EFFECT OF ORGANIC MANURE AND SPACING ON GROWTH AND YIELD OF LETTUCE

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EFFECT OF ORGANIC MANURE AND SPACING ON GROWTH AND YIELD OF LETTUCE

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CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF ORGANIC MANURE AND SPACING ON GROWTH AND YIELD OF LETTUCE"*** *submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of Master of Science in Horticulture, embodies the result of a piece of bona fide research work carried out by* ***AFSANA FERDOWSY,*** *Registration No.* ***06-1898*** *under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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ABSTRACT

The field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from Novembre 2011 to January 2012. In experiment, the treatment consisted of four organic manures viz. OM_0: no organic manure, OM_1: Cowdung, OM_2: Poultry manure, OM_3: Vermicompost and three spacing viz. S_1 (40 cm × 20 cm), S_2 (40 cm × 25 cm), S_3 (40 cm × 30 cm).Two factorial experiment was laid out in Randomized Complete Block Design with three replications. Significant variations in all parameter were recorded due to effect of organic manure and spacing at different DAT. In case of vermicompost, maximum gross yield (26.71 t/ha) was obtained from OM_3 and minimum (18.02 t/ha) was from OM_0. For spacing, highest gross yield (24.74t/ha) was recorded from S_2 and lowest (22.40t/ha) was from S_1. In case of combined effect, highest gross yield (28.42 t/ha) was obtained from OM_3S_2 and lowest (16.90 t/ha) was from OM_0S_1. The highest benefit cost ratio (2.46) was obtained from OM_3S_2 and the lowest (1.78) was recorded form OM_0S_1. So, vermicompost with 40 cm × 25 cm spacing showed better performance.

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LIST OF ABBREVIATED TERMS

FULL NAME	ABBREVIATION
Agro-Ecological Zone	AEZ
And others	*et al.*
Bangladesh Bureau of Statistics	BBS
Bangladesh Agriculture and Research Council	BARC
Centimeter	cm
Degree Celsius	°C
Dounum	Da
Date After Transplanting	DAT
Etcetera	etc
Food and Agriculture Organization	FAO
Gram	g
Hectare	ha
Hour	hr
Kilogram	kg
Meter	m
Millimeter	mm
Month	mo
Nitrogen	N
Number	no.
Potassium	K
Phosphorus	P
Percent	%
Randomized Complete Block Design	RCBD
Sher-e-Bangla Agricultural University	SAU
Square centimeter	cm^2
United Nations Development Program	UNDP

Chapter III

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the popular salad crop in the world. It belongs to the family compositae. It is leafy herb , milky juice crop. It produces a short stem early in the season, a cluster of leaves varying considerably in shape, character and colour in different varieties. Later in the season a seed stock is produced (Ryder, 1979). Lettuce is originated from Southern Europe and Western Asia (Rashid, 1999). It mainly grows in temperate region and in some cases in the tropic and sub-tropic region. It is mainly a cold loving crop. The best temperature range for lettuce cultivation is 18ºC to 25ºC at day and the night temperature is 10ºC to 15ºC (Ryder, 1998).

Lettuce is popular for its delicate, crispy, texture and slightly bitter taste as fresh condition. The nutritive value of lettuce is very high and also contain a good content of minerals and a moderate storage of vitamins to the human diet plus substantial amount of fibre and that of water (Work, 1997). It also contains protein, carbohydrate and vitamin C. Per hundred gram of edible portion of lettuce contains moisture 93.4 g, protein 2.1 g, fat 0.3 g, minerals 1.2 g, fibre 0.5 g, carbohydrates 2.5 g, calcium 310 mg, phosphorus 80 mg, iron 2.6 mg, vitamin A 1650 I.U, thiamine 0.09 mg, riboflavin 0.13 mg and vitamin C 10 mg (Gopalan and Balaraman 1966). It is usually used as salad with tomato, carrot, cucumber or other salad vegetable. It is often served alone or with dreessing. Its nutritive value is not spoiled. Moreover, it is anadyne, sedative, diuretic and expectorant (Kallo, 1986).

Lettuce is a newly introduced crop in our country and getting popularity day by day. Its production package is not much known to Bangladeshi farmers.

At present the use of organic manure is considered an important strategy in the effort to preserve the global environment (Nishimune, 1993). Organic manure contains nutrient elements that can support crop production and enhance the chemical and physical properties of soil. In addition to the major nutrient elements, manure contains several trace elements required by the crop and a large amount of organic matter needed for soil improvement (Manitoba Agriculture and Food, 2001). Soil organic matter improves the tilt and structure of soil. It improves the ability of soil to hold water and plant nutrients. Furthermore, it improves the buffering capacity of the soil i.e. keeps soil from over-reacting. Organic matter supports the soil's microbial activity, which contributes both major and minor nutrients and helps to release nutrients slowly (Stephens, 2002). Organic manure improves soil structure as well as increase its water holding capacity. Moreover, it facilitates aeration in soil. Recently organic farming is appreciated by vegetable consumers as it enhances quality of the produce.

The chemical fertilizers used in conventional agriculture contain just a few minerals, which dissolve quickly in damp soil and give the plants large doses of minerals .Organic fertilizers can therefore be used to reduce the amount of toxic compounds (such as nitrates) produced by conventional chemical fertilizers in vegetables like lettuce and thus improving the quality of leafy vegetables produced

as well as human health. Increased consumer awareness of food safety issues and environmental concerns has contributed to the development of organic farming over the last few years (Worthington, 1998; Worthington, 2001; Relf *et al.*, 2002). Thus, it may be possible to lessen the escalating effects of diseases such as cancer and boost immunity of humans. Farm income will also improve when farmers use less money on fertilizers and pesticides for growing crops, (Vernon, 1999). There is increased demand of organically produced vegetables in view of its health and nutritional benefits.

Plant spacing for lettuce cultivation is an important criterion for attaining maximum vegetative growth and an important aspect of crop production for maximizing the yield. Optimum plant spacing ensures judicious use of natural resources and makes the intercultural operations easier. It helps to increase the number of leaves, branches and healthy foliage. Densely planted crops cause problems with the proper growth and development. On the other hand wider spacing ensures the basic nutritional requirements but decreases the total number of plants as well as total yield. Yield may be increased for any crop up to 25% by using optimum spacing in leafy vegetable (Bansal, *et al*., 1995).

In Bangladesh proper information about lettuce production is insufficient. The farmers of Bangladesh cultivate this crop by using their own knowledge due to the unavailablity of instructions of standard production technique. As a result, they do not get satisfactory yield and return from investment .

Considering the above factors, the present experiment was undertaken to study the following objectives.

- To study the effect of different spacing on growth and yield of lettuce.
- To identify the appropiate organic manure for lettuce production.
- Tofind out the combined effect of organic manure and spacing for ensuring the higher growth and yield of lettuce.

Chapter II

REVIEW OF LITERATURE

Lettuce is one of the most popular salad vegetable of the world as well as in Bangladesh and received much attention of the researcher of different countries including Bangladesh. Like many other vegetables such as root and tuber crops as well as spices, the growth and yield of lettuce are influenced by organic fertilizer as well as spacing. A number of factors like temperature, soil moisture along with organic fertilizer as well as spacing influence the growth and yield of a crop. There is a little or no combined research work to the effect of organic fertilizer as well as spacing on growth and yield of lettuce in Bangladesh. The literature related to the present study are reviewed in this chapter.

2.1 Effect of organic manure of the growth and yield of lettuce

Lettuce is the most important leaf vegetable grown in Argentina mainly in the green belts. This species requires 90 to 100 kg ha^{-1} nitrogen, which can be supplied by synthetic chemical fertilizers or organic supplements. 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. At harvest, vermicompost addition affected

nitrate content in leaf lettuce (cv Brisa) increasing its concentration. Yield was not affected by vermicompost application.

Asaduzzaman *et al, (*2010*)* conducted an experement in the field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2009 to January 2010 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 M3 = 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 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 $M_2 OM_3$ (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 (Benefit cost ratio) treatment M_1OM_2(Dry water hyacinth + poultry manure : 3.37) was more economic than the M_2OM_3 .

Masarirambi *et al*, (2010) was conducted an experement in the University of Swaziland. The organic fertilizers were (a) bounce back compost, (b) cattle manure and(c) chicken manure. 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 ($P< 0.05$) 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.

The effect of three types of organic manures, its combination within and with chemical fertilizer was studied under the nylon net house. Cow dung (CD), chicken manure (CM) and duck manure (DM) were applied 4.5, 4.7 and 5.8 t/ha, respectively, contributing 81 kg nitrogen each. In the case of combination treatments each combination contributed 1:1 ratio of nitrogen. A treatment with recommended dose of chemical fertilizer (CF) providing 81 kg nitrogen was also included. The crop grown with 4.7 t/ha of CM alone and its combination with CF (2.35 ton CM plus 156 kg complete fertilizer i.e., 15-15-15 together with 82 kg/ha of ammonium sulfate) gave a significantly higher yield throughout the crop season. Combination treatments within organic manures did not establish any statistical significance. In spite of the differences in total yield, fiber content and

dry matter percentage showed not significant results irrespective of treatments and crop seasons (Paudel *et al*. 2004).

Johannessen *et al,* (2004) observed 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. However, others have suggested that there is a risk by using manure. There is a need for more research in the field.

Stintzing *et al, (*2002) observed that the field trial showed 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.

Rodrigues and Casali (1999) observed that the highest estimated yields of 119.5, 119.4 and 153.9 g/plant were obtained with 37.7 t organic compost/ha with no

mineral fertilizer application, 18.9t 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.

Tisselli (1999) reported that maximum rates of organic manure (usually poultry manure) and NPK recommended in 1998 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.

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 (a 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 1st and 2nd crops, respectively.

Zarate *et al*, (1997) observed that the interaction between rate and method of application of manure 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 the significantly highest yield (20.0 t fresh matter/ha).

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 KNO3/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.

Stopes *et al*, (1989) mentioned that there was no significant difference in nitrate accumulation among cultivars but there was a significant effect of the fertilizer type used on nitrate accumulation, with plants accumulating more nitrate when fertilized with readily soluble compound fertilizer (1410 and 1387 ppm. nitrate in FW at 80 and 160 kg N/ha, respectively) compared with FYM (1184 and 1191 ppm., respectively). Fertilization with FYM did not significantly increase nitrate accumulation when compared with an unfertilized control (1051 ppm.). Yield was increased by fertilization, but there was no significant difference between the FYM and compound fertilizer treatments at the high rate of N application.

Larion *et al*, (1984) reported that yields and mineral and protein contents of butterhead lettuce were similar in plants fertilized with mineral fertilizer (ammonium nitrate or Chilean nitrate of soda) or an organic fertilizer (castor oil seed cake) at 120 or 200 kg N/ha. The nitrate content of organically grown plants was lower than that of plants receiving mineral fertilizer.

2.2 Effect of Spacing on the growth and yield of lettuce

Firoz *et al,* (2009) was conducted an experement at the Hill Agricultural Research Station, Khagrachari from November 2002 to May 2003 to find out the effect of sowing time (10, 20, 30 November and l0, 20, and 30 December) and spacing (50 x 30 cm and 50 x 45 cm) on lettuce seed production. Maximum lettuce seed yield (770 kg/ha) was found from 10 November sowing with 50 × 45 cm spacing followed by same sowing time with 50 x 30 cm and 20 November with both spacings. There was a trend to decrease seed yield with the advance of sowing time irrespective of spacing. Germination (%) and other quality also showed satisfactory result in the same treatment.

A fiekd experiment was conducted by Moniruzzaman (2006) with three levels of spacing (40×20 cm, 40×30 cm and 40×40 cm) and two levels of mulching (mulch and non-mulch). Plant spacing, mulching and their interaction showed significant effect on yield and yield components of lettuce. The highest fresh yield of lettuce was obtainde from the closest spacing (40×20 cm) that was statistically similar to that recorded of medium spacing (40×30 cm) during both the years. The highest yield (25.9 t/ha in 1999-00 and 28.3 t/ha in 2000-01 with an average of 27.10 t/ha) was observed in the spacing 40×20 cm with mulch, which was statistically as per with the spacing of 40×30 cm with mulch. The results also revealed that higher gross return (Tk. 216800) was obtained from the closest spacing in combination with mulch followed by medium spacing (40×30 cm) with mulch (Tk. 210,160). The treatment combination of 40×30 cm spacing and mulching gave the highest benefit cost ration (8.84), but the benefit cost ratio (4.22) from the treatmetnt

combination of 40×20 cm spacing and mulching was less due to the involvement of higher seedling cost.

