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RESEARCH ARTICLE

INTERACTIVE EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF HYBRID CAPSICUM (*Capsicum annuum L.*) IN ROOF TOP GARDEN

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ABSTRACT

The experiment was conducted at the roof of third floor of Biotechnology department of Sher-e-Bangla Agricultural University, Dhaka during October, 2017 to March, 2018. The two factorial experiments were laid out in Completely Randomized Design (CRD) with three replications. Here, three levels of nitrogen dose N_0: 0 kg N ha^{-1}, N_1: 100 kg N ha^{-1}, N_2: 130 kg N ha^{-1} and three levels of phosphorous dose P_0: 0 kg P_2O_5 ha^{-1}, P_1: 50 kg P_2O_5 ha^{-1}, P_2: 80 kg P_2O_5 ha^{-1} were used in this experiment. Growth and yield contributing parameters significantly influenced by different doses of nitrogen and phosphorus fertilizers. The dose of N_2 treatment gave the highest plant height (87.45 cm) and most of the growth parameters increased with increasing nitrogen levels up to N_2 treatment. The dose of P_2 treatment gave the highest plant height (79.45 cm) and most of the growth parameters increased with increasing phosphorus levels up to P_2 treatment. The treatment combination N_2P_2 gave the highest fruit diameter (4.26 cm), fruit length (11.91 cm), yield of fruits plant^{-1} (200 g), average fruit yield plot^{-1} (0.81 kg), individual fruit weight (0.84 g) and average fruit yield (6.79 ton/ha). Based on the findings, it can be suggested that the combined use of 130 kg N ha^{-1} with 80 kg P_2O_5 ha^{-1} increased plant growth and fruit yield of chili in rooftop garden. It is apparent that growth and yield of *Capsicum annuum* may be increased by using nitrogen and phosphorus fertilizer except loses through leaching or other factors.

KEYWORDS

Chili, Roof top garden, NPK, Organic Fertilizer, Nitrogen, Phosphorus.

1. INTRODUCTION

The present world is called the world of rapid urbanization. United Nations investigation founded that more than 54 percent of the population of the planet is living in urban areas and they expected to increase the population to 70 percent by 2050. In that circumstance, rapid urbanization is placed on high demand for urban food supply and security systems. In that situation, urban agriculture plays a significant role to give a possible solution to reduce the impact of this problem [1].

Bangladesh is a densely populated country in the world where more than 175.50 million people are living and urbanization occurs so rapidly in everywhere in Bangladesh. Dhaka, the capital of Bangladesh is one of the fasted growing megacities and the cultivable land in this area has been covered with high rise buildings. In that case, the agricultural land in this locality decreased at an alarming rate [2]. So, rooftop farming can be a workable solution to minimize the food problems as well as make the urban area much more self-sufficient to produce fresh vegetables more reachable to urban area [3]. A recent survey showed that most of the roofs of Dhaka city are suitable for gardening, which doesn't require major improvement but also needs some modifications [2].

In Bangladesh, Capsicum (*Capsicum annuum L*) is one of the most important vegetable crops in Bangladesh which needs in every cooking process. Due to the practice of Capsicum production on the rooftop garden, Capsicum production will be increased which meets the demand of urban people and also reduce the costs of transport as well as encourage the verities of vegetable production in the urban area. Nitrogen and phosphorus are very important nutrient elements for the growth and development of *Capsicum annuum.* The profit obtained from the use of organic fertilizers has been so often revealed by the experiment that there is no question about the necessity of using the right fertilizers and the economic returns resulting from them. The optimum doses of fertilizer enhance the growth and yield of crops. It also ensures the availability of other essential nutrient elements for the plant. Fertilizer rates increased capsaicin content and color of green and powered pepper. In general, a large amount of nitrogen fertilizers is required for the growth of the leaf and stem of Capsicum [4]. It also plays a vital role as a constituent of protein, nucleic acid, and chlorophyll. Nitrogen progressively increases the marketable yield, but an adequate supply of nitrogen is essential for vegetative growth, and desirable yield [5]. Phosphorus (P) is the second most frequently limiting macronutrients which are required for optimum growth and reproduction. It is involved in several key plant functions, including energy transfer, photosynthesis, the transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next [6]. Due to the lack of soil in an urban area, green roof was constructed with less than 20% organic matter combined with coarse, heat-expanded materials, such as slate or shale. This provides for high permeability and low cation exchange capacity in the soil [7]. For this reason, substrate organic matter breaks down over time. This breakdown of organic matter can result in nutrient leaching. The nutrient loss is higher when the roof ages are gradually increase [8]. In order to maintain rooftop productivity, these lost nutrients must replace. Among all this situation, the application of nitrogen (N) and phosphorus (P) fertilizer in chili production should be judicious. Rooftop farmers should also be especially careful of applying various doses of nitrogen and phosphorus fertilizers will be used and the optimum dose that is beneficial for Capsicum production in rooftop will be identified [9]. Considering the above mentioned facts this experiment will satisfy the following objectives: 1) To find out the optimum dose of nitrogen and phosphorus for growth and maximum yield of *Capsicum annuum* (hybrid) in rooftop garden; 2) To study the combined effect of nitrogen and phosphorus for obtaining a desirable yield of *Capsicum annuum* in rooftop. 3) To compare the production of Capsicum in rooftop garden to field condition.

