EFFECT OF SEEDLING AGE AND NITROGEN ON GROWTH AND YIELD OF LETTUCE

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CERTIFICATE

*This is to certify that the thesis entitled '**Effect of Seedling Age and Nitrogen on Growth and Yield of Lettuce**' 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 **Hemel Sarkar**, Registration No. **11-04365** 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.

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during November 2016 to January 2017. The experiment consisted of two factors, such as Factor A: Seedling age (3 levels) as- S_1: Transplanting of 15 days old seedlings, S_2: Transplanting of 20 days old seedlings, S_3: Transplanting of 25 days old seedlings and Factor B: Levels of nitrogen (4 levels) as N_0: 0 kg N/ha (control), N_1: 80 kg N/ha, N_2: 90 kg N/ha and N_3: 100 kg N/ha. The two factorial experiment was laid out in Randomized Complete Block Design with three replications. Seedling age and levels of nitrogen influenced significantly on most of the parameters. In case of seedling age, the highest yield (13.50 t/ha) was found from S_2 and the lowest yield (12.30 t/ha) was found from S_3. For levels of nitrogen, N_2 performed the highest yield (13.68 t/ha) and the lowest (11.54 t/ha) was from N_0. For combined effect, the highest yield (14.54 t/ha) was obtained from S_2N_2 and the lowest yield (10.88 t/ha) from S_3N_0. The highest benefit cost ratio (2.16) was noted from the combination of S_2N_2 and the lowest benefit cost ratio (1.63) from S_3N_0. So, transplanting of 20 days old seedlings with 90 kg N/ha can be used for letuce 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 Transplanting	DAT
and others	*et al.*
and other	etc
Food and Agriculture Organization	FAO
Journal	J.
Least Significance Difference	LSD
Muriate of Potash	MoP
Parts per million	ppm
Sher-e-Bangla Agricultural University	SAU
Soil Resources Development Institute	SRDI
Triple Superphosphate	TSP

CHAPTER I

INTRODUCTION

Lettuce (*Lactuca sativa* L.) belongs to the family Compositae is the most popular crop among the salad vegetables (Awaad *et al*., 2016). It produces a short stem early in the season, a cluster of leaves varying considerably in shape, character and colour in different varieties. Lettuce is mainly a cold loving crop and the best temperature range for lettuce cultivation is 18^0C to 25^0C and the night temperature is 10^0C to 15^0C (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 but rests largely upon 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). 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). It has not as yet been cultivated in large scale, but its importance is gradually increasing (Chohura and Eugeniusz, 2009).

Lettuce is a newly introduced vegetable 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). Among various factors responsible for higher yield, production technology and supply of nutrient play vital role in the production and quality of lettuce. Suitable production technology is an important factor for attaining highest yield of lettuce (Orzolek, 2004). Deficiency of soil nutrient is now considered as one of the major constraints to successful upland 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 (Singh *et al*., 1976; Thompson and Kelly, 1988). Its production can be increased by adopting improved management practices. The cultivation of lettuce requires

proper supply of plant nutrient. This requirement can be provided by applying optimum doses of fertilizers.

Seedling age greatly influences the vegetative development of the crop, vegetative mass, biochemical composition, output of standard transplants, plant growth after transplantation and resistance to several critical conditions (Henare and Ravanloo, 2008). Seedlings of an older age are more tolerant to stress and produce fruits earlier, while young transplants are less tolerant (Vavrina, 1998). Seedlings transplanted at their older age develop reproductive phase quicker than vegetative phase (Orzolek, 2004). To encourage quick plant growth and early harvest, the technique of transplanting lettuce seedlings may be applied and optimum seedling age for better plant establishment could enhance productivity (Handley and Hutton, 2003). The effect of seedling age on yield is an issue often introduced by the growers to maximize production potential (Holcomb, 1994). Optimum seedlings age determine early production as well as higher yield of crop which favors the farmers to get higher market price.

Chemical fertilizers have made substantial contributions to increased crop yields and food nutrition (Fageria, 2009 and Wang *et al*., 2008). Generally, chemical fertilizers increase the growth and yield but excessive application of chemical fertilizers in crop production causes health hazards, create problem to the environment including the pollution of soil, air and water. Application of fertilizer in appropriate time, appropriate dose and proper method is the pre-requisite of crop cultivation (Islam, 2003). However, excessive fertilizer application can have adverse environmental effects on water quality, leaching, and runoff (Heckman, 2007, Heckman *et al*., 2003 and Manotti *et al*., 1994). Therefore, it is important to determine fertilizer application rates that maximize yields while minimizing environmental pollution (Fontes *et al*., 1997 and Heckman *et al*., 2003). Nitrogen fertilizers positively affects plant growth, fresh and dry plant weights, plant diameter and the number of total marketable leaves, whereas the yield and other yield components remained unaffected by N sources (Bozkurt *et al*., 2009, Gulser *et al*., 2010). Some vegetable crops, especially

those with short lifespan such as lettuce, have the ability to accumulate proportionally nitrate.

The leaf lettuce, like other species in the group of leafy vegetables, has a short growing period and is marked by a fairly high tendency towards the accumulation of nitrates, which in effect can lead to the lowering of its quality (Rozek, 2000). This undesirable phenomenon can be controlled by efficient fertilization with nitrogen, taking into account the nutritional requirements of the plants and the mineral nitrogen content in the soil. The important things in the cultivation of lettuce are the size of the nitrogen dose, the type of the nitrogenous fertilizer, and also the time and technique of application (Kowalska *et al*., 2006). Application of nitrogen fertilizer in appropriate time, appropriate dose and proper method with other management practices especially seedling age is the pre-requisite lettuce cultivation. But the information related to optimum seedling age and appropriate doses of nitrogen are not adequate and conclusive.

Considering the above mentioned context and situation, the present experiment was conducted with the following objectives:

- To find out the suitable seedling age for growth and higher yield of lettuce;
- To ascertain the different levels of nitrogen on plant growth and yield of lettuce.

CHAPTER II

REVIEW OF LITERATURE

Lettuce is one of the most important and popular salad vegetable in Bangladesh and as well as many countries of the world. The crop has conventional less concentration by the researchers on various aspects because it is newly introduced crop. For that a very few studies on the related to growth and yield of lettuce have been carried out in our country as well as many other countries of the world in different aspects. So the research work so far done in Bangladesh and is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the seedling age and nitrogen so far been done at home and abroad on this crop have been reviewed in this chapter under the following headings-

2.1 Effect of seedling age on growth and yield

Sarker *et al*. (2017) conducted an experiment in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October, 2010 to March, 2011 to find out the effect of seedling age on the growth and yield of tomato. Three different seedling ages such as S_1= 20 days, S_2= 25 days and S_3= 30 days old seedling were used. The experiment was laid out in RCBD with three replications. Highest yield (87.57 t/ha) was obtained from (S_3= 30 days old seedling) while the lowest yield (59.21 t/ha) was obtained from (S_1= 20 days old seedling).

Staugaitis and Viskelis (2005) carried out an experiment to evaluate the changes of the macro-element amounts and the influence of seedling age in the heads and plant residues of Chinese cabbage. Chinese cabbage hybrid Manoko F_1 was planted in the last ten days of July with different seedling age with optimum fertilizer doses. The soil texture was loamy sand on light loam. Findings revealed that the crop planted with 30 days old seedling produced 44 t/ha yields, total plant mass being 76.6 t/ha.

Rajbir *et al*. (2005) conducted a field experiment to find out the effect of transplanting time (10 and 30 December and 20 January) on the growth and yield of tomato cultivar Rupali. Early planting (10 December) resulted in the highest vegetative growth, yield attributes, early and total fruit yield, whereas the lowest values for the parameters measured were lowest with 20 January transplanting. The highest net returns (Rs. 52,700/ha) was recorded with transplanting on 10 December.

Csizinszky and Schuster (2005) conducted an experiment with residual effects of N (0, 50, 100 and 150 kg/ha) and organic manure (control, rice straw litter or farmyard manure (FYM)), supplied to rice seedlings transplanted on 15 and 30 June, on the yield, yield components. Results revealed that transplanting dates of had no significant residual effects on the yield, yield components and nutrient uptake. Seedling transplanted in 15 June gave the highest yield considered the other transplanted dated.

Zhao and Chen (2004) conducted to determine the effect of nutritive area on the growth of tomato seedlings grown in plug trays. They recommended to transplant middle-aged seedlings by evaluating the effects of seedling age and plug tray nursery area on yield.

Aparajita (2002) reported that the age (3, 4, 5 and 6-week-old) of the seedlings of tomato cv. Pusa Ruby and augergines cv. Pusa Purple had significant effect on the yield contributing characters and yield of tomato.

Choi *et al*. (2002) reported that the effects of seedling containers and seedling ages on the growth and yield of tomato plants were examined to establish the criteria for appropriate seedling production methods in the summer season. The quality of seedlings was better when seedlings were grown in polyethylene pots than in 72-cell plug trays. Seedling quality was better with increasing the growth duration in black polyethylene pots, whereas growth durations did not affect seedling quality in plug trays. Fruits matured earlier with pot-grown seedlings

for a long duration than with plug tray-grown seedlings for a short duration. The yields of tomato during the first two months were significantly higher in pot-nursed seedlings than the plug tray-nursed seedlings. Also, the total yield of tomato during the four month period was highest in pot-nursed seedlings. In pot-grown seedlings, there were no yield differences between 35 and 45 days old seedlings during the first two months of harvest, while the yields of 25 days old seedlings were much lower than the older seedlings (35 and 45 days old). Seedling ages had no effect on the cumulative yield for 3 months after the first harvest. With plug tray-grown transplants, the cumulative yield for the initial 3 months was highest in plants grown for 35 days in the nursery, followed by 25 days and 45 days. However, there were no significant differences among seedling ages in the total yield.

Okano *et al*. (2000) reported the effects of seedling age at planting on the quality of nursery plants, on plant from after planting and on growth rate and fruit yield. The younger the seedling at planting, the faster the plant grew after planting. When seedlings were raised for >35 days, growth was considerably retarded. Dry weight of roots and stems at harvest were higher when tomatoes were planted at a younger age. However, leaf dry weight, total leaf area and fruit yield were highest in the 25 and 35 days old seedling plots. Total leaf area per plant was positively correlated with fruit yield.

Cerne *et al*. (2000) conducted an experiment and reported that two softleaved cultivars (Atrakcija and Meraviglia delle Quattro Stagioni) gave the same yield but 18 days earlier at transplanting than at direct sowing. These two cultivars had lower yield than the crisp-leaved lettuce cultivars Ljubljanska Ledenka and Great Lakes at transplanting and at direct sowing. At transplanting cv. Ljubljanska Ledenka and cv. Great Lakes gave the yield 19 days earlier in comparison with the direct sowing. Transplanted soft-leaved lettuce developed the heads 28 days earlier than directly-sown crisp-leaved lettuce.

2.2 Effect of nitrogen on growth and yield

Hasan *et al*. (2017) conducted an experiment in the Research Field of Sher-e-Bangla Agricultural University, Dhaka to determine the optimum level of nitrogen fertilizer and proper plant spacing for better growth and yield of lettuce. The experiment consisted of two factors. Factor A: Nitrogen (4 levels) N_0: 0 (Control); N_1: 50; N_2: 100 and N_3: 150 kg/ha respectively; and Factor B: Plant spacing (3 levels), S_1: 40 cm × 20 cm, S_2: 40 cm × 25 cm; S_3: 40 cm × 30 cm. In case of nitrogen the highest yield (29.99 t/ha) was recorded from N_3 and lowest (18.65 t/ha) from N_0. The highest BCR value (3.88) was recorded from N_3S_2 and lowest (2.1) from N_0S_1.

Mhamdi *et al*. (2014) carried out an experiment to study the effect of nitrogen fertilizer level on growth and nitrate accumulation was studied in six lettuce cultivars (*Lactuca sativa* L.) and three nitrogen levels: 0, 120 and 240 Kg/ha was applied. 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. The highest nitrate concentration was recorded in external leaves whereas the lowest concentration was recorded in the central leaves for all cultivars. Furthermore, nitrate distribution and chlorophyll fluorescence on the leaves are closely related. This study revealed also correlation between root nitrate concentration, chlorophyll fluorescence and sugar content for all cultivars. This correlation depended on nitrogen fertilization level and the cultivar used.

Chohura and Eugeniusz (2009) conducted two field experiments with leaf lettuce and each of them was set up in a random sub-block design in 3 replications and a two-factorial system. The first factor represented different nitrogen doses that were used to obtain the required N level in the soil prior to planting the seedlings, the levels being: 50, 100 and 150 mg $N \cdot dm^{-3}$. The second factor

incorporated 4 nitrogenous fertilizers which were different in terms of chemical composition, and, more importantly, contained different nitrogen forms for introduction to the soil: ammonium nitrate 34% N-[NH_4NO_3], calcium nitrate 15.5% N-[$Ca(NO_3)_2 \times H_2O$ + NH_4NO_3], ammonium sulphate 20.0% N-[$(NH_4)_2SO_4$], and ENTEC 26% N-[NH_4NO_3 + $(NH_4)_2SO_4$ + 0.8% DMPP]. The best sources of nitrogen for the lettuce plants were the fertilizers ENTEC 26 and ammonium nitrate, which in contrast to calcium nitrate and ammonium sulphate made it possible to obtain significantly higher yields of lettuce. Irrespective of the kind of the nitrogenous fertilizer used, increasing the concentration of nitrogen in the soil from 50 mg $N \cdot dm^{-3}$ to 100 mg $N \cdot dm^{-3}$ resulted in a significant increase in the marketable yield of lettuce. At 150 mg $N \cdot dm^{-3}$ this yield remained at a level similar to that at 100 mg $N \cdot dm^{-3}$. The use of gradually higher doses of nitrogen resulted in a reduced dry weight content and lower levels of total and reducing sugars in lettuce leaves. With respect to yield size and quality, the recommended concentration of nitrogen in the soil for leaf lettuce should not exceed 100 mg $N \cdot dm^{-3}$.

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. Results indicated that different levels of nitrogen fertilizer on all growth characteristics were significant at 1% level of probability. Increased plant length, fresh and dry weights of leaves, leaf area and number of leaves and yield were shown upto 120 kg N/ha. Nitrogen fertilizer caused head formation to accelerate and delayed the bolting date of lettuce. The highest yield was obtained with 120 kg/ha treatment by ‘Pich Ahwazi’.

