INFLUENCE OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF LETTUCE (*Lactuca sativa L.*)

BY

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Registration Number 00918

A Thesis

Submitted to the Department of Horticulture and Postharvest Technology

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfillment of the requirements

for the degree

of

MASTER OF SCIENCE

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2008

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CERTIFICATE

This is to certify that the thesis entitled, "**Influence of nitrogen and phosphorus on growth and yield of lettuce (Lactuca sativa L.)**" submitted to the Department of Horticulture and Postharvest Technology, 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 authentic research work carried out by **MD. SHARIFUL ISLAM**, Registration Number 00918 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ACKNOWLEDGEMENT

All praises are due to the omniscient, omnipresent and omnipotent Allah Who enabled the author to complete the research work and the thesis leading to Master of Science (MS).

The author feels proud to express his profound respect, deepest sense of gratitude, heartful appreciation to **Prof. A.K.M. Mahatabuddin** Supervisor, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his constant inspiration, scholastic guidance and invaluable suggestions during the conduct of the research and for his constructive criticism and whole hearted cooperation during preparation of this thesis.

The author express his heartfelt gratitude and indebtness to **Associate prof. Md. Hasanuzzaman Akand** Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for his assistance in planning and execution of the study and for his constructive instruction, critical reviews and heartiest cooperation during preparation of the manuscript.

The author also always grateful to **Prof. Md. Ruhul Amin** chairman, Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka, for his kindness to make a bona fide research work and a falconic overview in my paper and also a special thanks for him to give me a pragmatic view about theses writing.

The author also express his heartfelt thanks to all the teachers of the Dept. of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University, Dhaka for their help, valuable suggestions and encouragement during the period of study. The Author is also wish to acknowledge is indebtedness to the Farm Division of SAU and other staff of the Department of Horticulture and Postharvest Technology for their co-operation in the implementation of research works. The Author is also thankful to Arif Hossain, Fazlul Huque, Khalid Hossain, Ekram, Rezaul Hassan for their constant encouragement and also special thanks to Ziniatul Fardous for her candid direction. At last but not the least, the Author feel indebtedness to be beloved parents and relatives, whose sacrifice, inspiration, encouragement and continuous blessing paved the way to his higher education.

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ABSTRACT

An experiment was conducted at the Farm of Sher-e- Bangla Agricultural University, Dhaka, Bangladesh during November 2007 to February 2008 to study the growth and yield of lettuce as influenced by nitrogen and phosphorus. The experiment consist of two factors; viz. four levels of nitrogen (N_0=0 kg N/ha, N_1=110 kg N/ha, N_2=160 kg N/ha, N_3=210 kg N/ha) and four levels of phosphorus (P_0=0 kg P/ha, P_1=75 kg P/ha, P_2 =100 kg P/ha, P_3=125 kg P/ha).The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. In case nitrogen N_3 performed maximum plant height, number of leaves, leaf yield per plant (393.28 g), yield per hectare (39.39 t/ha) and minimum was recorded from control. In case of phosphorus tallest plant height, number of leaves per plant, leaf yield per plant (385.35 g), yield per hectare (38.57 t/ha) was recorded from P_3 and minimum was recorded from control. Among different treatment combinations N_2P_3 contributed the highest (38.09 t/ha) yield. The highest (2.24) benefit cost ratio was obtained from the treatment combination of N_2P_3 and the lowest benefit cost ratio(1.46) was recorded from control. So, 160 kg N/ha with 125 kg P/ha of fertilizer was the best combination for lettuce production.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	And others
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
°C	Degree Celsius
DAT	Days After Transplanting
etc	Et cetera
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
hr	Hour
kg	Kilogram
m	Meter
mm	Millimeter
MoP	Murate of Potash
no.	Number
%	Per cent
RCBD	Randomized Complete Block Design
SRDI	Soil Resources Development Institute
SAU	Sher-e-Bangla Agricultural University
m^2	Square meter
TSP	Triple Superphosphate
UNDP	United Nations Development Program

Chapter 1

Introduction

CHAPTER I

INTRODUCTION

Lettuce (*Lactuca sativa L.)* belongs to the family Compositae, is the most popular salad crops in the world. It is a annual leafy herb with milky juice. It produces a short stem early in the season, a cluster of leaves varying considerably in shape, size, character and colour in different varieties. Later in the season a seed stock is produced (Ryder, 1979). Lettuce is originated from Southern Europe and Western Asia (Rashid, 1999). It mainly grows in temperate region and in some cases in the tropic and sub-tropic region. Lettuce largely produced in greenhouse in temperate region (Lindquist, 1960). It is mainly a cold loving crop. But, it can be grown in wide range of temperature. The best temperature range for lettuce cultivation is 15^0C to 25^0C and the night temperature is 10^0C to 15^0C (Ryder, 1998). In higher temperature, number of leaves will decrease and tastes may bitter. Above 25^0C temperature early flowering occur (Rashid, 1999).

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 fiber and that of water (Work, 1997). 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, fiber 0.5 g, carbohydrates 2.5 g, calcium 320 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). Its tender leaves and heads are chopped and used as salad with salt and vinegar in raw or fresh condition. It is often served alone or with dressing. So, 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). Nitrogen is critically deficient and is the most limiting element in soils of Bangladesh (Hoque, 1993). The cultivation of lettuce requires proper supply of plant nutrient.

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). 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). On the other hand, excessive application of nitrogen is not only uneconomical but also induces physiological disorder.

The effect of phosphorus on the formation and translocation of carbohydrates, root development, nodulation, growth and other agronomic characters are well recognized. Phosphorus induces earliness in flowering and maturity. Phosphorus also makes its contribution through its favorable effect on flowering and fruiting including seed formation. (Buckman and Bradey, 1980).

Considering the above facts on lettuce production the present study was undertaken with the following objectives:

i. to identify the optimum doses of nitrogen and phosphorus for the growth, development and yield of lettuce;

ii. to know the combined effect of nitrogen and phosphorus on lettuce production.

Chapter 2

Review of literature

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of nitrogen and phosphorus 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 NO_3 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 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.

It was reported that in an attempt to reduce the hydroponic 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 flow technique (DFT) as and re-circulation nutrient film technique (NFT) treated with soilless nutrient solution (NSI) 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 (Jaenaksorn and Ikeda, 2004).

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.

It was reported in a trials with early head lettuce, cultivated in soils with different 4 levels of phosphorus 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 (Wijk 2000).

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 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/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.

The 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 (Tisselli,1999).

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.

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.

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 2^{nd} 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 (5^0C) and high (20^0C) 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 (20^0C) and in cold chamber (5^0C).

Sanchez and EL –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.

Custic *et al.* (1994) conducted trials on the effects of N fertilizer on the yield and N content of lettuce in several locations of Croatia over a number of years. The results indicated N fertilizer application led to an increase in nitrate content of the crop tissues without significantly increasing yield even though the nitrate contents were below the maximum prescribed by FAO standards and most European countries. Yields of 5.35-6.29 kg/m square for winter lettuces grown in the green house by application of N at 80-160 kg/ha. This resulted in low nitrate concentration in tissues of lettuce (1820-2237 mg nitrate per kg FW) which would allow the crops to be sold on even the most demanding of world markets.

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 beds to require s 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.

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.

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.

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.

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.

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

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.

Bose *et al.* (1991) stated that nitrates were estimated in 56 samples of 5 vegetables 19 of which had been treated with organic fertilizers and 37 with mineral fertilizers. Mean nitrate in sweet chard treated with organic and mineral fertilizers was 1940 and 3386 mg KNO3/kg respectively, in lettuce 975 and 1688, in carrots 681 and 626, in leeks 671 and 569, and in green beans 661 and 274 mg/kg. Differences between values for sweet chard and lettuce were significant

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 were 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.

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.

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.

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.

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.

Chapter 3

Materials and methods

CHAPTER III

MATERIALS AND METHODS

A field experiment was conducted during November 2007 to February 2008 to find out the effect of nitrogen and phosphorus on the growth and yield of lettuce.

3.1 Experimental Site

The experiment was conducted at the Central Farm of Sher-e-Bangla Agricultural University and the Laboratory of Horticulture and Postharvest Technology of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The experimental site is situated in $23^0 41^{\prime}$N latitude and $90^0 22^{\prime}$E longitude with an elevation of 8.2 meter from sea level (UNDP, 1988)

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was Shallow Red Brown Terrace Soil. The selected experimental plot was medium high land, pH 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 Soil Testing Laboratory, SRDI, Farmgate, Dhaka (Appendix – I).

3.3 Climatic 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, and rainfalls during the period of the experiment were collected from the Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar, Dhaka (Appendix – II).

3.4 Planting Materials

Grand Rapid lettuce cultivar was used in the experiment. The seeds were collected from Dhaka Seed Store, Siddique Bazar, Dhaka.

3.5 Treatment of the Experiment

The experiment considered two factors:

Factor A: Nitrogen (4 levels)

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

ii. N_1: 110 kg N/ha (Urea 240kg/ha)

iii. N_2: 160 kg N/ha (Urea 390kg/ha)

iv. N_3: 210 kg N/ha (Urea 455kg/ha)

Factor B: Phosphorus (4 levels)

i. P_0: 0 kg P_2O_5/ha (Control)

ii. P_1: 75 kg P_2O_5/ha (TSP 155kg/ha)

iii. P_2: 100 kg P_2O_5/ha (TSP 208kg/ha)

iv. P_3: 125 kg P_2O_5/ha (TSP 260kg/ha)