The effects of spacing, hoeing and mulching on the yield and quality of lettuces under integrated control were determined by Petrikova and Pokluda (2004). Marketable lettuce yields reached 80-99%. Planting density, cultivar and mulching affected the quality of lettuce heads. The quality of lettuce heads were determined by the cultivar, as well as by mulching and hand hoeing. The size of lettuce heads were positively correlated with losse spacing.

Sharma et al, (2001) tested with twenty-four treatment combination of six trasplanting dates in lettuce cv. Alamo-1 viz., 1st Aug., 16th Aug., 1st Sept., 16th sept., 1st Oct. and 16th October and four spacing levels viz., 30×30 cm, 45×30 cm, 45×45 cm and 60×45 cm and evaluated in a split plot design with three replications. Too early/late transplanting resulted in decreased yield and other horticultual traits. The maximum yield of 241.3 q/ha was obtained when the trasplanting was done on 1st september followed by 226.5 q/ha on 16th september. In this case the plants also took less number of days to 50% maturity. The widest spacing of 60×45 cm gave the maximum fresh weight and dry weight perplant (yield/plant) but lowerst per hectare. The closest spacing on 30×30 cm recorded minimum yield/plant, shich did not compensate optimum yield per hectare. A plant spacing of 45×30 cm was found best for getting optimum yield per plant as well as per hectare. On the basis of overall effect of dates of planting and plant spacing on yield and its attributes, the planting date of 1st september and plat

spacing of 45×30 cm proved to be the most promising for getting optimum yield in lettuce cv. Alamo-1 under kullu valley conditions of Himachal pradesh.

Echer *et al,* (2001) evaluated the performance of 5 lettuce cultivars (Brisa, Grade Rapida, Marisa, Vera and Veronica) in 2 spacing treatment (0.20×0.25m and 0.25×0.25m) The cultivars with the best performances were Vera, Marisa and Brisa. In the small spacing (0.20×0.25m) treatment, there was higher production area per plant within commercial standards than in the large spacing (0.25×0.25m). A higher correlation between leaf fresh matter and fresh matter of aerial parts was observed in Vera compared to other cultivars.

Silva *et al,* (2000) carried out an experiment with lettuce cv. Great lakes, Elisa and Baba de Verao, the effects of different plant spacing (20×20, 25 or 30 cm, 25×25 cm, 25×30cm of 30×30 cm) on leaf yield under high temperature and simple sunlight conditions. An additional treatment of cv. Great Lakes at 20×20 cm under constant shading was also studied. Plant heigt and diameter, leaf number per plant, shoot dry matter content, leaf yield, gross and net incomes and rate of return were studied. Cv. Great Lakes had the greatest leaf yield and economic indices. Leaf yield, shoot dry matter and economic indices were greatest at a spacing of 20×20cm. leaf number per plant was highest in cv. Elisa and was unaffected by spacing.

Steingrobe and Schenk (1994) reported that seeds of lettuce cv. ‘Clarion’ were sown in 4×4 cm peat blocks and seedlings were planted out 3 weeks later at a spacing of 30×30 cm. Seedlings received different amounts of N fertilizer before

and after plating. They found that N application increased root growth in the first 3 weeks after planting out, but hat no effects on yield

EL-Hassan, (1990) had grown lettuce cv. Dark Green lettuce on experimental plot in Cairo in the winter seasons of 1987 and 1988. The effects of various planting systems and app1ication of 20 or 40 kg N/feddan on head weight, dry matter content and N content were recorded. The higher N rate and wide spacing (30 cm) gave greater head weight, % dry matter. Total % N in dry matter and NO_3-N content in fresh leaf midribs. The highest total and saleable yields and the highest total dry matter content were achieved with the higher N rate, spacing at 10 cm and planting on both sides of the planting ridges.

Chapter III

MATERIALS AND METHODS

In Bangladesh, lettuce is grown in a very limited scale, but a good deal of interest has been generated among farmers for raising its demand in fastfood shops. It is necessary to explore the possibilities of growing lettuce in order to raise its yield level like as effect of organic manure and spacing on growth and yield of lettuce. So, this experiment has undertaken to find out optimum doses of organic manure and effective spacing for exploiting the growth and yield potential of this crop.

3.1 Experimental Site

The experiment was conducted at the Horticulture Farm and Laboratories of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2011 to January 2012.The location of the site is in 23º 74ó N latitude and 90º 35ó E longitude with an elevation of 8.2 meter from sea level .(anonymous,1989)

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The total rainfall of the experimental site was 83.6 mm during the study period. The average monthly maximum and minimum temperature were 27.17ºC and 15.6ºC repectively during the

experimental period. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented (Appendix I).

3.3 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988). The analytical data of the soil sample collected from the experimental area were determined in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and presented in appendix II.

The experimental site was a medium high land and pH of the soil was 5.6. The morphological characters of soil of the experimental plots as indicated by FAO (1988) are given below –

AEZ No. 28

Soil series – Tejgaon

General soil- Non-calcarious dark grey.

3.4 Plant Materials

Seed of lettuce cultivar, Green Raphid was used in the experiment and sown on 10th November ,2011. It is leafy and spreading type as well as heat tolerant in nature.

3.5 Treatments of the experiment

The experiment was conducted to study the effects of organic manure and spacing on growth and yield of lettuce. The experiment consisted of two factors as follows:

Factor A: Organic Manure (Four levels)

i. Control (OM_0)
ii. Cowdung (OM_1) – 20 t/ha
iii. Poultry manure (OM_2) – 12 t/ha
iv. Vermicompost (OM_3)-10 t/ha

Factor B : spacing (three levels)

i. S_1 – 40 cm×20 cm.
ii. S_2 – 40 cm ×25 cm.
iii. S_3 – 40 cm ×30 cm.

3.6 Experimental design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 170 m^2 was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment were allotted at random. Thus there were 36 unit plots altogether in the experimental field. The size of each plot was 1.6 m × 1.5 m. The distance between two blocks

and two plots were kept 0.5 m and 0.5 m respectively. A layout of the experiment has been shown in Appendix.III.

3.7 Seed bed preparation, seed germination and raising of seedlings

The selected seed bed was 3m × 1m in size. Seed beds were prepared with a mixture of sand, soil and compost. It was raised 15cm from ground level. Germination of lettuce seed is a major problem in lettuce cultivation. Lettuce seed usually fails to germinate at temperature above 30ºC. Several workers have found that most lettuce seed may go into dormancy when subjected to high temperature and its exposure to chilling at 4-6ºC for 3-5 days result in breaking dormancy (Thomson and Kelly 1957). Lettuce seed were soaked in water for 48 hours and then seeds were mixed with soil and sown in seed bed. Lettuce seeds were sown on 10th november, 2011. Complete germination of seed took place in five days. When the seedlings were thirty days old they were transplanted in the experimental field on 10 th December , 2011.

3.8 Land preparation

The land which was selected to conduct the experiment opened 25 November, 2011 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. After that it was prepared by ploughing and cross ploughing followed by laddering. Deep ploughing was done to have good tilth which was necessary for getting better yield of the crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

3.9 Application of manures

The sources of N, P and K as cowdung, poultry manure and vermicompost were applied. The entire amount of organic manure was applied during the final land preparation. The following amount of manure were used which was shown as tabular form.

Table**1.Composition of cowdung, poultry manure and vermicompost (Fertilizer Recomandation ,BARC,1997)**

Manures	Amount(%)		
	N	P	K
Cowdung	0.5-1.5	0.4-0.8	0.5-0.9
Poultry manure	1.6	1.5	0.85
Vermicompost	1.5-2.5	0.9-2.4	1.5-2.4

3.10 Transplanting of seedlings

Healthy and uniform sized, thirty days old seedlings were transplanted on 10th December, 2011 in the afternoon and light irrigation was given around each seedlings for their better establishment. The transplanted seedlings were protected from scorching sunlight by providing shed using banana leaf sheath. Dead seedlings were replaced by new seedlings from same stock.

3.11 Intercultural operation

When the seedlings were established in the beds , it was always kept under careful observation. Various intercultural operations like thinning, weeding were accomplished for better growth and development of lettuce seedlings.

3.11.1 Gap filing

Dead, injured and weak seedlings were replaced by new vigourous seedlings from the stock kept on the border line of the experiment field.

3.11.2 Weeding

Weeding was done three times in these plots where it was necessary.

3.11.3 Irrigation

Light irrigation was given just after transplanting of the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation.The plots were irrigated in every alternative day with a hosepipe untill the entire plot was properly wet. Again, whenever the plants of a plot had shown the symptoms of wilting the plots were irrigated again.

3.11.4 Insects and Diseases

There was no incidence of insects and diseases.

3.12 Harvesting

Randomly selected five plants were harvested from each plot for data collection for 2 times. First harvest were done at 30 DAT and second 40 DAT.

3.13 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Five (5) plants were sampled randomly from each unit plot for the collection of data.

3.13.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scalc at 30and 40 days after transplanting (DAT) from the point of attachment of the leaves to the ground level up to the tip of the longest leaf.

3.13.2 Number of leaves per plant

Five number of leaves of randomly selected plants were counted at 30 and 40 DAT. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting. The average number of leaves of five plants gave number of leaves per plant.

3.13.3 Leaf area index (cm^2)

Five plants were randomly selected from each plot and three fully mature leaves which attain edibility were collected at 40 DAT. Leaf areas of these leaves were measured with leaf area meter. Average was expressed in centimeter square (cm^2).

3.13.4 Length of leaf(cm)

The length of leaf was measred by using a meter scale. The measurement was taken from base to tip of the leaf . Average length of leaves which were matured and attained edibility was taken from five randomly selected plants. Data were recorded from 30 and 40 DAT. Average was expressed in centimeter (cm).

3.13.5 Breadth of leaf(cm)

The average breadth of leaves (which were matured and attain edibility) were taken from five randomly selected plants from each plot started at 30 and 40 DAT.Average was expressed in centimeter (cm).

3.14.6 Fresh weight of leaves per plant (g)

Leaves of five randomly selected plants (which were matured and attained edibiliyty) at 30 and 40 DAT were detached by a sharp knife and average fresh weight of leaves was recorded in gram(g).

3.13.7 Dry wieght(g) and dry matter content (%) in plant

After harvesting, 100g of leaf sample previously sliced into very thin pieces were put into envelop and placed in oven and dried at 60°C for 72 hours. The sample was then transfered into desciccator and allowed to cool down to the room

temprature and then final weight of the sample was taken to get dry weight. The dry matter contents (%) of leaves were computed by simple calculation from the weight recorded by the following formula.

Dry matter (%) = Dry weight of plant/Fresh weight of plant x 100

3.13.8 Organoleptic test

A panel of Judges consisting of 25 members were assigned to evaluate appearance crispiness, sweetness, bitter ness , sourness, taste and flavour by organoleptic test on the basis of aceptibility: Highly Acceptable (HA=7), Moderately Acceptable (MA=5) and Unacceptable (UA=2) for crispiness, taste and flavour (sweetness, bitterness and sourness) and appearance respectively (Villared *et al.*, 1979).

3.13.9 Yield per plot (kg)

Yield of lettuce per plot was recorded as the whole plant in every harvest within a plot (1.6m×1.5 m).Then fresh weight of head was taken by a triple beam balance at 30 and 40 DAT and the average weight was expressed in kilogram (kg).

3.13.10 Gross yield (t/ha)

The yield of lettuce per hectare was calculated in ton by converting the total yield of leaves per plot.