Parente *et al.* (2006) carried out an experiment to study the production and accumulation of nitrate by new cultivars of lettuce in response to nitrogen doses

applied to the soil. Two field trials were carried out and the soil had received 30 and 64 kg/ha of N, respectively, for the two trials as a pre-transplanting treatment. 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 application of nitrogen by fertilization increased yield compared with the unfertilized control but with no difference between doses and rates of fertilizer application.

Mahmoudi (2005) conducted an experiment on lettuce and found that by increasing the rate of nitrogen fertilizer to 300 kg/ha increased plant height, number of leaves, yield and dry matter of lettuce but between 100 and 200 kg N/ha was not significantly different. However, the yield response of lettuce to increasing N rate varies with different environmental variables, including weather, soil type, fertility, moisture, seasons and cultivar. This study aimed to evaluate the effect of different nitrogen levels applied as urea on the growth and productivity of two cultivars of lettuce, which can help to predict the optimal N fertilizer requirement and to improve the practice of lettuce production.

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. The maximum growth was observed in the treatment using 283 mg of N/pot. The use of higher rates did not increase plant growth but raised nitrate accumulation in shoot organs.

Liao-YuLin *et al.* (2005) carried out an experiment to investigate the effects of N rates on the yield and quality and N use efficiency of lettuce using 15N trace technique in pot experiments. Results showed that the correlation between N rates and yield followed a regression equation, which indicated that adequate N rates could improve quality, reduce N loss and increase N use efficiency.

Troyanos *et al.* (2004) carried out an experiment to know the effect of the application rate of nitrogen fertilizer on yield and nitrogen concentration of lettuce grown in a commercial vegetable field. Results showed that the optimum nitrogen application rate was 140 kg/ha. The optimum total nitrogen concentration in the above ground dried plant material was 3% (DW).

Pascale *et al.* (2004) carried out a study on problems of growing lettuce organically, while meeting the requirements for EEC regulations 194/97 and 864/99 concerning permissible nitrate levels, are discussed in 1999 in Italy with lettuce (cultivars Ilona and Batavia), grown in tunnels. N fertilizer was applied at rates of 0, 100, 200 and 300 kg/ha, using fertilization. The highest rate increased yields by 55% (compared to the unfertilized control) and also increased water content.

Tittonell *et al*. (2003) carried out an experiment and found that lettuce showed that increasing nitrogen fertilizer from 0 to 150 kg/ha increased the plant height, leaf number, fresh weight and dry weight of the crop.

Kavak *et al.* (2003) conducted a field experiment to determine the effects of different nitrogen sources on yield, quality, mineral, nitrate and nitrite contents in head lettuce. N fertilizer was applied at 0, 5, 10, 15, and 20 kg/da as calcium nitrate and ammonium sulfate. Head weight, head diameter and height, number of discarded leaves, marketable head weight, number of leaves in marketable head, and total yield were determined. Calcium nitrate had a significant effect on head weight, head diameter, height, marketable head weight, and yield. Calcium nitrate at 15 kg N/da showed the highest yield (3531.4 kg/da). Moreover, ammonium sulfate had significant effect on head weight, head diameter, number of discarded leaves, number of leaves in marketable head, marketable head weight, and yield. Ammonium sulfate at 20 kg N/da showed the highest yield (3480.7 kg/da).

Rincon *et al.* (2002) investigated the effect of N (25, 50, 100, 150 and 200 kg/ha), applied in fertilization, on the yield and nitrate content of iceberg lettuce in Murcia, Spain. Crop yield increased with N levels of up to 100 kg/ha, obtaining green biomass of 53.4 t/ha and commercial lettuce heads of 33.1 t/ha. Biomass and yield index decreased with N at 150 and 200 kg/ha. The nitrate content in the soil solution increased with the 150 and 200 kg N/ha treatments, and decreased with the 25 and 50 kg N/ha treatments. Nitrate concentration remained uniform during the growth cycle when 100 kg N/ha was applied, and the availability of nitrate was balanced with the absorption by the plant.

Marsic and Osvald (2002) conducted an experiment with lettuce plants cv. Vanity were grown aeroponically using four different amounts of nitrogen (12, 8 and 4 mM/litre) in nutrient solutions. Differences among averages of fresh shoot weights were statistically significant in all three experiments. In the first experiment, the maximum final fresh weight average was 999.0 g in treatment 8 mM. In the second experiment the largest amount of nitrogen 12 mM NO_3-N significantly ($p<0.05$) increased the fresh shoot weight of lettuce plants. The low level of nitrate in the nutrient solution (4 mM NO_3-N) significantly ($p<0.05$) increased the fresh weight of the final roots regarding the level of nitrate in standard nutrient solution (12 mM NO_3-N).

Soundy and Cantliffe (2001) studied with 'South Bay' lettuce seedlings and these were fertilized in floating styrofoam flats in nutrient solutions containing N at 0, 15, 30, 45, or 60 mg/litre. Increasing N from 0 to 60 mg litre-1 resulted in an increase in transplant shoot and root mass. The increase in shoot mass was much greater than for root mass in response to N rate and resulted in lower values for root: shoot ratios.

Grazia *et al.* (2001) evaluated the effect of light radiation and temperature on the growth patterns of a leafy lettuce cultivar and their interaction with fertilizer application through trials which combined three shade levels (65, 35 and 0%) with three fertilizer application rates (0, 75 and 150 kg N/ha). The results

showed that radiation level was the most important factor controlling growth in lettuce, whereas the effect of N fertilizer application was only observed in those treatments in which light intensity was not a limiting factor. Results indicated that N fertilizer application rates higher than 75 kg N/ha do not provide any significant benefit to leafy lettuce crops under open field conditions neither in winter nor in spring sowing dates.

Rehman *et al.* (2001) studied the effect of sowing dates and nitrogen levels (0, 20, 40, 60 and 80 kg/ha) on the leaf yield of lettuce cv. Crinkle, an experiment was conducted at Horticulture Farm, NWFP Agricultural University Peshawar, Pakistan. Nitrogen application @ 80 kg/ha significantly affected the number of leaves per plant, leaf area, leaves weight and yield per hectare. Maximum number of leaves per plant (14.88), leaf area (83.83 cm^2), leaves weight (17.19 g/plant) and yield/ha (13.6 ton) were noted in plots which received nitrogen at the rate of 80 kg/ha compared to other levels of nitrogen.

Tittonell *et al.* (2001) studied the effects of N fertilizer application (0, 75 and 150 kg/ha) and crop density on the postharvest quality of lettuce cv. Grand Rapids. The yield was not significantly affected by the application of 150 kg N/ha. N application decreased the dry matter but increased the nitrate N contents of the upper biomass of lettuce.

Above cited reviews revealed that seedling age and nitrogen fertilizer greatly influences the growth and as well as yield of lettuce. The literature revealed that the effects of nitrogen is more or less conclusive but seedling age of lettuce in transplanting time have not been yet studied well and have no definite conclusion for the production of lettuce under the agro climatic condition of Bangladesh even in the world.

CHAPTER III

MATERIALS AND METHODS

The study was conducted to find out the effect of seedling age and nitrogen on growth and yield of lettuce. The materials and methods that were used for conducting the experiment i.e. experimental period, location, soil and climate condition of experimental site, materials used for the experiment, design of the experiment, data collection procedure and data analysis methods have been 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 at the period of November 2016 to January 2017.

3.1.2 Experimental location

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

3.1.3 Soil characteristics

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 have been presented in Appendix II.

3.1.4 Climatic condition

The climate of study site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall of the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department and presented in Appendix III. During this period the maximum temperature (25.8^0C) was recorded in the month of November 2016, while the minimum temperature (12.4^0C) in January 2017. The highest humidity (78%) was recorded in November, 2016, whereas there was no rainfall during the study period.

3.2 Experimental details

3.2.1 Planting materials

The seeds of lettuce variety 'Green wave' were used as planting materials for this experiment.

3.2.2 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Seedling age (3 levels) as

i S_1: Transplanting of 15 days old seedlings

ii. S_2: Transplanting of 20 days old seedlings

iii. S_3: Transplanting of 25 days old seedlings

Factor B: Levels of nitrogen (4 levels) as

i. N_0: 0 kg N/ha (control)

ii. N_1: 80 kg N/ha

iii. N_2: 90 kg N/ha

iv. N_3: 100 kg N/ha

There were 12 (3 × 4) treatments combination such as S_1N_0, S_1N_1, S_1N_2, S_1N_3, S_2N_0, S_2N_1, S_2N_2, S_2N_3, S_3N_0, S_3N_1, S_3N_2 and S_3N_3.

3.2.3 Design and layout of the experiment

The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 352.80 m^2 with length 31.5 m and width 11.2 m which were divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination allotted at random. There were 36 unit plots and the size of each plot was 2.4 m × 2.0 m. The distance between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.2.4 Preparation of the main field

The selected plot of the experiment was opened in the 2nd week of November 2016 with a power tiller and left exposed to the sun for a week. Subsequently cross ploughing was done five times with a country plough followed by laddering to make the land suitable for transplanting the seedlings. All weeds, stubbles and residues were eliminated from the field. Finally, a good tilth was achieved. 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 soil inhibiting insects such as cutworm and mole cricket.

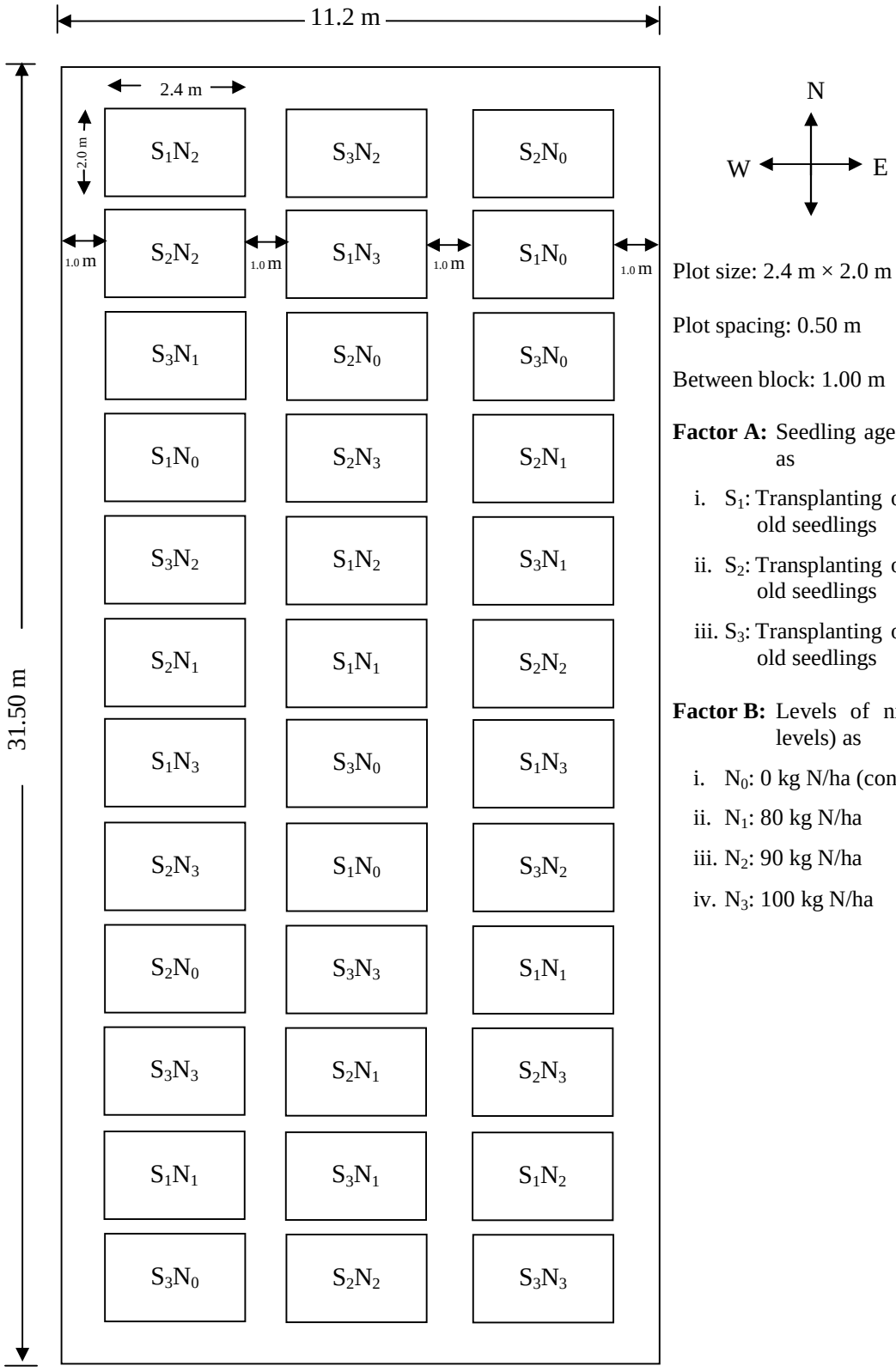
3.2.5 Application of manure and fertilizers

Urea, TSP and MoP were used as the fertilizer sources of nutrient elements N, P, and K, respectively. A standard dose of potassium and phosphorus @ 75 kg/ha were used in all treatments. Nitrogen were applied as per treatment. The following doses of manure and fertlizer were used for the present study.

Table 1. Dose and method of fertilizers application in lettuce field

Manure and Fertilizers	Dose/ha	Application (%) at DAT		
		Basal	20	40
Cowdung	10 tonnes	100	--	--
Urea	As per treatment	50	25	25
TSP	75 kg	100	--	--
MoP	75 kg	100	--	--

Source: BARI, 2017



Plot size: 2.4 m × 2.0 m

Plot spacing: 0.50 m

Between block: 1.00 m

Factor A: Seedling age (3 levels) as

i. S_1: Transplanting of 15 days old seedlings

ii. S_2: Transplanting of 20 days old seedlings

iii. S_3: Transplanting of 25 days old seedlings

Factor B: Levels of nitrogen (4 levels) as

i. N_0: 0 kg N/ha (control)

ii. N_1: 80 kg N/ha

iii. N_2: 90 kg N/ha

iv. N_3: 100 kg N/ha

Figure 1. Layout of the experimental plot

The total amount of cowdung and TSP and MoP and half urea was applied as basal dose at the time of land preparation. The rest urea was applied in two equal installments at 20 and 40 day after transplanting.

