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EFFECT OF DIFFERENT LEVELS OF NITROGEN (N) AND PHOSPHORUS (P) FERTILIZER ON GROWTH AND YIELD OF LETTUCE IN COASTAL ZONE OF BANGLADESH

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ABSTRACT

The experiment was conducted at the Agriculture Field laboratory of Noakhali Science and Technology University, Noakhali, Bangladesh during the period from December 2020 to February 2021 to observe the effect of different levels of nitrogen (N) and phosphorus (P) fertilizer on growth and yield of lettuce. The experiment comprised of two factors. Two inorganic fertilizers like different level of nitrogen and phosphorus viz; nitrogen-control 0 kgha^{-1} (N_0), 100 kgha^{-1} (N_1), 150 kgha^{-1} (N_2) and 200 kgha^{-1} (N_3) and phosphorus-control 0 kgha^{-1} (P_0), 50 kgha^{-1} (P_1), 62.5 kgha^{-1} (P_2) and 75 kgha^{-1} (P_3). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Application of different levels of nitrogen and phosphorus significantly influenced the plant height, leaves number plant^{-1}, leaf area, fresh leaf yield plant^{-1}, gross yield, and dry matter content of lettuce. The maximum plant height, leaves number plant^{-1}, leaf area, fresh leaf yield plant^{-1}, gross yield and dry matter content were obtained with the application of 200 kg N ha^{-1}. On the other hand, with the application of 75 kg P ha^{-1} the maximum plant height, leaves number plant^{-1}, leaf area, fresh leaf yield plant^{-1}, gross yield and dry matter content were found. In case of different treatment interaction, N_3P_3 (200 kg N ha^{-1} + 75 kg P ha^{-1}) produced the highest gross yield (32.2 tha^{-1}) and the lowest gross yield (16.11 tha^{-1}) found from control treatment.

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INTRODUCTION

Bangladesh is predominantly an agrarian country of the world. It has very fertile land and favorable weather, so varieties of crops grow abundantly in this country. Agriculture sector contributes about 13.02 percent (p) FY 2019-20 to the country's Gross Domestic Product (GDP) and employs around 40.60 percent of total labor force (BBS, 2021). Lettuce (*Lactuca sativa* L.) is the most popular salad crop in the world including Bangladesh. Lettuce is a vegetable that originated in Southern Europe and Western Asia (Rashid, 1999). It belongs to the family Compositae. This crop is still relatively new, but it is rapidly acquiring economic relevance in Bangladesh, both in terms of income and nutritional value (Bannayan *et al.,* 2011). It is an annual leafy herb vegetable. The outer, deeper green leaves have the maximum nutritious content (FAO, 2009). It's known for its pleasant, crunchy texture and slightly bitter taste, as well as its fresh milky juice (Squire *et al.,* 1987). Lettuce is mainly a cold loving crop. Lettuce contains very high nutritive value and, also contains a good amount of minerals and a limited source of vitamins to the human diet and supplies substantial amount of fiber and that of water (Work, 1997). It also contains carbohydrate, protein and vitamin C. Water 93.4 g, protein 2.1 g, fat 0.3 g, fiber 0.5 g, carbs 2.5 g, minerals 1.2 g, calcium 310 mg, phosphorous 80 mg, iron 2.6 mg, vitamin A 1650 I.U, thiamine 0.09 mg, riboflavin 0.13 mg, and vitamin C 10 mg per 100 g edible quantity of lettuce (Gopalan and Balaraman, 1966).

