EFFECT OF MANURE ON GROWTH AND YIELD OF THREE LETTUCE VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled ***'EFFECT OF MANURE ON GROWTH AND YIELD OF THREE LETTUCE VARIETIES'*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the results of a piece of bonafide research work carried out by* ***MOST. SAYMA JAHAN****, Registration No.* ***11-04660*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2017
Dhaka, Bangladesh

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DEDICATED
TO
MY BELOVED PARENTS

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BY

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ABSTRACT

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka from November 2016 to February 2017. The experiment consisted of two factors, such as Factor A: Lettuce variety (3) as- V_1: Green wave, V_2: New red fire, V_3: Legacy and Factor B: Manure (3) as- M_0: 0 kg M/ha (control), M_1: Cowdung @ 20 t/ha, M_2: Poultry manure @ 8 t/ha. The two factor experiment was laid out in Randomized Complete Block Design with three replications. Lettuce variety and manure significantly influenced on different growth and yield parameter of lettuce varieties. In case of lettuce variety, the highest yield (20.49 t/ha) was found from V_1 and the lowest yield (17.66 t/ha) from V_2. Considering the manure application, M_2 produced the highest yield (20.78 t/ha) and the lowest (16.61 t/ha) was from M_0. Regarding the interaction effect, the highest yield (22.64 t/ha) was obtained from treatment combination V_1M_2 and the lowest yield (15.32 t/ha) from V_2M_0. The highest benefit cost ratio (2.53) was noted from the combination of V_1M_2 and the lowest benefit cost ratio (1.87) from V_2M_0. So, variety Green wave with Poultry manure @ 8 t/ha can be used for lettuce production.

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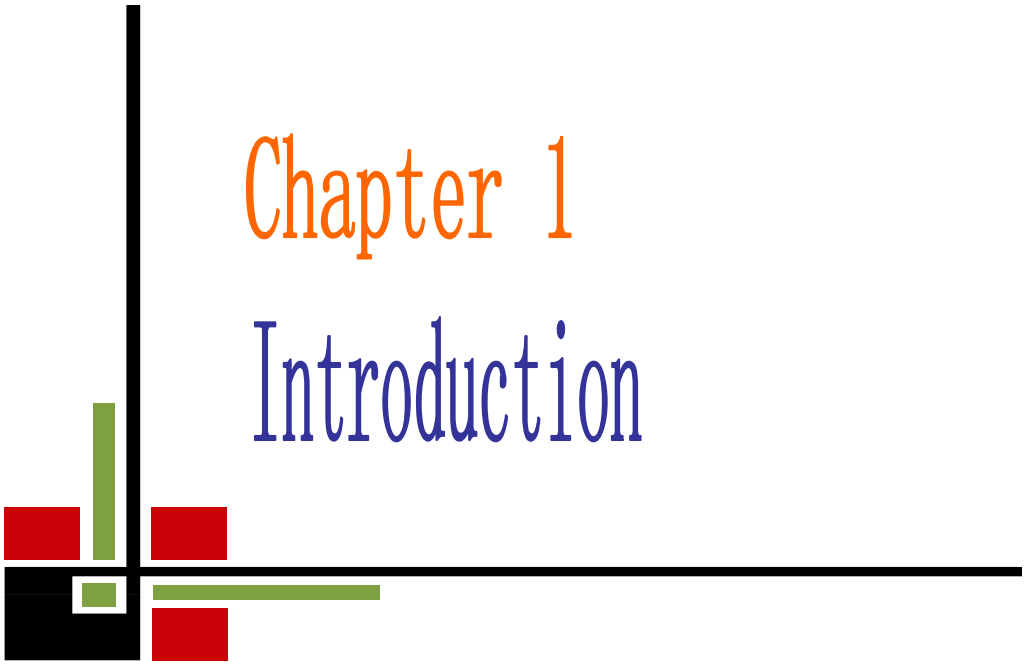
SOME COMMONLY USED ABBREVIATIONS

FULL WORD	ABBREVIATION
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Co-efficient of variation	Cv
Days After Sowing	DAS
and others	*et al.*
Etcetera	Etc
Food and Agriculture Organization	FAO
Journal	J.
Least Significance Difference	LSD
Sher-e-Bangla Agricultural University	SAU
Soil Resources Development Institute	SRDI



Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Lettuce (*Lactuca sativa* L.) belongs to the family Compositae is an important leafy salad crop and as an excellent nutritive source of minerals and vitamins since it is consumed as fresh green salad (Abu-Rayyan *et al*., 2004). Lettuce is the most popular according to the highest consumption rate and economic importance through the world (Coelho *et al*., 2005). It has not as yet been cultivated in large scale, but its importance is gradually increasing (Chohura and Eugeniusz, 2009). It produces a cluster of leaves varying considerably in shape, character and colour in different varieties. It is popular for its delicate, crispy, texture and slightly bitter taste with milky juice as fresh condition. The leaf of lettuce contains moisture 94%, protein 1.8%, carbohydrate 2.9%, vitamin-A 300-1500 I.U, thiamine 0.09 mg, riboflavin 0.12 mg, minerals 10 mg, calcium 50 mg, iron 2.0 mg and other nutrients (BARI, 2017).

Lettuce is a newly introduced crop in Bangladesh and getting popularity day by day but its production package is not much known to the farmers of our country (Kowalska *et al*., 2006). Yield and quality of lettuce can be affected by various factors such as environmental condition (La Malfa and Ruggeri, 1988), nutritional management (Acar *et al*., 2008; Khah and Arvanitoyannis, 2003) and growing season (Saplaouras *et al*., 2001; Khah *et al*., 2012). Suitable production technology is pre-requisite for attaining highest yield of lettuce (Orzolek, 2004). Deficiency of soil nutrient is considered as one of the major constraints to successful crop production in Bangladesh (Islam and Noor, 1982). Lettuce responds greatly to major essential elements like N, P and K in respect of its growth and yield and its production can be increased by adopting improved management practices (Thompson and Kelly, 1988). The successful cultivation of lettuce requires proper supply of nutrients and it can be provided by applying optimum doses of fertilizers and manure in appropriate variety.

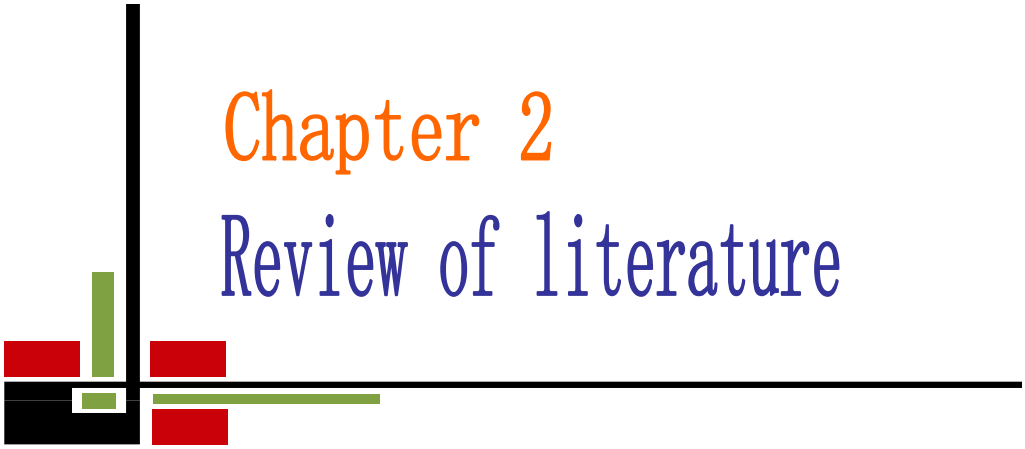
In Bangladesh, the yield of lettuce is not satisfactory in comparison with other lettuce growing countries of the World (Lucic and Perkovic, 2013). The low yield of lettuce in Bangladesh however is not an indication of low yielding potentially of this crop but the fact may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, fertilizer management, pest infestation and improper irrigation facilities as well as different abiotic stress conditions (Lawlor and Cornic, 2002). The environmental stresses resulting from drought, temperature, salinity, air pollution, heavy metals, pesticides, soil pH, insect pests, diseases etc. are the major limiting factors in crop production (Alqudah *et al*., 2011). Adaptation of suitable variety may be minimize the attributed low yielding potentiality. On the other hand, chemical fertilizers have made substantial contributions to increased crop yields but with the application of excess or very lower doses caused crop failure and as well as create health hazards (Fageria, 2009). Proper application of organic manure as an alternative source of nutrients is more safe and economic in this context.

Variety plays an important role in producing high yield of lettuce because different varieties perform differently for their genotypic characters. Improved variety is the first and foremost requirement for initiation and accelerated crop production program. Lettuce can be grown throughout the year using cultivars with different environmental requirements (Leon *et al*., 2012). In Bangladesh most of the lettuce variety comes from other country and BARI have only one released variety. Availability of suitable high yielding cultivars and use of organic materials as nutrient source may help the farmers to achieve more returns per unit area. The abundance of different types and varieties of lettuce and its affiliation with yellow-green-red vegetables are available at present (Acamovic-Dokovic *et al*., 2011). Varietal influences of lettuce were recorded in terms of growth characteristics, on fresh and dry weights of leaves and on leaf number, leaf length, plant length, yield and different researchers observed different varietal characteristics for different variety (Santamaria *et al.*, 2000; Boroujerdnia and Ansari, 2007; Tsiakaras *et al*., 2014).

Manures was reffered the fertilizers that derive from animal matter, animal excreta, human excreta, and different plant matter (Dittmar *et al*., 2009). Manures improves soil structure, facilitates aeration in soil as well as increase water holding capacity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Recently organic farming is appreciated by vegetable consumers as it enhances quality of the produce. Now a days the peoples are willing to get the vegetable without the inorganic fertilizer, because the peoples are suffering with some serious disease which are due to the affect of inorganic fertilizers (Relf *et al*., 2002). Increased consumer awareness of food safety issues and environmental concerns has contributed to the development of organic farming over the last few years (Worthington, 2001). In particular, the lettuce crop responds positively to the application of different organic supplements, although the recommendations on application rates vary between different researchers and type of fertilizers that used (Polat *et al*., 2004; Jae-Jung *et al*., 2004; Mastouri *et al*., 2005).

With conceiving the above scheme in mind, the present research work has been undertaken in order to fulfilling the following objectives:

- To study the growth and yield of different lettuce varieties;
- To determine the effect of different manures on growth and yield of lettuce; and
- To find out the interaction effects of different varieties and manures on growth and yield of lettuce.



Chapter 2
Review of literature

CHAPTER II

REVIEW OF LITERATURE

Lettuce is one of the most important and popular salad vegetables in Bangladesh as well as many countries of the world. As a newly introduced crop it has conventional less concentration by the researchers on various production aspects of its growth and management practices and a very few studies on the growth and yield of lettuce have been carried out in our country as well as many other countries of the world. Therefore, the research work on different management for highest production so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important informative works and research findings related to variety and organic manure on lettuce so far done at home and abroad have been reviewed in this chapter under the following headings:

2.1 Growth and yield of lettuce for different varieties

Mhamdi *et al*. (2014) conducted an experiment to find out the effect of nitrogen fertilizer level on growth and nitrate accumulation was studied in six lettuce cultivars (*Lactuca sativa* L.): 'Batavia rouge', 'Vitalia', 'Great Lakes', 'Type Beurre', 'Romaine' and 'Romaine LO_3'. Three nitrogen levels: 0, 120 and 240 Kg/ha was applied. During plant growth, agronomical parameters (leaves weight, root weight, dry matter and head diameter) and physiological parameters (nitrate concentration, chlorophyll fluorescence and sugar content) were evaluated. Results showed significant differences between cultivars and nitrogen treatment for the most agronomical and physiological parameters. The nitrogen treatment affects head weight and nitrate concentration in all cultivars; the cvs 'Great Laks' and 'Type beurre' accumulated respectively the less and high nitrate concentration.

Tsiakaras *et al*. (2014) conducted an experiment to study the effect of both nitrogen application rate and gibberellic acid (GA_3) on yield and earliness of production and marketability of three commercial cultivars [cv. 'Kismy' and

‘Marady’ (loose-leaf types) and cv. ‘Adranita’ (romaine type)] in an unheated plastic greenhouse for three consecutive growing periods. Results revealed that cultivar had a significant effect on growth characteristics, on fresh and dry weights of leaves and on leaf number and plant length.

Lucic and Perkovic (2013) conducted a three year study with three varieties of lettuce (Archimeds RZ, RZ Santoro, Kibo RZ). Each row with these varieties was exposed to the following variants of covering: control-planting on bare soil, mulching before sowing with PE-black foil, agro textile covering plants after planting with agro textile (17 g), a combination of mulching + agro textile. The results show that the highest yield was recorded in agro textile variant (14 kg/10 m^2), and lowest in controls (9.31 kg/10 m^2). Throughout of all the three years of the trial, it was continuously evidenced that the variety Santoro had the biggest heads and the highest yield (15.33 kg/10 m^2), which leads to conclusion that the yield of lettuce is a varietal characteristics.

Leon *et al*. (2012) carried out a trail to evaluate the effect of the application of vermicompost on the growth parameters of lettuce in two commercial types: leaf lettuce (cv Brisa) and butterhead (cv Daguan). During cultivation and at harvest measurements of fresh and dry weight, leaf number and area, nitrate and reducing sugar concentrations were made and found that cv Brisa was superior in consideration of most of the studied characters.