3.3 Growing of crops

3.3.1 Collection of seeds

The seed of lettuce variety 'Green wave' was collected from Siddique Bazar market, Dhaka.

3.3.2 Raising of seedlings

The seedlings of lettuce were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3 m × 1 m size seed bed. The soil of the seed bed was well ploughed with a spade and prepared into loose friable dried masses and to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. The seed bed was raised 15 cm from ground level. Germination of lettuce seed is a major problem in lettuce cultivation. Weeds, stubbles and dead roots of the previous crop were removed. The seedbed was dried in the sun to destroy the soil insect and protect the young seedlings from the attack of damping off disease. To control damping off disease Cupravit fungicide were applied. 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. 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 1st November, 2016. Complete germination of lettuce seeds took place within five days of seeds sowing.

3.3.3 Transplanting of seedlings

Healthy and uniform seedlings of 15, 20 and 25 days old seedlings as per treatment were transplanting in the experimental plots on November 20, 25 and 30, 2016. The seedlings were uploaded carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the

seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row was 40 cm and plant to plant was 25 cm. As a result there are 48 seedlings were accommodated in each plot according to the design of the plot size at 2.4 m × 2.0 m. The young transplanted seedlings were shaded by banana leaf sheath during day to protect them from scorching sunshine up to 5 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

3.3.4 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 broccoli seedlings.

3.3.4.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. 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. The transplants were given shading and watering for 5 days for their proper establishment.

3.3.4.2 Weeding

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

3.3.4.3 Earthing up

Earthing up was done at 15 and 25 days after transplanting and urea was used as top dressing on both sides of rows by taking the soil from the space between the rows by a small spade.

3.3.4.4 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seedling 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. Birds pest such as nightingales (common Bulbuli) were seen visiting the broccoli field very frequently. The nightingale visited the fields in the morning and afternoon. The birds found to puncture the newly initiated curd and were controlled by striking a kerosene tin of metallic container frequently during day time.

3.4 Harvesting

Harvesting of the lettuce was not possible on a certain or particular date because the growth of lettuce leaf was not uniform. Usually to estimate lettuce yield four harvesting were done at different growth stages and total 12 plants were harvested in each harvesting time. First harvesting was done at 15 days after transplanting (DAT). Second, third and fourth harvesting were done at 22, 29 and 36 DAT, respectively. Data of different yield contributing character have been recorded from the mean of five harvested plants which were selected at random based on best growth from each unit plot of every harvesting stage.

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 seedling age and levels of nitrogen of this experiment. Data on plant height, number of leaves/plant, leaf length, length breadth, fresh weight of plant, dry matter content in plant and plot yields of lettuce were collected at 15, 22, 29 and 36 days after transplanting (DAT).

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 15 days after transplanting (DAT) and continued upto 36 DAT 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 15 days after transplanting (DAT) and continued upto 36 DAT 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 15, 22, 29 and 36 DAT.

3.5.4 Leaf breadth

Leaf breadth was counted from five randomly selected plants at 7 days interval starting from 15 DAT and continued upto 36 DAT and their mean value was calculated and recorded.

3.5.5 Fresh weight of plant

Fresh weight of plant was recorded from five randomly selected plants in grams (g) with a beam balance and the mean data were recorded at 15, 22, 29 and 36 DAT.

3.5.6 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. The dry matter contents in plant were computed by simple calculation from the weight recorded by the following formula:

$$\text{Dry matter content in plant (\%)} = \frac{\text{Dry weight in plant}}{\text{Fresh weight in plant}} \times 100$$

3.5.7 Yield per plot

Yield of lettuce per plot was recorded as the whole plant in every harvest within a plot and was expressed in kilogram. Yield included weight of leaves at different harvesting time starting from 15 DAT and continued upto 36 DAT at 10 days interval.

3.5.8 Total yield per plot

Total yield of lettuce per plot was recorded by adding the yield of different harvesting time and it was included weight of leaves at different harvesting time and was expressed in kilogram.

3.5.9 Yield per hectare

Yield/hectare was measured by converted total yield per plot into yield per hectare and was expressed in ton. It included weight of leaves at different harvesting time from 15 DAT and continued upto 36 DAT at 7 days interval.

3.5.10 Total yield per hectare

Total yield of lettuce per hectare was recorded by adding the yield of different harvesting time and it was included weight of leaves at different harvesting time and was expressed in ton.

3.6 Statistical analysis

The data obtained for different characters were statistically analyzed to find out the significance of the difference for different seedling age and levels of nitrogen on growth and yield of lettuce. 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 seedling age and nitrogen for lettuce cultivation. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of lettuce that exists 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 IV

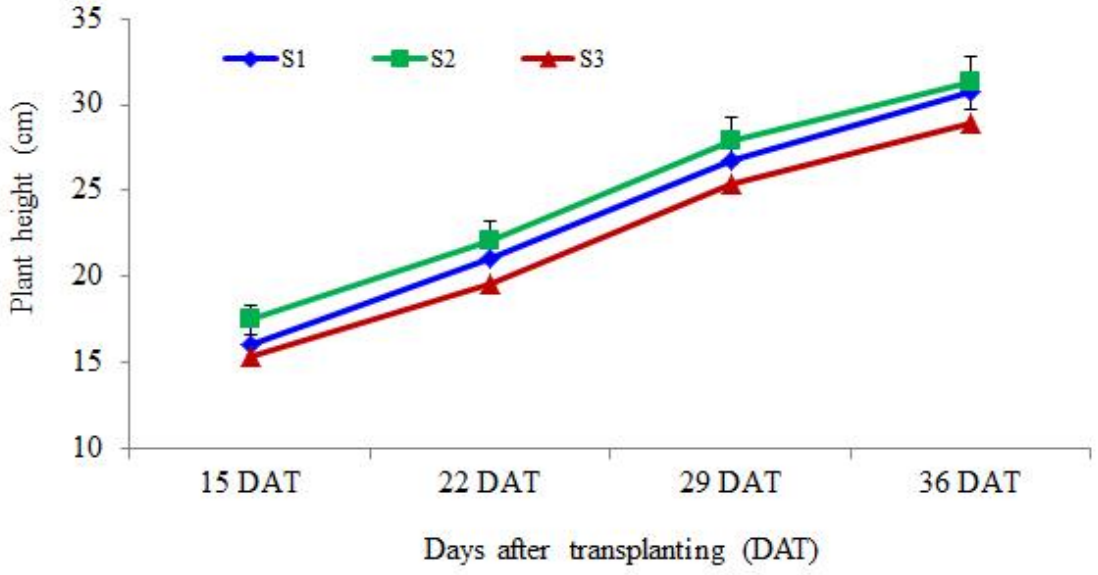
RESULTS AND DISCUSSION

The study was conducted to find out the effect of seedling age and nitrogen on growth and yield of lettuce. Analyses of variance (ANOVA) of the data on different growth and yield parameters of lettuce are presented in Appendix IV-XI. The results have been presented and discusses with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height of lettuce at 15, 22, 29 and 36 DAT (days after transplanting) showed statistically significant differences for different seedling age (Figure 2). At 15, 22, 29 and 36 DAT, the tallest plant (17.48, 22.09, 27.92 and 31.27 cm, respectively) was recorded from S_2 (transplanting of 20 days old seedlings) treatment which was statistically similar (16.05, 21.09, 26.72 and 30.70 cm, respectively) to S_1 (transplanting of 15 days old seedlings) treatment, whereas the shortest plant (15.30, 19.56, 25.43 and 28.90 cm, respectively) was observed from S_3 (transplanting of 25 days old seedlings) treatment. Rajbir *et al*. (2005) reported the highest vegetative growth, whereas the lowest values for the parameters measured late planting.

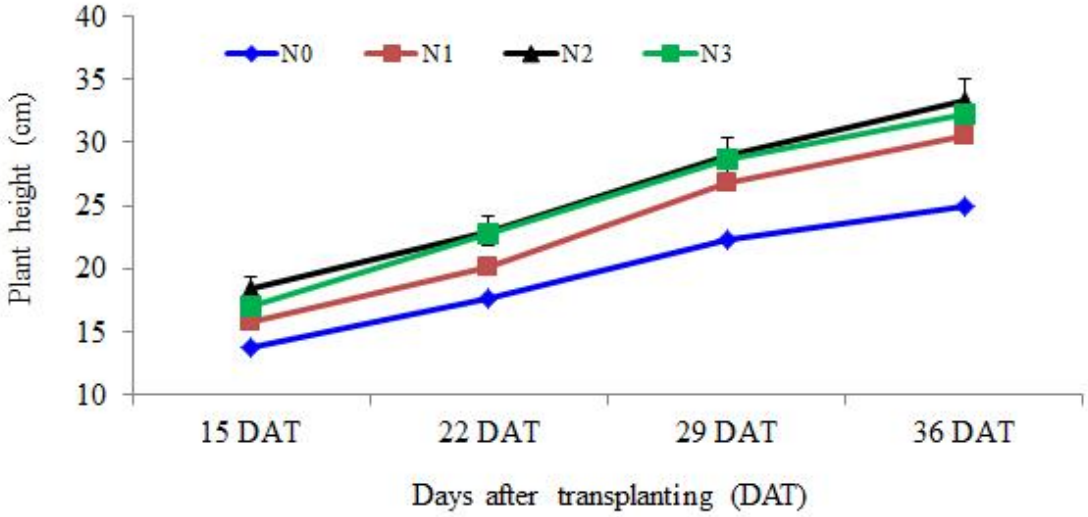
Statistically significant variation was recorded due to different levels of nitrogen in terms of plant height of lettuce at 15, 22, 29 and 36 DAT (Figure 3). At 15, 22, 29 and 36 DAT, the tallest plant (18.38, 22.96, 28.92 and 33.38 cm, respectively) was found from N_2 (90 kg N/ha) treatment which was statistically similar (17.08, 22.81, 28.63 and 32.30 cm, respectively) to N_3 (100 kg N/ha) and closely followed (15.83, 20.19, 26.83 and 30.53 cm, respectively) by N_1 (80 kg N/ha), while the shortest plant (13.82, 17.70, 22.38 and 24.95 cm, respectively) was recorded from N_0 (0 kg N/ha i.e. control condition) treatment. Tittonell *et al*. (2003) reported that increasing nitrogen fertilizer in lettuce from 0 to 150 kg/ha increased the plant height.



S_1: Transplanting of 15 days old seedlings S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

Figure 2. Effect of different seedling age on plant height of lettuce. (Vertical bars represent LSD value at 5% level of probability)



N_0: 0 kg N/ha (control) N_1: 80 kg N/ha

N_2: 90 kg N/ha N_3: 100 kg N/ha

Figure 3. Effect of different levels of nitrogen on plant height of lettuce. (Vertical bars represent LSD value at 5% level of probability)

Combined effect of different seedling age and levels of nitrogen showed statistically significant variation in terms of plant height of lettuce at 15, 22, 29 and 36 DAT (Table 2). At 15, 22, 29 and 36 DAT, the tallest plant (19.91, 24.49, 31.05 and 35.08 cm, respectively) was observed from S_2N_2 (transplanting of 20 days old seedlings with 90 kg N/ha), whereas the shortest plant (12.86, 15.61, 19.72 and 20.95 cm, respectively) was found from S_3N_0 (transplanting of 25 days old seedlings with 0 kg N/ha i.e. control condition) treatment combination.

4.2 Number of leaves per plant

Different seedling age showed statistically significant differences in terms of number of leaves per plant of lettuce at 15, 22, 29 and 36 DAT (Table 3). At 15, 22, 29 and 36 DAT, the maximum number of leaves per plant (15.28, 21.73, 24.35 and 26.04, respectively) was found from S_2 which was statistically similar (14.47, 21.20, 23.15 and 24.32, respectively) to S_1, while the minimum number (13.13, 19.57, 22.23 and 23.65, respectively) was recorded from S_3 treatment.

Number of leaves per plant of lettuce at 15, 22, 29 and 36 DAT varied significantly due to different levels of nitrogen in terms of (Table 3). At 15, 22, 29 and 36 DAT, the maximum number of leaves per plant (15.27, 23.22, 25.44 and 26.76, respectively) was recorded from N_2 treatment which was statistically similar (15.07, 22.31, 24.91 and 26.38, respectively) to N_3 and closely followed (14.36, 21.00, 23.29 and 24.63, respectively) by N_1 and the minimum number (12.49, 16.80, 19.33 and 20.91, respectively) was observed from N_0 treatment. Rehman *et al.* (2001) observed that nitrogen application @ 80 kg/ha produced the maximum number of leaves per plant (14.88).

Statistically significant variation was recorded due to the combined effect of different seedling age and levels of nitrogen in terms of number of leaves per plant of lettuce at 15, 22, 29 and 36 DAT (Table 4). At 15, 22, 29 and 36 DAT, the maximum number of leaves per plant (17.60, 24.00, 27.73 and 29.08, respectively) was observed from S_2N_2, while the minimum number (11.27, 14.13, 17.87 and 19.00, respectively) from S_3N_0 treatment combination.