2. MATERIALS AND METHODS

2.1 Experimental site and land preparation

The experiment was conducted at the roof of the third floor of Biotechnology department of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The duration of the experiment was October, 2017 to March, 2018. The average maximum temperature during the period of experiment was 29.35°C and the average minimum temperature was 15.10°C. The soil of the experimental site was collected from outside of Dhaka city which was sandy clay. The 30 days old hybrid seedling of winter Capsicum were collected from BARI, Joydebpur, Gazipur. The experiment was laid out in Complete Block Design (CRD) having single factors with three replications. An area of 9 m x 4 m was divided into three equal blocks. Each block was consists of 9 plots where 2 treatments were allotted two block. There were 27 unit plots in the experiment. The size of each plot was 1 m x 1 m, which accommodated 4 plants at a spacing 0.3 m x 0.3 m. The distance between two blocks and two plots were kept 0. 5 m and 0.25 m respectively. The doses and application method of fertilizers were given below:

Table 1: Manures and fertilizers application method on Capsicum field

Name of manure and fertilizers	Doses/ha	Application (%)			
		Basal	25 DAT	50 DAT	75 DAT
Cowdung	10 ton	100	-	-	-
Urea (N_1)	110 kg	50	16.67	16.67	16.67
Urea (N_2)	130 kg	65	16.67	16.67	16.67
TSP (P_1)	50kg	100	-	-	-
TSP (P_2)	80 kg	100	-	-	-

2.2 Collection of Data

Four plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment. The data on pant height, number of leaves per plant, leaf length of plant, leaf breadth of plant, number of branches per plant, length of fruit, diameter of fruit, length of pedicel, individual fruit weight, yield of fruits per plant, yield of fruits per plot and yield of fruits per hectare were recorded.

$$\text{Fruit yield (ton) per hectare} = \frac{\text{Fruit yield per plot (kg) x 10000(m}^2\text{)}}{\text{Area of plot in square meter (m}^2\text{) x1000(kg)}}$$

2.3 Statistical analysis

The data obtained from different yield components and yields were statistically analyzed for analysis of variance using the MSTAT-C statistical package program to find out the significance of the difference among the treatments and their combinations. The analysis was performed by F-variance test, and the significance of the difference between pairs of treatment means was evaluated by the DMRT test at 5% and 1% levels of probability.

