et al.* (1999).

Table 6. Effect of chemical and organic fertilizers and their combinations on seed yield, stover yield, biological yield and harvest index of lentil

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_0	498.33 h	718.40 g	1216.73 i	40.93 c
T_1	1838.67 a	2287.60 a	4126.27 a	44.56 a
T_2	1678.33 bc	2186.67 bc	3865.00 cd	43.42 a-c
T_3	1486.67 d	2140.00 c	3626.67 e	40.99 bc
T_4	880.67 f	1648.33 e	2529.00 g	34.83 d
T_5	1761.67 ab	2233.33 ab	3995.00 b	44.10 ab
T_6	1585.00 cd	2173.33 bc	3758.33 d	42.17 a-c
T_7	966.67 ef	1710.00 de	2676.67 f	36.10 d
T_8	1740.00 ab	2226.67 ab	3966.67 bc	43.86 a-c
T_9	1015.00 e	1716.67 d	2731.67 f	36.95 d
T_{10}	676.67 g	1160.00 f	1836.67 h	36.84 d
LSD(0.05)	121.42	66.01	123.62	3.12
CV (%)	5.55	2.11	2.33	4.53

T_0 = No fertilizer(Control)
T_1 = All chemical fertilizer as Recommended Dose(RD)
T_2 = Cowdung as RD + 75% chemical fertilizer as RD
T_3 = Cowdung as RD + 50% chemical fertilizer as RD
T_4= Cowdung as RD + 25% chemical fertilizer as RD
T_5= Vermi-compost as RD + 75% chemical fertilizer as RD
T_6 = Vermi-compost as RD + 50% chemical fertilizer as RD
T_7= Vermi-compost as RD + 25% chemical fertilizer as RD
T_8 = Poultry manure as RD + 75% chemical fertilizer as RD
T_9 = Poultry manure as RD + 50% chemical fertilizer as RD
T_{10} = Poultry manure as RD + 25% chemical fertilizer as RD

4.3.4 Harvest index (%)

Harvest index for different chemical and organic fertilizers, and their combinations treatments showed significant differences (Table 6). The highest harvest index (44.56%) was recorded from T_1 which was similar with T_5 (44.10%), T_8 (43.86%), T_2 (43.42%) and T_6(42.17%). The lowest harvest index was recorded from T_4 (34.83%). Reddy *et al.* (1987) reported the significant increase in yield attributes resulted in significant increase in harvest index (%).

Chapter V

Summary and Conclusion

CHAPTER V
SUMMARY AND CONCLUSION

The present research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2015 to March, 2016 to study the feasibility of replacing chemical fertilizer by using organic fertilizer on growth, yield components and yield performance in Lentil. The experiment comprised 11 different treatments of organic and inorganic fertilizer and their combination viz., T_0: Control (without Organic & Inorganic fertilizer), T_1: All chemical fertilizer as recommended dose(RD), T_2: Cowdung as RD + 75% chemical fertilizers as RD, $T_{3:}$ Cowdung as RD + 50% chemical fertilizers as RD, T_4: Cowdung as RD + 25% chemical fertilizers as RD, $T_{5:}$ Vermi-compost as RD + 75% chemical fertilizers as RD:, T_6: Vermi-compost as RD + 50% chemical fertilizers as RD, T_7: Vermi-compost as RD + 25% chemical fertilizers as RD, T_8: Poultry manure as RD + 75% chemical fertilizers as RD, T_9: Poultry manure as RD + 50% chemical fertilizers as RD and T_{10}: Poultry manure as RD + 25% chemical fertilizers as RD on growth and yield performance of lentil. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Results showed that a significant influence was observed among the treatments regarding most of the parameters observed. The collected data were statistically analyzed for evaluation of the treatment effect.

