GROWTH AND YIELD OF LETTUCE (*Lactuca sativa* L.) AS INFLUENCED BY NITROGEN AND MULCHING

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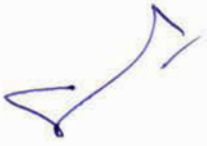

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CERTIFICATE

This is to certify that the thesis entitled **"Growth and Yield of Lettuce (*Lactuca sativa* L.) as Influenced by Nitrogen and Mulching"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in HORTICULTURE, embodies the result of a piece of bona fide research work carried out by Zinia Tul Fardous, Registration number 06-02156 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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Dedicated to
My
Beloved Parents

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The Author

GROWTH AND YIELD OF LETTUCE (Lactuca sativa L.) AS INFLUENCED BY NITROGEN AND MULCHING

ABSTRACT

An experiment was conducted at the farm of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2006 to February 2007 to study the effect of nitrogen and mulching on growth and yield of lettuce. The experiment considered two factors. Factor A: Levels of nitrogen (4 levels) i.e. 0 kg N/ha (Control), 60 kg N/ha (N_1), 80 kg N/ha (N_2), 100 kg N/ha (N_3); Factor B: Mulching (4 levels) i.e. No mulch (M_0), rice straw (M_1), water hyacinth (M_2), black polythene (M_3). Data were collected in respect of the plant growth characters and green yield of lettuce at different days after transplanting. At 55 DAT the tallest (30.49 cm) plant height was recorded from N_2, while control gave the shortest (24.04 cm) plant height. The maximum (28.01) number of leaves per plant was recorded from N_3, while control gave the minimum (22.67) number of leaves per plant. The maximum (474.24 g) leaf yield per plant was recorded from N_3, while control gave the minimum (374.92 g) leaf yield per plant. The maximum (15.35%) dry matter content in plant was recorded from N_2, while control gave the minimum (11.43%). The maximum (10.21 kg) yield per plot was recorded from N_2, while control gave the minimum (7.88 kg) yield per plot. The maximum (42.56 t/ha) yield was recorded from N_2 at 55 DAT, while control gave the minimum (32.85 t/ha) yield. At 55 DAT the tallest (31.06 cm) plant height was recorded from M_3 and the shortest (21.69 cm) was found from control. The maximum (28.29) number of leaves per plant was recorded from M_3, while the minimum (21.15) was found from control. The maximum (487.48 g) leaf yield per plant was recorded from M_3, while the minimum (326.59 g) was found from control. The maximum (14.40%) dry matter content in plant was recorded from M_3, while the minimum (12.28%) was found from control. The maximum (11.03 kg) yield per plot was recorded from M_3, while the minimum (5.27 kg) was found from control. Maximum yield (45.96 t/ha) was recorded from M_3, while the minimum (21.97 t/ha) was found from control at 55 DAT. Among different treatment combinations N_2M_3 (80 kg N/ha + black polythene mulch) was more effective than those of others. The highest (3.64) benefit cost ratio was performed from the treatment combination of N_2M_3 and the lowest benefit cost ratio (0.81) was obtained from control treatment i.e. N_0M_0.

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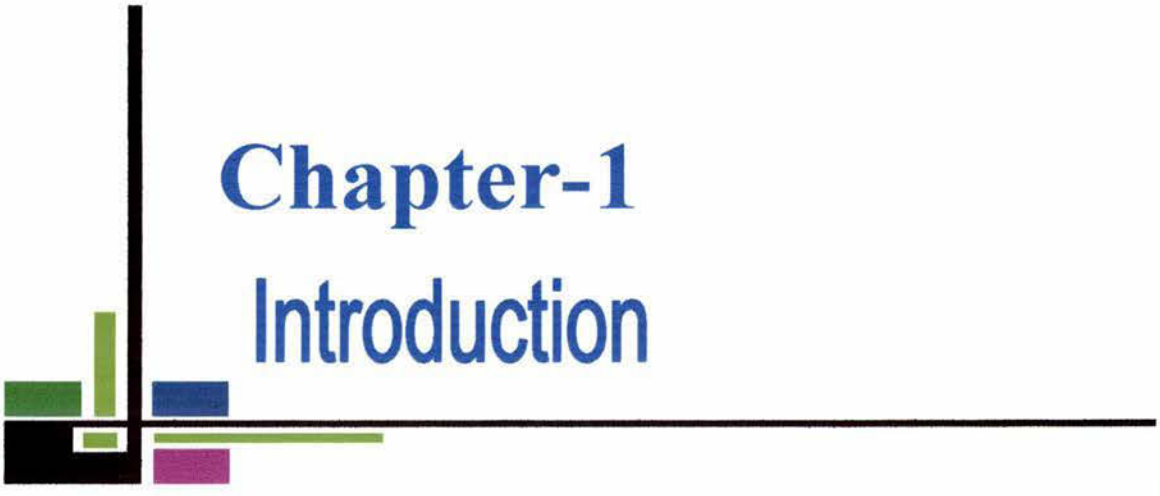


Chapter-1

Introduction

INTRODUCTION

Lettuce (*Lactuca sativa L.)* belongs to the family Compositae that is the most popular salad crops in the world. It is leafy herb with milky juice crop. It produces a short stem early in the season, a cluster of leaves varying considerably in shape, character and colour in different varieties. Later in the season a seed stock is produced (Ryder, 1979). It is mainly a cold loving crop. 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 in 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). It also contains protein, carbohydrate and vitamin C. Per hundred gram of edible portion of lettuce contains moisture 93.4 g, protein 2.1 g, fat 0.3 g, minerals 1.2 g, fibre 0.5 g, carbohydrates 2.5 g, calcium 310 mg, phosphorus 80 mg, iron 2.6 mg, vitamin A 1650 I.U thiamine 0.09 mg, riboflavin 0.13 mg and vitamin C 10 mg (Gopalan and Balaraman, 1966). It is usually used as salad with tomato, carrot, cucumber or other salad vegetable. It is often served alone or with dressing. Its nutritive value is not spoiled. Moreover, it is anodyne, sedative, diuretic and expectorant (Kallo, 1986).

Lettuce is a newly introduced crop in our country and getting popularity day by day. Its production package is not much known to Bangladeshi farmers. Among various factors responsible for higher yield, supply of nutrient and availability of moisture play vital role in the production and quality of lettuce. Deficiency of soil nutrient is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor,

1982). The cultivation of lettuce requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both.

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 cultural practices. Fertilizer plays a vital role in proper growth and development of lettuce. Fertilizer application in appropriate time, appropriate dose and proper method is the prerequisite of crop cultivation (Islam, 2003). 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.

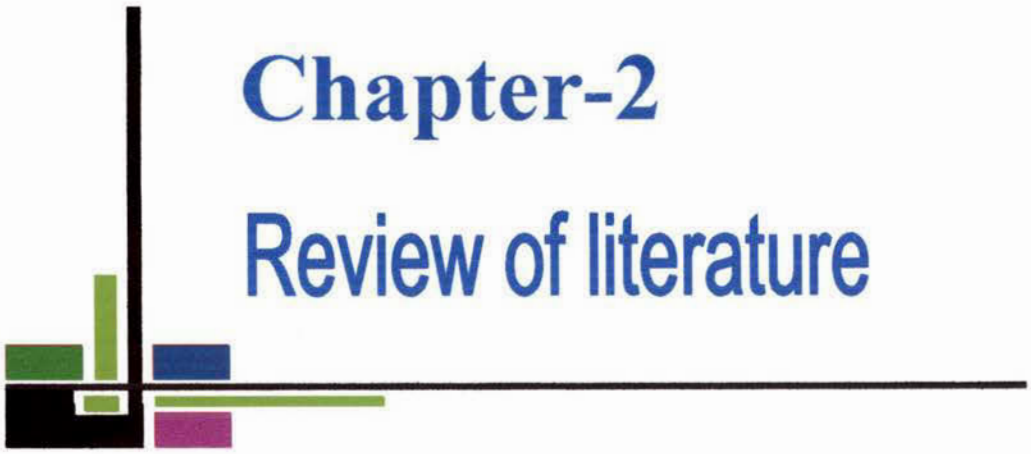
Generally, a large amount of nitrogen is required for the production of leafy vegetable (Opena *et al.*, 1988). It plays a vital role as a constituent of protein, nucleic acid and chlorophyll. It is also the most different element to manage in a fertilization system such that an adequate, but not excessive amount of nitrogen is available during the entire growing season (Anon., 1972). Nitrogen progressively increases the marketable yield (Obreza and Vavrina, 1993) but an adequate supply of nitrogen is essential for vegetative growth, and desirable yield (Yoshizawa *et al.*, 1981). Excessive application of nitrogen on the other hand is not only uneconomical but also induces physiological disorder.

In Bangladesh, lettuce is grown during winter season where rainfall is scanty. Being a succulent vegetable, it needs plenty of water for its normal growth and development. Irrigation is, therefore, essential for its successful production. But additional irrigation causes increased cost of production. Under such condition, mulching may be practiced in

crop cultivation which can substitute irrigation to minimize cost of production. Mulch is again highly effective in checking evaporation and hence is recommended for most crops of home garden like potato, sweet potato, carrot and ginger (Kim *et al.* 1988; Chowdhury *et al.*, 1993; Jaiswal *et al.*, 1996). Mulching also suppress weed infestation effectively. Furthermore, it stimulates microbial activity in soil through increasing soil temperature which improves agro-physical properties of soil.

Nitrogen and mulching are also effective for the production of any crop. Mulching increases the availability of nitrogen ensuring soil moisture. Considering the above factors, the present experiment was undertaken to study the following objectives.

i. To identify the optimum doses of nitrogen for the growth and development of lettuce;
ii. To know the effect of mulching on growth and yield of lettuce production and identify the best one;
iii. To know the combined effect of nitrogen fertilizer and mulching on lettuce production.



Chapter-2

Review of literature

REVIEW OF LITERATURE

Lettuce is one of the most important and popular salad vegetable in Bangladesh 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 growth and yield of lettuce have been carried out in our country as well as many other countries of the world. Therefore, the research work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important informative works and research findings related to nitrogen and mulching 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 nitrogen on growth and yield of lettuce

Lei *et al.* (2004) stated that the rules of nitrate accumulation in Dian Lake (Beijing, China) drainage area in intensive cultivation were studied. Results showed that fertilizer N was the prime cause of the accumulation of No3 in soil. The effects of P on NO3 accumulation in soil differ from crops to crops. The fertilizer P input evidently influenced the accumulation of NO_3 in the soil of cultivating pimiento [*Capsicum annuum*], and the increase of fertilizer P input decreased NO_3 accumulation. The effects of P on NO3 accumulation were different according to the changes of N input. No evident effects were observed on the NO_3 accumulation in the soil of cultivating lettuce with P input.

Jaenaksorn and Ikeda (2004) reported that in an attempt to reduce the hydrophonic growing cost and to facilitate the preparation and source of nutrient solution, soil fertilizer was evaluated as a substitute for soilless nutrient solution in Osaka Prefecture, Japan in 1999. Comparisons of growth and nutrient uptake were made with pak choi (*Brassica chinensis*), lettuce (*Lactuca sativa*) and Chinese cabbage (*B. pekinensis*) in deep fiow technique (DFT)

as and re-circulation nutrient film technique (NFT) treated with soilless nutrient solution (NS1) and soil fertilizer solution (NS2). The nutrient solution was chemically analyzed every week to monitor its change. Satisfactory results were achieved in all vegetables tested.

Feller *et al.* (2003) observed that bunching carrots, Japanese radish, dill, lambs' lettuce, rocket salad, celeriac and celery. Harvesting tabulates the average removal of nutrients by harvesting for N, P, K and Mg. Nitrogen demand and the N main target value in kg/ha are compared with data published in 2001. Data are within a 10% variation range, however Japanese radish and celery had higher demands due to strong vegetative growth. The highest N demand was found in celery (270 kg N/ha), followed by Japanese radish (245 kg N/ha), spring onion (160 kg N/ha), bunching carrot (145 kg/ha), dill (110 kg N/ha), rocket salad (100 kg N/ha) and lambs' lettuce (38 kg N/ha). For rocket salad, nitrogen uptake curves modeled and measured are presented for different sowing dates.

Nadasy (1999) reported that the greatest dry matter production was found at 80mg/kg N. The fresh and dry weights were lower after the application of calcium nitrate. Applying N in the ammonium form produced similar results to applying both nitrate and ammonium forms. Dry matter production was greatest when both N forms were applied. Increasing N rates up to 320 mg/kg gradually raised the N content of the lettuce leaves.

Nadasy (1999) set up experiments in 1995 and 1996 using lettuce cv. Balaton under greenhouse conditions. N was applied as NO3-N, NH4-N or both at a ratio of 1:1 using calcium nitrate (7.6%N), ammonium sulphate (20.2%N) and ammonium nitrate (34.7%N). Nitrogen rates were 0, 40, 80, 160, 320, and 640 mg N/kg. The plants were harvested after 6 weeks. Leaf fresh weight was highest with 80 or 160 mg/kg N. The greatest dry production

was found at 80 mg/mg K Dry matter production was greatest when both N forms were applied. Increasing N rates tip to 320 mg/kg gradually raised the N content of the lettuce leaves. Leaf N content was highest when calcium nitrate was applied.

Tisselli (1999) reported that maximum rates of organic manure (usually poultry manure) and NPK recommended in 1998 by the Crop for use in lettuce crops in Emilia-Romagna, Italy are tabulated. Trials showed that a combination of organic and mineral fertilizers gave higher yielder of marketable heads, fewer rejects and a better average weight/head than mineral.

Bastelaere (1998) stated that different fertilizer treatments with ammonium nitrate (3.5-8 kg/acre), patent potassium (3.5-8 kg/acre) and triple phosphate (3.65 kg/acre) were carried out during 1997-98 in 6 green houses with lettuce (cv. Completo, Alfredo, Omega and Samir) in Belgium. Soil analysis was carried out before and after fertilizer applications and at harvest. Ten out of 12 trials showed the greatest crop weights and better crop quality in treatments with equal amounts of ammonium nitrate and patent potassium. Lower crop weights occurred in the treatment with standard fertilizer plus Papaver (46 kg/acre). Nitrate content in heads at harvesting was not influenced by nitrogen fertilizer levels. However, these fertilizer treatments can result in more leaf veins, leaf vein rot and yellow leaves.

Sajjan *et al.* (1998) observed that with the application of 150, 75 and 75 kg N, P_2O_5 and K_2O, respectively per ha, under protective irrigated conditions, led to the production of high quality lettuce cv. Great Lakes seeds in terms of germination percentage, root length, shoot length, seedling dry matter accumulation, 1000-seed weight and seedling vigour index.

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

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

Anez and Pino (1997) evaluated the methods and timing for the application of nitrogen fertilizer to lettuce Great Lakes. Ten nitrogen treatments (side dressing of 100 kg/N ha at transplantation or 15, 30, 45, and 60 days after transplanting (DAT), side dressing of 50 kg N/ha plus 50 kg N/ha applied or foliar fertilizer applied at transplantation or 15, 30, 45 and 60 DAT, control without nitrogen fertilizer) were tested on a sandy-loam soil in Merida, Venezuela. Significant differences were found between methods of application and the control when 100 kg N/ha were applied by the 45 DAT. No significant differences were observed between the treatments and the control when 100 kg N ha was applied after 45 DAT.

Kowalska (1997) conducted green house trials in two winter-spring seasons, N fertilizer in the form of urea, ammonium or nitrate was applied once before planting to pot grown plants of lettuce cv. Alka in peat or a soil-based mixture (peat: sand: mineral soil, 1:1:1). The average fresh head weight and dry matter yield of plants grown in peat was considerably

higher than that of plants grown in the soil mixture. Application of fertilizer with reduced nitrogen forms increased the ammonium content of plants, where as nitrate-N increased nitrate accumulation. It is concluded that application of reduced forms of N significantly improved the quality of the lettuce by reducing the accumulation of nitrates especially in plants grown in peat which has a slower rate of nitrification.

Stancheva *et al.* (1997) investigated the effects of three fertilizer rates and two N sources (ammonium nitrate or urea) on growth and plant nutrition of lettuce in green house. Increasing N rates and soil acidity influenced growth and plant nutrition. A beneficial effect of urea on lettuce fresh and dry biomass was observed in plants grown at pH 5.8 and particularly at pH 4.9. Application of urea increased N, P, K, Ca and Mg contents of plants grown at pH 6.1; plants grown at pH 5.8, similar effects were observed in the presence of ammonium nitrate. Lettuce grown at pH 4.9 showed higher N and Mg contents when the N source was urea and higher K and Ca contents when N was applied as ammonium nitrate.

Abdel-Razik (1996) carried two experiments at the Experiment Station Farm of Agriculture and Veterinary Medicine College, King Saud University, Saudi Arabia, in the winter of 1991-92 and 1992-93. Seeds of the lettuce cv. White Paris were sown in a nursery in October 1991 and 1992. Seedlings were transplanted in December. N as ammonium sulphate (20.5%N) was applied at 0, 100, 200 and 300 kg/ha in 3 equal doses 3, 5 and 7 weeks after transplanting. Increasing N concentration resulted in increases in all measured parameters. Head fresh weight and total yield both increased with increasing applications of N. It concluded that to maximize lettuce yields the optimum N application was 200 kg/ha.

Belligno *et al.* (1996) observed that the effect of different fertilizers on nitrate contents in two lettuce cultivars, Iceberg and Romana was studied. Plants cultivated in a sandy-loam soil were fertilizer with ammonium nitrate, calcium-nitrate, ammonium-sulphate, urea and oxamide (100, 200, 300 kg/ha) and compared with a control with no added N. Several genotypes of lettuce differed significantly in $N\text{-}NO_3$ accumulation. Nitrogen application rates and different fertilizer influenced nitrate content.

