Journal BiNET
Scientific Publication

Published with Open Access at Journal BiNET
Vol. 23, Issue 01: 1872-1884
Journal of Bioscience and Agriculture Research

Journal Home: www.journalbinet.com/jbar-journal.html

Effects of nitrogen and phosphorus fertilizer on yield and yield attributes of lettuce (*Lactuca sativa* L.)

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Article received: 06.08.19; Revised: 04.09.19; First published online: 10 December 2019.

ABSTRACT

An experiment was conducted to assess the effects of different nitrogen and phosphorus fertilizers applied alone or combined with on lettuce plant yield during the period 2011. The experiment considered two factors; viz. Factor A: four levels of nitrogen kg/ha (0, 110, 160 and 210); and Factor B: four levels phosphorus kg/ha (0, 110, 160 and 210). The experiment was laid out in randomized complete block design (RCBD) with three replications. Data on yield and yield attributes of lettuce were collected at different days after transplanting and green yield of lettuce were collected at harvesting time. At 55 DAT (at harvest) the longest plant height (27.76 cm), leaf yield per plant (393.28 g), yield per hectare (39.39 t/ha), was recorded from N_3 (210 kg/ha) and the shortest plant height (23.14 cm), leaf yield per plant (314.67 g), yield per hectare (31.51 t/ha), was recorded from control whereas the maximum (31.30) number of leaves per plant was recorded from N_2 (160 kg/ha). At harvest the longest (27.88 cm) plant height, number of leaves per plant (31.74), leaf yield per plant (385.35 g), yield per hectare (38.57 t/ha) was observed in P_3 (210 kg/ha) and the shortest plant height (22.87 cm), the minimum number of leaves (24.61), yield per plant (320.86 g), yield per hectare (31.09 t/ha) observed from control. Among different treatment combinations N_2P_3 (160 kg N/ha +125 kg P/ha) performed the highest (38.09 t/ha) yield. So N_2P_3 was the suitable combination for lettuce production than those of others. The highest (2.24) benefit cost ratio was performed from the treatment combination of N_2P_3 (160 kg N/ha +125 kg P/ha) and the lowest benefit cost ratio (1.46) was obtained from control treatment. The study found that the higher yield and economic return of lettuce production could be obtained by cultivating the crop with 160 kg N/ha and 125 kg P/ha. The results indicated that application of urea-formaldehyde as a slow release nitrogen fertilizer solely or combined with phosphorus significantly improved yield and yield quality of lettuce plants grown in Bangladesh.

Key words: *Nitrogen, Phosphorus, Lettuce, Yield and Yield attributes*

Cite Article: Islam, M. S., Islam, M. H., Rouf, M. A., Sultana, M. P. and Haque, M. S. (2019). Effects of nitrogen and phosphorus fertilizer on yield and yield attributes of lettuce (*Lactuca sativa* L.). Journal of Bioscience and Agriculture Research, 23(01), 1872-1884.
Crossref: https://doi.org/10.18801/jbar.230119.231

I. Introduction

Lettuce (*Lactuca sativa* L.) belongs to the family Compositae that is the most popular salad crops in the world including Bangladesh. In Bangladesh, this crop is relatively new but is increasingly gaining high levels of economic importance both in generation of income and provision of nutritional value (Mohammad et al., 2011). Lettuce is an important vegetable crop for both formers and consumers. For farmers, it is consider a fast cash crop in the winter season. For consumers, lettuce is eaten fresh and salad, where it is rich in vitamins and minerals. Most of vegetables growers are often over fertilized their crops by mineral fertilizers due to high relatively return of extra yields (Stewart et al., 2005; Schenk, 2006). Vegetable crops require nitrogen in large amounts because it's essential for plant productivity (Marschner, 1995). The extra availability of nitrogen which is not tailored to the plant requirement may reduce product quality through nitrate accumulation in the edible parts (Parente et al., 2006). Moreover, overuse of mineral fertilizers is causing environmental pollution due to the excessive accumulation and leaching of harmful elements to the ground water (Ju et al., 2007). Leafy vegetables particularly lettuce may accumulate nitrate when the supply of nitrogen is high (Reinink, 1991; Premuzic et al., 2004; Prasad and Chetty, 2008), although it's short cultivation cycle. Therefore, nitrogen fertilization process in lettuce fields has to take into accounts not only farming economics but also the consumer preference and human health as well as environmental issues (Schenk, 2006). 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.. 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^{0}C to 25^{0}C and the night temperature is 10^{0}C to 15^{0}C (Ryder, 1998). In higher temperature number of leaves will decrease and tastes may bitter. Above 25^{0}C 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. Nitrogen, phosphorus and potassium progressively increase the marketable yield but an adequate supply is essential for vegetative growth, and desirable yield. Excessive application is not only uneconomical but also induces physiological disorder Yoshizawa et al. (1981). 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. It plays a vital role as a constituent of protein, nucleic acid and chlorophyll (Opena et al., 1988). 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 (Anonymous, 1972). Nitrogen progressively increases the marketable yield (Obreza and Vavrina, 1993) but an adequate supply of 150 kg/ha 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