Boroujerdnia and Ansari (2007) conducted an experiment at Shahid Chamran University of Ahwaz, Iran to determine the effect of nitrogen fertilizer rates and cultivars on growth and critical yield of lettuce. The treatments included four nitrogen rates (0, 60, 120, and 180 kg N/ha) as the main plot and two lettuce cultivars (‘Pich Ahwazi’ and ‘Pich Varamini’) as the sub-plot. The criteria measured were plant length, fresh and dry weights of leaves, leaf area, number of leaves, crop growth rate (CGR), leaf area index (LAI) and yield. Results indicated that cultivar had a significant effect on growth characteristics, on fresh and dry weights of leaves and on leaf number but not on plant length and leaf

area. The highest yield was obtained from ‘Pich Ahwazi’. Also, it took ‘Pich Varamini’ longer to form a head and to flower than ‘Pich Ahwazi’.

Parente *et al.* (2006) carried out an experiment that the present work aimed to study production and accumulation of nitrate by new cultivars of lettuce in response to nitrogen doses applied to the soil. The main objective was to compare a control unfertilized treatment with two nitrogen doses (75 and 150 kg/ha) applied by fertilization to different cultivars of lettuce belonging to the following types: Lollo Bionda, Canasta, Lollo Rossa, and, in the second trial, Oakleaf. The Lollo Rossa cultivars produced 26 and 56% less than the Canasta type, respectively, in the first and the second year, probably due to the absence of a real head in the Lollo type.

Mantovani *et al.* (2005) carried out an experiment using pots under greenhouse conditions to evaluate the influence of nitrogen fertilizer application on the growth and nitrate accumulation of lettuce cultivars. Treatments consisted of five nitrogen rates (0, 141.5, 283.0, 566.0 and 1132.0 mg/pot N as urea) and five lettuce cultivars viz. Lucy Brown, Taina, Vera, Veronica and Elisa. Results revealed that Lucy Brown and Taina accumulated more nitrate than Vera, Veronica and Elisa cultivars.

Echer *et al.* (2001) evaluated the performance of 5 lettuce cultivars (Brisa, Grande Rapida, Marisa, Vera and Veronica) in 2 spacing treatments (0.20 × 0.25 m and 0.25 × 0.25 m) in Sao Paulo, Brazil. The following parameters were evaluated: fresh matter of aerial parts per plant; number of leaves per plant; leaf fresh matter per plant; average fresh matter of one leaf; relationship between leaf fresh matter per plant and fresh matter of aerial parts per plant; and average total production per area. No significant interaction between cultivar and spacings were found. The cultivars with the best performances were Vera, Marisa and Brisa. A higher correlation between leaf fresh matter and fresh matter of aerial parts was observed in Vera compared to other cultivars.

Simonne *et al.* (2001) carried out an experiment with the objectives to evaluate the effect of the N-source used as injection material on the field performance and sensory attributes of three lettuce types. Three lettuce types, Romaine ('Parris Island'), butterhead ('Optima') and looseleaf ('Sierra'), where grown with plasticulture and sidedressed with weekly injections of calcium nitrate, potassium nitrate, or ammonium nitrate, each at a rate of 7 kg N/ha/week. All lettuce type reached marketable size 49 days after transplanting and variety effects marketable yield and head number was not significant.

Santamaria *et al.* (2000) conducted an experiment with two trials aimed at evaluating yield and nitrate content of 6 lettuce (*Lactuca sativa*) cultivars and to study the possibility of decreasing nitrate content in heads by changing nutrient solution composition near harvest, are reported. Plants were grown in a greenhouse with a soilless system (subirrigated gully). In both trials the cultivars were Alisia and Jessica (botanical variety: longifolia), Tibet and Mindoro (bot. var.: capitata), and Estilia and Carminia (bot. var.: crispa). Results revealed that yields and dry matter contents were higher in longifolia cultivars than in capitata and crispa cultivars.

Silva *et al.* (2000) evaluated the nutritional efficiency of nitrogen in 17 cultivars of lettuce, aiming to identify the nitrogen dose and the most adapted character for genetic studies, as well as to classify them for efficiency. The experiment was carried out in a greenhouse in polyethylene pots containing 4.5 dm^3 of substratum (a part of sand and two of soil), in which four doses of N were used (25, 75, 125 and 200 mg N/dm^3). There was a genetic variability among the cultivars in the study. The dry and fresh matters of the aerial part were the most important characters to discriminate the cultivars as to its nutritional efficiency for N. 'Vitoria de Verao' was considered efficient for the 75 and 125 mg N/dm^3 doses; 'Nativa' for the 75 mg N/dm^3 dose; and 'Regina de Verao' for the 125 mg N/dm^3. Cultivars 'Grandes Lagos', 'Maravilha de Verao' and 'Grand Rapids' were inefficient for both doses.

2.2 Growth and yield of lettuce for different organic manure

Hossain and Ryu (2017) conducted a greenhouse experiment to identify the suitable dose of organic fertilizer for lettuce production. Different doses of organic fertilizer (6.5, 13 and 26 t/ha) and the recommended dose of chemical fertilizer (RDCF) as standard were selected for this experiment. Application of 13 t/ha organic fertilizer significantly increased leaf size (length and breadth) of lettuce. This treatment also increased 14, 25, 21, 32, 24, 27, 36 and 168% fresh weight, dry weight, N, P, K, Ca, Mg and Na uptake over RDCF, respectively. Organic matter content was increased of 17.79, 43.82 and 89.89 % in 6.5, 13 and 26 t/ha organic fertilizer treated plots respectively over recommended dose of chemical fertilizers. Positive and significant correlation was observed on yield and yield attributes of lettuce and soil nitrogen, organic matter with pH, total nitrogen with mineral nitrogen and negative correlation was found with applied organic fertilizer with cadmium and lead. Based on these results, organic fertilizer @ 13 t/ha without chemical fertilizer could be recommended to increase lettuce yield as well as mitigate heavy metals in soil.

Farag *et al*. (2013) carried out an investigation for two seasons into white polyethylene container filled with coconut fiber, to study the effect of three nitrogen levels (50, 100 and 150 ppm) applied by fertilization system and three compost levels (0, 2 and 4% by volume). Lettuce plant with two types' Iceberg and Romaine lettuce were transplanted to study the effect of treatments on vegetative growth, nutrients content (nitrogen, phosphors, potassium, calcium, magnesium and nitrate) as well as total yield. The obtained results indicated that compost at 4% gave the highest vegetative growth and yield comparing with the other treatments. The highest nitrogen level (150 ppm) combined with compost 4% increased significantly vegetative growth and total yield of lettuce. On the other hand, 50 ppm nitrogen gave the highest nitrogen use efficiency (NUE) and the least value of nitrate content in leaves followed by 100 ppm.

Masarirambi *et al.* (2012) carried out an experiment in a lath house at Luyengo Campus, Horticulture Farm, University of Swaziland to assess the effects of varied levels of chicken manure on growth, yield and quality of lettuce. The cultivar used was 'Taina'. The levels of chicken manure used were 60, 40 and 20 t/ha. A control of inorganic fertilizer 2:3:2 (22) + 0.5% Zn was used at a rate of 955 kg/ha basal dressing and limestone ammonium nitrate (LAN 28%) at a rate of 100 kg/ha as side dressing. The results showed that chicken manure levels significantly affected growth, yield and nutritional quality of lettuce. A trend of superiority of the different level of chicken manure application was observed as lettuce provided with 60 t/ha exhibited higher values in number of leaves, plant height, marketable yield and mean leaf dry mass. The second best results were obtained from plants supplied with 40 t/ha followed by plants previously fertilized with 20 t/ha and the lowest from those provided with inorganic fertilizer. However, there was no significant difference in iron content on fresh mass basis for all treatments. Results of this experiment showed that inorganic fertilizer was less suitable in lettuce production. Lettuce may be grown using 60 ton/ha chicken manure for a more productive enterprise.

Leon *et al*. (2012) carried out an experiment to evaluate the effect of the application of vermicompost on the growth parameters of lettuce in two commercial types: leaf lettuce (cv Brisa) and butterhead (cv Daguan). During cultivation and at harvest measurements of fresh and dry weight, leaf number and area, nitrate and reducing sugar concentrations were made. Results revealed that at harvest, vermicompost addition affected nitrate content in leaf lettuce increasing its concentration and yield was not affected by vermicompost application.

Masarirambi *et al*. (2010) was conducted an experiment in the University of Swaziland with the organic fertilizers- (a) bounce back compost, (b) cattle manure and(c) chicken manure and the rates of application were 40 tons per hectare (t/ha) for chicken and cattle manures, 1.5 t/ha basal dressing and 1.0 t/ha

side dressing for bounce back compost. Inorganic fertilizers 2:3:2 (22) + 0.5% zinc (Zn) and limestone ammonium nitrate (LAN 28%) were included at specific application rates of 955 kg/ha basal dressing and 100 kg/ha side dressing as control. The results showed that type of fertilizer applied significantly affected growth, yield and nutritional quality of lettuce. A trend in superiority of the different types of organic fertilizers was observed as the chicken manure exhibited relatively higher values on number of leaves, plant height, marketable yield and mean leaf dry mass. Cattle manure was second, and then bounce back compost and lastly the inorganic fertilizers. Results of this experiment showed that inorganic fertilizers were less suitable in lettuce production in river sand when compared to organic fertilizers. It is recommended that lettuce can be grown successfully using organic fertilizers.

Asaduzzaman *et al.* (2010) conducted an experiment in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the combined effect of mulch materials and organic manure on the growth and yield of lettuce. Four levels of mulch materials viz., Mo = No mulching, M_1 = Dry water hyacinth, M_2 = Black polythene and M_3 = Dry rice straw and four levels of organic manure viz. OMo= no organic manure, OM_1 = Cow dung (20 t/ha), OM_2 = Poultry manure (10 t/ha) and OM_3 = Vermicompost (10 t/ha) were also used as experimental variables. The results showed that most of the growth parameters were influenced by the mulch materials and organic manure. All of the recorded the parameters viz. number of leaves/plant, leaf length (cm), leaf breath (cm), dry matter accumulation (%), yield (g/plant) and yield (t/ha) performed better in case of M_2OM_3 (Black polythene + vermicompost: 10 (t/ha). Although the highest gross and net returns were obtained from the M_2OM_3 and it was apparently from the above results that the treatment combination of M_2OM_3 was more profitable compared with other treatments but from economic point of view treatment M_1OM_2 (Dry water hyacinth + poultry manure : 3.37) was more economic than the M_2OM_3.

Johannessen *et al.* (2004) reported that no difference in bacteriological quality could be detected in lettuce at harvest after application of various types of manure-based fertilizers grown under Norwegian conditions. Significance and impact of the study, the results may indicate that the use of manure does not have considerable influence on the bacteriological quality of organic lettuce. Further research on lettuce with organic manure is needed.

Stintzing *et al.* (2002) conducted an experiment and showed that the pelleted broiler manure gave a better effect on yield than stored broiler manure. Nutrient balances showed that it was difficult to attain a good balance between application and uptake of nutrients when using broiler manure, especially pelleted. Soil samples indicate that the amount of mineral nitrogen in the soil after harvest did not differ significantly between the two broiler manures at the two levels of application.

El-Shinawy *et al*. (1999) reported that the highest in the control treatment, followed by chicken manure, pigeon manure and finally buffalo manure. Mineral composition of plants was influenced by treatment. The results suggested that chicken manure, with some modifications, could be used as an organic source under the nutrient film technique system.

Tisselli (1999) reported that maximum rates of organic manure (usually poultry manure) and NPK recommended by the crop for use in lettuce crops in Emilia-Romagna, Italy are tabulated. Trials showed that a combination of organic and mineral fertilizers gave higher yields of marketable heads, fewer rejects and a better average weight/head than mineral fertilizer alone.

Rodrigues and Casali (1999) observed that the highest estimated yields of 119.5, 119.4 and 153.9 g/plant with 37.7 t organic compost/ha with no mineral fertilizer application, 18.9 t organic compost/ha with half the recommended mineral fertilizer rate and 13 t organic compost/ha with the recommended mineral fertilizer rate. Organic compost application resulted in lower foliar N and Ca

concentrations and higher foliar P, K and Na concentrations compared with mineral fertilizer application.

Rodrigues and Casali (1998) observed that the performance of 11 lettuce cultivars in organic fertilizer was correlated with their N utilization efficiency. High K availability reduced the absorption of K and Mg, and cultivars which were more responsive to the organic fertilizer tended to be more efficient in absorption and translocation of Ca and Mg.

Zarate *et al*. (1997) observed that the interaction between organic manure rate and method of application was significant. In the absence of incorporated manure, surface application of 14 t manure/ha gave significantly higher yields (17.8 t fresh matter/ha) than other rates. When 7 t/ha was incorporated, the rate of surface application had no significant effect on yields (13.3-17.1 t/ha), whereas when 14 t/ha was incorporated, surface application of 7 t manure/ha gave significantly the highest yield (20.0 t fresh matter/ha).

