# EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF LETTUCE



**ABU SAYEM MD. TAUHIDUL ISLAM**

**DEPARTMENT OF HORTICULTURE AND POSTHARVEST TECHNOLOGY**

**SHER-E-BANGLA AGRICULTURAL UNIVERSITY**

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**By**

**ABU SAYEM MD. TAUHIDUL ISLAM**
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**Approved by:**

| | |
|---|---|
| Supervisor | Co- supervisor |
| **(A. K. M. Mahtabuddin)** | **(Dr. Md. Nazrul Islam)** |
| Professor | Associate Professor |
| Dept. of Horticulture & Postharvest Technology | Dept. of Horticulture & Postharvest Technology |
| Sher-e-Bangla Agricultural University, | Sher-e-Bangla Agricultural University, |
| Dhaka | Dhaka |

Chairman
Examination Committee
**(Dr. Md. Nazrul Islam)**
Associate Professor
Department of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University, Dhaka

# CERTIFICATE



This is to certify that the thesis entitled, "*EFFECT OF NITROGEN AND PHOSPHORUS ON THE GROWTH AND YIELD OF LETTUCE*" 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 bonafide research work carried out by ***ABU SAYEM MD. TAUHIDUL ISLAM, Registration No. 21792/00268*** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

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

**Dated:**
**Dhaka, Bangladesh**

Supervisor
**(Prof. A. K. M. Mahtabuddin)**
Dept. of Horticulture & Postharvest Technology
Sher-e-Bangla Agricultural University
Dhaka

*Dedicated to*

*My*

*Parents & Teachers those who laid the foundation of my success*

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*Dated:*

*The Author*

# Effect of Nitrogen and Phosphorus on the Growth and Yield of Lettuce

**By**

**Abu Sayem Md. Tauhidul Islam**

## ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October 2004 to January 2005 to study the effect of different levels nitrogen (N) and phsophorus ($P_2O_5$) on the growth and yield of lettuce. The different treatments of nitrogen were control ($N_0$), nitrogen 50 kg/ha ($N_{50}$), nitrogen 100 kg/ha ($N_{100}$) and nitrogen 150 kg/ha ($N_{150}$) as well as different treatments of phosphorus were control ($P_0$), phosphorus 50 kg/ha ($P_{50}$) and phosphorus 100 kg/ha ($P_{100}$). The experiment was conducted in the Randomized Complete Block Design (RCBD) with three replications. Data were recorded from ten randomly selected plants of each unit plot on growth and yield of plants. Parameters on plant height, leaves number, leaf area, fresh leaf yield per plant, gross yield, marketable yield, dry matter content and fiber content were studied. Application of different levels of nitrogen and phosphorus significantly influenced the growth and yield of lettuce. The best performance was obtained from $N_{150}P_{100}$ treatment combination in case of all parameters that was considered to be the best combination of fertilizer management for maximizing the yield of lettuce. The treatment $N_{150}$ resulted the highest gross (44.50 t/ha) and marketable yield (43.52 t/ha). The highest gross yield (40 t/ha) was recorded from $P_{100}$ treatment, while the lowest (35.5 t/ha) was recorded form $P_0$ treatment. The combined effect of various levels of nitrogen and phosphorus were also found significant in case of yield lettuce. The treatment combination of $N_{150}P_{100}$ produced the highest gross (45.50 t/ha) and marketable yield (44.50 t/ha). The lowest gross (32.0 t/ha) and marketable yield (31.0 t/ha) were recorded from the control treatment. The benefit cost ratio was maximum (2.97) in the treatment combination of $N_{150}P_{100}$ whereas the minimum (2.18) was recorded from the control treatment ($N_0P_0$).

# LIST OF ABBREVIATED TERMS

| FULL NAME | ABBREVIATION |
|---|---|
| Agro-Ecological Zone | AEZ |
| And others | *et al.* |
| Bangladesh Bureau of Statistics | BBS |
| Dounum | Da |
| Days After Transplanting | DAT |
| Etcetera | etc |
| Food and Agriculture Organization | FAO |
| Hectare | ha |
| Hour | hr |
| Murate of Potash | MP |
| Randomized Complete Block Design | RCBD |
| Sher-e-Bangla Agricultural University | SAU |
| Triple Super Phosphate | TSP |
| United Nations Development Program | UNDP |

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# CHAPTER I

# INTRODUCTON

# INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most popular salad crop in the world. It is leafy herb and belongs to the family compositae. It produces a short stem early in the season and later in the season a seed stalk is produced (Ryder, 1979). A cluster of leaves varying considerably in shape, character and colour in different varieties. It is mainly a cold loving crop. The best day temperature range for lettuce cultivation is 18°C to 25°C and the night temperature is 10°C to 15°C (Ryder, 1998).

Lettuce is popular for its delicate, crispy, texture as fresh condition. The nutritive value of lettuce is very high and contain a good amount of minerals and a moderate source of vitamins to the human diet and supply 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). Moreover, it is anadyne, sedative, diuretic and expectorant (Kallo, 1986).

Lettuce is a newly introduced crop in our country and getting popularity day by day. Its production package is not much known to Bangladeshi farmers. Among various factors responsible for higher yield, suply of nutrient play vital role in the production and quality of lettuce. The cultivation of lettuce requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both. Nitrogen is critically deficient and is the most limiting element in soils of Bangladesh. For successful crop poduction it must have an adequate supply of all necessary nutrient which are taken up by plants from the soil.

As it's a leafy vegetable nitrogen is the most important fertilizer nutrient for successful lettuce production. Nitrogen exhibits marked effect on the vegetaive growth, leaf and seed yield, fibre and protien content of lettuce. Nutrient removal from soils by the lettuce is modest but fertility requirements are generally high because of the limited root system and the necessity for rapid continuous growth (Mitra and Bose, 1990).

The effect of phosphorus on the fromation and translocation of carbohydrates and root development, nodulation, growth and other agronomic characters are well recognized. Phosphorus enhance earlyness in flowering and maturity.

Execess application of inorganic fertilizer causes hazard to public health and environment which is also favorable for higher yield. Any of nutrient element is lacking or present in improper proportion, normal plant growth will be hampered. Among different major plant nutrient nitrogen and phosphorus are important for all the crops in general.

Considering the above facts, the present experiment was undertaken to study the effect of nitrogen and phophorus on the growth and yield of lettuce with the following objectives-

- To identify the proper dose of nitrogen for lettuce production.
- To identify the proper dose of phosphorous for lettuce production.
- To know the combined effect of nitrogen and phosphorous for lettuce production.

# CHAPTER II

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

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

## 2.1 Effect of nitorgen and phosphorus on the growth and yield of lettuce

Wilson (1976) conducted experiments with winter lettuce in which phosphorus was applied at 100, 200 and 300 kg/ha. He noted that maturity was advanced and the yield was increased by higher rates of P.

Rahim and Siddique (1982) obtained 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) reported 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 lb/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.

Bakker *et al.* (1984) investigated the effects of method of application on yield and nitrate content of lettuce. Plants grown by applying N through the irrigation system (fertigation) were compared with plants fertilizer with broadcast nitrogen. Fertigation 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 effected by method of fertilization.

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

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 appl ication 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).

Sajjan *et al.* (1991) conducted an experiment in which seedlings of lettuce cv. Great lakes 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.

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 358 g 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 (0.266-0.332%). It was concluded that application of N at 50 kg/da resulted in optimum lettuce yield and quality.

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.

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 ($5^0$C) and high ($20^0$C) temperatures. N form 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 ($20^0$C) and in cold chamber ($5^0$C).

Sanchez and Hout (1995) conducted four field experiments in Florida to compare the relative responses of different lettuce types to P fertilizer application. P was applied at 0, 50, 100, 200 and 300 kg/ha as triple super phosphate. All lettuce types showed large yield and quality responses to P fertilizer. Because environmental conditions affected yield potential, P rate required for optimal yield varied for lettuce types across experiments.

Abdel (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 maximise lettuce yields the optimum N application was 200 kg/ha.

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; in 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.

Nadasy (1999) set up experiments in 1995 and 1996 using lettuce cv. Balaton under greenhouse conditions. N was applied as $NO_3$-N, $NH_4$-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/kg N. 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.

Wijk (2000) described the results obtained in trials with early head lettuce, cultivated in soils with different 4 levels of P status combined with 2 rates of P fertilizer dressing, during 1996-98 in Netherlands. The best rate of P fertilizer dressing was strongly linked to the P status of the soil and the cultivation method. Because of the strong phosphate requirement of lettuce, there was a big response to phosphate fertilization on soils with a low P level.

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, $P_2O_5$, $K_2O$/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.

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 $NO_3$ in soil. The effects of P on $NO_3$ 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 $NO_3$ 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 pakchoi (*Brassica chinensis*), lettuce (*Lactuca sativa*) and Chinese cabbage (*B. pekinensis*) in deep flow technique (DFT) as and re-circulation nutrient film technique (NFT) treated with soilless nutrient solution ($NS_1$) and soil fertilizer solution ($NS_2$). 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 is 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 N/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.

Johannessen *et al.* (2004) observed that no difference in bacteriological quality could be detected in lettuce at harvest after application of various types of manure-based fertilizers grown under Norwegian conditions. Significance and Impact of the Study, the results may indicate that the use of manure does not have considerable influence on the bacteriological quality of organic lettuce. However, others have suggested that there is a risk by using manure. There is a need for more research in the field.

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

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.

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

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.

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

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

Milagrosa *et al.* (1999) reported that in lettuce, Bokashi and/or EM-1 did not increase the height of plants. Plots treated according to TFP were taller than in any other treatment. However, the highest yield of lettuce heads was obtained from the plot treated with inorganic fertilizer + Bokashi + EM-1, followed by EM-1 treatment. The lowest number of marketable lettuce heads was recorded in plots treated with TFP, due to the development of soft rot.

Nadasy (1999) reported that the greatest dry matter production was found at 80 mg/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.

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

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

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

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.

Neuvel and Kanters (1999) observed that two butter head lettuce cultivars were sown on a sandy soil in the Netherlands on 26 March 1998 (cv. Milly) and 28 May 1998 (cv. Sumian). Cultivars were harvested on 22 May and 15 July, respectively. Both cultivars were fertilized with 0, 120 and 480 kg $K_2O$/ha. Crop yields (55 t/ha) did not vary significantly between treatments, and crop wastes was approximately 14 t/ha (including 2 t/ha of roots). Dry mater production of the spring cultivation was 1000 kg/ha more than of the summer cultivation, but K fertilizer did not influence dry mater production. Uptake of K increased with increasing fertilizer rate (254, 293 and 332 kg $K_2O$/ha for spring cultivation, and 196, 226 and 234 kg $K_2O$/ha for summer cultivation, respectively).

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

Bastelaere (1999) stated that fertilizer application (12.5 kg/ha) in the autumn on well-leached soils resulted in glassiness and rib blight. However, after soil disinfection, an application of 25 kg/ha was sometimes necessary. Greater application rates resulted in stagnated growth and lower crop weight.