Fertilizer plays an important role in appropriate growth and development of lettuce. The prerequisite of crop cultivation is the application of fertilizer in appropriate time, appropriate dose, and proper method of application (Islam, 2003). The marketable yield of crop can progressively be increased by the application of nitrogen and phosphorus fertilizer, but an adequate supply is essential for vegetative growth and desirable yield. Excessive application is not economically beneficial and induces physiological disorder (Yoshizawa *et al.,* 1981). Nitrogen plays a vital role as a constituent of protein, nucleic acid, and chlorophyll (Opena *et al.,* 1988). Being leafy vegetable nitrogen is the most important nutrient for successful lettuce cultivation. Nitrogen exhibits noticeable effect on the vegetative growth, seed yield, fiber, and protein content of lettuce. As lettuce has limited root system, the removal of nutrients from the soil by lettuce is modest but fertility requirements are generally high for rapid and continuous growth (Mitra and Bose, 1990). Nitrogen positively affects the fresh and dry weight of plant, diameter of plant and the total number of leaves (Kharade *et al.,* 2021). Nitrogen fertilizer significantly affected maximum yield, dry weight, fresh weight, and ultimately produced maximum production of lettuce (Gashaw and Haile, 2020). Phosphorus is required for leafy vegetables for the formation and translocation of carbohydrates, development of root system, nodulation, growth, and other agronomic characters. It enhances maturity and earliness in flowering (Buckman and Bradey, 1980). Different levels of nitrogen and phosphorus fertilizers applied alone or combined with on lettuce plant produce maximum number of leaves per plant and highest yield of lettuce per hectare of land (Islam *et al.*, 2019).

Now-a-days in Bangladesh, huge quantity of lettuce is used with fast food shop and in various star hotels as fresh vegetable like salad. Although lettuce production is suitable during winter season in Bangladesh, but lettuce subsector has been already identified as one of the potential value chains to intervene. There is a several research works have done on lettuce all over the world in different aspects but not specifically done in that coastal region in Bangladesh. So, the primary view of the research work is to find out the effect of nitrogen and phosphorus on lettuce production in coastal region of Bangladesh. Hopefully this research work will be end up with a positive outcome and helps to contribute the production of lettuce as well as agricultural sector.

MATERIALS AND METHODS

The research was carried out at Agriculture Field laboratory, Noakhali Science & Technology University, Noakhali, Bangladesh from December 2020 to February 2021.

Description of the experimental site

Location and soil

The research site belongs to Young Meghna Estuarine Flood Plain under the soil of Agro Ecological Zones (AEZ)-18 (FAO 1988). The site is used for cultivation of horticultural and cereal crops. The experiment field was almost level land having sandy loam soil, moderately alkaline, with pH value 7.3 to 8.5. General fertility is medium but low in organic matter.

Climate

The experimental area is under the tropical climate zone. The average annual temperature is 25.0 °C and the average annual rainfall is about 2200 mm. The average air temperature during December to February remains 26.4°C.

Experimental design and layout

Two-factor experiment was laid out at Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into three blocks each representing a replication. Each block was then divided into 16 plots. Therefore, the total number of plots was 48. The size of unit plot was 4m × 1.5m = 6 m^2 where block to block and plot to plot distance was 1m and 0.5m respectively. The spacing was 40cm × 25cm.

Experimental treatment detail

The experiment was designed to study the effect of nitrogen and phosphorus on the growth and yield of lettuce. The following are the two factors that were used in the experiment: Factor A: Nitrogen (N): 0 $kgha^{-1}$ (N_0), 100 $kgha^{-1}$ (N_1), 150 $kgha^{-1}$(N_2), 200 $kgha^{-1}$(N_3) and Factor B: Phosphorus (P): 0 $kgha^{-1}$ (P_0), 50 $kgha^{-1}$(P_1), 62.5 $kgha^{-1}$(P_2), 75 $kgha^{-1}$(P_3). There were 16 treatment combinations in total, including the following: N_0P_0, N_0P_3, N_0P_2, N_0P_1, N_3P_0, N_3P_3, N_3P_2, N_3P_1, N_2P_0, N_2P_3, N_2P_2, N_2P_1, N_1P_0, N_1P_3, N_1P_2, N_1P_1.

Planting materials: Seeds of lettuce cultivar, 'Lettuce Tropical' were used and sown on 8th December 2020.

Seed bed preparation and raising of seedlings

A mixture of sand, dirt, and compost was used to prepare seed beds. It was raised 15cm from ground level. Lettuce seeds were soaked in water for 48 hours and then mixed with soil and sown in seed bed on 8th December 2020. Germination of seed took place five days after sowing of seeds. When the seedlings were thirty days old, they were transplanted in the experimental field on 7th January 2021.