3. RESULTS AND DISCUSSION

3.1 Effect of nitrogen and phosphorus on morphological parameters of Capsicum

The plant height of Capsicum was statistically significant with various levels (30, 45, 60 and 75 DAT) of nitrogen (Table 2). The result revealed that at 30 DAT the tallest plant was recorded from N_2 (44.80 cm) which was statistically similar with N_1 (37.33 cm) whereas the shortest plant height was found from N_0 (23.09). At 45 DAT the highest plant height (59.91 cm) was observed from the N_2 treatment which was statistically similar to N_1 (50.11 cm) whereas, the lowest (37.33 cm) was observed in N_0 treatment. At 65 DAT the highest plant height (74.44 cm) was observed from the N_2 treatment which was statistically similar to N_1 (67.14 cm) whereas, the lowest (50.95 cm) was observed from N_0 treatment. At 75 DAT the highest plant height (87.45 cm) was observed from the N_2 treatment which was statistically similar with N_1 (82.31 cm) whereas, the lowest (55.78 cm) was observed from N_0 treatment. It was revealed that increased plant height up to a certain level then decreases due to increasing the nitrogen fertilizer. The result was similar to that of [10-11]. They observed an improvement in plant height with increasing nitrogen applications. The plant height of Capsicum was statistically significant with various levels (30, 45, 60 and 75 DAT) of phosphorus (Table 2). The result revealed that at 30 DAT the tallest plant was recorded from P_2 (37.24 cm) which was statistically similar with P_1 (35.59 cm) whereas the shortest plant height was found from P_0 (32.39 cm). At 45 DAT the highest plant height (52.66 cm) was observed from the P_2 treatment which was statistically similar to P_1 (49.65 cm) whereas, the lowest (45.69 cm) was observed in P_0 treatment. At 65 DAT the highest plant height (67 cm) was observed from the P_1 treatment which was statistically similar to P_2 (64.26 cm) whereas, the lowest (61.26 cm) was observed from P_0 treatment. At 75 DAT the highest plant height (79.45 cm) was observed from the P_2 treatment which was statistically similar with P_1 (75.02 cm) whereas the lowest (71.08 cm) was observed from P_0 treatment. It was revealed that increased plant height up to a certain level then decreases due to increasing the nitrogen fertilizer. It revealed that with the increase of application of phosphorus, plant height showed an increasing trend, but after a certain level plant height increases very slowly. The combined effect of different levels of nitrogen and phosphorus showed a significant variation on plant height of Capsicum at 30, 45, 60 and 75 DAT (Table 3). At 30 DAT the tallest plant (47.57 cm) was observed from N_2P_2 which was statistically similar to N_2P_1 (44.903 cm) whereas the shortest plant was recorded from N_0P_0 (20.667 cm). At 45 DAT the tallest plant (64.02 cm) was observed from N_2P_2 whereas the shortest plant was recorded from N_0P_0 (34.55 cm). At 60 DAT the tallest plant was observed from N_2P_2 (77.04 cm) which was statistically similar with N_2P_1 (73.73 cm) whereas the shortest plant was recorded from N0P0 (48.38 cm) which was statistically similar to N_0P_1 (50.41 cm), N_0P_2 (54.07cm. At 75 DAT the tallest plant was observed from N_2P_2 (92.90 cm) which was statistically similar to N_2P_1 (86.82 cm), N_1P_2 (85.82 cm), N_1P_1 (82.8 cm), N_1P_2 (82.64 cm), N_1P_0 (78.30 cm) whereas the shortest plant was recorded from N_0P_0 (52.29 cm) which was statistically similar to N_0P_1 (55.44 cm), N_0P_2 (59.63 cm. Similar results were found by [31]. They stated that among the various N and P combinations, 120 kg N + 60 kg P ha-1 recorded the greatest plant height (64.83 cm) were also found similar results [12].

Nitrogen fertilizer doses showed a significant effect on the number of leaves per plant of Capsicum at 30, 45, 60 and 75 DAT (Table 4). At 30 DAT the highest number of leaves per plant (67.00) was observed from the N_2 treatment which was statistically similar to N_1 (54.67) whereas the lowest (42.11) was observed from N_0 treatment. At 45 DAT the highest number of leaves per plant (103.11) was observed from the N_2 treatment whereas the lowest (54.89) was observed from N_0 treatment. At 60 DAT the highest number of leaves per plant was observed from the N_2 (144.000) treatment whereas the lowest was observed from N_0 (84.333) treatment. At 75 DAT the highest number of leaves per plant was observed from the N_2 (182.44) treatment which was statistically similar to N_1 (167.22) whereas the lowest was observed from N_0 (84.33) treatment. As data showed, nitrogen fertilization increased leaf number which was in agreement with findings of [13-14]. The number of leaves per plant of Capsicum varied significantly for different levels (30, 45, 65 and 80 DAT) of phosphorus (Table 4). At 30 DAT the highest number of leaves (58.44) was recorded in P_2 which was statistically identical P_1 (54.44) whereas the lowest number of leaves was recorded from P_0 (50.89). At 45 DAT the highest number of leaves (87.00) was recorded in P_2 which was statistically similar to P_1 (83.44) whereas the lowest number of leaves was recorded from P_0 (79.89). At 60 DAT the highest number of leaves was recorded in P_1 (129.000) whereas the lowest number of leaves was recorded from P_0 (86.000). At 75 DAT the highest number of leaves (164.78) was recorded in P_2 whereas the lowest number of leaves was recorded from P_0 (157.44). The results showed a significant variation in the number of leaves per plant with increasing phosphorus in P_1 treatment up to P_2 treatment. The significant combined effect between nitrogen and phosphorus on number of leaves was observed of Capsicum at 30, 45, 60 and 75 DAT (Table 5). At 30 DAT N_2P_2 showed the maximum (70.33) number of leaves which was statistically similar to N_2P_1 (66.67), N_2P_0 (64.00), N_1P_2 (59.67) while N_0P_0 condition showed the minimum (39.00) number of leaves which was statistically similar to N_0P_1 (42.00). At 45 DAT N_2P_2 showed the maximum (106.33) number of leaves while N_0P_0 condition showed the minimum (51.33) number of leaves which was statistically similar to N_0P_1 (55.00). At 60 DAT the maximum (153.67) number of leaves observed in N_2P_2 while N0P0 condition showed the minimum (86.89) number of leaves. At 75 DAT N_2P_2 showed the maximum (187.67) number of leaves while N_0P_0 condition showed the minimum (131.00) number of leaves which was statistically similar to N_0P_1 (136.33) and N_0P_3 (136.33). The results showed significant variation in the interaction of nitrogen and phosphorus treatments. These results agree with Manchanda and Singh (1988). They concluded that number of the leaf per plant increased with increase fertilizer dose of NP.