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.

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

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 $PO_4$-P concentration was not affected by treatments, but leaf $NO_3$-N at heading was significantly increased by all treatments.

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

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

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

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 fertilized 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-$NO_3$ accumulation. Nitrogen application rates and different fertilizers influenced nitrate content.

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 lb N/acre for the largest head size and highest yield. Excessive N fertilizer application (> 200 lb/acre) reduced yields. P fertilizer application did not increase yield or quality.

Zhou *et al.* (1995) mentioned that 15N-Labelled ammonium sulfate and rice straw were applied alone or in combination to lettuces 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.

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 cos 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.

Benoit and Ceustermans (1994) observed that two treatments summer and particularly autumn were most severely affected by the heat and gave low yields. Nitrate contents of the harvested lettuces 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.

Abaquita (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.

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.

# CHAPTER III

# MATERIALS AND METHODS

# MATERIALS AND METHODS

In Bangladesh, lettuce is being grown in a very limited scale, but a good deal of interest has been generated for raising this crop due to its demand in fastfood shops. Nitrogen and phosphorus has an effect on growth and yield of lettuce. So, this experiment has undertaken to find out appropriate or optimum doses of nitrogen and phosphorous for exploiting the yield potential of this crop.

### 3.1 Experimental Site

The experiment was conducted at the Horticulture Farm and Laboratories of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from October 2004 to February 2005. The location of the site in 23° 74′N latitude and 90° 35′E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

### 3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). There was no rainfall during the growing period except the month of October (208mm). The average monthly maximum and minimum temperature were 29.45°C and 13.86°C respectively during the experimental period. Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity, rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented in appendix I.

### 3.3 Soil

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

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

AEZ No. 28

Soil series – Tejgaon

General soil- Non-calcarious dark grey.

### 3.4 Plant materials

Seeds of lettuce cultivar, 'Green Rapid' were used and sown on 15th October, 2004. It is spreading type as well as heat tolerant in nature.

### 3.5 Experimental design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. An area of 25.7m × 10m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments were allotted at random. Thus there were 36 unit plots altogether in the experiment. The size of each plot was 2m×1.6 m. The distance between two blocks and two plots were kept 1 m and 0.5 m respectively. The spacing was 40 cm × 25 cm. A layout of the experiment has been shown in Fig. 1.

### 3.6 Treatment of the experiment

The experiment was designed to study the effect of nitrogen and phosphorus on the growth and yield of lettuce. The experiment consisted of two factors are as follows:

Factor A: Nitrogen ($N_2$), four levels

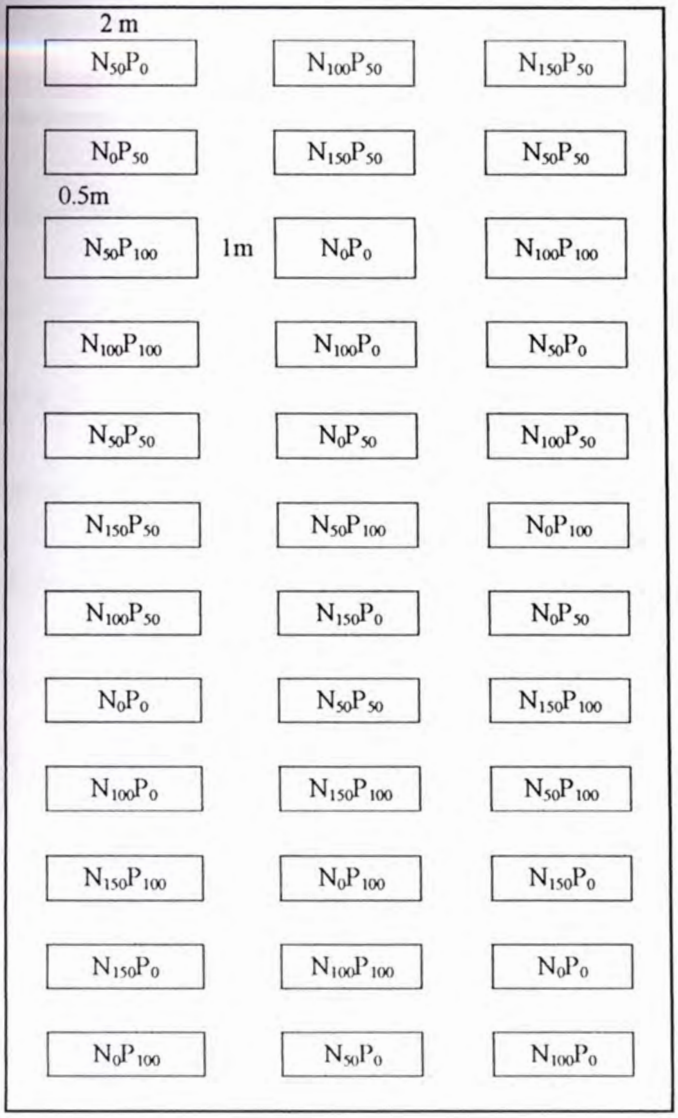
- $N_0$ = Control
- $N_{50}$ = Nitrogen 50 kg/ha
- $N_{100}$ = Nitrogen 100 kg/ha
- $N_{150}$ = Nitrogen 150 kg/ha

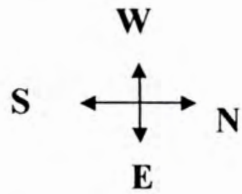
Factor B : Phosphorus ($P_2O_5$), three levels

- $P_0$ = Control
- $P_{50}$ = Phosphorus 50 kg/ha
- $P_{100}$ = Phosphorus 100 kg/ha

There were altogether 12 treatments combination such as-

$N_0P_0$, $N_0P_{50}$, $N_0P_{100}$, $N_{50}P_0$, $N_{50}P_{50}$, $N_{50}P_{100}$, $N_{100}P_0$, $N_{100}P_{50}$, $N_{100}P_{100}$, $N_{150}P_0$, $N_{150}P_{50}$, $N_{150}P_{100}$.




Plot size: 2 m × 1.6 m
Spacing: 25 cm × 40 cm

Plot spacing: 0.5 m

Between replication: 1 m

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

Fig. 1. Field layout of the two fectors experiment in the Randomized Complete Block Design (RCBD)

### 3.7 Seed bed preparation and raising of seedlings

Seed beds were prepared with a mixture of sand, soil and compost. It was raised 15cm from ground level. Germination of lettuce seed is a major problem in lettuce cultivation. Lettuce seed usually fails to germination at temperature above 30°C. Several researchers have found that most lettuce seed may go into dormancy when subjected to high temperature. Exposure to chilling at 4-6°C for 3-5 days result in breaking dormancy (Thomson and Kelly, 1957). Lettuce seeds were soaked in water for 48 hours and then mixed with soil and sown in seed bed on 15th October, 2004. Germination of seed took place five days after sowing of seeds. When the seedlings were thirty days old, they were transplanted in the experimental field on 15 th November, 2004.

### 3.8 Land preparation

The land which was selected to conduct as experiment field was opened 30 October, 2004 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made until good tilth.

### 3.9 Application of manures and fertilizers

Manures and fertilizers were applied according to the treatment in each plot. This were given as follows:

| Manures and fertilizers | Doses/ha |
|---|---|
| Cowdung | 5 ton |
| MP | 200 kg |
| N (as urea) | 0, 50, 100 and 150 kg |
| $P_2O_5$ (as TSP) | 0, 50 and 100 kg |

Half of the quantities of cowdung were applied during land prreparation. The remaining half of the cowdung, entire quantity of TSP and MP and one-third of urea were applied during pit preparation. The rest of urea were applied as top-dressing into two equal split at 10 and 30 days after transplanting.

### 3.10 Transplanting of seedlings

Thirty days of old seedlings were transplanted on 15th November, 2004 in the afternoon and light irrigation was given around each seedlings for their better establishment in the field. The transplanted seedlings were protected from scorching sunlight from 9:00 am to 2:00 pm by providing shed using banana leaf sheath upto 15 days from transplanting.

## 3.11 Intercultural operation

### 3.11.1 Gap filing

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

### 3.11.2 Weeding

Weeding was done three times in each and every plot as necessary.

### 3.11.3 Irrigation

Light irrigation was given just after transplanting the seedlings. A week after transplanting the requirement of irrigation was envisaged through visual estimation. Whenever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wetted.

### 3.11.4 Insects and Diseases

There was no incidence of insects and diseases.

## 3.12 Harvesting

The haeds were harvested on the diferents dates because of asyncronize maturity which was found due to use of different levels of fertilizer in the different treatment. Harvesting was started on the 26$^{th}$ December, 2004 and terminated on the 6$^{th}$ January,

2005. The head was cut just above the ground level with the help of a sharp knife and over mature and external parts were excluded.

### 3.13 Data collection



Data were recorded on the following parameters from the sample plants during the course of experiment. Ten (10) plants were sampled randomly from each unit plot for the collection of data.

#### 3.13.1 Plant height (cm)

Plant height was measured in centimeter (cm) by a meter scale at harvest from the point of attachment of the leaves to the ground level up to the tip of the longest leaf.

#### 3.13.2 Number of leaves per plant

Number of leaves from each of the plant were counted at harvest (above 6cm length). All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from counting.

#### 3.13.3 Leaf area

The leaf area was recorded from ten randomly selected plants on the basis of leaf length and leaf breath in square centimeter ($cm^2$).

#### 3.13.4 Fresh weight of leaves per plant (g)

Leaves of each of the collected plants from each treatment at harvest were detached by a sharp knife and average fresh weight of leaves was recorded in gram (g).

### 3.13.5 Yield/plant (g)

Ten randomly selected plants were cut above ground by a sharp knife and fresh weight of head was taken by a digital balance at harvest and the mean weight was recorded in gram (g).

### 3.13.6 Gross yield (t/ha)

The yield per plot was calculated by converting the yield per plant and the yield (t/ha) was calculated from the yield per plot.

### 3.13.7 Marketable yield (t/ha)

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

### 3.13.8 Qualitative characters

The sample of 100 g fresh leaves were collected from each of the plot for the analysis of qualitative characters.

1. Dry matter content (%)
2. Fibre content (%)

## 3.14 Laboratory procedure

### 3.14.1 Dry matter estimation

One hundred gram of leaf sample previously cut into thin pieces were sundried, after that samples were placed in an envelop and placed in oven maintained at $70^0C$ for 72 hours. The sample then was transferred into a desiccator and allowed to cool down to the room temperature. The dry weight of the sample was taken. The dry matter contents were computed by simple calculation from the weight by the following formula-

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

### 3.14.2 Fibre Estimation

Hundred gram of fresh leaf was randomly collected from each plot. Then the leaves were cut into small pieces and boiled for 25 minutes. The boiled laeves sample were meshed and sieved. After seiving, found fibre was drieds at room temperature and weighted. The fibre contents were computed by simple calculation from the record by the following formula-

$$\text{Fibre (\%)} = \frac{Fibre\ weight}{Fresh\ weight\ of\ leaves} \times 100$$

### 3.15 Statistical analysis

The data collected from the experimental plots were statistically analyzed. The mean values for all the treatments was calculated and the analysis of variance for most of the characters was accomplihsed by 'DMRT'. The significance of difference between pair of means was tested by the least significant difference (lsd) test at 5% and 1% level of probabilty (Gomez and Gomez, 1984).