Vidigal *et al*. (1997) mentioned that dried pig manure gave the highest yields 65 days after sowing (54.4 t/ha), an increase of 33.3% above those supplied with NPK, with similar results in a succeeding crop planted on the same ground in late September (39.4% increase over NPK). Napier grass + coffee straw + pig slurry was the best mixture, increasing yields 10.8% and 17.6% above those produced by NPK in 1^{st} and 2^{nd} crops, respectively.

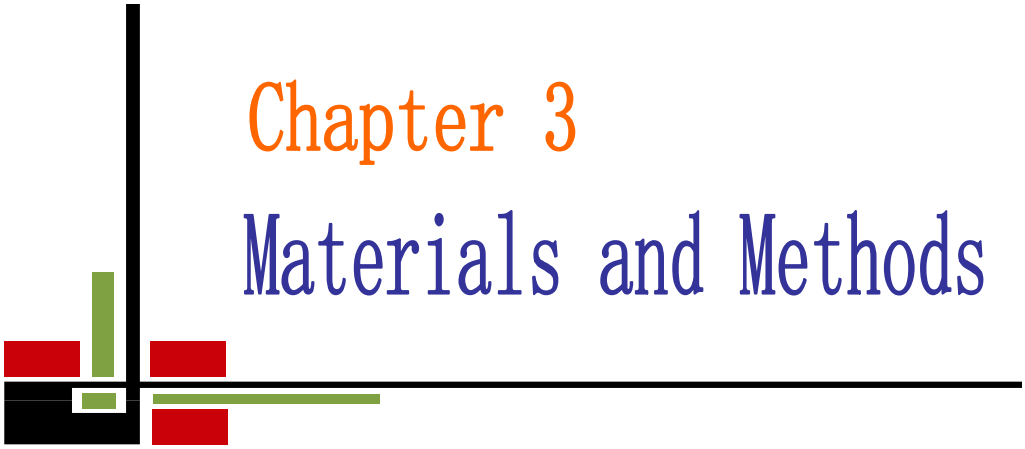
McQuilken *et al*. (1994) reported that manure-straw mixtures composted and water extracts, made by incubating compost in water for 3 to 18 d, were assessed for antagonistic activity against B Weekly sprays of 8-d-old extracts onto lettuce in the glasshouse and found no effect on the incidence of grey mould, but significantly reduced its severity and increased marketable yield. The use of compost extracts in bio-control of plant diseases and their possible mode of action is discussed.

Huang and Tsai (1993) applied hog manure to a red soil and an older slate alluvial soil in a pot trial. The growth rate of spinach and leaf lettuce was proportional to the quantity of hog manure added. An application equivalent to 20 t/ha was the most effective and resulted in a yield increase over unfertilized controls of 113% and 44.9% for spinach and leaf lettuce, respectively, on the red soil and 80.2% and 59.4%, respectively, on the alluvial soil.

Baca *et al*. (1993) reported that green manure, equivalent to 40 and 80 kg N/ha, was incubated with a sand-soil mixture for 2 and 5 months and tested in a greenhouse experiment with lettuce. Before and after the incubation period, the total organic carbon was extracted by the $Na_4P_2O_7$-NaOH 0.1M method and purified with PVP resin. There was no difference between the quantities of humic carbon extracted after the different treatments with phosphorus, but there was a difference in quality. The mixture incubated with phosphorus showed a positive effect on plant growth but those incubated only with green manure showed a negative response.

Bosch *et al*. (1991) stated that nitrates were estimated in 56 samples of 5 vegetables 19 of which had been treated with organic fertilizers and 37 with mineral fertilizers. Mean nitrate in sweet chard treated with organic and mineral fertilizers was 1940 and 3386 mg KNO_3/kg respectively, in lettuce 975 and 1688, in carrots 681 and 626, in leeks 671 and 569, and in green beans 661 and 274 mg/kg. Differences between values for sweet chard and lettuce were significant.

Above cited reviews revealed that variety and organic manure are the important factors for attaining optimum growth and yield of lettuce. The literature revealed that the effects of variety and organic manure have not been studied well and have no definite conclusion for the production of lettuce in the agro climatic condition of Bangladesh.



Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out to assess the effect of manure on growth and yield of three varieties of lettuce. The materials and methods i.e. experimental period, location, climate condition and soil of experimental site, planting materials, design of the experiment, data collection and data analysis procedure that were used for conducting the experiment are presented in this chapter under the following headings and sub-headings-

3.1 Description of the experimental site

3.1.1 Experimental period

The experiment was conducted during the period from November 2016 to February 2017.

3.1.2 Experimental location

The present study was conducted in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the experimental site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level.

3.1.3 Climatic condition

The monthly average temperature, humidity and rainfall during the crop growing period were collected from Bangladesh Meteorological Department, Agargoan, Dhaka-1212 and presented in Appendix I. During this experimental period the maximum temperature (27.1^0C) and maximum rainfall 30 mm was recorded in the month of February 2017, whereas the minimum temperature (12.4^0C) in January 2017. The highest humidity (78%) was recorded in the month of November, 2016.

3.1.4 Characteristics of soil

The soil of the experimental field belongs to the Tejgaon series under the Agroecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the study. The collected soil was air-dried, grind and passed through 2 mm sieve and analyzed at Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka for some important physical and chemical properties. The soil was having a texture of sandy loam with pH and organic matter capacity 5.6 and 0.78%, respectively and the the soil composed of 27% sand, 43% silt, 30% clay. Details descriptions of the characteristics of soil are presented in Appendix II.

3.2 Experimental details

3.2.1 Planting materials

The seeds of lettuce variety ‘Green wave, New red fire and Legacy’ as per the treatment were used as planting materials for this experiment.

3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Lettuce variety (3) as

i V_1: Green wave

ii. V_2: New red fire

iii. V_3: Legacy

Factor B: Manure (3) as

i. M_0: 0 kg M/ha (control)

ii. M_1: Cowdung @ 20 t/ha

iii. M_2: Poultry manure @ 8 t/ha

There were 9 (3 × 3) treatments combination such as V_1M_0, V_1M_1, V_1M_2, V_2M_0, V_2M_1, V_2M_2, V_3M_0, V_3M_1 and V_3M_2.

Plate 1. Photograph showing different lettuce variety

3.2.3 Design and layout of the experiment

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 132.00 m^2 with length 15.0 m and width 8.8 m which were divided into three equal blocks. Each block was divided into 9 plots where 9 treatments combination allotted at random. There were 27 unit plots and the size of each plot was 1.6 m × 1.0 m. The distance was maintained between two blocks and two plots that were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.2.4 Preparation of experimental field

The selected plot of the experiment was opened in the last week of November 2016 with a power tiller, and left exposed to the sun for a week. Subsequently cross ploughing was done followed by laddering to make the land suitable for seed sowing of lettuce. All weeds, stubbles and residues were eliminated from the experimental plot and finally, a good tilth was achieved for seed sowing of lettuce. The soil was treated with insecticides (Cinocarb 3G @ 4 kg/ha) at the time of final land preparation to protect young plants from the attack of cutworm and mole cricket.

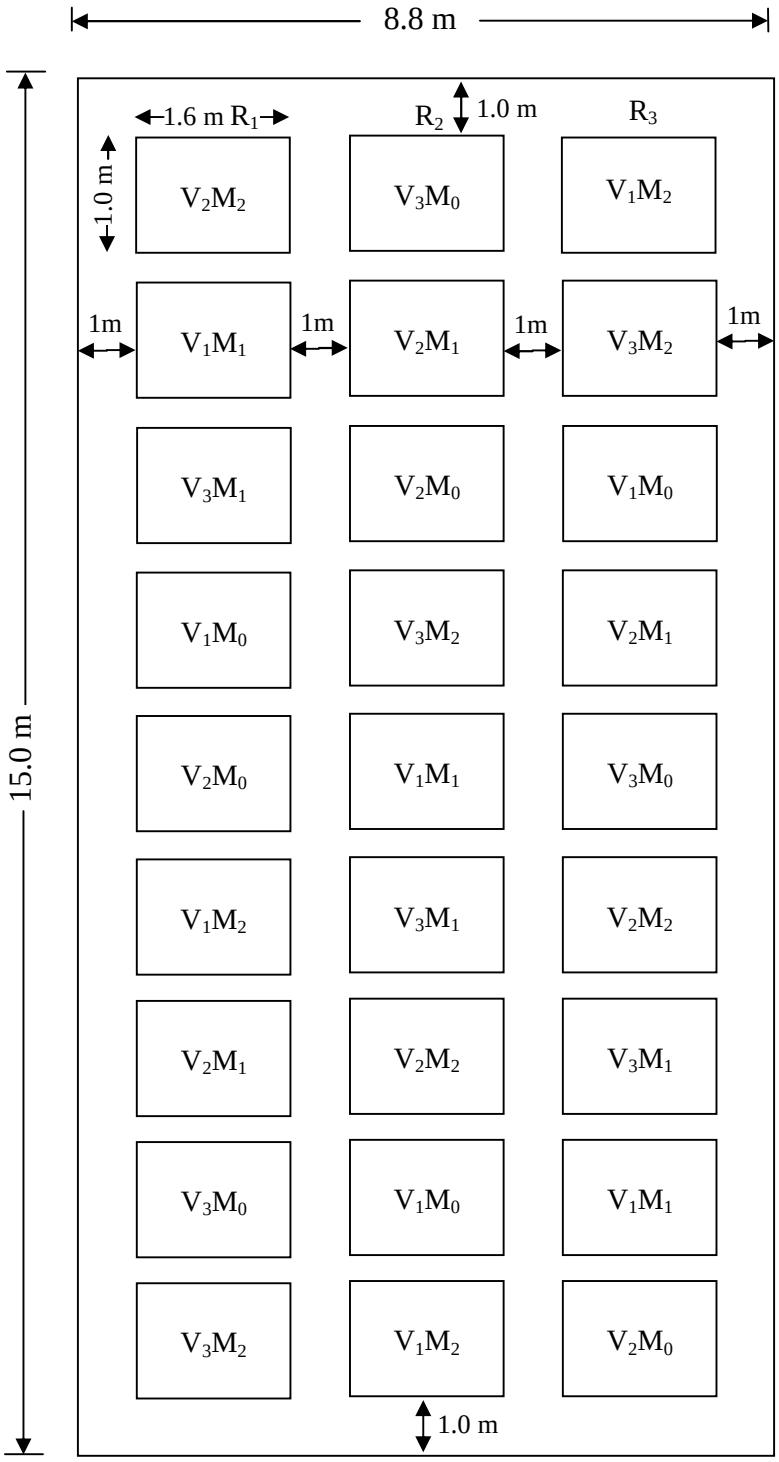
3.2.5 Application of manure

The sources of N, P and K cowdung and poultry manure were applied as per treatment. The entire amount of cowdung and poultry manure was applied during final land preparation. The following amount of manure were used which was shown as tabular from in Table 1.

Table 1. Composition of cowdung and poultry manure

Manures	Nutrients		
	N (%)	P ((%)	K (%)
Cowdung	o.5 – 1.5	0.4 – 0.8	0.5 – 0.9
Poultry manure	1.6	1.5	0.85

Source: BARC, 1987



Plot size: 1.6 m × 1.0 m

Plot spacing: 50 cm

Between replication: 1.0 m

Factor A: Lettuce variety (3) as

i V_1: Green wave

ii. V_2: New red fire

iii. V_3: Legacy

Factor B: Manure (3) as

i. M_0: 0 kg M/ha (control)

ii. M_1: Cowdung @ 20 t/ha

iii. M_2: Poultry manure @ 8 t/ha

Figure 1. Layout of the experimental plot

3.3 Growing of crops

3.3.1 Collection of seeds

The seed of lettuce variety ‘Green wave, New red fire and Legacy’ was collected from Siddique Bazar market, Dhaka.

3.3.2 Seed sowing

The seeds of lettuce were raised directly in the field that was prepared as experimental plot. Before sowing of seeds it were soaked in water for 48 hours and then seeds were mixed with soil and sown in seed bed. Lettuce seeds were sown on 11 December, 2016. Complete germination of lettuce seeds took place within five days of seeds sowing. A number of seeds were also sown in the border of the experimental plots for gap filling if necessary.

Plate 2. Photograph showing the experimental plot

3.3.3 Intercultural operation

After raising seedlings, various intercultural operations such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the lettuce seedlings.

3.3.3.1 Gap filling

The raised seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after few days of germination

and such seedlings were replaced by new seedlings from the same stock from border side. Replacement was done with healthy seedling having a boll of earth which was also planted on the same date by the side of the unit plot. They were given shading and watering for 5 days for their proper establishment.

3.3.3.2 Weeding

The hand weeding was done 15, 25 and 35 days after sowing to keep the plots free from weeds.

3.3.3.3 Earthing up

Earthing up was done at 15, 25 and 35 days after seeds sowing followed by weeding and irrigation.

3.3.4.4 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedlings in the field. In spite of Cirocarb 3G applications during final land preparation, few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2 g per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.4 Harvesting

Harvesting of the lettuce was done based on the optimum vegetative growth of tender leaves. Data of yield contributing characters have been recorded from five harvested plants which were selected at random from each unit plot.