Leaf length of Capsicum was statistically influenced by different levels of nitrogen (Table 6). The longest length of leaf (11.80 cm) was observed from N_2 while the shortest length of leaf (10.457 cm) was found from N_0 or control treatment. The increase in leaf area brought by the N supply causing expansion of individual leaves has also been reported, because N stimulated the cell division and cell expansion [15-16]. Length of the leaf of Capsicum varied significantly for different levels of phosphorus (Table 6). The longest length of leaf (11.667 cm) was observed from P_2 which was statistically identical to P3 (11.00 cm) whereas the shortest length of the leaf was recorded from P_0 (9.63 cm) or control condition. The beneficial effect of phosphorus on the leaf length has been reported by a research in cowpea in groundnut [17-18]. Significant influence was observed on leaf length of Capsicum due to the different doses of nitrogen and phosphorus (Table 7). The longest leaf length (11.913 cm) was obtained from N_2P_2 similar to N_2P_1, N_2P_0, and N_1P_1. In contrast to the lowest leaf length (9.55 cm) was observed from N_0P_0 or control condition.

Leaf breadth of Capsicum was statistically influenced by different doses of nitrogen (Table 6). The highest leaf breadth (3.87 cm) was observed from N_2 which was statistically identical to N_1 (3.52 cm) while the shortest leaf breadth (3.00 cm) was found from N_0 or control condition. A critical observation of the data indicated that leaf breadth increased with increasing levels of nitrogen up to 100 kg/ha and then a decreasing trend was observed with an increase in nitrogen levels [19]. The breadth of the leaf of Capsicum varied significantly for different levels of phosphorus (Table 6). The highest leaf breadth (3.56 cm) was observed from P_2 which was statistically identical to P_1 (3.39 cm) whereas the shortest length of the leaf was recorded from P_0 (3.26 cm) or control condition. They reported that a linear increase was observed on leaf breadth with the increasing application of phosphorus up to 180 kg/ha [20]. Significant influence was observed on leaf length of Capsicum due to the different doses of nitrogen and phosphorus (Table 7). The longest leaf length (4.26 cm) was obtained from N_2P_2 which was statistically identical to N_2P_1 (3.76 cm) & N_2P_0 (3.59 cm). In contrast to the lowest leaf length (2.95 cm) was observed from N_0P_0 or control condition.

The number of branches of Capsicum varied significantly for different levels of nitrogen (Table 6). The maximum number of branches (15.00) was observed from N_2 and the minimum number of branches was recorded from N_0 (7.00) or control condition. Nitrogen has a significant effect on number of branches per plant as it activates vegetative growth [21]. They concluded that branches per plant increase with the increasing nitrogen rate. The number of branches of Capsicum was statistically influenced by different doses of phosphorus (Table 6). The maximum number of branches was observed from P_2 (12.22) which was statistically similar to P_1 (11.11) while the minimum number of branches was found from P_0 (8.45) or control condition. Phosphorus had a significant effect on number of branches per plant and increased with the increasing of phosphorus rate. A similar result was found [22]. Significant influence was observed on the number of branches of Capsicum due to the different doses of nitrogen and phosphorus (Table 7). The maximum number of branches (16.33) was obtained from N_2P_2 which was statistically identical to N_2P_1 (14.67). In contrast to the minimum number of branches (6.00) was observed from N_0P_0 or control condition which was statistically identical to N_0P_1 (7.00). These results showed that a higher dose of nitrogen and phosphorus was influential nutrients for the number of branches per plant at the final harvesting stage.

3.2 Effect of nitrogen and phosphorus on yield contributing character of Capsicum

Significant variation was observed among the different treatments due to different doses of nitrogen in respect of the average fruit length of Capsicum (Table 8). Fruit length was recorded 3.972 cm, 4.326 cm, 4.827 cm in N_0, N_1 and N_2 treatments respectively. Maximum (4.827 cm) fruit length was found in N_2 treatment which was statistically similar to N_1 (4.326 cm) treatment whereas minimum fruit length was recorded from N_0 (3.972 cm) or control treatment. The results are to some extent in agreement with who observed an improvement in fruit size with increasing nitrogen application [11]. Significant variation was found among the different treatments due to different doses of phosphorus in respect of fruit length of Capsicum (Table 8). The average fruit length was recorded 4.457 cm, 4.392 cm, and 3.776 cm in P_2, P_1, and P_0 treatments respectively. However, maximum (4.457 cm) fruit length was found in P_2 treatment whereas minimum fruit length was recorded in P_0 (3.776 cm). The combined effect of nitrogen and phosphorus doses showed a significant variation on the fruit diameter of Capsicum (Table 9). Maximum (4.99 cm) fruit length was recorded in N_2P_2 treatment whereas minimum (3.893 cm) fruit length was recorded in N0P0 or control treatment. These results are similar to that of [11,23]. A study obtained the highest yield due to an improvement in fruit size in response to 80 kg N and 90 kg P [11].