3.13.11 Marketable yield (t/ha)

It consisted of only quality leaf of lettuce and was also calculated in ton per hectare by converting the total yield of leaves per plot.

3.14 Statistical analysis

The recorded data on various parameters were statistically analyzed by using MSTAT statistical package programmed. The average for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT) according to Gomez and Gomes, (1984).

3.15 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of organic manure and plant spacing. All input cost included the cost for lease of land and interests of running capital in computing the cost of production. The interests were calculated @ 15% in simple rate. Analysis was done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ration} = \frac{\text{Gross return per hectate (TK)}}{\text{Total cost of production per hectare (TK)}}$$

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the effect of different organic manure and different spacing on the growth and yield of lettuce. The analyses of variances for different characters have been presented in appendices IV toVIII. Data on different parameters were analyzed statistically and the results have been presented in the Tables 2 to 14 and Figures 1 to 12. The results of the present study have been presented and discussed in this chapter under the following headings.

4.1 Plant height

The plant height was recorded at different stages of growth as 30 and 40 (days after transplanting) DAT. The plant height varied significantly due to different organic manure (Fig.1 and appendix IV). The maximum plant height (18.1cm and 20.2 cm at 30 and 40 DAT respectively) was recorded in OM_3 treatment. On the other hand, the shortest plant (13.9 cm and 15.6 cm at 30 and 40 DAT respectively) was recorded in OM_0 treatment. Organic manure ensures available essential nutrients for the plant for that organic manure gave the highest plant height compared to control. Among the different organic manure vermicompost was found more effective than other organic manure.

Significant variation on plant height of lettuce was calculated due to different plant spacing at 30 and 40 DAT (appendix IV). During the period of plant growth

the tallest plant (18.2 cm and 20.0 cm at 30 and 40 DAT respectively) was measured from S_1 treatment and minimum (14.7 cm and 16.1cm at 30 and 40 DAT respectively) in S_3 treatment (Fig.2). Results under the present experiment showed that closer spacing showed higher plant height where wider plant spacing showed lower plant height because of closer spacing plant compete for light which helps to elongate plant than the wider spacing. Moniruzzaman (2006) reported similar findings from the closer spacing.

The plant height was significantly influenced by the interaction effect of organic manure and spacing (appendix IV). The combined effect of organic manure and spacing at different DAT was also significant. The tallest plant (21.4 cm and 23.3 cm at 30 and 40 DAT respectively) was obtained from OM_3S_1 treatment and the shortest plant (12.48 cm and 14.37 cm at 30 and 40 DAT respectively) was recorded from the OM_0S_3 treatment (Table 2).

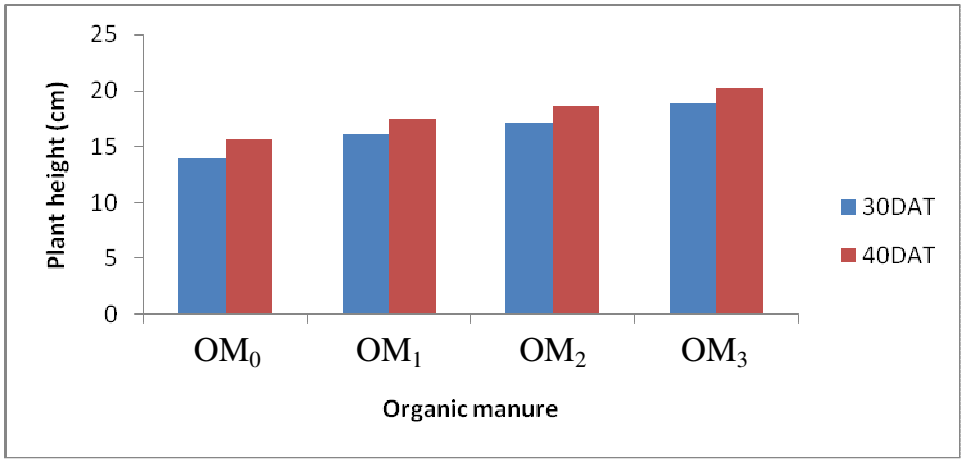

Fig. 1. Effect of organic manure on plant height of lettuce at different days after transplanting

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

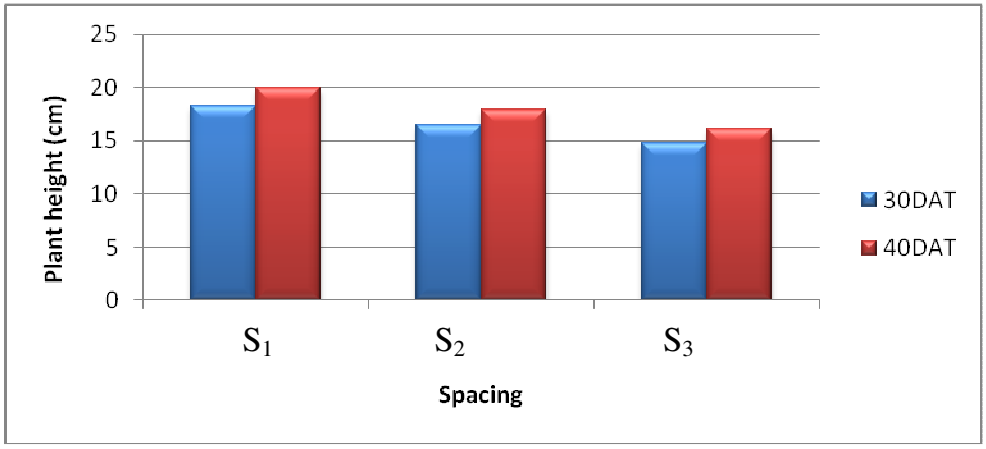

Fig. 2. Effect of spacing on plant height of lettuce at different days after transplanting

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

Table 2. Combined effect of organic manure and spacing on plant height and number of leaves per plant of lettuce

Treatment	Plant height(cm)		Number of leaves per plant	
	30DAT	40DAT	30DAT	40DAT
OM_0S_1	15.10 fg	1.87 fg	10.13 g	12.13 f
OM_0S_2	14.13 g	15.67 gh	11.13 f	15.53 d
OM_0S_3	12.48 h	14.37 i	12.72 de	16.67 cd
OM_1S_1	17.48 cd	19.07 cd	12.20 e	14.13 e
OM_1S_2	16.33 e	17.70 ef	13.40 d	16.70 cd
OM_1S_3	14.53 fg	15.53 hi	14.40 c	18.13 b
OM_2S_1	19.10 b	20.87 b	13.10 de	15.60 d
OM_2S_2	16.93 de	18.47 c-e	14.40 c	17.60 bc
OM_2S_3	15.30 f	16.63 f-h	15.23 bc	19.53 a
OM_3S_1	21.43 a	23.30 a	14.47 c	17.43 bc
OM_3S_2	18.27 bc	19.60 c	15.40 b	18.30 b
OM_3S_3	16.80 de	17.87 def	16.67 a	20.53 a
CV (%)	6.69	7.96	8.82	7.11

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

4. 2 Number of leaves per plant

Applications of organic manure significantly increase the production of leaves per plant (Fig.3 and appendix IV)) at 30 and 40 DAT. The maximum number of leaves per plant (15.5 and 18.7 at 30 and 40 DAT respectively) was produced by OM_3 treatment and the minimum (11.3 and 14.7 at 30 and 40 DAT respectively) was produced by the OM_0 treatment. Organic manure ensured available essential nutrients for the plant and organic manure gave the highest number of leaves per plant compare to control condition and among the different organic manure vermicompost was more effective than other organic manure to increase the number of leaves per plant.

Significant variation was found in case of production of leaves per plant due to the effect of spacing (Fig.4 and appendix IV)). The maximum number of leaves (14.7 and 18.7 at 30 and 40 DAT respectively) was obtained from S_3 treatment. The S_1 treatment gave minimum number of leaves (12.48 and 14.82 at 30 and 40 DAT respectively) per plant showing significantly different results from other treatments. It was revealed that with the increases of spacing, number of leaves per plant also increased. Enough space for vertical and horizontal expansion in the optimum spacing leads to the production of maximum number of leaves per plant than closer spacing. Steingrobe and Schenk (1994) also reported similar results earlier.

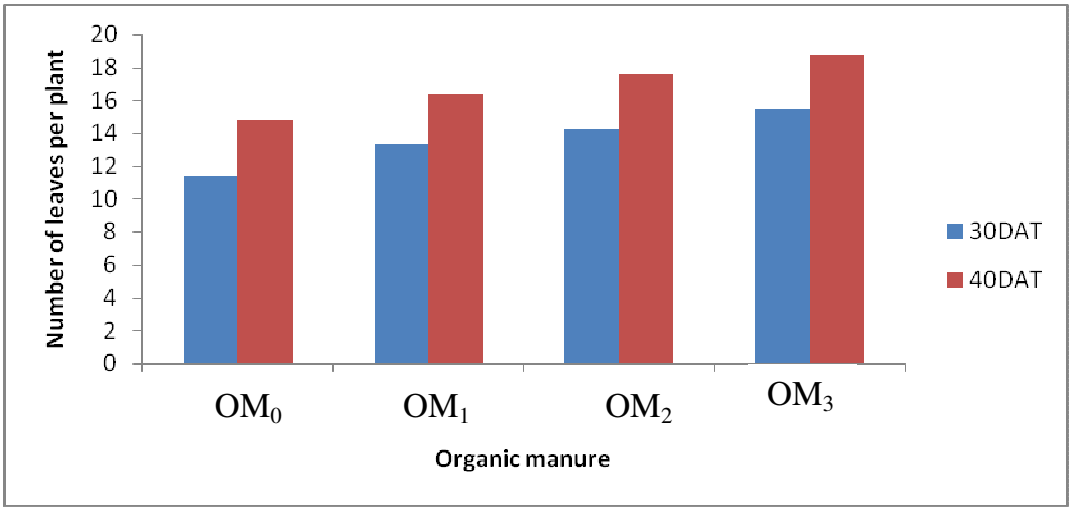

Fig. 3.Effect of organic manure on number of leaves per plant of lettuce at different days after transplanting

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

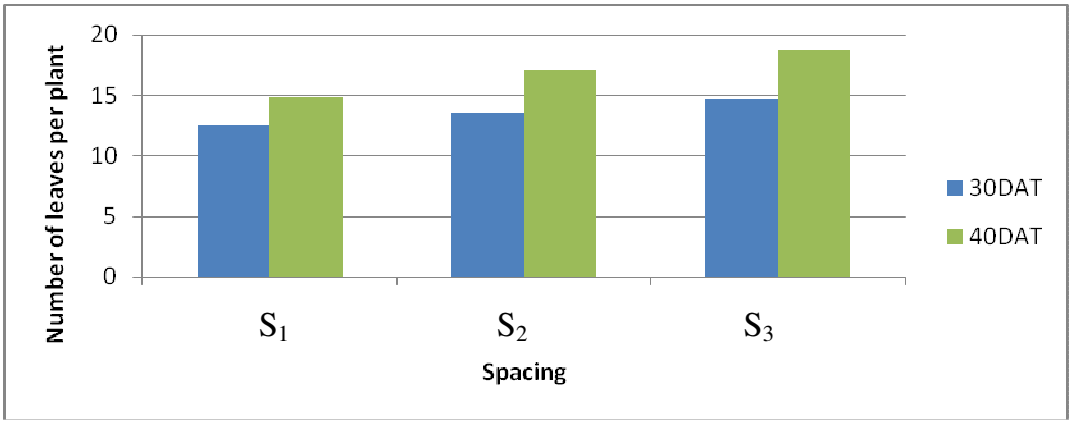

Fig. 4.Effect of spacing on number of leaves per plant of lettuce at different days after transplanting

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

The number of leaves per plant was also significantly influenced by the interaction effect of organic manure and spacing (Appendix IV). The number of leaves per plant was recorded to be the highest (16.6cm and 20.5 cm at 30 and 40 DAT respectively) from the treatment combination OM_3S_3 treatment. The lowest number of leaves (10.13 cm and 12.13 cm at 30 and 40 DAT, respectively) was obtained from the OM_0S_1 treatment (Table 2).