3.5 Data collection

Five plants were randomly selected from each harvesting plants which was recorded plot wise. Data were collected in respect of yield attributes and yields as affected by lettuce variety and organic manure. Data on plant height, number of leaves/plant, leaf length and length breadth of lettuce were collected at 30, 37,

44, 51 days after sowing (DAS) and at harvest, weight of individual plant, dry matter content in plant, number of roots/plant, length of longest root and plot yields of lettuce were recorded at final harvest time.

3.5.1 Plant height

Plant height was measured from five randomly selected plants by using meter scale in centimeter from the ground level to the tip of the longest leaf at 7 days interval starting from 30 days after sowing (DAS) and continued upto 51 DAS and at harvest and their mean value was calculated.

3.5.2 Number of leaves per plant

Number of leaves per plant was counted from five randomly selected plants at 7 days interval starting from 30 days after sowing (DAS) and continued upto 51 DAS and at harvest and their average was recorded.

3.5.3 Leaf length

Leaf length was measured from five randomly selected plants in centimeter from lower level to the tip of the longest leaf and then average was calculated. Data were collected at 30, 37, 44 and 51 DAS and at harvest.

3.5.4 Leaf breadth

Leaf breadth was counted from five randomly selected plants at 7 days interval starting from 30 DAS and continued upto 51 DAS and at harvest and their mean value was calculated and recorded.

3.5.5 Leaf area

Leaf area was estimated from leaf length and leaf breadth at 7 days interval starting from 30 DAS and continued upto 51 DAS and at harvest and their mean value was calculated and recorded.

3.5.6 Weight of individual plant

Weight of individual plant was recorded was measured from five randomly selected plants in grams (g) with a beam balance at final harvest.

3.5.7 Dry matter content in plant

At first selected plant were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 70^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken and express in gram.

3.5.8 Number of roots/plant

Number of roots/plant was counted from five randomly selected plants at at final harvest and their average number was recorded.

3.5.9 Length of longest root

Length of longest root was measured from five randomly selected plants in centimeter from the junction of roots to the tip of the longest roots and then average was calculated and expressed in cm.

3.5.10 Yield/plot

Yield of lettuce/plot was recorded as the leaf of whole plant at final harvest within a plot and was expressed in kilogram.

3.5.11 Total yield/hectare

Total yield of lettuce/hectare was recorded by converted total yield per plot into yield per hectare and was expressed in ton.

3.5.12 Organoleptic test

A panel of Judges was formed consisting of 25 members and they were the students of Sher-e-Bangla Agricultural University, Dhaka. They were assigned to evaluate crispness, sweetness, bitterness, sourness and appearance through organoleptic test on the basis of acceptability. Scoring was made on the score-Highly Acceptable (HA=7), Slightly Acceptable (SA=5) and Not acceptable (NA=2) for crispness, sweetness, bitter ness, sourness and appearance, respectively (Villared *et al*., 1979). Finally, acceptability score was done by using the following formula-

$$\text{Highly Acceptable (HA)} = \frac{\text{Number of score} \times 100}{\text{Total number of Judges}} = \text{Results} \times 7$$

$$\text{Slightly Acceptable (SA)} = \frac{\text{Number of score} \times 100}{\text{Total number of Judges}} = \text{Results} \times 5$$

$$\text{Not Acceptable (NA)} = \frac{\text{Number of score} \times 100}{\text{Total number of Judges}} = \text{Results} \times 2$$

Finally, acceptability score was done by adding the score of highly acceptable, slightly acceptable and not acceptable.

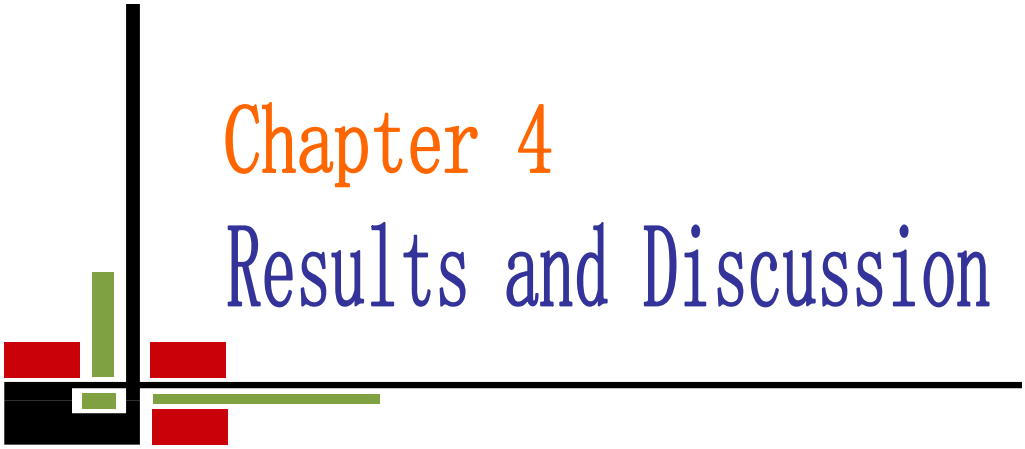
3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different lettuce variety and manure on growth and yield of lettuce. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.7 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different lettuce variety and manure for lettuce cultivation. All input cost and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of lettuce was considered for estimating the cost and return. Economic analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$



Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to assess the effect of manure on growth and yield of three varieties of lettuce. The analysis of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendices III-VIII. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height of lettuce at 30, 37, 44, 51 DAS (Days after sowing) and at harvest showed statistically significant differences due to different lettuce variety (Figure 2). At 30, 37, 44, 51 DAS and at harvest, the tallest plant (14.23, 23.02, 28.22, 38.35 and 41.40 cm, respectively) was recorded from V_1 (Green wave) which was closely followed (13.16, 21.08, 25.74, 35.23 and 38.06 cm, respectively) by V_3 (Legacy), whereas the shortest plant (11.81, 20.57, 24.55, 32.88 and 34.30 cm, respectively) was found from V_2 (New red fire). Data revealed that different variety produced different height of plant. Although plant height is a genetical characters but the management practices also influences plant height but varieties itself also manipulated it. Tsiakaras *et al*. (2014) reported that cultivar had a significant effect on plant length.

Different manure varied significantly in terms of plant height of lettuce at 30, 37, 44, 51 DAS and at harvest (Figure 3). At 30, 37, 44, 51 DAS and at harvest, the tallest plant (14.41, 23.52, 28.11, 39.24 and 40.83 cm, respectively) was observed from M_2 (Poultry manure @ 8 t/ha) which was statistically similar (13.34, 22.59, 26.93, 35.87 and 38.54 cm, respectively) to M_1 (Cowdung @ 20 t/ha), while the shortest plant (11.45, 18.56, 23.47, 31.34 and 34.40 cm, respectively) was recorded from M_0 (0 kg M/ha i.e., control). Masarirambi *et al*. (2010) reported from their earlier experiment that chicken manure exhibited relatively higher values on plant height.

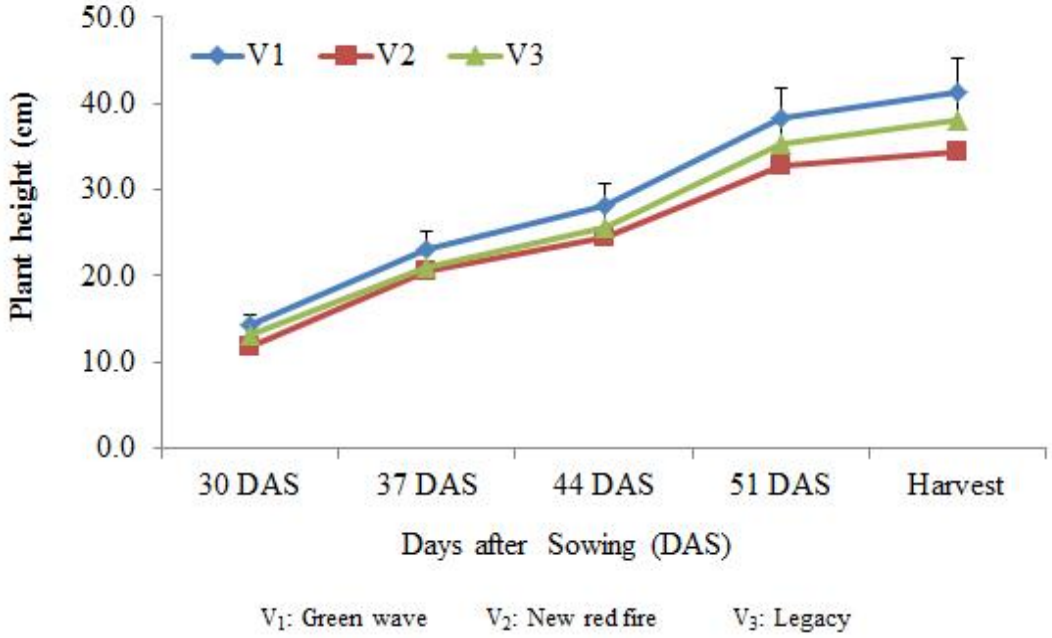


Figure 2. Effect of varieties on plant height of lettuce. Vertical bars represent LSD value at 5% level of probability

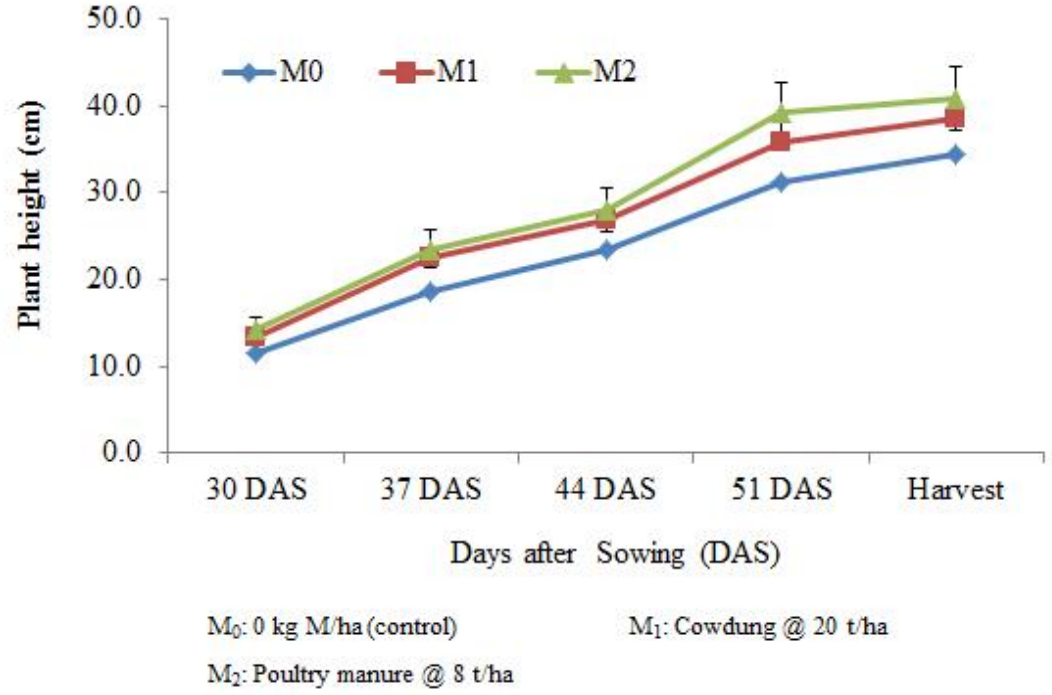


Figure 3. Effect of manure on plant height of lettuce. Vertical bars represent LSD value at 5% level of probability

Interaction effect of different lettuce variety and manure showed statistically significant variation in terms of plant height of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 2). At 30, 37, 44, 51 DAS and at harvest, the tallest plant (16.31, 24.12, 29.68, 43.83 and 46.11 cm, respectively) was observed from V_1M_2 (Green wave with Poultry manure @ 8 t/ha) and the shortest plant (11.24, 16.50, 20.07, 29.60 and 31.71 cm, respectively) was found from V_2M_0 (New red fire with 0 kg M/ha i.e., control) treatment combination.

4.2 Number of leaves/plant

Different lettuce variety varied significantly in terms of number of leaves/plant height of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 3). At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (13.27, 17.53, 20.71, 22.93 and 24.93, respectively) was observed from V_1 which was closely followed (12.36, 16.24, 18.84, 20.56 and 22.33, respectively) by V_3, while the lowest number (11.58, 14.42, 17.47, 18.84 and 20.93, respectively) was recorded from V_2. Tsiakaras *et al*. (2014) reported that cultivar had a significant effect on leaf number of lettuce.

Number of leaves/plant of lettuce at 30, 37, 44, 51 DAS and at harvest showed statistically significant differences due to different manure (Table 4). At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (13.18, 17.33, 20.69, 22.00 and 24.89, respectively) was found from M_2 which was followed (12.64, 16.49, 19.38, 21.02 and 23.07, respectively) by M_1, whereas the lowest number (11.38, 14.38, 16.96, 19.31 and 20.24, respectively) was observed from M_0. It was observed that application of different types of manure produced different number of leaves as per their genetical characters. Although number of leaves is a genetical characters of lettuce but the management practices also influences number of leaves/plant. Masarirambi *et al.* (2012) reported that lettuce provided with 60 t/ha exhibited higher values in number of leaves per plant of lettuce.