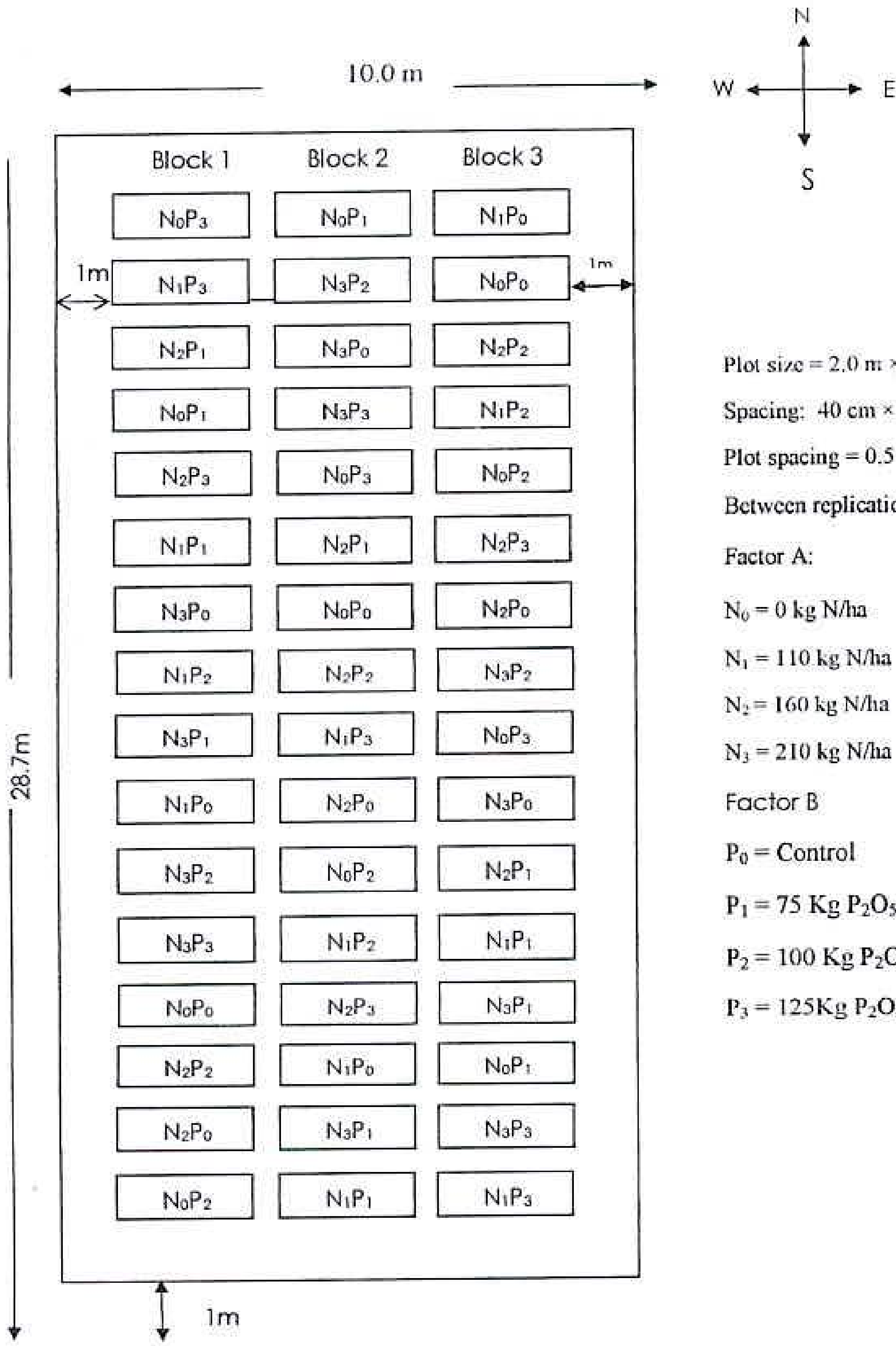
There were 16 (4 × 4) treatment combinations such as N_0P_0, N_0P_1, N_0P_2, N_0P_3, N_1P_0, N_1P_1, N_1P_2, N_1P_3, N_2P_0, N_2P_1, N_2P_2, N_2P_3, N_3P_0, N_3P_1, N_3P_2 and N_3P_3.

3.6 Experimental design and layout

Two factors experiment was laid out Randomized Complete Block Design (RCBD) with three replications. An area of 28.7 m × 10 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 m × 1.2 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 Fig. 1.

3.7 Raising of seedlings

The seedlings were raised at the Central 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 cow dung 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 01, 2007.



Plot size = 2.0 m × 1.2 m

Spacing: 40 cm × 25 cm

Plot spacing = 0.5 m

Between replication=1.0m

Factor A:

N_0 = 0 kg N/ha

N_1 = 110 kg N/ha

N_2 = 160 kg N/ha

N_3 = 210 kg N/ha

Factor B

P_0 = Control

P_1 = 75 Kg P_2O_5/ha

P_2 = 100 Kg P_2O_5/ha

P_3 = 125Kg P_2O_5/ ha

Figure 3: Field layout of two factors experiment in the Randomized Complete Block Design (RCBD)

3.8 Preparation of the Main Field

The selected experimental plot was opened in the last week of November 2007 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 was applied of each unit plot. The soil was treated with fungicide cupravit against the fungal attack.

3.9 Application of Manure and Fertilizers

The sources of N, P_2O_5, K_2O as urea, TSP and MoP were applied respectively. The entire amount of TSP was applied during the final land preparation. Urea and MP were applied in three equal installments at 15, 25 and 35 days after seedling transplanting. Well-rotten cow dung 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	Application (%)			
		Basal	10 DAT	20 DAT	30 DAT
Cow dung	10 tons	100	--	--	--
Nitrogen	As treatment	--	33.33	33.33	33.33
P_2O_5 (as TSP)	As treatment	100	--	--	--
K_2O (as MP)	150	--	33.33	33.33	33.33

3.10 Transplanting of Seedlings in the Main Field

Healthy and uniform sized 34 days old seedlings were transplanted in the main field according to the treatments on December 04, 2007. 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 40 cm × 25 cm between row to row and plant to plant were maintained. Each plot contained 24 seedlings. A number of seedlings were also planted in the border of the experimental plots for gap filling if necessary later on.

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

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting in every alternate day in the evening 1st harvest. Further irrigation was done and when needed.

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, the remaining doses of urea and MP were top-dressed in 3 equal installments. The fertilizers were 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 Harvesting

To evaluate yield, harvesting were done at 55 days after transplanting. To evaluate growth, data have been recorded from the mean of 10 sample plants which was selected at random of each unit plot at 25, 35, 45 and 55 days after transplanting.

3.13 Data collection

Data were recorded on the following parameters from the sample plants during the course of experiment. Ten 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.

3.13.1 Plant height (cm)

The height of plant was taken from 10 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.

3.13.2 Number of leaves per plant

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

3.13.3 Length of larger 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 10 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).

3.13.4 Breadth of larger leaf (cm)

Breadth of leaf was recorded as the average of 10 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).

3.13.5 Yield per plant (g)

Leaves of 10 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 10 random selected plants of inner rows of each plot at the harvesting time..

3.14.7 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.

3.14.8 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 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

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

3.15 Statistical Analysis

The data obtained from different parameters were statistically analyzed to find out the significance difference nitrogen and Potassium 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 potassium. 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

CHAPTER IV

RESULTS AND DISCUSSIONS

The results of the experiment have been discussed below in relation to the imposed treatment. Results were presented in Table 2 to 8 and Figures 4 to 15. The analysis of variance (ANOVA) of the data on different yield components and yield are given in Appendix III-VI. Possible interpretations have also been given under the following headings:

4.1.1 Plant height

The different levels of nitrogen application had a marked influence on plant height of lettuce at different days after transplanting (Fig. 2). The maximum plant height at 25 DAT (11.48cm), 35 DAT (16.76cm), 45 DAT (22.57cm) and 55 DAT (27.76cm) was recorded from N_3 (210 kg N/ha) treatment and the minimum was found in control treatment. It was found that plant height was increased with the increased in N application. This might be due to that n enhanced vegetative growth of plant. Similar results on lettuce were found by Hochmuth *et al.* (1994) and Karacal and Turetken (1992).

Plant height differed significantly due to the application of different levels of phosphorus at 25, 35, 45 and 55 DAT (Fig. 3). The maximum plant height at 25 DAT (12.42cm), 35 DAT (16.68cm), 45 DAT (23.45cm) and 55 DAT (27.88cm) was recorded from P_3 (125 kg P/ha) treatment and the minimum was found in control treatment. It was found that plant height was increased with the increased in P application. This might be due to that n enhanced vegetative growth of plant.

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of plant height at different days after transplanting (Table 2). The maximum plant height at 25 DAT (12.89 cm), 35 DAT (18.39 cm), 45 DAT (25.77 cm) and 55 DAT (30.61cm) was recorded from the treatment combination N_2P_3 (160 kg N/ha +125 kg P /ha) and the minimum was found in control treatment. From the results it was reveals that both nitrogen and phosphorus favored the plant height.

4.1.2 Number of leaves per plant

Number of leaves per plant differed significantly due to the application of different level of nitrogen at 25, 35, 45 and 55 DAT (Appendix III). At 25 DAT the maximum (7.37) number of leaves per plant was recorded from N_3 (210 kg N/ha) which was statistically identical (7.35) to N_2 (160 kg N/ha), while the control (0 kg N/ha) performed the minimum (6.26) number of leaves per plant . The highest (13.65) number of leaves per plant was observed from N_3 which was closely (13.54) followed by N_2 and the lowest (10.19) was found from control condition at 35 DAT. At 45 DAT the maximum (23.49) number of leaves per plant was recorded from N_3, which was statistically identical (23.22) to N_2 and the minimum (20.34) was from control. The highest (31.30) number of leaves per plant was recorded from N_2 at 55 DAT, which was statistically similar (31.24) to N_3, while control gave the lowest (25.41) number of leaves per plant (Fig. 4). This results in agreement with that of Islam *et al.*, (1998) in batishak.

Number of leaves per plant differed significantly due to the application of different level of phosphorus at 25, 35, 45 and 55 DAT (Appendix III). At 25 DAT, the maximum (7.59) number of leaves per plant was observed from P_3 (125 kg P/ha), while the control (0 kg P/ha) showed the minimum (6.21) number of leaves per plant. The highest (14.33) number of leaves per plant was observed from P_3 whereas, the lowest (10.61) was found from control condition at 35 DAT. At 45 DAT, the maximum (25.32) number of leaves per plant was recorded from P_3, which was statistically identical (23.42) to P_2 and the minimum (17.23) was observed from control. The highest (31.74) number of leaves per plant was recorded from P_2 at 55 DAT, which was statistically similar (30.42) to P_3, while control gave the lowest (24.61) number of leaves per plant (Fig. 5).

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of plant height at different days after transplanting (Appendix III). The maximum number of leaves per plant at 25 DAT (8.20), 35 DAT (16.02) 45 DAT (27.34) and 55 DAT (35.23) was recorded from the treatment combination N_2P_3 (160 kg N/ha +125 kg P /ha) and the minimum was found in control treatment. From the results it was reveals that both nitrogen and phosphorus favored the number of leaves per plant.