Rozek *et al.* (1995) presented the results of a 2-year study on the effect of nitrate-N and urea-N forms, applied to lettuce plants cultivated in a plastic tunnel in changes in quality parameters at harvest and during the storage of heads at low (50^0C) and high (200^0C) temperatures. N from had no effect on fresh weight, dry matter content, soluble sugars, starch, total protein or ascorbic acid concentrations. Cultivar's effects on plant composition were generally stronger than fertilizer effects. The effect of the form of applied N was more distinct during storage of the lettuce leaves both at room temperature (200^0C) and in cold chamber (50^0C).

Steingrobe and Schenk (1994) reported that seeds of lettuce cv. Clarion were sown in 4 X 4 cm peat blocks and seedlings were planted out 3 weeks later at a spacing of 30 x 30 cm. Seedlings received different amounts of N fertilizer before and after planting out N application increased root growth in the first 3 weeks after planting out, but had no effect on yield.

Baca *et al.* (1993) reported that green manure, equivalent to 40 and 80 kg N/ha, was incubated with a sand-soil mixture for 2 and 5 months and tested in a greenhouse experiment with lettuce. Before and after the incubation period, the total organic carbon was

extracted by the $Na_4P_2O_7$-NaOH0.1M method and purified with PVP resin. There was no difference between the quantities of humic carbon extracted after the different treatments with phosphorus, but there was a difference in quality. The mixture incubated with phosphorus showed a positive effect on plant growth but those incubated only with green manure showed a negative response.

Karacal and Turetken (1992) carried out a trial on the cultivation of lettuce cv. Lital in Turkey. N as ammonium sulphate, ammonium nitrate or urea was applied at 24 kg/da and P (as triple super phosphate) was applied at 0, 8, 16, or 24 kg/da. Yield and quality of lettuces were significantly improved by ammonium sulphate application with average yield of 7556 kg/da compared with 5417 kg/da for lettuces grown without N fertilizer. Average head weight was 497g for lettuces that received ammonium sulphate, compared with 358g for those grown without N fertilizer (1 dounum = 2500 m^2).

In another experiment, Karacal and Turetken (1992) also reported that lettuce received N at 0, 25, 50, 75 or 100 kg/da. Average head weight increased with increasing rate of N fertilizer (1173.2 g and 230.2 g with 100 and 0 kg/da, respectively). The critical tissue concentration of nitrate-N for human consumption (0.20%) was exceeded by application of 75 and 100 kg/da (0.226-0.332%). It was concluded that application of N at 50 kg/da resulted in optimum lettuce yield and quality.

Sajjan *et al.* (1992) studied that the response of lettuce cv. Great lakes to different dates of transplanting (20 July, 20 August and 20 September) and levels of fertilizer (50:25:25, 75:25:25, 100:50:50, 125:50:50, 150:75:75, and 175:75:75 kg N, P_2O_2 K_2O/ha) during 1988-89. The seed yield was highest when the crop was transplanted on August 20th. The

treatment receiving 175:75:75 kg N, P_2O_5, K_2O/ha gave the highest seed yield and interaction was significant. Significant increase in number of branch/plant, number of capsule/plant, number of seed/capsule and 1000 seed weight contributed to seed yield.

Karacal and Turetken (1992) observed that Lettuces received N, as ammonium sulphate, at 0, 25, 50, 75 or 100 kg/da. Average head weight increased with increasing rate of N fertilizer (1173.2 g and 230.2 g with 100 and 0 kg/da, respectively). The critical tissue concentration of nitrate-N for human consumption (0.20%) was exceeded by application of 75 and 100 kg N/da (0.266-0.332%). It was concluded that application of N at 50 kg/da resulted in optimum lettuce yield and quality.

Rubeiz *et al.* (1992) mentioned that the lack of significant response in yield was due to sufficient levels of soil NO_3-N and available P in the untreated soil. Manure or fertilizer application had no effect on soil EC, pH or available P. Soil NO_3-N at harvest was significantly increased only by NH_4NO_3. Leaf PO–P concentration was not affected by treatments, but leaf NO_3-N at heading was significantly increased by all treatments.

Sajjan *et al.* (1991) reported that seedlings of the cultivar Great Lakes, planted in a sandy clay soil [details given] in July, Aug. or Sep., received N, P and K at 6 different rates. Data are tabulated on FW in g/plant and head yield in t/ha. The highest yield (17 t/ha) was obtained from plants transplanted on 20 Sep. and fertilized with N at 175, P at 75 and K at 75 kg/ha.

Sajjan *et al.* (1991) conducted an experiment in which seedlings of lettuce cv. Great takes planted in a sandy clay soil in July-August or September, received N, P and K at six

different rates. Data are tabulated on fresh weight in g/plant and head in t/ha. The highest yield (17 t/ha), was obtained from plants transplanted on 20 September and fertilizer with N at 175, P at 75 and K at 75 kg/ha.

EL-Hassan, (1990) had grown lettuce cv. Dark Green lettuce on experimental plot in Cairo in the winter seasons of 1987 and 1988. The effects of various planting systems and application of 20 or 40 kg N/feddan on head weight, dry matter content and N content were recorded. The higher N rate .and wide spacing (30 cm) gave greater head weight, % dry matter, total N (%) in dry matter and NO_3-N content in fresh leaf midribs. The highest total and saleable yields and the highest total dry matter content were achieved with the higher N rate, spacing at 10 cm and planting on both sides of the planting ridges (1 feddan = 0.42 ha).

The effects of method of application on yield and nitrate content of lettuce was carried out by Bakker *et al.* (1984). Plants grown by applying N through the irrigation system (fertilization) were compared with plants fertilizer with broadcast nitrogen. Fertilization proved to increase the availability and uptake of N, hence increasing the nitrate content of the crop compared to broadcast fertilization. Yield however much less affected by method fertilization.

Rahim and Siddique (1982) reported from their experiment that the highest yield 32 t/ha of lettuce cv. Kiser when 30 kg N/ha was applied as a basal dressing and another 30 kg N/ha as foliar spray in weekly intervals after transplanting. Welch *et al.* (1983) observed that the application of N at 120 Ib/acre and nitrapyrin (a nitrification inhibitor) gave a significantly higher yield then N at 180 Ib/acre and almost as good a yield with N at 240 Ib/acre. They also found that the efficiency of N uptake ranged from 12% for 180 Ib N/acre as a single

application to 25% for 60 Ib N/acre as a split application. The use of nitrapyrin significantly increased N uptake.

2.2 Effect of mulching on the growth and yield of lettuce

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU, Bangladesh and observed that black polythene mulch and organic manure (cowdung) significantly resulted the highest yield of his experiment. Zhou *et al.*(1995) mentioned that 15N-Labelled ammonium sulfate and rice straw were applied alone or in combination to lettuce in pots. The C:N ratio of the materials applied and the amount of rice straw used were inversely correlated with the N mineralization rate and utilization rate and positively correlated with the amount of residual rice straw-15N.

Haraguchi *et al.* (2003) reported that it is necessary to pay attention to the leaching of nutrient from the viewpoint of the effective utilization of fertilizer and water environmental preservation. Although some literatures describe that plastic mulching system has the benefit to reduce fertilizer loss because the rain that falls in a plastic-mulching field can run into furrows immediately flowing on the impervious plastic film, the facts that water can infiltrate the soil through a transplanting hole have been also reported. To analyze in detail the water movement under the mulching condition the procedure to evaluate the water collection function of crop was proposed, and the results of water collection experiment were used to consider the water flow into transplanting holes. The water collection characteristics of leafy vegetables (broccoli, lettuce and cabbage) were described relating the geometry of leaves. The results of analysis for the water movement under the mulching

condition indicated that the infiltration of rainfall into transplanting holes was white larger than the quantity of the water that broccoli crop could collect to the centre.

Luik *et al.* (2002) worked on the influence of intercropping and sawdust mulching on carrot yield and entomofunna. They observed that intercropping of carrot with garden beans (40 cm row spacing) and mulching with fresh sawdust significantly disoriented pests and decreased the damage of carrots by *Trioza viridula (Trizola cirin)* and *Psila rosae*. Intercropping and sawdust separately did not significantly affect pests. Nineteen species of carbides were found in carrot beds.

Utilization of indigenous materials, i.e. rice straw, wheat straw, rice husks and rice husk charcoal, as soil aerating materials to increase the yield of storage root of carrot under field conditions in wet lowland was investigated by Islam *et al.* (1998). The materials were placed in soil ridges to make aerial spaces in the soil for better storage root development. The fresh and dry weight of storage root were greatest in the rice husk charcoal mass, followed by rice husk charcoal mixture, rice husk mass, rice straw mass and rice husk mixture.

Lee *et al.* (1997) in Korea stated that the higher emergence (87%) was occurred by using transparent film and black polythene film mulches in taro (*Colocasia autiquorum).* Black film mulch also resulted in the tallest (164 cm.) plants with the highest leaf stalk yield (41.65 t/ha) while cormel yield was promoted by transparent film treatment. It was conducted that transparent film was the best as mulching material.

Hossain (1996) observed that plant height leaf number, pseudo stem and bulb diameter, dry manure content of foliage, bulb weight and bulb yield were found significantly higher for mulched than the non-mulched plants in garlic.

Rasul *et al.* (1994) conducted an experiment at the Regional Agricultural Research Station, Jessore on the production of Mukhi Kachu with different types of mulching materials and stated that the mulches significantly improved plant growth and yield.

Shaheen *et al.* (1993) conducted an experiment at the Bangladesh Sugarcane Research Institute (BSRI), Ishurdi, Pabna to investigate the effect of duration of straw mulch on potato intercrop as well as intercropped sugarcane. They observed that straw mulch played a positive role increase the yield of both potato and sugarcane. Shrivastava *et al.* (1994) reported that black polythene mulch reduced 95% weed infestation.

Benoit and Ceustermans (1993) observed that two treatments summer and particularly autumn were most severely affected by the heat and gave low yields. Nitrate contents of the harvested lettuce were much higher than those of controls, since the mulches prevented leaching from the soil. Yields were considerably higher on control than on mulched plots; Trickle irrigation, treatment summer, was not particularly beneficial to growth but resulted in lower nitrate contents than the other treatments. Hochmuth *et al.* (1994) carried out a field trial in Gainesville, USA in spring 1994, in which crisphead lettuce cv. Desert Queen Plants were grown on beds covered with a polythene mulch and drip-system. Plants were found to require a maximum of 185 Ib N/acre for the largest head size and highest yield. Excessive N fertilizer application (> 200 Ib/acre) reduced yields. P fertilizer application did not increase yield or quality.

Choudhury *et al.* (1993) conducted an experiment on sweet potato at BAU with mulching trail and stated that mulching significantly influenced the yield contributing characters of the crop. Better yield (43.03 t/ha) was obtained from mulch treatment with three irrigation at 30 days interval. However, highest yield (46.90 t/ha) was obtained from one irrigation at 30 DAP followed by mulching. Hochmuth and Howell (1993) reported that, leaf area leaf number, total dry weight and the highest marketable yield (18.6 t/ha) was obtained from mulched raised beds where flat non-mulched bed gave the lowest yield (7.0 t/ha).

Abaquia (1992) conducted a trial on ginger and studied the interaction effect of three factors i.e. shade, mulch and fertilizers. He found that the highest significant yield of 17.21 t/ha was obtained from the treatment 200-50-50 kg NPK/ha + mulch followed by the treatment 150-50-50 kg NPK/ha mulch with a mean of 16.20 t/ha. The lowest rhizome yield was obtained from the treatment 0-0-0 kg NPK/ha +shade with a mean yield and only 5.52 t/ha.

Al-Assir *et al.* (1991) mentioned that application of clear plastic mulch with or without N fertilizer did not significantly increase ($P>0.05$) yield of lettuce (cv. Paris Island), grown in autumn on a polyethylene-clad greenhouse in the Mediterranean mountains. Yield ranged from 31 to 38 kg/50 heads. Leaf NO_3-N and total P levels were higher in mulched than in unmulched plants, and in fertilized than in unfertilized plants and were always above the sufficiency level in all treatments. Soil levels of NO_3-N were higher in mulched than unmulched plots, and in fertilized than in unfertilized plots. Soil NO_3-N levels in the top 15 cm of unmulched, unfertilized plots were >41 ppm. This indicates ample supply of N and thus explains the lack of response to added N. It may be concluded that in mild climates and on soils with adequate N, lettuce will not respond to the use of clear mulch and N fertilizer.

For crop growth and yield, soil moisture conservation is an important aspect. Suh *et al.* (1991) conducted an experiment, transparent polythene film and black polythene film mulches were applied to onion crops. They stated the mean soil water content was 2.1-2.8% higher in the mulched plots than in the non-mulched plots. Taja and Vander (1991) reported that, mulching by rice straw with optimum inorganic fertilizer application of 50 kg N/ha was good for canopy coverage of potato. They also found rice straw mulch gave higher yield in potato.

Antil *et al.* (1990) conducted an experiment at various sites in the UK to evaluate crop covers and mulches against vegetable pests. They found that, crop covers showed considerable promise against *Delia radicum* on cauliflower and significantly reduced number of *Psila rosae* on carrot but in the latter case yield tended to be lower compared with those from a full standard spray programme. Mulching with polythene showed some promise in reducing the incidence of *Delia radicum* on Brussels sprouts but did not provide an effective barrier against pemphigus bursarius on lettuce.

In the experiment of Eichin and Deiser (1990) growth and development of cabbage were not much affected by polyethylene mulching but the incidence of rot in the outer leaves was reduced, weed control was better, the final product was cleaner in the mulched plots. Sequential cropping of polyethylene mulched, vegetables with either drip or sprinkler irrigation resulted in more complete use of mulch, fertilizer, fumigant, fuel and labour and reduced mulch disposal problem than a single crop (*Clough et al.* 1990).

Siddique and Rashid (1990) conducted an experiment for 3 seasons to study the effect irrigation and mulching on the yields of 3 varieties of potato (Challisha, Lalpakr and Pakri

Lalita). Water hyacinth was used for mulching. From the results obtained they stated that the varieties response very well to both irrigation and mulching.

Vizzotto and Muller (1990) carried out an experiment on 6 soil covers in carrot cultivation such as shaded plot, sugarcane bagasse, rice husk, say dust, dry straw or sand. They found that, emergence occurred 14 days after sowing encase of shaded plot, which was followed by sugarcane bagasse, rice husk and saw dust.

Mulching tomatoes with different colored polyethylene and paper mulch the development of different group of microorganisms was increased and an increase in ammonification and nitrification occurred from improving temperature, water and air in polyethylene green house (Boyajieve and Rankov, 1989).

Singh and Randhawa (1988) observed that the effect of intercropping and mulch on yield and quality of turmeric (*Curcuma longa*). They stated that intercropping of turmeric with pigeon pea (*Cajanus cajan*), maize or green gram (*Vigna radiata)* reduced the availability of light and the rhizome yield and the application of straw mulch was more beneficial than 1988) reported that the growth and yield of cabbage increases with irrigation upto 209.37 mm of water/ha but in the presence of mulch maximum growth and yield were obtained with 161.72 mm of water/ha. The yield of cabbage was reported to have increased significantly from 14.6 kg/plot in unmulched plot to 31.5 kg/plot when mulched with straw.

Baldev *et al.* (1988) stated that rice straw decreased soil temperature at 10 cm depth by 1-6^0C, conserved soil water suppressed weed growth and increased water used efficiency.

According to Berle *et al.* (1988) black polythene mulch increased yields, gross and net returns over conventional practices of muskmelon production.

Setiawan and Rangsdale (1987) investigated the efficiency of aluminum foil and oat-straw mulches for the control of *Macrosteles fascifrons,*a vector of aster yellow in carrots, was compared with a conventional malathion spray program, in field trail. Both mulches reduced *Macrosteles fascifrons* numbers on carrots compared with an untreated control and a malathion spray treatment. The amount of reflected light was significantly higher in both aluminum foil and oat-straw mulched plots compared with non-mulched controls. Devaux and Haverkort (1987) observed that mulching reduced the soil temperature due to better ground cover.

Sutater (1987) in field trail found that the yields were higher in potato with mulch than without mulch. Mulch reduced day soil temperature. Struzina and Kromer (1988) stated from the economic point of view, the use of straw mulch gave profitable yields covering all additional costs.

Aliuddin (1986) reported the result of study conducted on garlic cv. Lunlbu Hijau mulched with rice straw, rice husk, grass weeds (*Penicum distachyum).* The yield was observed to be the highest (9.18 t/ha) with straw mulch compared with 7.58 t/ha in non-mulched plot.

Djigma and Diemkouma (1986) conducted trials with plastic mulch in dry tropical zones on vegetable crops. Eggplants yielded 33.48% higher with black polyethylene mulch than control. Tomatoes yielded 110.9 t/ha with and 47.6 t/ha without mulch. The higher yield due to polyethylene mulch occurred from better moisture conservation, effective weed

control and early crop. In a trial in the hot season however, mulching of vegetables had adverse effects except with okra. A cost analysis showed that the saving on the cost of water and weed control; and higher productivity justify investment in mulching in cool season.

Kiss (1986) reported that mulching with plastic sheet improved soil and air temperature. Kim *et al.* (1988) stated that, Mulching with white polythene gave 36.1 and 22.7 t/ha yields of potato cv. Dejima and Russet Burbank, respectively compared with 11.5 and 10.6 t/ha obtained from no mulching.