Table 2. Interaction effect of manure on plant height at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Plant height (cm) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
V_1M_0	11.63 d	21.76 a	27.66 ab	34.71 b	38.74 bc
V_1M_1	14.75 ab	23.18 ab	27.33 ab	36.51 b	39.35 bc
V_1M_2	16.31 a	24.12 a	29.68 a	43.83 a	46.11 a
V_2M_0	11.24 d	16.50 c	20.07 c	29.60 c	31.71 e
V_2M_1	11.42 d	22.17 ab	27.45 ab	35.71 b	37.20 bcd
V_2M_2	12.76 cd	23.04 ab	26.12 b	33.32 bc	34.00 cde
V_3M_0	11.47 d	17.41 c	22.68 c	29.71 c	32.74 de
V_3M_1	13.84 bc	22.44 ab	26.00 b	35.40 b	39.07 bc
V_3M_2	14.18 bc	23.39 ab	28.52 ab	40.57 a	42.38 ab
$LSD_{(0.05)}$	1.597	2.038	3.090	3.909	4.932
Level of significance	0.05	0.05	0.05	0.01	0.05
CV(%)	7.06	5.46	6.82	6.36	7.51

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg OM/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Table 3. Effect of manure on number of leaves/plant at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Number of leaves/plant at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Different lettuce varieties					
V_1	13.27 a	17.53 a	20.71 a	22.93 a	24.93 a
V_2	11.58 c	14.42 c	17.47 c	18.84 c	20.93 b
V_3	12.36 b	16.24 b	18.84 b	20.56 b	22.33 b
$LSD_{(0.05)}$	0.378	1.031	0.779	1.419	1.405
Level of significance	0.01	0.01	0.01	0.01	0.01
Different manures					
M_0	11.38 c	14.38 b	16.96 c	19.31 b	20.24 c
M_1	12.64 b	16.49 a	19.38 b	21.02 a	23.07 b
M_2	13.18 a	17.33 a	20.69 a	22.00 a	24.89 a
$LSD_{(0.05)}$	0.378	1.031	0.779	1.419	1.405
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	5.05	6.42	4.10	6.83	6.19

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

V_1: Green Wave

V_2: New red fire

V_3: Legacy

M_0: 0 kg M/ha (control)

M_1: Cowdung @ 20 t/ha

M_2: Poultry manure @ 8 t/ha

Statistically significant variation was observed due to the interaction effect of different lettuce variety and manure in terms of number of leaves/plant of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 4). At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (14.33, 19.40, 23.27, 26.13 and 27.67, respectively) was found from V_1M_2 and the lowest number (10.93, 14.07, 16.33, 17.93 and 18.80, respectively) was recorded from V_2M_0 treatment combination.

4.3 Leaf length

Statistically significant variation was observed due to different lettuce variety in terms of leaf length of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 5). At 30, 37, 44, 51 DAS and at harvest, the longest leaf (13.14, 17.83, 20.34, 22.93 and 25.22 cm, respectively) was found from V_1 which was closely followed (12.92, 16.17, 19.05, 20.92 and 23.03 cm, respectively) by V_3, while the shortest leaf (11.68, 15.33, 17.65, 19.92 and 22.18 cm, respectively) was recorded from V_2. Santamaria *et al.* (2000) reported higher leaf length in longifolia cultivars than in capitata and crispa cultivars.

Leaf length of lettuce at 30, 37, 44, 51 DAS and at harvest showed statistically significant differences due to different manure (Table 5). At 30, 37, 44, 51 DAS and at harvest, the longest leaf (13.74, 18.03, 20.96, 23.36 and 25.53 cm, respectively) was observed from M_2 which was followed (13.07, 17.20, 19.44, 22.06 and 24.63 cm, respectively) by M_1, whereas the shortest leaf (10.93, 14.10, 16.65, 18.35 and 20.27 cm, respectively) was found from M_0.

Interaction effect of different lettuce variety and manure varied significantly in terms of leaf length of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 6). At 30, 37, 44, 51 DAS and at harvest, the longest leaf (14.88, 19.09, 22.31, 25.79 and 27.60 cm, respectively) was recorded from V_1M_2, while the shortest leaf (10.47, 12.33, 15.34, 17.30 and 19.36 cm, respectively) was found from V_2M_0 treatment combination.

Table 4. Interaction effect of manure on number of leaves/plant at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Number of leaves/plant at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
V_1M_0	12.13 cd	14.80 c	18.00 d	20.40 bcd	20.87 de
V_1M_1	13.33 b	18.40 ab	20.87 b	22.27 b	26.27 ab
V_1M_2	14.33 a	19.40 a	23.27 a	26.13 a	27.67 a
V_2M_0	10.93 e	14.07 c	16.33 e	17.93 d	18.80 e
V_2M_1	11.87 d	14.20 c	17.67 de	19.73 bcd	21.67 d
V_2M_2	11.93 d	15.00 c	18.40 cd	18.87 cd	22.33 cd
V_3M_0	11.07 e	14.27 c	16.53 e	19.60 bcd	21.07 de
V_3M_1	12.73 bc	16.87 b	19.60 bc	21.07 bc	21.27 de
V_3M_2	13.27 b	17.60 ab	20.40 b	21.00 bc	24.67 bc
$LSD_{(0.05)}$	0.655	1.785	1.350	2.458	2.434
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	5.05	6.42	4.10	6.83	6.19

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Table 5. Effect of manure on leaf length at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf length (cm) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Different lettuce varieties					
V_1	13.14 a	17.83 a	20.34 a	22.93 a	25.22 a
V_2	11.68 b	15.33 b	17.65 c	19.92 c	22.18 c
V_3	12.92 a	16.17 b	19.05 b	20.92 b	23.03 b
$LSD_{(0.05)}$	0.763	1.048	0.912	0.885	0.673
Level of significance	0.01	0.01	0.01	0.01	0.01
Different manures					
M_0	10.93 b	14.10 b	16.65 c	18.35 c	20.27 c
M_1	13.07 a	17.20 a	19.44 b	22.06 b	24.63 b
M_2	13.74 a	18.03 a	20.96 a	23.36 a	25.53 a
$LSD_{(0.05)}$	0.763	1.048	0.912	0.885	0.673
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.07	7.38	4.80	5.17	5.87

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

V_1: Green Wave

V_2: New red fire

V_3: Legacy

M_0: 0 kg M/ha (control)

M_1: Cowdung @ 20 t/ha

M_2: Poultry manure @ 8 t/ha

Table 6. Interaction effect of manure on leaf length at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf length (cm) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
V_1M_0	11.39 ef	15.52 bc	16.99 c	19.05 d	21.56 d
V_1M_1	13.15 bcd	18.88 a	21.72 a	23.95 b	26.50 a
V_1M_2	14.88 a	19.09 a	22.31 a	25.79 a	27.60 a
V_2M_0	10.47 f	12.33 d	15.34 d	17.30 e	19.36 e
V_2M_1	12.73 cde	17.16 ab	18.15 bc	21.19 c	23.12 c
V_2M_2	11.84 def	16.49 b	19.46 b	21.26 c	24.08 bc
V_3M_0	10.92 f	14.46 c	17.60 c	18.70 de	19.90 e
V_3M_1	13.34 bc	15.55 bc	18.44 bc	21.03 c	24.27 bc
V_3M_2	14.49 ab	18.51 a	21.11 a	23.03 b	24.91 b
$LSD_{(0.05)}$	1.322	1.815	1.579	1.534	1.166
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	6.07	7.38	4.80	5.17	5.87

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

4.4 Leaf breadth

Leaf breadth of lettuce at 30, 37, 44, 51 DAS and at harvest showed statistically significant differences due to different lettuce variety (Table 7). At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (14.57, 16.40, 19.00, 21.53 and 23.26 cm, respectively) was observed from V_1 which was followed (13.25, 14.73, 17.27, 19.60 and 22.48 cm, respectively) by V_3, while the lowest leaf breadth (12.21, 13.72, 15.49, 17.97 and 21.39 cm, respectively) was recorded from V_2. Echer *et al.* (2001) reported the highest leaf breadth in Vera variety compared to other cultivars

Statistically significant differences was observed in terms of leaf breadth of lettuce at 30, 37, 44, 51 DAS and at harvest due to different manure (Table 7). At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (14.68, 16.63, 19.44, 21.72 and 24.16 cm, respectively) was observed from M_2 which was followed (13.73, 15.39, 18.23, 20.82 and 23.27 cm, respectively) by M_1, whereas the lowest leaf breadth (11.62, 12.84, 14.08, 16.56 and 19.70 cm, respectively) was recorded from M_0.

Leaf breadth of lettuce at 30, 37, 44, 51 DAS and at harvest showed statistically significant differences due to the interaction effect of different lettuce variety and manure (Table 8). At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (16.15, 18.29, 21.35, 24.09 and 25.42 cm, respectively) was observed from V_1M_2, while the lowest leaf breadth (10.62, 11.25, 12.67, 15.12 and 18.49 cm, respectively) was found from V_2M_0 treatment combination.

4.5 Leaf area

Different lettuce variety varied significantly in terms of leaf area of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 9). At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (193.50, 294.49, 391.51, 500.22 and 592.15 cm^2, respectively) was found from V_1 which was followed (173.56, 242.19, 332.32, 415.03 and 521.29 cm^2, respectively) by V_3, while the lowest leaf area (143.95, 214.17, 276.56, 361.81 and 478.11 cm^2, respectively) from V_2.

Table 7. Effect of manure on leaf breath at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf breadth (cm) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Different lettuce varieties					
V_1	14.57 a	16.40 a	19.00 a	21.53 a	23.26 a
V_2	12.21 c	13.72 c	15.49 c	17.97 c	21.39 b
V_3	13.25 b	14.73 b	17.27 b	19.60 b	22.48 a
$LSD_{(0.05)}$	0.559	0.904	0.939	0.847	0.947
Level of significance	0.01	0.01	0.01	0.01	0.01
Different manures					
M_0	11.62 c	12.84 c	14.08 c	16.56 c	19.70 b
M_1	13.73 b	15.39 b	18.23 b	20.82 b	23.27 a
M_2	14.68 a	16.63 a	19.44 a	21.72 a	24.16 a
$LSD_{(0.05)}$	0.559	0.904	0.939	0.847	0.947
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.19	6.05	5.44	4.30	6.24

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

V_1: Green Wave

V_2: New red fire

V_3: Legacy

M_0: 0 kg M/ha (control)

M_1: Cowdung @ 20 t/ha

M_2: Poultry manure @ 8 t/ha

Table 8. Interaction effect of manure on leaf breath at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf breadth (cm) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
V_1M_0	13.10 d	14.90 c	16.13 d	18.70 d	20.39 d
V_1M_1	14.47 bc	16.02 bc	19.52 b	21.82 b	23.99 abc
V_1M_2	16.15 a	18.29 a	21.35 a	24.09 a	25.42 a
V_2M_0	10.62 e	11.25 d	12.67 e	15.12 e	18.49 e
V_2M_1	13.11 d	15.46 c	16.70 d	19.76 cd	23.31 bc
V_2M_2	12.90 d	14.46 c	17.09 cd	19.04 d	22.35 c
V_3M_0	11.14 e	12.37 d	13.44 e	15.86 e	20.22 d
V_3M_1	13.60 cd	14.69 c	18.47 bc	20.89 bc	22.50 c
V_3M_2	15.00 b	17.14 ab	19.89 ab	22.04 b	24.71 ab
$LSD_{(0.05)}$	0.968	1.566	1.626	1.467	1.640
Level of significance	0.05	0.01	0.05	0.05	0.05
CV(%)	4.19	6.05	5.44	4.30	6.24

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Table 9. Effect of manure on leaf area at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf area (cm^2) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Different lettuce varieties					
V_1	193.50 a	294.49 a	391.51 a	500.22 a	592.15 a
V_2	143.95 c	214.17 c	276.56 c	361.81 c	478.11 c
V_3	173.56 b	242.19 b	332.32 b	415.03 b	521.29 b
$LSD_{(0.05)}$	16.43	25.68	22.86	33.54	22.43
Level of significance	0.01	0.01	0.01	0.01	0.01
Different manures					
M_0	127.58 c	183.16 c	234.99 c	304.85 c	399.96 c
M_1	179.77 b	265.77 b	355.62 b	460.38 b	573.44 b
M_2	203.65 a	301.90 a	409.78 a	511.84 a	618.14 a
$LSD_{(0.05)}$	16.43	25.68	22.86	33.54	22.43
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	9.65	10.27	6.86	7.88	4.23

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Leaf area of lettuce at 30, 37, 44, 51 DAS and at harvest showed statistically significant differences due to different manure (Table 9). At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (203.65, 301.90, 409.78, 511.84 and 618.14 cm^2, respectively) was observed from M_2 which was followed (179.77, 265.77, 355.62, 460.38 and 573.44 cm^2, respectively) by M_1, whereas the lowest leaf area (127.58, 183.16, 234.99, 304.85 and 399.96 cm^2, respectively) was found from M_0.

Interaction effect of different lettuce variety and manure varied significantly in terms of leaf area of lettuce at 30, 37, 44, 51 DAS and at harvest (Table 10). At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (240.28, 349.16, 476.56, 622.19 and 701.27 cm^2, respectively) was recorded from V_1M_2, while the lowest leaf area (111.28, 138.09, 194.23, 261.59 and 357.64 cm^2, respectively) was found from V_2M_0 treatment combination.