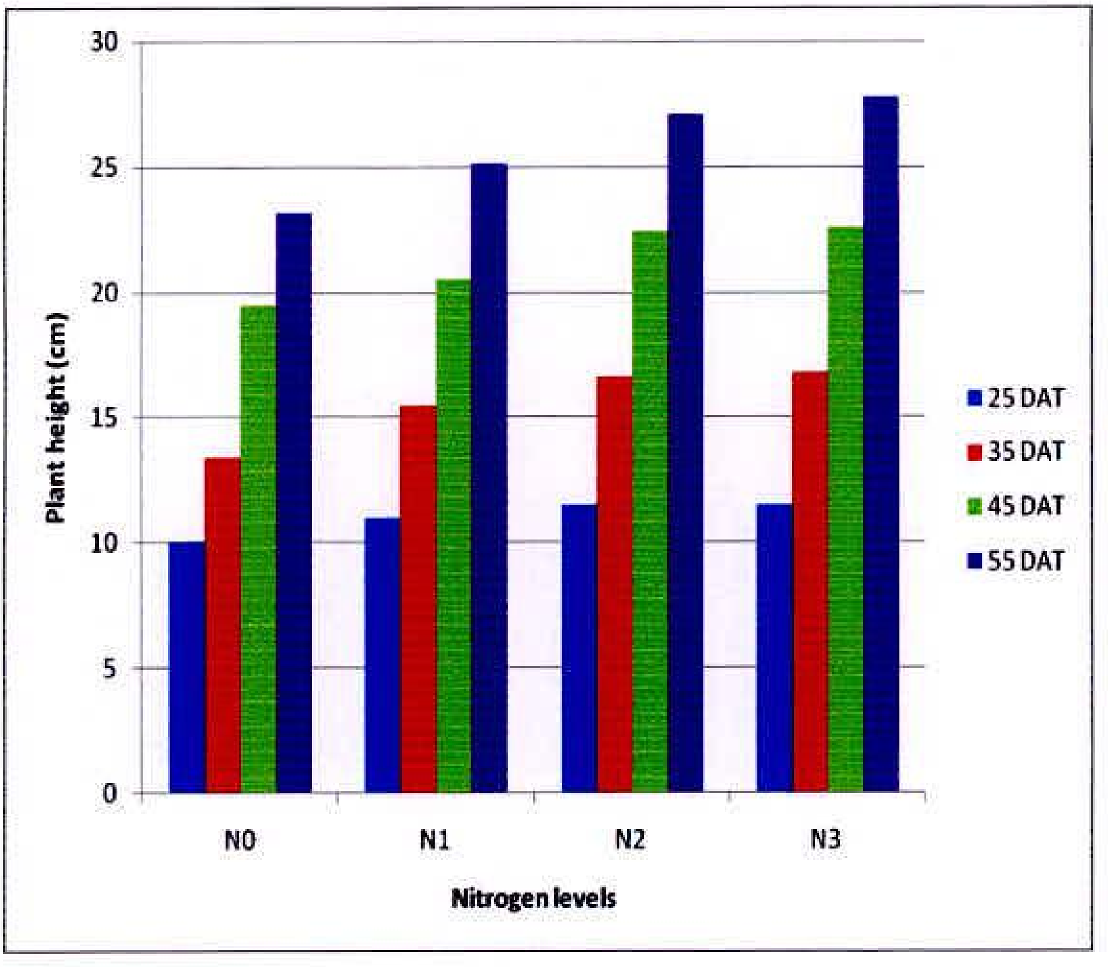


Fig. 2: Effect of nitrogen on plant height of lettuce

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

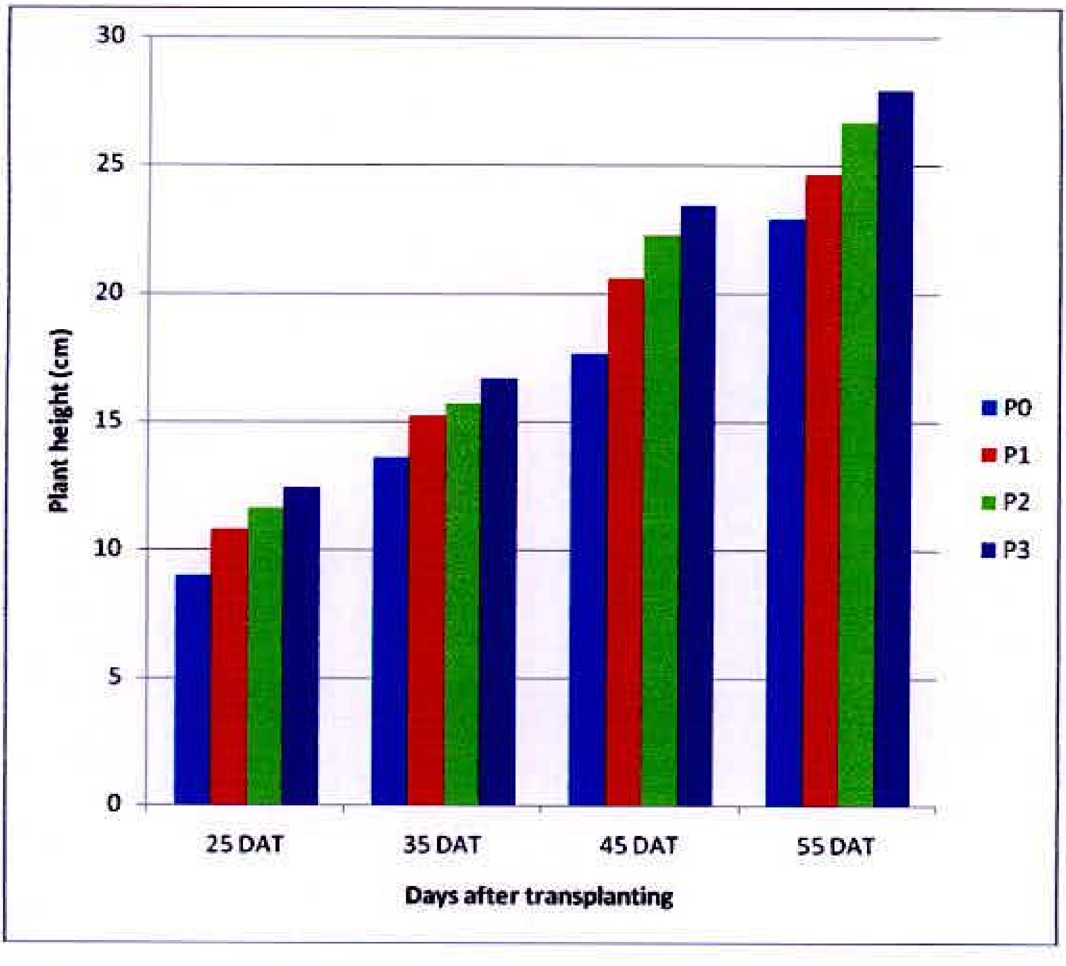


Fig. 3: Effect of phosphorus on plant height of lettuce

P_0 = Control

P_1 =75 kg P_2O_5/ha

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

Table2. Combined effect of nitrogen and phosphorus on plant height of lettuce

Treatment combinations	Plant height (cm) at different days after transplanting			
	25 DAT	35 DAT	45 DAT	55 DAT
N_0P_0	8.22 d	10.42 g	14.98 h	18.80 h
N_0P_1	12.16 ab	15.16 cde	20.67 def	23.90 fg
N_0P_2	11.37 b	12.81 f	20.75 def	24.55 ef
N_0P_3	12.11 ab	14.97 cde	21.56 cde	25.28 ef
N_1P_0	8.45 d	13.79 ef	16.86 gh	22.03 g
N_1P_1	11.26 b	16.38 abc	20.62 def	25.07 ef
N_1P_2	11.39 b	15.86 bcd	21.06 cde	25.73 def
N_1P_3	12.64 a	15.79 bcde	23.36 bc	27.54 bcd
N_2P_0	9.16 cd	14.11 def	18.37 fg	24.08 fg
N_2P_1	11.79 ab	16.53 abc	22.33 bcde	25.90 cdef
N_2P_2	11.88 ab	17.37 ab	23.12 bcd	27.66 bcd
N_2P_3	12.89 a	18.39 a	25.77 a	30.61 a
N_3P_0	10.07 c	16.05 bcd	20.32 ef	26.57 bcde
N_3P_1	11.91 ab	16.72 abc	22.78 bcde	27.64 bcd
N_3P_2	11.92 ab	16.68 abc	24.07 ab	28.74 ab
N_3P_3	12.05 ab	17.58 ab	23.10 bcd	28.09 bc
Level of significance	*	*	*	*
CV (%)	**5.43**	**7.04**	**6.14**	**4.56**

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

* 5% level of significance

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

P_0 = Control

P_1 =75 kg P_2O_5/ha)

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of number of leaves per plant at different days after transplanting (Appendix III). The maximum (8.20) number of leaves per plant was recorded at 25 DAT from the combined effect of N_2P_3 (160 kg N/ha +125 kg P/ha), which was statistically similar (7.78 and 7.87) to N_3P_2 and N_3P_3 while N_0P_0 (0 kg N/ha +0 kg P/ha) gave the minimum (5.52) number of leaves per plant. At 35 DAT, the maximum (16.02) number of leaves per plant was observed from the treatment combination of N_2P_3, whereas the minimum (9.29) was recorded from N_0P_0. At 45 DAT, the maximum (27.34) number of leaves per plant was recorded from the treatment combination of N_2P_3 which was statistically identical (25.90) to N_3P_3 and the minimum (14.23) was recorded from N_0P_0. The maximum (35.23) number of leaves per plant was recorded from the treatment combination of N_2P_3 which was statistically similar (33.76 & 33.70) to N_2P_3 and N_2P_3 while the minimum (20.28) was recorded from the treatment combination of N_0P_0 at 55 DAT (Table 3).