In a field trial with three tomato cultivars, Olasantan (1985) reported that mulching increased seedling dry matter content. The amount of dry matter was increased by 49-207%, depending on plant species and growing date. Mulching also increased leaf chlorophyll content. Mulching and staking significantly improved vegetative growth, yield and yield contributing character of the tomato plants. Mulched plants grew taller and had more branches and a greater number and weight of fruits than staked plants. Improved cultivars responded better to mulching and staking than the local one. Jacobson *et al.* (1980) reported that during the hot season, black polythene sheet mulch increased soil temperature by 8-12^{0}C in the upper 5 cm layer and thereby controlled the weed in the mulched plots and carrot grew normally.

Azad and Nabi (1984) stated that, mulching of potatoes with water hyacinth increased yields significantly over mulching earthing up. Asandhi *et al* (1989) reported that, straw was found to be better mulch material for garlic production than transparent plastic, black plastic and cabbage residues. Largest bulbs and the highest number of cloves/bulb were recorded with straw mulch.

Lang (1984) found that polythene mulch increased the yield of potato (31.14-32.5 t/ha) compared with no mulch (23.2-32.6 t/ha). Manrique and Mayer (1984) observed that plastic mulches raised soil temperature during the winter giving significantly higher yield. In summer, plastic mulches increased day soil temperature to above 30^0C giving an unfavorable environment for plant growth and tuber formation in potato. But favorable soil temperature in both winter and summer was maintained by straw mulch.

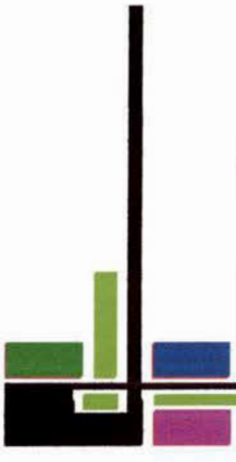
Manrique and Meyer (1984) found that during the winter, soil temperature due to plastic mulched plots increased from 18 to 26^0C. In general, an increase in temperature results in an accelerator salt absorption within a relatively narrow range (Devline and Witham, 1983). These condition gave relatively high tuber yield in most cultivars. In summer, plastic mulches significantly increased dry soil temperature to above 30^0C giving an unfavorable environment from plant growth and tuber formation. Straw mulches maintained stable soil temperature ($<20^0$C) in winter. In summer, straw mulches considerable reduced day soil temperature but soil temperature during the night were always$>20^0$C.

Roy and Singh (1983) in an experiment with rainfed wheat found that mulches reduce the losses of moisture through evaporation and moisture use efficiency was highest under polyethylene mulch followed by straw stubble and no mulch. They observed that when the tomato plants were mulched with rice straw or black plastic, or shaded with transparent plastic, the fruit storage and quality indices were the best in variants mulched with plastic or shade.

Leaf area, leaf number and total shoot dry weight of sweet potato were higher for mulched than for unmulched plants grown during June-September, 1982 in northern U.S.A

(Hochmuth and Howel, 1983). Yield was higher in both flat and raised beds when the mulch was present. The highest marketable yield (18.6 t/ha) was obtained from mulched raised beds. Flat numulched beds gave the lowest yield (7.0 t/ha). Mannan and Rashid (1983) reported that the use of stable mulch increased the yield of panchamukhi kachu. They indicated that mulching might have reduced the evaporation of soil moisture and thus helped in conserving the moisture received in the form of rains during the early stage of plant growth.

Rashid *et al.* (1981) conducted another experiment in Bangladesh and found an increase in height of potato plant when mulched with straw and water hyacinth. They also found the highest tuber yield with water hyacinth mulch followed by rice straw mulch. Yu *et al.* (1981) quantified increased microbial populations as fungi, actinomycetes, ammonifying bacteria. N-fixing bacteria phospho-bacteria in the mulched plots were 58.3, 25.8, 47.3, 56.3 and 56.1%. respectively higher that in the control.



Chapter-3

Materials and Methods

MATERIALS AND METHODS

A field experiment was conducted in the field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2006 to February 2007 to find out the effect of nitrogen and mulching on the growth and yield of lettuce. The materials and methods conducted for the experiment are presented under the following headings:

3.1 Experimental Site

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University and the laboratory of Horticulture and Postharvest Technology of Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is situated in $23^0 74'$N latitude and $90^0 35'$E longitude (Anon, 1989).

3.2 Characteristics of Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was non-calcarious dark grey. The selected experimental plot was medium high land, p^H of the soil was 5.6 and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the SRDI, Soil testing Laboratory, Khamarbari, Dhaka and presented in Appendix - I.

3.3 Weather Condition of the Experimental Site

The climate of experimental site was under the subtropical climate, characterized by three distinct seasons, the monsoon or the rainy season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Metrological data related to the temperature, relative humidity, rainfalls and sunshine during the period of the experiment was collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar, Dhaka and presented in Appendix - II.

3.4 Planting Materials

Seeds of lettuce cultivar, Grand rapid were used in the experiment on 11th November, 2006. The seeds were collected from Dhaka seed store, Siddique Bazar, Dhaka.

3.5 Treatment of the Experiment

The experiment was carried out to find out the effects of different levels of nitrogen and mulching on the growth and yield of lettuce. The experiment considered two factors:

Factor A: Nitrogen (4 levels)

i. N_0: 0 kg N/ha (Control)
ii. N_1: 60 kg N/ha
iii. N_2: 80 kg N/ha
iv. N_3: 100 kg N/ha

Factor B: Mulching (4 types)

i. M_0: No mulching (Control)
ii. M_1: Rice straw
iii. M_2: Water hyacinth
iv. M_3: Black polythene

There were 16 (4 × 4) treatment combinations such as N_0M_0, N_0M_1, N_0M_2, N_0M_3, N_1M_0, N_1M_1, N_1M_2, N_1M_3, N_2M_0, N_2M_1, N_2M_2, N_2M_3, N_3M_0, N_3M_1, N_3M_2 and N_3M_3.

3.6 Experimental design and layout

Two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 25.5 m × 11.2 m was divided into three equal blocks. Each block was divided into 16 plots where 16 treatment combinations were allotted at random. There were 48 unit plots altogether in the experiment. The size of each plot was 2.4 m × 1.0 m. The distance between two blocks and two plots were 1.0 m and 0.5 m respectively. The seeds were sown maintaining distance row to row 40 cm and plant to plant 25 cm. The layout of the experiment is shown in Figure – 1:

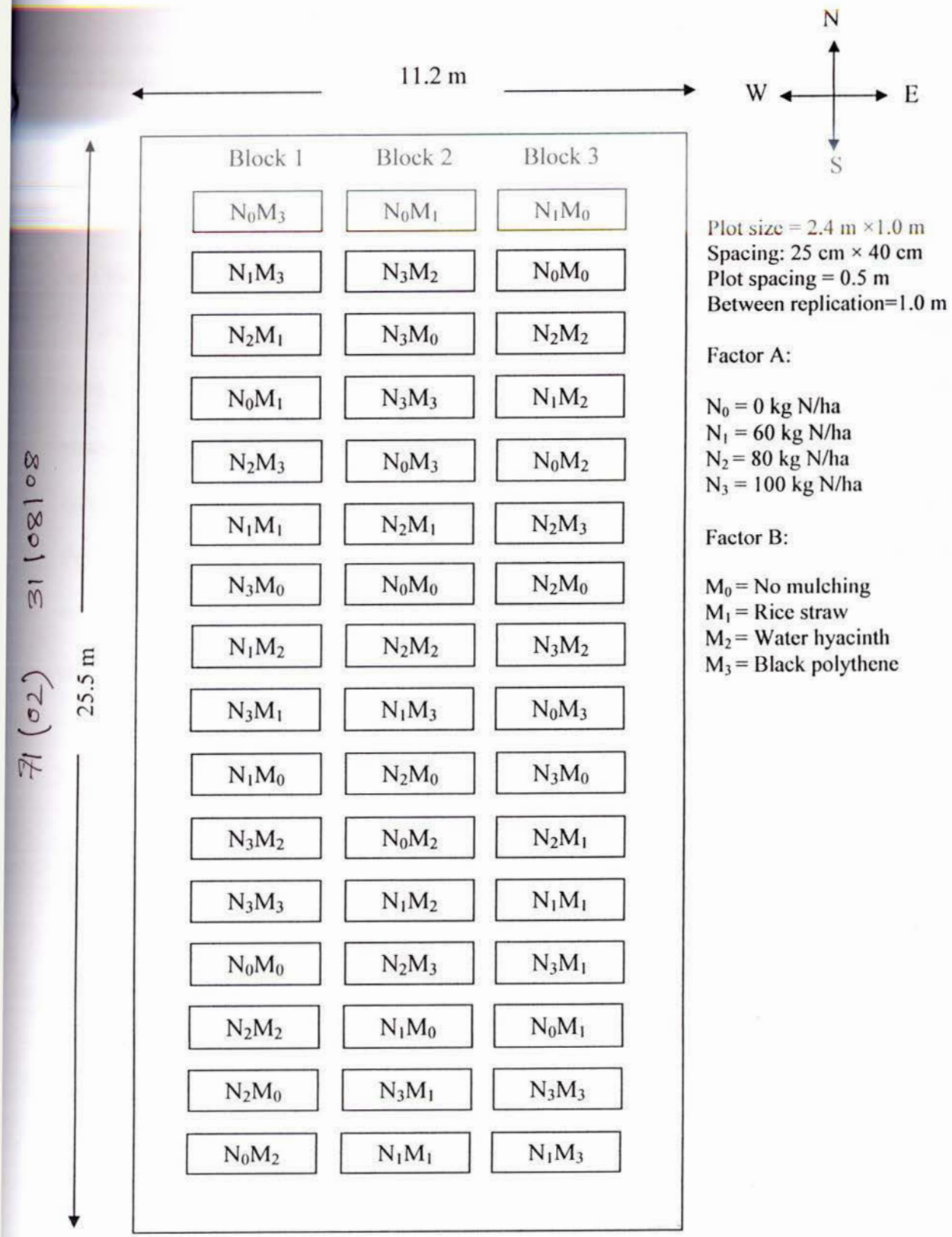


Figure 1: Field layout of two factors experiment in the Randomized Complete Block Design (RCBD)

3.7 Raising of seedlings

The seedlings were raised at the Horticultural Farm, SAU, Dhaka under special care in a 3m × 1m size seed bed. The soil of the seed bed was well ploughed with spade and prepared into loose friable dried masses to obtain good tilth to provide a favorable condition for the vigorous growth of young seedlings. 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. Decomposed cowdung was applied to prepare seedbed at the rate of 10 t/ha. Lettuce seeds were soaked in water for 48 hours and then seeds were mixed with soil and sown in seed bed. Ten (10) grams of seeds were sown in each seedbed on November 11, 2006.

3.8 Preparation of the Main Field

The selected experimental plot was opened in the last week of November 2006 with a power tiller and was exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for planting of lettuce seedlings. The experimental plot was partitioned into the unit plots in accordance with the experimental design nitrogen and mulching as per treatments were applied of each unit plot. The soil was treated with fungicide cupravit against the fungal attack.

3.9 Transplanting of Seedlings in the Main Field

Healthy and uniform sized seedlings were transplanted in the main field according to the treatments on December 07, 2006. The seedlings were uprooted carefully from the seedbed

to avoid any damage to the root system. To minimize the roots damage of the seedlings the seedbed was watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. During transplanting a spacing of 25 cm × 40 cm between row to row and plant to plant were maintained. A number of seedlings were also planted in the border of the experimental plots for gap filling if necessary later on.

3.10 Application of Manure and Fertilizers

The sources of N as urea, TSP and MP were applied respectively. The entire amounts of TSP and MP were applied during the final land preparation. Urea was applied in three equal installments at 10, 20 and 30 days after seedling transplanting. Well-rotten cowdung 10 t/ha was also applied during final land preparation. The following amount of manures and fertilizers were used which are shown as tabular form recommended by Rashid (1993).

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

Fertilizers	Dose/ha	Application (%)			
		Basal	10 DAT	20 DAT	30 DAT
Cowdung	10 tons	100	--	--	--
Nitrogen	As treatment	--	33.33	33.33	33.33
P_2O_5 (as TSP)	150	100	--	--	--
K_2O (as MP)	200	100	--	--	--

3.11 Intercultural operation

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

3.11.1 Irrigation and drainage

Slight over-head irrigation was provided with a watering can to each plot once immediately after transplanting seedling in the main field for better establishment of seedlings.

3.11.2 Weeding

Weeding was done to keep the plots free from weeds, easy aeration of soil, which ultimately ensured better growth and development. Breaking the crust of the soil was done when needed.

3.11.3 Top Dressing

After basal dose of entire cowdung, TSP, and MP at final land preparation, the total amount of urea were applied as per treatment in each plot, were used as top dressed in 3 equal installment at 10,20 and 30 days after seedlings transplanting. The urea was applied on both sides of plant rows and mixed well with the soil by hand. Earthing up was done with the help of nirani immediately after top-dressing of nitrogen fertilizer.

3.12 Plant Protection

For controlling leaf caterpillars Nogos @ 1 ml/L water were applied 2 times at an interval of 10 days starting soon after the appearance of infestation. No remarkable attack of disease was found.

3.13 Harvesting

To evaluate yield, four harvesting were done at different growth stage. First harvesting was done at 25 days after transplanting. Second, third and forth harvesting were done 35, 45 and 55 days after transplanting respectively. Different yield contributing data have been

recorded from the mean of 5 harvested sample plants which was selected at random of each unit plot of every harvesting stage.

3.14 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Five plants were randomly selected from each plot for the collection of data while the whole plot crop was harvested to record per plot data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect.

3.14.1 Plant height (cm)

The height of plant was taken from 5 random selected plants from inner row of each plot and expressed in centimeter (cm) at 25, 35, 45 and 55 days after transplanting (DAT) in the experimental plots. The height was measured from the attachment of the ground level up to the tip of the growing point.

3.14.2 Number of leaves per plant

The total number of leaves per plant was counted. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot starting from 25 to 55 DAT at 10 days interval.

3.14.3 Length of leaf (cm)

The length of leaf was measured by using a meter scale. The measurement was taken from base to tip of the leaf. Average length of leaves was taken from 5 random selected plants from inner rows of each plot. Data was recorded from 25 to 55 DAT at 10 days interval. Mean was expressed in centimeter (cm).

3.14.4 Breadth of leaf (cm)

Breadth of leaf was recorded as the average of 5 petiole selected at random from the plant of inner rows of each plot starting from 25 to 55 DAT at 10 days interval. Thus mean was recorded and expressed in centimeter (cm).

3.14.5 Yield per plant (g)

Leaves of 5 randomly selected plants were detached by a sharp knife and fresh weight of leaves was recorded in gram. Data were recorded as the average of 5 random selected plants of inner rows of each plot starting from 25 to 55 DAT at 10 days interval.

3.14.6 Dry matter content in plant (%)

After harvesting 100g of leaf sample previously sliced into very thin pieces were put into envelop and placed in oven and dried at 60^0C for 72 hours. The sample was then transferred into desiccators and allowed to cool down to the room temperature and then final weight of the sample was taken. The dry matter contents of leaves were computed by simple calculation from the weight recorded by the following formula

$$\% \text{ Dry matter content} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.14.7 Yield per plot (kg)

Yield of lettuce per plot was recorded as the whole plant in every harvest within a plot (2.4 m × 1.0 m) and was expressed in kilogram. Yield included weight leaves at different harvested time.

3.14.8 Yield per hectare (tonnes)

Yield per hectare of lettuce was calculated by converting the weight of plot yield to hectare and was expressed in ton.

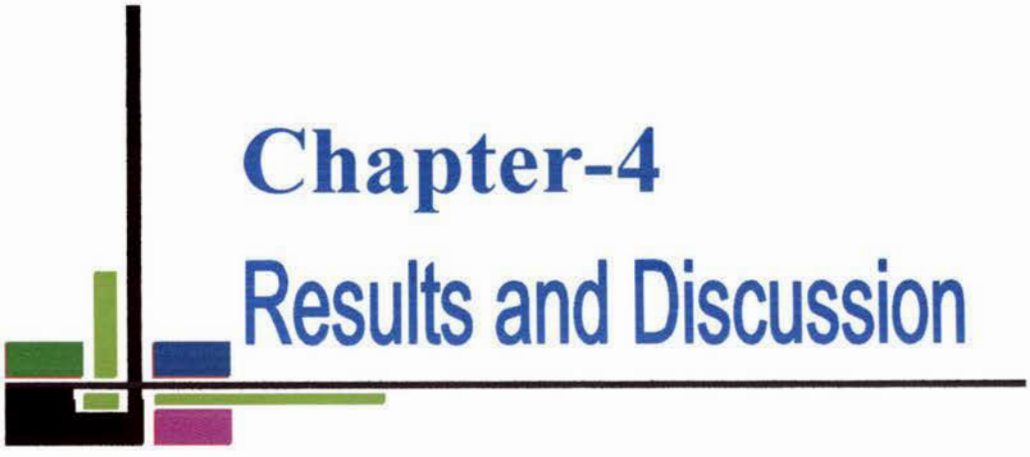
3.15 Statistical Analysis

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

3.16 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of nitrogen and mulching. All input cost were considered in computing the cost of production. The market price of lettuce was considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

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



Chapter-4

Results and Discussion

RESULTS AND DISCUSSIONS

The present experiment was conducted to determine the effect of different levels of nitrogen and mulching on growth and yield of lettuce. Data on different yield contributing characters and yield at different days after transplanting (DAT) were recorded to find out the optimum levels of nitrogen and effective mulch material on lettuce. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VI. The results have been presented and discussed, and possible interpretations given under the following headings:

4.1 Plant height

Plant height differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Figure 2 & 3). At 25 DAT the tallest (16.77 cm) plant height was recorded from N_2 (80 kg N/ha) which was statistically identical (16.04 cm) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the shortest (11.65 cm) plant height. The tallest (23.42 cm) plant height was observed from N_2 (80 kg N/ha), which statistically similar (21.79 cm) with N_3 and the shortest (17.44 cm) was found from control at 35 DAT. At 45 DAT the tallest (28.65 cm) plant height was recorded from N_2 which was statistically identical (27.24 cm) with N_3 and the shortest (21.94 cm) was from control. The tallest (30.49 cm) plant height was recorded from N_2 at 55 DAT which was statistically similar (29.88 cm) with N_3, while control gave the shortest (24.04 cm) plant height. These results indicate that nitrogen increases the growth of lettuce which ensured the tallest plant height than control. In generally plant height increased gradually in the early stage and latter on it follow a slower trend of increse. Similar results were found in lettuce by Hochmuth *et al.* (1994) and Karacal and Turetken (1992) from their experiment. The findings of this experiment also conflict with the findings of Baca *et al.* (1993) and they reported that 80 kg n/ha gave the best performance in lettuce.