4.6 Weight of individual plant

Different lettuce variety varied significantly in terms of weight of individual plant of lettuce (Table 11). The highest weight of individual plant (189.24 g) was found from V_1 which was followed (174.19 g) by V_3, while the lowest weight (164.56 g) was observed from V_2. Tsiakaras *et al*. (2014) reported that cultivar had a significant effect on fresh weights of leaves.

Weight of individual plant of lettuce showed statistically significant differences due to different manure (Table 11). The highest weight of individual plant (192.63 g) was recorded from M_2 which was followed (181.48 g) by M_1, whereas the lowest weight (153.88 g) was found from M_0.

Interaction effect of different lettuce variety and manure showed statistically significant differences in terms of weight of individual plant of lettuce under the present trial (Table 12). The highest weight of individual plant (208.89 g) was observed from V_1M_2 and the lowest weight (142.63 g) was found from V_2M_0 treatment combination.

Table 10. Interaction effect of manure on leaf area at different days after sowing (DAS) and harvest on three varieties of lettuce

Treatments	Leaf area (cm^2) at				
	30 DAS	37 DAS	44 DAS	51 DAS	Harvest
V_1M_0	149.86 ef	231.58 c	274.14 de	355.99 d	439.50 d
V_1M_1	190.37 bc	302.72 ab	423.82 b	522.48 b	635.67 b
V_1M_2	240.28 a	349.16 a	476.56 a	622.19 a	701.27 a
V_2M_0	111.28 g	138.09 d	194.23 f	261.59 e	357.64 e
V_2M_1	167.50 c-e	265.51 bc	302.91 cd	418.90 c	538.87 c
V_2M_2	153.06 de	238.89 c	332.53 c	404.95 cd	537.80 c
V_3M_0	121.59 fg	179.82 d	236.59 e	296.97 e	402.75 d
V_3M_1	181.45 cd	229.09 c	340.13 c	439.74 c	545.77 c
V_3M_2	217.62 ab	317.65 a	420.24 b	508.37 b	615.36 b
$LSD_{(0.05)}$	28.46	44.47	39.59	58.10	38.85
Level of significance	0.05	0.01	0.05	0.05	0.05
CV(%)	9.65	10.27	6.86	7.88	4.23

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Table 11. Effect of manure on yield contributing characters and yield of three varieties of lettuce

Treatments	Weight of individual plant (g)	Dry matter content in plant (g)	Number of roots/plant	Length of longest root (cm)	Yield/hectare (ton)
Different lettuce varieties					
V_1	189.24 a	17.36 b	29.64 a	13.25 a	20.49 a
V_2	164.56 c	14.63 a	25.82 c	11.72 c	17.66 c
V_3	174.19 b	15.89 a	27.35 b	12.35 b	18.79 b
$LSD_{(0.05)}$	8.315	0.914	1.122	0.460	0.773
Level of significance	0.01	0.01	0.01	0.01	0.01
Different manures					
M_0	153.88 c	14.18 b	24.01 c	11.09 c	16.61 c
M_1	181.48 b	16.44 a	28.73 b	12.78 b	19.55 b
M_2	192.63 a	17.27 a	30.07 a	13.44 a	20.78 a
$LSD_{(0.05)}$	8.315	0.914	1.122	0.460	0.773
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.73	5.93	4.07	3.70	4.08

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Table 12. Interaction effect of manure on yield contributing characters and yield of three varieties of lettuce

Treatments	Weight of individual plant (g)	Dry matter content in plant (g)	Number of roots/plant	Length of longest root (cm)	Yield/hectare (ton)
V_1M_0	172.60 c	16.21 bc	27.01 d	12.15 d	18.62 d
V_1M_1	186.24 bc	16.86 b	30.02 abc	13.14 bc	20.23 bc
V_1M_2	208.89 a	19.02 a	31.90 a	14.46 a	22.64 a
V_2M_0	142.63 d	12.74 e	22.05 e	10.45 e	15.32 e
V_2M_1	177.93 c	16.08 bc	27.37 d	12.46 cd	19.00 cd
V_2M_2	173.11 c	15.08 cd	28.03 cd	12.25 d	18.66 d
V_3M_0	146.41 d	13.58 de	22.96 e	10.69 e	15.88 e
V_3M_1	180.26 c	16.37 bc	28.82 bcd	12.75 cd	19.43 cd
V_3M_2	195.90 ab	17.70 ab	30.27 ab	13.61 b	21.04 b
$LSD_{(0.05)}$	14.40	1.584	1.944	0.797	1.340
Level of significance	0.05	0.05	0.05	0.05	0.05
CV(%)	4.73	5.93	4.07	3.70	4.08

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

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

4.7 Dry matter content in plant

Dry matter content in plant of lettuces showed statistically significant differences due to different lettuce variety (Table 11). The highest dry matter content in plant (15.89 g) was found from V_1 which was statistically similar (14.63 g) to V_3, while the lowest (14.63 g) was recorded from V_2. Tsiakaras *et al*. (2014) reported that cultivar had a significant effect on dry weights of leaves.

Different manure varied significantly in terms of dry matter content in plant of lettuce (Table 11). The highest dry matter content in plant (17.27 g) was observed from M_2 which was statistically similar (16.44 g) to M_1, whereas the lowest (14.18 g) was found from M_0. Masarirambi *et al.* (2012) reported that lettuce provided with 60 t/ha exhibited higher values in mean leaf dry mass.

Statistically significant variation was observed due to the interaction effect of different lettuce variety and manure in terms of dry matter content in plant of lettuce (Table 12). The highest dry matter content in plant (19.02 g) was recorded from V_1M_2, while the lowest (12.74 g) was found from V_2M_0 treatment combination.

4.8 Number of roots/plant

Statistically significant variation was observed in terms of number of roots/plant of lettuces due to different lettuce variety (Table 11). The highest number of roots/plant (29.64) was observed from V_1 which was followed (27.35) by V_3, while the lowest number of roots (25.82) was recorded from V_2.

Different manure varied significantly in terms of number of roots/plant of lettuce (Table 11). The highest number of roots/plant (30.07) was observed from M_2 which was closely followed (28.73) by M_1, whereas the lowest number (24.01) was recorded from M_0.

Statistically significant variation was observed due to the interaction effect of different lettuce variety and manure in terms of number of roots/plant of lettuce (Table 12). The highest number of roots/plant (31.90) was recorded from V_1M_2,

while the lowest number (22.05) was observed from V_2M_0 treatment combination.

4.9 Length of longest root

Different lettuce variety varied significantly in terms of length of longest root lettuce (Table 11). The highest length of longest root (13.25 cm) was found from V_1 which was followed (12.35 cm) by V_3, while the lowest (11.72 cm) was recorded from V_2. Masarirambi *et al.* (2012) reported that lettuce provided with 60 t/ha exhibited higher values in mean length of longest root.

Length of longest root of lettuce showed statistically significant differences due to different manure (Table 11). The highest length of longest root (13.44 cm) was found from M_2 which was followed (12.78 cm) by M_1, whereas the lowest (11.09 cm) was recorded from M_0.

Interaction effect of different lettuce variety and manure showed statistically significant differences in terms of length of longest root of lettuce (Table 12). The highest length of longest root (14.46 cm) was found from V_1M_2 and the lowest (10.45 cm) was found from V_2M_0 treatment combination.

4.10 Yield/plot

Yield/plot of lettuces showed statistically significant differences due to different lettuce variety (Figure 4). The highest yield/plot (3.28 kg) was observed from V_1 which was followed (3.01 kg) by V_3, while the lowest (2.83 kg) was recorded from V_2. Parente *et al.* (2006) reported that Lollo Rossa cultivars produced 26 and 56% less than the Canasta type, respectively, in the first and the second year, probably due to the absence of a real head in the Lollo type.

Different manure varied significantly in terms of yield/plot of lettuce (Figure 5). The highest yield/plot (3.32 kg) was observed from M_2 which was followed (3.13 kg) by M_1, whereas the lowest (2.66 kg) was recorded from M_0. Masarirambi *et al.* (2012) reported that lettuce provided with 60 t/ha exhibited higher values in marketable yield.

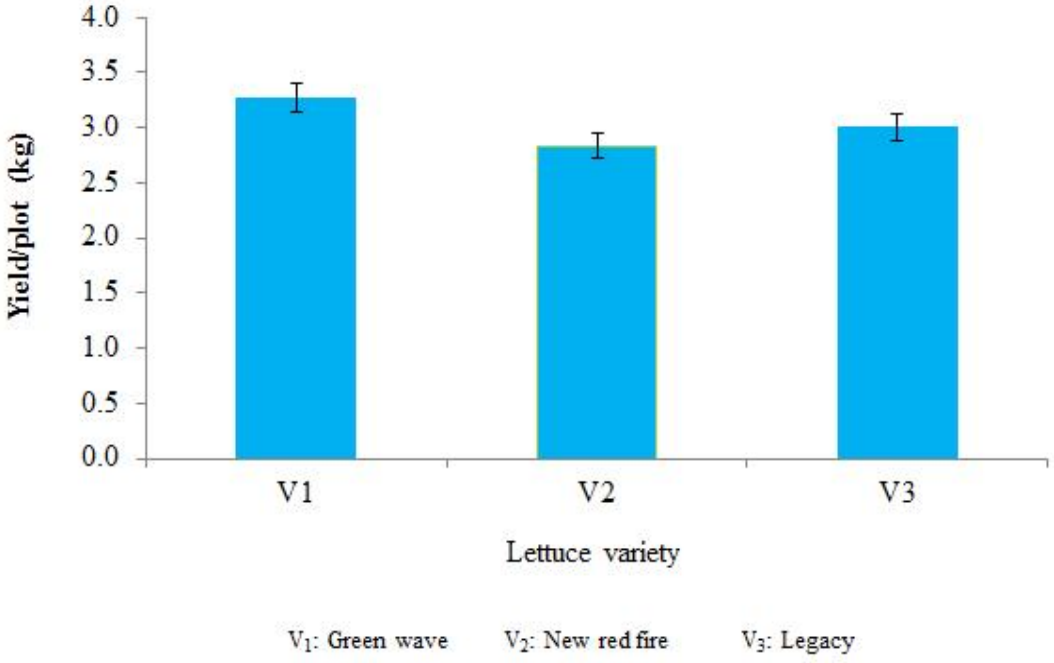


Figure 4. Effect of varieties on yield/plot of lettuce. Vertical bars represent LSD value at 5% level of probability

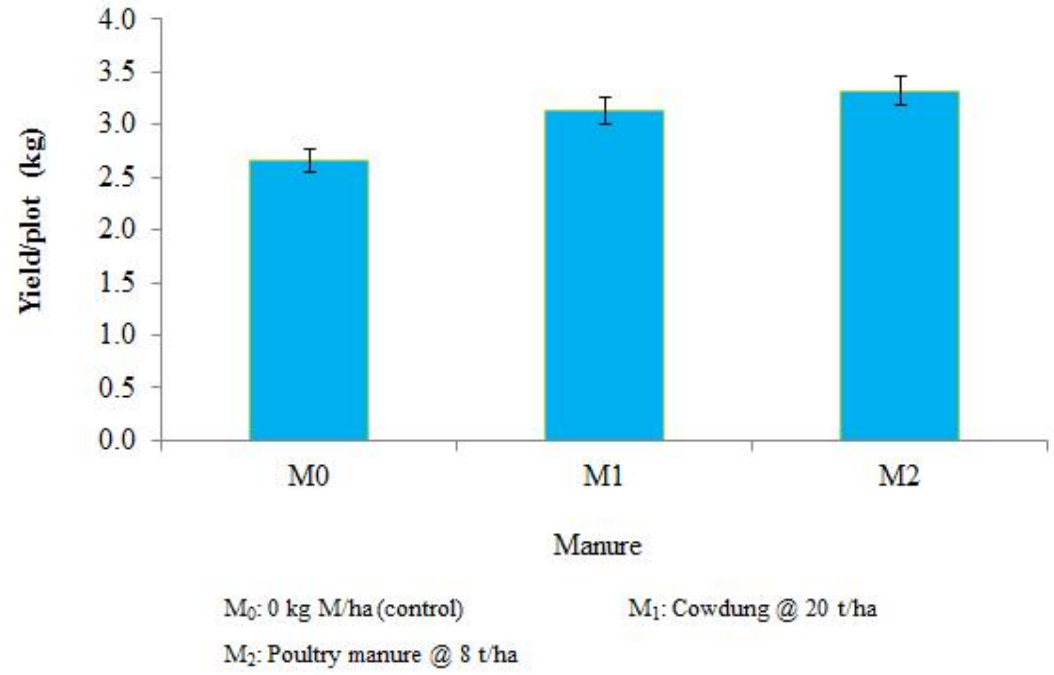


Figure 5. Effect of manure on yield/plot of lettuce. Vertical bars represent LSD value at 5% level of probability

Statistically significant variation was observed due to the interaction effect of different lettuce variety and manure in terms of yield/plot of lettuce (Figure 6). The highest yield/plot (3.62 kg) was observed from V_1M_2, while the lowest (2.45 kg) was found from V_2M_0 treatment combination.