Significant variation was observed among the different treatments due to different doses of nitrogen in respect of the average fruit diameter of Capsicum (Table 8). Fruit diameter was recorded 0.81, 0.70 and 0.67 cm in N_2, N_1, and N_0 treatments respectively. Maximum (0.81 cm) fruit diameter was found in N_2 treatment which was statistically similar to N_1 (0.70 cm) treatment whereas minimum fruit diameter was recorded in N_0 (0.67 cm) or control treatment. A research documented a similar report on the fruit diameter of Capsicum. According to the length and diameter of fruits and nos. fruits per plant increased significantly with increasing nitrogen dose at N_2 treatment (110 kg N ha^{-1}). A significant variation was found in the fruit diameter due to the effect of different levels of phosphorus in Capsicum (Table 8). Fruit diameter was recorded 0.69, 0.73 and 0.76 cm in P_0, P_1, and P_2 treatments respectively. Maximum (0.75 cm) fruit diameter was found in P_2 treatment which was statistically similar to P_1 (0.73 cm) whereas minimum fruit diameter was recorded in P_0 (0.69 cm) or control treatment. The combined effect of nitrogen and phosphorus doses showed a significant variation on fruit diameter of Capsicum (Table 9). Maximum (0.84 cm) fruit diameter was recorded in N_2P_2 treatment whereas minimum (0.66 cm) fruit diameter was recorded in N_0P_0.

There was a significant variation in single fruit weight among different doses of nitrogen treatments (Table 10). Individual fruit weight was recorded 1.270 gm, 1.714 gm and 1.912 gm in N_0, N_1, and N_2 treatments respectively. The highest individual fruit weight (1.912 gm) was found in N_2 treatment whereas the lowest individual fruit weight was found in N_0 (1.27 gm) or control treatment. The result showed an increase in nitrogen levels increases the fruit weight. The results were also similar to who also reported that increasing the rate of nitrogen fertilizers increases the average fruit weight and volume of pepper [24]. This result is also in agreement with. There was a significant variation in single fruit weight among different doses of phosphorus treatments (Table 10). Individual fruit weight was recorded 1.384, 1.62 and 1.692 gm in P_0, P_1, and P_2 treatments respectively. The highest individual fruit weight (1.692 gm) was found in P_2 treatment whereas the lowest single fruit weight was found in P_0 (1.384 gm) or control treatment. The combined effect of nitrogen and phosphorus doses showed a significant variation on single fruit weight (Table 11). The highest single fruit weight (2.02) was found in N_2P_2 treatment whereas the lowest single fruit weight was found in N_0P_0 (1.24) or control treatment.

There was a significant variation on the number of fruits per plant among different treatments (Table 10). The highest number of fruits per plant was found in N_2 (195.33) treatment whereas the lowest number of fruits per plant was found in N_0 (114.22) or control treatment. It was revealed that at optimum level nitrogen fertilizer gave the highest yield $plant^{-1}$ and increase nitrogen fertilization delayed flowering. A study found that flowering was delayed with an increase in nitrogen fertilization due to the diversion of photosynthetic for vegetative growth of the plant [25]. Also found similar results. Significant variation was found among the different treatments due to different doses of phosphorus in respect of the number of fruits per plant (Table 16) [26]. The highest number of fruits per plant was found in P_2 (164.78) treatment whereas the lowest number of fruits per plant was found in P_0 (136.89) or control treatment. An increase in fruits increasing per plant with the increasing levels of phosphorus and the maximum number being at P_2 levels in pea [27]. The combined effect of nitrogen and phosphorus doses showed a significant variation on number of fruits per plant (Table 11). The highest number of fruits per plant (200.00) was found in N_2P_2 treatment whereas the lowest (111.00) number of fruit per plant was found in N_0P_0. The high yield will obtain due to high nitrogen and phosphorus rate. These results agree with the findings who obtained the maximum fruits per plant at a higher rate of nitrogen and phosphorus [21].