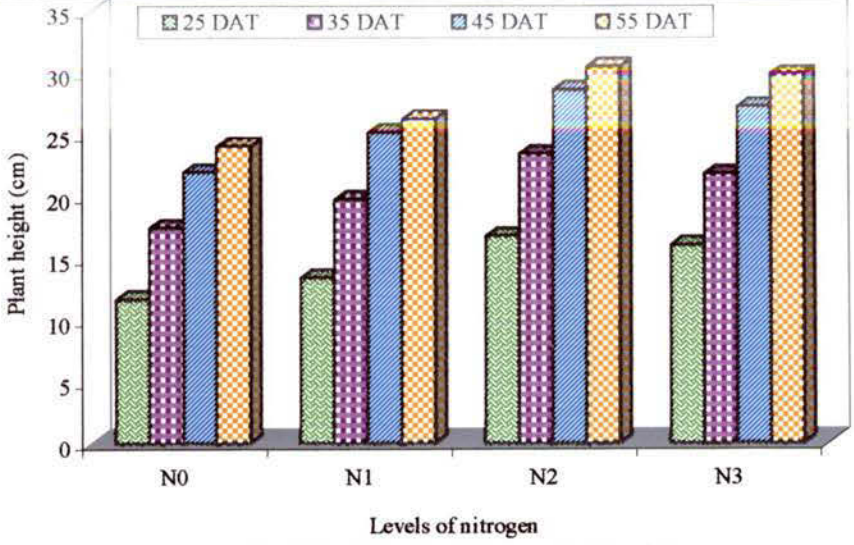


Figure 2. Effect of nitrogen on the plant height of lettuce

N_0 : 0 kg N ha^{-1} N_1 : 60 kg N ha^{-1}

N_2 : 80 kg N ha^{-1} N_3 : 100 kg N ha^{-1}

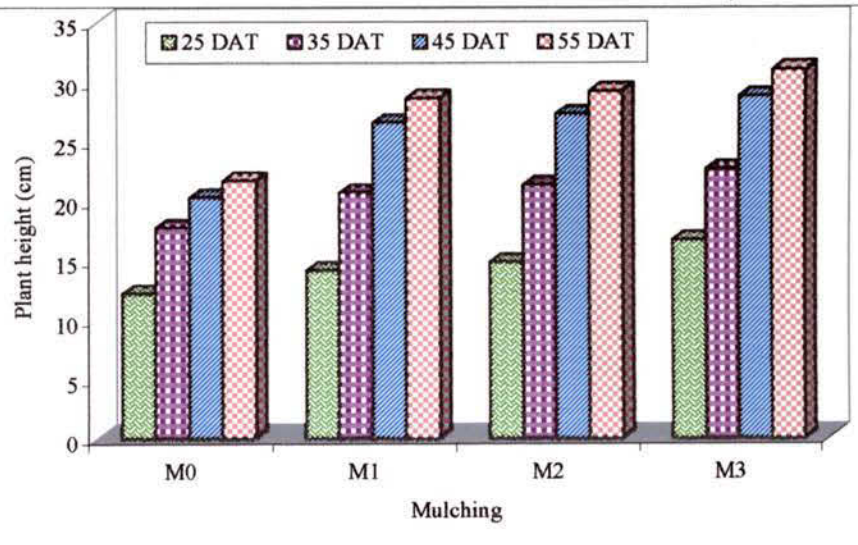


Figure 3. Effect of mulching on plant height of lettuce

M_0 : No mulch M_1 : Rice straw

M_2 : Water hyacinth M_3 : Black polythene

Different mulching showed significant variations on the plant height at 25, 35, 45 and 55 DAT. The tallest (16.70 cm) plant height was recorded from M_3 (black polythene) which was closely (14.84 cm and 14.14 cm) followed by M_2 (Water hyacinth) and M_1 (rice straw), respectively and the shortest (12.18 cm) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the tallest (22.63 cm) plant height was found from M_3 which was statistically similar (21.30 cm) with M_2, while the shortest (17.76 cm) was found from control. The tallest (28.82 cm) plant height was recorded from M_3 which was similar (27.32 cm) with M_2 and the shortest (20.27 cm) was recorded from control at 45 DAT. At 55 DAT the tallest (31.06 cm) plant height was recorded from M_3 which was statistically identical (29.25 cm) with M_2 and the shortest (21.69 cm) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial. Azad and Nabi (1984) stated that similar findings from their experiment with potato cultivation.

A significant variation was found due to combined effect of nitrogen and mulching in terms of plant height at different days after transplanting (Appendix III). The tallest (20.51 cm) plant height was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch) which was similar (19.11 cm) to N_2M_2, while N_0M_2 (0 kg N/ha + water hyacinth) gave the shortest (10.50 cm) plant height (Table 2). At 35 DAT the tallest (27.01 cm) plant height was observed from the treatment combination of N_2M_3, which was followed by N_2M_1 (24.15 cm) and N_2M_2 (25.65 cm), whereas the shortest (16.09 cm) was recorded from N_1M_0 (60 kg N/ha+ no mulch). At 45 DAT the tallest (33.91 cm) plant height was recorded from the treatment combination of N_2M_3 and the shortest (19.07 cm) was recorded from N_1M_0. The tallest (36.00 cm) plant height was recorded from the treatment combination of N_2M_3 and the shortest (19.40 cm) was found from the treatment combination of N_2M_0 at 55 DAT. From the results it was reveals that both nitrogen and mulching favored the plant height.

Table 2. Combined effect of nitrogen and mulching on plant height and number of leaves per plant of lettuce

Treatment	Plant height (cm) at				Number of leaves per plant			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
N_0M_0	11.78 fg	17.61 fgh	22.11 def	24.37 fgh	11.33 ef	19.19 fghi	21.42 cd	23.04 efg
N_0M_1	11.30 fg	16.73 gh	21.60 ef	23.50 fgh	11.14 ef	19.36 efghi	21.22 cd	22.45 fg
N_0M_2	10.50 g	16.57 gh	20.97 ef	22.52 gh	10.45 f	18.86 ghi	20.74 cd	21.54 g
N_0M_3	13.01 efg	18.84 efgh	23.08 def	25.78 efg	12.22 def	19.78 efgh	22.17 bc	23.66 efg
N_1M_0	11.35 fg	16.09 h	19.07 f	20.02 h	11.82 ef	17.93 hi	18.79 cd	19.62 g
N_1M_1	12.95 efg	20.07 defg	26.02 cde	27.20 defg	12.91 cdef	22.15 bcdef	25.46 ab	26.40 cdef
N_1M_2	13.76 def	20.85 cdef	26.87 cd	28.01 cdef	13.24 cde	22.37 bcde	25.79 ab	26.07 def
N_1M_3	15.56 cde	21.88 cde	28.71 bc	29.70 bcde	14.57 bcd	23.71 abc	26.77 a	27.29 bcde
N_2M_0	10.53 g	16.86 gh	18.33 f	19.40 h	11.18 ef	16.71 i	18.01 d	19.78 g
N_2M_1	16.92 bc	24.15 abc	30.07 abc	32.22 abcd	15.35 bc	23.93 abc	27.35 a	28.62 abcd
N_2M_2	19.11 ab	25.65 ab	32.30 ab	34.37 ab	16.56 ab	24.71 ab	28.46 a	30.85 ab
N_2M_3	20.51 a	27.01 a	33.91 a	36.00 a	18.02 a	25.93 a	29.32 a	31.74 a
N_3M_0	15.04 cde	20.50 def	21.58 ef	22.98 fgh	14.36 bcd	20.15 defgh	21.31 cd	22.17 fg
N_3M_1	15.40 cde	21.75 cde	28.61 bc	31.68 abcd	14.58 bcd	21.48 cdefg	26.20 a	28.70 abcd
N_3M_2	16.00 cd	22.14 cde	29.16 abc	32.12 abcd	14.92 bc	21.93 bcdef	26.42 a	30.70 abc
N_3M_3	17.72 bc	22.77 bcd	29.60 abc	32.76 abc	16.47 ab	23.04 abcd	27.17 a	30.47 abc
$LSD_{(0.05)}$	2.523	3.198	4.490	4.550	2.169	2.688	3.498	3.875
CV(%)	10.46	9.31	10.46	9.86	9.50	7.56	8.68	9.00

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

4.2 Number of leaves per plant

Number of leaves per plant differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Figure 4 and 5). At 25 DAT the maximum (15.28) number of leaves per plant was recorded from N_2 (80 kg N/ha) which was statistically identical (15.08) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (11.28) number of leaves per plant (Figure 4). The maximum (22.82) number of leaves per plant was observed from N_2 which was closely (21.65) followed by N_3 and the minimum (19.30) was found from control condition at 35 DAT. At 45 DAT the maximum (25.78) number of leaves per plant was recorded from N_2, which was statistically identical (25.28) with N_3 and the minimum (21.39) was from control. The maximum (28.01) number of leaves per plant was recorded from N_3 at 55 DAT, which was statistically similar (27.75) with N_2, while control gave the minimum (22.67) number of leaves per plant.

Different mulching showed significant variations on the number of leaves per plant at 25, 35, 45 and 55 DAT. The maximum (15.32) number of leaves per plant was recorded from M_3 (black polythene) which was closely (13.79 and 13.50) followed by M_2 (water hyacinth) and M_1 (rice straw) respectively and the minimum (12.17) was obtained from control i.e. no mulching at 25 DAT (Figure 5). At 35 DAT the maximum (23.11) number of leaves per plant was found from M_3 which was closely (21.97 and 21.73) followed by M_2 and M_1, respectively, while the minimum (18.49) was found from control. The maximum (26.36) number of leaves per plant was recorded from M_3 which was statistically similar (25.35 and 25.06) with M_2 and M_1, while the minimum (19.88) was recorded from control at 45 DAT. At 55 DAT the maximum (28.29) number of leaves per plant was recorded from M_3 which was statistically identical (27.29) with M_2, while the minimum (21.15) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial. Lang (1984) found that polythene mulch increased the yield of potato.

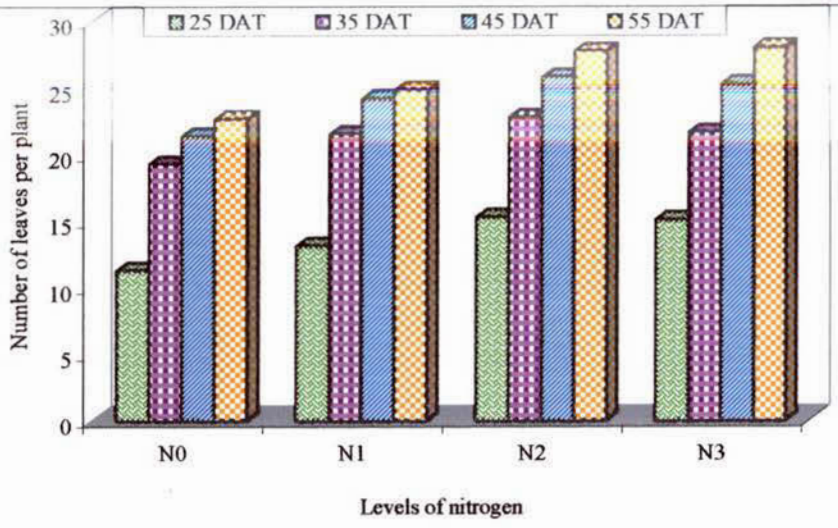


Figure 4. Effect of nitrogen on number of leaves of lettuce

N_0 : 0 kg N ha^{-1} N_1 : 60 kg N ha^{-1}

N_2 : 80 kg N ha^{-1} N_3 : 100 kg N ha^{-1}

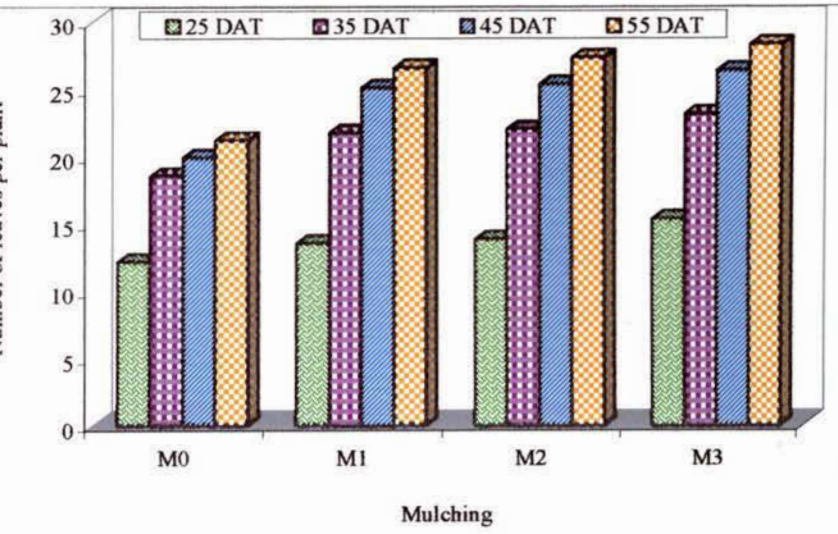


Figure 5. Effect of mulching on number of leaves of lettuce

M_0 : No mulch M_1 : Rice straw

M_2 : Water hyacinth M_3 : Black polythene

A significant variation was found due to combined effect of nitrogen and mulching in terms of number of leaves per plant at different days after transplanting (Appendix III). The maximum (18.02) number of leaves per plant was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), which was statistically similar (16.56 and 16.47) to N_2M_2 and N_3M_3, while N_0M_2 (0 kg N/ha + water hyacinth) gave the minimum (10.45) number of leaves per plant (Table 2). At 35 DAT the maximum (25.93) number of leaves per plant was observed from the treatment combination of N_2M_3, whereas the minimum (16.71) was recorded from N_2M_0. At 45 DAT the maximum (29.32) number of leaves per plant was recorded from the treatment combination of N_2M_3 and the minimum (18.01) was recorded from N_2M_0. The maximum (31.74) number of leaves per plant was recorded from the treatment combination of N_2M_3 and the minimum (19.62) was recorded from the treatment combination of N_1M_0 at 55 DAT.

4.3 Length of leaf

Length of leaf differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Table 3). At 25 DAT the maximum (14.05 cm) length of leaf was recorded from N_2 (80 kg N/ha) which was statistically identical (13.74 cm) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (10.27 cm) length of leaf .The maximum (19.68 cm) length of leaf was observed from N_2 which statistically similar (18.50 cm) to N_3 and (18.40) to N_1, while the minimum (16.06 cm) was found from control at 35 DAT. At 45 DAT the maximum (21.97 cm) length of leaf was recorded from N_2 which was statistically identical (21.38 cm) with N_3 and (20.79) with N_1, while the minimum (18.34 cm) was from control. The maximum (25.17 cm) length of leaf was recorded from N_3 at 55 DAT, which was statistically similar (25.05 cm) with N_2, while control gave the minimum (19.94 cm) length of leaf. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum length of leaf than control.

Different mulching showed significant variations on the length of leaf at 25, 35, 45 and 55 DAT. The maximum (14.09 cm) length of leaf was recorded from M_3 (black polythene), the minimum (10.92 cm) was obtained from control i.e. no mulching at 25 DAT (Table 3). At 35 DAT the maximum (19.95 cm) length of leaf was found from M_3 which was statistically similar (18.80 cm) to M_2 water hyacinth, while the minimum (15.33 cm) was found from control. The maximum (22.65 cm) length of leaf was recorded from M_3 which was similar (21.66 cm and 21.45 cm) with M_2 and M_1, while the minimum (16.72 cm) was recorded from control at 45 DAT. At 55 DAT the maximum (25.45 cm) length of leaf was recorded from M_3 which was statistically identical (24.39 cm and 23.91 cm) with M_2 and M_1, while the minimum (18.99 cm) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial.