# CHAPTER IV

# RESULTS AND DISCUSSION

# RESULTS AND DISCUSSION

The experiment was conducted to investigate the effect of different levels of nitrogen and phosphorus on the growth and yield of lettuce. The analyses of variances for different characters have been presented in appendices III and IV. Data of the different parameters analyzed statistically and the results have been presented in the Tables 1 to 6 and Figures 2 to 11. The results of the present study have been presented and discussed in this chapter under the following headings.

## 4.1. Plant height

### 4.1.1 Main effect of nitrogen on plant height of lettuce

The level of nitrogen application had marked influence on plant height of lettuce at final harvest. The plant height was found to be increased significantly with the increase in nitrogen level upto 150 kg per hectare (Fig. 2). During the period of plant growth the maximum plant height (26.32 cm) was observed in $N_{150}$ treatment where 150 kg N was applied which was not identical with $N_{50}$ and $N_{100}$ treatments. In general, plant height increased gradually in the early stages. The shortage plant height 16.36 cm was found in control plot ($N_0$). Similar results are found in lettuce by Hochmuth *et al.* (1994) and Karacal and Turetken (1972).

### 4.1.2 Main effect of phosphorus on plant height of lettuce

The application of phosphorus was significantly influenced on the plant height of lettuce. The highest plant height (23.27 cm) was obtained from $P_{100}$ treatment which was followed by $P_{50}$ (22.47 cm) and $P_0$ (20.64 cm) in descending order (Fig. 3). The lowest plant height was found in $P_0$ treatment (20.64 cm).

### 4.1.3 Interaction effect of nitrogen and phosphorus on plant height of lettuce

The plant height was significantly influenced by the interaction effect of nitrogen and phosphorus application on lettuce (Appendix III). The maximum vegetative growth was recorded at final harvest. The highest plant height of 28.2 cm was found from the $N_{150}P_{100}$ treatment combination and the lowest (15.7 cm) from the control treatment (Table 1).

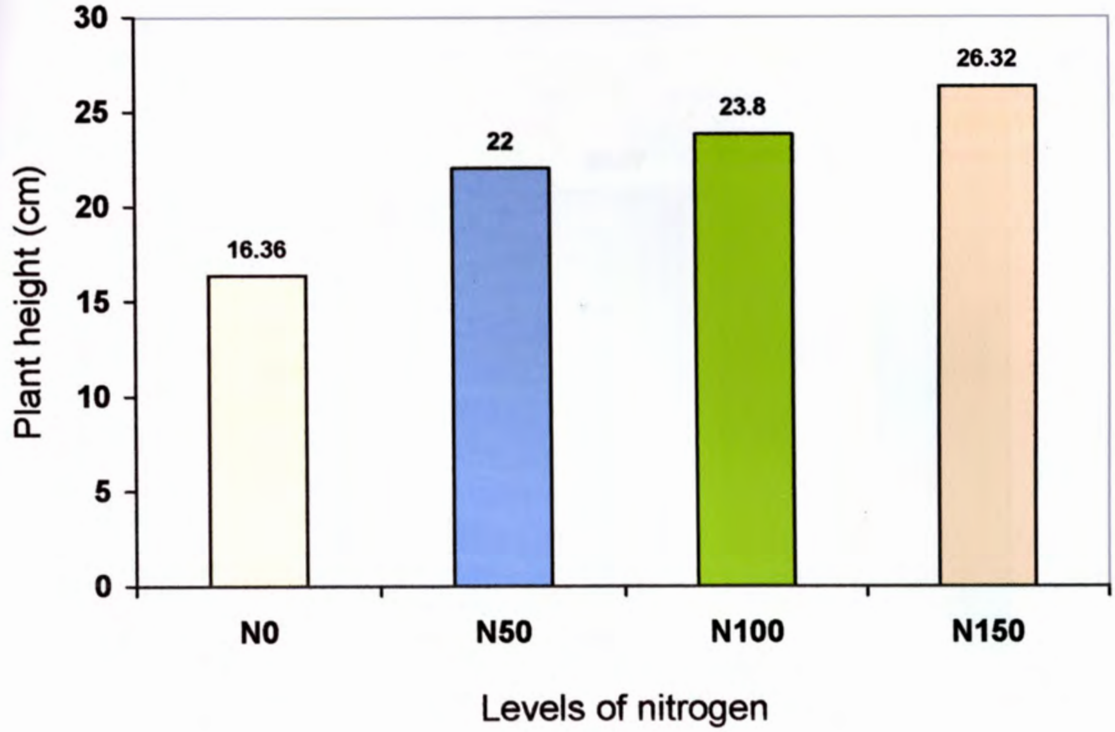



Fig. 2. Main effect of nitrogen on plant height of lettuce

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

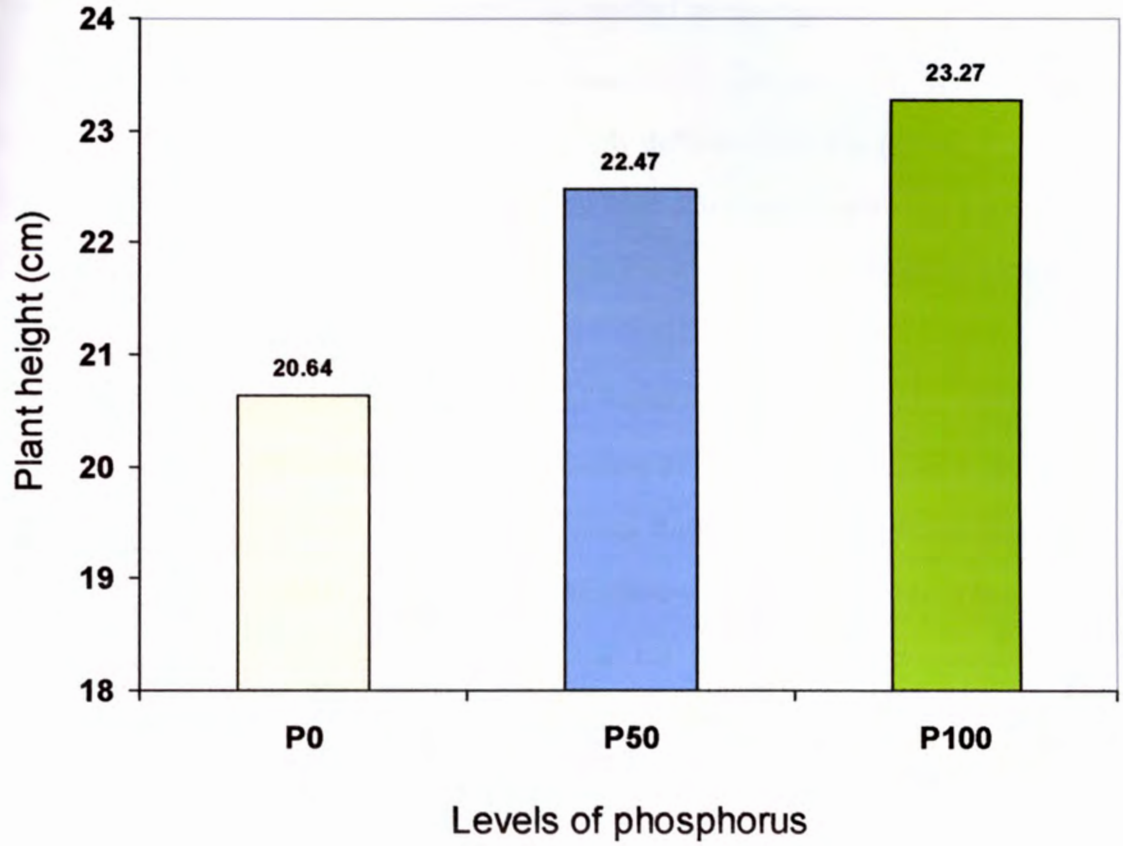



Fig. 3. Main effect of phosphorus on plant height of lettuce

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

### 4.2 Number of leaves per plant

#### 4.2.1 Main effect of nitrogen on number of leaves of lettuce

Application of nitrogen significantly increases the production of leaves per plant (Fig. 4). The application of nitrogen in treatment $N_{150}$ resulted in the highest number of leaves (30.28) which was statistically identical with $N_{100}$ (30.13). The lowest (25.26) number of leaves found at $N_0$ treatment which was statistically different from $N_{50}$ (28.48). From the observation it was found that with the increasing level of nitrogen application the number of leaves increased. This results in agreement with that of Islam *et al.* (1998) in Batisak.

#### 4.2.2 Main effect of phosphorus on number of leaves of lettuce

Significant variation was found in case of production of leaves per plant due to the effect of phosphorus (Fig. 5) at final harvest. At final harvest $P_{100}$ phosphorus treatment produced maximum (30.02) number of leaves, followed by $P_{50}$ (28.40). The control treatment gave minimum number of leaves (27.19) per plant showing significantly different result from other treatments.

#### 4.2.3 Interaction effect of nitrogen and phosphorus on number of leaves of lettuce

The number of leaves per plant was also significantly influenced by the interaction effect of nitrogen and phosphorus (Appendix III). At final harvest, the plant receiving the treatment $N_{150}P_{100}$ produced the highest number of leaves (33.3). The lowest number of leaves (24.6) was observed from the control treatments, where no nitrogen and phosphorus were used which have been shown in table 1.