The yield of green fresh fruit of Capsicum was recorded 0.458, 0.698 and 0.786 kg/plot in N_0, N_1, and N_2 treatments respectively (Table 10). Maximum (0.786 kg/plot) yield was obtained in N_2 treatment and a minimum (0.458 kg/plot) was found in N_0 treatment or control treatment. N fertilization significantly increased fruit number, yield per plant and total yield comparing to control, which were in agreement with reported that nitrogen application @ 100 kg ha-1 significantly increased brinjal yield [28-30]. Likewise, also observed the same results in pea. The yield of fruits of Capsicum was recorded 0.440, 0.647 and 0.665 kg/plot in P_0, P_1, and P_2 treatments respectively (Table 10) [26] [1]. Maximum (0.665 kg/plot) yield was obtained in P_2 treatment and a minimum (0.44 kg/plot) was found in P_0 treatment or control treatment. Significant influence was observed on the yield of Capsicum per plot due to the different doses of nitrogen and phosphorus (Table 11). The maximum yield of 0.807 kg/plot was obtained from N_2P_2. In contrast to the minimum (0.328 kg/plot) was observed from N_0P_0 or control condition. The result was similar to that of [11,23]. Obtained the highest yield due to an improvement in fruit size in response to 100 kg N, 80 kg P (N_2P_2). It means that the recommended fertilization may affect the fruit size and other growth parameters as well [11].

The yield of green fresh fruit of Capsicum was recorded 3.82, 5.82 and 6.57 ton/ha in N_0, N_1 and N_2 treatments respectively (Table 10). A maximum (6.57 ton/ha) yield was obtained in N_2 treatment and a minimum (3.82

ton/ha) was found in N_0 treatment or control treatment. Nitrogen fertilization improved plant growth but did not influence fruiting time. Reported that nitrogen application @ 110-130 kg ha-1 significantly increased brinjal yield [30]. In pea, also found the same results [27]. The yield of fruits of Capsicum was recorded 4.25, 5.39 and 5.56 ton/ha in P_0, P_1 and P_2 treatments respectively (Table 10). A maximum (5.564 ton/ha) yield was obtained in P_3 treatment and a minimum (4.25 ton/ha) was found in P_0 treatment or control treatment. Significant influence was observed on the yield of Capsicum per plot due to the different doses of nitrogen and phosphorus (Table 11). The maximum yield of 6.79 tons/ha was obtained from N_2P_2. In contrast to the minimum (2.67 ton/ha) was observed from N_0P_0 or control condition. These results are in accordance with the findings of who assessed the growth and yield performance of hot pepper varieties to various doses of nitrogen and phosphorous [31]. Reported that different doses of nitrogen and phosphorus behaved significantly different for total yield [32]. Besides the sun beating down on the roof, there is ambient heat being reflected from the roof surface, surrounding buildings, streetcars and metal exhaust and utility structures [33]. The higher temperature greatly reduced the yield of Capsicum because of the lack of moisture content in the soil. But in agricultural field condition, the frequent irrigation facilitate to maintain the moisture content as well as maintain the soil temperature which increases the yield performance of Capsicum.

3.3 Comparison of total yield of chili in rooftop garden to agricultural field

Capsicum annuum, an important spice and vegetable crop of Bangladesh is widely grown both in winter and summer seasons. The area under chili cultivation was 93.55 thousand hectares producing about 102.25 thousand tons in the year 2015-16 (BBS 2015). In field condition, average yield should be gained around 10-12 ton/ha and the average plant height is around 75-85 cm (Krishi Projockti Hathboi-7th edition-2017). But in the rooftop garden, the highest yield obtained from N_2P_2 treatment which is 6.787 tons/ha and the lower production obtained from N_0P_0 treatment which is around 2.67 tons/ha. Average highest soil temperature (32.98 ^{0} C) was recorded from N_0P_0 treatment which create negative effect on chili production. The lowest soil temperature was recorded from N_2P_1 treatment (27.12 ^{0} C) which increase chili yield. The highest moisture was recorded 34.44 N_2P_0 and the lowest moisture was recorded 28.09 % in N_0P_0 (control) treatment. The highest light intensity was observed (34.59 flux) from N_1P_2 treatment whereas the lowest light intensity was recorded (30.79 flux) from N_0P_1 treatment. Due to the lack of soil moisture and light availability the yield of chili in roof top garden were lower than field condition. Temperature also play a significant role in rooftop farming. In roof top garden, the temperature always higher than normal field condition which greatly influence on morphology and yield of chili. Wind can whip down straight urban streets, especially on high-rises. That's why flower and fruit dropped at a high extent than normal field conditions and the fruit number greatly reduced by the interaction of high wind.

