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Regular Article

Nitrogen and Phosphorus Efficiency on the Fruit Size and Yield of *Capsicum*

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ABSTRACT: A field experiment was conducted to study the effects of nitrogen and phosphorus on the fruit size and yield of *Capsicum*. The treatments comprised 4 levels of N (0, 50, 100 & 150 kg ha^{-1}) and 3 levels of P (0, 30 & 60 kg ha^{-1}). Length and breadth of fruit and number of fruits per plant increased significantly with increasing nitrogen doses up to 100 kg N ha^{-1}. However, average weight of fruit content increased significantly up to 150 kg N ha^{-1}. On the other hand, average weight of fruit and yield increased significantly with increasing levels of P up to the treatment 30 kg P ha^{-1}, whereas length of fruit and number fruits per plant was increased significantly up to the 60 kg P ha^{-1}. Considering the combined effect of nitrogen and phosphorus, the maximum significant length of *Capsicum*, breadth of *Capsicum*, number of fruits per plant and, average weight of fruit as well as yield were found in the treatment combination of 150 kg N and 30 kg P ha^{-1}.

Key words: Sweet pepper, Fruit bearing, Nitrogen, Phosphorus, Yield

Introduction

Sweet pepper botanically referred to as the genus *Capsicum* is the member of *Solanaceae* family. The genus *Capsicum* consists of about 20 species and only four species are under cultivation (Farris, 1988). Sweet pepper is relatively non-pungent or less pungent with thick flesh and it is the world second most important vegetables after tomato (AVRDC, 1989). It may be used as cooked or raw salad. The leaves are also consumed as salad, soups or eaten with rice (Lovelook, 1973). It was also discovered to be a good source of medicinal preparation for black vomit, tome for gout and paralysis (Knott and Deanon, 1967). Sweet pepper has little energy value but the nutritive value of sweet pepper is high especially for vitamin A and vitamin C.

Fertilizer is one of the major factors of crop production. Among the factors, nitrogen is very much essential for good plant establishment and expected growth (Uddin and Khalequzzaman, 2003). Use of inorganic and organic fertilizers has amused a great significance in recent years in vegetables production, for two reasons. Firstly, the need for continued increase production and per hectare yield of vegetables requires the increase amount of nutrients. Secondly, the results of a large number of experiments on inorganic and organic fertilizers conducted in several countries reveal that inorganic fertilizer alone cannot sustain the productivity of soils under highly intensive cropping systems (Singh and Jain, 2004).

Optimum dose of fertilizers increase the proper growth, development and maximize the yield of sweet pepper. Slow release fertilizers also hold great promise for the production of solanaceous vegetables such as eggplant and tomato (Gezerel and Donmez, 1988). They found that slow-release fertilizers produce 92 t ha^{-1} of tomato, compared to only 42 t ha^{-1} when ordinary commercial fertilizers are used. Many researchers of different countries of the world have been attempting for commercial cultivation of sweet pepper under various cultural aspects. Fertilizer rate influenced quantity and quality of *capsicum*. Fertilizer rates influenced capsaicin content and colour of powdered pepper (Yodpetch, 1997).

Therefore, the present investigation was undertaken to study the effect of nitrogen and phosphorus and their combined effect on the fruit size, number of fruits per plant and yield of sweet pepper.

Materials and Methods

Experimental site

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka ($23^0 77'$ N latitude and $90^0 3'$ E longitude) during November 2009 to March 2010. The General soil type of the experimental field is Deep Red Brown Terrace Soil. Topsoil is silty clay loam in texture. Organic matter content is very low (0.89%) and soil pH is 5 .8. The land is above flood level and well drained. The experimental area has sub-tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site was 2152 mm and potential evapotranspiration was 1297 mm. The average maximum temperature was 30.34^0C and average minimum temperature was 21.21^0C. The average mean temperature was 25.17^0C. The experiment was done during the Rabi season. Temperature during the cropping period ranged between 12.2^0 and 29.2^0C. The humidity varied from 71.52 to 81.2 5%. The day length was 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting.