A significant variation was found due to combined effect of nitrogen and mulching in terms of length of leaf at different days after transplanting (Appendix IV). The maximum (16.80 cm) length of leaf was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), which was similar (15.36 cm) to N_2M_2 (80 kg N/ha + water hyacinth), while N_0M_2 (0 kg N/ha + water hyacinth) gave the minimum (9.69 cm) length of leaf (Table 4). At 35 DAT the maximum (22.86 cm) length of leaf was observed from the treatment combination of N_2M_3 whereas the minimum (13.56 cm) was recorded from N_2M_0. At 45 DAT the maximum (25.56 cm) length of leaf was recorded from the treatment combination of N_2M_3 and the minimum (14.39 cm) was recorded from N_2M_0. The maximum (28.90 cm) length of leaf was recorded from the treatment combination of N_2M_3 and the minimum (17.41 cm) was recorded from the treatment combination of N_2M_0 at 55 DAT. Kim *et al.* (1988) stated that, Mulching with white polythene gave 36.1 and 22.7 t/ha yields of potato cv. Dejima and Russet Burbank, respectively compared with 11.5 and 10.6 t/ha obtained from no mulching.

Table 3: Main effect of nitrogen and mulching on length and breadth of leaf of lettuce

Treatment	Length of leaf (cm) at				Breadth of leaf (cm) at			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Nitrogen								
N_0	10.27 c	16.06 b	18.34 b	19.94 c	6.60 b	9.14 d	21.07 c	23.39 b
N_1	11.90 b	18.40 a	20.79 a	22.59 b	7.07 b	10.82 c	23.88 b	25.50 b
N_2	14.05 a	19.68 a	21.97 a	25.05 a	8.81 a	12.64 a	26.26 a	29.89 a
N_3	13.74 a	18.50 a	21.38 a	25.17 a	8.44 a	11.84 b	26.49 a	28.28 a
$LSD_{(0.05)}$	1.047	1.289	1.465	1.604	0.617	0.756	1.995	2.545
Mulching								
M_0	10.92 c	15.33 c	16.72 b	18.99 b	6.78 c	9.77 c	19.14 b	21.30 c
M_1	12.30 b	18.57 b	21.45 a	23.91 a	7.47 b	11.16 b	25.50 a	27.25 b
M_2	12.65 b	18.80 ab	21.66 a	24.39 a	7.85 b	11.37 b	26.05 a	28.01 ab
M_3	14.09 a	19.95 a	22.65 a	25.45 a	8.82 a	12.14 a	27.01 a	30.51 a
$LSD_{(0.05)}$	1.047	1.289	1.465	1.604	0.617	0.756	1.995	2.545
CV(%)	10.05	8.51	8.52	8.30	9.58	8.16	9.80	11.40

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

Table 4: Combined effect of nitrogen and mulching on length and breadth of leaf of lettuce

Treatment	Length of leaf (cm) at				Breadth of leaf (cm) at			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
N_0M_0	10.23 g	15.94 ghij	18.36 d	20.28 def	6.66 fg	9.21 f	21.42 def	23.50 def
N_0M_1	10.09 g	16.11 fghij	18.57 d	20.14 ef	6.40 g	8.89 f	21.20 def	23.52 def
N_0M_2	9.69 g	15.62 hij	17.58 d	18.66 f	6.04 g	8.64 f	19.78 ef	22.40 ef
N_0M_3	11.07 fg	16.56 efghi	18.85 cd	20.67 def	7.28 defg	9.81 ef	21.88 de	24.13 def
N_1M_0	10.58 g	14.77 ij	16.63 de	18.89 f	6.22 g	9.18 f	18.61 ef	20.63 f
N_1M_1	11.72 efg	19.00 cdef	21.67 bc	23.70 cd	6.78 efg	11.07 de	25.43 bcd	25.73 cdef
N_1M_2	12.01 defg	19.26 bcde	21.90 bc	23.22 cde	7.14 defg	11.13 de	25.12 cd	26.59 cde
N_1M_3	13.29 bcdef	20.57 abc	22.97 ab	24.56 bc	8.14 cde	11.90 cd	26.35 abc	29.06 bcd
N_2M_0	9.92 g	13.56 j	14.39 e	17.41 f	5.97 g	9.40 f	17.05 f	19.99 f
N_2M_1	14.11 bcd	20.81 abc	23.34 ab	25.92 abc	8.77 bc	12.97 abc	27.61 abc	30.52 abc
N_2M_2	15.36 ab	21.50 ab	24.59 ab	27.97 ab	9.86 ab	13.73 ab	29.72 ab	33.08 ab
N_2M_3	16.80 a	22.86 a	25.56 a	28.90 a	10.65 a	14.45 a	30.66 a	35.99 a
N_3M_0	12.94 cdef	17.04 defghi	17.49 d	19.40 f	8.26 cd	11.27 de	19.47 ef	21.07 ef
N_3M_1	13.29 bcdef	18.36 cdefgh	22.24 ab	25.89 abc	7.93 cdef	11.70 cd	27.75 abc	29.23 bcd
N_3M_2	13.55 bcde	18.81 bcdefg	22.56 ab	27.72 ab	8.36 cd	11.98 cd	29.59 abc	29.97 bc
N_3M_3	15.19 abc	19.81 bcd	23.22 ab	27.69 ab	9.19 bc	12.39 bcd	29.16 abc	32.86 ab
$LSD_{(0.05)}$	2.093	2.578	2.929	3.208	1.234	1.513	3.990	5.090
CV(%)	10.05	8.51	8.52	8.30	9.58	8.16	9.80	11.40

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

4.4 Breadth of leaf

Breadth of leaf differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Table 3). At 25 DAT the maximum (8.81 cm) breadth of leaf was recorded from N_2 (80 kg N/ha) which was statistically identical (8.44 cm) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (6.60 cm) breadth of leaf. The maximum (12.64 cm) breadth of leaf was observed from N_2 and the minimum (9.14 cm) was found from control condition at 35 DAT. At 45 DAT the maximum (26.49 cm) breadth of leaf was recorded from N_3 which was statistically identical (26.26 cm) with N_2 and the minimum (21.07 cm) was from control. The maximum (29.89 cm) breadth of leaf was recorded from N_2 at 55 DAT, which was statistically similar (28.28 cm) with N_3, while control gave the minimum (23.39 cm) breadth of leaf. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum breadth of leaf than control.

Different mulching showed significant variations on the breadth of leaf at 25, 35, 45 and 55 DAT (Table 3). The maximum (8.82 cm) breadth of leaf was recorded from M_3 (black polythene) and the minimum (6.78 cm) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the maximum (12.14 cm) breadth of leaf was found from M_3, while the minimum (9.77 cm) was found from control. The maximum (27.01 cm) breadth of leaf was recorded from M_3 which was statistically similar (26.05 cm and 25.50 cm) with M_2 and M_1, while the minimum (19.14 cm) was recorded from control at 45 DAT. At 55 DAT the maximum (30.51 cm) breadth of leaf was recorded from M_3 which was statistically identical (28.01 cm) with M_2, while the minimum (21.30 cm) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial.

A significant variation was found due to combined effect of nitrogen and mulching in terms of breadth of leaf at different days after transplanting (Appendix IV). The maximum (10.65

cm) breadth of leaf was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), which was statistical identical (9.98 cm) with N_2M_2 (80 kg N/ha + water hyacinth), while N_0M_2 (0 kg N/ha + water hyacinth) gave the minimum (6.04 cm) breadth of leaf (Table 4). At 35 DAT the maximum (14.45 cm) breadth of leaf was observed from the treatment combination of N_2M_3, which was similar (13.73cm and 12.97 cm) to N_2M_2 and N_2M_1, whereas the minimum (8.64 cm) was recorded from N_0M_2. At 45 DAT the maximum (30.66 cm) breadth of leaf was recorded from the treatment combination of N_2M_3 and the minimum (18.61 cm) was recorded from N_1M_0. The maximum (35.99 cm) breadth of leaf was recorded from the treatment combination of N_2M_3 and the minimum (19.99 cm) was recorded from the treatment combination of N_2M_0 at 55 DAT.

4.5 Leaf yield per plant

Leaf yield per plant differed significantly due to the application of different level of nitrogen and mulching at 30, 40, 50 and 55 DAT (Table 5). At 25 DAT the maximum (279.08 g) leaf yield per plant was recorded from N_2 (80 kg N/ha) which was statistically identical (273.81 g) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (203.78 g) leaf yield per plant. The maximum (349.81 g) leaf yield per plant was observed from N_2 which statistically similar (333.09 g and 327.17 g) with N_3 and N_1, while the minimum (295.73 g) was found from control at 35 DAT. At 45 DAT the maximum (423.75 g) leaf yield per plant was recorded from N_2 which was statistically identical (411.68 g and 391.55 g) with N_3 and N_1, the minimum (354.66 g) was found from control. The maximum (474.24 g) leaf yield per plant was recorded from N_3 at 55 DAT which was statistically similar (472.24 g) with N_2, while control gave the minimum (374.92 g) leaf yield per plant. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum leaf yield per plant than control. The result is consistent with that of Hochmuth and Howell (1983) from their experiment.

Different mulching showed significant variations on the leaf yield per plant at 25, 35, 45 and 55 DAT. The maximum (277.91 g) leaf yield per plant was recorded from M_3 (black polythene) and the minimum (221.36 g) was obtained from control i.e. no mulching at 25 DAT (Table 5). At 35 DAT the maximum (354.91 g) leaf yield per plant was found from M_3 which was statistically similar (339.27 g and 333.54 g) with M_2 and M_1, while the minimum (278.08 g) was found from control. The maximum (438.99 g) leaf yield per plant was recorded from M_3 which was similar (420.70 g and 414.31 g) with M_2 and M_1, while the minimum (307.64 g) was recorded from control at 45 DAT. At 55 DAT the maximum (487.48 g) leaf yield per plant was recorded from M_3 which was statistically identical (464.74 g and 449.13 g) with M_2 and M_1, while the minimum (326.59 g) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial.

A significant variation was found due to combined effect of nitrogen and mulching in terms of leaf yield per plant at different days after transplanting (Appendix V). The maximum (327.46 g) leaf yield per plant was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), which was statistically identical (301.4g and 298.87g) with N_2M_2 (80 kg N/ha+ water hyacinth) and N_3M_3 (100 kg N/ha +black polythene), while N_0M_2 (0 kg N/ha + water hyacinth) gave the minimum (189.77 g) leaf yield per plant (Table 6). At 35 DAT the maximum (399.16 g) leaf yield per plant was observed from the treatment combination of N_2M_3 whereas the minimum (250.17 g) was recorded from N_2M_0. At 45 DAT the maximum (493.25 g) leaf yield per plant was recorded from the treatment combination of N_2M_3 and the minimum (267.75 g) was recorded from N_2M_0. The maximum (562.99 g) leaf yield per plant was recorded from the treatment combination of N_2M_3 and the minimum (286.34 g) was recorded from the treatment combination of N_1M_0 at 55 DAT.

Table 5: Main effect of nitrogen and mulching on leaf yield per plant and dry matter content of lettuce

Treatment	Leaf yield (g/plant at				Dry matter content (%) in plant at			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Nitrogen								
N_0	203.78 c	295.73 b	354.66 b	374.92 b	8.12 c	8.44 c	10.02 c	11.43 c
N_1	238.70 b	327.17 a	391.55 a	406.20 b	9.07 b	9.87 b	11.21 b	13.66 b
N_2	279.08 a	349.81 a	423.75 a	472.24 a	10.42 a	11.59 a	12.90 a	15.35 a
N_3	273.81 a	333.09 a	411.68 a	474.58 a	8.85 b	9.83 b	11.20 b	13.56 b
$LSD_{(0.05)}$	19.44	22.59	33.41	41.95	0.528	0.691	0.719	0.688
Mulching								
M_0	221.36 c	278.08 b	307.64 b	326.59 b	8.12 c	8.85 c	10.33 c	12.28 c
M_1	244.87 b	333.54 a	414.31 a	449.13 a	9.16 b	9.79 b	11.22 b	13.50 b
M_2	251.22 b	339.27 a	420.70 a	464.74 a	9.39 ab	10.35 ab	11.65 ab	13.81 ab
M_3	277.91 a	354.91 a	438.99 a	487.48 a	9.79 a	10.75 a	12.13 a	14.40 a
$LSD_{(0.05)}$	19.44	22.59	33.41	41.95	0.528	0.691	0.719	0.688
CV(%)	9.37	8.30	10.13	11.65	6.95	8.35	7.61	6.11

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

Table 6: Combined effect of nitrogen and mulching on leaf yield per plant and dry matter content of lettuce

Treatment	Leaf yield (g/plant at				Dry matter content (%) in plant at			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
N_0M_0	204.64 fg	295.77 def	355.42 cd	382.83 efgh	8.14 e	8.47 f	10.06 efg	11.48 gh
N_0M_1	199.69 fg	294.38 def	350.69 cde	369.22 efghi	8.14 e	8.29 f	9.96 g	11.61 fgh
N_0M_2	189.77 g	291.83 ef	342.94 de	350.20 fghi	7.93 e	8.36 f	9.81 g	11.05 h
N_0M_3	221.01 efg	300.93 def	369.60 bcd	397.43 efg	8.29 de	8.62 f	10.25 defg	11.58 fgh
N_1M_0	213.99 fg	256.39 f	279.73 ef	286.34 i	8.32 de	8.61 f	10.12 efg	12.69 defg
N_1M_1	232.88 defg	340.41 bcde	417.80 abc	442.12 cdef	8.86 cde	9.68 def	11.15 defg	13.75 cd
N_1M_2	243.63 cdef	345.67 bcd	424.45 abc	434.42 defg	9.37 cd	10.46 cd	11.65 cdef	13.79 cd
N_1M_3	264.30 bcd	366.21 ab	444.20 ab	461.94 bcde	9.73 bc	10.73 cd	11.90 cd	14.41 bc
N_2M_0	206.04 fg	250.17 f	267.75 f	292.17 hi	7.74 e	8.76 ef	10.02 fg	11.91 efgh
N_2M_1	281.33 bc	368.93 ab	455.89 a	490.90 abcd	10.70 ab	11.50 bc	12.91 bc	15.39 b
N_2M_2	301.48 ab	380.96 ab	478.13 a	542.90 ab	11.52 a	12.70 ab	14.05 ab	17.02 a
N_2M_3	327.46 a	399.16 a	493.25 a	562.99 a	11.71 a	13.41 a	14.62 a	17.07 a
N_3M_0	260.79 bcde	309.98 cde	327.65 def	345.04 ghi	8.29 de	9.55 def	11.12 defg	13.05 cdef
N_3M_1	265.58 bcd	330.43 bcde	432.85 ab	494.28 abcd	8.95 cde	9.68 def	10.86 defg	13.26 cde
N_3M_2	270.01 bcd	338.61 bcde	437.28 ab	531.43 abc	8.73 cde	9.86 def	11.09 defg	13.37 cde
N_3M_3	298.87 ab	353.32 abc	448.93 a	527.55 abcd	9.42 cd	10.23 cde	11.73 cde	14.55 bc
$LSD_{(0.05)}$	38.88	45.18	66.82	83.90	1.056	1.382	1.437	1.375
CV(%)	9.37	8.30	10.13	11.65	6.95	8.35	7.61	6.11

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

4.6 Dry matter content in plant

Dry matter content in plant differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Table 5). At 25 DAT the maximum (10.42%) dry matter content in plant was recorded from N_2 (80 kg N/ha), while the control (0 kg N/ha) gave the minimum (8.12%) dry matter content in plants. The maximum (11.59%) dry matter content in plant was observed from N_2 and the minimum (8.44%) was found from control condition at 35 DAT. At 45 DAT the maximum (12.90%) dry matter content in plant was recorded from N_2 and the minimum (10.02%) was found from control. The maximum (15.35%) dry matter content in plant was recorded from N_2 at 55 DAT, while control gave the minimum (11.43%) dry matter content in plant.

Different mulching showed significant variations on the dry matter content in plant at 25, 35, 45 and 55 DAT (Table 5). The maximum (9.79%) dry matter content in plant was recorded from M_3 (black polythene) which was statistically similar (9.39%) with M_2 (water hyacinth) and the minimum (8.12%) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the maximum (10.75%) dry matter content in plant was found from M_3 which was statistically identical (10.35%) M_2, while the minimum (8.85%) was found from control. The maximum (12.13%) dry matter content in plant was recorded from M_3 which was statistically similar (11.65%) with M_2, while the minimum (10.33%) was recorded from control at 45 DAT. At 55 DAT the maximum (14.40%) dry matter content in plant was recorded from M_3 which was statistically identical (13.81%) with M_2, while the minimum (12.28%) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial.

A significant variation was found due to combined effect of nitrogen and mulching in terms of dry matter content in plant at different days after transplanting (Appendix V). The maximum (11.71%) dry matter content in plant was recorded at 25 DAT from the combined

effect of N_2M_3 (80 kg N/ha + black polythene mulch), which was closely related (11.52% and 10.70%) with N_2M_2 and N_2M_1, while N_0M_2 (0 kg N/ha + water hyacinth) gave the minimum (7.93%) dry matter content was recorded from N_0M_2 in plant (Table 6). At 35 DAT the maximum (13.41%) dry matter content in plant was observed from the treatment combination of N_2M_3, whereas the minimum (8.29%) was recorded from N_0M_1. At 45 DAT the maximum (14.62%) dry matter content in plant was recorded from the treatment combination of N_2M_3 which was statistically similar (14.05%) with N_2M_2 (80 kg N/ha + water hyacinth) and the minimum (9.81%) was recorded from N_0M_2. The maximum (17.07%) dry matter content in plant was recorded from the treatment combination of N_2M_3 which was followed (17.02%) by N_2M_2 (80 kg N/ha +water hyacinth) and the minimum (11.05%) was recorded from the treatment combination of N_0M_2 at 55 DAT.