Table 2. Combined effect of seedling age and levels nitrogen on plant height of lettuce at different days after transplanting (DAT)

Treatments	Plant height (cm) at			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	14.09 fg	19.31 c-e	25.19 de	28.06 d
S_1N_1	17.24 b-d	21.36 a-d	27.38 b-d	31.97 bc
S_1N_2	17.08 b-d	20.87 b-d	26.29 c-e	32.06 bc
S_1N_3	15.79 d-f	22.82 ab	28.03 bc	30.72 c
S_2N_0	14.50 e-g	18.20 d-f	22.24 fg	25.85 d
S_2N_1	16.58 c-e	22.38 a-c	28.90 a-c	31.83 bc
S_2N_2	19.91 a	24.49 a	31.05 a	35.08 a
S_2N_3	18.95 ab	23.31 ab	29.50 ab	32.34 bc
S_3N_0	12.86 g	15.61 f	19.72 g	20.95 e
S_3N_1	13.67 fg	16.83 ef	24.22 ef	27.79 d
S_3N_2	18.16 a-c	23.51 ab	29.41 ab	33.02 a-c
S_3N_3	16.49 c-e	22.30 a-c	28.38 a-c	33.84 ab
$LSD_{(0.05)}$	2.063	3.066	2.565	2.479
Level of significance	0.05	0.05	0.01	0.01
CV(%)	7.49	8.66	7.15	8.45

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 3. Effect of seedling age and nitrogen on number of leaves per plant of lettuce at different days after transplanting (DAT)

Treatments	Number of leaves per plant at			
	15 DAT	22 DAT	29 DAT	36 DAT
Seedling age				
S_1	14.47 a	21.20 a	23.15 ab	24.32 a
S_2	15.28 a	21.73 a	24.35 a	26.04 a
S_3	13.13 b	19.57 b	22.23 b	23.65 b
$LSD_{(0.05)}$	0.972	0.812	1.207	1.156
Level of significance	0.01	0.01	0.01	0.01
Levels of nitrogen				
N_0	12.49 c	16.80 c	19.33 c	20.91 c
N_1	14.36 b	21.00 b	23.29 b	24.63 b
N_2	15.27 a	23.22 a	25.44 a	26.76 a
N_3	15.07 a	22.31 a	24.91 a	26.38 a
$LSD_{(0.05)}$	1.122	0.938	1.393	1.335
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.03	6.92	7.13	8.33

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 4. Combined effect of seedling age and nitrogen on number of leaves per plant of lettuce at different days after transplanting (DAT)

Treatments	Number of leaves/plant at			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	14.27 c-e	18.07 f	20.87 de	22.33 ef
S_1N_1	13.80 d-f	20.80 cd	22.60 b-d	24.07 c-e
S_1N_2	13.80 d-f	23.27 ab	24.93 b	25.73 bc
S_1N_3	16.00 a-c	22.67 ab	24.20 bc	25.13 b-d
S_2N_0	11.93 fg	18.20 ef	19.27 ef	21.41 f
S_2N_1	15.00 b-d	22.40 a-c	25.20 b	26.81 ab
S_2N_2	17.60 a	24.00 a	27.73 a	29.08 a
S_2N_3	16.60 ab	22.33 a-c	25.20 b	26.88 ab
S_3N_0	11.27 g	14.13 g	17.87 f	19.00 g
S_3N_1	14.27 c-e	19.80 de	22.07 cd	23.00 d-f
S_3N_2	14.40 c-e	22.40 a-c	23.67 bc	25.47 b-d
S_3N_3	12.60 e-g	21.93 bc	25.33 ab	27.13 ab
$LSD_{(0.05)}$	1.943	1.624	2.413	2.312
Level of significance	0.01	0.05	0.05	0.05
CV(%)	8.03	6.92	7.31	8.33

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

4.3 Length of leaf

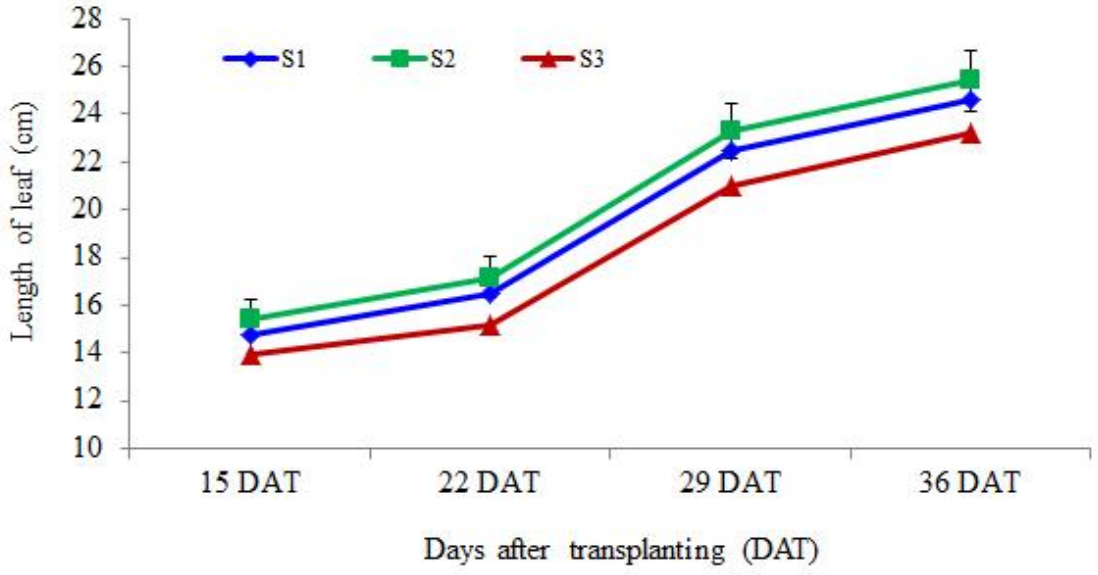
Length of leaf of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences for different seedling age (Figure 4). At 15, 22, 29 and 36 DAT, the longest leaf (15.45, 17.15, 23.29 and 25.40 cm, respectively) was recorded from S_2 treatment which was statistically similar (14.72, 16.50, 22.49 and 24.64 cm, respectively) to S_1 treatment, whereas the shortest leaf (13.93, 15.15, 20.97 and 23.25 cm, respectively) was found from S_3 treatment. Rajbir *et al*. (2005) reported the highest yield attributes from planting in optimum time, whereas the lowest values for the parameters measured late planting.

Statistically significant variation was recorded due to application of different levels of nitrogen on length of leaf of lettuce at 15, 22, 29 and 36 DAT (Figure 5). At 15, 22, 29 and 36 DAT, the longest leaf (16.13, 17.91, 24.50 and 26.64 cm, respectively) was observed from N_2 which was statistically similar (15.83, 17.10, 23.99 and 26.30 cm, respectively) to N_3 and closely followed (14.39, 16.10, 21.68 and 23.88 cm, respectively) by N_1, while the shortest leaf (12.44, 13.96, 18.84 and 20.90 cm, respectively) was recorded from N_0 treatment.

Due to combined effect of different levels of seedling age and nitrogen showed statistically significant variation on length of leaf of lettuce at 15, 22, 29 and 36 DAT (Table 5). At 15, 22, 29 and 36 DAT, the longest leaf (17.19, 19.36, 25.76 and 27.85 cm, respectively) was observed from S_2N_2 and the shortest leaf (11.32, 14.23, 17.06 and 19.20 cm, respectively) was recorded from S_3N_0 treatment combination.

4.4 Breadth of leaf

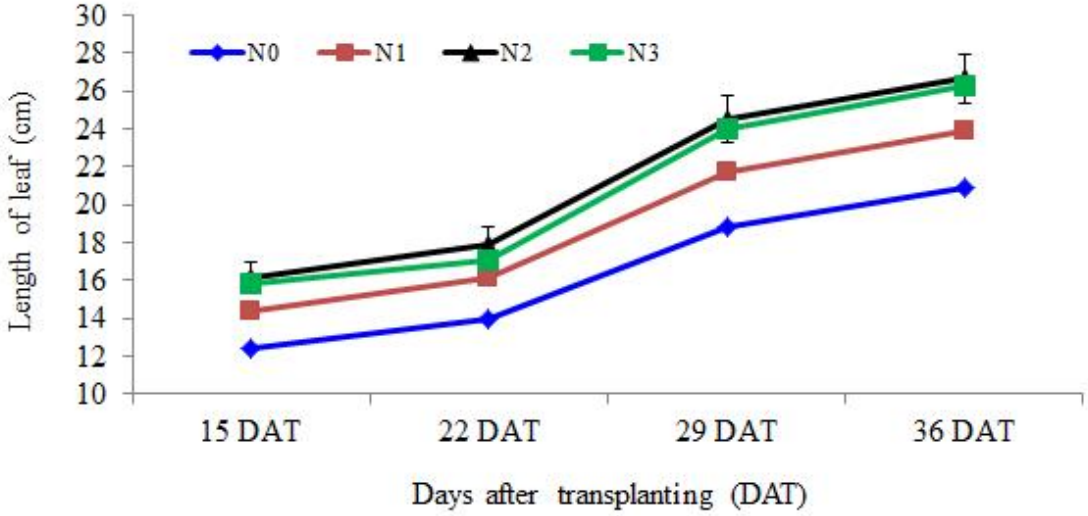
Statistically significant variation was recorded in terms of breadth of leaf of lettuce at 15, 22, 29 and 36 DAT for different seedling age (Table 6). At 15, 22, 29 and 36 DAT, the highest breadth of leaf (14.43, 16.19, 20.69 and 23.04 cm, respectively) was recorded from S_2 treatment which was followed (13.04, 15.22, 19.56 and 21.31 cm, respectively) by S_1 and the lowest breadth of leaf (12.53, 13.96, 18.62 and 20.16 cm, respectively) was observed from S_3 treatment.



S_1: Transplanting of 15 days old seedlings S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

Figure 4. Effect of different seedling age on length of leaf of lettuce. (Vertical bars represent LSD value at 5% level of probability)



N_0: 0 kg N/ha (control) N_1: 80 kg N/ha

N_2: 90 kg N/ha N_3: 100 kg N/ha

Figure 5. Effect of different levels of nitrogen on length of leaf of lettuce. (Vertical bars represent LSD value at 5% level of probability)

Table 5. Combined effect of seedling age and nitrogen on length of leaf of lettuce at different days after transplanting (DAT)

Treatments	Length of leaf (cm) at			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	13.99 de	13.87 d	20.30 e	22.49 ef
S_1N_1	14.35 c-e	16.61 bc	21.74 d	24.03 de
S_1N_2	15.16 b-d	17.91 ab	24.10 bc	25.97 bc
S_1N_3	15.38 b-d	17.62 ab	23.82 bc	26.05 bc
S_2N_0	12.02 fg	13.78 d	19.16 e	21.00 f
S_2N_1	15.56 bc	16.59 bc	23.24 c	25.35 cd
S_2N_2	17.19 a	19.36 a	25.76 a	27.85 a
S_2N_3	17.01 a	18.89 a	25.02 ab	27.42 ab
S_3N_0	11.32 g	14.23 d	17.06 f	19.20 g
S_3N_1	13.27 ef	15.11 cd	20.05 e	22.26 f
S_3N_2	16.05 ab	16.48 bc	23.64 bc	26.10 bc
S_3N_3	15.09 b-d	14.79 cd	23.12 cd	25.42 cd
$LSD_{(0.05)}$	1.305	1.700	1.427	1.591
Level of significance	0.01	0.05	0.05	0.05
CV(%)	9.95	7.60	8.09	8.35

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 6. Effect of seedling age and nitrogen on breadth of leaf of lettuce at different days after transplanting (DAT)

Treatments	Breadth of leaf (cm) at			
	15 DAT	22 DAT	29 DAT	36 DAT
Seedling age				
S_1	13.04 b	15.22 b	19.56 b	21.31 b
S_2	14.43 a	16.19 a	20.69 a	23.04 a
S_3	12.53 b	13.96 c	18.62 c	20.16 c
$LSD_{(0.05)}$	0.834	0.684	0.636	0.792
Level of significance	0.01	0.01	0.01	0.01
Levels of nitrogen				
N_0	10.85 c	12.60 d	16.35 c	18.32 c
N_1	13.01 b	14.96 c	19.34 b	21.10 b
N_2	15.00 a	16.88 a	21.66 a	23.63 a
N_3	14.48 a	16.07 b	21.14 a	22.95 a
$LSD_{(0.05)}$	0.963	0.789	0.734	0.915
Level of significance	0.01	0.01	0.01	0.01
CV(%)	8.19	7.32	8.43	8.79

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

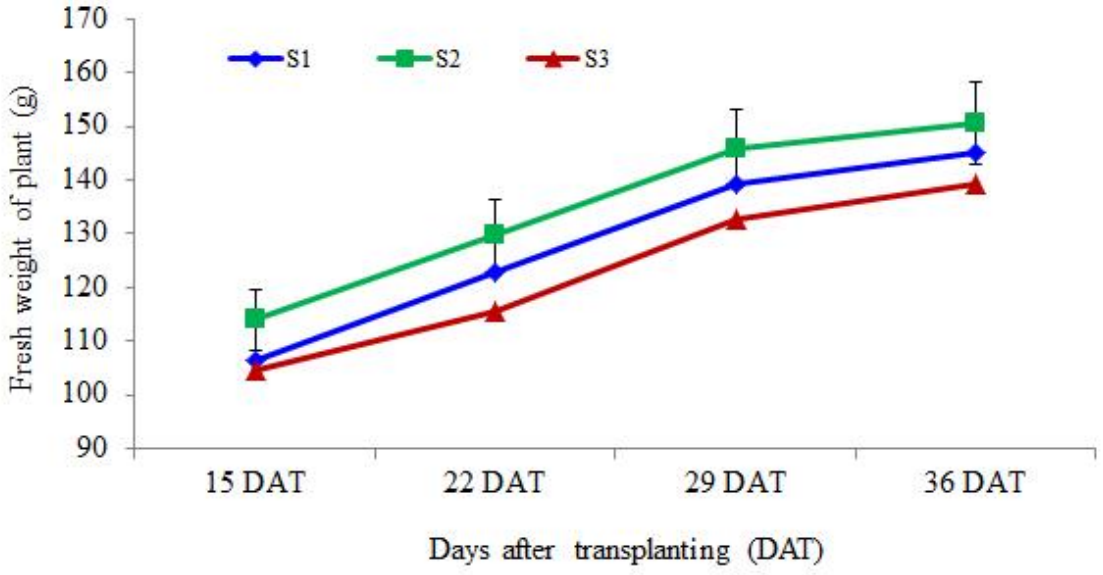
N_3: 100 kg N/ha

Breadth of leaf of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences due to application of different levels of nitrogen (Table 6). At 15, 22, 29 and 36 DAT, the highest breadth of leaf (15.00, 16.88, 21.66 and 23.63 cm, respectively) was found from N_2 treatment which was statistically similar (14.48, 16.07, 21.14 and 22.95 cm, respectively) to N_3 and closely followed (13.01, 14.96, 19.34 and 21.10 cm, respectively) by N_1, whereas the lowest breadth of leaf (10.85, 12.60, 16.35 and 18.32 cm, respectively) was recorded from N_0 treatment. It was observed that different breadth of leaves of lettuce was produced due to the application of different level of nitrogen.