Among the applied treatments T_1 (all chemical fertilizer as recommended dose) produced the superior growth and T_0 (control) gave the lowest performance at every stage of data recording. Plant height varied significantly at 20, 40, 60, 80 DAS, and at harvest for different chemical and organic fertilizer and their combinations under the present trial. However, the tallest plant (7.74, 17.13, 23.29, 35.52 and 35.54 cm at 20, 40, 60, 80 DAS and at harvest, respectively) was recorded in T_1 (all chemical fertilizer at recommended dose). Treatment T_1 (all chemical fertilizer as recommended dose) also produced the maximum number of primary branches per plant however the maximum number of primary branches per plant (0.93, 5.13, 9.00, 13.20 and 13.33 number of primary branch at 20, 40, 60 ,80 and at harvest, respectively). Dry weight per plant was thehighest (0.42, 0.77, 4.67 and 4.89 g at 30, 60, 90 DAS and at harvest, respectively) was found in T_1 treatment. The lowest days to emergence(80%), days to flowering(50%) and days to maturity(80%) was 6, 53 and 91 days in T_1 treatment. The highest shelling percentage 80. The highest CGR was found in T_1 (0.27, 2.67 and 1.14 g m^{-2} day^{-1} at 30-60, 60-90 DAS and 90- harvest, respectively). RGR were performed the best (0.03 g g^{-1} day^{-1} at 30-60DAS), T_1 (0.07 g g^{-1} day^{-1} at 60-90 DAS)), and $T_{5,}$ T_8 (0. 03 g g^{-1} day^{-1} at 90- at harvest)in T_0 treatment.

The maximum number of pod $plant^{-1}$ was found in T_1 (104.67) similarly T_5(101.23) and T_8(99.07) number of pod per plant. The maximum number of seed pod^{-1} was found in T_1 (1.87) similarly T_5(1.83) and T_8(1.80). The highest weight of 1000 seeds (19.95 g) was recorded from T_1 treatment. The highest seed yield (1838.67 kg ha^{-1}**)** was obtained from T_1 treatment. On the other hand, the lowest seed yield (498.33 kg ha^{-1}) was found in T_0 treatment. The highest stover yield was observed in T_1 (2287.60 kg ha^{-1}).

Significant variation was recorded in biological yield and harvest index of lentil for different chemical and organic fertilizer and their combinations. The highest biological yield was found in T_1 (4126.27 kg ha^{-1}) and that of the lowest (1216.73 kg ha^{-1}) from T_0. The highest harvest index was recorded from T_1 (44.56%), which was similar with T_5 (44.10%) and the lowest harvest index was recorded from T_4(34.83%).

From the above results, it may be concluded that all chemical fertilizer at recommended dose showed the better performance on growth and yield contributing characters of lentil but treatments, vermi-compost as RD + 75% chemical fertilizers as RD and poultry manure as RD + 75% chemical fertilizers as RD showed statistically similar performance. So, considering the above observation vermi-compost as RD + 75% chemical fertilizers as RD or poultry manure as RD + 75% chemical fertilizers as RD may be possible to use in replacing chemical fertilizer which will reduce 25% chemical fertilizer use without significant yield reduction.

Recommendations

Considering the above observation of the present experiment, further studies in the following areas may be suggested.

- Vermi-compost as RD + 75% chemical fertilizers as RD or Poultry manure as RD + 75% chemical fertilizers as RD fertilizers combinations which would reduce the use of 25% chemical fertilizer along with soil improvement might be suggested to be followed in highest lentil production.
- Expansion of integrated fertilizer management study to know the growth and yield performance of lentil in different agro-ecological zones (AEZ) of Bangladesh for regional variability.