4.3 Leaf area

The leaf area was recorded at 30 days after transplanting (Apendix V). The leaf area varied significantly due to the application of different organic manure. The maximum leaf area (319.2 cm^2) was obtained from OM_3 treatment and the minimum leaf area (241.1 cm^2) was recorded from OM_0 treatment (Fig. 5).

The leaf area varied significantly due to the different types of spacing (Fig.6 and (Appendix V)). The leaf area was the highest irrespective of S_3 treatments being maximum (304.6 cm^2) and minimum (253.70 cm^2) was recorded from S_1 treatment at 40 DAT.

The highest leaf area was significantly influenced by the interaction effect of organic manure and spacing (Appendix V). The maximum leaf area (405.8 cm^2) was found from OM_3S_3 and the lowest leaf area (225.40 cm^2) from the (OM_0S_1) treatment at 40 DAT. (Table 3)

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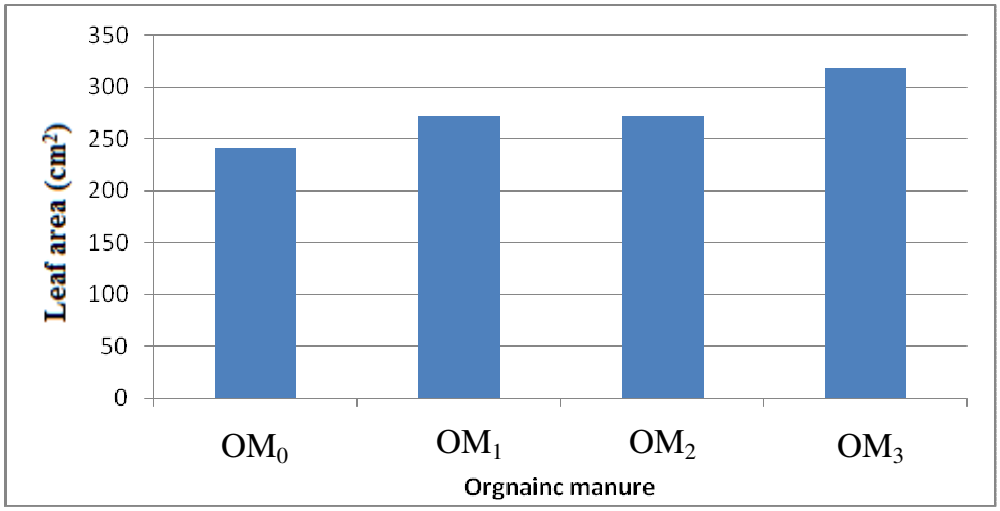

Fig. 5.Effect of organic manure on leaf area of lettuce at different days after transplanting

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

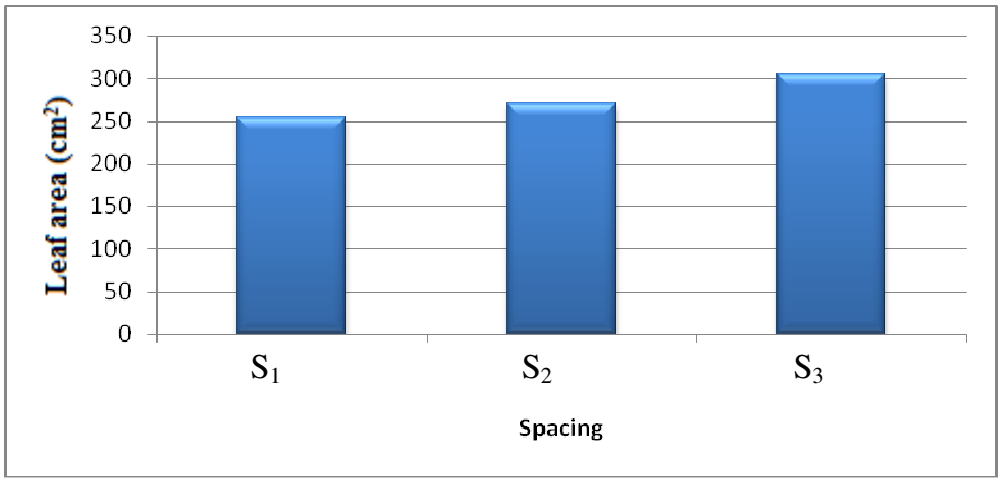

Fig. 6.Effect of spacing on leaf area of lettuce at different days after transplanting

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

Table 3. Combined effect of organic manure and spacing on leaf area, length of leaf and breath of leaf of lettuce

Treatment	Leaf area index (cm^2)	Length of leaf (cm)		Breath of leaf (cm)	
		30DAT	40DAT	30DAT	40DAT
OM_0S_1	225.40 j	13.10 g	14.17 f	11.93 f	13.50 e
OM_0S_2	290.40 c	13.40 fg	14.50 ef	12.67 ef	13.60 e
OM_0S_3	265.40 fg	14.93 cd	15.60 cd	14.23 cd	14.40 cde
OM_1S_1	261.50 g	14.53 de	14.93 de	13.33 de	13.93 de
OM_1S_2	251.80 h	15.60 abc	16.20 bc	13.80 de	14.63 cde
OM_1S_3	246.10 i	16.13 a	16.87 ab	15.50 b	15.70 bcd
OM_2S_1	279.50 d	14.00 ef	15.00 de	13.80 de	14.40 cde
OM_2S_2	272.30 e	15.97 ab	16.27 bc	15.37 bc	14.60 cde
OM_2S_3	301.00 b	15.33 bc	16.27 bc	16.30 ab	16.97 ab
OM_3S_1	248.40 hi	15.07 cd	15.43 d	13.87 de	14.73 cde
OM_3S_2	267.70 ef	15.00 cd	16.43 b	15.93 b	16.00 bc
OM_3S_3	405.80 a	16.27 a	17.43 a	17.20 a	18.23 a
LSD $_{(0.05)}$	5.16	0.63	0.62	1.16	1.79
CV (%)	6.89	5.75	5.8	7.39	7.03

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

4.4 Length of leaf

The results on effects of organic manure showed that organic manure had significant effect on length of leaf at 30 and 40 DAT (Appendix V). The OM_3 gave the maximum length of leaf (15.4 cm and 16.4 cm at 30 and 40 DAT respectively). The OM_0 treatment gave minimum (13.8 cm and 14.7 cm at 30 and 40 DAT respectively) length of leaf (Fig.7).

The length of leaf per plant measured at 30 and 40 DAT was significantly influenced by spacing (Appendix V). Treatment S_3 produced maximum length of leaf (15.6 cm and 16.6 cm at 30 and 40 DAT respectively) and the minimum (14.1 cm and 14.4 cm at 30 and 40 DAT respectively) length of leaf was recorded in S_1 treatment (Fig. 8). It was revealed that with the increases of spacing leaf length resulted increasing trend. In case of closer spacing plant compete for light and leaf length decreases with the time being. Sodkowski and Rekowska (2003) reported longest leaf from closer spacing.

Interaction effect of organic manure and spacing had a significant variation on length of leaf. The maximum length of leaf (16.27 cm and 17.43 cm at 30 and 40 DAT respectively) was obtained from OM_3S_3 treatment while the minimum length of leaf (13.10 cm and 14.17 cm at 30 and 40 DAT respectively)was found from OM_0S_1 treatment (Table 3).

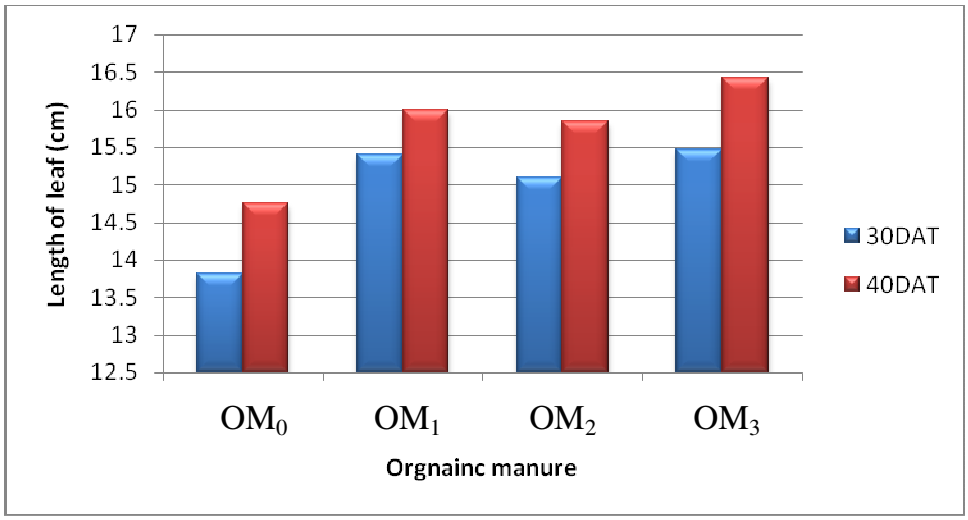

Fig. 7.Effect of organic manure on leaf length of lettuce at different days after transplanting

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

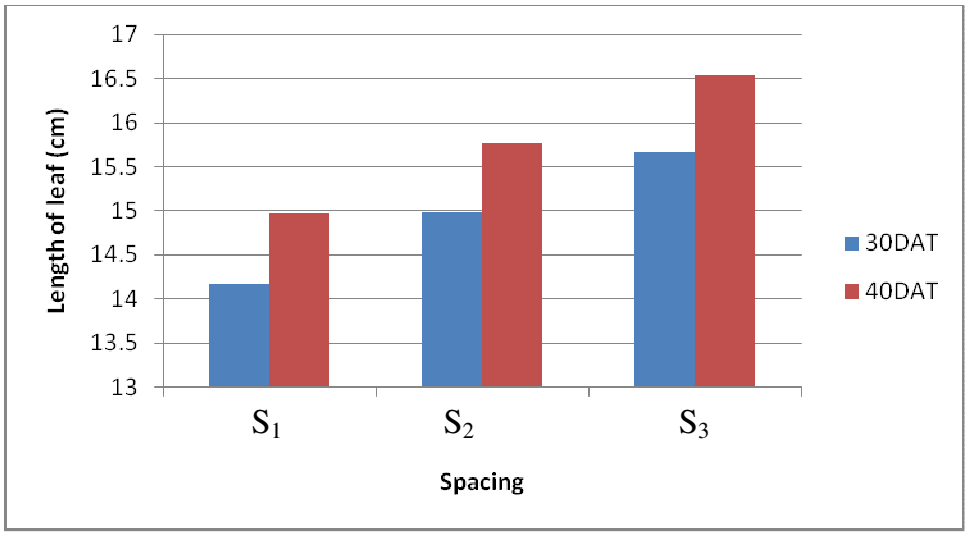

Fig. 8. Effect of spacing on length of leaf at different days after transplanting

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

4.5 Breadth of leaf per plant

The effect of organic manure was significant in case of breadth of leaf per plant (Appendix V). OM_3 produced the widest (15.60 cm and 16.31 cm at 30 and 40 DAT respectively) leaf breadth and OM_0 treatment produced narrowest leaf (12.92 cm and 13.83 cm at 30 and 40 DAT respectively) (Fig.9).

The Breadth of leaf counted at DAT was significantly influenced by spacing (Appendix V). Treatment S_3 produced maximum Breadth of leaf (15.84 cm and 16.30 cm at 30 and 40 DAT respectively) and the minimum (13.20 cm and 14.11 cm at 30 and 40 DAT respectively) Breadth of leaf was recorded in S_1 treatment (Fig. 10). It was revealed that with the increases of spacing leaf breath showed increasing trend. In case of closer spacing plant compete for light and with the time being leaf breath decreases.

The interaction effects of organic manure and spacing were significant in respect of breadth of leaf (Appendix V). Numerically the highest breadth of leaf (17.20 cm and 18.23 cm at 30 and 40 DAT respectively) was obtained from the treatment combination of OM_3S_3 and the minimum breadth of leaf (11.93 cm and 13.50 cm at 30 and 40 DAT respectively) was measured in the treatment combination of OM_0S_1 treatment (Table 3).