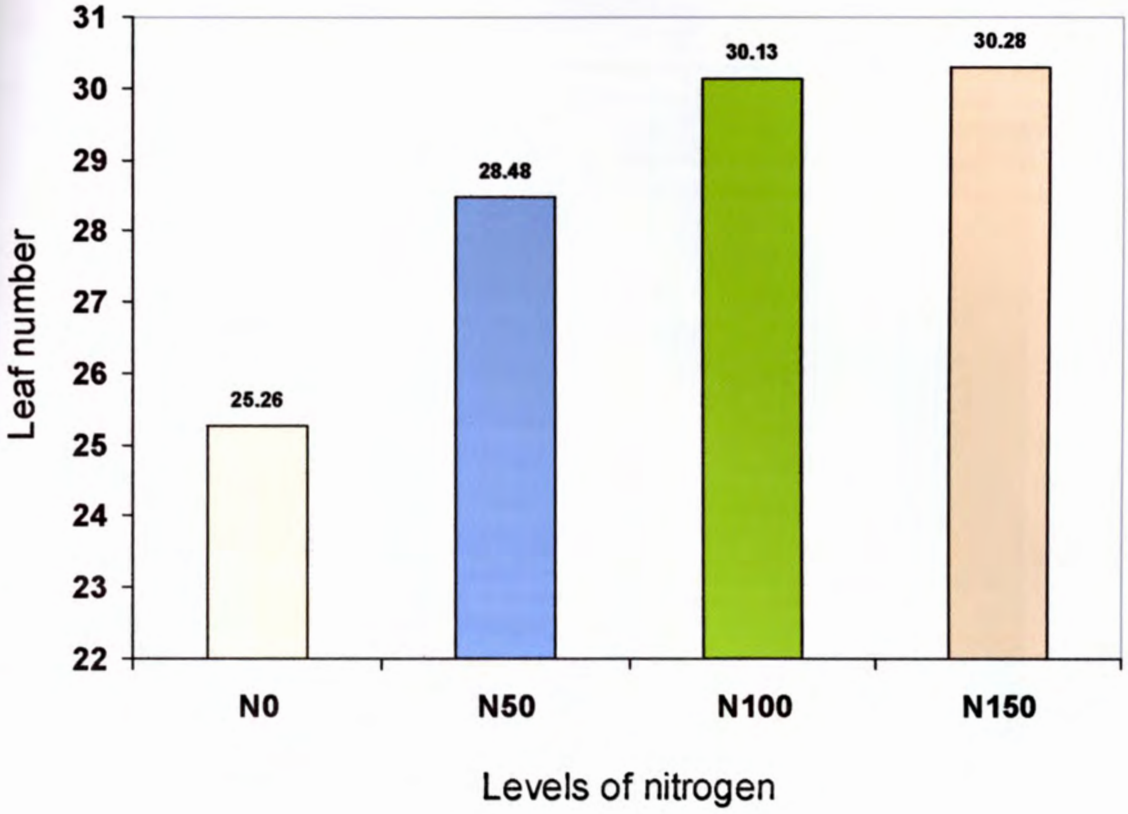



Fig. 4. Main effect of nitrogen on leaf number of lettuce

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

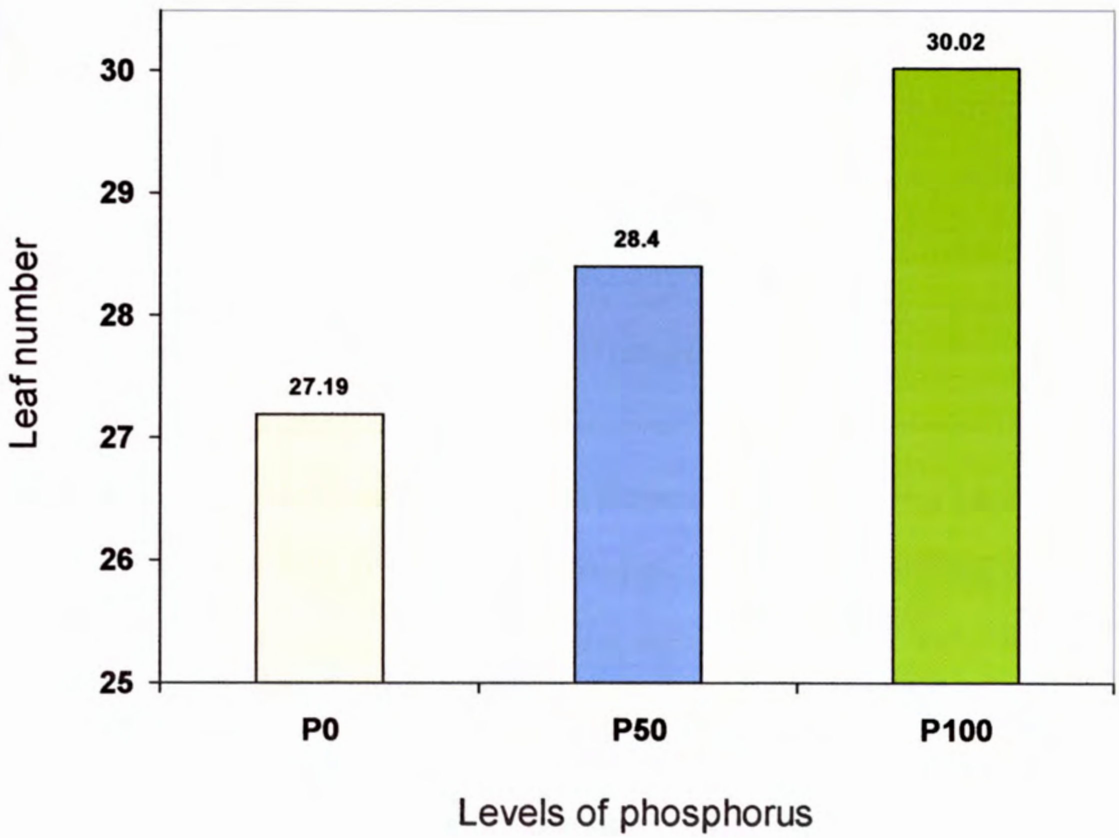



Fig. 5. Main effect of phosphorus on leaf number of lettuce

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

### 4.3 Leaf area

#### 4.3.1 Main effect of nitrogen on leaf area of lettuce

The leaf area varied significantly due to the application of different nitrogen levels. During the period of plant growth the maximum (416.4 $cm^2$) leaf was observed in $N_{150}$ treatment followed by $N_{100}$ and $N_{50}$ treatment (Fig. 6). The smallest leaf (342.5$cm^2$) was found from the control treatment $N_0$. From the result it was found that with increasing the level of nitrogen application, leaf area of lettuce increased. This result in agreement with that of Islam *et al.* (1998) in Batisak.

#### 4.3.2 Main effect of phosphorus on leaf area of lettuce

In respect of leaf area significant variation was observed (Fig. 7). Maximum leaf area (397.16 $cm^2$) was obtained from $P_{100}$ which was followed by $P_{50}$ (382.90 $cm^2$) and $P_0$ was the minimum (367.08 $cm^2$) in this regard. From the observation it was found that leaf area increased with increasing rate of phosphorus application from zero kg/ha upto 100 kg/ha. This is in agreement with Nagata *et al.* (1992).

#### 4.3.3 Interaction effect of nitrogen and phosphorus on leaf area of lettuce

The highest leaf area was significantly influenced by the interaction effect of nitrogen and phosphorus. The maximum leaf area (445 $cm^2$) was found from the treatment combination ($N_{150}P_{100}$) at final harvest and the lowest (342 $cm^2$) from the control treatment ($N_0P_0$), which have been shown in table 1.