Land preparation and fertilizer application

The experimental field was opened 1st January 2021 with the help of a power tiller and then it was kept open to sun for 5 days prior to further ploughing. Following that, it was ploughed and cross ploughed before being laddered. After each laddering, the weeds and stubbles were cleared. At the same time, the clods were broken, and the soil was created till it had a good tilth. Cowdung @ 5 tha^{-1} and MOP 200 $kgha^{-1}$ was applied during final land preparation. The urea (N) and TSP (P) were applied according to the treatments of the experiment.

Transplanting of seedlings

Thirty days of old seedlings were transplanted on 7th January 2021 in the afternoon and light irrigation was given around each seedling for their better establishment in the field.

Intercultural operation

Dead, injured and weak seedlings were replaced by new vigour seedling from the stock kept on the border line of the experiment. Weeding was done three times in each plot as necessary and when necessary. After transplanting the seedlings, a light irrigation was applied. A week after transplanting the requirement of irrigation was envisaged through visual estimation. Whenever the plants of a plot had shown the symptoms of wilting the plots were irrigated on the same day with a hosepipe until the entire plot was properly wetted.

Data collection

During the experiment, data on the growth and yield parameters were collected from the sample plants. Five plants were sampled randomly from each unit plot for the collection of data.

Statistical analysis

The experimental plots' data was statistically analyzed. The mean values for all the treatments were calculated and the analysis of variance for most of the characters was accomplished by 'Minitab-17'. The significance of difference

between pair of means was tested by the least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of nitrogen on plant height

The plant height was found to be increased significantly with the increase in nitrogen level upto 200 kgha^{-1}. During the period of plant growth, the maximum plant height (19.3 cm) was observed at applied N_3 treatment (200 kgha^{-1} N) which was statically identical with N_2 (150 kgha^{-1} N) treatment, and the shortage plant height (15.77 cm) was found in control plot (Fig. 1). The results showed that nitrogen boosts lettuce growth, resulting in the longest plants. Similar results were found in lettuce by Hochmuth and Howell (1994) at the application of 0, 110 160 and 210 kg nitrogen ha^{-1}. On the other hand, Karacal and Turetken (1992) from their experiment was found same result with the application of 0, 50, 100 and 150 kg nitrogen ha^{-1}. From these two experiment it was found that application of increased rate of nitrogen significantly increased plant height of lettuce.