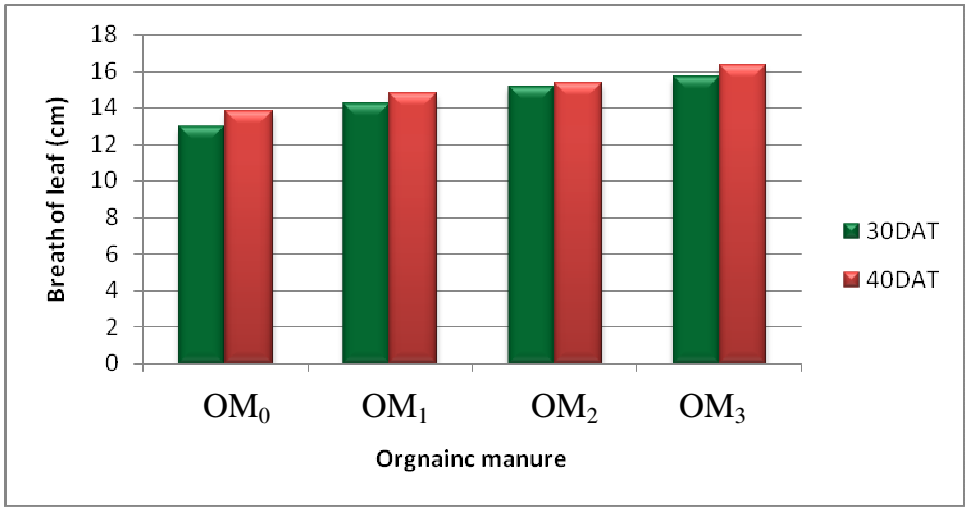

Fig. 9.Effect of organic manure on breath of leaf of lettuce at different days after transplanting

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

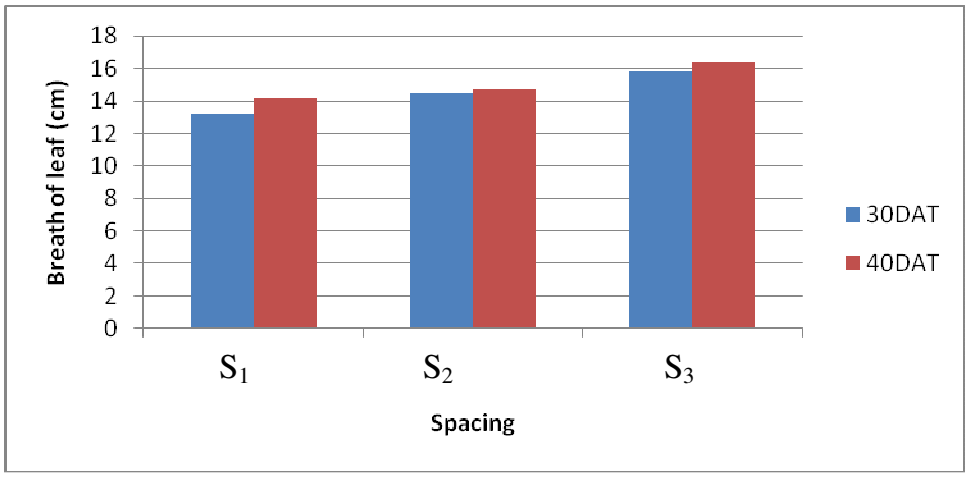

Fig. 10. Effect of spacing on breath of leaf of lettuce at different days after transplanting

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

4.6 Fresh weight of leaves per plant (g)

Organic manure significantly influenced the fresh weight of leaves per plant at 30 and 40 DAT (Appendix VI). The maximum weight of fresh leaves per plant (226.50 g and 284.50 g at 30 and 40 DAT respectively) was recorded from OM_3 and the minimum weight (170.30 g and 184.30 g at 30 and 40 DAT respectively) was measured in the OM_0 (Table 4). Among the different organic manure Vermicompost was more effective than those of other organic manure. Huang and Tsai (1993) observed that an application equivalent to 20 t/h was the most effective and resulted in a yield increase over unfertilized controls of 11.3% and 44.9% for spinach and leaf lettuce, respectively, on the red soil and 80.2% and 59.4%, respectively on the alluvial soil.

The fresh weight of leaves per plant was significantly influenced by plant spacing (Appendix-VI). Treatment S_3 produced maximum fresh weight of leaves per plant (241.25 g and 285.20 g at 30 and 40 DAT respectively) and the minimum fresh weight of leaves per plant (169.53 g and 201.42 g at 30 and 40 DAT respectively) was recorded from S_1 treatment (Table-5). It was revealed that with the increases of spacing fresh weight of leaves per plant showed increasing trend. In case of wider spacing plant receive enough light and nutrients which leads to attain the maximum fresh weight of leaves per plant. Similar trends of result was also observed by Sharma *et al*. (2001).

Table 4.Effect of organic manure on fresh weight of leaf per plant and dry weight per plant and dry matter content of lettuce

Treatment	Fresh weight of leaf per plant (g)		Dry weight per plant (g)		Dry matter content (%)	
	30DAT	40DAT	30DAT	40DAT	30DAT	40DAT
OM_0	170.30 b	184.30 b	7.01 c	9.07 d	4.26 b	4.97 b
OM_1	219.30 a	253.20 a	10.05 b	12.24 c	4.60 ab	4.93 b
OM_2	220.31 a	256.60 a	11.19 b	14.81 b	5.21 ab	5.87 ab
OM_3	226.50 a	284.50 a	14.10 a	20.29 a	6.21 a	7.13 a
LSD $_{(0.05)}$	27.11	37.37	2.37	2.356	1.51	1.65
CV (%)	11.13	10.61	9.03	8.81	7.89	5.68

OM_0=control, OM_1= cow dung, OM_2= Poultry manure, OM_3= Vermicompost

Table 5.Effect of spacing on fresh weight of leaf per plant, dry weight of leaf per plant and dry matter content of lettuce

Treatment	Fresh weight of leaf per plant (g)		Dry weight per plant (g)		Dry matter content (%)	
	30DAT	40DAT	30DAT	40DAT	30DAT	40DAT
S_1	169.53 b	201.42 b	8.92 b	12.28 b	5.3 a	5.98 a
S_2	214.20 a	247.40 a	10.99 a	14.77 a	5.06 a	5.77 a
S_3	241.25 a	285.20 a	11.84 a	15.27 a	4.8 a	5.33 a
LSD $_{(0.05)}$	36.66	50.52	3.204	3.185	2.04	2.24
CV (%)	11.13	10.61	9.03	8.81	7.89	5.68

S_1=40 cm × 20 cm, S_2=40 cm ×25 cm S_3=40 cm × 30 cm

The interaction effects of organic manure and plant spacing were significant in respect of fresh weight of leaves per plant (Appendix-VI). The highest (260.20 g and 310.10 g at 30 and 40 DAT respectively) and the lowest (137.00 g and 144.90 g at 30 and 40 DAT respectively) fresh weight of leaves per plant were recorded from the treatment combination of OM_3S_3 and OM_0S_1 respectively. (Table 6)

4.7 Dry weight per plant (g)

Organic manure significantly influenced the dry weight per plant at 30 and 40 DAT (Appendix VI). The maximum dry weight per plant (14.10 g and 20.29 g at 30 and 40 DAT respectively) was recorded from OM_3 and the minimum dry weight (7.01g and 9.07 g at 30 and 40 DAT respectively) was recorded from OM_0 (Table 4).

The dry weight per plant was not significantly influenced by plant spacing (Appendix VI). Treatment S_3 produced maximum dry weight per plant (11.84 g and 15.27 g at 30 and 40 DAT respectively) and the minimum dry weight per plant (8.92 g and 12.28 g at 30 and 40 DAT respectively) was recorded in S_1 treatment (Table-5). It was revealed that with the increase of spacing dry weight per plant showed increasing trend because of less competition for nutrients among the plants during growth stages. Similar result was also observed by Sharma *et al.* (2001).

The interaction effects of organic manure and plant spacing were significant in respect of dry weight per plant (Appendix VI). The highest (16.13 g and 21.40 g at 30 and 40 DAT respectively) and the lowest (6.62 g and 7.10 g at 30 and 40

DAT respectively) dry weight per plant were obtained from the treatment combination OM_3S_3 and OM_0S_1 respectively. (Table 6)

Table 6.Combined effect of organic manure and spacing on fresh weight of leaf per plant and dry weight per plant and dry matter content of lettuce

Treatment	Fresh weight of leaf per plant (g)		Dry weight per plant (g)		Dry matter content (%)	
	30DAT	40DAT	30DAT	40DAT	30DAT	40DAT
OM_0S_1	137.00 f	144.90 g	6.62 h	7.10 f	4.80 bcde	4.90 bcd
OM_0S_2	166.10 e	188.82 f	7.09 gh	9.76 ef	4.27 ef	5.20 cde
OM_0S_3	197.80 d	219.10 e	7.33 gh	10.36 e	3.70 f	4.80 de
OM_1S_1	173.90 e	202.40 ef	8.30 fg	10.85 e	4.80 cdef	5.40 cde
OM_1S_2	229.30 c	252.60 d	10.57 de	12.79 d	4.60 def	5.10 cde
OM_1S_3	254.80 b	304.70 ab	11.29 cde	13.09 d	4.40 def	4.30 e
OM_2S_1	180.00 e	199.11 ef	9.78 ef	13.03 d	5.70 bc	6.60 b
OM_2S_2	228.70 c	264.00 cd	11.15 cde	15.19 c	4.90 bcde	5.80 bcd
OM_2S_3	252.21 b	306.80 ab	12.64 bc	16.21 c	5.00 bcde	5.30 cde
OM_3S_1	187.20 de	259.28 d	11.04 bcd	18.15 b	5.90 b	7.00 b
OM_3S_2	232.71 c	284.20 bc	15.13 ab	21.32 ab	6.50 a	7.50 a
OM_3S_3	260.20 a	310.11 a	16.13 a	21.40 a	6.20 ab	6.90 b
LSD $_{(0.05)}$	5.51	12.29	1.55	1.54	0.99	1.08
CV (%)	11.13	10.61	9.03	8.81	7.89	5.68

OM_0=control, OM_1= cow dung, OM_2= Poultry manure, OM_3= Vermicompost

S_1=40 cm × 20 cm, S_2=40 cm ×25 cm S_3=40 cm × 30 cm

4.8 Dry matter content (%)

Organic manure was not significantly influenced the dry matter content at 30 and 40 DAT (Appendix-VI). The maximum dry matter content (6.20 % and 7.13 % at 30 and 40 DAT respectively) was calculated from OM_3 and the minimum dry matter content (4.26 % and 4.97 % at 30 and 40 DAT respectively) was calculated from the OM_0 (Table 4).

The dry matter content was not significantly influenced by plant spacing (Appendix-VI). Treatment S_1 produced the maximum dry matter content (5.30 % and 5.98 % at 30 and 40 DAT respectively) and the minimum (4.80 and 5.33 % at 30 and 40 DAT respectively) dry matter content was recorded in S_3 treatment (Table 5).

The interaction effects of organic manure and plant spacing were significant in respect of dry matter content (Appendix-VI). The highest (6.50% and 7.5 % at 30 and 40 DAT respectively) and lowest (3.70% and 4.30 % at 30 and 40 DAT respectively) dry matter content were measured from the treatment combination OM_3S_2 and OM_0S_3 (Table-6) respectively.

4.9 Organoleptic test of different treatments of lettuce

Different parameters were used for organoleptic test. There was a panel of 25 judges of 25-45 years age group to evaluate it. All panel members were the teachers, students and staff of Sher-e-Bangla Agricultural University (SAU), Dhaka. Consumer acceptability of lettuce depends on appearance viz. color, size and taste viz. crispiness, sweetness, sourness, and bitterness. For observing

acceptability of lettuce a questionnaire and lettuce samples were served among the teachers, students and staff of the university.

Hossain (1996) conducted an experiment in amaranth by taking parameters of flavor taste, fibreness, and sweetness.