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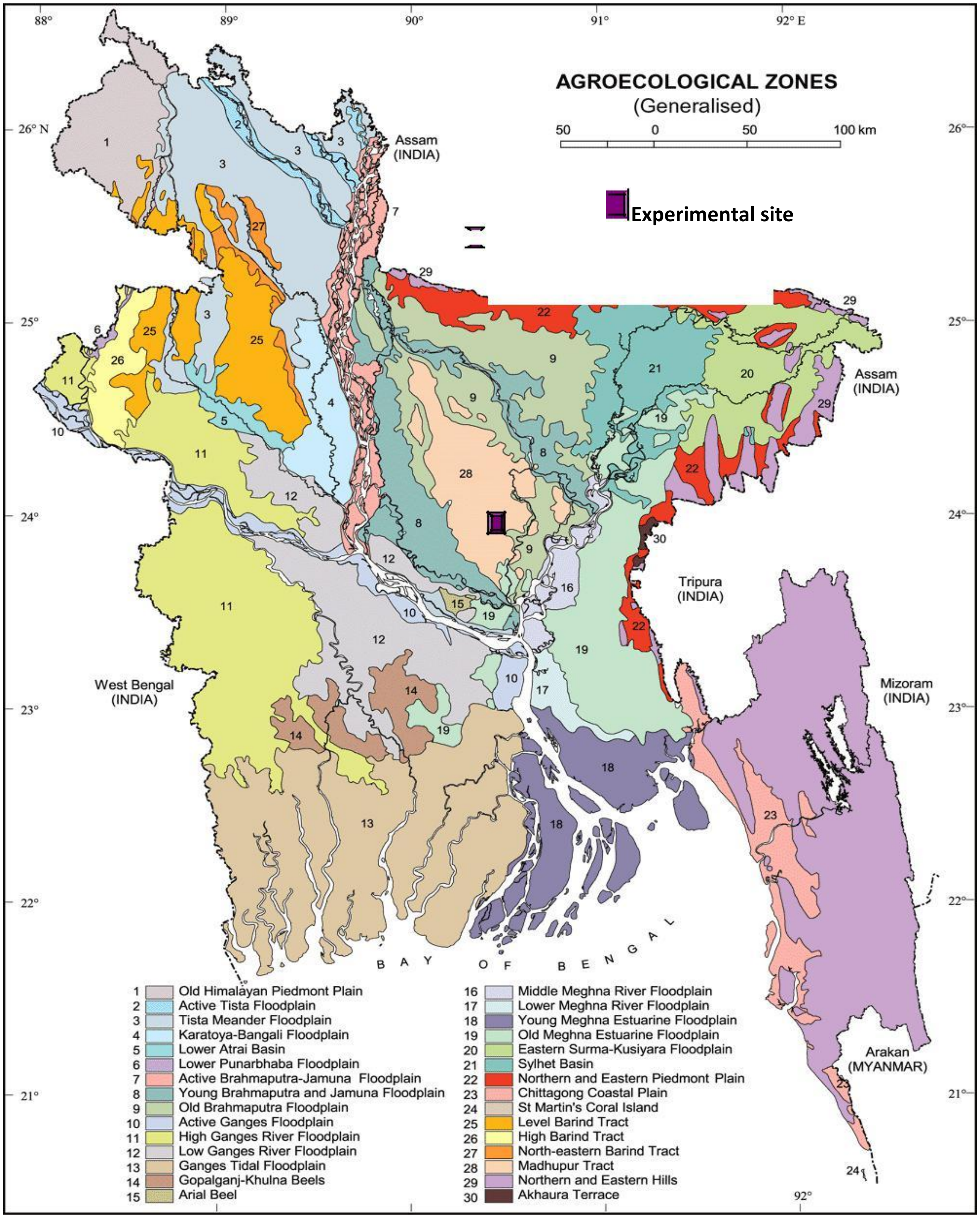
Appendices