4.7 Yield per plot

Yield per plot differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Figure 6 and 7). At 25 DAT the maximum (5.67 kg) yield per plot was recorded from N_2 (80 kg N/ha) which was statistically identical (5.57 kg) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (4.16 kg) yield per plot. The maximum (7.66 kg) yield per plot was observed from N_2 which statistically similar (7.23 kg and 7.19 kg) with N_1 and N_3, while the minimum (5.88 kg) was found from control at 35 DAT. At 45 DAT the maximum (9.08 kg) yield per plot was recorded from N_2 which was statistically identical (8.60 kg and 8.44 kg) with N_3 and N_1, the minimum (7.13 kg) was found from control. The maximum (10.21 kg) yield per plot was recorded from N_2 at 55 DAT which was statistically similar (10.16 kg) with N_3, while control gave the minimum (7.88 kg) yield per plot. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum yield per plot than control.

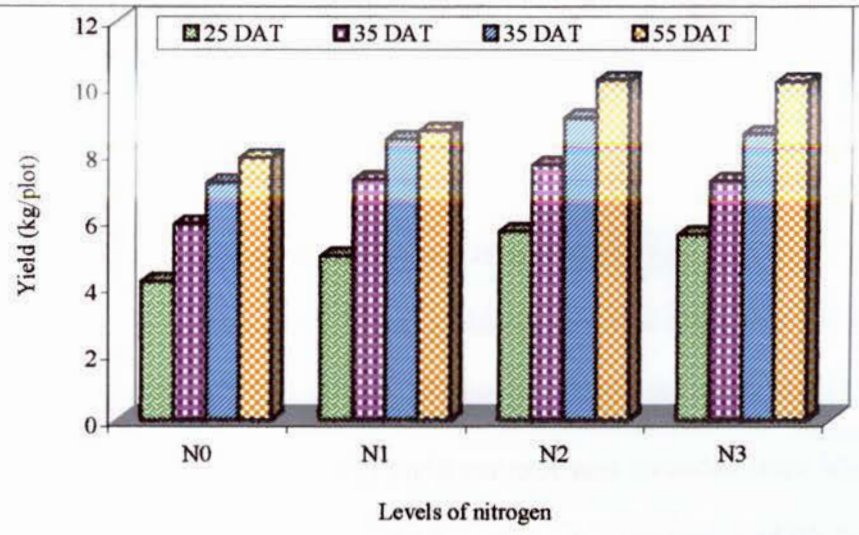


Figure 6. Effect of nitrogen on yield per plot of lettuce

N_0 : 0 kg N ha^{-1} N_1 : 60 kg N ha^{-1}

N_2 : 80kg N ha^{-1} N_3 : 100kg N ha^{-1}

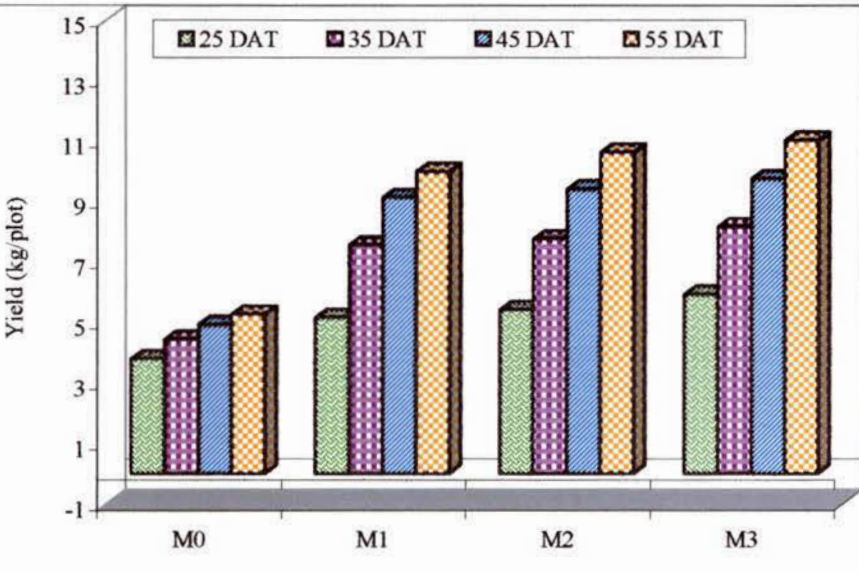


Figure 7. Effect of mulching on yield per plot of lettuce

Mulching

M_0 : No mulch M_1 : Rice straw

M_2 : Water hyacinth M_3 : Black polythene

Different mulching showed significant variations on the yield per plot at 25, 35, 45 and 55 DAT. The maximum (5.94 kg) yield per plot was recorded from M_3 (black polythene) which was closely (5.42 kg and 5.17 kg) followed by M_2 (water hyacinth) and M_1 (rice straw), respectively and the minimum (3.80 kg) was obtained from control i.e. no mulching at 25 DAT (Figure 7). At 35 DAT the maximum (8.17 kg) yield per plot was found from M_3 which was statistically similar (7.77 kg and 7.57 kg) with M_2 and M_1, while the minimum (4.44 kg) was found from control. The maximum (9.76 kg) yield per plot was recorded from M_3 which was similar (9.42 kg and 9.14 kg) with M_2 and M_1, while the minimum (4.93 kg) was recorded from control at 45 DAT. At 55 DAT the maximum (11.03 kg) yield per plot was recorded from M_3 which was statistically identical (10.64 kg and 10.00 kg) with M_2 and M_1, while the minimum (5.27 kg) was found from control. From the results it was found that black polythene was more effective than other mulching materials under the trial.

A significant variation was found due to combined effect of nitrogen and mulching in terms of yield per plot at different days after transplanting (Appendix VI). The maximum (6.84 kg) yield per plot was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), while N_0M_0 (0 kg N/ha + no mulch) gave the minimum (3.00 kg) yield per plot (Table 7). At 35 DAT the maximum (9.15 kg) yield per plot was observed from the treatment combination of N_2M_3 whereas the minimum (3.43 kg) was recorded from N_0M_0. At 45 DAT the maximum (10.74 kg) yield per plot was recorded from the treatment combination of N_2M_3, which was statistical similar (10.57 kg and 10.09 kg) to N_2M_2 and N_2M_1 and the minimum (3.78 kg) was recorded from N_0M_0. The maximum (12.53 kg) yield per plot was recorded from the treatment combination of N_2M_3 and the minimum (3.97 kg) was recorded from the treatment combination of N_0M_0 at 55 DAT.

Table 7: Combined effect of nitrogen and mulching on yield per plot and hectare of lettuce

Treatment	Yield (kg/plot) at				Yield (t/ha) at			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
N_0M_0	3.00 i	3.43 i	3.78 h	3.97 h	12.51 i	14.29 i	15.76 h	16.55 h
N_0M_1	4.21 fgh	6.43 f	7.95 f	8.62 f	17.53 fgh	26.77 f	33.13 f	35.91 f
N_0M_2	4.45 efg	6.63 f	8.23 f	9.29 ef	18.55 efg	27.64 f	34.29 f	38.72 ef
N_0M_3	4.97 def	7.03 ef	8.57 ef	9.65 def	20.71 def	29.30 ef	35.70 ef	40.20 def
N_1M_0	4.03 gh	4.76 gh	5.50 g	5.91 g	16.77 gh	19.84 gh	22.92 g	24.63 g
N_1M_1	4.94 def	7.84 cde	9.14 de	9.56 ef	20.58 def	32.65 cde	38.10 de	39.82 ef
N_1M_2	5.17 cde	7.93 bcd	9.31 cd	9.18 ef	21.53 cde	33.05 bcd	38.78 cd	38.26 ef
N_1M_3	5.60 bcd	8.38 abcd	9.80 cd	10.09 cde	23.35 bcd	34.91 abcd	40.83 cd	42.04 cde
N_2M_0	3.48 hi	4.30 h	4.90 g	5.33 g	14.49 hi	17.92 h	20.40 g	22.19 g
N_2M_1	5.97 abc	8.46 abc	10.09 abc	10.87 bcd	24.86 abc	35.26 abc	42.04 abc	45.29 bcd
N_2M_2	6.39 ab	8.73 ab	10.57 ab	12.13 ab	26.64 ab	36.38 ab	44.06 ab	50.54 ab
N_2M_3	6.84 a	9.15 a	10.74 a	12.53 a	28.49 a	38.11 a	44.76 a	52.22 a
N_3M_0	4.69 efg	5.28 g	5.54 g	5.88 g	19.53 efg	22.00 g	23.07 g	24.52 g
N_3M_1	5.59 bcd	7.54 de	9.38 cd	10.96 bc	23.27 bcd	31.41 de	39.08 cd	45.67 bc
N_3M_2	5.67 bcd	7.80 cde	9.56 cd	11.94 ab	23.61 bcd	32.51 cde	39.84 cd	49.73 ab
N_3M_3	6.34 ab	8.13 bcd	9.92 bcd	11.86 ab	26.41 ab	33.89 bcd	41.32 bcd	49.40 ab
$LSD_{(0.05)}$	0.807	0.766	0.702	1.197	3.358	3.191	2.920	4.988
CV(%)	9.51	6.57	5.06	7.77	9.51	6.57	5.06	7.77

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

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

4.8 Yield per hectare

Yield per hectare differed significantly due to the application of different level of nitrogen and mulching at 25, 35, 45 and 55 DAT (Figure 8 and 9). At 25 DAT the maximum (23.62 t/ha) yield was recorded from N_2 (80 kg N/ha) which was statistically identical (23.21 t/ha) with N_3 (100 kg N/ha), while the control (0 kg N/ha) gave the minimum (17.33 t/ha) yield. The maximum (31.92 t/ha) yield was observed from N_2 which statistically similar (30.11 t/ha and 29.95 t/ha) with N_1 and N_3, while the minimum (24.50 t/ha) was found from control at 35 DAT. At 45 DAT the maximum (37.81 t/ha) yield was recorded from N_2 which was statistically identical (35.83 t/ha and 35.16 t/ha) with N_3 and N_1, the minimum (29.72 t/ha) was found from control. The maximum (42.56 t/ha) yield was recorded from N_2 at 55 DAT which was statistically similar (42.33 t/ha) with N_3, while control gave the minimum (32.85 t/ha) yield. Similar results were found in lettuce by Hochmuth *et al.* (1994) and Karacal and Turetken (1992) from their experiment. The findings of this experiment also argument with the findings of Baca *et al.* (1993) and they reported that 80 kg n/ha gave the best performance in lettuce.

Different mulching showed significant variations on the yield per hectare at 25, 35, 45 and 55 DAT. The maximum (24.74 t/ha) yield was recorded from M_3 (black polythene) which was closely (22.58 t/ha and 21.56 t/ha) followed by M_2 (water hyacinth) and M_1 (rice straw), respectively and the minimum (15.83 t/ha) was obtained from control i.e. no mulching at 25 DAT (Figure 9). At 35 DAT the maximum (34.05 t/ha) yield was found from M_3 which was statistically similar (32.39 t/ha and 31.52 t/ha) with M_2 and M_1, while the minimum (18.51 t/ha) was found from control. The maximum (40.65 t/ha) yield was recorded from M_3 which was similar (39.25 t/ha and 38.09 t/ha) with M_2 and M_1, while the minimum (20.53 t/ha) was recorded from control at 45 DAT. At 55 DAT the maximum (45.96 t/ha) yield was recorded from M_3 which was statistically identical (44.32 t/ha) with M_2, while the minimum (21.97 t/ha) was found from control.

A significant variation was found due to combined effect of nitrogen and mulching in terms of yield per hectare at different days after transplanting (Appendix VI). The maximum (28.49 t/ha) yield was recorded at 25 DAT from the combined effect of N_2M_3 (80 kg N/ha + black polythene mulch), while N_0M_0 (0 kg N/ha + no mulch) gave the minimum (12.51 t/ha) yield per hectare (Table 7). At 35 DAT the maximum (38.11 t/ha) yield was observed from the treatment combination of N_2M_3, whereas the minimum (14.29 t/ha) was recorded from N_0M_0. At 45 DAT the maximum (44.76 t/ha) yield was recorded from the treatment combination of N_2M_3 and the minimum (15.76 t/ha) was recorded from N_0M_0. The maximum (52.22 t/ha) yield was recorded from the treatment combination of N_2M_3 and the minimum (16.55 t/ha) was recorded from the treatment combination of N_0M_0 at 55 DAT.

4.9 Economic analysis

Input costs for land preparation, seed cost, fertilizer, thinning, irrigation and man power required for all the operations from sowing to harvesting of lettuce were recorded and converted into cost per hectare. Prices of lettuce were considered in market rate basis. The economic analysis was done to find out the gross and net return and the benefit cost ratio in the present experiment and presented under the following headings-

4.10.1 Gross return

The combination of nitrogen and mulching showed different gross return under the trial (Table 8). The highest gross return (Tk. 817,990/ha-) was obtained from the treatment combination of N_2M_3 (80 kg N/ha + black polythene mulch) and the second highest gross return (Tk. 7,88,187/ha-) was obtained in N_2M_2 (80 kg N/ha + water hyacinth mulch). The lowest gross return (Tk. 2,95,581/ha-) was obtained from the control treatment i.e. N_0M_0 (0 kg N/ha + no mulch).

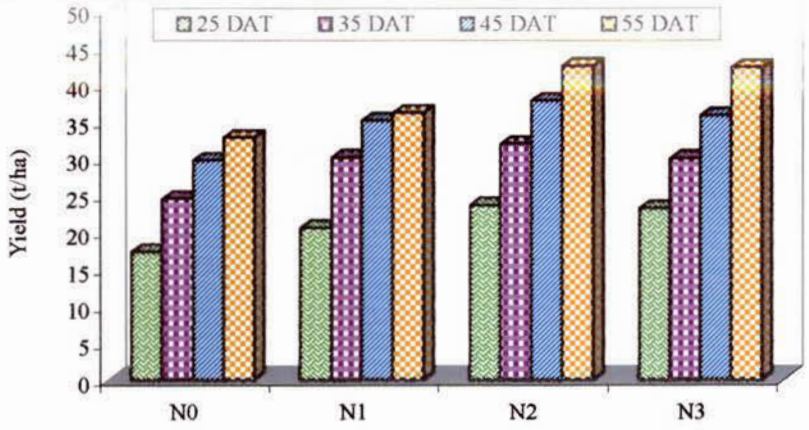


Figure 8. Effect of nitrogen on yield per ha of lettuce

N_0 : 0 kg N ha^{-1} N_1 : 60 kg N ha^{-1}

N_2 : 80 kg N ha^{-1} N_3 : 100 kg N ha^{-1}

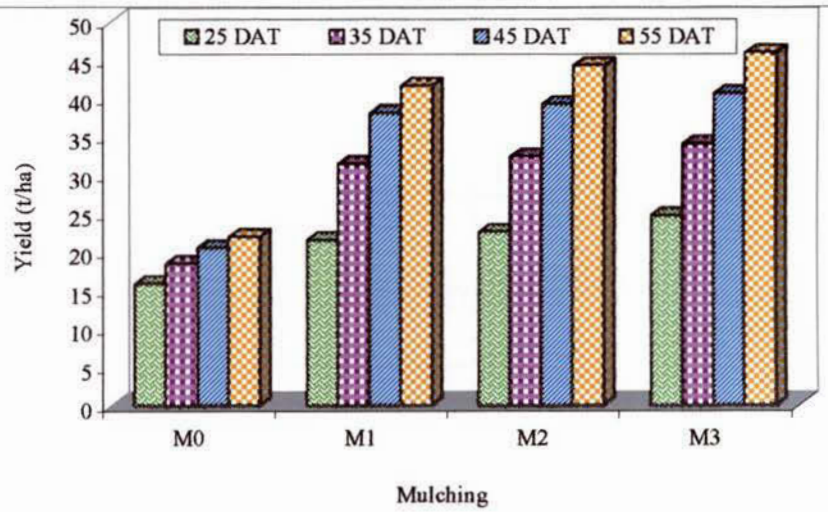


Figure 9. Effect of mulching on yield per ha of lettuce

M_0 : No mulch M_1 : Rice straw

M_2 : Water hyacinth M_3 : Black polythene

Table 8: Cost and return of lettuce cultivation as influenced by nitrogen and mulching

Treatment Combination	Cost of Production (Tk./ha)	Yield at harvest				Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
		25 DAT	35 DAT	45 DAT	55 DAT			
N_0M_0	1,63,183	12.51	14.29	15.76	16.55	2,95,581	132398	0.81
N_0M_1	1,64,845	17.53	26.77	33.13	35.91	5,66,763	401918	2.44
N_0M_2	1,61,624	18.55	27.64	34.29	38.72	5,96,066	434442	2.69
N_0M_3	1,76,296	20.71	29.30	35.70	40.20	6,29,620	453324	2.57
N_1M_0	1,53,798	16.77	19.84	22.92	24.63	4,20,844	267047	1.74
N_1M_1	1,64,845	20.58	32.65	38.10	39.82	6,55,822	490978	2.98
N_1M_2	1,61,624	21.53	33.05	38.78	38.26	6,58,171	496547	3.07
N_1M_3	1,76,296	23.35	34.91	40.83	42.04	7,05,727	529431	3.00
N_2M_0	1,53,798	14.49	17.92	20.40	22.19	3,75,040	221242	1.44
N_2M_1	1,64,845	24.86	35.26	42.04	45.29	7,37,331	572486	3.47
N_2M_2	1,61,624	26.64	36.38	44.06	50.54	7,88,187	626563	3.58
N_2M_3	1,76,296	28.49	38.11	44.76	52.22	8,17,990	641694	3.64
N_3M_0	1,53,799	19.53	22.00	23.07	24.52	4,45,647	291848	1.90
N_3M_1	1,64,845	23.27	31.41	39.08	45.67	6,97,227	532382	3.23
N_3M_2	1,61,624	23.61	32.51	39.84	49.73	7,28,532	566908	3.51
N_3M_3	1,76,296	26.41	33.89	41.32	49.40	7,55,183	578887	3.28

Market price of lettuce @ Tk. 5,000/t

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

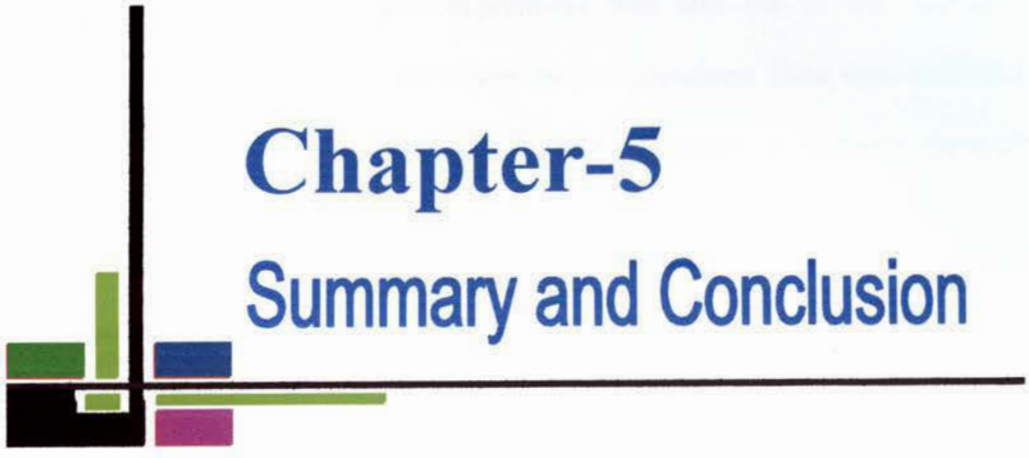
M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

4.10.2 Net return

In case of net return different treatment combination showed unlike types of net return. The highest net return (Tk. 6,41,694/ha-) was obtained from the treatment combination of N_2M_3 and the second highest net return (Tk. 6,26,563/ha-) was obtained from the treatment combination of N_2M_2. The lowest net return (Tk. 1,32,398/ha-) was obtained from the control treatment (Table-8).