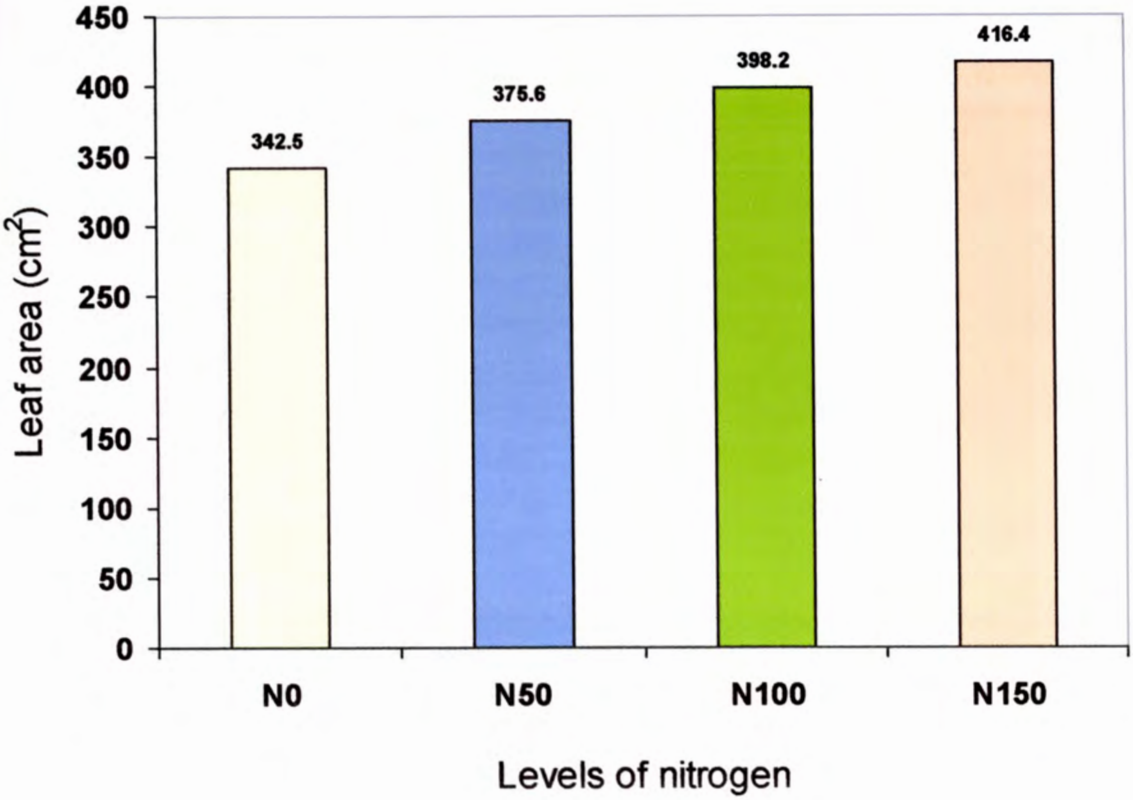



Fig. 6. Main effect of nitrogen on leaf area of lettuce

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

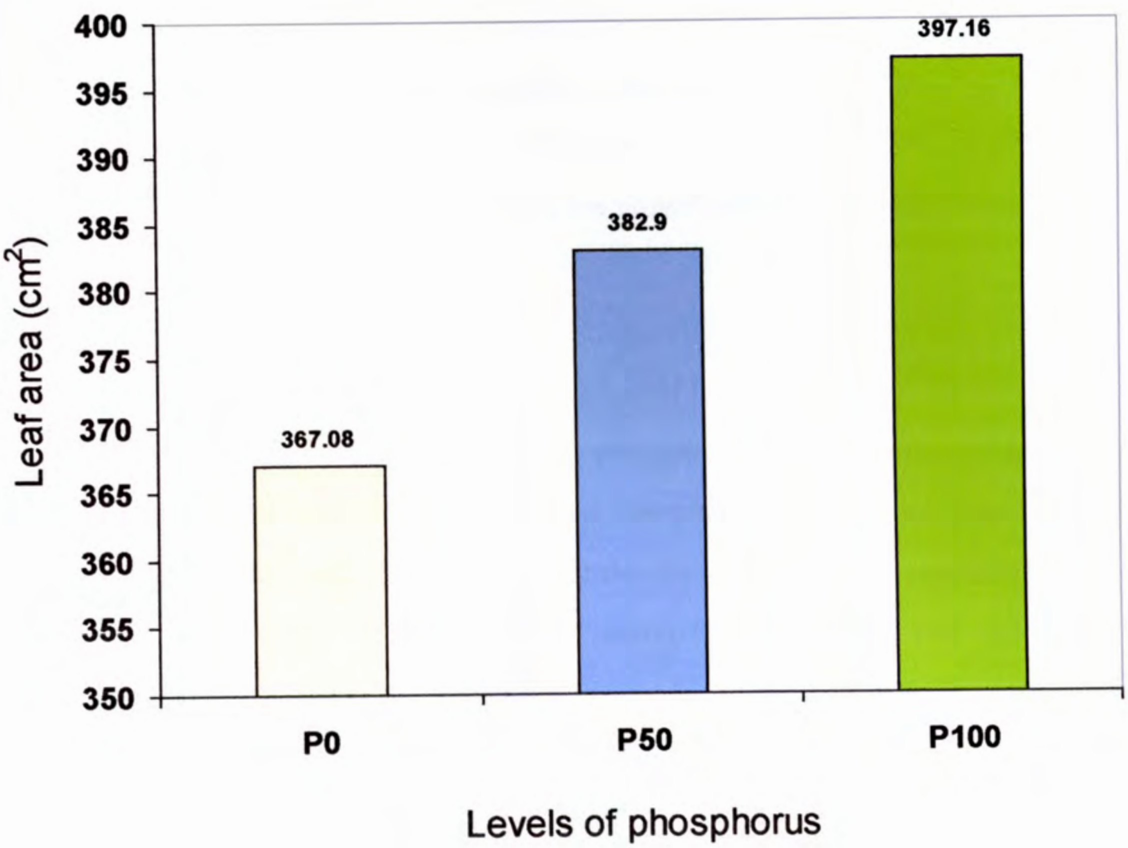



Fig. 7. Main effect of phosphorus on leaf area of lettuce

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

### 4.4 Leaf yield/plant

#### 4.4.1 Main effect of nitrogen on leaf yield per plant of lettuce

The leaf yield per plant varied form 332.16 g to 445.41 g due to application of different level of nitrogen in lettuce (Fig. 8). The maximum fresh weight of leaves per plant was 445.41 g was contributed by $N_{150}$ treatment followed by $N_{100}$ (415.46 g). The lowest (332.16 g) yield was found from $N_0$ treatment. The present findings either partially or fully agree with the previous works of El-Hassan (1990); Anez and Pino (1997) and Kowalska (1997). Nitrogen promoted vegetative growth which ultimately increases the yield.

#### 4.4.2 Main effect of phosphorus on yield per plant of lettuce

Significant difference was varied in leaf yield per plant due to application of different levels of phosphorus (Fig. 9). The maximum yield per plant (409.15 g) was found by $P_{100}$ which was not identical with $P_{50}$ treatment and the minimum yield per plant (377.95 g) was found from $P_0$ treatment. The possible reason for such higher leaf yield with increasing phosphorus might be that the plants produced more carbohydrate through better photosynthesis.

#### 4.4.3 Interaction effect of nitrogen and phosphorus on leaf yield per plant of lettuce

The interaction effect of nitrogen and phosphorus was significant on fresh weight of leaves per plant. The combined effect of nitrogen and phosphorus was also significant on fresh weight of leaves per plant (Appendix III). The maximum leaf yield per plant (455.5 g) was obtained from $N_{150}P_{100}$ treatment combination which was not statistically similar with other treatment. The lowest leaf yield per plant (320.5 g) was found in $N_0P_0$ treatment combination (Table 1). The possible reason such higher leaf yield is that the uptake of phosphorus involved with enhanced photosynthesis resulting the increasing nitrogen uptake that also promote better yield.

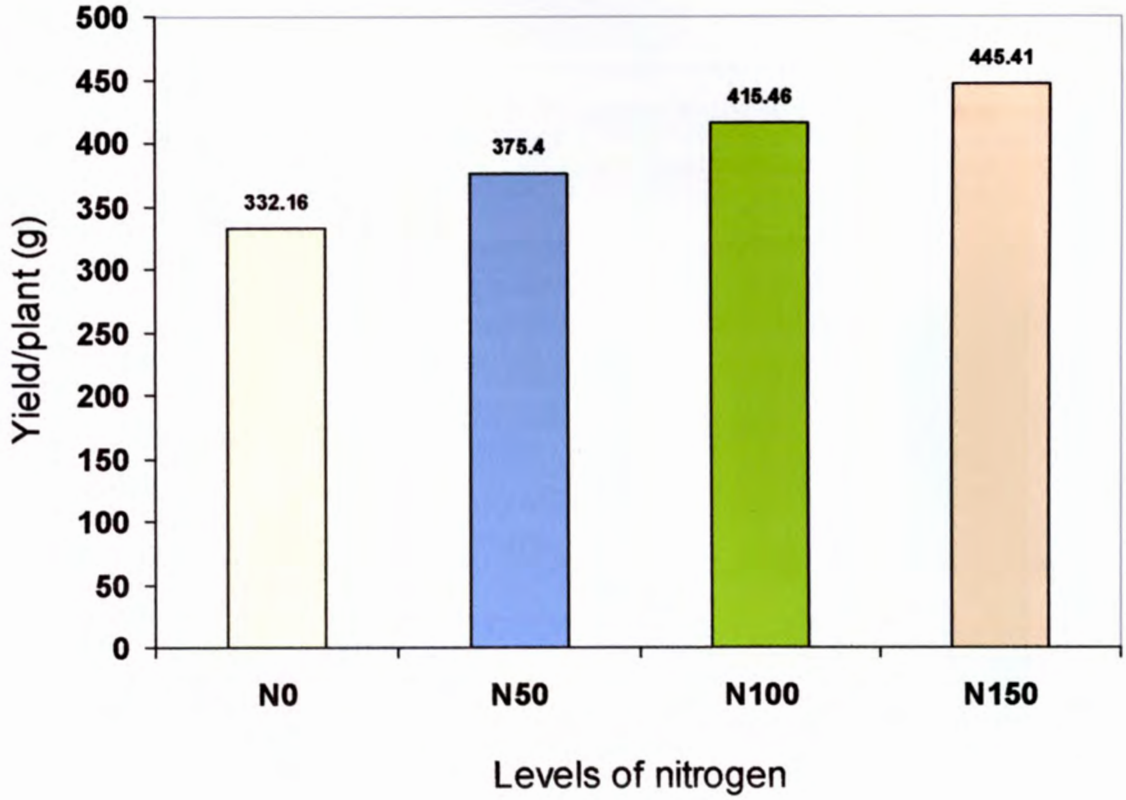



Fig. 8. Main effect of nitrogen on yield/plant (g) of lettuce

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

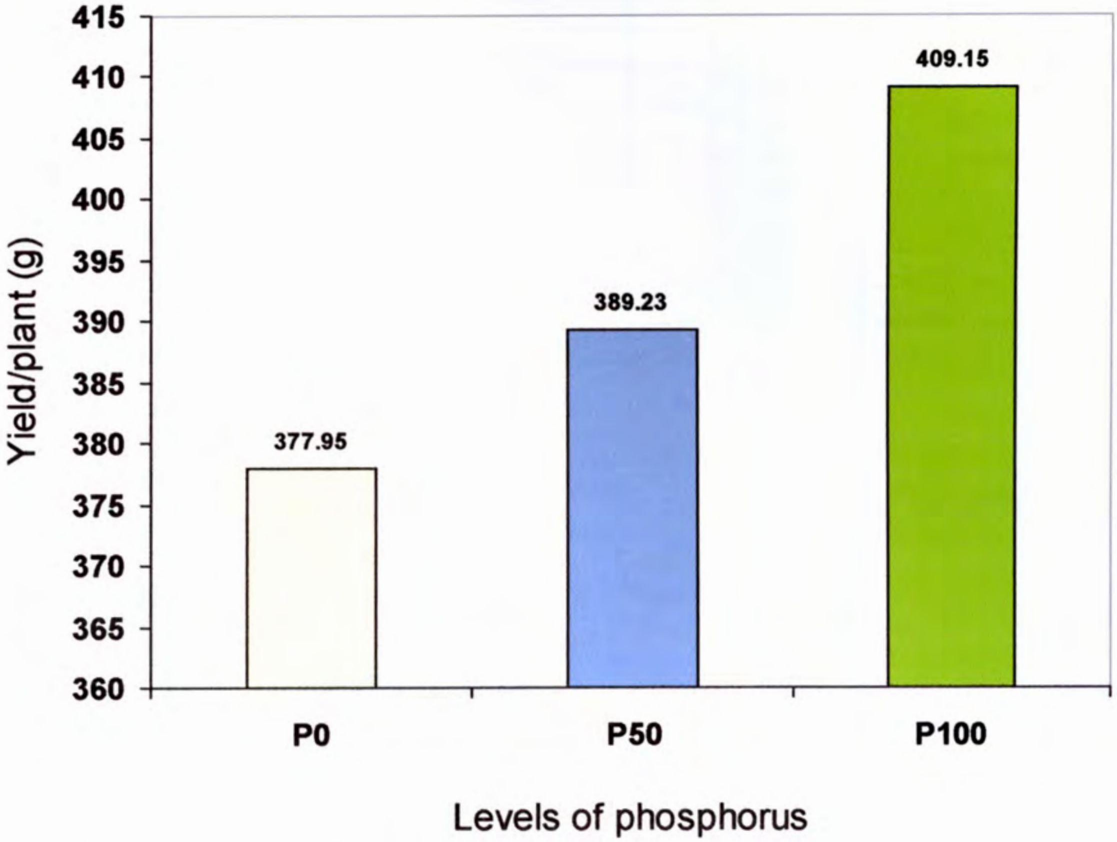



Fig. 9. Main effect of phosphorus on yield/plant (g) of lettuce

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

**Table 1. Combined effect of N & P on yield contributing characters of lettuce**

| Treatment combinations | Plant height (cm) | Number of leaf per plant | Number of leaf area ($cm^2$) | Leaf yield per plant (g) |
|---|---|---|---|---|
| $N_0P_0$ | 15.7 | 24.6 | 342.00 | 320.50 |
| $N_0P_{50}$ | 16.6 | 25.1 | 354.30 | 325.50 |
| $N_0P_{100}$ | 16.8 | 26.1 | 358.30 | 350.50 |
| $N_{50}P_0$ | 20.6 | 27.2 | 355.60 | 360.50 |
| $N_{50}P_{50}$ | 22.6 | 28.66 | 373.30 | 375.50 |
| $N_{50}P_{100}$ | 22.8 | 29.6 | 382.00 | 390.20 |
| $N_{100}P_0$ | 22.1 | 28.6 | 378.66 | 395.50 |
| $N_{100}P_{50}$ | 24.1 | 30.66 | 391.60 | 410.50 |
| $N_{100}P_{100}$ | 25.3 | 31.1 | 403.30 | 440.40 |
| $N_{150}P_0$ | 24.16 | 28.3 | 392.00 | 435.30 |
| $N_{150}P_{50}$ | 26.6 | 29.2 | 412.30 | 445.40 |
| $N_{150}P_{100}$ | 28.2 | 33.3 | 445.00 | 455.50 |
| LSD 5% | 0.227 | 0.0927 | 19.40 | 0.3076 |
| Level of significance | ** | NS | NS | ** |

NS = Non significant

** Significance at 1% level

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

## 4.5 Gross yield (t/ha)

### 4.5.1 Main effect of nitrogen on gross yield of lettuce

The different level of nitrogen application influenced on the gross yield (t/ha) of lettuce (Fig. 10). The yield range of the present study varied from 44.5 t/ha to 32.16 t/ha. The maximum gross yield (44.5 t/ha) was observed from $N_{150}$ treatment which was identical with $N_{100}$ and $N_{50}$ treatment and the lowest (32.16 t/ha) was found from the control treatment ($N_0$). The possible reason for such yield due to increase in the nitrogen level because nitrogen posses the vegetative growth witch resulting the better yield.