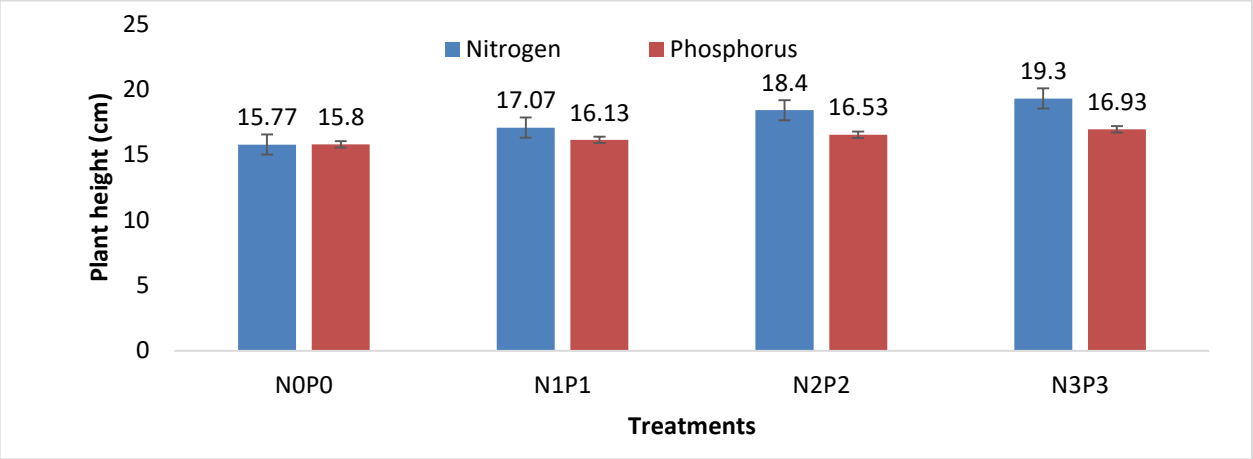

Figure 1. Effect of nitrogen and phosphorus on plant height of lettuce

Effect of phosphorus on plant height

In this experiment, the highest plant height (16.93 cm) was obtained from application of P_3 (75 kgha^{-1} P) treatment followed by P_2 (62.5 kgha^{-1} P) treatment and the lowest plant height (15.8) was found from control treatment (Fig.1). Islam *et al.* (2003) found the similar findings with application of 125 kg P ha^{-1} produced highest plant height (27.88 cm) which was statistically identical (26.67 cm) with 100 kg P ha^{-1}, while the control performed the shortest (22.87 cm) plant height. Mota *et al.* (2003) also reported significant response of phosphorus on plant height of lettuce @ 0, 300, 600 and 900kg P_2O_5 ha^{-1}.

Interaction effect of nitrogen and phosphorus on plant height

The plant height was not significantly influenced by the interaction effect of nitrogen and phosphorus application on lettuce. The maximum vegetative growth was recorded at final harvest. The highest plant height (21.8 cm) was found from the N_3P_3 treatment combination (200 kgha^{-1} N + 75 kgha^{-1} P) and the lowest (15.77 cm) observed from the control treatment. Both nitrogen and phosphorus favored plant height according to the findings. Similar result was found by Islam *et al.* (2019) with the combined application of nitrogen and phosphorus @ 160 kg N+ 125 kg P ha^{-1}. The longest (30.61cm) plant height was recorded from the treatment combination of 160 kg N+ 125 kg P ha^{-1} which was statistically similar (28.78 cm) with 210 kg N+ 110 kg P ha^{-1} and the shortest (18.80 cm) was found from the treatment combination of 0 kg N+ 0 kg P ha^{-1}.

Effect of nitrogen on number of leaves plant^{-1}

Application of nitrogen significantly increases the production of leaves plant^{-1}of lettuce. The application of N_3 treatment (200 kgha^{-1} N) resulted in the maximum number of leaves (22.33) followed by N_2 treatment (150 kgha^{-1} N) and the minimum number of leaves (13.33) was found at application of control treatment (Fig. 2). According to the observation, the number of leaves increase as the degree of nitrogen application increased. Because nitrogen fertilizer promotes lettuce growth, the maximum number of leaves plant^{-1} was recorded for the highest quantity of nitrogen. Similar findings were observed by Tittonell *et al.* (2003) with the application of 0,75 and 150 kg N ha^{-1}. Rincon *et al.* (1998) @ applied 25, 50, 100, 150, 200 kg N ha^{-1}found the similar observation. Maximum number of leaves plant^{-1} was recorded for highest level of nitrogen because nitrogenous fertilizer ensures favorable condition for the growth of lettuce.

Effect of phosphorus on number of leaves plant^{-1} of lettuce

Production of leaves plant^{-1} due to the effect of phosphorus was found statistically significant. Treatment P_3 (75 kgha^{-1} P) resulted in the maximum number of leaves (19.67) followed by P_2 (62.5 kgha^{-1} P) treatment and the minimum number of leaves (13.33) was found at control treatment (Fig. 2). According to Sajjan *et al.* (1991), P increases the quantity of lettuce leaves.