Experimental treatment and design

The experiment comprised of 4 levels of N viz. 0, 50, 100 and 150 kg N ha^{-1} (designated as N_0, N_{50}, N_{100} and N_{150}, respectively) and 3 levels of P viz. 0, 30 and 60 kg P ha^{-1} (designated as P_0, P_{30} and P_{60}, respectively). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations.

Crop husbandry

California Wonder, a high yielding variety of capsicum *(Capsicum annum* Lin.) was used in this study. The land was well prepared and converted into loose friable and dried mass to obtain fine tilth. Twenty (20) grams of seeds were sown in each seed bed on 25 October 2009. After sowing, the seeds were covered with light soil. Miral 3-GN was applied in each seed bed as precautionary measure against ants and worms. Complete germination of the seeds took place with 6 days after seed sowing. Fertilizer treatments were randomly distributed in each block as per treatment. The N, P, K and Zn fertilizers were applied according to Fertilizer Recommendation Guide through urea, triple super phosphate (TSP), muriate of potash (MP) and zinc oxide, respectively. One third (1/3) of whole amount of Urea and full amount of MP, TSP and zinc oxide were applied at the time of final land preparation for each treatment. The remaining Urea was top dressed in two equal installments- at 20 days after transplanting (DAT) and 50 DAT, respectively. Healthy and uniform sized 30 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field maintaining a spacing of 55 cm and 27.5 cm between the rows and plants, separately. Gap filling, weeding, irrigation and pest management were done as per requirement.

Data collection and analysis

Fruits were harvested at 8 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of size of fruits. Ten (10) plants from each plot were selected randomly and

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were tagged for the data collection. The sample plants were uprooted and dried properly in the sun. The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan`s Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

Results and Discussion

Length of *Capsicum*

It was found that the length of *Capsicum* significantly increased with the increase of nitrogen level (Table 1). The highest length of *Capsicum* (7.63 cm) was found with 150 kg N ha^{-1} and which was statistically similar (7.41 cm) with 100 kg N ha^{-1} and the lowest length of *Capsicum* (5.83 cm) was found in control treatment. Length of *Capsicum* increased gradually with the increase of nitrogen dose. For the reason of higher availability of nitrogen and their uptake by plant that sequentially increased the length of *Capsicum*. Length of *Capsicum* was increased significantly with the increment of phosphorus (Table 2). The highest length of *Capsicum* (7.38 cm) was observed with 60 kg ha^{-1} of phosphorus fertilizer which was followed by 30 kg ha^{-1} (6.80 cm). The lowest result (6.51 cm) was identified in the control treatment. Combined treatment of nitrogen and phosphorus had significant effect (Table 3) on length of *Capsicum*. Length of *Capsicum* had the highest value (8.00 cm) in N_3P_1 treatment. The lowest length of *Capsicum* (5.05 cm) was observed in control treatment (N_0P_0). From these results it was observed that higher dose of nitrogen and phosphorus was influential nutrients for length of *Capsicum* up to a certain limit. Gowda *et al.* (2002) reported increased fruit length with 75 percent nitrogen, phosphorus plus 100 percent potassium in addition to the inoculation of *Azotobacter, Azospirillum*, PSB and VAM.

Breadth of *Capsicum*

Breadth of *Capsicum* was found to be significantly increased with the increase of nitrogen level up to a certain limit (Table 1). The highest breadth of *Capsicum* (4.86 cm) was found with 100 kg N ha^{-1} and the lowest breadth of *Capsicum* (2.97 cm) was found in control treatment. Mary *et al.* (1990) found that the greatest fruit length and girth obtained from plants receiving the highest N rates (N - 87.5 kg ha^{-1}). Breadth of *Capsicum* did not increase with the increment of phosphorus of *Capsicum* significantly (Table 2). The greatest breadth of *Capsicum* (3.92 cm) was observed with 30 kg ha^{-1} of phosphorus fertilizer. The lowest result (3.74 cm) was observed in the control treatment. Combined treatment of nitrogen and phosphorus had significant effect (Table 3) on breadth of *Capsicum*. Highest breadth of *Capsicum* was observed in N_3P_1 treatment (5.00 cm). The lowest breadth of *Capsicum* (2.59 cm) was observed in control treatment (N_0P_0). From these results, it was observed that higher dose of nitrogen and phosphorus was influential nutrients for breadth of *Capsicum* up to a certain limit.