Combined effect of different seedling age and levels of nitrogen showed statistically significant variation on breadth of leaf of lettuce at 15, 22, 29 and 36 DAT (Table 7). At 15, 22, 29 and 36 DAT, the highest breadth of leaf (15.76, 18.27, 23.08 and 25.65 cm, respectively) was observed from S_2N_2, while the lowest breadth of leaf (10.43, 11.46, 15.16 and 16.59 cm, respectively) was found from S_3N_0 treatment combination.

4.5 Fresh weight of plant

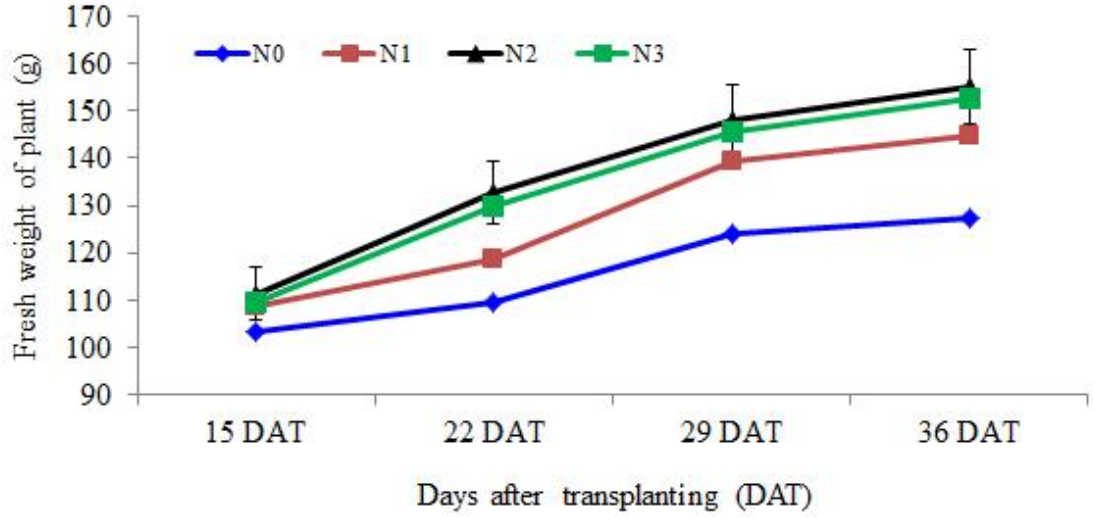
Fresh weight of plant of leaf of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences for different seedling age (Figure 6). At 15, 22, 29 and 36 DAT, the highest fresh weight of plant (113.91, 129.70, 145.82 and 150.57 g, respectively) was found from S_2 treatment which was followed (106.49, 122.93, 139.08 and 145.16 g, respectively) by S_1 treatment, while the lowest weight (104.52, 115.41, 132.77 and 139.17 g, respectively) was observed from S_3 treatment. Data revealed that different fresh weight of plant was observed for different seedling age of lettuce. Rajbir *et al*. (2005) reported the highest yield from planting in optimum time, whereas the lowest values for the parameters measured late planting.



S_1: Transplanting of 15 days old seedlings S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

Figure 6. Effect of different seedling age on fresh weight of plant of lettuce. (Vertical bars represent LSD value at 5% level of probability)



N_0: 0 kg N/ha (control) N_1: 80 kg N/ha

N_2: 90 kg N/ha N_3: 100 kg N/ha

Figure 7. Effect of different levels of nitrogen on fresh weight of plant of lettuce. (Vertical bars represent LSD value at 5% level of probability)

Table 7. Combined effect of seedling age and nitrogen on breadth of leaf of lettuce at different days after transplanting (DAT)

Treatments	Breadth of leaf (cm) at			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	10.94 bc	13.53 d	17.37 de	19.53 e
S_1N_1	11.69 bc	15.68 c	18.68 d	20.37 de
S_1N_2	14.42 a	16.52 bc	21.15 bc	22.83 bc
S_1N_3	15.11 a	15.16 c	21.04 bc	22.51 c
S_2N_0	11.17 bc	12.81 de	16.53 e	18.83 e
S_2N_1	15.12 a	16.35 bc	21.19 bc	23.25 bc
S_2N_2	15.76 a	18.27 a	23.08 a	25.65 a
S_2N_3	15.67 a	17.34 ab	21.96 ab	24.43 ab
S_3N_0	10.43 c	11.46 e	15.16 f	16.59 f
S_3N_1	12.22 bc	12.85 de	18.15 d	19.70 e
S_3N_2	14.82 a	15.85 c	20.75 bc	22.42 c
S_3N_3	12.65 b	15.69 c	20.41 c	21.93 cd
$LSD_{(0.05)}$	1.668	1.367	1.272	1.585
Level of significance	0.05	0.01	0.05	0.05
CV(%)	8.19	7.32	8.43	8.79

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Statistically significant variation was recorded due to different levels of nitrogen on fresh weight of plant of lettuce at 15, 22, 29 and 36 DAT (Figure 7). At 15, 22, 29 and 36 DAT, the highest fresh weight of plant (111.39, 132.74, 148.19 and 155.03 g, respectively) was recorded from N_2 treatment which was statistically similar (109.64, 129.76, 145.46 and 152.03 g, respectively) to N_3 and closely followed (108.71, 118.78, 139.22 and 144.68 g, respectively) by N_1, whereas the lowest weight (103.49, 109.45, 124.02 and 127.50 g, respectively) was observed from N_0 treatment. Tittonell *et al*. (2003) reported similar results.

Combined effect of different levels of seedling age and nitrogen showed statistically significant variation on fresh weight of plant of lettuce at 15, 22, 29 and 36 DAT (Table 8). At 15, 22, 29 and 36 DAT, the highest fresh weight of plant (120.48, 140.99, 158.49 and 161.72 g, respectively) was observed from S_2N_2 and the lowest weight (100.59, 104.85, 113.43 and 116.47 g, respectively) was recorded from S_3N_0 treatment combination.

4.6 Dry matter content in plant

Dry matter content in plant of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences for different seedling age (Table 9). At 15, 22, 29 and 36 DAT, the highest dry matter content in plant (8.47, 14.06, 16.38 and 16.95%, respectively) was recorded from S_2 treatment which was followed (7.97, 13.41, 15.37 and 16.04%, respectively) by S_1 treatment and the lowest (7.54, 12.78, 13.90 and 14.66%, respectively) was observed from S_3 treatment.

Different levels of nitrogen varied significantly due to in terms of dry matter content in plant of lettuce at 15, 22, 29 and 36 DAT (Table 9). At 15, 22, 29 and 36 DAT, the highest dry matter content in plant (8.82, 14.71, 16.98 and 17.65%, respectively) was found from N_2 treatment which was statistically similar (8.53, 14.52, 16.50 and 17.10%, respectively) to N_3 and closely followed (7.82, 13.27, 15.00 and 15.69%, respectively) by N_1, whereas the lowest (6.82, 11.17, 12.39 and 13.09%, respectively) was observed from N_0 treatment. Tittonell *et al*. (2003) reported that increasing nitrogen fertilizer in lettuce from 0 to 150 kg/ha increased the dry weight of the crop.

Table 8. Combined effect of seedling age and nitrogen on fresh weight of plant of lettuce at different days after transplanting (DAT)

Treatments	Fresh weight of plant (g)			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	105.79 c-e	113.36 ef	132.19 d-f	135.11 cd
S_1N_1	110.15 b-d	119.11 de	141.43 b-e	148.11 b
S_1N_2	106.18 c-e	130.86 bc	144.63 b-d	150.94 ab
S_1N_3	103.83 de	128.38 bc	138.06 c-f	146.47 bc
S_2N_0	104.08 c-e	110.13 f	126.46 f	130.93 d
S_2N_1	112.87 a-c	130.86 bc	146.37 a-c	152.78 ab
S_2N_2	120.48 a	140.99 a	158.49 a	161.72 a
S_2N_3	118.22 ab	136.82 ab	151.95 ab	156.87 ab
S_3N_0	100.59 e	104.85 f	113.43 g	116.47 e
S_3N_1	103.11 de	106.36 f	129.87 ef	133.16 d
S_3N_2	107.50 c-e	126.38 cd	141.43 b-e	152.43 ab
S_3N_3	106.87 c-e	124.08 cd	146.36 a-c	154.63 ab
$LSD_{(0.05)}$	7.781	8.331	11.87	11.62
Level of significance	0.05	0.05	0.05	0.01
CV(%)	7.25	8.12	8.55	8.07

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 9. Effect of seedling age and nitrogen on dry matter content in plant of lettuce at different days after transplanting (DAT)

Treatments	Dry matter content in plant (%) at			
	15 DAT	22 DAT	29 DAT	36 DAT
Seedling age				
S_1	7.97 b	13.41 b	15.37 b	16.04 b
S_2	8.47 a	14.06 a	16.38 a	16.95 a
S_3	7.54 c	12.78 c	13.90 c	14.66 c
$LSD_{(0.05)}$	0.288	0.615	0.579	0.548
Level of significance	0.01	0.01	0.01	0.01
Levels of nitrogen				
N_0	6.82 c	11.17 c	12.39 c	13.09 c
N_1	7.82 b	13.27 b	15.00 b	15.69 b
N_2	8.82 a	14.71 a	16.98 a	17.65 a
N_3	8.53 a	14.52 a	16.50 a	17.10 a
$LSD_{(0.05)}$	0.330	0.710	0.668	0.633
Level of significance	0.01	0.01	0.01	0.01
CV(%)	7.65	8.10	9.07	9.13

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Dry matter content in plant of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences due to combined effect of different levels of seedling age and nitrogen (Table 10). At 15, 22, 29 and 36 DAT, the highest dry matter content in plant (9.44, 15.70, 18.50 and 19.04%, respectively) was recorded from S_2N_2, while the lowest (6.25, 10.14, 11.11 and 11.97%, respectively) was found from S_3N_0 treatment combination.

4.7 Yield per plot

Statistically significant variation was recorded in terms of yield per plot of lettuce at 15, 22, 29 and 36 DAT for different seedling age (Table 11). At 15, 22, 29 and 36 DAT, the highest yield per plot (1.37, 1.56, 1.75 and 1.82 kg, respectively) was recorded from S_2 treatment which was followed (1.28, 1.48, 1.67 and 1.74 kg, respectively) by S_1 treatment, while the lowest yield per plot (1.25, 1.38, 1.59 and 1.67 kg, respectively) was observed from S_3 treatment. Rajbir *et al*. (2005) reported the highest yield from planting in optimum time, whereas the lowest values for the parameters measured late planting.

Different levels of nitrogen showed significant variation on yield per plot of lettuce at 15, 22, 29 and 36 DAT (Table 11). At 15, 22, 29 and 36 DAT, the highest yield per plot (1.34, 1.59, 1.78 and 1.86 kg, respectively) was found from N_2 treatment which was statistically similar (1.32, 1.56, 1.75 and 1.83 kg, respectively) to N_3 and closely followed (1.25, 1.43, 1.67 and 1.74 kg, respectively) by N_1, while the lowest yield per plot (1.18, 1.31, 1.49 and 1.53 kg, respectively) was recorded from N_0 treatment.

Statistically significant variation was observed due to the combined effect of different seedling age and levels of nitrogen in terms of yield per plot of lettuce at 15, 22, 29 and 36 DAT (Table 12). At 15, 22, 29 and 36 DAT, the highest yield per plot (1.45, 1.69, 1.90 and 1.94 kg, respectively) was observed from S_2N_2, whereas the lowest yield per plot (1.21, 1.26, 1.36 and 1.40 kg, respectively) was found from S_3N_0 treatment combination.

Table 10. Combined effect of seedling age and nitrogen on dry matter content in plant of lettuce at different days after transplanting (DAT)

Treatments	Dry matter content in plant (%) at			
	15 DAT	22 DAT	29 DAT	36 DAT
S_1N_0	7.21 e	12.13 c	13.16 d	13.80 e
S_1N_1	7.92 d	13.54 b	15.49 c	16.10 d
S_1N_2	8.47 cd	13.89 b	16.55 bc	17.36 bc
S_1N_3	8.27 cd	14.06 b	16.28 c	16.91 cd
S_2N_0	6.98 e	11.25 cd	12.89 d	13.49 e
S_2N_1	8.38 cd	14.45 ab	16.55 bc	17.16 b-d
S_2N_2	9.44 a	15.70 a	18.50 a	19.04 a
S_2N_3	9.10 ab	14.83 ab	17.59 ab	18.11 ab
S_3N_0	6.25 f	10.14 d	11.11 e	11.97 f
S_3N_1	7.15 e	11.80 c	12.97 d	13.82 e
S_3N_2	8.57 bc	14.53 ab	15.89 c	16.55 cd
S_3N_3	8.21 cd	14.65 ab	15.63 c	16.29 cd
$LSD_{(0.05)}$	0.577	1.230	1.157	1.096
Level of significance	0.05	0.01	0.05	0.05
CV(%)	7.65	8.10	9.07	9.13

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 11. Effect of seedling age and nitrogen on yield per plot at different days after transplanting (DAT) and total yield of lettuce

Treatments	Yield per plot (kg) at				
	15 DAT	22 DAT	29 DAT	36 DAT	Total
Seedling age					
S_1	1.28 b	1.48 b	1.67 b	1.74 b	6.16 b
S_2	1.37 a	1.56 a	1.75 a	1.82 a	6.48 a
S_3	1.25 b	1.38 c	1.59 c	1.67 b	5.90 c
$LSD_{(0.05)}$	0.046	0.046	0.071	0.071	0.156
Level of significance	0.01	0.01	0.01	0.01	0.01
Levels of nitrogen					
N_0	1.18 c	1.31 c	1.49 c	1.53 c	5.51 c
N_1	1.25 b	1.43 b	1.67 b	1.74 b	6.14 b
N_2	1.34 a	1.59 a	1.78 a	1.86 a	6.57 a
N_3	1.32 a	1.56 a	1.75 ab	1.83 a	6.45 a
$LSD_{(0.05)}$	0.054	0.054	0.082	0.082	0.180
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.24	4.01	5.03	4.73	5.98

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 12. Combined effect of seedling age and nitrogen on yield per plot at different days after transplanting (DAT) and total yield of lettuce

Treatments	Yield per plot (kg) at				
	15 DAT	22 DAT	29 DAT	36 DAT	Total
S_1N_0	1.27 c-e	1.36 ef	1.59 d-f	1.62 cd	5.84 d
S_1N_1	1.32 b-d	1.43 de	1.70 b-e	1.78 b	6.23 c
S_1N_2	1.27 c-e	1.57 bc	1.74 b-d	1.81 ab	6.39 c
S_1N_3	1.25 de	1.54 c	1.66 c-f	1.76 bc	6.20 c
S_2N_0	1.25 de	1.32 fg	1.52 f	1.57 d	5.66 d
S_2N_1	1.35 a-c	1.57 bc	1.76 a-c	1.83 ab	6.51 bc
S_2N_2	1.45 a	1.69 a	1.90 a	1.94 a	6.98 a
S_2N_3	1.42 ab	1.64 ab	1.82 ab	1.88 ab	6.77 ab
S_3N_0	1.21 e	1.26 g	1.36 g	1.40 e	5.22 e
S_3N_1	1.24 de	1.28 fg	1.56 ef	1.60 d	5.67 d
S_3N_2	1.29 c-e	1.52 cd	1.70 b-e	1.83 ab	6.33 c
S_3N_3	1.28 c-e	1.49 cd	1.76 a-c	1.86 ab	6.38 c
$LSD_{(0.05)}$	0.093	0.093	0.142	0.142	0.312
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	4.24	4.01	5.03	4.73	5.98

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

4.8 Total yield per plot

Total yield per plot of lettuce showed statistically significant differences for different seedling age (Table 11). The highest total yield per plot (6.48 kg) was found from S_2 treatment which was followed (6.16 kg) by S_1 treatment and the lowest total yield per plot (5.90 kg) was recorded from S_3 treatment.