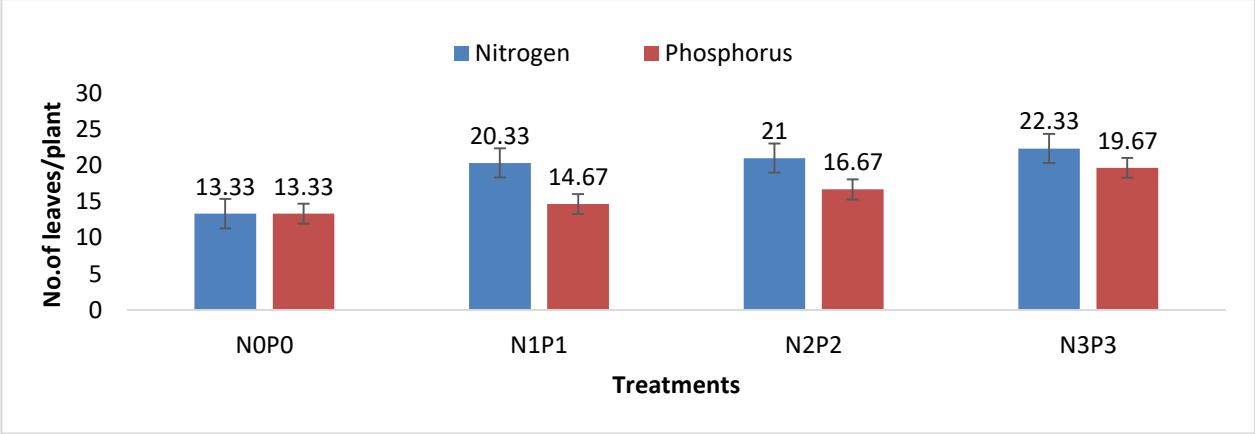

Figure 2. Effect of nitrogen and phosphorus on number of leaves per plant of lettuce

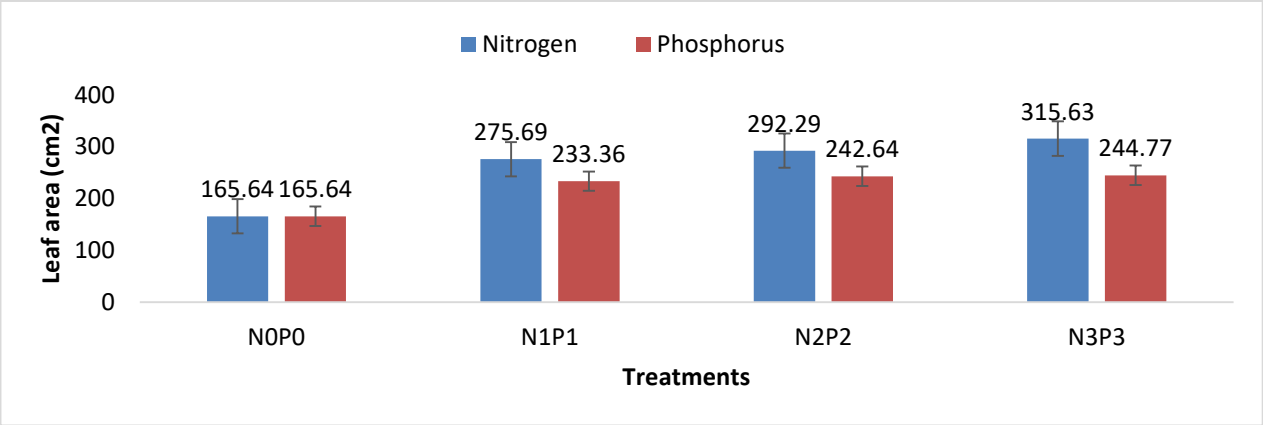

Figure 3. Effect of nitrogen and phosphorus on leaf area of lettuce

Interaction effect of nitrogen and phosphorus on number of leaves plant^{-1} of lettuce

The number of leaves plant^{-1} was significantly influenced by the interaction effect of nitrogen and phosphorus. At final harvest, the plant receiving the treatment N_3P_3 (200 kgha^{-1} N + 75 kgha^{-1} P) produced the highest number of leaves (25.67) and the lowest number of leaves (13.33) was observed from the control (N_0P_0) treatments (Fig. 2). This results in agreement with that of Islam *et al.* (2019) in lettuce production. Islam et al. (2019) found that the maximum (35.23) number of leaves per plant was recorded from the treatment combination of 160 kg N+ 125 kg P ha^{-1} which was statistically similar (33.76 & 33.70) to 210 kg N+ 125 kg P ha^{-1} and 160 kg N+ 100 kg P ha^{-1} while the minimum (20.28) was recorded from the treatment combination of N_0P_0.

Effect of nitrogen on leaf area

The leaf area varied significantly due to the application of different nitrogen levels. The highest leaf area was 315.63 cm² recorded in N_3 treatment (200 kgha^{-1} N) followed by 292.29 cm² leaf area and the lowest leaf area was 165.64 cm² recorded from control treatment (Fig.3). This result is in agreement with that of Islam *et al*. (1998) in Batishak production.