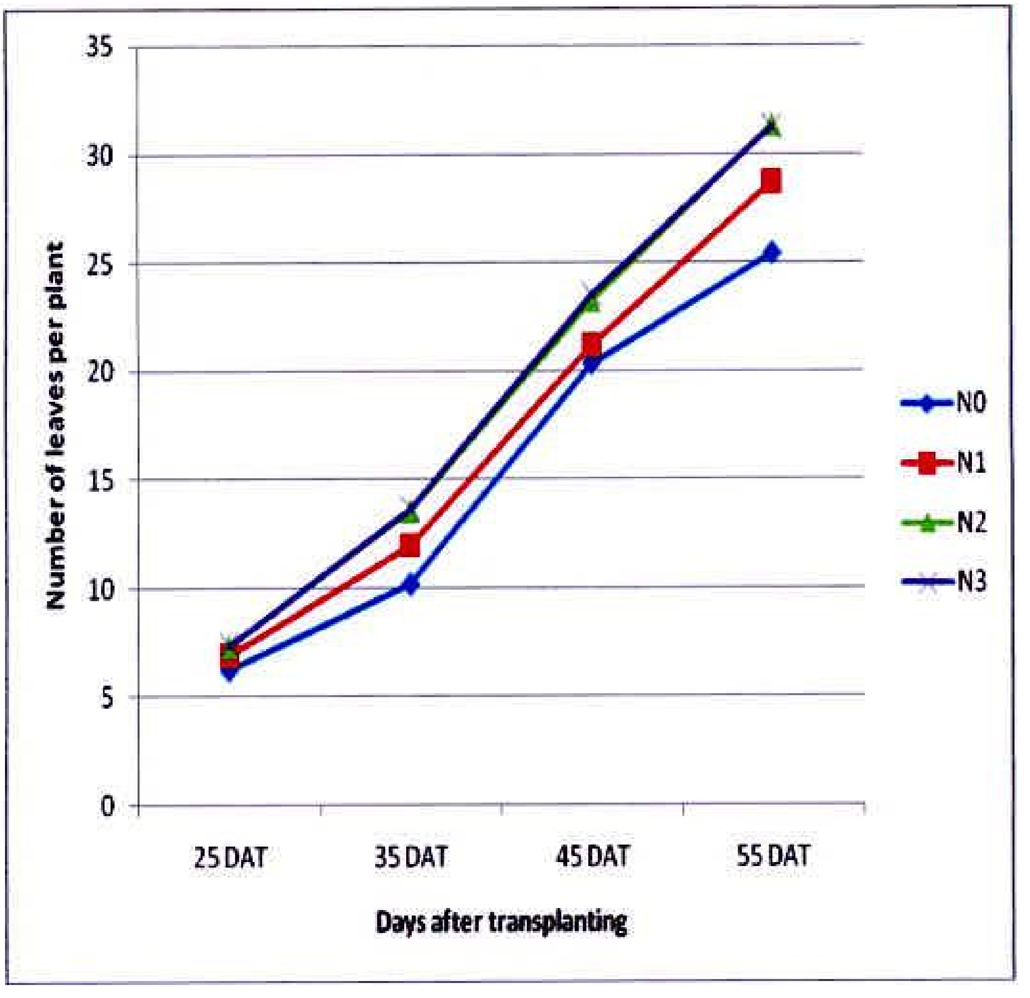


Fig.4: Effect of nitrogen on number of leaves per plant

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

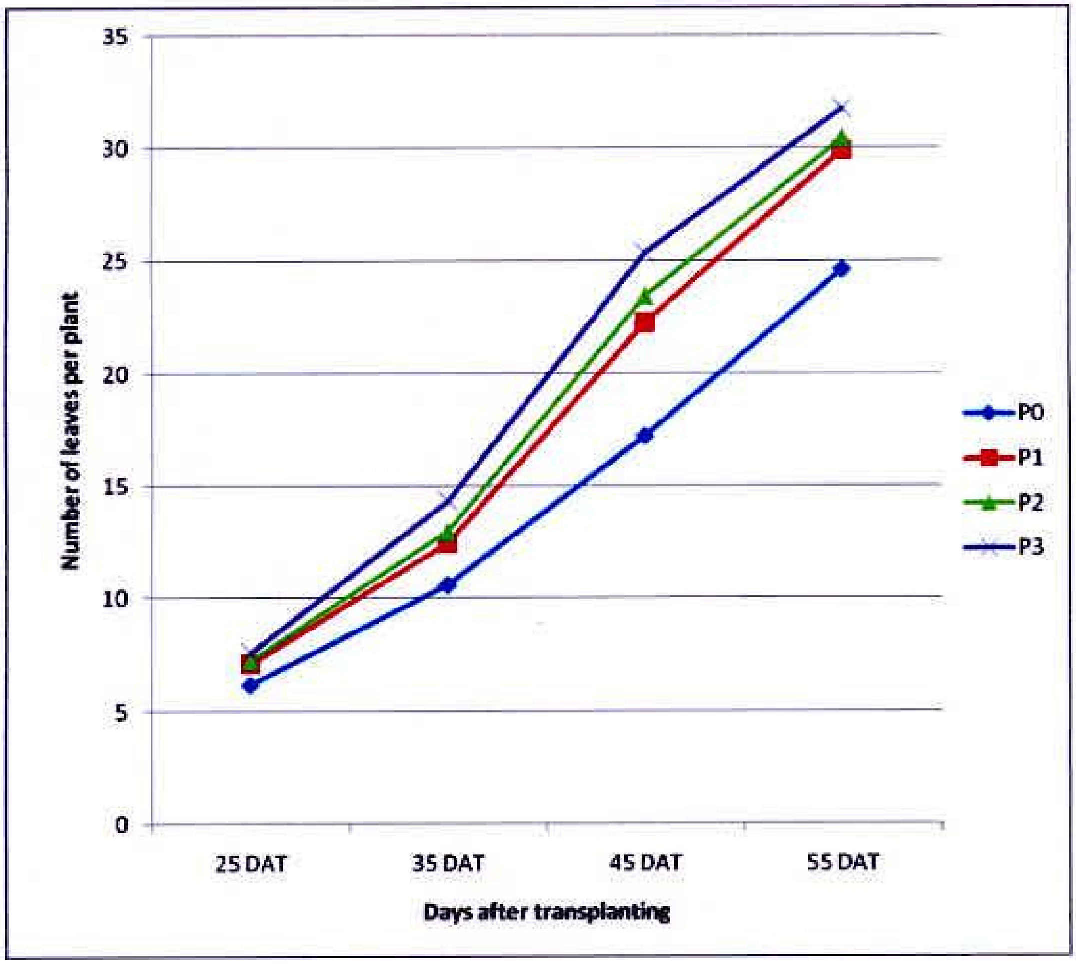


Fig. 5: Effect of phosphorus on number of leaves per plant

P_0 = Control

P_1 =75 kg P_2O_5/ha

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5ha

Table3: Combined effect of nitrogen and phosphorus on number of leaves/plant of lettuce

Treatment combinations	Number of leaves/plant at different days after transplanting			
	25 DAT	35 DAT	45 DAT	55 DAT
N_0P_0	5.52 h	9.29 g	14.23e	20.28f
N_0P_1	6.39fg	11.77cdefg	20.87cd	27.70cde
N_0P_2	6.75defg	10.78efg	22.87bc	26.47de
N_0P_3	7.18bcd	12.94bcde	23.39abc	27.20de
N_1P_0	6.12gh	9.70fg	16.57e	25.35e
N_1P_1	7.03 def	12.20bcdef	20.57cd	29.43bcde
N_1P_2	7.24bcd	12.21bcdef	22.91bc	29.22bcde
N_1P_3	7.10cde	13.58abcd	24.63abc	30.78abcd
N_2P_0	6.79defg	10.97defg	17.46 de	25.25e
N_2P_1	7.18bcd	12.90bcde	24.75abc	31.02abcd
N_2P_2	7.24bcd	14.28abc	23.33abc	33.70ab
N_2P_3	8.20 a	16.02 a	27.34 a	35.23a
N_3P_0	6.41efg	12.42bcdef	20.67cd	27.57cde
N_3P_1	7.43bcd	12.86bcde	22.85bc	31.37abcd
N_3P_2	7.78abc	14.53abc	24.55abc	32.27abc
N_3P_3	7.87ab	14.76ab	25.90ab	33.76ab
Level of significance	*	*	*	*
CV (%)	**5.39**	**11.29**	**10.09**	**8.69**

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
* 5% level of significance

N_0: 0 kg N/ha	P_0 = Control
N_1: 110 kg N/ha	P_1 =75 kg P_2O_5/ha)
N_2: 160 kg N/ha	P_2 = 100 kg P_2O_5/ha
N_3: 210 kg N/ha	P_3 =125 kg P_2O_5/ha

4.1.3 Length of leaf

Length of leaf differed significantly due to the application of different level of nitrogen and phosphorus at 25, 35, 45 and 55 DAT (Appendix IV). At 25 DAT the maximum (10.86 cm) length of leaf was recorded from N_3 (210 kg N/ha) which was statistically identical (10.70 cm) to N_2 (160 kg N/ha), while the control (0 kg N/ha) gave the minimum (9.43 cm) length of leaf. The largest (15.85 cm) leaf length was observed from N_3 which statistically similar (15.73cm) to N_2 and (14.58) to N_1, while the smallest (12.36 cm) was found from control at 35 DAT. At 45 DAT, the maximum (21.53 cm) length of leaf was recorded from N_3 which was statistically identical (21.18 cm) to N_2, while the minimum (18.13 cm) was from control. The highest (23.83 cm) length of leaf was recorded from N_3 at 55 DAT, which was statistically similar (23.08 cm) to N_2, while lowest (20.34 cm) length of leaf observed from control (Table 4). These results indicate that nitrogen increases the growth of lettuce which ensured the maximum length of leaf than control.

Different levels of phosphorus showed significant variations on the length of leaf at 25, 35, 45 and 55 DAT (Appendix IV). The maximum (11.51 cm) length of leaf was recorded from P_3 (125 kg P/ha) which was statistically similar (10.86 cm & 10.66 cm) to P_2 (100 kg P/ha & 75 kg P/ha) and the minimum (8.10 cm) was obtained from control at 25 DAT (Figure 6). At 35 DAT, the maximum (16.93 cm) length of leaf was found from P_3 which was statistically similar (15.40 cm &15.01 cm) to P_2 &P_1, while the minimum (13.19 cm) was observed from control. The maximum (21.99 cm) length of leaf was recorded from P_3 which was similar (20.73 cm and 20.18 cm) to P_2 and P_1, while the minimum (17.26 cm) was recorded from control at 45 DAT. At 55 DAT, the maximum (23.23 cm) length of leaf was recorded from P_3 which was statistically identical (22.12 cm and 22.09 cm) to P_2 and P_1, while the minimum (19.89 cm) was found from control (Table 4). From the results it was found that phosphorus increases the growth of lettuce which ensured the maximum length of leaf than control. This is an agreement with Nagata *et al.*, (1992).

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of length of leaf at different days after transplanting (Appendix IV). The maximum (12.34 cm) length of leaf was recorded at 25 DAT from the combined effect of N_2P_3 (160 kg N/ha +125 kg P/ha), which was similar (12.12 cm) to N_3P_1 (210 kg N/ha +75 kg P/ha), while N_0P_0 (0 kg N/ha +0 kg P/ha) gave the minimum (7.58 cm) length of leaf. At 35 DAT, the highest (18.91 cm) length of leaf was noted from the treatment combination of N_2P_3 whereas the lowest (11.86 cm) was recorded from N_0P_0. At 45 DAT the maximum (24.04 cm) length of leaf was obtained from the treatment combination of N_2P_3 and the minimum (15.14 cm) was recorded from N_0P_0. The maximum (25.40 cm) length of leaf was recorded from the treatment combination of N_2P_3 and the minimum (17.74 cm) was found from the treatment combination of N_0P_0 at 55 DAT (Table 5).

4.1.4 Breadth of leaf

Breadth of leaf differed significantly due to the application of different levels of nitrogen and phosphorus at 25, 35, 45 and 55 DAT (Appendix IV). At 25 DAT the maximum (11.96 cm) breadth of leaf was recorded from N_3 (210 kg N/ha) which was statistically identical (11.43 cm) to N_2 (160 kg N/ha), while the control (0 kg

N/ha) gave the minimum (9.66 cm) breadth of leaf. The maximum (17.47 cm) breadth of leaf was observed from N_3 which was statistically similar (17.22) to N_2 and the minimum (13.87 cm) was found from control condition at 35 DAT. At 45 DAT the highest (21.34 cm) breadth of leaf was recorded from N_3 which was statistically identical (21.08 cm) to N_2 and the lowest (18.42 cm) was from control (Table 4). The maximum (22.98 cm) breadth of leaf was recorded from N_3 at 55 DAT, which was statistically similar (22.35 cm) to N_2, while control gave the minimum (20.17 cm) breadth of leaf. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum breadth of leaf than control.

Different levels of phosphorus showed significant variations on the breadth of leaf at 25, 35, 45 and 55 DAT (Appendix IV).The maximum (12.14 cm) breadth of leaf was recorded from P_3 (125 kg P/ha) which was statistically identical to P_1 and P_2 while the minimum (8.39 cm) was obtained from control (0 kg P/ha) at 25 DAT. At 35 DAT, the maximum (17.44 cm) breadth of leaf was found from P_3, while the minimum (13.38 cm) was found from control. The maximum (21.65 cm) breadth of leaf was recorded from P_3 which was statistically similar to P_2 (20.99 cm) and P_1 (20.30 cm), while the minimum (17.34 cm) was recorded from control at 45 DAT. At 55 DAT, the maximum (22.93 cm) breadth of leaf was recorded from P_3 which was statistically identical (22.17 cm) to P_2, while the minimum (20.25 cm) was found from control (Table 4). These results revealed that phosphorus increases the growth of lettuce which ensured the maximum breadth of leaf than control.

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of breadth of leaf at different days after transplanting (Appendix IV). The maximum (13.28 cm) breadth of leaf was recorded at 25 DAT from the combined effect of N_2P_3 (160 kg N/ha +125 kg P/ha), which was statistical identical (12.51 cm) to N_2P_1 (160 kg N/ha +75 kg P/ha), while N_0P_2 (0 kg N/ha +0 kg P/ha) gave the minimum (8.37 cm) breadth of leaf. At 35 DAT, the maximum (19.40 cm) breadth of leaf was observed from the treatment combination of N_2P_3, which was similar to N_3P_3 (18.44 cm) and N_3P_2 (18.23 cm), whereas the minimum (11.48 cm) was recorded from N_0P_0. At 45 DAT, the maximum (22.66 cm) breadth of leaf was recorded from the treatment combination of N_2P_3 which was statistically identical to N_2P_2 (22.24 cm) & N_3P_3 (22.16 cm) and the minimum (14.86 cm) was recorded from N_0P_0. The maximum (22.96 cm) breadth of leaf was recorded from the treatment combination of N_2P_3 which was statistically similar to N_2P_2 (22.66cm) & N_3P_3 (22.55 cm) whereas the minimum (17.83 cm) was recorded from the treatment combination of N_0P_0 at 55 DAT (Table 6).