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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 study was conducted with following objectives, i) to identify the optimum doses of nitrogen and phosphorus for the growth, development and yield of lettuce; and ii) to know the combined effect of nitrogen and phosphorus on lettuce production.

II. Materials and Methods

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 date of experiment 2011. The experiment consisted of four levels of nitrogen treatments viz., control (0 kg N/ha), 110 kg N/ha, 160 kg N/ha, 210 kg 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 altogether 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 following amount of manures and fertilizers were used which are shown as tabular form recommended by Rashid (1999). Data were recorded on the following parameters from the sample plants during the course of experiment. The height of plant, number of leaves per plant, length of larger leaf, breadth of larger leaf 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. Leaves of 10 randomly selected plants were detached by a sharp knife and fresh weight of leaves was recorded in gram. Yield of lettuce per plot was recorded as the whole plant after harvest from each plot (2.0 m × 1.2 m) and was expressed in kilogram. Yield per hectare of lettuce was calculated by converting the weight of plot yield to hectare and was expressed in ton.

Dry matter content per plant

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

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

Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of nitrogen and potassium. All input cost was 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:

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

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).

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III. Results and Discussion

The different levels of nitrogen application had a marked influence on plant height of lettuce at different days after transplanting. At 25 DAT the highest (11.48 cm) plant 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) treatment gave the shortest (9.94 cm) plant height. At 35 DAT the longest (16.76 cm) plant height was observed from N_3 (210 kg N/ha), which statistically similar (16.60 cm) to N_2 and the shortest (13.34 cm) was found from control. The highest (22.57 cm) plant was recorded from N_3 which was statistically identical (22.39 cm) with N_2 and the shortest (19.49 cm) was investigated from control at 45 DAT. The longest (27.76 cm) plant height was recorded from N_3 at 55 DAT which was statistically similar (27.06 cm) to N_2, while control treatment gave the shortest (23.14 cm) plant height. These results indicate that nitrogen increases the growth of lettuce which ensured the longest plant height than control. Similar results were found in lettuce by Hochmuth and Howell (1994) and Karacal and Turetken (1992) from their experiment. The findings of this experiment also conflict with the findings of Baca et al. (1993) and they reported that 80 kg N/ha gave the best performance in lettuce. Nitrogen fertilizer ensured favorable condition for the elongation of lettuce plant with optimum vegetative growth and the ultimate results was the tallest plant. Similar results were observed by Tittonell et al. (2003), Rincon et al. (1998) and Boroujerdnia and Ansari (2007). Plant height differed significantly due to the application of different levels of phosphorus at 25, 35, 45 and 55 DAT. At 25 DAT, the longest (12.42 cm) plant height was recorded from P_3 (125 kg P/ha) which was statistically identical (11.64 cm) with P_2 (100 kg P/ha), while the control (0 kg P/ha) performed the shortest (8.97 cm) plant height. The longest (16.68 cm) plant height was observed from P_3 (125 kg P/ha), which statistically similar (15.68 cm &15.18 cm) to P_2& P_1 and the shortest (13.59 cm) was found from control at 35 DAT. At 45 DAT, the longest (23.45 cm) plant height was recorded from P_3 which was statistically identical (22.25 cm) to P_2 and the shortest (17.63 cm) was obtained from control. The longest (27.88 cm) plant height was recorded from P_3 at 55 DAT which was statistically similar (26.67 cm) to P_2, while control showed the shortest (22.87 cm) plant height. Mota et al. (2003) reported significant response on plant height of lettuce.