Statistically significant variation was recorded due to different levels of nitrogen in terms of total yield per plot of lettuce (Table 11). The highest total yield/plot (6.57 kg) was observed from N_2 treatment which was statistically similar (6.45 kg) to N_3 and closely followed (6.14 kg) by N_1, whereas the lowest total yield per plot (5.51 kg) was found from N_0 treatment.

Combined effect of different seedling age and levels of nitrogen showed statistically significant variation in terms of total yield per plot of lettuce (Table 12). The highest total yield per plot (6.98 kg) was observed from S_2N_2, while the lowest total yield per plot (5.22 kg) was recorded from S_3N_0 treatment combination.

4.9 Yield per hectare

Different seedling age showed statistically significant differences in terms of yield per hectare of lettuce at 15, 22, 29 and 36 DAT (Table 13). At 15, 22, 29 and 36 DAT, the highest yield per hectare (2.85, 3.24, 3.65 and 3.76 ton, respectively) was recorded from S_2 treatment which was followed (2.66, 3.07, 3.48 and 3.60 ton, respectively) by S_1 treatment, whereas the lowest yield per hectare (2.61, 2.89, 3.32 and 3.48 ton, respectively) was observed from S_3 treatment. Handley and Hutton (2003) reported that to encourage quick plant growth and early harvest, the technique of transplanting lettuce seedlings may be applied and optimum seedling age for better plant establishment could enhance productivity.

Table 13. Effect of seedling age and nitrogen on yield per hectare at different days after transplanting (DAT) and total yield of lettuce

Treatments	Yield per hectare (ton) at				
	15 DAT	22 DAT	29 DAT	36 DAT	Total
Seedling age					
S_1	2.66 b	3.07 b	3.48 b	3.60 b	12.81 b
S_2	2.85 a	3.24 a	3.65 a	3.76 a	13.50 a
S_3	2.61 b	2.89 c	3.32 c	3.48 b	12.30 c
$LSD_{(0.05)}$	0.096	0.104	0.149	0.144	0.325
Level of significance	0.01	0.01	0.01	0.01	0.01
Levels of nitrogen					
N_0	2.51 c	2.74 c	3.10 c	3.19 c	11.54 c
N_1	2.65 b	2.97 b	3.48 b	3.62 b	12.78 b
N_2	2.78 a	3.32 a	3.70 a	3.88 a	13.68 a
N_3	2.74 a	3.24 a	3.64 ab	3.82 a	13.44 a
$LSD_{(0.05)}$	0.112	0.120	0.172	0.167	0.375
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	4.24	4.01	5.03	4.73	5.98

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Table 14. Combined effect of seedling age and nitrogen on yield per hectare at different days after transplanting (DAT) and total yield of lettuce

Treatments	Yield per hectare (ton) at				
	15 DAT	22 DAT	29 DAT	36 DAT	Total
S_1N_0	2.64 c-e	2.83 ef	3.30 d-f	3.38 cd	12.16 d
S_1N_1	2.75 b-d	2.98 de	3.54 b-e	3.70 b	12.97 c
S_1N_2	2.65 c-e	3.27 bc	3.62 b-d	3.77 ab	13.32 c
S_1N_3	2.60 de	3.21 bc	3.45 c-f	3.66 bc	12.92 c
S_2N_0	2.60 de	2.75 f	3.16 f	3.27 d	11.79 d
S_2N_1	2.82 a-c	3.27 bc	3.66 a-c	3.82 ab	13.57 bc
S_2N_2	3.01 a	3.52 a	3.96 a	4.04 a	14.54 a
S_2N_3	2.96 ab	3.42 ab	3.80 ab	3.92 ab	14.10 ab
S_3N_0	2.51 e	2.62 f	2.84 g	2.91 e	10.88 e
S_3N_1	2.58 de	2.66 f	3.25 ef	3.33 d	11.81 d
S_3N_2	2.69 c-e	3.16 cd	3.54 b-e	3.81 ab	13.19 c
S_3N_3	2.67 c-e	3.10 cd	3.66 a-c	3.87 ab	13.30 c
$LSD_{(0.05)}$	0.193	0.207	0.298	0.288	0.649
Level of significance	0.05	0.05	0.05	0.01	0.01
CV(%)	4.24	4.01	5.03	4.73	5.98

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

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

Statistically significant variation was recorded due to different levels of nitrogen in terms of yield per hectare of lettuce at 15, 22, 29 and 36 DAT (Table 13). At 15, 22, 29 and 36 DAT, the highest yield per hectare (2.78, 3.32, 3.70 and 3.88 ton, respectively) was found from N_2 treatment which was statistically similar (2.74, 3.24, 3.64 and 3.82 ton, respectively) to N_3 and closely followed (2.65, 2.97, 3.48 and 3.62 ton, respectively) by N_1, while the lowest yield per hectare (2.51, 2.74, 3.10 and 3.19 ton, respectively) was recorded from N_0 treatment.

Yield per hectare of lettuce at 15, 22, 29 and 36 DAT showed statistically significant differences for the combined effect of different seedling age and levels of nitrogen (Table 14). At 15, 22, 29 and 36 DAT, the highest yield per hectare (3.01, 3.52, 3.96 and 4.04 ton, respectively) was observed from S_2N_2, whereas the lowest yield per hectare (2.51, 2.62, 2.84 and 2.91 ton, respectively) was found from S_3N_0 treatment combination.

4.10 Total yield per hectare

Total yield per hectare of lettuce showed statistically significant differences for different seedling age (Table 13). The highest total yield per hectare (13.50 ton) was observed from S_2 treatment which was followed (12.81 ton) by S_1 treatment, while the lowest total yield per hectare (12.30 ton) was found from S_3 treatment. Rajbir *et al*. (2005) reported the highest yield from planting in optimum time, whereas the lowest values for the parameters measured late planting. Rehman *et al.* (2001) observed that nitrogen application @ 80 kg/ha produced maximum yield/ha (13.6 ton) were noted in plots which received nitrogen at the rate of 80 kg/ha compared to other levels of nitrogen.

Statistically significant variation was recorded due to application of different levels of nitrogen in terms of total yield per hectare of lettuce (Table 13). The highest total yield per hectare (13.68 ton) was recorded from N_2 treatment which was statistically similar (13.44 ton) to N_3 and followed (12.78 ton) by N_1, whereas the lowest total yield per hectare (11.54 ton) from N_0 treatment. Hasan *et al*. (2017) recorded the highest yield (29.99 t/ha) from 150 kg/ha of N.

Combined effect of different seedling age and levels of nitrogen varied significantly in terms of total yield per hectare of lettuce (Table 14). The highest total yield per hectare (14.54 ton) was found from S_2N_2 and the lowest total yield per hectare (10.88 ton) from S_3N_0 treatment combination.

4.11 Economic analysis

All types of operational cost from seeds sowing to harvesting of lettuce as costs for land preparation, fertilizers, seeds, manpower etc. were recorded as per plot and converted into hectare. Price of lettuce was considered as per present market price situation and benefit cost of lettuce cultivation were presented in Table 15 and details production cost were presented in Appendix XII. The economical analysis of lettuce production presented under the following headings-

4.11.1 Gross return

The combination of seedling age and levels of nitrogen showed different value in terms of gross return for lettuce production (Table 15). The highest gross return (581,600 Tk./ha) was obtained from the treatment combination S_2N_2 and the second highest gross return (564,000 Tk./ha) was found in S_2N_3, whereas the lowest gross return (435,200 Tk./ha) was obtained from S_3N_0.

4.11.2 Net return

In case of net return, seedling age and levels of nitrogen showed different net return under the present trial (Table 15). The highest net return (312,465 Tk./ha) was found from the treatment combination S_2N_2 and the second highest net return (294,643 Tk./ha) was obtained from the combination S_2N_3. The lowest (167,802 Tk./ha) net return was obtained S_3N_0.

4.11.3 Benefit cost ratio

For seedling age and levels of nitrogen, the highest benefit cost ratio (2.16) was estimated from the combination of S_2N_2 and the second highest (2.09) was found from the combination of S_2N_3. The lowest benefit cost ratio (1.63) was recorded from S_3N_0 (Table 15). From economic point of view, it is apparent that the combination of S_2N_2 was best than rest of the combination in lettuce cultivation.

Table 15. Cost and return of lettuce cultivation as influenced by seedling age and nitrogen

Treatments	Cost of production (Tk./ha)	Yield of lettuce (ton/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
S_1N_0	267,398	12.16	486,400	219,002	1.82
S_1N_1	268,948	12.97	518,800	249,852	1.93
S_1N_2	269,135	13.32	532,800	263,665	1.98
S_1N_3	269,357	12.92	516,800	247,443	1.92
S_2N_0	267,398	11.79	471,600	204,202	1.76
S_2N_1	268,948	13.57	542,800	273,852	2.02
S_2N_2	269,135	14.54	581,600	312,465	2.16
S_2N_3	269,357	14.10	564,000	294,643	2.09
S_3N_0	267,398	10.88	435,200	167,802	1.63
S_3N_1	268,948	11.81	472,400	203,452	1.76
S_3N_2	269,135	13.19	527,600	258,465	1.96
S_3N_3	269,357	13.30	532,000	262,643	1.98

Market price of lettuce @ BDT 40.00/kg

S_1: Transplanting of 15 days old seedlings

S_2: Transplanting of 20 days old seedlings

S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)

N_1: 80 kg N/ha

N_2: 90 kg N/ha

N_3: 100 kg N/ha

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted at the period of November 2016 to January 2017 in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka to find out the effect of seedling age and nitrogen on growth and yield of lettuce. The seeds of lettuce variety 'Green wave' were used as planting materials for this experiment. The experiment consisted of two factors: Factor A: Seedling age (3 levels) as- S_1: Transplanting of 15 days old seedlings, S_2: Transplanting of 20 days old seedlings, S_3: Transplanting of 25 days old seedlings and Factor B: Levels of nitrogen (4 levels) as N_0: 0 kg N/ha (control), N_1: 80 kg N/ha, N_2: 90 kg N/ha and N_3: 100 kg N/ha. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on yield contributing characters and yield were recorded and significant variation was observed for different treatment.

In case of seedling age, at 15, 22, 29 and 36 DAT the tallest plant (17.48, 22.09, 27.92 and 31.27 cm, respectively) was recorded from S_2, whereas the shortest plant (15.30, 19.56, 25.43 and 28.90 cm, respectively) was observed from S_3 treatment. The maximum number of leaves per plant (15.28, 21.73, 24.35 and 26.04, respectively) was found from S_2 treatment, while the minimum number (13.13, 19.57, 22.23 and 23.65, respectively) was recorded from S_3 treatment. The longest leaf (15.45, 17.15, 23.29 and 25.40 cm, respectively) was recorded from S_2, whereas the shortest leaf (13.93, 15.15, 20.97 and 23.25 cm, respectively) was found from S_3 treatment. The highest breadth of leaf (14.43, 16.19, 20.69 and 23.04 cm, respectively) was recorded from S_2 and the lowest breadth of leaf (12.53, 13.96, 18.62 and 20.16 cm, respectively) was observed from S_3 treatment. The highest fresh weight of plant (113.91, 129.70, 145.82 and

150.57 g, respectively) was found from S_2 treatment, while the lowest weight (104.52, 115.41, 132.77 and 139.17 g, respectively) was observed from S_3 treatment. The highest dry matter content in plant (8.47, 14.06, 16.38 and 16.95%, respectively) was recorded from S_2 treatment and the lowest (7.54, 12.78, 13.90 and 14.66%, respectively) was observed from S_3 treatment. The highest yield/plot (1.37, 1.56, 1.75 and 1.82 kg, respectively) was recorded from S_2 treatment, while the lowest yield per plot (1.25, 1.38, 1.59 and 1.67 kg, respectively) was observed from S_3 treatment. The highest total yield per plot (6.48 kg) was found from S_2 treatment and the lowest total yield per plot (5.90 kg) was recorded from S_3 treatment. The highest yield per hectare (2.85, 3.24, 3.65 and 3.76 ton, respectively) was recorded from S_2 treatment, whereas the lowest yield per hectare (2.61, 2.89, 3.32 and 3.48 ton, respectively) was observed from S_3 treatment. The highest total yield per hectare (13.50 ton) was observed from S_2 treatment, while the lowest total yield per hectare (12.30 ton) was found from S_3 treatment.