Table 3: Main effect of nitrogen and phosphorus 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	9.43a	12.36b	18.13b	20.34b	9.66a	13.87b	18.42b	20.17b
N_1	9.55a	14.58a	19.33ab	21.26ab	10.29a	14.99ab	19.45ab	21.42ab
N_2	10.7a	15.73a	21.18a	23.08a	11.43a	17.22a	21.08a	22.35a
N_3	10.86a	15.85a	21.53a	23.83a	11.96a	17.47a	21.34a	22.98a
$LSD_{(0.05)}$	2.796	3.245	2.432	2.237	3.084	2.795	2.119	1.662
Phosphorus								
P_0	8.1b	13.19b	17.26b	19.87b	8.39b	13.38b	17.34b	20.25b
P_1	10.66ab	15.4ab	20.18ab	22.09ab	11.51a	16.46a	20.30a	21.69ab
P_2	10.86ab	15.01ab	20.73ab	22.12ab	11.29ab	16.27a	20.99a	22.17a
P_3	11.51a	16.93a	21.99a	23.23a	12.14a	17.44a	21.65a	22.93a
$LSD_{(0.05)}$	2.796	3.245	2.432	2.237	3.084	2.795	2.119	1.662
CV(%)	10.46	8.25	4.67	3.93	10.95	6.77	4.06	2.97

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 P_0 = Control

N_1: 110 kg N/ha P_1 =75 kg P_2O_5/ha)

N_2: 160 kg N/ha P_2 = 100 kg P_2O_5/ha

N_3: 210 kg N/ha P_3 =125 kg P_2O_5/ha

Table 5: Combined effect of nitrogen and phosphorus on length of leaf of lettuce

Treatment combinations	Length of leaf at different days after transplanting			
	25 DAT	35 DAT	45 DAT	55 DAT
N_0P_0	7.58c	11.86e	15.14e	17.74e
N_0P_1	11.40a	15.60bc	18.34d	21.60bcd
N_0P_2	11.37a	14.37bcd	19.36cd	20.74d
N_0P_3	11.38a	15.63bc	19.71cd	21.30cd
N_1P_0	7.73c	13.09de	15.76e	18.53e
N_1P_1	8.73bc	14.08cde	19.60cd	21.79bcd
N_1P_2	10.33ab	14.64bcd	19.96cd	21.55bcd
N_1P_3	11.40a	16.50bc	22.00b	23.17b
N_2P_0	8.29c	13.10de	18.27d	21.70bcd
N_2P_1	11.19a	15.84bc	20.73bc	22.05bcd
N_2P_2	10.98a	15.07bcd	21.67b	23.15b
N_2P_3	12.34a	18.91a	24.04a	25.40a
N_3P_0	8.83bc	14.71bcd	19.92cd	22.31bcd
N_3P_1	12.12a	16.08bc	22.05b	22.92bc
N_3P_2	10.76a	15.94bc	21.93b	23.10b
N_3P_3	10.93a	16.69b	22.21b	23.04b
Level of significance	*	*	*	*
CV (%)	**10.46**	**8.25**	**4.67**	**3.93**

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
* 5% level of significance

N_0: 0 kg N/ha	P_0 = Control
N_1: 110 kg N/ha	P_1 =75 kg P_2O_5/ha)
N_2: 160 kg N/ha	P_2 = 100 kg P_2O_5/ha
N_3: 210 kg N/ha	P_3 =125 kg P_2O_5/h

Table 6: Combined effect of nitrogen and phosphorus on breadth of leaf of lettuce

Treatment combinations	Breadth of leaf at different days after transplanting			
	25 DAT	35 DAT	45 DAT	55 DAT
N_0P_0	8.37c	11.48h	14.86g	17.83f
N_0P_1	11.13ab	15.14ef	19.60def	21.33bcd
N_0P_2	11.36ab	13.68fg	19.67def	21.17cd
N_0P_3	11.77ab	15.17ef	19.55ef	20.36de
N_1P_0	8.29c	12.58gh	15.56g	19.64e
N_1P_1	10.39bc	15.62def	19.06f	21.10cd
N_1P_2	10.31bc	15.10ef	20.94bcde	22.09abc
N_1P_3	12.17ab	16.75bcde	21.22ab	22.06a
N_2P_0	8.28c	13.61fg	18.35f	21.28cd
N_2P_1	12.51ab	17.70abc	21.08bcd	22.50ab
N_2P_2	11.67ab	18.17ab	22.24ab	22.66a
N_2P_3	13.28a	19.40a	22.66a	22.96a
N_3P_0	8.61c	15.85cde	20.61cde	22.23abc
N_3P_1	12.03ab	17.38bcd	21.48abc	21.83abc
N_3P_2	11.83ab	18.23ab	21.11bcd	21.57a
N_3P_3	11.37ab	18.44ab	22.16ab	22.55a
Level of significance	*	*	*	*
CV (%)	**10.95**	**6.77**	**4.06**	**2.97**

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

* 5% level of significance

N_0: 0 kg N/ha | P_0 = Control

N_1: 110 kg N/ha | P_1 =75 kg P_2O_5/ha)

N_2: 160 kg N/ha | P_2 = 100 kg P_2O_5/ha

N_3: 210 kg N/ha | P_3 =125 kg P_2O_5/ha

4.1.5 Leaf yield per plant

The leaf yield per plant varied significantly from 314.67 g to 393.28 g at harvesting stage due to the application of different levels of nitrogen. The maximum yield (393.28 g) per plant was contributed by N_3 (210 kg N/ha) which was statistically identical (390.15 g) to N_2 (160 kg N/ha).The plant receiving the treatment N_0 was the lowest (314.67 g) in this respect. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum leaf yield per plant than control (Fig. 6). The result is consistent with that of Hochmuth and Howell (1983) from their experiment.

Significant variation was observed for leaf yield per plant due to different level of phosphorus (Appendix V).The maximum yield (385.35 g) per plant was produced by P_3 (125 kg P/ha) which was statistically similar (380.42 g) to P_2 (100 kg p/ha).The plant receiving the treatment P_0 was the lowest (320.86 g) in this respect (Fig. 7). The possible reason for such higher leaf yield with increasing phosphorus might be that the plants produced more carbohydrates through better photosynthesis (Nimje and Jagdish, 1987).

Significant variation was found due to combined effect of nitrogen and phosphorus in terms of leaf yield per plant at harvesting stage (Appendix V). The maximum (439.00 g) leaf yield per plant was produced from the treatment combination of N_2P_3 (160 kg N/ha +125 kg P/ha), which was statistically identical to N_2P_2 (421.33 g) and N_3P_2 (420.67 g). The lowest leaf yield per plant (273.33 g) was observed in N_0P_0 (0 kg N/ha +0 kg P/ha) treatment combination (Table 7).