Table 2: The effect of different levels of nitrogen and phosphorous on plant height of Capsicum

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
Levels of Nitrogen				
N_0	23.091 c	37.977 c	50.953 b	55.784 b
N_1	37.329 b	50.113 b	67.140 a	82.309 a
N_2	44.798 a	59.906 a	74.439 a	87.454 a
Levels of Phosphorus				
P_0	32.393 b	45.686 b	61.263 b	71.077 b
P_1	35.589 ab	49.653 ab	64.269 a	75.021 ab
P_2	37.236 a	52.657 a	67.000 a	79.450 a
LSD (0.01)	6.040	5.857	7.477	7.589
CV%	7.22%	4.98%	4.89%	4.23%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 3: The combined effect of different levels of nitrogen and phosphorous on plant height of Capsicum

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
N_0P_0	20.667 ^{g}	34.550 ^{g}	48.380 ^{f}	52.287 ^{e}
N_0P_1	24.830 ^{f}	38.453 ^{f}	50.410 ^{ef}	55.440 ^{de}
N_0P_2	23.777 ^{fg}	40.927 ^{f}	54.070 ^{e}	59.627 ^{d}
N_1P_0	34.597 ^{e}	46.437 ^{e}	62.863 ^{d}	78.303 ^{c}
N_1P_1	37.033 ^{de}	50.877 ^{d}	68.663 ^{c}	82.803 ^{bc}
N_1P_2	40.357 ^{cd}	53.027 ^{cd}	69.893 ^{bc}	85.820 ^{b}
N_2P_0	41.917 ^{bc}	56.070 ^{c}	72.547 ^{abc}	82.640 ^{bc}
N_2P_1	44.903 ^{ab}	59.630 ^{b}	73.733 ^{ab}	86.820 ^{b}
N_2P_2	47.573 ^{a}	64.017 ^{a}	77.037 ^{a}	92.903 ^{a}
LSD (0.01)	3.487	3.382	4.317	4.381
CV%	7.22%	4.98%	4.89%	4.23%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 4: The effect of different levels of nitrogen and phosphorous on number of leaves plant-1 of Capsicum

Treatment	Number of Leaves Plant-1			
	30 DAT	45 DAT	60 DAT	75 DAT
Levels of Nitrogen				
N_0	42.111 c	54.889 c	84.333 c	135.444 c
N_1	54.667 b	92.333 b	129.667 b	167.222 b
N_2	67.000 a	103.111 a	144.000 a	182.444 a
Levels of Phosphorus				
P_0	50.889 c	79.889 b	86.000 b	157.444 a
P_1	54.444 b	83.444 ab	129.000 ab	162.889 a
P_2	58.444 a	87.000 a	121.333 a	164.778 a
LSD (0.01)	3.273	4.811	5.172	9.307
CV%	2.51%	2.42%	1.75%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 5: The combined effect of different levels of nitrogen and phosphorous on number of leaves plant-1 of Capsicum

Treatment	Plant Height (cm)			
	30 DAT	45 DAT	60 DAT	75 DAT
N_0P_0	39.000 i	51.333 i	86.889 i	131.000 e
N_0P_1	42.000 h	55.000 h	87.000 h	136.333 de
N_0P_2	45.333 g	58.333 g	90.333 g	139.000 d
N_1P_0	49.667 f	88.333 f	131.000 f	165.000 c
N_1P_1	54.667 e	92.333 e	135.333 e	169.000 c
N_1P_2	59.667 d	96.333 d	140.333 d	167.667 c
N_2P_0	64.000 c	100.000 c	143.667 c	176.333 b
N_2P_1	66.667 b	103.000 b	149.000 b	183.333 a
N_2P_2	70.333 a	106.333 a	153.667 a	187.667 a
LSD (0.01)	1.890	2.777	2.986	5.373
CV%	2.51%	2.42%	1.75%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 6: The effect of different levels of nitrogen and phosphorous on morphological parameters of Capsicum

Treatment	Leaf Length (cm)	Leaf Breadth (cm)	Number of Branches Plant^{-1} (cm)
Levels of Nitrogen			
N_0	9.662 b	3.000 b	7.000 c
N_1	11.663 a	3.322 b	11.222 b
N_2	11.540 a	3.871 a	15.000 a
Levels of Phosphorus			
P_0	10.896 a	3.260 a	9.889 a
P_1	10.880 a	3.394 a	11.111 a
P_2	11.090 a	3.562 a	12.222 a
LSD (0.01)	1.232	0.328	2.508
CV%	4.72%	4.09%	9.50%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 7: The combined effect of different levels of nitrogen and phosphorous on morphological parameters of Capsicum

Treatment	Leaf Length (cm)	Leaf Breadth (cm)	Number of Branches Plant^{-1} (cm)
N_0P_0	9.550 b	2.953 f	6.000 g
N_0P_1	9.750 b	3.143 ef	7.000 fg
N_0P_2	9.687 b	2.973 f	8.000 f
N_1P_0	11.777 a	3.233 e	10.000 e
N_1P_1	11.543 a	3.280 de	11.333 de
N_1P_2	11.670 a	3.453 cd	12.333 cd
N_2P_0	11.360 a	3.593 bc	13.667 bc
N_2P_1	11.347 a	3.760 b	15.000 ab
N_2P_2	11.913 a	4.260 a	16.333 a
LSD (0.01)	0.7115	0.1898	1.448
CV%	4.72%	4.09%	9.50%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 8: The effect of different levels of nitrogen and phosphorous on yield contributing parameters of Capsicum