### 4.5.2 Main effect of phosphorus on gross yield of lettuce

The gross yield of lettuce per hectare was found statistically significant due to application of different levels of phosphorus (Fig. 11). The highest (40 t/ha) yield was obtained from $P_{100}$ treatment which was identical with $P_{50}$. The lowest (35.25 t/ha) was obtained from the control treatment ($P_0$).

### 4.5.3 Interaction effect of nitrogen and phosphorus on gross yield of lettuce

The interaction effect of nitrogen and phosphorus was not significant variation on gross yield/ha (Appendix III). The range of gross yield varied from 32 t/ha to 45.5 t/ha. The highest gross yield (45.5 t/ha) obtained from $N_{150}P_{100}$ which was statistically similar with other treatments. The lowest yield (32.0 t/ha) was obtained from $N_0P_0$ treatment combination. Although the treatment $N_{150}P_{100}$ produced the highest gross yield but the treatment $N_{100}P_{100}$ and $N_{150}P_{50}$ gave the statistically same yield with higher doses. So the treatment $N_{150}P_{50}$ was considered to be the best treatment combination of nitrogen and phosphorus for maximum leaf yield of lettuce (Table 2). This findings support the result of Sajjan *et al.* (1991) in lettuce.

### 4.6 Marketable yield (t/ha)

#### 4.6.1 Main effect of nitrogen on marketable yield of lettuce

Marketable yield of lettuce varied significantly due to different fertilizer levels of nitrogen. The maximum marketable yield (43.52 t/ha) was found from $N_{150}$ treatment while the minimum marketable yield (31.83 t/ha) in this regards was found control treatment (Fig. 10).

#### 4.6.2 Main effect of phosphorus on marketable yield of lettuce

The marketable yield of lettuce leaves per hectare was found to be statistically significant due to application of different levels of phosphorus (Fig. 11). The highest marketable yield (39.6 t/ha) was obtained from $N_{150}$ treatment which was statistically different than other treatments. The lowest (34.0 t/ha) was obtained from the control treatment $P_0$.

#### 4.6.3 Interaction effect of nitrogen and phosphorus on marketable yield of lettuce

The interaction effect of nitrogen and phosphorus on marketable yield was not statically significant. The highest marketable yield of lettuce (44.5 t/ha) was obtained from $N_{150}P_{100}$ which was identical with $N_{150}P_{50}$ (43.5 t/ha) and statistically different with other treatments. The lowest 31.0 t/ha was observed control treatment ($N_0P_0$) has been presented in table 2.

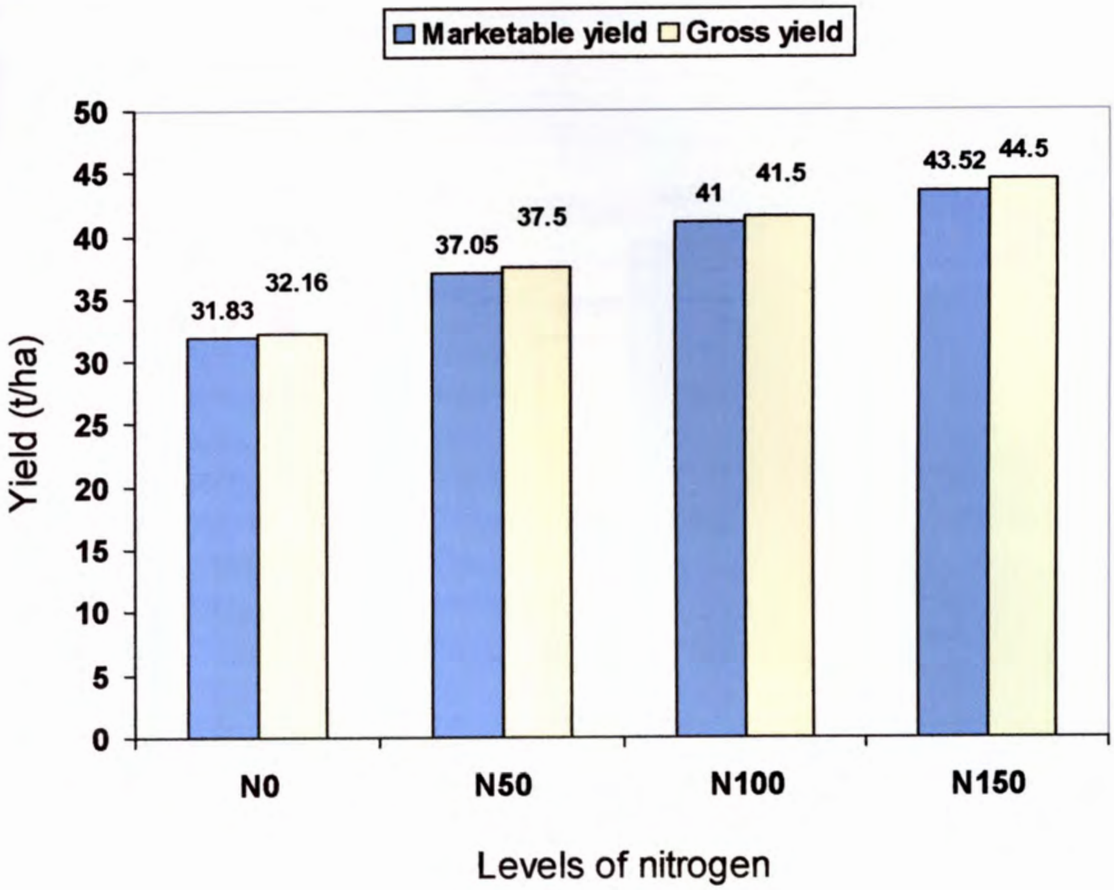



Fig. 10. Effect of nitrogen on marketable and gross yield of lettuce

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

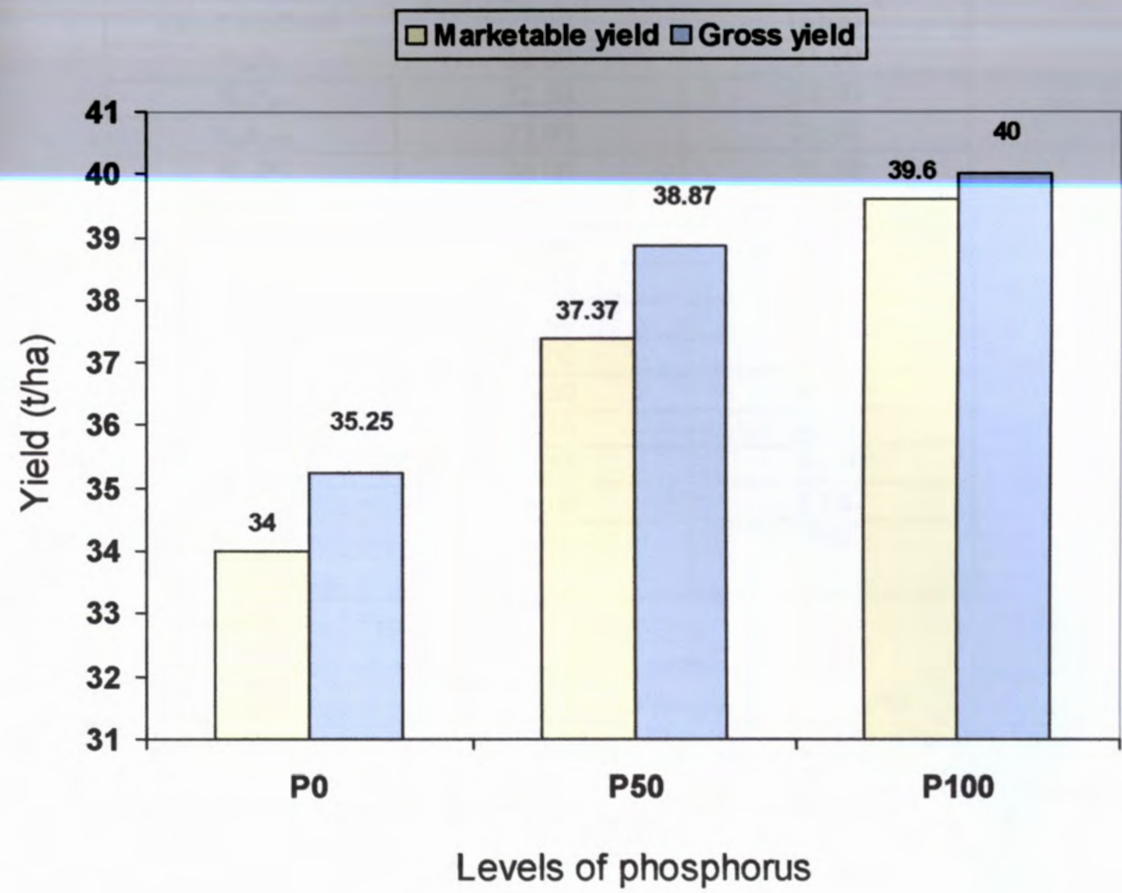



Fig. 11. Effect of phosphorus on marketable and gross yield of lettuce

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

**Table 2. Combined effect of nitrogen & phosphorus on gross yield (t/ha) of lettuce**

| Treatment combinations | Gross yield (t/ha) | Marketable yield (t/ha) |
|---|---|---|
| $N_0P_0$ | 32.00 | 31.00 |
| $N_0P_{50}$ | 32.50 | 32.00 |
| $N_0P_{100}$ | 35.00 | 33.00 |
| $N_{50}P_0$ | 36.00 | 35.50 |
| $N_{50}P_{50}$ | 37.50 | 37.30 |
| $N_{50}P_{100}$ | 38.80 | 38.30 |
| $N_{100}P_0$ | 39.50 | 39.00 |
| $N_{100}P_{50}$ | 41.60 | 41.16 |
| $N_{100}P_{100}$ | 44.00 | 42.80 |
| $N_{150}P_0$ | 41.50 | 40.50 |
| $N_{150}P_{50}$ | 44.50 | 43.50 |
| $N_{150}P_{100}$ | 45.50 | 44.50 |
| LSD 5% | 11.60 | 1.187 |
| Level of significance | NS | NS |

* NS = Non significant

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

### 4.7 Percentage of dry matter content

#### 4.7.1 Main effect of nitrogen on percentage of dry matter content of lettuce

The percentage of dry matter content of lettuce leaves also varied significantly with different nitrogen levels. The dry matter of lettuce leaves was recorded to be the highest (11.77%) where $N_{150}$ treatment was applied. The lowest dry matter (9.16%) of leaf was obtained from the control ($N_0$) treatment (Table 3). The possible reason regarding high dry matter is that proper dose of nitrogen uptake other nutrient in balance condition which accumulated more plant nutrient that gave more dry matter in plant.