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones ofBangladesh



Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

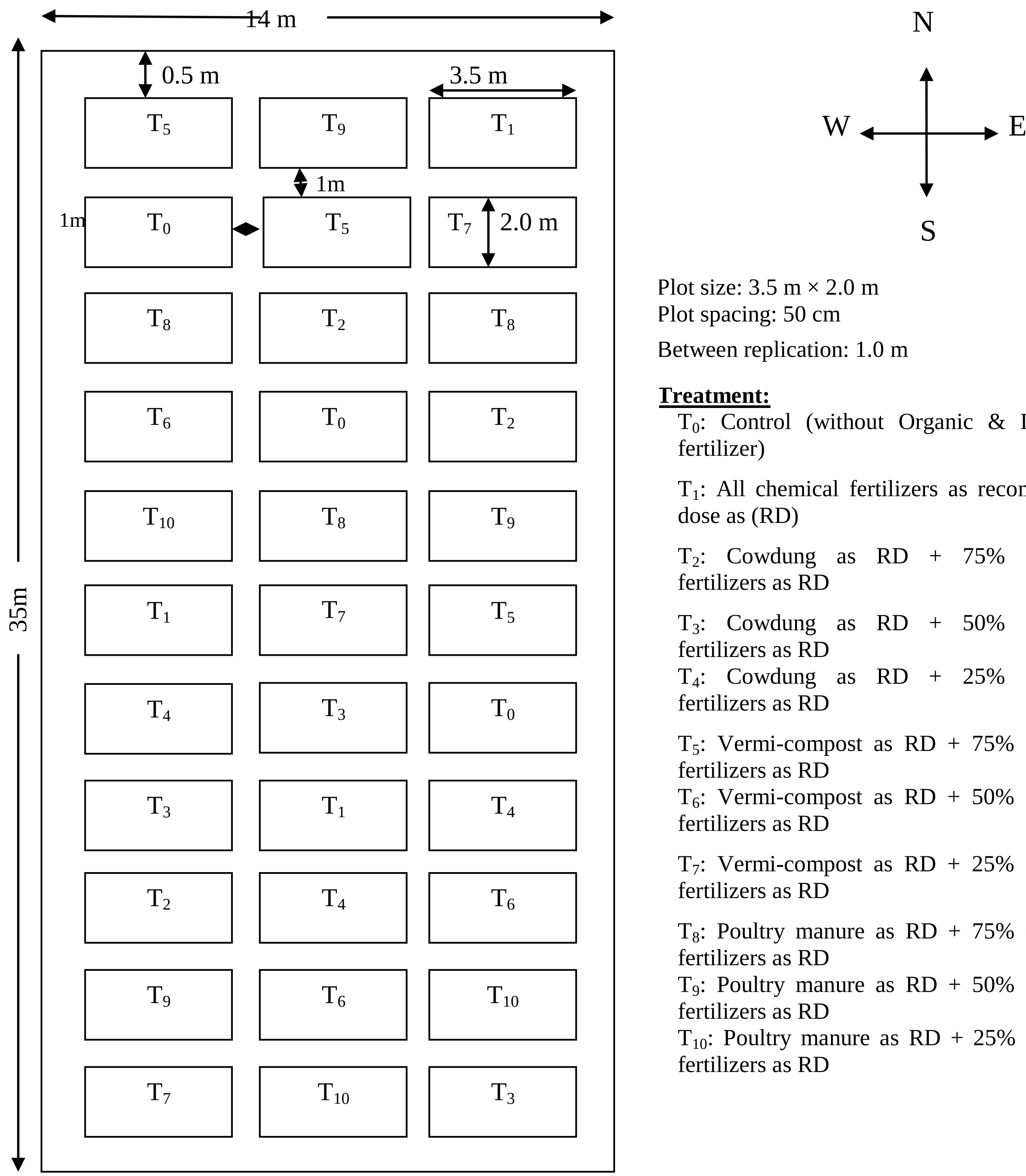
Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III. Monthly average Temperature, Relative Humidity and Total Rainfall and sunshine of the experimental site during the period from November, 2015 toMarch, 2016

Month	Air temperature (ºc)		Relative humidity (%)	Total Rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
November, 2015	34.8	18.0	77	227	5.8
December, 2015	32.3	16.3	69	0	7.9
January, 2016	29.0	13.0	79	0	3.9
February, 2016	28.1	11.1	72	1	5.7
March, 2016	33.9	12.2	55	1	8.7

Source: Bangladesh Meteorological Department (Climate & Weather Division), Agargoan, Dhaka -1212

Appendix IV. Layout of the Experimental plot



Plot size: 3.5 m × 2.0 m
Plot spacing: 50 cm
Between replication: 1.0 m

Treatment:

T_0: Control (without Organic & Inorganic fertilizer)

T_1: All chemical fertilizers as recommended dose as (RD)

T_2: Cowdung as RD + 75% chemical fertilizers as RD

T_3: Cowdung as RD + 50% chemical fertilizers as RD

T_4: Cowdung as RD + 25% chemical fertilizers as RD

T_5: Vermi-compost as RD + 75% chemical fertilizers as RD

T_6: Vermi-compost as RD + 50% chemical fertilizers as RD

T_7: Vermi-compost as RD + 25% chemical fertilizers as RD

T_8: Poultry manure as RD + 75% chemical fertilizers as RD

T_9: Poultry manure as RD + 50% chemical fertilizers as RD

T_{10}: Poultry manure as RD + 25% chemical fertilizers as RD