A significant variation was found due to combined effect of nitrogen and phosphorus in terms of plant height at different days after transplanting. The highest (12.89 cm) plant was observed at 25 DAT from the combined effect of N_2P_3 (160 kg N/ha +125 kg P /ha) which was similar (12.64 cm) to N_1P_3, while N_0P_0 (0 kg N/ha +0 kg P/ha) gave the shortest (8.22 cm) plant. At 35 DAT, the longest (18.39 cm) plant height was observed from the treatment combination of N_2P_3, which was followed by N_3P_3 (17.58 cm) and N_2P_2 (17.37 cm), whereas the shortest (10.42 cm) was obtained from N_0P_0 (0 kg N/ha+0 kg P/ha). At 45 DAT, the longest (25.77 cm) plant height was recorded from the treatment combination of N_2P_3 which was statistically identical (24.06) to N_3P_2 and the shortest (14.97 cm) was recorded from N_0P_0. The longest (30.61cm) plant height was recorded from the treatment combination of N_2P_3 which was statistically similar (28.78) with N_3P_2 and the shortest (18.80 cm) was found from the treatment combination of N_0P_0 at 55 DAT. From the results it was revealed that both nitrogen and phosphorus favored the plant height (Table 01 and Figure 01).

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. 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. This results in agreement with that of Islam et al. (1998) in batishak. Maximum number of leaves/plant was recorded for highest level of nitrogen because nitrogenous fertilizer ensures favorable condition for the growth of lettuce. Similar findings were observed by Tittonell et al. (2003), Rincon et al. (1998) and Boroujerdnia and Ansari (2007).

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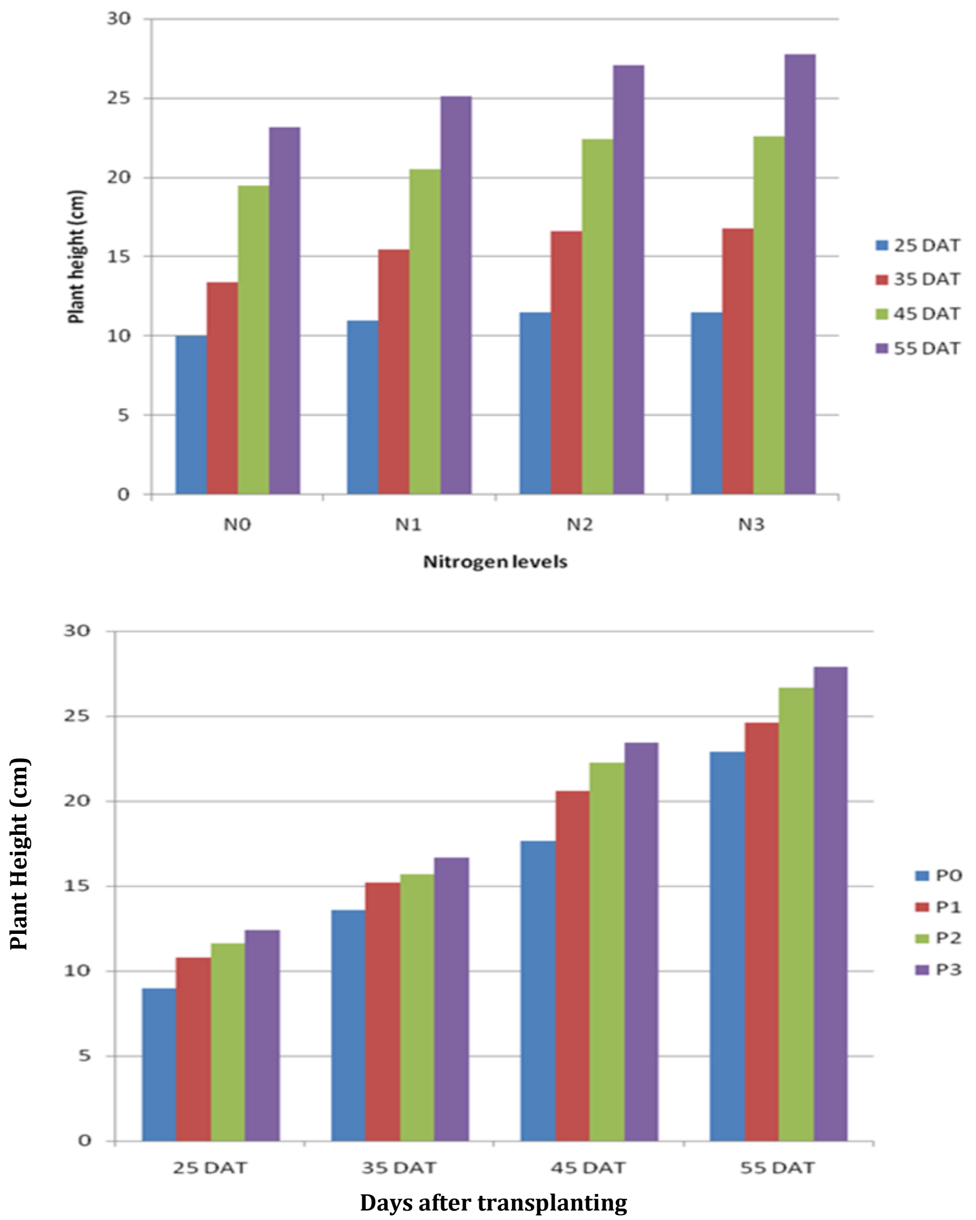