For different levels of nitrogen at 15, 22, 29 and 36 DAT, the tallest plant (18.38, 22.96, 28.92 and 33.38 cm, respectively) was found from N_2, while the shortest plant (13.82, 17.70, 22.38 and 24.95 cm, respectively) was recorded from N_0 treatment. The maximum number of leaves per plant (15.27, 23.22, 25.44 and 26.76, respectively) was recorded from N_2 treatment and the minimum number (12.49, 16.80, 19.33 and 20.91, respectively) was observed from N_0 treatment. The longest leaf (16.13, 17.91, 24.50 and 26.64 cm, respectively) was observed from N_2 treatment, while the shortest leaf (12.44, 13.96, 18.84 and 20.90 cm, respectively) was recorded from N_0 treatment. The highest breadth of leaf (15.00, 16.88, 21.66 and 23.63 cm, respectively) was found from N_2 treatment, whereas the lowest breadth of leaf (10.85, 12.60, 16.35 and 18.32 cm, respectively) was recorded from N_0 treatment. The highest fresh weight of plant (111.39, 132.74, 148.19 and 155.03 g, respectively) was recorded from N_2 treatment, whereas the lowest weight (103.49, 109.45, 124.02 and 127.50 g, respectively) was observed from N_0 treatment. The highest dry matter content in

plant (8.82, 14.71, 16.98 and 17.65%, respectively) was found from N_2 treatment, whereas the lowest (6.82, 11.17, 12.39 and 13.09%, respectively) was observed from N_0 treatment. The highest yield per plot (1.34, 1.59, 1.78 and 1.86 kg, respectively) was found from N_2 treatment, while the lowest yield per plot (1.18, 1.31, 1.49 and 1.53 kg, respectively) was recorded from N_0 treatment. The highest total yield per plot (6.57 kg) was observed from N_2 treatment, whereas the lowest total yield per plot (5.51 kg) was found from N_0 treatment. The highest yield per hectare (2.78, 3.32, 3.70 and 3.88 ton, respectively) was found from N_2 treatment, while the lowest yield per hectare (2.51, 2.74, 3.10 and 3.19 ton, respectively) was recorded from N_0 treatment. The highest total yield per hectare (13.68 ton) was recorded from N_2, whereas the lowest total yield per hectare (11.54 ton) was observed from N_0 treatment.

Due to the combined effect of different seedling age and levels of nitrogen at 15, 22, 29 and 36 DAT, the tallest plant (19.91, 24.49, 31.05 and 35.08 cm, respectively) was observed from S_2N_2, whereas the shortest plant (12.86, 15.61, 19.72 and 20.95 cm, respectively) was found from S_3N_0 treatment combination. The maximum number of leaves per plant (17.60, 24.00, 27.73 and 29.08, respectively) was observed from S_2N_2, while the minimum number (11.27, 14.13, 17.87 and 19.00, respectively) was recorded from S_3N_0 treatment combination. The longest leaf (17.19, 19.36, 25.76 and 27.85 cm, respectively) was observed from S_2N_2 and the shortest leaf (11.32, 14.23, 17.06 and 19.20 cm, respectively) was recorded from S_3N_0 treatment combination. The highest breadth of leaf (15.76, 18.27, 23.08 and 25.65 cm, respectively) was observed from S_2N_2, while the lowest breadth of leaf (10.43, 11.46, 15.16 and 16.59 cm, respectively) was found from S_3N_0 treatment combination. The highest fresh weight of plant (120.48, 140.99, 158.49 and 161.72 g, respectively) was observed from S_2N_2 and the lowest weight (100.59, 104.85, 113.43 and 116.47 g, respectively) was recorded from S_3N_0 treatment combination. The highest dry matter content in plant (9.44, 15.70, 18.50 and 19.04%, respectively) was recorded from S_2N_2, while the lowest (6.25, 10.14, 11.11 and 11.97%, respectively) was found from S_3N_0 treatment combination. The highest yield per

plot (1.45, 1.69, 1.90 and 1.94 kg, respectively) was observed from S_2N_2, whereas the lowest yield per plot (1.21, 1.26, 1.36 and 1.40 kg, respectively) was found from S_3N_0 treatment combination. The highest total yield per plot (6.98 kg) was observed from S_2N_2, while the lowest total yield per plot (5.22 kg) was recorded from S_3N_0 treatment combination. The highest yield per hectare (3.01, 3.52, 3.96 and 4.04 ton, respectively) was observed from S_2N_2, whereas the lowest yield per hectare (2.51, 2.62, 2.84 and 2.91 ton, respectively) was found from S_3N_0 treatment combination. The highest total yield per hectare (14.54 ton) was found from S_2N_2 and the lowest total yield per hectare (10.88 ton) was recorded from S_3N_0 treatment combination.

In gross return for lettuce production, the highest gross return (581,600 Tk./ha) was obtained from the treatment combination S_2N_2 and the lowest gross return (435,200 Tk./ha) was obtained from S_3N_0. In case of net return, the highest net return (312,465 Tk./ha) was found from the treatment combination S_2N_2 and the lowest (167,802 Tk./ha) net return was obtained S_3N_0. For seedling age and levels of nitrogen, the highest benefit cost ratio (2.16) was estimated from the combination of S_2N_2 and the lowest benefit cost ratio (1.63) was recorded from S_3N_0. From economic point of view, it is apparent that the combination of S_2N_2 was best than rest of the combination in lettuce cultivation.

Conclusion

Among the combination of different seedling age and levels of nitrogen, transplanting of 20 days old seedlings and 90 kg N/ha provided superior growth, yield and benefit of lettuce cultivation.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

- The experiment was conducted only one growing season under AEZ No. 28. Before more confirmation and recommendation further such type study is required in different agro-ecological zones of Bangladesh.

REFERENCES

Alam, M.S., Iqbal, T.M.T., Amin, M. and Gaffar, M.A. (1989). Krishitattic Fasaler Utpadan O Unnayan (in Bengali). T. M. Jubair Bin Iqbal, Sirajgonj. pp. 231-239.

Aparajita B. (2002). Effect of seedling age on growth and yield of tomato and brinjal. Department of Nematology, Assam Agricultural University, Jorhat 785013, Assam, India. pp. 120-130.

Awaad, M.S., Badr, R.A., Badr, M.A. and Abd-elrahman, A.H. (2016). Effects of different nitrogen and potassium sources on lettuce (*Lactuca sativa* L.) yield in a sandy soil. *Eurasian J. Soil Sci*., **5**(4): 299 - 306

BARI (Bangladesh Agricultural Research Institute). (2017). Krishi Projockti Hatboi-7th Edition. p. 189.

Boroujerdnia, M. and Ansari, N.A. (2007). Effect of Different Levels of Nitrogen Fertilizer and Cultivars on Growth, Yield and Yield Components of Romaine Lettuce (*Lactuca sativa* L.). Department of Horticultural, Faculty of Agriculture, Shahid Chamran University, Ahwaz, Iran. *Middle Eastern and Russian J. Plant Sci. Biotech.,* **12**(2): 45-51.

Bozkurt, S.M., Mansuroglu, G.S., Kara, M., Onder, S. (2009). Responses of lettuce to irrigation levels and nitrogen forms. *African J. Agril. Res.*, **4**(11): 1171-1178.

Cerne, D.S., Riesen, U. and Scharpf, H.C. (2000). Effect of variety and transplanting time of lettuce. *J. Hebei. Agril. Uni.,* **22**(1): 50-54.

Chohura, K. and Eugeniusz, Y.P. (2009). Effect of different nitrogen doses that were used to obtain the required N level in the soil prior to planting the seedlings. *Cienciae Investigation, Agaria*. **22** (1): 20-24.

Chohura, P. and Eugeniusz, K. (2009). Effect of nitrogen fertilization on the yieldand quality of field-grown leaf lettuce for spring harvest. *Veg. Crops Res. Bull*., **71**: 41-49.

Choi, Y.H., Cho, J.L., Rhee, H.C., Park, D.K., Kwon, J.K. and Lee, J.H. (2002). Effect of summer grown seedling quality on growth and yield of tomato. *J. Korean Soc. Hort. Sci*., **43** (4): 395-398.

Csizinszky, A.A. and Schuster, D.J. (2005). Response of cabbage to seedling age plant spacing and fertilizer rates. *J. Amer. Soc. Hort. Sci.,* **110**(6): 888-893.

Fageria, N.K. (2009). The use of nutrients in crop plants. Taylor and Francis Group, Boca Raton, FL. *Hort. Technol.,* **2**: 382-386.

Fontes, P.C.R., Pereira, P.R.G. and Conde, R.M. (1997). Critical chlorophyll, total nitrogen and nitrate nitrogen in leaves associated to maximum lettuce yield. *J. Plant Nutr*., **20**: 1061-1068.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedure for Agricultural Research (2nd edn.). *Intl. Rice Res. Inst., A Willey Int. Sci*., pp. 28-192.

Grazia, J.D., Tittonell, P.A. and Chiesa, A. (2001). Effects of sowing date, radiation and nitrogen nutrition on growth pattern and yield of lettuce (*Lactuca sativa* L.) crop. Madrid, Spain: Instituto Nacional de Investigacion y Tecnologia Agraria y Alimentaria (INIA). Invest. *Agraria Prod. Prot. Veg*., **16**(3): 355-365.

Gulser, F., Sonmez, F., Boysan, S. (2010). Effect of calcium nitrate and humic acid applications on growth and yield criteria of pepper seedling under salt stress. *J. Envir. Biol.*, **31**(5): 873-876.

Handley, D. and Hutton, M. (2003). Effect of seeding date, transplant size and container on growth and yield of pickling cucumbers. *J. American Soc. Hort. Sci*., **38**: 672-679.

Hasan, M.R., Tahsin, A.K.M.M., Islam, M. N., Ali, M.A. and Uddain, J. (2017). Growth and Yield of Lettuce (*Lactuca Sativa* L.) Influenced As Nitrogen Fertilizer and Plant Spacing. *J. Agric. Vet. Sci*., **10**(6): 62-71.

Heckman, J.R. (2007). Sweet corn nutrition uptake and removal. *Hort. Technol*., **17**: 82-86.

Heckman, J.R., Sims, J.T., Beegle, D.E., Coale, F.J., Herbert, S.J., Bruulsema, T.W. and Bamka, W.J. (2003). Nutrient removal by corn grain harvest. *Agron. J*., **95**: 587-591.

Henare, M. and Ravanloo, A. (2008). Effect of transplanting stage and planting depth of seedling on growth and yield of tomato. Book of abstracts. IV Balkan Symposium on *Vegetables and Potatoes*. *Plovdiv*, **96**: 43-51.

Holcomb, E.J. (ed.). (1994). Bedding Plants IV. Ball Publishing, Batavia, III.

Islam, M.M. (2003). Response of lettuce to plant density and NPK nutrients. *Indian J. Agric. Sci*., **65**(11): 818-820.

Islam, M.S. and Noor, S. (1982). Performance of broccoli under levels of fertilization in flood plain soil of Jamalpur. *Bangladesh J. Agric. Res*., **7**(1): 35-40.

Kavak, S., Bozokalfa, M.K., Ugur, A., Yagmur, B. and Esiyok, D. (2003). The effects of different nitrogen sources on yield, quality and mineral matter

content in head lettuce (*Lactuca sativa* var. capitata). *Acta Hort*., **40**(3): 33-40.

Kowalska I., Sady W. and Szura A. (2006). Effect of nitrogen form, foliar nutrition and growing place on yield and quality of lettuce. *Acta Agrophysica.,* **7**: 619-630.

Liao-YuLin, Rong, X.M., Liu, Q., Xiao, S.Y., Li, H.S. and Fan, M.R. (2005). Effects of nitrogen rates on yield and quality and nitrogen use efficiency of asparagus lettuce. Changsha, China: Hunan Agricultural University. *J. Hunan Agril. Uni*., **31**(1): 47-49.

Mahmoudi, K.F. (2005) Effects of rates and sources nitrogen fertilizer on nitrate accumulation and yield of lettuce. MSc Thesis, Department of Soil Science, Science and Research Branch, Islamic Azad University, Tehran, Iran, p. 78.

Manotti, P.L., Halseth, D.E. and Sieczka, J.B. (1994). Field chlorophyll measurements to assess the N status of potato varieties. *Hort. Sci*., **29**: 1497-1500.

Mantovani, J.R., Ferreira, M.E., Cruz, M.C.P. (2005). Lettuce growth and nitrate accumulation in relation to nitrogen fertilization. Botucatu, Brazil: Sociedade de Olericultura do Brasil, UNESP - FCA. *Hort. Brasileira*, **23**(3): 758-762.

Marsic, N.K. and Osvald, J. (2002). Effects of different nitrogen levels on lettuce growth and nitrate accumulation in iceberg lettuce (*Lactuca sativa* var. capitata L.) grown hydroponically under greenhouse conditions. Stuttgart, Germany. *J. Veg. Res*., **67**(4): 128-134.

Mhamdi, M., Boughattas, I., Chikh-Rouhou, H., Souhli, E. and Bettaieb, T. (2014). Effect of different levels of nitrogen fertilizer on morphological

and physiological parameters and nitrates accumulation of lettuce cultivars (*Lactuca sativa* L.). *Res. Plant Biol*., **4**(4): 27-38.

Okano, K., Sakamoto, Y. and Watanabe, S. (2000). Effects of seedling age at planting on plant from and fruit productivity of single truss tomato grown hydrophonically. *Ornamental Plants and Tea*. **15**: 123-134.

Orzolek, M. (2004). Evaluating vegetable transplants. Vegetable, small fruit and specialty crops. *Virginia Cooper. Extn.*, **3**(3): 9-16.

Parente, A., Gonnella, M., Santamaria, P., Labbate, P., Conversa, G and Elia, A. (2006). Nitrogen fertilization of new cultivars of lettuce. Leuven, Belgium: International Society for Horticultural Science (ISHS). *Acta Hort*., **700**: 137-140.

Pascale, D., Cruces, P. and Valdes, V. (2004). Problems of growing lettuce organically concerning permissible nitrate levels. *J. Agril. Res.*, **46**(1): 305-313.

Rajbir, S., Ram-Asrey and Satyendra, K. (2005). Effect of transplanting time and mulching on growth and yield of tomato. *Indian J. Hort*., **62** (4): 350-353.

Rehman, Z., Hussain, S.A., Abdur-Rab and Sajid, M. (2001). Effect of nitrogen levels and sowing dates on yield of lettuce. Peshawar, Pakistan: NWFP Agricultural University. *Sarhad J. Agric*., **17**(3): 359-362.

Rincon, L., Pellicer, C. and Saez, J. (1998). Effect of different nitrogen application rates on yield and nitrate concentration in lettuce crops. *Agrochemia*, **42**: 304-312.