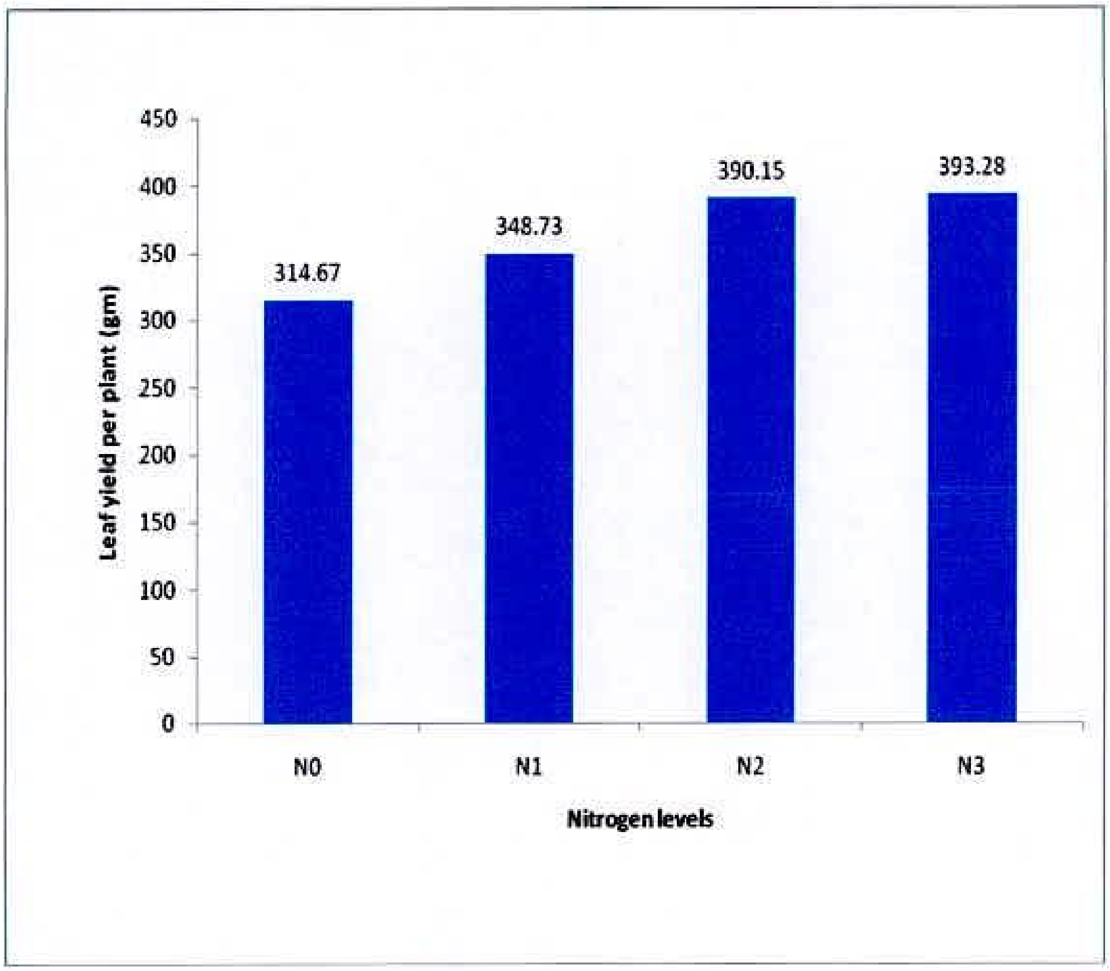


Fig.6: Effect of nitrogen on leaf yield per plant

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

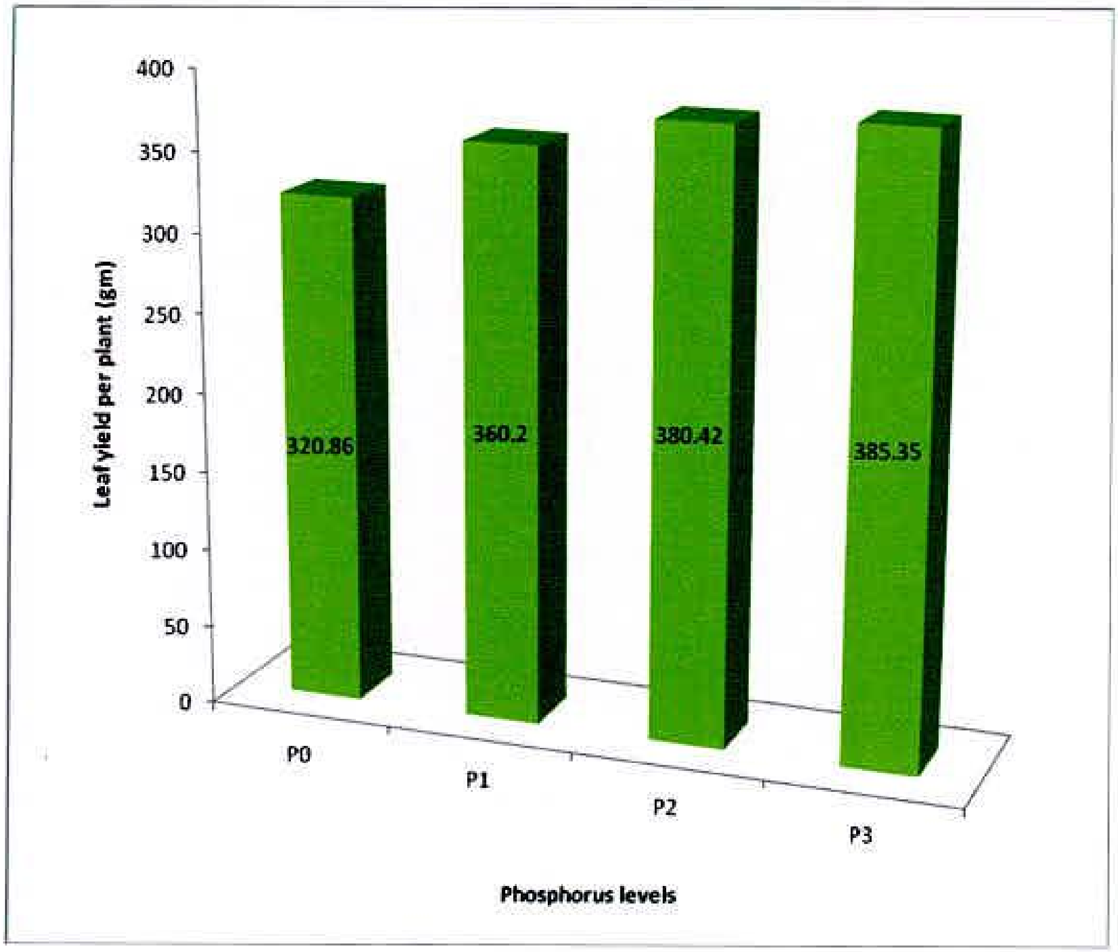


Fig. 7: Effect of phosphorus on leaf yield per plant

P_0 = Control

P_1 =75 kg P_2O_5/ha

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

4.1.7 Yield per hectare

Different levels of nitrogen application influenced significantly the leaf yield per hectare (Appendix V). The yield range of the present study varied from 31.51 to 39.48 t/ha. The highest leaf yield (39.39 t/ha) was obtained from N_3 (210 kg N/ha) which was statistically identical (39.02 t/ha) to N_2 (160 kg N/ha). The lowest yield (31.51 t/ha) was found in N_0 (0 kg N/ha). Data revealed that leaf yield increased with the increase of N level up to 150 kg/ha. (Fig.10). This findings of this experiment is in partial or fully agreement with that of Rahim and Siddique (1982).

Different levels of phosphorus application exerted significant influence on the leaf yield per hectare (Appendix V). The maximum leaf yield (38.57 t/ha) was obtained from P_3 (125 kg P/ha) which was statistically similar (38.09 t/ha) to P_2 (100 kg P/ha). The minimum yield (31.09 t/ha) was observed in N_0 (0 kg P/ha). From the data it was justified that leaf yield increased with the increased application of phosphorus in lettuce (Fig.11). This is an agreement with Wilson (1976), Larion *et al.*,(1984) and Wijk (2000) in lettuce.

The combined effect of nitrogen and phosphorus application exerted significant influence on the leaf yield per hectare (Appendix V). The highest leaf yield (43.90 t/ha) was obtained from N_2P_3 (125 kg P/ha) and the lowest yield (27.33 t/ha) was observed in N_0P_0 (0 kg N/ha + 0 kg P/ha) (Table 7). This findings support the results of Sajjan *et al.*, (1991) in lettuce.

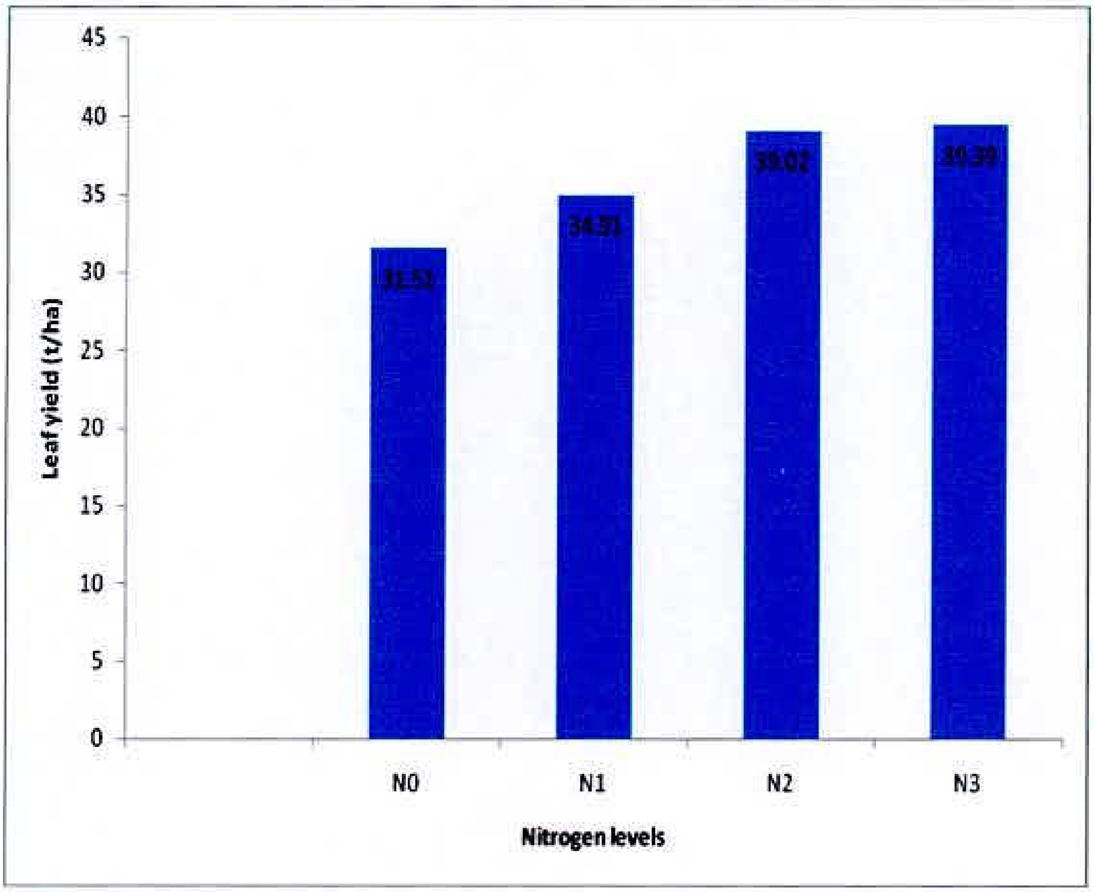


Fig.8: Effect of nitrogen on leaf yield per hectare

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

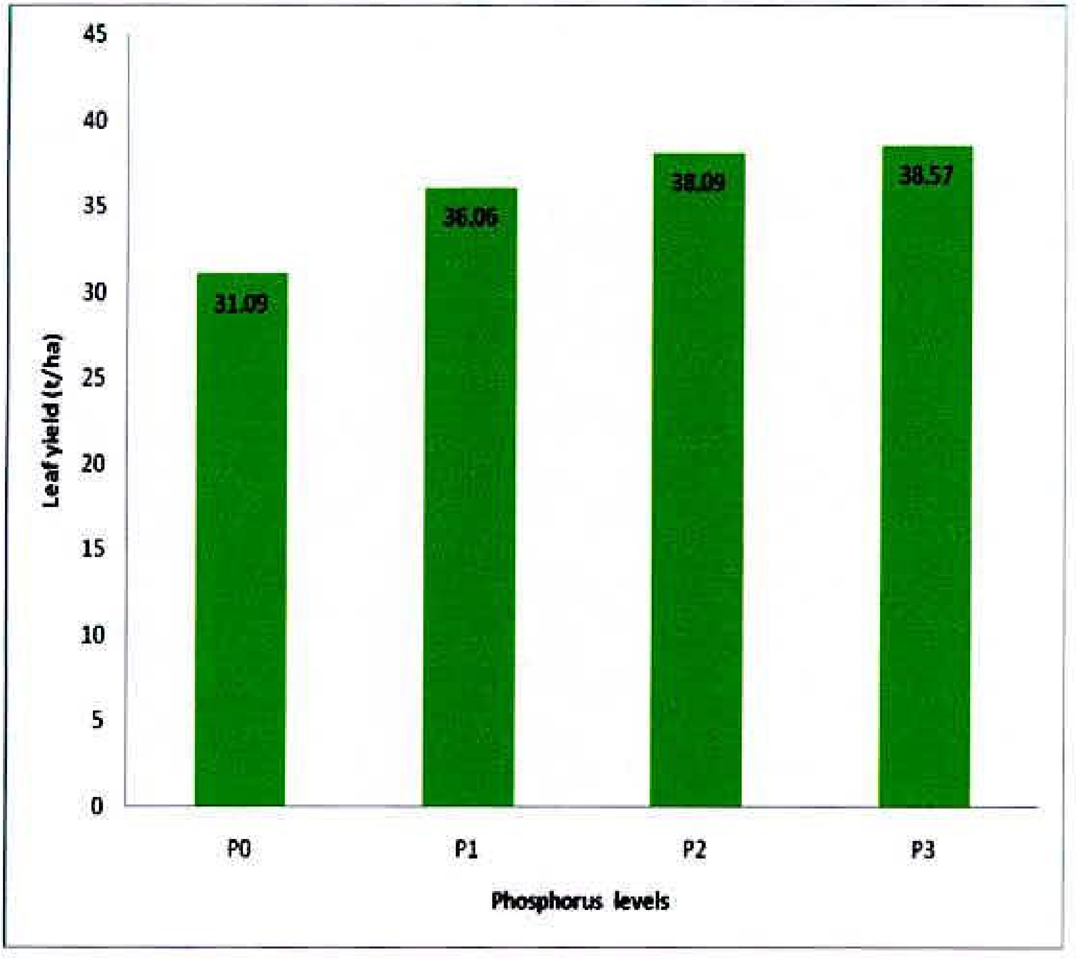


Fig. 9: Effect of phosphorus on leaf yield per hectare

P_0 = Control

P_1 =75 kg P_2O_5/ha

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

4.1.8 Dry matter content in plant

Dry matter content in plant differed significantly due to the application of different level of nitrogen and phosphorus at harvesting stage (Appendix V). The maximum (5.08%) dry matter content in plant was recorded from N_2 (160 kg N/ha), which was statistically similar (4.99%) to N_3 while the control (0 kg N/ha) treatment gave the minimum (4.22%) dry matter content in plants (Fig. 12).

Different levels of phosphorus showed significant variations on dry matter content in plant at harvesting stage (Appendix V). The maximum (5.25%) dry matter content in plant was recorded from P_3 (125 kg P/ha) which was statistically similar (4.96%) to P_2 (100 kg P/ha) and the minimum (4.17%) was obtained from control (0 kg P/ha) (Fig. 13).

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of dry matter content in plant at harvesting stage ((Appendix V). The maximum (5.48%) dry matter content in plant was recorded from N_2P_3 (160 kg N/ha +125 kg P/ha)), which was closely followed with N_2P_2 by (5.30%) and N_2P_3 by (5.25%), while N_0P_0 (0 kg N/ha + 0 kg P/ha) gave the minimum (4.20%) dry matter content (Table 7).