Figure 01. Effect of nitrogen and phosphorus on plant height of lettuce

Number of leaves per plant differed significantly due to the application of different level of phosphorus at 25, 35, 45 and 55 DAT. 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 P2 at 55 DAT, which was statistically similar (30.42) to P_3, while control gave the lowest (24.61) number of leaves per plant. 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. 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_3P_3 and N_2P_2 while the minimum (20.28) was recorded from the treatment combination of

N_0P_0 at 55 DAT (Table 01 and Figure 02). Sajjan et al. (1992) reported that P increase number of leaves of lettuce.

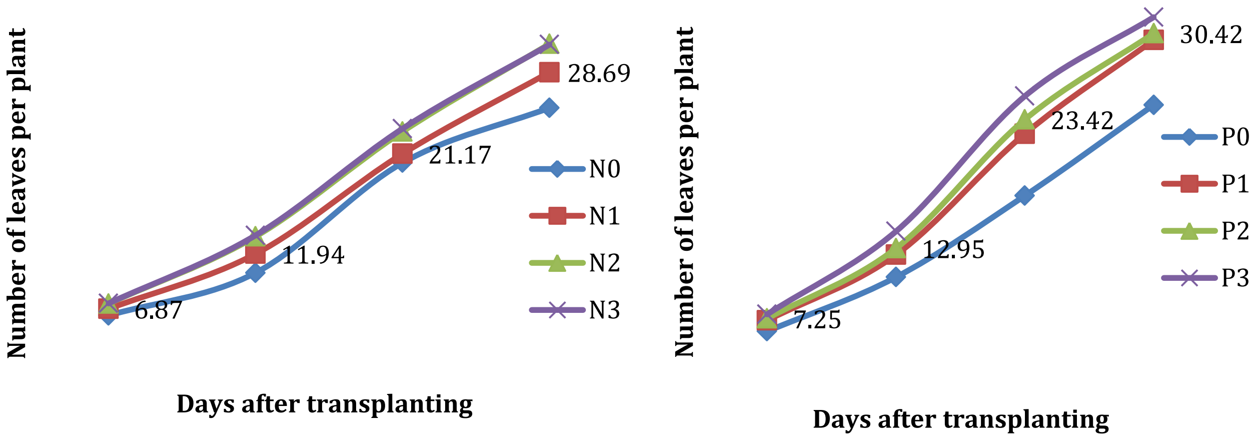

Figure 02. Effect of nitrogen and phosphorus on number of leaves per plant

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. 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 N3 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. These results indicate that nitrogen increases the growth of lettuce which ensured the maximum length of leaf than control. Results showed that higher doses of nitrogen cause higher leaf length. Optimum vegetative growth was occurred due to higher amount of nitrogen fertilizer that leads for the growth of lettuce and the ultimate results was the longest leaf. The results obtained earlier by Boroujerdnia and Ansari (2007) were similar with the present study. Different levels of phosphorus showed significant variations on the length of leaf at 25, 35, 45 and 55 DAT. The maximum (11.51cm) 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 (Table 01). 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 P3 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. 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 . 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. Rubeiz et al. (1992) reported that leaf length would be increased with the application of phosphorus.

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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. 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 01). 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. Results showed that higher doses of nitrogen cause higher leaf breadth. Optimum vegetative growth was occurred due to higher amount of nitrogen fertilizer that leads for the growth of lettuce and the ultimate results was the widest leaf. The results obtained earlier by Boroujerdnia and Ansari (2007) was similar with the present study. Different levels of phosphorus showed significant variations on the breadth of leaf at 25, 35, 45 and 55 DAT. 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 P3 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. 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. 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. Rubeiz et al. (1992) reported that leaf breadth would be increased with the application of phosphorus.

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. The result is consistent with that of Hochmuth and Howell (1994) from their experiment. Significant variation was observed for leaf yield per plant due to different level of phosphorus. 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 (Table 01). 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. The maximum (439.00 g) leaf yield per plant was produced from the treatment combination of N2P3 (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.