Rozek S. (2000). Factors affected on nitrate accumulation in vegetable yields. Zes. *Nauk. Agril*., **71**: 19-31.

Ryder, E.J. (1998). Lettuce, Endive and Chicory. CABI Publishing Company, USA. p. 79.

Sarker, R., Ray, S.P., Paul, J., Nusrat, A and Tithi, M.J. (2017). Effect of Seedling Age on Growth and Yield of Tomato. *Intl. J. Agril. Papers*, **2**(2): 13-17.

Singh, C.B., Pandita, M.L. and S.C. Khurana. (1976). Studies on the effect of root age, size and spacing on seed yield of Amaranth. *Veg. Sci.* **16**(2): 119-124.

Soundy, P. and Cantliffe, D.J. (2001). Improving lettuce transplant quality in response to nitrogen nutrition in a floatation production system. Goldenrod, USA: Florida State Horticultural Society. *Proc. Florida State Hort. Soc*., **114**: 294-303.

Staugaitis, G. and Viskelis, P. (2000). The effect of nitrogen rates and mineral nitrogen in soil on head lettuce. Babtai, Lithuania: Lietuvos Sodininkystes ir Darzininkystes Institutas (Lithuanian Institute of Horticulture). *Acta Hort*., **19**(2): 82-97.

Thomson, H.C. and Kelly, W.C. (1988). Vegetable Crops. Mcgrasw Hill Book Co. Inc., New York. pp. 230-255.

Tittonell, P., Grazia, J.D. and Chiesa, A. (2001). Effect of nitrogen fertilization and plant population during growth on lettuce (*Lactuca sativa* L.) postharvest quality. Leuven, Belgium: International Society for Horticultural Science (ISHS). : *Acta Hort*., **553**(1): 67-68.

Tittonell, P.A., Grazia, J. and Chiesa, A. (2003) Nitrate and dry water concentration in a leafy lettuce (*Lactuca sativa* L.) cultivar as affected by N fertilization and plant population. *Agril. Tropica Subtropica*, **36**: 82-87.

Troyanos, Y.E., Assimakopoulou, A. and Moustaka, E. (2004). Effect of nitrogen fertilization on the yield and nitrogen concentration of lettuce (*Lactuca sativa*). Kifissia, Greece: Benaki Phytopathological Institute. *Annals Benaki Phytopathol. Inst*., **20**(1): 20-28.

Vavrina, C.S. (1998). Transplant age in vegetable crops. *Hort. Tech.,* **8**(4): 550–555.

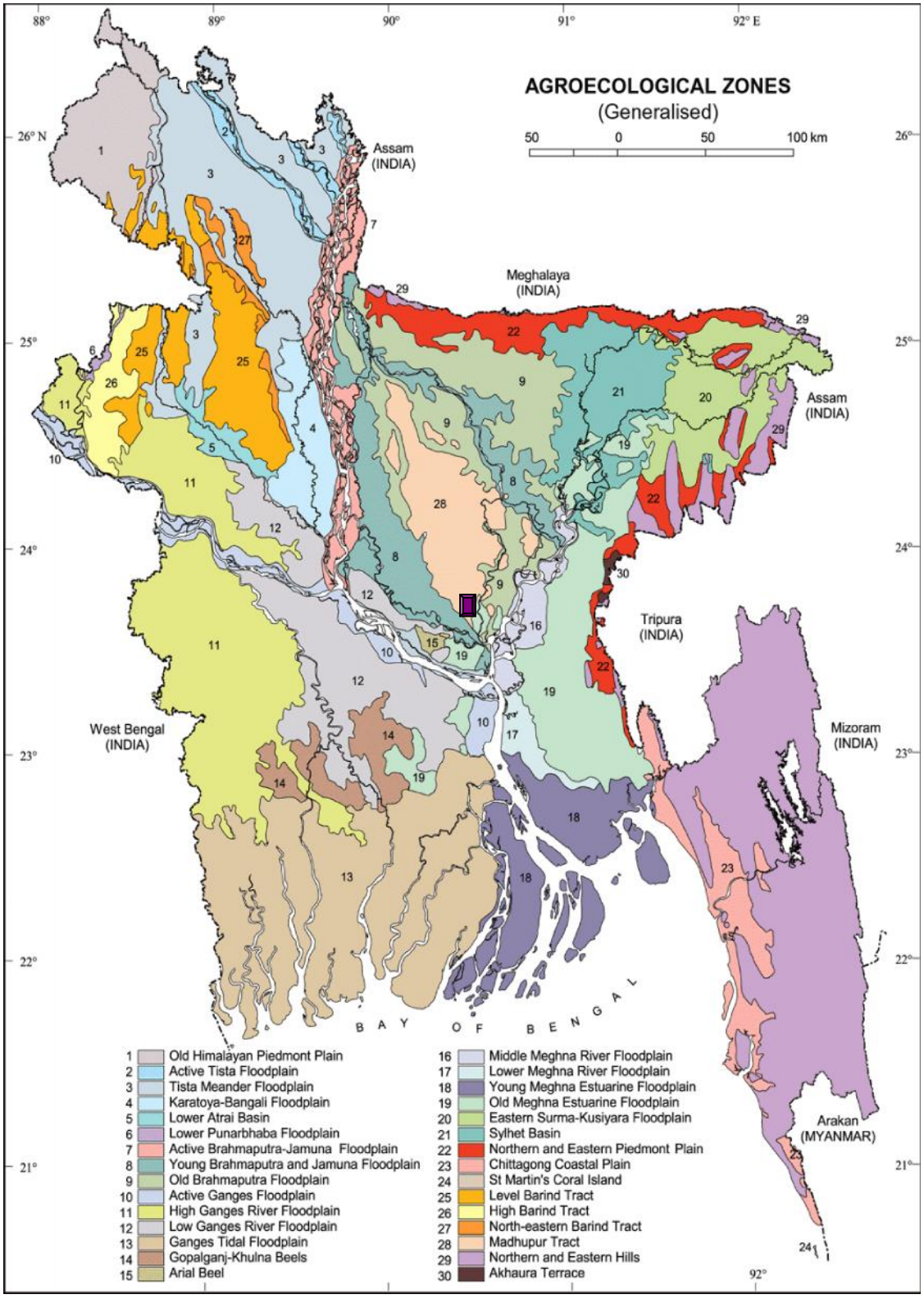
Wang, Z.H., Li, S. and Malhi, S. (2008). Effects of fertilization and other agronomic measures on nutritional quality of crops. *J. Sci. Food Agron*., **88**: 7-23.

Work, M.U. (1997). The nutritive value of lettuce. *J. Hebei. Agril. University*. **20**(2): 50-54.

Zhao, R. and Chen, J.Q. (2004). Study on age and nutritive area of tomato seedlings grown in plug tray. *China Veg.*, **4**: 19-21.

APPENDICES

Appendix I. A Map of the experimental location



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 (%)	0.45
Organic matter (%)	0.78
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. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from November, 2016 to January 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

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

Appendix IV. Analysis of variance of the data on plant height at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	0.159	0.804	2.105	0.215
Seedling age (A)	2	14.831**	19.527**	18.609**	18.431**
Levels of nitrogen (B)	3	33.987**	55.774**	81.921**	126.485**
Interaction (A×B)	6	4.183*	9.614*	13.426**	17.528**
Error	22	1.485	3.278	2.294	2.144

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

Appendix V. Analysis of variance of the data on number of leaves/plant at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Number of leaves/plant at			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	0.001	0.123	0.004	1.030
Seedling age (A)	2	14.134**	15.293**	13.521**	18.308**
Levels of nitrogen (B)	3	14.416**	72.559**	68.750**	64.193**
Interaction (A×B)	6	6.963**	2.736*	5.271*	5.954*
Error	22	1.317	0.920	2.031	1.865

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

Appendix VI. Analysis of variance of the data on leaf length at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Leaf length (cm) at			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	0.434	0.004	0.165	0.494
Seedling age (A)	2	6.876**	12.527**	16.778**	14.376**
Levels of nitrogen (B)	3	25.559**	26.309**	60.152**	63.497**
Interaction (A×B)	6	3.052**	3.112*	1.832*	2.470*
Error	22	0.594	1.008	0.710	0.883

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

Appendix VII. Analysis of variance of the data on leaf breadth at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Leaf breadth (cm) at			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	0.754	0.056	0.105	0.810
Seedling age (A)	2	11.628**	15.009**	12.959**	25.239**
Levels of nitrogen (B)	3	31.080**	31.151**	51.666**	50.811**
Interaction (A×B)	6	2.733*	2.403**	1.731*	2.320*
Error	22	0.970	0.652	0.564	0.876

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

Appendix VIII. Analysis of variance of the data on fresh weight of plant at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Fresh weight of plant (g)			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	7.378	8.254	7.639	32.725
Seedling age (A)	2	294.63**	612.82**	510.64**	390.253**
Levels of nitrogen (B)	3	104.01**	1025.23**	1050.61**	1396.50**
Interaction (A×B)	6	54.143*	62.466*	125.035*	134.689**
Error	22	21.113	24.208	49.129	47.070

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

Appendix IX. Analysis of variance of the data on dry matter content in plant at different days after transplanting (DAT) of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square			
		Dry matter content in plant (%) at			
		15 DAT	22 DAT	29 DAT	36 DAT
Replication	2	0.010	0.015	0.214	0.234
Seedling age (A)	2	2.600**	4.888**	18.718**	16.019**
Levels of nitrogen (B)	3	7.177**	23.778**	38.431**	37.327**
Interaction (A×B)	6	0.302*	2.186**	1.225*	1.015*
Error	22	0.116	0.528	0.467	0.419

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

Appendix X. Analysis of variance of the data on yield per plot at different days after transplanting (DAT) and total of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square				
		Yield per plot (kg) at				
		15 DAT	22 DAT	29 DAT	36 DAT	Total
Replication	2	0.001	0.001	0.001	0.005	0.013
Seedling age (A)	2	0.042**	0.088**	0.074**	0.056**	1.004**
Levels of nitrogen (B)	3	0.015**	0.148**	0.151**	0.201**	1.780**
Interaction (A×B)	6	0.008*	0.009*	0.018*	0.019**	0.161**
Error	22	0.003	0.003	0.007	0.007	0.034

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

Appendix XI. Analysis of variance of the data on yield/hectare at different days after transplanting (DAT) and total of lettuce as influenced by seedling age and nitrogen

Source of variation	Degrees of freedom	Mean square				
		Yield/hectare (kg) at				
		15 DAT	22 DAT	29 DAT	36 DAT	Total
Replication	2	0.005	0.005	0.005	0.020	0.055
Seedling age (A)	2	0.184**	0.383**	0.319**	0.244**	4.356**
Levels of nitrogen (B)	3	0.065**	0.641**	0.657**	0.873**	7.726**
Interaction (A×B)	6	0.034*	0.039*	0.078*	0.084**	0.698**
Error	22	0.013	0.015	0.031	0.029	0.147

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

Appendix XII. Per hectare production cost of lettuce as influenced by seedling age and nitrogen (Cont'd)

A. Input cost

Treatments	Labour cost	Ploughing cost	Seedling Cost	Water for seedlings establishment	Manure and fertilizers				Insecticide/ pesticides	Sub total (A)
					Cowdung	Urea	TSP	MoP		
S_1N_0	45,000	34,000	15,000	25,000	20,000	0	1,875	3,375	16,000	160,250
S_1N_1	45,000	34,000	15,000	25,000	20,000	1,392	1,875	3,375	16,000	161,642
S_1N_2	45,000	34,000	15,000	25,000	20,000	1,560	1,875	3,375	16,000	161,810
S_1N_3	45,000	34,000	15,000	25,000	20,000	1,760	1,875	3,375	16,000	162,010
S_2N_0	45,000	34,000	15,000	25,000	20,000	0	1,875	3,375	16,000	160,250
S_2N_1	45,000	34,000	15,000	25,000	20,000	1,392	1,875	3,375	16,000	161,642
S_2N_2	45,000	34,000	15,000	25,000	20,000	1,560	1,875	3,375	16,000	161,810
S_2N_3	45,000	34,000	15,000	25,000	20,000	1,760	1,875	3,375	16,000	162,010
S_3N_0	45,000	34,000	15,000	25,000	20,000	0	1,875	3,375	16,000	160,250
S_3N_1	45,000	34,000	15,000	25,000	20,000	1,392	1,875	3,375	16,000	161,642
S_3N_2	45,000	34,000	15,000	25,000	20,000	1,560	1,875	3,375	16,000	161,810
S_3N_3	45,000	34,000	15,000	25,000	20,000	1,760	1,875	3,375	16,000	162,010

S_1: Transplanting of 15 days old seedlings
S_2: Transplanting of 20 days old seedlings
S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)
N_1: 80 kg N/ha
N_2: 90 kg N/ha
N_3: 100 kg N/ha

Appendix XII. Per hectare production cost of lettuce as influenced by seedling age and nitrogen

B. Overhead cost

Treatments	Cost of lease of land (12% of value of land 14,00000 Tk./year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 12% of cost/year)	Sub total (Tk.) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
S_1N_0	84,000	8,013	15,136	107,148	267,398
S_1N_1	84,000	8,082	15,223	107,306	268,948
S_1N_2	84,000	8,091	15,234	107,325	269,135
S_1N_3	84,000	8,101	15,247	107,347	269,357
S_2N_0	84,000	8,013	15,136	107,148	267,398
S_2N_1	84,000	8,082	15,223	107,306	268,948
S_2N_2	84,000	8,091	15,234	107,325	269,135
S_2N_3	84,000	8,101	15,247	107,347	269,357
S_3N_0	84,000	8,013	15,136	107,148	267,398
S_3N_1	84,000	8,082	15,223	107,306	268,948
S_3N_2	84,000	8,091	15,234	107,325	269,135
S_3N_3	84,000	8,101	15,247	107,347	269,357

S_1: Transplanting of 15 days old seedlings
S_2: Transplanting of 20 days old seedlings
S_3: Transplanting of 25 days old seedlings

N_0: 0 kg N/ha (control)
N_1: 80 kg N/ha
N_2: 90 kg N/ha
N_3: 100 kg N/ha

Appendix XIII. Photographs of the experiment

Plate 1. Photograph showing experimental plot

Plate 2. Photograph showing lettuce at harvesting stage