Khan (1993) also conducted the same type of experiment on long yard bean by taking the parameter of skin color, shape and flavor taste, sweetness (after boiling).

The results of the preferential from the panelist have been summarized in table 7. When the preferential comments were converted into acceptability score lettuce grown with OM_3S_2 treatment got the top score (2677) on the basis total acceptability ranking. While the lowest score (2351) was recorded in the treatment combination of OM_0S_1 treatment.

In respect of crispiness, OM_3S_2 scored top (633) among the treatments and the lowest score was 495 in OM_0S_2. In case of sweetness, OM_2S_2 scored top (522) and the lowest (379) was in the OM_0S_3 treatment. In respect of bitterness, highest score (554) was found in the treatment combination of treatment OM_0S_2 and the lowest score (492) was recorded in treatment OM_2S_3. In case of sourness, the highest score was (478) recorded in OM_3S_3 treatment and the lowest (375) was from treatment OM_2S_3. Considering appearance, the highest score was recorded (625) in OM_3S_2 treatment and the lowest (504) was in OM_0S_1 treatment combination.

Prince *et al*. (1990) conducted the experiment in lettuce taking the parameter relation between chemical and sensory properties of exotic salad crops colored lettuce and chicory and reported that red color lettuce had more bitterness than those of conventional lettuce and chicory.

Acceptability ranking may vary according to the nationality of the people member. The present finding gives an indication of the consumers' likings the characteristic of the lettuce.

Table 7.Combined effect of organic manure and spacing on organoleptic test of lettuce

Treatment Combination	Acceptability score					
	Crispiness	**Sweetness**	**Bitterness**	**Sourness**	**Appearance**	**Total**
OM_0S_1	531	421	503	392	504	2351
OM_0S_2	495	421	554	422	565	2457
OM_0S_3	550	379	524	426	575	2454
OM_1S_1	560	452	512	447	583	2554
OM_1S_2	541	483	518	467	543	2552
OM_1S_3	548	495	540	405	551	2539
OM_2S_1	590	478	535	426	554	2583
OM_2S_2	564	522	496	393	589	2564
OM_2S_3	543	462	492	375	606	2478
OM_3S_1	552	465	518	381	577	2493
OM_3S_2	633	488	507	424	625	2677
OM_3S_3	588	426	517	478	557	2566

Organoleptic test was done by following formula of Villared *et al.*, (1979).
Highly Acceptable (HA=7),
Moderately Acceptable (MA=5) and
Unacceptable (UA=2)

OM_0=control, OM_1= cow dung, OM_2= Poultry manure, OM_3= Vermicompost

S_1=40 cm × 20 cm, S_2=40 cm ×25 cm S_3=40 cm × 30 cm

4.10 Leaf yield per plot

A significant variation was obtained on fresh weight of leaves per plot due to the use of organic manure (Appendix-VII). The maximum fresh weight of leaves per plot (5.34 kg and 6.41 kg at 30 and 40 DAT respectively) was recorded from OM_3 treatment, while the minimum yield (3.93 kg and 4.32 kg at 30 and 40 DAT respectively) was from the control (OM_0) treatment (Table. 8).

The fresh weight of leaves per plot also differed significantly by spacing treatment (Table. 9 and Appendix-VII)). The maximum fresh weight of leaves per plot (5.14 kg and 5.94 kg at 30 and 40 DAT respectively) was obtained from S_2 treatment. The S_1 treatment showed the minimum fresh weight of leaves per plot (4.57 kg and 5.38 kg at 30 and 40 DAT respectively). It was revealed that with the increases of spacing individual weight per plant increased. So, in spite of less population, total yield per plot may higher due to higher individual plant weight and optimum spacing ensured the highest yield with maximum vegetative growth. Moniruzzaman (2006) reported that the highest yield (25.9 t/ha in 1999-2000 and 28.30 t/ha in 2000-2001 with an average of 27.10 t/ha) was observed in the spacing of 40×20 cm with mulch, which was statistically at per with the spacing of 40×30 cm. Similar result was also tested by sharma *et al*. (2001).

A significant interaction effect of organic manure and spacing was recorded on yield of leaves per plot (Appendix-VII). The maximum yield of leaves per plot (5.59 kg and 6.82 kg at 30 and 40 DAT respectively) was recorded from the treatment OM_3S_2 and the lowest (3.84 kg and 4.06 kg at 30 and 40 DAT respectively) was measured from OM_0S_1. (table 10)

Table 8.Effect of organic manure on yield per plot of lettuce

Treatment	Yield per plot (kg)	
	30DAT	40DAT
OM_0	3.93 c	4.32 c
OM_1	5.15 b	5.94 b
OM_2	4.95 b	6.02 ab
OM_3	5.34 a	6.41 a
LSD $_{(0.05)}$	0.64	0.84
CV (%)	9.44	9.09

OM_0=Control, OM_1 =Cow dung, OM_2 =poultry manure, OM_3 =Vermicompost

Table 9. Effect of spacing on yield per plot of lettuce

Treatment	Yield per plot (kg)	
	30DAT	40DAT
S_1	4.57 b	5.38 b
S_2	5.14 a	5.94 a
S_3	4.83 ab	5.70 a
LSD $_{(0.05)}$	0.35	0.22
CV (%)	9.44	9.09

S_1=40 cm × 20 cm S_2=40 × 25 cm S_3=40 cm × 30 cm

Table 10.Combined effect of organic manure and spacing on yield per plot of lettuce

Treatment	Yield per plot (kg)	
	30DAT	40DAT
OM_0S_1	3.84 e	4.06 e
OM_0S_2	3.99 e	4.53 e
OM_0S_3	3.96 e	4.38 e
OM_1S_1	4.87 cd	5.67 cd
OM_1S_2	5.50 ab	6.06 bcd
OM_1S_3	5.10 bcd	6.09 bcd
OM_2S_1	4.32 d	5.58 d
OM_2S_2	5.49 ab	6.34 ab
OM_2S_3	5.04 bcd	6.13 bcd
OM_3S_1	5.24 abc	6.21 bc
OM_3S_2	5.59 a	6.82 a
OM_3S_3	5.20 ab	6.20 bc
LSD $_{(0.05)}$	0.41	0.55
CV (%)	9.44	9.09

OM_0=Control

OM_1 =Cow dung

OM_2 =poultry manure

OM_3 =Vermicompost

S_1=40 x 20 cm

S_2=40 x 25 cm

S_3=40 x 30 cm

4.10 Gross yield of lettuce leaves (t/ha)

Gross yield of lettuce leaves was significantly influenced by the effect of organic manure (Table. 11 and Appendix-VII). The maximum yield (22.26 t/ha and 26.71 t/ha at 30 and 40 DAT respectively) was recorded from OM_3 treatment and the lowest (16.36 t/ha and 18.02 t/ha at 30 and 40 DAT respectively) was from the OM_0.

The yield of lettuce leaves per hectare was found to be statistically significant due to spacing (Table. 12 and Appendix-VII)). The highest gross yield(21.42 t/ha and 24.74 t/ha at 30 and 40 DAT respectively) was obtained from S_2 and the lowest (19.03 t/ha and 22.40 t/ha at 30 and 40 DAT respectively) was from S_1. It was revealed that with the increases of spacing individual weight per plant increased. So, in spite of less population, total yield per plot was higher due to higher individual plant weight and optimum spacing ensured the highest yield with maximum vegetative growth. Similar result was also obtained by sharma *et al.* (2001).

The interaction effect of organic manure and spacing on yield was significant. The combined effect of organic manure and spacing treatment was also significant on yield of lettuce leaves per hectare (Appendix VII). The highest yield of lettuce (23.27 t/ha and 28.42 t/ha at 30 and 40 DAT respectively) was measured from OM_3S_2 treatment and the lowest yield (15.98 t/ha and 16.90 t/ha at 30 and 40 DAT respectively) was in OM_0S_1 .(table 13)

Table 11. Effect of organic manure on yield of lettuce

Treatment	Gross Yield (t/ha)	
	30DAT	40DAT
OM_0	16.36 c	18.02 c
OM_1	21.48 a	24.76 b
OM_2	20.61 b	25.07 b
OM_3	22.26 a	26.71 a
LSD $_{(0.05)}$	1.993	1.7
CV (%)	9.44	10.07

OM_0=Control

OM_1 =Cow dung

OM_2 =poultry manure

OM_3 =Vermicompost

Table 12. Effect of spacing on yield of lettuce

Treatment	Gross yield (t/ha)	
	30DAT	40DAT
S_1	19.03 b	22.4 b
S_2	21.42 a	24.74 a
S_3	20.10 ab	23.76 ab
LSD $_{(0.05)}$	1.523	2.298
CV (%)	9.44	10.07

S_1=40 cm × 20 cm

S_2=40 cm × 25 cm

S_3=40 cm ×30 cm

Table 13.Combined effect of organic manure and spacing on yield of lettuce

Treatment	Gross yield (t/ha)	
	30DAT	40DAT
OM_0S_1	15.98 f	16.90 f
OM_0S_2	16.61 f	18.88 e
OM_0S_3	16.48 f	18.26 e
OM_1S_1	20.28 d	23.62 d
OM_1S_2	22.93 a	25.26 c
OM_1S_3	21.23 bc	25.39 c
OM_2S_1	18.00 e	23.23 d
OM_2S_2	22.88 a	26.41 b
OM_2S_3	21.02 c	25.56 c
OM_3S_1	21.84 b	25.87 c
OM_3S_2	23.27 a	28.42 a
OM_3S_3	21.68 b	25.83 c
LSD $_{(0.05)}$	0.73	1.11
CV (%)	9.44	10.07

OM_0=Control

OM_1 =Cow dung

OM_2 =poultry manure

OM_3 =Vermicompost

S_1=40 × 20 cm

S_2=40×25 cm

S_3=40 × 30 cm

4.11 Marketable yield (t/ha) of lettuce leaves

Marketable yields of lettuce varied significantly due to different organic manure. The maximum marketable yield (21.43t/ha and 26.17 t/ha at 30 and 40 DAT respectively) was recorded from OM_3 treatment. The minimum yield (15.44 t/ha and 16.92 t/ha at 30 and 40 DAT respectively) in this respect was recorded from OM_0 treatment (Fig.11).

The marketable yield of lettuce leaves per hectare was found to be statistically significant due to spacing (Fig.11). The highest marketable yield (20.42 t/ha and 23.64 t/ha at 30 and 40 DAT respectively) was obtained from S_2 treatment and the lowest (18.24, 21.30 t/ha at 30 and 40 DAT respectively) in this regard was obtained from S_1 treatment.