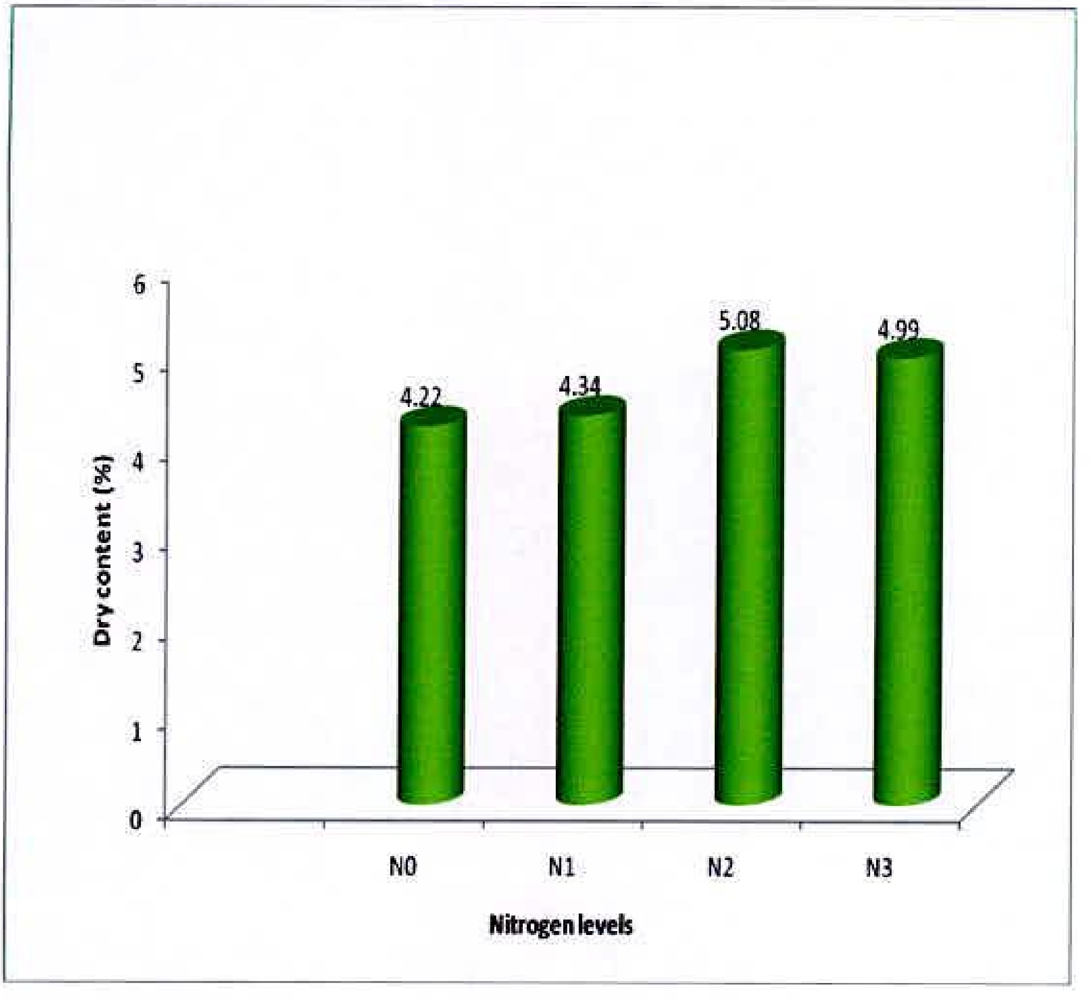


Fig.10: Effect of nitrogen on dry matter content in lettuce plant

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

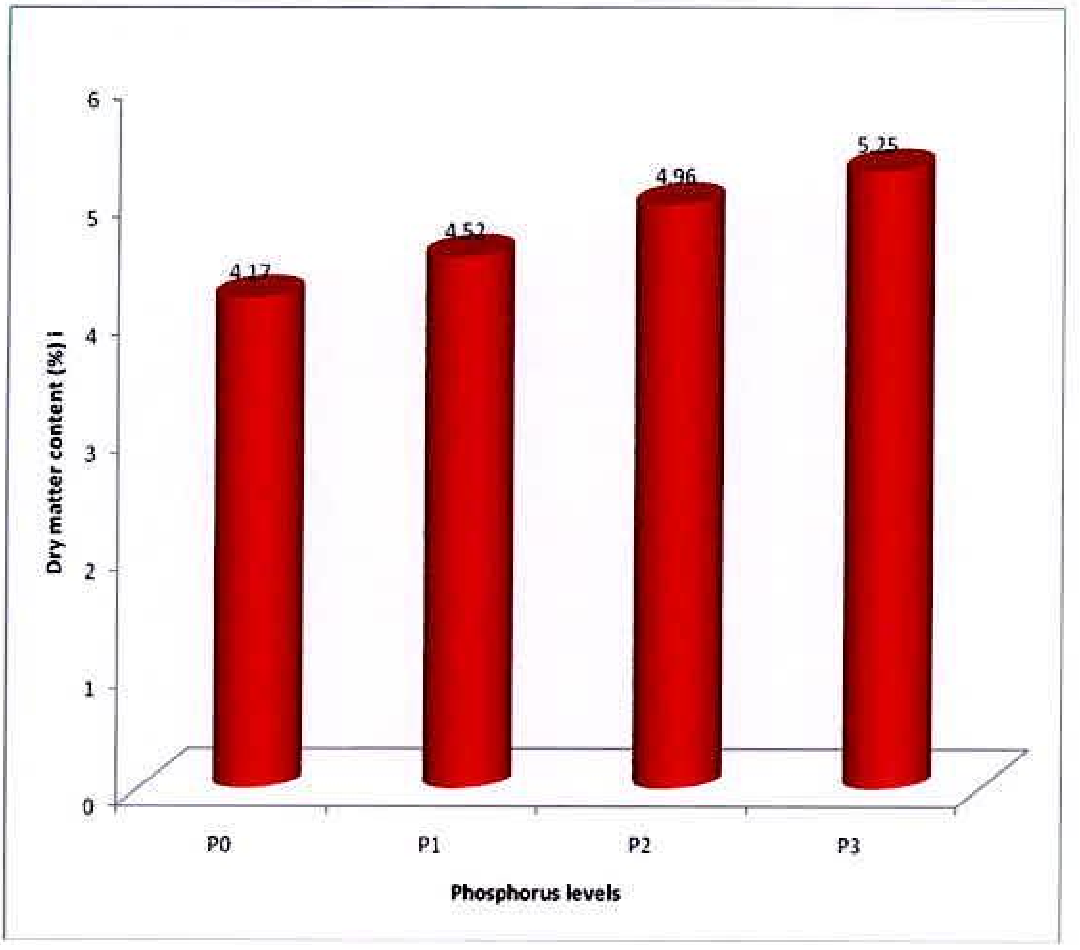


Fig. 11: Effect of phosphorus on dry matter content in lettuce plant

P_0 = Control

P_1 =75 kg P_2O_5/ha

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

Table 7: Combined effect of nitrogen and phosphorus on leaf yield (gm/plant), (kg/plot), (t/ha) and dry matter content of lettuce

Treatment combinations	leaf yield (gm/plant)	Plot Yield (kg/plot) at	Yield (t/ha)	Dry matter content (%) in plant
N_0P_0	273.33f	6.58f	27.33g	4.20f
N_0P_1	335.33cde	8.04cde	33.71cdef	4.31ef
N_0P_2	318.33e	7.63e	31.83f	4.84bcd
N_0P_3	331.67cde	7.96cde	33.17def	4.72cde
N_1P_0	318.83e	7.66e	31.88f	4.49def
N_1P_1	357.33bcd	8.58bcd	35.73bcde	5.04abc
N_1P_2	361.33bc	8.67bc	36.13bcd	5.00abc
N_1P_3	357.40bcd	8.58bcd	35.89bcde	4.83bcd
N_2P_0	324.47de	7.79de	32.45ef	4.93bcd
N_2P_1	375.80b	9.03b	37.59b	4.88bcd
N_2P_2	421.33a	10.11a	42.13a	5.30abc
N_2P_3	439.00a	10.54a	43.90a	5.48a
N_3P_0	366.80bc	8.79bc	36.72bcd	5.07abc
N_3P_1	372.33b	8.97b	37.23bc	4.73cde
N_3P_2	420.67a	10.21a	42.27a	4.93bcd
N_3P_3	403.33a	9.92a	40.33a	5.25ab
Level of significance	*	*	*	*
CV (%)	**5.32**	**5.26**	**5.39**	**5.28**

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
* 5% level of significance

N_0: 0 kg N/ha	P_0 = Control
N_1: 110 kg N/ha	P_1 =75 kg P_2O_5/ha)
N_2: 160 kg N/ha	P_2 = 100 kg P_2O_5/ha
N_3: 210 kg N/ha	P_3 =125 kg P_2O_5/ha

4.2 Economic analysis

Input costs for land preparation, seed cost, fertilizer, thinning, and 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-

4.2.1 Gross return

The combination of nitrogen and phosphorus showed different gross return under the trial. The highest gross return (Tk. 351200/ha-) was obtained from the treatment combination of N_2P_3 (160 kg N/ha +125 kg P/ha) and the second highest gross return (Tk. 338160/ha-) was obtained from N_3P_2 (210 kg N/ha +100 kg P/ha). The lowest gross return (Tk. 218640/ha-) was recorded from the control treatment combination of N_0P_0 (Table 8).

4.2.2 Net return

In case of net return different treatment combination showed unlike types of net return. The highest net return (Tk. 194360/ha-) was found from the treatment combination of N_2P_3 and the second highest net return (Tk. 181886/ha-) was obtained from the treatment combination of N_3P_2. The lowest net return (Tk. 69167/ha-) was obtained from the control treatment (Table-8).

Table8: Cost and return of lettuce due to nitrogen and phosphorus treatments

Treatment combinations	Cost of production (Tk/ha)	Yield (t/ha) at harvest	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
N_0P_0	149473	27.33	218640	69167	1.46
N_0P_1	152818	33.71	269680	116862	1.76
N_0P_2	153933	31.83	254640	100707	1.65
N_0P_3	155048	33.17	265360	110312	1.71
N_1P_0	150699	31.88	255040	104341	1.69
N_1P_1	154044	35.73	285840	131796	1.85
N_1P_2	155159	36.13	289040	133881	1.86
N_1P_3	156274	35.89	287120	130846	1.83
N_2P_0	151257	32.45	259600	108343	1.72
N_2P_1	154602	37.59	300560	145958	1.94
N_2P_2	155717	42.13	337040	181323	2.16
N_2P_3	156832	43.90	351200	194360	2.24
N_3P_0	151814	36.72	293760	141946	1.93
N_3P_1	155159	37.23	297840	142681	1.96
N_3P_2	156274	42.27	338160	181886	2.17
N_3P_3	157389	40.33	322640	165251	2.05

N_0: 0 kg N/ha

N_1: 110 kg N/ha

N_2: 160 kg N/ha

N_3: 210 kg N/ha

P_0 = Control

P_1 =75 kg P_2O_5/ha)

P_2 = 100 kg P_2O_5/ha

P_3 =125 kg P_2O_5/ha

Note: Sale of lettuce @ Tk. 8000.00 /t

Total income = Marketable yield (t/ha) × Tk 8000.00

BCR = Gross return ÷ Total cost of production

Chapter 5

Summary and conclusion

4.2.3 Benefit cost ratio

The combination of nitrogen and phosphorus for benefit cost ratio was different in all treatment combination (Table 7). The highest (2.24) benefit cost ratio was performed from the treatment combination of N_2P_3 and the second highest benefit cost ratio (2.17) was estimated from the treatment combination of N_3P_2. The lowest befit cost ratio (1.46) was obtained from the control treatment i.e. N_0P_0. From economic point of view, it is apparent from the above results that the treatment combination of N_2P_3 was more profitable than rest of the treatment combination.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Central Farm of Sher-e-Bangla Agricultural University, Dhaka, to evaluate the effects of nitrogen and phosphorus on growth and yield of lettuce during the period of November 2007 to February 2008. The experiment consisted of four levels of nitrogen treatments viz., control(0 kg N/ha), 110 kg N/ha, 160 kg N/ha, 210kg N/ha, and four levels of phosphorus treatments viz., control(0 kg P/ha), 75 kg P/ha, 100 kg P/ha, 125kg P/ha,

The factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were alltogether 16 treatment combinations in this experiment. Each unit plot size was 2 m × 1.2 m where 1.0 m and 0.5 m gap between blocks and plots respectively were maintained. The experimental plots were fertilized with 10 ton cowdung, 150 kg MP as three installment, different levels of nitrogen were applied as Urea as three installment and phosphorus fertilizer were applied as TSP during final land preparation according to different levels of treatments. The lettuce seeds of cv. Green Wave were sown on 01 November 2007 in seedbed and transplanted in main field on 04 December, 2008 and harvested on 55 DAT . All the intercultural operations were done as per requirements. Data of growth and yield parameters were collected 10 randomly selected plants of each plots and analyzed statistically. The mean differences were adjusted by Duncan's Multiple Range Test (DMRT).