#### 4.7.2 Main effect of phosphorus on percentage of dry matter content of lettuce

Application of phosphorus showed significant varied on percentage of dry matter production in lettuce leaves (Table 4). The maximum dry matter of leaves (11.05%) was found from $P_{100}$ treatment followed by $P_{50}$ treatment (10.80). The minimum (10.24%) in this respect was found from the control treatment ($P_0$).

#### 4.7.3 Interaction effect of nitrogen and phosphorus on percentage of dry matter content of lettuce

Both the interaction and combined effects were significant in respect of dry matter percentage of lettuce leaves (Appendix III). However, the maximum dry matter of lettuce leaves (12.3%) was observed in the treatment combination $N_{150}P_{100}$ treatment and the minimum dry matter (8.5%) was recorded from the control treatment (Table 5).

### 4.8 Percentage of fibre content

#### 4.8.1 Main effect of nitrogen on percentage of fibre content of lettuce

The percentage of fibre content of lettuce was significantly influenced by the effect of different nitrogen levels (Table 3). The maximum fibre production was found (2.59%) from $N_{150}$ treatment and the minimum (1.80%) were in the control treatment ($N_0$).

#### 4.8.2 Main effect of phosphorus on percentage of fibre content of lettuce

Application of different levels of phosphorus showed significant influenced on the percent of fibre content of lettuce leaves (Table 4). The highest fibre content (2.36%) was found from $P_{100}$ treatment followed by treatment. The lowest (2.04%) in this regard was from control treatment ($P_0$).

#### 4.8.3 Interaction effect of nitrogen and phosphorus on fibre content of lettuce

Both the interaction and combined effects were significant on fibre content of leaves (Appendix III). However, the highest fibre content (2.85%) was observed in the treatment $N_{150}P_{100}$ treatment. The lowest fibre content (1.72%) was recorded from the control treatment ($N_0P_0$) has been shown in table 5.

**Table 3. Main effect of nitrogen on qualitative characters of lettuce**

| Treatment | Dry matter (%) | Fibre (%) |
|---|---|---|
| $N_0$ | 9.16 | 1.86 |
| $N_{50}$ | 10.62 | 2.18 |
| $N_{100}$ | 11.22 | 2.29 |
| $N_{150}$ | 11.77 | 2.59 |
| LSD 5% | 0.1721 | 0.00309 |
| level of significant | ** | ** |

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

**Table 4. Main effect of phosphorus on qualitative characters of lettuce**

| Treatment | Dry matter (%) | Fibre (%) |
|---|---|---|
| $P_0$ | 10.24 | 2.04 |
| $P_{50}$ | 10.80 | 2.28 |
| $P_{100}$ | 11.05 | 2.36 |
| LSD 5% | 0.1491 | 0.002677 |
| level of significant | ** | ** |

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

**Table 5. Combined effect of N & P on qualitative characters of lettuce**

| Treatment combinations | Dry matter (%) | Fibre (%) |
|---|---|---|
| $N_0P_0$ | 8.50 | 1.72 |
| $N_0P_{50}$ | 9.40 | 1.92 |
| $N_0P_{100}$ | 9.60 | 1.95 |
| $N_{50}P_0$ | 10.46 | 2.10 |
| $N_{50}P_{50}$ | 10.66 | 2.20 |
| $N_{50}P_{100}$ | 10.73 | 2.25 |
| $N_{100}P_0$ | 10.70 | 2.10 |
| $N_{100}P_{50}$ | 11.40 | 2.30 |
| $N_{100}P_{100}$ | 11.56 | 2.40 |
| $N_{150}P_0$ | 11.30 | 2.20 |
| $N_{150}P_{50}$ | 11.70 | 2.70 |
| $N_{150}P_{100}$ | 12.30 | 2.85 |
| LSD 5% | 0.2981 | 0.0053 |
| Level of significance | * | ** |

** Significance at 1% level

* Significance at 5% level

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg/ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

### 4.9 Cost and return analysis

The cost and return analysis were done and have been presented in table 6 and appendix IV. Materials (1A), non materials (1B) and over head costs were recorded for all the treatments of unit plot and calculated on per hectare basis (Marketable yield) the price of lettuce leaves at the local market rate were considered.

The total cost of production ranges between Tk. 70856 to 74992 per hectare among the different treatment combinations. The variation was due to different cost of fertilizer. The highest cost of production Tk. 74992 per ha was involved in the treatment combination of $N_{150}P_{100}$, while the lowest cost of production Tk 70856 per ha was recorded from control treatment (Appendix IV). Gross return from the different treatment combinations range is between Tk. 222500 and Tk. 155000 per ha.

Among the different treatment combinations $N_{150}P_{100}$ gave the highest net return Tk. 148508 per hectare while the lowest net return Tk. 82144 was obtained from the treatment combination of $N_0P_0$.

The benefit cost ratio (BCR) was found to be the highest (2.97) in the treatment combination of $N_{150}P_{100}$. The lowest BCR (2.18) was recorded from control treatment ($N_0P_0$).

**Table 6. Effect of nitrogen and phosphorus on cost and return of lettuce**

| Treatment combinations | Marketable yield (t/ha) | Gross return (Tk/ha) | Total cost of production (Tk/ha) | Net return (Tk/ha) | Benefit cost ratio (BCR) |
|---|---|---|---|---|---|
| $N_0P_0$ | 31.0 | 155000 | 70856 | 82144 | 2.18 |
| $N_0P_{50}$ | 32.0 | 160000 | 72892 | 84608 | 2.20 |
| $N_0P_{100}$ | 33.0 | 165000 | 73772 | 91228 | 2.24 |
| $N_{50}P_0$ | 35.5 | 177500 | 72440 | 105060 | 2.45 |
| $N_{50}P_{50}$ | 37.3 | 186500 | 73332 | 113168 | 2.54 |
| $N_{50}P_{100}$ | 38.3 | 191500 | 74212 | 117288 | 2.58 |
| $N_{100}P_0$ | 39.0 | 195000 | 72882 | 122118 | 2.68 |
| $N_{100}P_{50}$ | 41.2 | 205800 | 73772 | 132028 | 2.79 |
| $N_{100}P_{100}$ | 42.8 | 214000 | 74652 | 139348 | 2.87 |
| $N_{150}P_0$ | 42.5 | 212500 | 73332 | 139168 | 2.90 |
| $N_{150}P_{50}$ | 43.5 | 217500 | 74212 | 143288 | 2.93 |
| $N_{150}P_{100}$ | 44.5 | 222500 | 74992 | 148508 | 2.97 |

$N_0$ = Control
$N_{50}$ = Nitrogen 50 kg /ha
$N_{100}$ = Nitrogen 100 kg/ha
$N_{150}$ = Nitrogen 150 kg/ha

$P_0$ = Control
$P_{50}$ = Phosphorous 50 kg/ha
$P_{100}$ = Phosphorous 100 kg/ha

Note: Sale of lettuce @ Tk. 5000.00 /t

Total income = Marketable yield (t/ha) × Tk 5000.00

BCR = Gross return ÷ Total cost of production

# CHAPTER V

# SUMMARY AND CONCLUSION

## SUMMARY AND CONCLUSION

An experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, to evaluate the effects of nitrogen and phoshoprus on the growth and yield of lettuce during the period of October 2004 to January 2005. The experiment consisted of four levels of nitrogen viz. control ($N_0$), nitrogen 50 kg/ha ($N_{50}$), nitrogen 100 kg/ha ($N_{100}$) and nitrogen 150 kg/ha ($N_{150}$) as well as different levels of phosphorus viz. control ($P_0$), phosphorus 50 kg/ha ($P_{50}$) and phosphorus 100 kg/ha ($P_{100}$).

The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were all together 12 treatment combinations in this experiment. Each unit plot size was 2 m × 1.6 m where 1.0 m and 0.5 m gap between blocks and plots respectively were maintained. The experimental plots were fertilized according to the specific doses of fertilizers. Nitrogen fertilizers were applied by three split doses. First one-third during land preparation, second one-third after 10 days of transplanting and final one-third after 30 days after transplanting. All the phosphorus fertilizer applied during land preparation. The lettuce seeds of cv. 'Green Rapid' were sown on 15th October 2004 and transplanted on 15 November 2004 and harvested on 26 December 2004 to 6 January 2005. All the intercultural operations were done as and when needed. Data of growth and yield parameters were collected and analyzed statistically. The mean differences were adjusted by least significant different (lsd) test.

Different levels of nitrogen doses significantly influenced all the parameters. Application of 150 kg/ha nitrogen gave the maximum plant height 26.32 cm and maximum number of leaves (30.28) per plant was recorded at final harvest. At harvest the maximum fresh weight of leaves per plant (445.41 g), leaf area (416.4 $cm^2$), highest gross yield (44.50 t/ha), marketable yield (43.52 t/ha), percentage of dry matter content (11.77), percentage of fibre content (2.59) were recorded from $N_{150}$ treatement which was significantly superior to all other nitrogen treatments. However, the minimum plant height (16.36 cm), number of leaves per plant (25.26), leaf area (342.5 $cm^2$), leaf yield per plant (332.16 g), gross yield (32.16 t/ha), marketable yield (31.83 t/ha), dry matter content (9.16%) and fibre content (1.86%) were recorded from control treatment ($N_0$).

Phosphorus treatments also showed a significant difference on plant height, number of leaf, leaf area , leaf yield per plant, gross yield, marketable yield, percentage of fibre content, percentage of dry matter content per hectare at final harvest. All these parameters showed to its maximum values in plants grown over $P_{100}$ treatment and the minimum was in the control ($P_0$). The maximum values were in plants hight (23.27 cm), numbers of leaves (30.02), fresh leave weight (409.15 g) per plant, leaf area (397.16 $cm^2$), gross yield (40.0 t/ha), markatable yield (39.6 t/ha), percentage of dry matter content (11.05) and percentage of fibre content (2.36) were recorded from $P_{100}$ treatment at final harvest. On the other hand, the minimum plant height (20.64 cm), number of leaves per plant (27.19), leaf area (367.08 $cm^2$), leaf yield per plant (377.95 g), marketable yield (34.0 t/ha), gross yield (35.25 t/ha), dry matter content (10.24%) and fibre content (2.04 %) were recorded from control treatment ($P_0$).