Effect of phosphorus on leaf area

In respect of leaf area significant variation was observed due to different level of phosphorus. Maximum leaf area (244.77 cm²) was obtained from P_3 treatment (75 kgha^{-1} P) and the minimum leaf area was (165.64 cm²) was obtained from treatment from control (Fig.3). Nagata *et al.* (1992) agrees with this finding when application of 0, 25, 50, 100 and 200 kg P ha^{-1} found that increasing rate of P increased leaf area of lettuce.

Interaction effect of nitrogen and phosphorus on leaf area

The highest leaf area was significantly influenced by the interaction effect of nitrogen and phosphorus. The maximum leaf area (373.52 cm²) was found from the treatment combination of (N_3P_3) and the lowest leaf area (165.64 cm²) was observed from the control treatment. Islam *et al.* (2019) also find out the similar results in lettuce production.

Effect of nitrogen on yield plant^{-1} of lettuce

The maximum fresh weight of leaves plant^{-1} was (275.69 g) contributed by N_3 (200 kgha^{-1} N) treatment followed by (266.81 g) yield plant^{-1} at N_2 (150 kgha^{-1} N) treatment and the lowest (121.12 g) yield was found from control treatment (Fig.4). These findings show that nitrogen promotes lettuce growth, resulting in a higher leaf yield plant^{-1} than the control. Hochmuth and Howell (1994) obtained similar results from their experiment.

Effect of phosphorus on yield plant^{-1} of lettuce

Significant difference was varied in leaf yield plant^{-1} due to application of different levels of phosphorus. The maximum yield plant^{-1} (238.15 g) was found at P_3 (75 kgha^{-1} P) treatment, and the minimum yield plant^{-1} (121.12 g) was observed from control treatment (Fig.4). It's likely that the plants produced more glucose through enhanced photosynthesis when phosphorus levels increased which was also claimed by Nimje and Jagdish (1987).

Interaction effect of nitrogen and phosphorus on yield plant^{-1} of lettuce

The interaction effect of nitrogen and phosphorus was significant on fresh weight of leaves plant^{-1}. The highest yield plant^{-1} (322 g) was obtained from N_3P_3 treatment combination, and the lowest yield plant^{-1} (121.12 g) was found in N_0P_0 treatment combination. The possible reason such higher leaf yield is that the uptake of phosphorus involved with enhanced photosynthesis resulting the increasing nitrogen uptake that also promote better yield. Similar result was found by Islam *et al.* (2019).

Effect of nitrogen on gross yield (tha^{-1})

The different level of nitrogen application influenced on the gross yield (tha^{-1}) of lettuce. The yield range of the present study varied from 16.11 tha^{-1} to 21.24 tha^{-1}. The maximum gross yield (21.24 tha^{-1}) was observed from N_3 (200 kgha^{-1} N) treatment followed by 20.7 tha^{-1} from N_2 (150 kgha^{-1} N) treatment and the lowest gross yield (16.11 tha^{-1}) was found from control treatment (Fig. 5). The possible reason for such yield due to increase in the nitrogen level because nitrogen possess the vegetative growth which resulting the better yield. This finding of this experiment is fully agreement with that of Rahim and Siddique (1982).

Effect of phosphorus on gross yield (tha^{-1})

The gross yield of lettuce per hectare was found statistically significant due to application of different levels of phosphorus. The maximum gross yield (20.82 tha^{-1}) was found with application of P_3 (75 kgha^{-1}) treatment, and the lowest gross yield (16.11 tha^{-1}) was obtained from the control treatment (P_0). From the figure 5, it was demonstrated that greater phosphorus application boosted lettuce leaf output. This is an agreement with Wilson (1976), Larion *et al.* (1984) and Wijk (2000) in lettuce production.