Nitrogen significantly influenced in most of the parameters at different days after transplanting. However at the harvesting stage the highest (27.76cm) plant height, leaf length(22.82 cm), leaf breadth(22.98 cm) , fresh weight of leaves per plant(393.28 gm), yield per plot(9.47 kg), and yield per hectare(39.39 ton) was observed in 210 kg N/ha(N_3) and only incase of number of leaves per plants(31.30) and also dry matter content(5.08%) was found in 160kg N/ha but it was close(31.24 and 4.99%) to N_3. Whereas the control treatment showed lowest plant height(23.13 cm), number of leaves(25.41), leaf length(20.34cm), leaf breadth(20.17 cm) , fresh weight (314.67 gm), yield per plot(7.55 kg), and yield per hectare(31.51 ton), dry matter content(4.22%) .

Different levels of phosphorus also significantly influenced all the growth and yield contributing parameters at different days after transplanting. At the harvesting stage the maximum plant height(27.88cm), number of leaves per plants(31.74) leaf length(23.22 cm), leaf breadth(22.18 cm),fresh weight of leaves per plant(385.35 gm), yield per plot(9.25 kg), and yield per hectare(38.57 ton) dry matter content(5.05%), was recorded in 125 kg P/ha(P_3). Whereas the control treatment showed lowest performance above these case.

Different levels of nitrogen and phosphorus had significant combined effects on the growth and yield contributing parameters at different days after transplanting. But that was not significant incase of dry matter content. Among the combination of all the treatments of different levels of nitrogen and phosphorus, the combination N_2P_3 (160 kg N/ha +125 kg P/ha) showed the better performance at the harvesting stage. This combination produced highest plant height (30.61 cm), number of leaves per plant (35.23), leaf length(25.41 cm), leaf breadth(22.96 cm),fresh weight of leaves per plant(439.00 gm), yield per plot(10.54 kg), yield per hectare(43.90 ton) and dry matter content(5.48%). Whereas the combination of control treatment N_0P_0 (0 kg N/ha +0 kg P/ha) showed lowest plant height (18.81 cm), number of leaves per plant (20.28), leaf length(17.74 cm), leaf breadth(17.84 cm), fresh weight of leaves per plant(273.33 gm), yield per plot(6.58 kg), yield per hectare (27.33 ton) and dry matter content(4.2%).

The highest net return Tk. (194360/ha-) was obtained from the treatment combination of N_2P_3 (160 kg N/ha +125 kg P/ha) and the second highest net return (Tk. 181886/ha-) was found from the treatment combination of N_3P_2 (210 kg N/ha +100 kg P/ha). The lowest net return (Tk. 69167/ha-) was obtained from the control (0 kg N/ha +0 kg P/ha) treatment .The cost and return analysis indicated that the highest BCR (2.24) was obtained from the treatment combination of N_2P_3 (160 kg N/ha +125 kg P/ha) and lowest from control (0 kg N/ha +0 kg P/ha).

Therefore, considering the present study it may be suggested that the higher yield and economic return of lettuce could be obtained by cultivating the crop with 160 kg N/ha and 125 kg P/ha.

A few works has been done on lettuce in Bangladesh in relation to fertilizer application . considering the present experiment, further studies in the following areas may be suggested

1. For regional adaptibility more experiment is needed in different agro eco-logical zones(AEZ)
2. Different levels of fertilizer combination may also practices
3. With the increasing levels of nitrogen and phosphorus yield was increased. But in the combination both treatment yield was increased upto certain level of nitrogen . Some of the case yield was similar . So for ensuring the higher yield of lettuce nitrogen doses should maintain properly and another higher doses of phosphorus may be include in the experiment for more conformation.
4. Experiment should also conducted in one year and a certain place only.

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CHAPTER VI

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Appendices

APPENDICES

Appendix I: Results of Physical and chemical properties of soil of the experimental plot

Physical properties

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

Chemical analysis

Soil properties	Amount
Soil pH	5.6
Organic carbon (%)	1.32
Total nitrogen (%)	0.075
Available P (ppm)	19.5
Exchangeable K (%)	0.2

Source: SRDI, Farmgate, Dhaka.

Appendix II: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November 2007 to February 2008

Month	Air temperature (^0C)			Average RH (%)	Total rainfall (mm)
	Maximum	Minimum	Mean		
November 07	28.18	16.26	22.72	72.52	25
December 07	24.82	14.04	20.53	70.61	16
January 08	24.6	11.5	17.6	65	0
February 08	27.1	15.8	21.05	66	09

Source: Bangladesh Meteorological Department (Climate division)

Agargoan, Dhaka - 1212

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

Source of variation	Degrees of freedom	Mean square Plant height (cm) at				Mean square Number of leaves per plant			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	0.36	1.281	22.687	2.469	0.337	1.365	133.87	9.359
Nitrogen (A)	3	1.039^{NS}	29.807*	26.933*	52.135*	2.276*	17.546*	28.577*	92.712*
Phosphorus (B)	3	27.945*	22.131*	76.165*	54.809*	4.117*	28.33*	143.13*	117.771*
Interaction (A×B)	9	0.75^{NS}	2.536*	3.00*	4.213*	0.817*	2.422*	4.84*	4.418*
Error	30	0.37	1.197	1.697	1.382	0.143	2.018	4.949	6.426

*: Significant at 0.05 level of probability   NS=Non Significant

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

Source of variation	Degrees of freedom	Mean square Length of leaf (cm) at				Mean square Breadth of leaf (cm) at			
		25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
Replication	2	1.249	13.442	5.558	0.548	2.363	2.115	6.772	1.805
Nitrogen (A)	3	3.066^{NS}	21.328*	30.561*	20.226*	2.811^{NS}	36.683*	22.991*	12.404*
Phosphorus (B)	3	26.913*	85.113*	47.808*	20.715*	33.522*	36.679*	43.275*	9.763*
Interaction (A×B)	9	1.997*	20.146*	2.02*	2.958*	1.118^{NS}	1.877*	3.795*	1.878*
Error	30	1.158	46.79	0.876	0.741	1.409	1.157	0.665	0.409

*: Significant at 0.05 level of probability   NS=Non Significant

Appendix V: Analysis of variance of the data on leaf yield g/ plant, kg/ plot, t/ha and dry matter(%) content in plant of lettuce as influenced by nitrogen and phosphorus

Source of variation	Degrees of freedom	Mean square			
		Leaf yield(g/plant)	Yield (kg/plot) at	Yield (t/ha) at	Dry matter content (%)
Replication	2	884.873	0.476	9.252	0.053
Nitrogen (A)	3	16749.58*	9.831*	167.055*	0.754*
Phosphorus (B	3	10319.71*	6.001*	104.277*	0.499*
Interaction (A×B)	9	1163.731*	0.876*	11.91*	0.133^{NS}
Error	30	370.881	0.209	3.808	0.066

*: Significant at 0.05 level of probability NS=Non Significant

Appendix VI. Cost of production of lettuce as influenced by nitrogen and phosphorus

A. Input cost

Treatment	Labour cost	Ploughing cost	Seed cost (Tk)	Irrigation Cost	Weeding cost	Pesticides	Manure and fertilizers				Sub Total (A)
							Cow dung	Urea	TSP	MP	
N_0P_0	35,000	10,000	4,500	4,000	3,000	3,000	30,000	-	-	3,750	93,250
N_0P_1	35,000	10,000	4,500	4,000	3,000	3,000	30,000	-	3,000	3,750	96,250
N_0P_2	35,000	10,000	4,500	4,000	3,000	3,000	30,000	-	4,000	3,750	97,250
N_0P_3	35,000	10,000	4,500	4,000	3,000	3,000	30,000		5,000	3,750	98,250
N_1P_0	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,100		3,750	94,350
N_1P_1	35,000	10,000	4,500	4,000	3,000-	3,000	30,000	1,100	3,000	3,750	97,350
N_1P_2	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,100	4,000	3,750	98,350
N_1P_3	35,000	10,000	4,500	4,000	3,000-	3,000	30,000	1,100	5,000	3,750	99,350
N_2P_0	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,600		3,750	94,850
N_2P_1	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,600	3,000	3,750	97,850
N_2P_2	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,600	4,000	3,750	98.850
N_2P_3	35,000	10,000	4,500	4,000	3,000	3,000	30,000	1,600	5,000	3,750	99,850
N_3P_0	35,000	10,000	4,500	4,000	3,000	3,000	30,000	2,100		3,750	95,350
N_3P_1	35,000	10,000	4,500	4,000	3,000	3,000	30,000	2,100	3,000	3,750	98,350
N_3P_2	35,000	10,000	4,500	4,000	3,000	3,000	30,000	2,100	4,000	3,750	99,350
N_3P_3	35,000	10,000	4,000	4,000	3,000	3,000	30,000	2,100	5,000	3,750	1,00,350

N_0: 0 kg N/ha
N_1: 110 kg N/ha
N_2: 160 kg N/ha
N_3: 210 kg N/ha

P_0 = Control
P_1 =75 kg P/ha)
P_2 = 100 kg P/ha
P_3 =125 kg P/ha

Appendix VI. Contd.
B. Overhead cost (Tk./ha)

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 700,000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of input cost)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
N_0P_0	45,500	4662	6061	56223	149473
N_0P_1	45,500	4812	6256	56568	152818
N_0P_2	45,500	4862	6321	56683	153933
N_0P_3	45,500	4912	6386	56798	155048
N_1P_0	45,500	4717	6132	56349	150699
N_1P_1	45,500	4867	6327	56694	154044
N_1P_2	45,500	4917	6392	56809	155159
N_1P_3	45,500	4967	6457	56924	156274
N_2P_0	45,500	4742	6165	56407	151257
N_2P_1	45,500	4892	6360	56752	154602
N_2P_2	45,500	4942	6425	56867	155717
N_2P_3	45,500	4992	6490	56982	156832
N_3P_0	45,500	4767	6197	56464	151814
N_3P_1	45,500	4917	6392	56809	155159
N_3P_2	45,500	4967	6457	56924	156274
N_3P_3	45,500	5017	6522	57039	157389