Yield per plot

Yield per plot differed significantly due to the application of different level of nitrogen and phosphorus at harvesting stage. In case of nitrogen the highest (9.47 kg) yield per plot was obtained from N_3 (210 kg N/ha) which was statistically identical (9.36 kg) to N_2 (160 kg N/ha), while the lowest (4.16 kg) yield per plot was produced in control (0 kg N/ha) These results indicate that nitrogen increases the growth of lettuce which ensured the maximum yield per plot than control. It was revealed that with increase of nitrogen maximizes lettuce yield because of increased nitrogen helps plant for higher vegetative growth. The results obtained earlier by Rincon et al. (1998), Tittonell et al. (2003), Boroujerdnia and Ansari (2007) and Mahmoudi (2005) were similar with the present study. In case of phosphorus the maximum (9.25 kg) yield per plot was obtained from P_3 (210 kg P/ha) which was statistically similar (9.36 kg) to P_2 (100 kg P/ha), while the minimum (7.70 kg) yield per plot was recorded in control (0 kg P/ha) treatment. These results revealed that phosphorus increases the growth of lettuce which ensured the highest yield per plot than control. A significant variation was found due to combined effect of nitrogen and phosphorus in terms of yield per plot at harvesting stage . The highest (10.54 kg) yield per plot was recorded from the combined effect of N_2P_3 (160 kg N/ha +125 kg P/ha), which was statistically similar to the treatment combination of N_3P_2 (10.21 kg) & N_2P_2 (10.11 kg) while N_0P_0 gave the lowest (6.58 kg) yield per plot (Table 02).

Yield per hectare

Different levels of nitrogen application influenced significantly the leaf yield per hectare. 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. This finding 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. 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 (Table 02). 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 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 02). This findings support the results of Sajjan et al. (1991) in lettuce.

Dry matter content per plant

Dry matter content per plant differed significantly due to the application of different level of nitrogen and phosphorus at harvesting stage. 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 per plants. Different levels of phosphorus showed significant variations on dry matter content per plant at harvesting stage. The maximum (5.25%) dry matter content per 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). A significant variation was found due to combined effect of nitrogen and phosphorus in terms of dry matter content in plant at harvesting stage. The maximum (5.48%) dry matter content per 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 02). Lana et al. (2004) reported significant responses to different P sources were also observed for dry matter production of aerial parts.

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.

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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 03).

Table 02. 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 (g/plant)	Plot Yield (kg/plot)	Yield (t/ha)	Dry matter content (%) in plant
N_0P_0	273.33f	6.58f	27.33g	4.20f
N_0P1	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
LSD(0.05)	32.11	0.762	3.254	0.428
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 at 5% level of probability

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 03).

Benefit cost ratio

The combination of nitrogen and phosphorus for benefit cost ratio was different in all treatment combination. 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 benefit 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 (Table 03).

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Table 03. Cost and return of lettuce due to nitrogen and phosphorus treatments

Treatments	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	691670	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

Note: Sale of lettuce @ Tk. 8000.00 /t, Total income = Marketable yield (t/ha) × Tk. 8000.00, BCR = Gross return; ÷ Total cost of production

IV. Conclusion

Nitrogen and phosphorus had the significant influences on yield and yield contributing characters of lettuce. Application of N_3 (210 kg N/ha), P_3 (160 kg P/ha) and in combination N_2P_3 (160 kg N/ha +125 kg P/ha) give the better growth and yield of lettuce.

Acknowledgement

The authors are grateful to the Ministry of National Science and Technology for allocation of funding to conduct the experiment.

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HOW TO CITE THIS ARTICLE?

Crossref: https://doi.org/10.18801/jbar.230119.231

MLA
Islam et al. “Effects of nitrogen and phosphorus fertilizer on yield and yield attributes of lettuce (*Lactuca sativa* L.)”. Journal of Bioscience and Agriculture Research 23(01) (2019): 1872-1884.