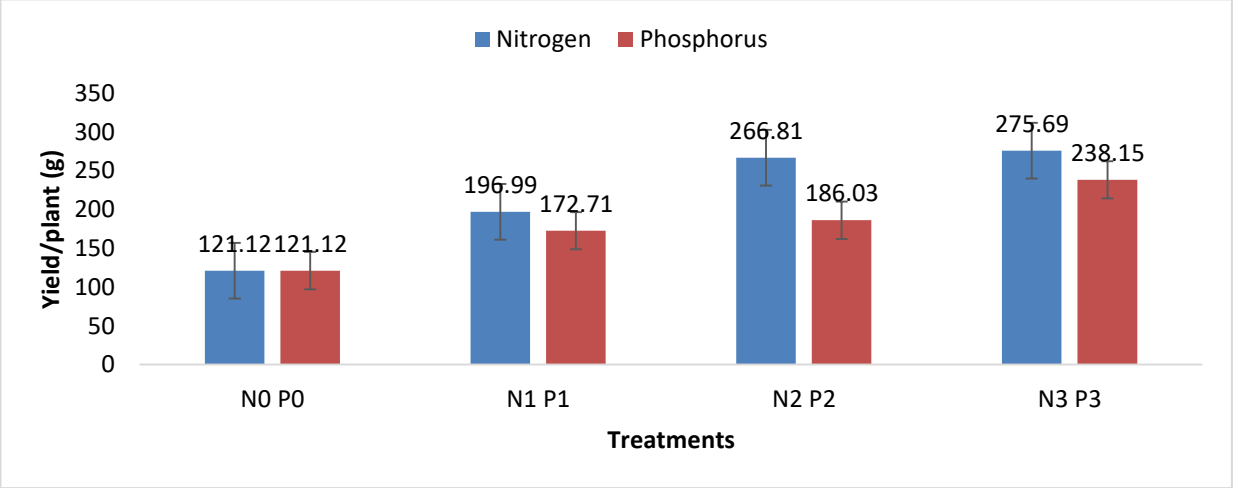

Figure 4. Effect of nitrogen and phosphorus on yield plant^{-1} of lettuce

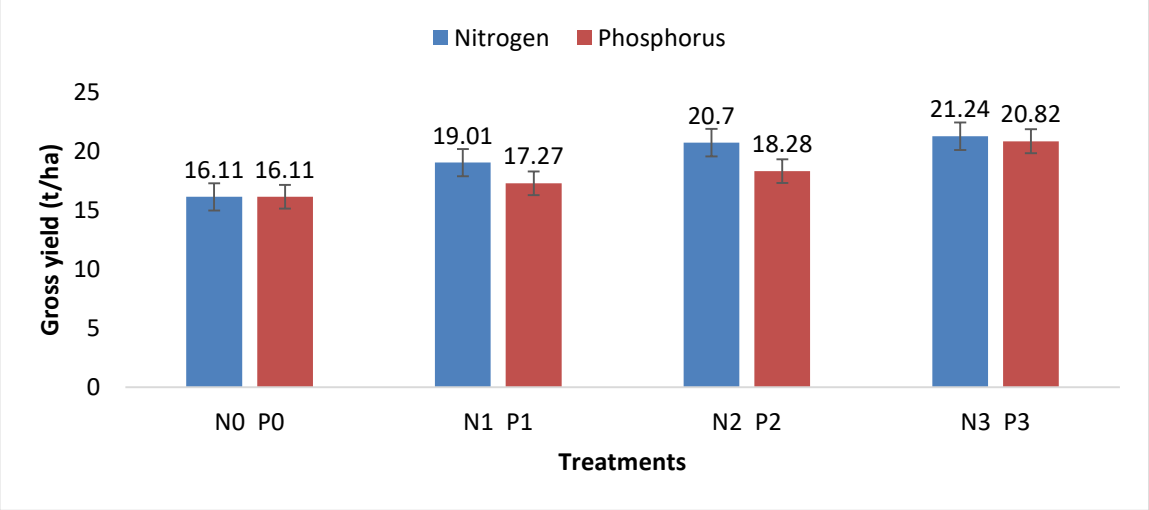

Figure 5. Effect of nitrogen and phosphorus on gross yield of lettuce

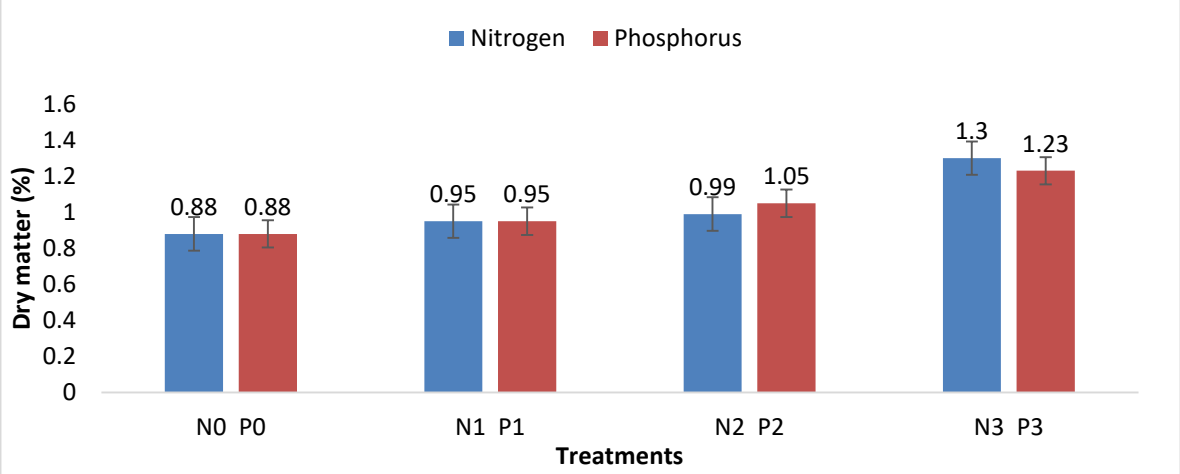

Figure 6. Effect of nitrogen and phosphorus on percentage of dry matter content of lettuce

Interaction effect of nitrogen and phosphorus on gross yield (tha^{-1})

The interaction effect of nitrogen and phosphorus was significant variation on gross yield tha^{-1}. The range of gross yield varied from 16.11 tha^{-1} to 32.2 tha^{-1}. The highest gross yield (32.2 tha^{-1}) obtained from the application of N_3P_3 treatment when the lowest yield (16.112 tha^{-1}) was obtained from N_0P_0 treatment combination. These findings support the result of Sajjan *et al.* (1991) in lettuce production.

Effect of nitrogen on percentage of dry matter content

The dry matter of lettuce leaves was recorded to be the highest (1.3%) where N_3 (200 kgha^{-1} N) treatment was applied and the lowest dry matter (0.88%) of leaf was obtained from the control (N_0) treatment (Fig. 6). The possible reason regarding high dry matter is that proper dose of nitrogen uptake other nutrient in balance condition which accumulated more plant nutrient that gave more dry matter in plant. Tei *et al.* (2000) also reported that increasing the rate of nitrogen fertilizer significantly increased the dry weight of leaves.

Effect of phosphorus on percentage of dry matter content