4.10.3 Benefit cost ratio

The combination of nitrogen and mulch for benefit cost ratio was different in all treatment combination (Table 8). The highest (3.64) benefit cost ratio was performed from the treatment combination of N_2M_3 and the second highest benefit cost ratio (3.58) was estimated from the treatment combination of N_2M_2. The lowest befit cost ratio (0.81) was obtained from the control treatment i.e. N_0M_0. From economic point of view, it is apparent from the above results that the treatment combination of N_2M_3 was more profitable than rest of the treatment combination.



Chapter-5

Summary and Conclusion

SUMMARY AND CONCLUSION

A field experiment was conducted in the experimental field of Sher-e Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2006 to February 2007 to study the effect nitrogen and mulching on growth and yield of lettuce. The experiment considered of two factors. Factor A: Levels of nitrogen (4 levels) i.e. 0 kg N/ha (Control), 60 kg N/ha (N_1), 80 kg N/ha (N_2), 100 kg N/ha (N_3); Factor B: Mulching (4 levels) i.e. No mulch (M_0), rice straw (M_1), water hyacinth (M_2), black polythene (M_3). There were on the whole 16 (4 × 4) treatment combinations. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Data were collected in respect of the plant growth characters and green yield of lettuce at different days after transplanting.

At 25 DAT the tallest (16.77 cm) plant was recorded from N_2 (80 kg N/ha), while the control (0 kg N/ha) gave the shortest (11.65 cm) plant. The tallest (23.42 cm) plant height was observed from N_2 and the shortest (17.44 cm) was found from control at 35 DAT. At 45 DAT the tallest (28.65 cm) plant height was recorded from N_2 and the shortest (21.94 cm) was from control. The tallest (30.49 cm) plant height was recorded from N_2 at 55 DAT, while control gave the shortest (24.04 cm) plant height. At 25 DAT the maximum (15.28) number of leaves per plant was recorded from N_2, while the control gave the minimum (11.28) number of leaves per plant. The maximum (22.82) number of leaves per plant was observed from N_2 and the minimum (19.30) was found from control condition at 35 DAT. At 45 DAT the maximum (25.78) number of leaves per plant was recorded from N_2 and the minimum (21.39) was from control. The maximum (28.01) number of leaves per plant was recorded from N_3 at 55 DAT, while control gave the minimum (22.67) number of leaves per plant. At 25 DAT the maximum (279.08 g) leaf yield per plant was recorded from N_2 (80 kg N/ha), while the control gave the minimum (203.78 g) leaf yield per plant. The maximum (349.81 g)

leaf yield per plant was observed from N_2, while the minimum (295.73 g) was found from control at 35 DAT. At 45 DAT the maximum (423.75 g) leaf yield per plant was recorded from N_2, the minimum (354.66 g) was found from control. The maximum (474.24 g) leaf yield per plant was recorded from N_3 at 55 DAT, while control gave the minimum (374.92 g) leaf yield per plant. At 25 DAT the maximum (10.42%) dry matter content in plant was recorded from N_2, while the control gave the minimum (8.12%) dry matter content in plants. The maximum (11.59%) dry matter content in plant was observed from N_2 and the minimum (8.44%) was found from control condition at 35 DAT. At 45 DAT the maximum (12.90%) dry matter content in plant was recorded from N_2 and the minimum (10.02%) was found from control. The maximum (15.35%) dry matter content in plant was recorded from N_2 at 55 DAT, while control gave the minimum (11.43%) dry matter content in plant. At 25 DAT the maximum (5.67 kg) yield per plot was recorded from N_2 (80 kg N/ha), while the control (0 kg N/ha) gave the minimum (4.16 kg) yield per plot. The maximum (7.66 kg) yield per plot was observed from N_2, while the minimum (5.88 kg) was found from control at 35 DAT. At 45 DAT the maximum (9.08 kg) yield per plot was recorded from N_2, while the minimum (7.13 kg) was found from control. The maximum (10.21 kg) yield per plot was recorded from N_2 at 55 DAT, while control gave the minimum (7.88 kg) yield per plot. At 25 DAT the maximum (23.62 t/ha) yield was recorded from N_2, while the control (0 kg N/ha) gave the minimum (17.33 t/ha) yield. The maximum (31.92 t/ha) yield was observed from N_2 while the minimum (24.50 t/ha) was found from control at 35 DAT. At 45 DAT the maximum (37.81 t/ha) yield was recorded from N_2, while the minimum (29.72 t/ha) was found from control. The maximum (42.56 t/ha) yield was recorded from N_2 at 55 DAT, while control gave the minimum (32.85 t/ha) yield.

The tallest (16.70 cm) plant height was recorded from M_3 (black polythene) and the shortest (12.18 cm) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the tallest (22.63 cm) plant height was found from M_3, while the shortest (17.76 cm) was found from

control. The tallest (28.82 cm) plant height was recorded from M_3 and the shortest (20.27 cm) was recorded from control at 45 DAT. At 55 DAT the tallest (31.06 cm) plant height was recorded from M_3 and the shortest (21.69 cm) was found from control. The maximum (15.32) number of leaves per plant was recorded from M_3 and the minimum (12.17) was obtained from control at 25 DAT. At 35 DAT the maximum (23.11) number of leaves per plant was found from M_3, while the minimum (18.49) was found from control. The maximum (26.36) number of leaves per plant was recorded from M_3, while the minimum (19.88) was recorded from control at 45 DAT. At 55 DAT the maximum (28.29) number of leaves per plant was recorded from M_3, while the minimum (21.15) was found from control. The maximum (277.91 g) leaf yield per plant was recorded from M_3 and the minimum (221.36 g) was obtained from control at 25 DAT. At 35 DAT the maximum (354.91 g) leaf yield per plant was found from M_3, while the minimum (278.08 g) was found from control. The maximum (438.99 g) leaf yield per plant was recorded from M_3, while the minimum (307.64 g) was recorded from control at 45 DAT. At 55 DAT the maximum (487.48 g) leaf yield per plant was recorded from M_3, while the minimum (326.59 g) was found from control. The maximum (9.79%) dry matter content in plant was recorded from M_3 and the minimum (8.12%) was obtained from control at 25 DAT. At 35 DAT the maximum (10.75%) dry matter content in plant was found from M_3, while the minimum (8.85%) was found from control. The maximum (12.13%) dry matter content in plant was recorded from M_3, while the minimum (10.33%) was recorded from control at 45 DAT. At 55 DAT the maximum (14.40%) dry matter content in plant was recorded from M_3, while the minimum (12.28%) was found from control. The maximum (5.94 kg) yield per plot was recorded from M_3 (black polythene) and the minimum (3.80 kg) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the maximum (8.17 kg) yield per plot was found from M_3 (black polythene), while the minimum (4.44 kg) was found from control. The maximum (9.76 kg) yield per plot was recorded from M_3 (black polythene), while the minimum (4.93 kg) was

recorded from control at 45 DAT. At 55 DAT the maximum (11.03 kg) yield per plot was recorded from M_3, while the minimum (5.27 kg) was found from control. The maximum (24.74 t/ha) yield was recorded from M_3, (black polythene) while the minimum (15.83 t/ha) was obtained from control i.e. no mulching at 25 DAT. At 35 DAT the maximum (34.05 t/ha) yield was found from M_3, while the minimum (18.51 t/ha) was found from control. The maximum (40.65 t/ha) yield was recorded from M_3, while the minimum (20.53 t/ha) was recorded from control at 45 DAT. At 55 DAT the maximum (45.96 t/ha) yield was recorded from M_3, while the minimum (21.97 t/ha) was found from control.

Among different treatment combination of N_2M_3 (80 kg N/ha + black polythene mulch) was more effective than other combination, while N_0M_0 (0 kg N/ha + no mulch) gave the minimum performances. The highest gross return (Tk. 817,990/ha-) was obtained from the treatment combination of N_2M_3 (80 kg N/ha + black polythene mulch) and the lowest gross return (Tk. 295,581/ha-) was obtained from the control treatment i.e. N_0M_0 (0 kg N/ha + no mulch). The highest net return (Tk. 641,694/ha-) was obtained from the treatment combination of N_2M_3 and the lowest net return (Tk. 132,398/ha-) was obtained from the control treatment. The highest (3.64) benefit was performed from the treatment combination of N_2M_3 and the lowest befit cost ratio (0.81) was obtained from the control treatment i.e. N_0M_0. Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performances;
2. With the increasing of nitrogen yield increase so it is necessary to include another doses in the fertilization program may be taken for further study;
3. Another mulch materials may be included in the future program.


References

REFERENCES

Akand, M. H. 2003. Effect of organic manure and mulching on the growth and yield of carrot. MS. Thesis, Dept. of Hort., Bangladesh Agricultural University, Mymensingh. pp. 59-60.

Anez, B. and Pino, H. 1997. Methods and timing of nitrogen application in lettuce production Revista Forestal Venezolana. **31**: 87-90.

Abdel, A. H. 1996. Response of lettuce of N rates and wuxal foliar fertilizer in dandy soil. *Alexandria J. Agric. Res.* **41**(2): 359-368.

Abaquita, M. B.1992. Increase ginger yield through minimum fertilization and mulching. Philippines, *J. pl. Philippines,* **57** (1-2): 30-35.

Al-Assir, I. A., Rubeizb I. G. and Khoury, R.Y. 1991. Response of fall greenhouse cos: to clear mulch and nitrogen fertilizer. J. Plant Nutrition. New York, USA., **4**(10): 1017-1022.

Antil, D. N., Seniro,D., Blood-Smyth, J., Davies, J. and Emmett. 1990. Brighton crop protection conference, Pest and Diseases, UK, 1990. 355-360. [Cited from CAB Abst., 1990-1991].

Anonymous. 1989. Annual Weather Report, IPSA. Meteorological Station, IPSA, Salna, Gazipur. P. 8-15.

Asandhi, A. A., Djatnika, I., Pasetriyani. and Mulay Ningsih, F. 1989. The effect of several types of mulches and cabbage waste on garlic. Bull. Penelition. Hort, **18**(1):1-16.

Aliuddin, T. 1986. Effect of soil tillage and application of mulch on yield of field garlic. Bull. Penelition Hort. **14**(1): 23-27. [Cited from Hort. Abstr. 59(4): 319, 1989].

Anonymous. 1972. Chinese cabbage production. p. 146-157. In: Vegetable production in the sub-tropics and tropics overseas, Technical Co-operation Agency Japan. Text Book Series N.-25.

Azad, A. and Nabi. 1984. Agro-economic analysis of cropping patterns involving jute and potato. Workshop-papers-Agricultural-Economics and Social-Sciences-Programme. BARC, Dhaka, No.1.V14p.

Bastelaere, H. V. and Van, H.B. 1998. The use of fertilizer to avoid rib blight and glassiness in autumn lettuce. Proeftuinnieuws. **9**(8): 35-37.

Belligno, A., Fisichella, G., Tropea, M., Sambuco, G. and Muratore, G. 1996. Influence of different formulations of nitrogen on the content of nitrate in lettuce plants. Comparison of a new slow release formulation and traditional fertilizer. Univ. Catania, Italy. **40**(2): 85-93.

Benoit, F. and Ceustermans, N. 1994. Extended production of Bionda for spring culture under direct crop covering. Sint. Katelijne. Waver. **17**: 4-7.

Baca, M. T., Tobar, R., Nobili, M. and Gallardo, J.F. 1993. Effect of incubation of green manure treatment on a soil with and without Phosphate fertilizer. Salamanca, Spain. pp. 551-558.

Benoit, F. and Ceustermans, N. 1993. Environmentally-friendly autumn culture of head lettuce with soil mulching. European Vegetable Research and Development Centre, Belgium. p7.

Boyajieva, N. and Rankov, V. 1989. Effect of polymer aided tomato mulching on the soil biological activity. Pochvoznanie-i Agrokhimiya. **24**(4): 79-85.

Baldev, S., Aujla, T.S., Sandhu, B.S., Khera, K.L. and Singh, B.1988. Resource of autumn potato (Solanum tuberosum) to irrigation and straw mulching in northern India. Indian *J. Agril. Sci*, **58**(7): 521-524.

Berle, D., Esters, E.A., Sanders, D.C. and Lamont, W.J. 1988. Economic evolution of different cultural system for muskmelon production. Hort. Sci., **23**(2):323-326.

Bakker, M. J., Slangen, J.H.G. and Glas, W. 1984. Comparative investigation into the effect of fertigation and of breadcast fertigation on yield and nitrate content of lettuce. Netherlands *J. Agric. Sci.* **32** (4):330-333.

Choudhury, M. S. H., Siddique, M.A. and Rabbani, M.G. 1993. Irrigation and mulching effect on sweet potato yield. Bangladesh Hort., **21**(1): 43-47.

Clough, G. H., Locascio, S.J. and Olson, S.M. 1990. Yield of successively cropped polythene mulched vegetables as affected by irrigation method and fertilizer management. *J. Amen. Soc. Hort. Sci.***115** (6): 884-887.

Devux, A. and Haverkort, A.J. 1987. The effect of shifting planting dates and mulching on late blight and drought stress of potato crops grown under tropical highland conditions. Expt. Agric., **23**(3): 325-333.

Djigma, A. and Diemkouma, D. 1986. Plastic mulch in dry tropical zones. Trails on Vegetables Crops in Burkina Faso. Plasticculture. **69**(1): 19-24.

Eichin, R. and Deser, E. 1999. Paper mulch in cabbage lettuce. Gemuse Munchen. **26**(5): 264-267.

El-Hassan, E. A. A. 1990. Yield and nitrate content of lettuce in relation to somw culture practices. Bulletin of Faculty of Agriculture, University of Cairo. **41**(2): 414-417.

Edris, K. M., Islam, A. T., Chowdhury, M.T. and Haque, A.K.M.M. 1979. Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh, Dept. Soil Survey, Govt. People's Republic of Bangladesh. 118 p.

Feller, C., Strohmeyer, M. and Breuning. 2003. Phosphorous, potassium, magnesium and nitrogen in selected vegetables: new data for fertilizer use. Gemuse-Munchen., **39**(10): 14-15.

FAO. 1988. Production Year Book. Food and Agricultural of the United Nations Rome, Italy. **42**: 190-193.

Gomez, K.H. and Gmez. A.A. 1994. Statistical Procedures for Agricultural research. Second Edn. Wiley-Inter Science publication, John Wiley and Sono, New York. p.680.

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

Gopalan, R. and Balaraman, A.A. 1966. Health Bulletin of India Council of Medical Research. Special Report Series No. **42**. pp. 12-16.

Haraguchi, T. A., Marui., Mori, K. and Nakano, Y. 2003. Movement of water collected by vegetables in plastic mulching field. *J. Agric. Univ. Kyushu. Japan*, **48** (1/2): 237-245.

Hossain, M. I. 1996. Effect of mulches different manorial practices involving equal cost on the growth, yield and storability of garlic. MS Thesis, Dept. of Hort., Bangladesh Agricultural University, Mymensingh. pp. 65-65.

Hochmuth, G. J. and Howell, J.C. 1994. Effect of black plastic mulch and raised beds on sweet potato growth and root in a northern region. Hort Sci., **18**(4): 467-468.

Hochmuth, G. J. and Howell, J.C. 1982. Effect of plastic mulch and raised beds on sweet potato growth and root yield in a northern region. Hort Science. **18** (4): 467-468.

Islam, M. M. 2003. Response of grain amaranth (*Amaranthus hypochondriacus*) to plant density. Indian *J. Agric. Sci.*, **65**(11): 818-820.