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Table 01. Combined effect of nitrogen and phosphorus on plant height of lettuce

Treatments	Plant height (cm) at different days after transplanting				Number of leaves/plant at different days after transplanting				Length of leaf at different days after transplanting				Breadth of leaf at different days after transplanting			
	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT	25 DAT	35 DAT	45 DAT	55 DAT
N_0P_0	8.22 d	10.42 g	14.98 h	18.80 h	5.52 h	9.29 g	14.23e	20.28f	7.58c	11.86e	15.14e	17.74e	8.37c	11.48h	14.86g	17.83f
N_0P_1	12.16 ab	15.16 cde	20.67 def	23.90 fg	6.39fg	11.77cdefg	20.87cd	27.70cde	11.40a	15.60bc	18.34d	21.60bcd	11.13ab	15.14ef	19.60def	21.33bcd
N_0P_2	11.37 b	12.81 f	20.75 def	24.55 ef	6.75defg	10.78efg	22.87bc	26.47de	11.37a	14.37bcd	19.36cd	20.74d	11.36ab	13.68fg	19.67def	21.17cd
N_0P_3	12.11 ab	14.97 cde	21.56 cde	25.28 ef	7.18bcd	12.94bcde	23.39abc	27.20de	11.38a	15.63bc	19.71cd	21.30cd	11.77ab	15.17ef	19.55ef	20.36de
N_1P_0	8.45 d	13.79 ef	16.86 gh	22.03 g	6.12gh	9.70fg	16.57e	25.35e	7.73c	13.09de	15.76e	18.53e	8.29c	12.58gh	15.56g	19.64e
N_1P_1	11.26 b	16.38 abc	20.62 def	25.07 ef	7.03 def	12.20bcdef	20.57cd	29.43bcde	8.73bc	14.08cde	19.60cd	21.79bcd	10.39bc	15.62def	19.06f	21.10cd
N_1P_2	11.39 b	15.86 bcd	21.06 cde	25.73 def	7.24bcd	12.21bcdef	22.91bc	29.22bcde	10.33ab	14.64bcd	19.96cd	21.55bcd	10.31bc	15.10ef	20.94bcde	22.09abc
N_1P_3	12.64 a	15.79 bcde	23.36 bc	27.54 bcd	7.10cde	13.58abcd	24.63abc	30.78abcd	11.40a	16.50bc	22.00b	23.17b	12.17ab	16.75bcde	21.22ab	22.06a
N_2P_0	9.16 cd	14.11 def	18.37 fg	24.08 fg	6.79defg	10.97defg	17.46 de	25.25e	8.29c	13.10de	18.27d	21.70bcd	8.28c	13.61fg	18.35f	21.28cd
N_2P_1	11.79 ab	16.53 abc	22.33 bcde	25.90 cdef	7.18bcd	12.90bcde	24.75abc	31.02abcd	11.19a	15.84bc	20.73bc	22.05bcd	12.51ab	17.70abc	21.08bcd	22.50ab
N_2P_2	11.88 ab	17.37 ab	23.12 bcd	27.66 bcd	7.24bcd	14.28abc	23.33abc	33.70ab	10.98a	15.07bcd	21.67b	23.15b	11.67ab	18.17ab	22.24ab	22.66a
N_2P_3	12.89 a	18.39 a	25.77 a	30.61 a	8.20 a	16.02 a	27.34 a	35.23a	12.34a	18.91a	24.04a	25.40a	13.28a	19.40a	22.66a	22.96a
N_3P_0	10.07 c	16.05 bcd	20.32 ef	26.57 bcde	6.41efg	12.42bcdef	20.67cd	27.57cde	8.83bc	14.71bcd	19.92cd	22.31bcd	8.61c	15.85cde	20.61cde	22.23abc
N_3P_1	11.91 ab	16.72 abc	22.78 bcde	27.64 bcd	7.43bcd	12.86bcde	22.85bc	31.37abcd	12.12a	16.08bc	22.05b	22.92bc	12.03ab	17.38bcd	21.48abc	21.83abc
N_3P_2	11.92 ab	16.68 abc	24.07 ab	28.74 ab	7.78abc	14.53abc	24.55abc	32.27abc	10.76a	15.94bc	21.93b	23.10b	11.83ab	18.23ab	21.11bcd	21.57a
N_3P_3	12.05 ab	17.58 ab	23.10 bcd	28.09 bc	7.87ab	14.76ab	25.90ab	33.76ab	10.93a	16.69b	22.21b	23.04b	11.37ab	18.44ab	22.16ab	22.55a
CV (%)	5.43	7.04	6.14	4.56	5.39	11.29	10.09	8.69	10.46	8.25	4.67	3.93	10.95	6.77	4.06	2.97
Level of sig.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LSD (0.05)	1.01	1.82	2.17	1.96	0.63	2.369	3.71	4.227	1.794	2.083	1.561	1.435	1.979	1.794	1.36	1.066

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly at 5% level of probability

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