A significant combined effect of organic manure and spacing was also recorded on marketable yield of lettuce leaves per hectare (Appendix III). The highest marketable yield of lettuce (22.02 t/ha and 27.32 t/ha at 30 and 40 DAT respectively) was obtained from OM_3S_2 treatment and the lowest (14.73 t/ha and 15.8 t/ha) was from the treatment combination of OM_0S_1 .(table 14)

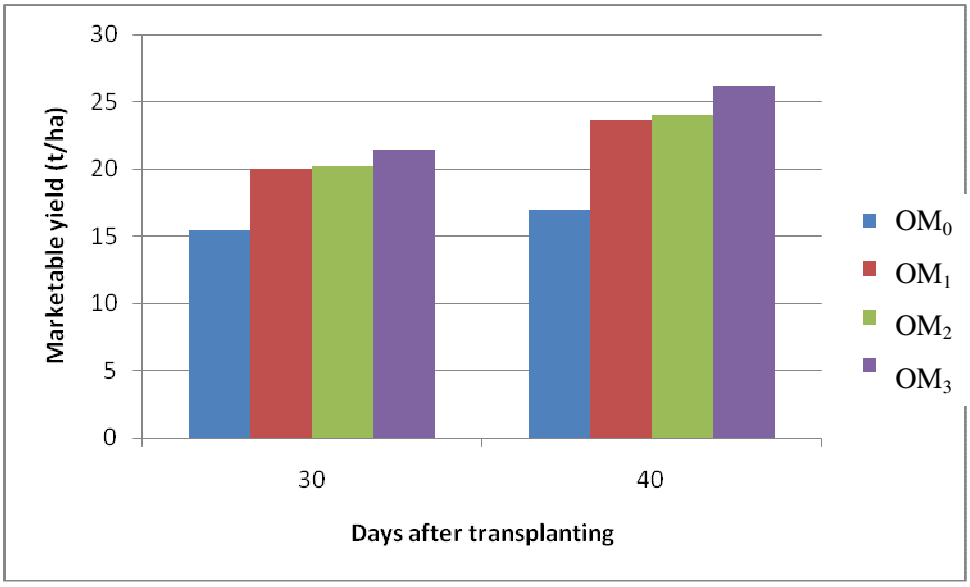

Fig. 11 Effect of organic manure on marketable yield at different days after transplanting

OM_0=Control
OM_1 =Cow dung
OM_2 =Poultry manure
OM_3 =Vermicompost

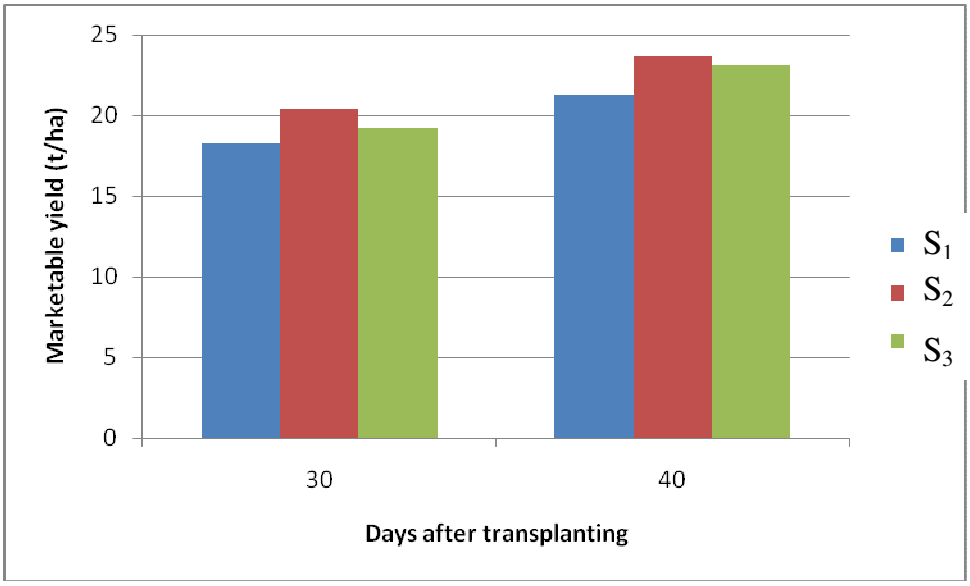

Fig. 12 Effect of spacing on marketable yield at different days after transplanting

S_1=40 cm × 20 cm
S_2=40 cm × 25 cm
S_3=40 cm ×30 cm

Table 14. Combined effect of organic manure and spacing on marketable yield of lettuce

Treatment	Marketable yield (t/ha)	
	30DAT	40DAT
OM_0S_1	14.73 e	15.8 f
OM_0S_2	15.78 e	17.78 e
OM_0S_3	15.23 e	17.16 ef
OM_1S_1	19.03 cd	22.52 d
OM_1S_2	21.68 ab	24.16 c
OM_1S_3	19.98 bcd	24.29 c
OM_2S_1	17.10 d	22.13 d
OM_2S_2	21.63 ab	25.31 b
OM_2S_3	19.77 bcd	24.46 c
OM_3S_1	20.59 abc	24.77 c
OM_3S_2	22.02 a	27.32 a
OM_3S_3	20.70 b	24.99 bc
LSD $_{(0.05)}$	1.724	1.522
CV (%)	8.44	7.07

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

S_1=40 cm × 20 cm

S_2=40 cm ×25 cm

S_3=40 cm × 30 cm

4.12 Cost and benefit analysis

The cost and return analysis were done and have been presented in table 14 and appendix VIII. Materials (1A), non materials (1B) and over head costs were recorded for all the treatments of unit plot and calculated on per hectare basis (Marketable yield) the price of lettuce leaves at the local market rate were considered.

The total cost of production ranges between Tk. 111225 and 88725 per hectare among the different treatment combinations. The variation was due to different cost of different types of manure. The highest cost of production Tk. 11225 per ha was involved in cow dung and vermicompost, while the lowest cost of production Tk. 88725 per ha was involved in the combination of no fertilizer and manure (Appendix IV). Gross return from the different treatment combinations ranged between Tk. 273181and Tk. 158025 per ha.

Among the different treatment combinations OM_3S_2 gave the highest return Tk. 167581 per ha while the lowest net return Tk. 69300 was obtained from the treatment combination OM_0S_1.

The benefit cost ratio (BCR) was found to be the highest (2.46) in the treatment combination OM_3S_2. The lowest BCR (1.78) was recorded from OM_0S_1. Thus it was apparent that OM_3S_2 treatment gave the highest marketable yield (27.32 t/ha) and the highest gross return (Tk. 273181).

Table 15.Cost and benefit of lettuce due to organic manure and spacing treatments

Treatment combinations	Marketable yield (t/ha) 40 DAT	Gross return (Tk./ha)	Total cost of production (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio (BCR)
OM_0S_1	15.80	158025	88725	69300	1.78
OM_0S_2	17.92	179218	88725	90492.8	2.01
OM_0S_3	17.16	171586	88725	82860.6	1.93
OM_1S_1	22.38	223783	111225	112558	2.02
OM_1S_2	24.16	241573	111225	130348	2.17
OM_1S_3	24.29	242891	111225	131666	2.18
OM_2S_1	22.12	221244	105600	115644	2.10
OM_2S_2	25.30	253027	105600	147427	2.40
OM_2S_3	24.05	240463	105600	134863	2.28
OM_3S_1	24.77	247657	111225	142057	2.23
OM_3S_2	27.32	273181	111225	167581	2.46
OM_3S_3	24.99	249863	111225	144263	2.25

Cow dung = 10 Tk./kg

Poultry manure= 15 Tk./kg

Vermicompost=20 Tk./kg

Price of lettuce @ 10 Tk./kg

OM_0=Control

OM_1 =Cow dung

OM_2 =Poultry manure

OM_3 =Vermicompost

S_1=40 cm x 20 cm

S_2=40 cm x 25 cm

S_3=40 cm x 30 cm

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from November 2011 to January 2012 to study the effect of organic manure and spacing on growth and yield of lattuce. In experiment, the treatment consisted of four organic manures viz. OM_0: on organic manure, OM_1: Cowdung, OM_2: Poultry manure, OM_3: Vermicompost and three spacing viz. S_1 (40 cm × 20 cm), S_2 (40 cm × 25 cm), S_3 (40 cm × 30 cm).

Two factorial experiments were laid out in the Randomized Complete Block Design (RCBD) with three replications. Whole experimental area 170 m^2 was first divided into three blocks. Then each block was divided into 12 unit plots those were total 36 (1.6 m × 1.5 m) unit plots. Seedlings were transplanted in the experimental plots on 10 th December, 2012. Healthy and uniform sized 30 days old seedlings were used as transplanting materials. Necessary intercultural operations were done as and when necessary. Data on different growth parameters and yield were recorded.

Results showed that a significant variation was recorded among the treatments in respect majority of the observed parameters. The collected data were statistically analyzed for evaluation of the treatment effect, using MSTAT statistical package program. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT).

The effect of organic manure demonstrated that, OM_3produced the tallest plant (18.13 cm and 20.26 cm at 30 and 40 DAT respectively). Significant variation in number of leaves was observed due to organic manure. The maximum number of leaves (15.51 and 18.76 at 30 and 40 DAT respectively) was counted from OM_3. The leaf area varied significantly due to the application of different organic manure. The maximum leaf area (319.20 cm^2 at 40 DAT) was recorded from OM_3. The results on effects of organic manure showed that different organic manure had significant effect on length of leaf at different DAT. OM_3 gave the maximum length of leaf (15.47 cm and 16.43 cm at 30 and 40 DAT respectively).

Vermicompost produced the widest (15.67 cm and 16.32 cm at 30 and 40 DAT respectively) leaf. Organic manure significantly influenced the fresh weight of leaves per plant. The maximum weight of fresh leaves per plant (226.5 g and 284.5 g at 30 and 40 DAT respectively) was recorded in the OM_3. The production of dry matter of leaves varied significantly due to the effect of different organic manure. The maximum dry weight of leaves (14.1 g and 20.29 g at 30 and 40 DAT respectively) was recorded from the OM_3. The maximum dry matter content (6.2 % and 7.13 % at 30 and 40 DAT respectively) was measured from OM_3. The results of different organic manure showed significant effect on yield of lettuce per plot and hectare. The maximum fresh weight of leaves per plot (5.34 kg and 6.41 kg at 30 and 40 DAT respectively) was recorded from OM_3. The maximum yield (22.26 t /ha and 26.71 t/ha at 30 and 40 DAT respectively) was recorded from OM_3. The

maximum marketable yield (21.43/ha and 26.17 t/ha at 30 and 40 DAT respectively) was obtained from OM_3.

The tallest plant (18.28 cm and 20.02 cm at 30 and 40 DAT respectively) was recorded from S_1. The maximum number of leaves per plant (14.75 and 18.72 at 30 and 40 DAT respectively) was counted from the spacing of S_3 .The leaf area was the highest irrespective of S_3 treatments being maximum (304.6 cm^2). Treatment S_3 resulted maximum length of leaf (15.67cm and 16.64 cm at 30 and 40 DAT respectively). Treatment S_3 produced maximum breadth of leaf (15.81 cm and 16.33 cm at 30 and 40 DAT respectively). The maximum fresh weight of leaves (241.25 kg and 285.20 kg at 30 and 40 DAT respectively) per plant was found at spacing S_3. The maximum dry weight of leaves (11.84g and 15.27 g at 30 and 40 DAT respectively) was obtained from S_3. Treatment S_2 produced maximum dry matter content (5.06 % and 5.77% at 30 and 40 DAT respectively). The maximum fresh weight of leaves per plot (5.14 kg and 5.94 kg at 30 and 40 DAT respectively) was obtained from S_2 treatment. The highest yield (21.42 t/ha and 24.74 t/ha at 30 and 40 DAT respectively) was recorded from S_2. The highest marketable yield (20.42 t/ha and 23.64 t/ha at 30 and 40 DAT respectively) was obtained from S_2 treatment.

Interaction effect of different organic manure and spacing had a significant variation on plant height. The tallest plant (21.43cm and 23.3 cm at 30 and 40 DAT respectively) was obtained from OM_3S_1 treatment. Interaction effect of different organic manure and spacing had a significant variation on number of leaves. The maximum number of leaves (16.67 and 20.53 at 30 and 40 DAT

respectively) was obtained from OM_3S_3 treatment. The maximum leaf area (405.8 cm^2) was measured from OM_3S_3. Interaction effect of different organic manure and spacing had a significant variation on length of leaf. The maximum length of leaf (16.27 cm and 17.43 cm at 30 and 40 DAT respectively) was obtained from OM_3S_3 treatment. The interaction effects of different organic manure and Spacing were found significant in respect of breadth of leaf. Numerically the highest breadth of leaf (17.20 cm and 18.23 cm at 30 and 40 DAT respectively) per plant was obtained from the treatment combination of OM_3S_3.

The interaction effects of different organic manure and spacing were significant in respect of fresh weight of leaves per plant. The highest fresh weight of leaves (260.2 g and 310.1g at 30 and 40 DAT respectively) per plant was found in the treatment combination OM_3S_3. The interaction effects of different organic manure and different spacing treatment were significantly influenced on the dry weight of leaves in lettuce. OM_3S_3 resulted in the highest dry weight of leaves (16.13g and 21.40 g at 30 and 40 DAT respectively) and the highest dry matter content also (6.5% and 7.5% at 30 and 40 DAT respectfully) was measured from OM_3S_2. OM_3S_2 treatment got the top score (2677) on the basis total acceptability ranking. While the lowest score (2351) was recorded in the treatment combination of OM_0S_1 treatment.