Different levels of nitrogen as well as phosphorus had also significant combined effects on different parameter studied. Maximum plant height (28.2 cm), number of leaves per plant (33.3), fresh weight of leaves per plant (455.50 g), leaf area (445 $cm^2$), gross yield of leaves (45.50 t/ha), marketable yield (44.50 t/ha), percentage of dry matter of leaves (12.3) and percentage of fibre content (2.85) at harvest were observed in the treatment combination of $N_{150}P_{100}$. However, minimum plant height (15.70 cm), number of leaves per plant (24.6), leaf area (342.0 $cm^2$), leaf yield per plant (320.5 g), marketable yield (31.0 t/ha), gross yield (32.0 t/ha), dry matter content (8.5%) and fibre content (1.7 2%) were recorded from control treatment ($N_0P_0$).

The highest BCR (2.97) was obtained from $N_{150}P_{100}$ treatment combination, while the lowest BCR (2.18) was recorded from control treatmnent ($N_0P_0$).

The best performace was obtained from $N_{150}P_{100}$ treatment that was considered to be the best combination of fertilizer management for maximising yield of lettuce. In order to confirm the result of this study, further experiment is suggested since this experiment was conducted in one year and in a certain place only.

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# APPENDICES

# APPENDICES

**Appendix I. Monthly record of year temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from October 2004 to March 2005**

| Year | Month | *Air temperature (°C) | | | Relative humidity (%) | Rainfall (mm) | Soil temperature | | | **Sunshine (hr) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Maximum | Minimum | Mean | | | 5 cm depth | 10 cm depth f | 20 cm depth | |
| 2004 | October | 30.97 | 23.31 | 27.14 | 75.25 | 208 | 16.09 | 17.2 | 17.3 | 208.9 |
| | November | 29.45 | 18.63 | 24.04 | 69.52 | 00 | 13.8 | 14.4 | 14.8 | 233.2 |
| | December | 26.85 | 16.23 | 21.54 | 70.61 | 00 | 12.6 | 13.6 | 14.0 | 210.5 |
| 2005 | January | 24.52 | 13.86 | 19.19 | 68.46 | 04 | 11.3 | 11.3 | 13.0 | 194.1 |
| | February | 28.88 | 17.98 | 23.43 | 61.04 | 03 | 12.9 | 12.9 | 13.8 | 221.5 |
| | March | 32.22 | 21.78 | 27.00 | 66.69 | 155 | 16.2 | 16.2 | 17.2 | 210.2 |

*Monthly average

** Monthly total

**Source:** Bangladesh Meteorological Department (Climate division)

Agargoan, Dhaka - 1212

**Appendix II. Characteristics of Horticulture Farm soil is analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

**A. Morphological characteristics of the experimental field**

| Morphological features | Characteristics |
|---|---|
| Location | Horticulture Garden ,SAU, Dhaka |
| AEZ | Madhupur Tract (28) |
| General Soil Type | Shallow red brown terrace soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly leveled |
| Flood level | Above flood level |
| Drainage | Well drained |
| Cropping pattern | Fellow – lettuce |

**B. Physical and chemical properties of the initial soil**

| Characteristics | Value |
|---|---|
| **Partical size analysis** | |
| % Sand | 28 |
| % Silt | 41 |
| % clay | 31 |
| **Textural class** | silty-clay |
| pH | 5.6 |
| Organic carbon (%) | 0.45 |
| Organic matter (%) | 0.78 |
| Total N (%) | 0.03 |
| Available P (ppm) | 20.00 |
| Exchangeable K (me/100 g soil) | 0.10 |
| Available S (ppm) | 45 |

**Source**: SRDI

**Appendix III. Analysis of variance of different characters of lettuce**

| Source of variation | Degree of freedom | Mean square |
|---|---|---|
| | | Plant height (cm) |
| Replication | 2 | 0.085 |
| Factor-A (Nitrogen) | 3 | 161.127** |
| Factor-B (Phosphorus) | 2 | 21.871** |
| Interaction(AB) | 6 | 1.271** |
| Error | 22 | 0.018 |

** Significance at 1% level

**Appendix III. Contd.**

| Source of variation | Degree of freedom | Mean square (No. of leaves / plant) |
|---|---|---|
| Replication | 2 | 1.756 |
| Factor-A (Nitrogen) | 3 | 48.828** |
| Factor-B (Phosphorus) | 2 | 24.243** |
| Interaction(AB) | 6 | 2.739 NS |
| Error | 22 | 2.082 |

** Significance at 1% level

NS = Non significant

**Appendix III. Contd.**

| Source of variation | Degree of freedom | Mean square | | |
|---|---|---|---|---|
| | | Yield/plant(g) | Gross yield (t/ha) | Marketable yield (t/ha) |
| Replication | 2 | 0.164 | 92.361 | 1.937 |
| Factor-A (Nitrogen) | 3 | 21776.907** | 105.361 NS | 233.751** |
| Factor-B (Phosphorus) | 2 | 2994.853** | 42.62 NS | 21.072** |
| Interaction(AB) | 6 | 105.092** | 28.632 NS | 0.726 NS |
| Error | 22 | 0.033 | 46.90 | 0.491 |

** Significance at 1% level

NS = Non significant

**Appendix III. Contd.**

| Source of variation | Degree of freedom | Mean square | |
|---|---|---|---|
| | | % of dry matter content | % of fibre content |
| Replication | 2 | 0.044 | 0.00 |
| Factor-A (Nitrogen) | 3 | 11.374** | 0.817** |
| Factor-B (Phosphorus) | 2 | 2.055** | 0.327** |
| Interaction(AB) | 6 | 0.140* | 0.039** |
| Error | 22 | 0.031 | 0.00 |

** Significance at 1% level

* Significance at 5% level

**Appendix III. Contd.**

| **Source of variation** | **Degree of freedom** | **Mean square(Leaf area, cm$^2$)** |
|---|---|---|
| Replication | 2 | 215.028 |
| Factor-A (Nitrogen) | 3 | 7001.519** |
| Factor-B (Phosphorus) | 2 | 2717.528** |
| Interaction(AB) | 6 | 213.935 NS |
| Error | 22 | 131.24 |

** Significance at 1% level

NS = Non significant

## Appendix IV. Cost of production of lettuce per hectare

### (A)Material cost (Tk.)

| Treatment combinations | Seed (kg/ha) | Fertilizer and manure | | | | Irrigation | Sub total 1 (A) |
|---|---|---|---|---|---|---|---|
| | | Cowdung | Urea | TSP | MP | | |
| $N_0P_0$ | 8000 | 6000 | - | - | 1120 | 1500 | 16620 |
| $N_0P_{50}$ | 8000 | 6000 | - | 800 | 1120 | 1500 | 17420 |
| $N_0P_{100}$ | 8000 | 6000 | - | 1600 | 1120 | 1500 | 18220 |
| $N_{50}P_0$ | 8000 | 6000 | 400 | - | 1120 | 1500 | 17020 |
| $N_{50}P_{50}$ | 8000 | 6000 | 400 | 800 | 1120 | 1500 | 17820 |
| $N_{50}P_{100}$ | 8000 | 6000 | 400 | 1600 | 1120 | 1500 | 18620 |
| $N_{100}P_0$ | 8000 | 6000 | 800 | - | 1120 | 1500 | 17420 |
| $N_{100}P_{50}$ | 8000 | 6000 | 800 | 800 | 1120 | 1500 | 18220 |
| $N_{100}P_{100}$ | 8000 | 6000 | 800 | 1600 | 1120 | 1500 | 19020 |
| $N_{150}P_0$ | 8000 | 6000 | 1200 | - | 1120 | 1500 | 17820 |
| $N_{150}P_{50}$ | 8000 | 6000 | 1200 | 800 | 1120 | 1500 | 18620 |
| $N_{150}P_{100}$ | 8000 | 6000 | 1200 | 1600 | 1120 | 1500 | 19420 |

| | | | |
|---|---|---|---|
| Lettuce seed | @ Tk. 8000/kg. | Water hyacinth | @ Tk.1500/ton. |
| Cowdung | @ Tk. 600/ton. | Rice straw | @ Tk.1500/ton |
| Urea | @ Tk.8/kg. | Black polythene | @ Tk.5.00/m. |
| TSP | @ Tk.16/kg. | MP | @ Tk.16/kg. |

Appendix IV. Contd.

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

| Treatment combination | Land preparation | Fertilizer and manure application | Seed sowing and transplanting | Intercultural operation | Harvesting | Sub total | Total input cost 1 (A) + 1 (B) |
|---|---|---|---|---|---|---|---|
| $N_0P_0$ | 10500 | - | 5250 | 10000 | 7500 | 33250 | 49870 |
| $N_0P_{50}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 51720 |
| $N_0P_{100}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52520 |
| $N_{50}P_0$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 51320 |
| $N_{50}P_{50}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52120 |
| $N_{50}P_{100}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52920 |
| $N_{100}P_0$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 51720 |
| $N_{100}P_{50}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52520 |
| $N_{100}P_{100}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 53320 |
| $N_{150}P_0$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52120 |
| $N_{150}P_{50}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 52920 |
| $N_{150}P_{100}$ | 10500 | 1050 | 5250 | 10000 | 7500 | 34300 | 53720 |

Labour cost @ Tk. 70 / day.

Appendix IV. Contd.

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

| Treatment combinations | Cost of lease of land | Miscellaneous cost (5% of input cost) | Interest on running capital for 6 months (10% of the total input cost) | Total | Total cost of production (input cost + overhead cost, Tk/ha) |
|---|---|---|---|---|---|
| $N_0P_0$ | 16000 | 2493 | 2493 | 20986 | 70856 |
| $N_0P_{50}$ | 16000 | 2586 | 2586 | 21172 | 72892 |
| $N_0P_{100}$ | 16000 | 2626 | 2626 | 21252 | 73772 |
| $N_{50}P_0$ | 16000 | 2560 | 2560 | 21120 | 72440 |
| $N_{50}P_{50}$ | 16000 | 2606 | 2606 | 21212 | 73332 |
| $N_{50}P_{100}$ | 16000 | 2646 | 2646 | 21292 | 74212 |
| $N_{100}P_0$ | 16000 | 2581 | 2581 | 21162 | 72882 |
| $N_{100}P_{50}$ | 16000 | 2626 | 2626 | 21252 | 73772 |
| $N_{100}P_{100}$ | 16000 | 2666 | 2666 | 21332 | 74652 |
| $N_{150}P_0$ | 16000 | 2606 | 2606 | 21212 | 73332 |
| $N_{150}P_{50}$ | 16000 | 2646 | 2646 | 21292 | 74212 |
| $N_{150}P_{100}$ | 16000 | 2636 | 2636 | 21272 | 74992 |