4.11 Yield/hectare

Different lettuce variety showed statistically significant differences in terms of yield/hectare of lettuces (Table 11). The highest yield/hectare (20.49 ton) was recorded from V_1 which was followed (18.79 ton) by V_3, while the lowest (17.66 ton) was found from V_2. Data revealed that yield of lettuce is a genetical character and different variety produced different amount of yield as a varietal characters. Parente *et al.* (2006) reported that variety Lollo Rossa cultivars produced 26 and 56% less than the Canasta type, respectively, in the first and the second year, probably due to the absence of a real head in the Lollo type of lettuce. Lucic and Perkovic (2013) reported that the variety Santoro had the biggest heads and the highest yield (15.33 kg/10 m^2), which leads to conclusion that the yield of lettuce is a varietal characteristics.

Yield/hectare of lettuce showed statistically significant differences due to different manure (Table 11). The highest yield/hectare (20.78 ton) was found from M_2 which was followed (19.55 ton) by M_1, whereas the lowest (16.61 ton) was observed from M_0. It was observed that that different manure influences different growth parameters of lettuce and ultimately the highest yield. Masarirambi *et al.* (2010) reported that chicken manure exhibited relatively higher values on marketable yield of lettuce.

Interaction effect of different lettuce variety and manure showed statistically difference in terms of yield/hectare of lettuce (Table 12). The highest yield/hectare (22.64 ton) was recorded from V_1M_2, while the lowest (15.32 ton) was observed from V_2M_0 treatment combination.

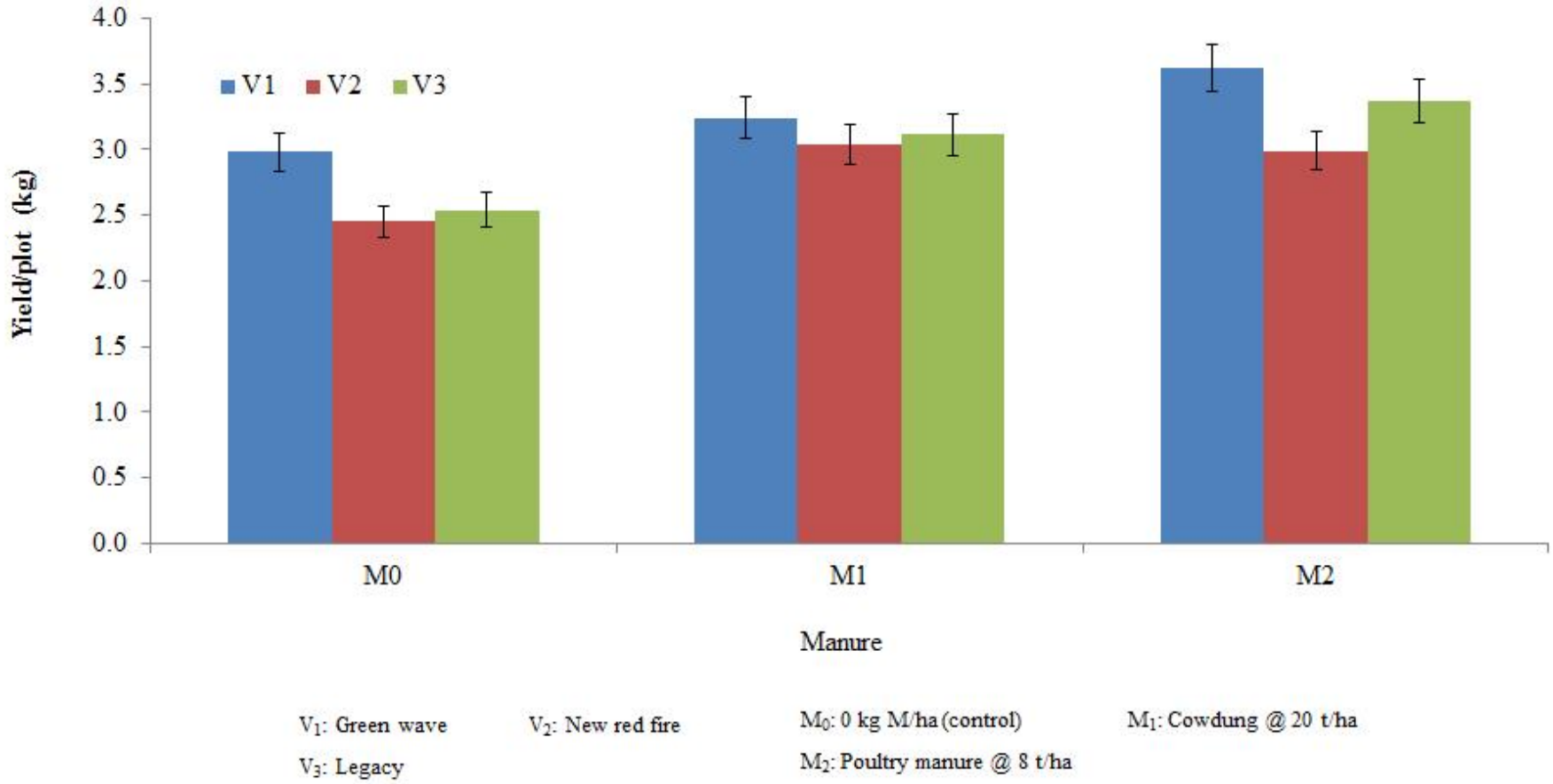


Figure 6. Interaction effect of varieties and manure on yield/plot of lettuce. Vertical bars represent LSD value at 5% level of probability

4.12 Organoleptic test

Different parameters were used for organoleptic test of lettuce leaf. There was a panel of 25 Judges and they were the students of Sher-e-Bangla Agricultural University, Dhaka. Consumer acceptability of lettuce depends on crispness, sweetness, bitterness, sourness and appearance of lettuce leaf. For observing acceptability of lettuce a questionnaire (Appendix IX) and lettuce sample collected from different treatment combinations of the study were served among the judges.

The results of the preferential from the panelist have been summarized and presented in Table 13. When the preferential comments were converted into acceptability score it was found that lettuce grown with V_1M_2 treatment combination got the highest score (2616) on the basis of total acceptability ranking, whereas the lowest score (2377) was recorded in the treatment combination of V_2M_0.

In respect of crispiness, V_1M_2 scored top (640) among the different treatment combination, while the lowest score (497) was in V_1M_0 treatment combination under the study (Table 13). Considering sweetness, the highest score (524) was obtained from V_3M_2, whereas the lowest score (379) was found from V_2M_0 treatment combination. In case of bitterness, the highest score (556) was found from V_2M_1 treatment combination, while the lowest score (440) was observed from V_1M_1 treatment combination. For sourness, the highest score (436) was found from V_2M_0 and the lowest score (340) was found from V_1M_2 treatment combination. Considering appearances, the highest score (632) was obtained from V_1M_2 treatment combination, whereas the lowest score (508) was found from V_2M_2 treatment combination. The present findings give an indication of the consumers' likings the different characteristics of lettuce. Prince *et al*. (1990) reported that red color lettuce had more acceptability score than those of conventional lettuce and chicory.

Table 13. Combined effect of manure on organoleptic characters of three varieties of lettuce

Treatments	Acceptability score					
	Crispness	Sweetness	Bitterness	Sourness	Appearance	Total
V_1M_0	497	492	536	432	548	2515
V_1M_1	596	520	440	426	544	2526
V_1M_2	640	508	496	340	632	2616
V_2M_0	508	379	540	436	514	2377
V_2M_1	520	480	556	408	516	2480
V_2M_2	568	500	548	405	508	2529
V_3M_0	532	512	488	412	584	2528
V_3M_1	584	505	512	421	580	2602
V_3M_2	596	524	468	393	584	2565

Organoleptic test was done by following formula of Villared *et al*. (1979)

Highly Acceptable (HA=7),

Slightly Acceptable (SA=5) and

Not acceptable (NA=2)

4.13 Economic analysis

Input costs for land preparation, fertilizer, mulch, manure and manpower required for all the operations from seed sowing to harvesting of lettuce were recorded as per plot and converted into cost/hectare (Appendix X). Price of lettuce was considered as per present market rate basis. The economic analysis presented under the following headings-

4.13.1 Gross return

The combination of different lettuce variety and manure showed different value in terms of gross return under the trial (Table 14). The highest gross return (BDT 792,400/ha) was obtained from the treatment combination of V_1M_2 and the second highest gross return (BDT 736,400/ha) was found in V_3M_2. The lowest gross return (BDT 536,200/ha) was obtained from V_2M_0 treatment combination.

4.13.2 Net return

In case of net return, different lettuce variety and manure showed different levels of net return under the present trial (Table 14). The highest net return (BDT 479,450/ha) was found from the treatment combination V_1M_2 and the second highest net return (BDT 423,450/ha) was obtained from the combination V_3M_2. The lowest (BDT 250,088/ha) net return was obtained V_2M_0.

4.13.3 Benefit cost ratio

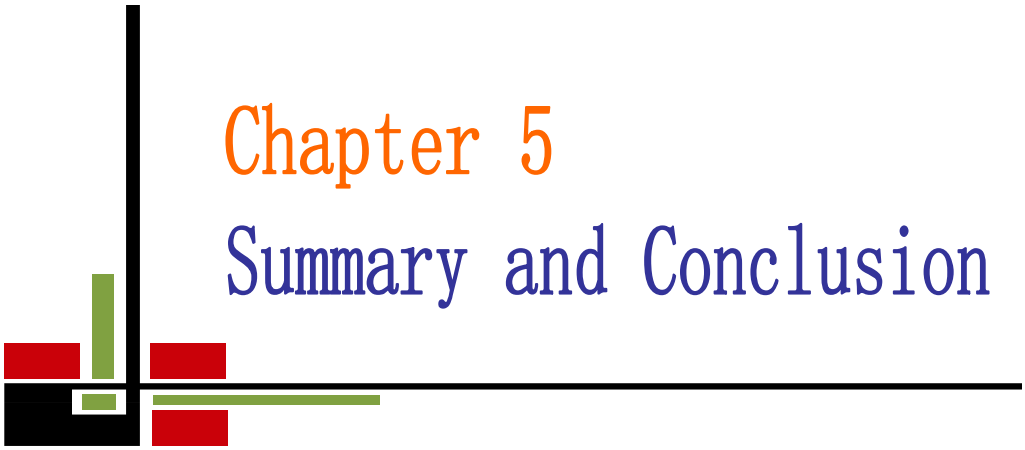
In the different lettuce variety and manure, the highest benefit cost ratio (2.53) was noted from the combination of V_1M_2 and the second highest benefit cost ratio (2.35) was estimated from the combination of V_3M_2. The lowest benefit cost ratio (1.87) was obtained from V_2M_0 (Table 14). From economic point of view, it is apparent from the above results that the combination of V_1M_2 was better than rest of the combination in lettuce cultivation.

Table 14. Cost and return of lettuce cultivation as influenced by different variety and manure

Treatments	Cost of production (BDT/ha)	Yield of lettuce (t/ha)	Gross return (BDT/ha)	Net return (BDT/ha)	Benefit cost Ratio
V_1M_0	286,112	18.62	651,700	365,588	2.28
V_1M_1	308,477	20.23	708,050	399,573	2.30
V_1M_2	312,950	22.64	792,400	479,450	2.53
V_2M_0	286,112	15.32	536,200	250,088	1.87
V_2M_1	308,477	19.00	665,000	356,523	2.16
V_2M_2	312,950	18.66	653,100	340,150	2.09
V_3M_0	286,112	15.88	555,800	269,688	1.94
V_3M_1	308,477	19.43	680,050	371,573	2.20
V_3M_2	312,950	21.04	736,400	423,450	2.35

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha



Chapter 5
Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out in the experimental farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November 2016 to February 2017 to assess the effect of manure on growth and yield of three varieties of lettuce. The seeds of lettuce variety 'Green wave, New red fire and Legacy' were used as planting materials for this experiment. The experiment consisted of two factors; Factor A: Lettuce variety (3) as- V_1: Green wave, V_2: New red fire, V_3: Legacy and Factor B: Manure (3) as- M_0: 0 kg M/ha (control), M_1: Cowdung @ 20 t/ha, M_2: Poultry manure @ 8 t/ha. The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data were recorded for different growth and yield parameters and significant variation was recorded for different treatment.

For diriment lettuce variety, at 30, 37, 44, 51 DAS and at harvest, the tallest plant (14.23, 23.02, 28.22, 38.35 and 41.40 cm, respectively) was recorded from V_1, whereas the shortest plant (11.81, 20.57, 24.55, 32.88 and 34.30 cm, respectively) was found from V_2. At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (13.27, 17.53, 20.71, 22.93 and 24.93, respectively) was observed from V_1, while the lowest number (11.58, 14.42, 17.47, 18.84 and 20.93, respectively) was recorded from V_2. At 30, 37, 44, 51 DAS and at harvest, the longest leaf (13.14, 17.83, 20.34, 22.93 and 25.22 cm, respectively) was found from V_1, while the shortest leaf (11.68, 15.33, 17.65, 19.92 and 22.18 cm, respectively) was recorded from V_2. At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (14.57, 16.40, 19.00, 21.53 and 23.26 cm, respectively) was observed from V_1, while the lowest leaf breadth (12.21, 13.72, 15.49, 17.97 and 21.39 cm, respectively) was recorded from V_2. At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (193.50, 294.49, 391.51, 500.22 and 592.15 cm^2, respectively) was found from V_1, while the lowest leaf area (143.95, 214.17, 276.56, 361.81 and 478.11 cm^2, respectively) from V_2. The highest

weight of individual plant (189.24 g) was found from V_1, while the lowest weight (164.56 g) was observed from V_2. The highest dry matter content in plant (15.89 g) was found from V_1, while the lowest (14.63 g) was recorded from V_2. The highest number of roots/plant (29.64) was observed from V_1, while the lowest number of roots (25.82) was recorded from V_2. The highest length of longest root (13.25 cm) was found from V_1, while the lowest (11.72 cm) was recorded from V_2. The highest yield/plot (3.28 kg) was observed from V_1, while the lowest (2.83 kg) was recorded from V_2. The highest yield/hectare (20.49 ton) was recorded from V_1, while the lowest (17.66 ton) was found from V_2.