A significant interaction effect of organic manure and spacing was recorded on fresh weight of leaves per plot. The maximum fresh weight of leaves per plot (5.59 kg and 6.82 kg at 30 and 40 respectively) was recorded from the

treatment combination OM_3S_2. The highest gross yield of lettuce (23.27 t/ha and 28.42 t/ha at 30 and 40 DAT respectively) was calculated from OM_3S_2 treatment. The highest marketable yield of lettuce (22.02t/ha and 27.32 t/ha at 30 and 40 DAT respectively) was obtained from OM_3S_2 treatment.

The benefit cost ratio (BCR) was found to be the highest (2.46) in the treatment combination of OM_3S_2. The lowest BCR (1.78) was recorded from the combination OM_0S_1. Thus it was apparent that OM_3S_2 treatment resulted the highest marketable yield (27.32 t/ha), the highest gross return (Tk. 273181) and highest BCR (2.46), so it was considered to be the best combination treatment for getting height yield.

In this experiment, vermicompost was found more effective than the cow dung and poultry manure in respect to growth and yield contributing characters. In case of spacing, 40 cm x 25 cm spacing gave best result in respect of yield contributing characters than other two spacing. For combined effect vermicompost with 40 cm x 25 cm spacing showed better performance in respect to yield and yield contributing characters.

Following studies can be carried out by considering the present status of this experiment.

i. Doses of the organic fertilizer used in this study may be rearranged for specification.
ii. Further investigation may carry out in different agro ecological zones of Bangladesh.

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APPENDICES

Appendix I. Monthly air temperature, rainfall and relative humidity of the experimental site during the study period (November, 2011 to January, 2012)

Year	Month	Air temperature (^{0}C)			Rainfall** (mm)	* Relative humidity (%)
		Max.	Min.	Mean		
2011	November	28.6	20.0	24.3	34.4	76.0
	December	27.6	14.4	21.00	12.8	68
2012	January	24.4	12.5	18.45	7.7	67.00

* Monthly average

** Monthly total

Source: The Meteorological Department (Weather division) of Bangladesh, Agargoan, Dhaka

Appendix II : **Soil characteristics of horticulture farm of Sher-e-Bangla Agricultural University were analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm , SAU, Dhaka
AEZ	Modhupur 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

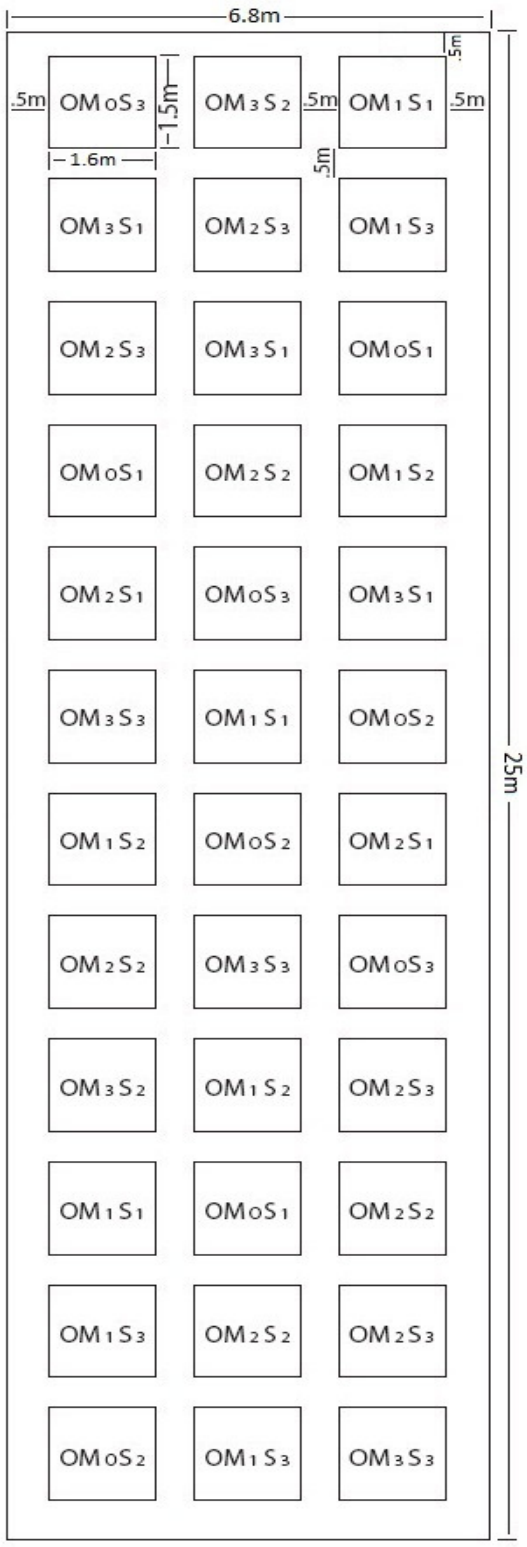
Source: SRDI

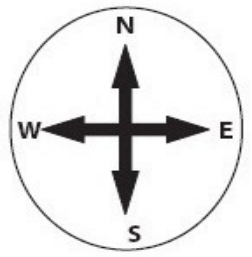
B. Physical and chemical properties of the initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
pH	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: SRDI

Appendix III. Layout and design of the experimental plot





Unit plot size:
1.6m x 1.5m
Total area= 170m^2

Factor A: Organic manure
OM0- Control
OM1- Cowdung
OM2- Poultry Manure
OM3- Vermicompost

Factor B: Spacing
S1- 40cm×20cm
S2-40cm×25cm
S3- 40cm×30cm

Figure: Layout of the Experimental Plot

Appendix IV. Analysis of variance of the data on plant height and number of leaves per plant of lettuce as influenced by organic manure and spacing

Source of Variance	Degrees of Freedom	Mean square			
		Plant height		No. leaf per plant	
		30DAT	40DAT	30DAT	40DAT
Replication	2	3.585	8.194	7.853	7.703
Factor A(Organic manure)	3	38.092*	34.318*	27.931*	26.2*
Factor B(Spacing)	2	36.765*	46.384*	15.565*	45.711*
AB	6	0.939*	1.486*	0.09*	0.862*
Error	22	0.371	0.508	0.271	0.48

* = Significant at 5% level of probability

Appendix V. Analysis of variance of the data on Leaf area, length of leaf and breath of leaf of lettuce as influenced by organic manure and spacing

Source of Variance	Degrees of Freedom	Mean square				
		Leaf Area	Length of leaf		Breath of leaf	
			30DAT	40DAT	30DAT	40DAT
Replication	2	546.75	4.572	5.006	2.757	5.493
Factor A(Organic manure)	3	9334.219*	5.367*	4.581*	12.882*	9.778*
Factor B (Spacing)	2	8055.724*	6.695*	7.443*	19.917*	15.403*
AB	6	4093.119*	0.912*	0.581*	0.469*	1.079*
Error	22	9.295	0.737	0.835	1.147	1.122

* = Significant at 5% level of probability
NS = Non Significant

Appendix VI. Analysis of variance of the data on fresh weight of leaves and dry matter content of leaves per plant of lettuce as influenced by organic manure and spacing

Source of Variance	Degrees of Freedom	Mean square			
		Fresh weight of leaves per plant		Dry matter content	
		30DAT	40DAT	30DAT	40DAT
Replication	2	102.967	2820.229	11.214	11.214
Factor A (Organic manure)	3	1933.594*	2446.227*	2.892*	26.357*
Factor B (Spacing)	2	44.094*	363.999*	3.977^{NS}	3.188^{NS}
AB	6	1091.596*	2899.576*	5.366*	14.602*
Error	22	14.283	17.366	0.832	0.832

* = Significant at 5% level of probability
NS = Non Significant

Appendix VII. Analysis of variance of the data on yield of lettuce as influenced by organic manure and spacing

Source of Variance	Degrees of Freedom	Mean square			
		Yield per plot		Yield (t/ha)	
		30DAT	40DAT	30DAT	40DAT
Replication	2	0.065	0.612	1.292	12
Factor A(Organic manure)	3	0.46*	0.835*	9.104*	16.563*
Factor B (Spacing)	2	2.404*	2.878*	47.475*	56.761*
AB	6	0.496*	0.959*	9.776*	18.894*
Error	22	0.053	0.18	1.05	3.552

* = Significant at 5% level of probability

Appendix VIII. Production cost of lettuce per hectare

(A)Material cost (Tk.)

Treatment combinations	Seed (kg/ha)	Fertilizer and manure			Sub total 1 (A)
		Cowdung	Poultry	Vermicompost	
OM_0S_1	8000	0	0	0	8000
OM_0S_2	8000	0	0		8000
OM_0S_3	8000	0	0	0	8000
OM_1S_1	8000	20000	0	0	28000
OM_1S_2	8000	20000	0	0	28000
OM_1S_3	8000	20000	0	0	28000
OM_2S_1	8000	0	15000	0	23000
OM_2S_2	8000	0	15000	0	23000
OM_2S_3	8000	0	15000	0	23000
OM_3S_1	8000	0	0	20000	28000
OM_3S_2	8000	0	0	20000	28000
OM_3S_3	8000	0	0	20000	28000

Appendix VIII. Contd.

(B) Non-material cost (Tk. / ha)

Treatment combination	Land preparation	Seed sowing and transplanting	Intercultural operation	Harvesting	Sub total	Total input cost 1 (A) + 1 (B)
OM_0S_1	12500	7200	8000	8500	36200	44200
OM_0S_2	12500	7200	8000	8500	36200	44200
OM_0S_3	12500	7200	8000	8500	36200	44200
OM_1S_1	12500	7200	8000	8500	36200	64200
OM_1S_2	12500	7200	8000	8500	36200	64200
OM_1S_3	12500	7200	8000	8500	36200	64200
OM_2S_1	12500	7200	8000	8500	36200	59200
OM_2S_2	12500	7200	8000	8500	36200	59200
OM_2S_3	12500	7200	8000	8500	36200	59200
OM_3S_1	12500	7200	8000	8500	36200	64200
OM_3S_2	12500	7200	8000	8500	36200	64200
OM_3S_3	12500	7200	8000	8500	36200	64200

Appendix VIII. Contd.

(C) Overhead cost and total cost of production (Tk.)

Treatment combinations	Cost of lease of land	Miscellaneous cost (5% of input cost)	Interest on running capital for 6 months (15% of the total input cost)	Total	Total cost of production (input cost + interest on running capital, Tk/ha)
OM_0S_1	39000	2210	3315	44525	88725
OM_0S_2	39000	2210	3315	44525	88725
OM_0S_3	39000	2210	3315	44525	88725
OM_1S_1	39000	3210	4815	47025	111225
OM_1S_2	39000	3210	4815	47025	111225
OM_1S_3	39000	3210	4815	47025	111225
OM_2S_1	39000	2960	4440	46400	105600
OM_2S_2	39000	2960	4440	46400	105600
OM_2S_3	39000	2960	4440	46400	105600
OM_3S_1	39000	2960	4440	46400	111225
OM_3S_2	39000	2960	4440	46400	111225
OM_3S_3	39000	2960	4440	46400	111225

Appendix IX. Questionnaire on taste and visual acceptability of lettuce.

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

Sample	Crispiness			Taste and Smell									Appearance		
	HA	MA	UA	Sweetness			Bitterness			Sourness			HA	MA	UA
				HA	MA	UA	HA	MA	UA	HA	MA	UA			
OM_0S_1															
OM_0S_2															
OM_0S_3															
OM_1S_1															
OM_1S_2															
OM_1S_3															
OM_2S_1															
OM_2S_2															
OM_2S_3															
OM_3S_1															
OM_3S_2															
OM_3S_3															

Note:
HA= Highly acceptable (7)
MA= Moderately acceptable (5)
UA= Unacceptable (2)

Name and signature of judge**:** …….. ……and…….
Address**:** ……
Age**:** ……Profession**:** ……
Date**:** …….