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

Jaenaksorn, T. and Ikeda, H. 2004. Possibility of substituting soilless fertilizer with soil for growing leafy vegetables in hydroponics. Acta – Hort., **664**: 351-357.

Jaiswal, J. P., Subedi, P.P. and Gurung, H.M. 1996. Fertilizer trail on carrot connected at outreach research sites for off-season production working paper. Lunle. Res. Centre, Kaksi, Nepal. **24**: 96-103.

Kiss, A. S. 1997.the advantage of green plastic film for soil covering. Kerte's Szo'ke'szet, **25**(4):3 [Cited from Hort. Abstr., 46(9):8180, 1996].

Kowalska, L. 1997. Effects of urea ammonium, and nitrate nitrogen on the yield and quality of greenhouse lettuce grown on different media. Folia Horticulture, **9**(2): 31-40.

Karacal, I. and Turetken, I. 1992. Effects of nitrogen form and phosphorous dose on the yield and nutrient uptake in the lettuce plant. Yuzuncu-Yil-Univ. Turkey, **2**(2): 95-106.

Kim, S.Y., Ryu, O.H. and Hahm, B.H. 1988. The effect of transparent polythene film mulch on the soil temperature, potato growth and yield of the spring crop. Reports of Rural Development Administration Horticulture, Korea Republic, **30**:292-298. [Cited from Field Crop abstr., **42**(10):8125, 1989].

Kallo, 1986. Lettuce In: Bose and Som (eds.) Vegetables Crops in India. Naya Prokash, Calcuta, India. pp. 692-708.

Lei, B. K., Bin, L.H., Yan, D.Z., Li, Z.W. and Yan, D.C. 2004. The effects of fertilizer N and P on nitrate accumulation in Dian Lake drainage area under protection. *J. Yunnan Agric. Univ. Kunming China*, **19**(3):330-334.

Luik, A., Heidemaa, M. and Viidalepp, V. 2002. The influence of intercropping sawdust mulching on carrot yield and entomofunna. Translocations of the Estonian – Agril. Univ., Agron. Dept. Pl. Protec, EAU, 64 Kreutzwaldi St, Estonia, **208**: 115- 120. [Cited from CAB Abstr., 2001-2002].

Lee, S. Y., Lee, G.H., Shin, H.M., Lee, C.H., Han, D.H., Jeong, I.M. and Kim, J.H. 1997. Effect of mulching films on growth and yield of trao, *RDA-J. Hort. Sci.*, **39**(1): 68-72.

Lang, H. 1984. Use of polythene film in early potato for reliability, yield and quality. Kar to effelbau, **35**(2): 65-69.

Manrique, L. A. and Meyer, R. 1984. Effects of soil mulches on soil temperature plant growth and potato yields in an aridic isothermic environment in Peru. **34**(4): 413-419.

Mannan, M.A. and Rashid, M.M. 1983. Effect of spacing and mulching on the yield and

profitability of panchamukhi kachu (*Colocasia sculenta*). Bangladesh *J. of Agril. Res.*, **8**(2):70-73.

Nadasy, I. E. 1999. Effect of N fertilizer application and N forms on the yield and NO_3 content of lettuce. Agrokemiaes Talajtan. **48**(4): 369-380.

Obreza, T. A. and Vavrina, C.S. 1993. Production of Chinese cabbage in relation to nitrogen Source, Rate and Leaf nutrient concentration in Soil Science and Plant Analysis. **24**: 13-14 [Cited from Hort. Abstr., 1994, **64** (4): 2751].

Opena, R. T., Kuo, C. C. and Yoon, J.Y. 1988. Breeding and Seed Production of Chinese cabbage in the Tropics and Subtropics. Tech. Bul., 17, AVRDC. p. 97.

Olasantan, F. A. 1985. Efect of intercropping, mulching and staking on growth and yield of tomatoes. Experimental Agriculture. **21** (2): 135-144.

Rodrigues, E. T. and Casali, V. W. D. 1998.Response of lettuce to organic fertilizer. II. Cocentration , content and utilization of macronutrients in cultivars. Revista-Ceres. Brazil, **45**(261): 437-449.

Rozek, S., Myezkowski, M.J. and Mareczek, A. 1995. The effect of fertilization with nitrate and urea forms of nitrogen on quality and storage ability of lettuce grown in a foil tunnel. Folia Horticulture. **7(1)**:91-105.

Rasul, M. G., Akter, M.S., Nahar, M.S., Manna, M.A and Rashid, M.M. 1994. Effect of mulches and seed types on the growth, yield attributes and yield of Mukhi Kachu. Bangladesh *J. Sci. and Ind. Res.*, **29**(3):53-61.

Rubeiz, I. G., Farran, M.T., Khoury, R.Y. and Assir, I.A. 1992. Comparative evaluation of broiler and layer poultry manure for greenhouse lettuce production.

Communications in Soil Science and Plant Analysis. New York, USA, **23** (7/8): 725-731.

Raham, M. A., Guha, D., Golder, P.C. and Sattar, M.A. 1989. Effect of irrigation and mulch on the growth and yield of cabbage in the hilly region. Bangladesh Horticulture. **17**(1):37-39.

Roy, K. and Shing, R.K. 1983. Effect of mulches and N on moisture use pattern and moisture efficiency in rainfed wheat. *Ind. J. Agril. Res.* **17**(4):203-208. [Cited from Field Crop Abstr., 1985. 35(10)]

Rahim, M A. and Siddique, M.A. 1982. Effect of different levels of nitrogen and methods of application on the yield of some leafy vegetables. Punjab Vegetables Grower. **18**: 30-36.

Rasihid A., Ahmed, K.U. and Habib, A.K.M.A. 1981. Effect of artificial mulching on the performance of potato. Bangladesh Hort., **9** (1):24-27.

Ryder, E. J. 1979. Leafy Salad Vegetables. AVI Publishing Company, USA. pp. 1-94.

Sajjan, A. S., Vyakaranahal, B. S., Kulkarni, G. N. and Shasidhara, S. D. 1992. Effect of date of transplanting and levels of fertilizers on seed yield and yield characters in lettuce (*Lactuca sativa* cv.) Great lakes. Kamataka J. Agril. Sci. **5**(4): 357-361.

Sajjan, A. S., Biradar, B.D. and Patil, Y.B. 1998. Studies on dates of transplanting and graded fertlizer on seed quality in lettuce (*Laktuca sativa* cv.)Great Lake). Advances in Agricultural research in India. **9**:87-90.

Stancheva.I., Arsova, A. and Dinew, N. 1997. Lettuce growth in relation to nitrogen source. Fertilizer rate and soil acidity. I. Yield and plant mineral composition. *Bulgarian J.Agric. Sci.***3** (2):143-152.

Srivastava, P.K., Parikh, M.M., Sawnia, N.G. and Rahman, S. 1994, Effect of drip irrigation and mulching on tomato yield. Water Management, **25**(2):179-184.

Steingrobe, B. and Schenk, M.K. 1994. Root distribution of lettuce and possibilities of fertilizer placement as well as N-stock fertilizer application rootballs to increase fertilizer efficiency. Gartenbauqissenschaft, **59 (4)** 167-172.

Shaheen, M.M., Ali Imam, S.A. and Rahman, M.K. 1993. Effect of mulching duration on the yield of intercropped potato and intercropped sugercane. Bangladesh *J. Sugercane,* 12-15; 4-78.

Sajjan, A. S., Madalageri, B.B. and Merwade, M.N. 1991. Effects of dates of planting and levels of fertilizer on yield of lettuce. Indian Hort., **39**(1): 60-61.

Suh, T.K., Kim, Y.B., Lee, Y.S., Lee, L.S. and Han, K.Y. 1991. Study of improvement of mulching and cultivation method on onion. Res.Rep. Rural Dev, Adv. Hort., **33**(3):31-36. [Cited from Absrt., 64(7):5350,1994].

Siddique, M. A. and Rashid, M.M. 1990. Scope for increasing indigenous potato varieties of Bangladesh. In: Seed potato in Bangladesh proceedings of the international seminar on seed potato. BADC. Dhaka. 1990.

Singh, J. and Randhawa, G.S. 1988. Effect of intercropping and mulch on yield and quality of turmeric. Acta Hort., **188**: 183-186.

Streuzina, A. and Kromer, K. H. 1988. Effect and cost of mulching. *J. Agric. Univ. Puerto Rico*, **72**(2): 43-48. [Cited from Hort. Abstr., 565(4): 2788, 1988].

Setiawan, D.P. and Ragsdale, D.W.1987. Use of aluminum-foil and Oat straw mulch for controlling aster leafhooper (*Maccrosteles fascifrons*) and ester yellow in carrot Great Lakes-Entomologist. Plant Quarantine Ministry Agric, Indonesia, **20**(2)103-109.

Sutater, T. 1987. Shading and mulching effect on potato yield. Buletin- Penelitian- Horticultura, **15**(2):191-198. [Cited from potato Abstr., 15(3):95, 1990].

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

Tisselli, V. 1999. Fertilizer application techniques with less environmental impact Informatore-Arrario. Italy, **55**(22): 45-47.

Vidigal, S. M., Garcia, N.C.P. and Dematos, A.T. 1997. Yield of lettuce grown with different organic compounds and pig manure. Hort. Brasileira. Brazil, **15**(1): 35-39.

Taja, H. and Vander, P. 1991. Organic residue management in the hot tropics: Influence on the growth and yield of solanum, potato and maize. Tropical Agric., **68**(2): 111-118.

Thompson, H. C. and Kelly, W.C. 1988. Cole Crops. In: Vegetable Crops McGraw Hill Book Co. New York. pp. 15, 280-281, 370.

UNDP. 1988. Land Resource Appraisal of Bangladesh for Agricultural Development Report 2: Agro-ecological Regions of Bangladesh, FAO, Rome, Italy, pp. 577.

Work, P. 1997. Vegetables Production and Marketing. Biotechnology Books, Tri Nagar, Delhi. p. 498.

Yoshizawa, T. C. H. and Roan, Y.C. 1981. Management of Summer Amaranth. AVRDC, Shanhua, Taiwan. p. 125.


Appendices

APPENDICES

Appendix I: **Results of mechanical and chemical analysis of soil of the experimental plot**

Mechanical analysis

Constituents	Percent
Sand	32.45
Silt	61.35
Clay	6.10
Textural class	Silty loam

Chemical analysis

Soil properties	Amount
Soil pH	6.15
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Appendix II: **Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November 2006 to February 2007**

Month	Air temperature (^{0}C)			Average RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
November 06	29.18	18.26	23.72	69.52	00
December 06	25.82	16.04	20.93	70.61	00
January 07	24.6	12.5	18.7	66	0
February 07	27.1	16.8	21.95	64	0

Appendix III: Analysis of variance of the data on plant height and number of leaves per plant of lettuce as influenced by nitrogen and mulching

Source of variation	Degrees of freedom	Plant height (cm) at				Number of leaves per plant			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	0.533	4.020	2.980	8.695	0.392	0.928	0.887	6.749
Nitrogen (A)	3	67.373**	80.497**	101.905**	112.383**	42.264**	25.918**	46.255**	77.469**
Mulching (B)	3	41.886**	50.631**	170.570**	202.814**	20.025**	47.151**	101.392**	122.187**
Interaction (A×B)	9	11.065**	12.031**	25.963**	31.093**	4.701*	9.396**	14.537**	18.341**
Error	30	2.290	3.678	7.250	7.445	1.692	2.599	4.400	5.400

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

Appendix IV. Analysis of variance of the data on length of leaf and breadth of leaf of lettuce as influenced by nitrogen and mulching

Source of variation	Degrees of freedom	Length of leaf (cm) at				Breadth of leaf (cm) at			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	0.311	0.331	0.685	5.110	0.072	0.952	1.767	2.707
Nitrogen (A)	3	37.088**	27.710**	30.464**	73.395**	13.591**	27.360**	76.791**	100.347**
Mulching (B)	3	20.349**	47.153**	84.516**	98.839**	8.664**	11.737**	153.726**	182.728**
Interaction (A×B)	9	4.570*	9.456**	13.415**	17.290**	2.509**	2.930**	24.034**	26.288*
Error	30	1.576	2.391	3.086	3.702	0.548	0.823	5.726	9.317

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

Appendix V. Analysis of variance of the data on leaf yield per plant and dry matter content in plant of lettuce as influenced by nitrogen and mulching

Source of variation	Degrees of freedom	Leaf yield (g/plant) at				Dry matter content (%) in plant at			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	55.973	44.242	578.981	3008.135	0.019	0.171	0.041	0.373
Nitrogen (A)	3	14685.481**	6135.569**	10972.483**	29422.130**	11.017**	20.015**	16.876**	30.907**
Mulching (B)	3	6485.786**	13456.482**	42400.438**	62214.007**	6.043**	8.121**	6.986**	9.554**
Interaction (A×B)	9	1470.366*	2772.943**	5910.233**	9256.038**	1.989**	2.483**	2.663**	3.707**
Error	30	543.586	733.995	1605.533	2531.636	0.401	0.687	0.743	0.680

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

Appendix VI. Analysis of variance of the data on yield per plot and hectare of lettuce as influenced by nitrogen and mulching

Source of variation	Degrees of freedom	Yield (kg/plot) at				Yield (t/ha) at			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	0.364	0.008	0.018	0.046	6.317	0.137	0.307	0.806
Nitrogen (A)	3	5.833**	7.099**	8.285**	15.777**	101.264**	123.240**	143.839**	273.913**
Mulching (B)	3	10.011**	35.344**	61.791**	85.882**	173.799**	613.614**	1072.763**	1491.003**
Interaction (A×B)	9	0.520*	0.485*	0.430*	1.351*	9.031*	8.420*	7.472*	23.452*
Error	30	0.234	0.211	0.177	0.515	4.056	3.663	3.066	8.947

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

Appendix VII. Cost of production of lettuce as influenced by nitrogen and mulching

A. Input cost

Treatment	Labour cost	Ploughing cost	Seed cost (Tk)	Irrigation Cost	Weeding cost	Pesticides	Manure and fertilizers				Mulching cost	Sub Total (A)
							Cowdung	Urea	TSP	MP		
N_0M_0	35,000	10,000	4,000	3,500	3,000	3,000	3,0000	-	2,700	3,000	-	94,200
N_0M_1	35,000	10,000	4,000	-	-	3,000	3,0000	1,380	2,700	3,000	1,5000	104,080
N_0M_2	35,000	10,000	4,000	-	-	3,000	3,0000	1,500	2,700	3,000	1,2000	101,200
N_0M_3	35,000	10,000	4,000	-	-	3,000	3,0000	1,620	2,700	3,000	2,5000	114,320
N_1M_0	35,000	10,000	4,000	3,500	3,000	3,000	3,0000	1	2,700	3,000	-	94,201
N_1M_1	35,000	10,000	4,000	-	-	3,000	3,0000	1,380	2,700	3,000	1,5000	104,080
N_1M_2	35,000	10,000	4,000	-	-	3,000	3,0000	1,500	2,700	3,000	1,2000	101,200
N_1M_3	35,000	10,000	4,000	-	-	3,000	3,0000	1,620	2,700	3,000	2,5000	114,320
N_2M_0	35,000	10,000	4,000	3,500	3,000	3,000	3,0000	1	2,700	3,000	-	94,201
N_2M_1	35,000	10,000	4,000	-	-	3,000	3,0000	1,380	2,700	3,000	1,5000	104,080
N_2M_2	35,000	10,000	4,000	-	-	3,000	3,0000	1,500	2,700	3,000	1,2000	101,200
N_2M_3	35,000	10,000	4,000	-	-	3,000	3,0000	1,620	2,700	3,000	2,5000	114,320
N_3M_0	35,000	10,000	4,000	3,500	3,000	3,000	3,0000	2	2,700	3,000	-	94,202
N_3M_1	35,000	10,000	4,000	-	-	3,000	3,0000	1,380	2,700	3,000	1,5000	104,080
N_3M_2	35,000	10,000	4,000	-	-	3,000	3,0000	1,500	2,700	3,000	1,2000	101,200
N_3M_3	35,000	10,000	4,000	-	-	3,000	3,0000	1,620	2,700	3,000	2,5000	114,320

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene

Appendix VII. Contd.

B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 800,000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 12 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
N_0M_0	45,500	4,710	18,773	68,983	163,183
N_0M_1	45,500	5,204	10,061	60,765	164,845
N_0M_2	45,500	5,060	9,864	60,424	161,624
N_0M_3	45,500	5,716	10,760	61,976	176,296
N_1M_0	45,500	4,710	9,387	59,597	153,798
N_1M_1	45,500	5,204	10,061	60,765	164,845
N_1M_2	45,500	5,060	9,864	60,424	161,624
N_1M_3	45,500	5,716	10,760	61,976	176,296
N_2M_0	45,500	4,710	9,387	59,597	153,798
N_2M_1	45,500	5,204	10,061	60,765	164,845
N_2M_2	45,500	5,060	9,864	60,424	161,624
N_2M_3	45,500	5,716	10,760	61,976	176,296
N_3M_0	45,500	4,710	9,387	59,597	153,799
N_3M_1	45,500	5,204	10,061	60,765	164,845
N_3M_2	45,500	5,060	9,864	60,424	161,624
N_3M_3	45,500	5,716	10,760	61,976	176,296

N_0: 0 kg N/ha
N_1: 60 kg N/ha
N_2: 80 kg N/ha
N_3: 100 kg N/ha

M_0: No mulch
M_1: Rice straw
M_2: Water hyacinth
M_3: Black polythene