Treatment	Fruit Length (cm)	Fruit Diameter (cm)
Levels of Nitrogen		
N_0	3.972 c	0.673 b
N_1	4.326 b	0.697 b
N_2	4.827 a	0.812 a
Levels of Phosphorus		
P_0	4.276 a	0.706 a
P_1	4.392 a	0.726 a
P_2	4.457 a	0.751 a
LSD (0.01)	0.2719	0.07541
CV%	2.62%	5.65%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 9: The combined effect of different levels of nitrogen and phosphorous on yield contributing parameters of Capsicum

Treatment	Fruit Length (cm)	Fruit Diameter (cm)
N_0P_0	3.893 e	0.657 d
N_0P_1	4.057 e	0.663 d
N_0P_2	3.967 e	0.700 cd
N_1P_0	4.223 d	0.673 cd
N_1P_1	4.340 cd	0.703 cd
N_1P_2	4.413 c	0.713 c
N_2P_0	4.710 b	0.787 b
N_2P_1	4.780 b	0.810 ab
N_2P_2	4.990 a	0.840 a
LSD (0.01)	0.1570	0.04354
CV%	2.62%	5.29%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 10: The effect of different levels of nitrogen and phosphorous on yield contributing parameters of Capsicum

Treatment	Individual Fruit Weight (g)	Yield Plant^{-1} (gm)	Yield Plot^{-1} (kg)	Yield ha^{-1} (ton)
Levels of Nitrogen				
N_0	1.270 c	114.222 c	0.458 c	3.818 c
N_1	1.714 b	172.667 b	0.698 b	5.820 b
N_2	1.912 a	195.333 a	0.786 a	6.571 a
Levels of Phosphorus				
P_0	1.584 b	156.889 b	0.630 b	5.250 b
P_1	1.620 a	160.556 ab	0.647 ab	5.394 ab
P_2	1.692 a	164.778 a	0.665 a	5.564 a
LSD (0.01)	0.1306	4.985	0.1847	
CV%	3.28%	2.41%	2.41%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 11: The combined effect of different levels of nitrogen and phosphorous on yield contributing parameters of Capsicum

Treatment	Individual Fruit Weight (g)	Yield Plant^{-1} (gm)	Yield Plot^{-1} (kg)	Yield ha^{-1} (ton)
N_0P_0	1.240 e	111.000 h	0.328 h	2.667 h
N_0P_1	1.267 e	114.333 g	0.450 g	3.833 g
N_0P_2	1.303 e	117.333 f	0.473 f	4.025 f
N_1P_0	1.670 d	168.000 e	0.680 e	5.667 e
N_1P_1	1.720 cd	173.000 d	0.700 d	5.840 d
N_1P_2	1.753 c	177.000 c	0.714 c	5.953 c
N_2P_0	1.843 b	191.667 b	0.770 b	6.417 b
N_2P_1	1.873 b	194.333 b	0.780 b	6.510 b
N_2P_2	2.020 a	200.000 a	0.807 a	6.787 a
LSD (0.01)	0.07541	2.878	2.878	2.878
CV%	3.28%	2.41%	2.41%	2.41%

Here, N_0: 0 kg N ha^{-1} (control); N_1: 100 kg N ha^{-1}; N_2: 130 kg N ha^{-1}

P_0: 0 kg P_2O_5 ha^{-1} (control); P_1: 50 kg P_2O_5 ha^{-1}; P_2: 80 kg P_2O_5 ha^{-1}

Table 12: Comparison of the morphological feature and yield of chili in agricultural field to the rooftop for *Capsicum*

Feature	Agricultural field	Rooftop garden
1. Plant height (cm)	70-80	55-92
2. Number of branch-1 plant	15-20	10-12
3. Number of fruit per plant	300-400	150-200
4. Yield (ton)	8-10	5-7

Source: Krishi Projockti Hathboi-7th edition-2017

4. CONCLUSION

Considering the above-mentioned results, it may be concluded that, different doses of nitrogen and phosphorus varied significantly for the growth and yield of Capsicum. The yield components and yield of Capsicum were positively influenced by the application of nitrogen and phosphorus on the rooftop garden. It was revealed that the application of 130 kg N ha^{-1} along with 80 kg P_2O_5 ha^{-1}(N_2P_2) produces maximum yield and yield contributing characters of Capsicum in the rooftop garden. It can be suggested that growth and yield of Capsicum may be increased by using nitrogen and phosphorus which create a favourable climatic condition in the soil environment at the rooftop garden.

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