The maximum dry matter of leaves (1.23%) was found from P_3 (75 kgha^{-1} P) treatment followed by P_2 treatment (1.05%) and the minimum (0.88%) in this respect was found from the control treatment (Fig. 6). Lana *et al.* (2004) reported responses of different P levels observed for dry matter production of aerial parts.

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

Interaction and combined effects were significant in respect of dry matter percentage of lettuce leave. However, the maximum dry matter of lettuce leaves (1.4%) was observed in the treatment combination N_3P_3 treatment, and the minimum dry matter (0.88%) was recorded from the control treatment. Islam *et al.* (2019) was found that the maximum (5.48%) dry matter content plant^{-1} was recorded from N_2P_3 (160 kg N/ha +125 kg Pha^{-1}), which was closely followed with N_2P_2 (160 kg N/ha +100 kg P ha^{-1}), by (5.30%) and N_3P_3 (210 kg N/ha +125 kg Pha^{-1}), by (5.25%), while N_0P_0 (0 kg N ha^{-1} + 0 kg P ha^{-1}) gave the minimum (4.20%) dry matter content.

CONCLUSION

The result of the experiment revealed that the application of N_3P_3 (200 kgha^{-1} N + 75 kgha^{-1} P) treatment gave the highest gross yield (32.2 tha^{-1}) among the tested treatments. From the findings of the study, it is suggested that farmers could cultivate cv. 'Lettuce Tropical' for higher Gross yield with the combined application of 200 kg N ha^{-1} & 75 kg P ha^{-1}.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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