In case of different manure, at 30, 37, 44, 51 DAS and at harvest, the tallest plant (14.41, 23.52, 28.11, 39.24 and 40.83 cm, respectively) was observed from M_2, while the shortest plant (11.45, 18.56, 23.47, 31.34 and 34.40 cm, respectively) was recorded from M_0. At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (13.18, 17.33, 20.69, 22.00 and 24.89, respectively) was found from M_2, whereas the lowest number (11.38, 14.38, 16.96, 19.31 and 20.24, respectively) was observed from M_0. At 30, 37, 44, 51 DAS and at harvest, the longest leaf (13.74, 18.03, 20.96, 23.36 and 25.53 cm, respectively) was observed from M_2, whereas the shortest leaf (10.93, 14.10, 16.65, 18.35 and 20.27 cm, respectively) was found from M_0. At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (14.68, 16.63, 19.44, 21.72 and 24.16 cm, respectively) was observed from M_2, whereas the lowest leaf breadth (11.62, 12.84, 14.08, 16.56 and 19.70 cm, respectively) was recorded from M_0.). At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (203.65, 301.90, 409.78, 511.84 and 618.14 cm^2, respectively) was observed from M_2, whereas the lowest leaf area (127.58, 183.16, 234.99, 304.85 and 399.96 cm^2, respectively) was found from M_0. The highest weight of individual plant (192.63 g) was recorded from M_2, whereas the lowest weight (153.88 g) was found from M_0. The highest dry matter content in plant (17.27 g) was observed from M_2, whereas the lowest (14.18 g) was found from M_0. The highest number of roots/plant (30.07) was observed from M_2, whereas the lowest number (24.01) was recorded from M_0.

The highest length of longest root (13.44 cm) was found from M_2, whereas the lowest (11.09 cm) was recorded from M_0. The highest yield/plot (3.32 kg) was observed from M_2, whereas the lowest (2.66 kg) was recorded from M_0. The highest yield/hectare (20.78 ton) was found from M_2, whereas the lowest (16.61 ton) was observed from M_0.

Due to the interaction effect of different lettuce variety and manure, at 30, 37, 44, 51 DAS and at harvest, the tallest plant (16.31, 24.12, 29.68, 43.83 and 46.11 cm, respectively) was observed from V_1M_2 and the shortest plant (11.24, 16.50, 20.07, 29.60 and 31.71 cm, respectively) was found from V_2M_0 treatment combination. At 30, 37, 44, 51 DAS and at harvest, the highest number of leaves/plant (14.33, 19.40, 23.27, 26.13 and 27.67, respectively) was found from V_1M_2 and the lowest number (10.93, 14.07, 16.33, 17.93 and 18.80, respectively) was recorded from V_2M_0 treatment combination. At 30, 37, 44, 51 DAS and at harvest, the longest leaf (14.88, 19.09, 22.31, 25.79 and 27.60 cm, respectively) was recorded from V_1M_2, while the shortest leaf (10.47, 12.33, 15.34, 17.30 and 19.36 cm, respectively) was found from V_2M_0 treatment combination. At 30, 37, 44, 51 DAS and at harvest, the highest leaf breadth (16.15, 18.29, 21.35, 24.09 and 25.42 cm, respectively) was observed from V_1M_2, while the lowest leaf breadth (10.62, 11.25, 12.67, 15.12 and 18.49 cm, respectively) was found from V_2M_0 treatment combination. At 30, 37, 44, 51 DAS and at harvest, the highest leaf area (240.28, 349.16, 476.56, 622.19 and 701.27 cm^2, respectively) was recorded from V_1M_2, while the lowest leaf area (111.28, 138.09, 194.23, 261.59 and 357.64 cm^2, respectively) was found from V_2M_0 treatment combination. The highest weight of individual plant (208.89 g) was observed from V_1M_2 and the lowest weight (142.63 g) was found from V_2M_0 treatment combination. The highest dry matter content in plant (19.02 g) was recorded from V_1M_2, while the lowest (12.74 g) was found from V_2M_0 treatment combination. The highest number of roots/plant (31.90) was recorded from V_1M_2, while the lowest number (22.05) was observed from V_2M_0 treatment combination. The highest length of longest root (14.46 cm) was found from

V_1M_2 and the lowest (10.45 cm) was found from V_2M_0 treatment combination. The highest yield/plot (3.62 kg) was observed from V_1M_2, while the lowest (2.45 kg) was found from V_2M_0 treatment combination. The highest yield/hectare (22.64 ton) was recorded from V_1M_2, while the lowest (15.32 ton) was observed from V_2M_0 treatment combination. It was found that lettuce grown with V_1M_2 treatment combination got the highest score (2616) on the basis of total acceptability ranking, whereas the lowest score (2377) was recorded in the treatment combination of V_2M_0.

The combination of different lettuce variety and manure, the highest gross return (BDT 792,400/ha) was obtained from the treatment combination V_1M_2 and the lowest gross return (BDT 536,200/ha) was obtained from V_2M_0. The highest net return (BDT 479,450/ha) was found from the treatment combination V_1M_2 and the lowest (BDT 250,088/ha) net return was obtained V_2M_0. The highest benefit cost ratio (2.53) was noted from the combination of V_1M_2 and the lowest benefit cost ratio (1.87) was obtained from V_2M_0. From economic point of view, it is apparent from the above results that the combination of V_1M_2 was better than rest of the combination in lettuce cultivation.

Recommendation:

Growers can consider lettuce Green wave with Poultry manure @ 8 t/ha for commercial production of lettuce.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November, 2016 to February 2017

Month	Air temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
November, 2016	25.8	16.0	78	00
December, 2016	22.4	13.5	74	00
January, 2017	24.5	12.4	68	00
February, 2017	27.1	16.7	67	30

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

Appendix II. Characteristics of the soil of experimental field

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Expeimental Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.47
Organic matter (%)	0.79
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

Appendix III. Analysis of variance of the data on plant height of lettuce at different days after sowing (DAS) and harvest as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square				
		Plant height (cm) at				
		30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Replication	2	0.428	0.575	1.116	0.111	0.112
Lettuce variety (A)	2	13.287**	15.058**	31.681**	67.798**	113.379**
Manure (B)	2	20.309**	62.653**	52.252**	141.364**	95.699**
Interaction (A×B)	4	2.668*	5.191*	12.398*	22.784**	24.640*
Error	16	0.851	1.387	3.187	5.099	8.118

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IV. Analysis of variance of the data on number of leaves/plant of lettuce at different days after sowing (DAS) and harvest as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square				
		Number of leaves/plant at				
		30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Replication	2	0.058	0.084	0.046	0.111	0.884
Lettuce variety (A)	2	6.431**	21.991**	23.864**	37.951**	37.080**
Manure (B)	2	7.693**	20.858**	32.286**	16.671**	49.284**
Interaction (A×B)	4	0.418*	3.336*	2.181*	6.736*	6.124*
Error	16	0.143	1.064	0.608	2.016	1.978

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix V. Analysis of variance of the data on leaf length of lettuce at different days after sowing (DAS) and harvest as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square				
		Leaf length (cm) at				
		30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Replication	2	0.032	0.951	0.389	0.303	0.087
Lettuce variety (A)	2	5.567**	14.567**	16.304**	21.110**	22.050**
Manure (B)	2	19.431**	38.566**	43.041**	60.751**	71.138**
Interaction (A×B)	4	1.780*	3.602*	2.879*	2.549*	1.441*
Error	16	0.583	1.099	0.832	0.785	0.454

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VI. Analysis of variance of the data on leaf breadth of lettuce at different days after sowing (DAS) and harvest as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square				
		Leaf breadth (cm) at				
		30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Replication	2	0.025	0.231	0.021	0.037	0.332
Lettuce variety (A)	2	12.604**	16.464**	27.738**	28.605**	8.016**
Manure (B)	2	22.083**	33.518**	71.185**	68.497**	50.093**
Interaction (A×B)	4	1.035*	3.485**	6.132*	2.313*	2.340*
Error	16	0.313	0.819	0.882	0.718	0.898

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VII. Analysis of variance of the data on leaf area of lettuce at different days after sowing (DAS) and harvest as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square				
		Leaf area (cm^2) at				
		30 DAS	37 DAS	44 DAS	51 DAS	Harvest
Replication	2	1.621	466.059	287.225	94.527	381.806
Lettuce variety (A)	2	5595.312**	14957.257**	29741.120**	43869.428**	29835.204**
Manure (B)	2	13622.434**	33342.287**	72058.445**	104522.777**	119542.494**
Interaction (A×B)	4	1072.433*	2683.134*	2182.446*	3690.808*	2007.795*
Error	16	270.274	660.099	523.123	1126.631	503.751

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix VIII. Analysis of variance of the data on yield contributing characters and yield of lettuce as influenced by different lettuce varieties and manure

Source of variation	Degrees of freedom	Mean square					
		Weight of individual plant (g)	Dry matter content in plant (g)	Number of roots/plant	Length of longest root (cm)	Yield/plot (kg)	Yield/hectare (ton)
Replication	2	4.834	0.089	0.191	0.023	0.003	0.107
Lettuce variety (A)	2	1393.27**	16.807**	33.351**	5.348**	0.470**	18.346**
Manure (B)	2	3581.30**	23.042**	91.316**	13.160**	1.060**	41.418**
Interaction (A×B)	4	222.706*	2.791*	3.071*	0.648*	0.054*	2.098*
Error	16	69.233	0.837	1.261	0.212	0.015	0.599

**: Significant at 0.01 level of significance; *: Significant at 0.05 level of significance

Appendix IX. Questionnaire on taste and visual acceptability of lettuce

Please give (√) against the desire treatment with the desire component

Treatments	Test and Smell														
	Crispness			Sweetness			Bitterness			Sourness			Appearance		
	HA	SA	NA	HA	SA	NA	HA	SA	NA	HA	SA	NA	HA	SA	NA
V_1M_0															
V_1M_1															
V_1M_2															
V_2M_0															
V_2M_1															
V_2M_2															
V_3M_0															
V_3M_1															
V_3M_2															

Highly Acceptable (HA=7), Slightly Acceptable (SA=5) and Not acceptable (NA=2)

Name and Signature of the Judges:…….. and……

Address:……...……

Age:…… Profession:……..

Date:……...

Appendix X. Per hectare production cost of lettuce

A. Input cost

Treatments	Labour cost	Ploughing cost	Seed cost	Irrigation cost	Manure		Insecticide/ pesticides	Sub total (A)
					Cowdung	Poultry manure		
V_1M_0	62,000	48,000	22,000	25,000	0	0	6,000	163,000
V_1M_1	62,000	48,000	22,000	25,000	20,000	0	6,000	183,000
V_1M_2	62,000	48,000	22,000	25,000	0	24,000	6,000	187,000
V_2M_0	62,000	48,000	22,000	25,000	0	0	6,000	163,000
V_2M_1	62,000	48,000	22,000	25,000	20,000	0	6,000	183,000
V_2M_2	62,000	48,000	22,000	25,000	0	24,000	6,000	187,000
V_3M_0	62,000	48,000	22,000	25,000	0	0	6,000	163,000
V_3M_1	62,000	48,000	22,000	25,000	20,000	0	6,000	183,000
V_3M_2	62,000	48,000	22,000	25,000	0	24,000	6,000	187,000

V_1: Green Wave
V_2: New red fire
V_3: Legacy

M_0: 0 kg M/ha (control)
M_1: Cowdung @ 20 t/ha
M_2: Poultry manure @ 8 t/ha

Appendix X. Per hectare production cost of lettuce (Cont'd)

B. Overhead cost (Tk./ha)

Treatments	Cost of lease of land (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
V_1M_0	97,500	8,150	17,462	123,112	286,112
V_1M_1	97,500	9,150	18,827	125,477	308,477
V_1M_2	97,500	9,350	19,100	125,950	312,950
V_2M_0	97,500	8,150	17,462	123,112	286,112
V_2M_1	97,500	9,150	18,827	125,477	308,477
V_2M_2	97,500	9,350	19,100	125,950	312,950
V_3M_0	97,500	8,150	17,462	123,112	286,112
V_3M_1	97,500	9,150	18,827	125,477	308,477
V_3M_2	97,500	9,350	19,100	125,950	312,950

V_1: Green Wave

V_2: New red fire

V_3: Legacy

M_0: 0 kg M/ha (control)

M_1: Cowdung @ 20 t/ha

M_2: Poultry manure @ 8 t/ha