Table 1. Influence of nitrogen on length and breadth of *Capsicum* fruit

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
N_0	5.86 c	2.97 c
N_1	6.68 b	3.21 c
N_2	7.41 a	4.86 a
N_3	7.63 a	4.23 b
$LSD_{0.05}$	0.72	0.31
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.
N_0 =Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 2. Influence of phosphorus on length and breadth of *Capsicum* fruit

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
P_0	6.51 b	3.74
P_1	6.79 ab	3.91
P_2	7.38 a	3.80
$LSD_{0.05}$	0.62	NS
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.
NS = Non significant
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 3. Interaction effect of nitrogen and phosphorus on the length and breadth of *Capsicum* fruit

Treatment	Length of *Capsicum* (cm)	Breadth of *Capsicum* (cm)
N_0P_0	5.05 d	2.59 e
N_0P_1	5.52 cd	3.21 d
N_0P_2	7.02 ab	3.11 de
N_1P_0	6.21 bcd	3.07 de
N_1P_1	6.73 abc	3.35 d
N_1P_2	7.11 ab	3.20 d
N_2P_0	6.93 ab	4.00 c
N_2P_1	7.41 ab	4.20 bc
N_2P_2	7.90 a	4.50 abc
N_3P_0	7.39 ab	4.69 ab
N_3P_1	8. 00 a	5. 00 a
N_3P_2	7.50 ab	4.90 a
$LSD_{0.05}$	1.24	0.54
CV (%)	10.64	8.26

Figure in column, having same letter(s) do not differ significantly at 5% level.
N_0 =Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Number of fruits per plant

The number of fruit per plant increased significantly with the increase of nitrogen level (Table 4). The highest number of fruits per plant (8.61) was found with 150 kg N ha^{-1} and the lowest number of fruits per plant (4.32) was found in control treatment. Number of fruits per plant increased gradually with the increase of nitrogen dose. Application of 100 kg N in combination with 25 kg P ha^{-1}recorded the highest number of fruits $plant^{-1}$ (Pundir *et al.,* 1999). Nitrogen fertilization improved plant growth, but did not influence fruiting time. Moderate nitrogen applications (150 kg N ha^{-1}) gave best yields in most field trials (Vos *et al.,* 1997). This investigation was supported by Sharma *et al.* (1996); Das *et al.* (1992); Mishriky and Alphonse (1994); Ingle *et al.* (1992); Shrivastava (1996). Nitrogen at 240 kg ha^{-1} + P at 180 kg ha^{-1} produced the highest mean number of fruits per plant (7.51). Srinivasan *et al.* (1997) also observed similar results. Number of fruit per plant increased with the increment of phosphorus of *capsicum* significantly (Table 5). The highest number of fruit per plant (7.44) was observed with 60 kg ha^{-1} of phosphorus fertilizer. It was found that the lowest number of fruit (6.17) per plant was identified in the control treatment. Combined treatment of nitrogen and phosphorus had significant effect (Table 6) on number of fruit per plant. Number of fruit per plant (9.50) was the highest in N_3P_1 treatment. The lowest number of fruit per plant (3.50) was observed in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for number of fruit per plant. Srinivasan *et al.* (1997) reported that N at 240 kg ha^{-1} + P at 180 kg ha^{-1} produced the highest mean number of fruits per plant (7.51). Shrivastava (1996) found that the highest number of fruits/plant (10.66) were observed in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}.

Average fruit weight

Average fruit weight per plant was measured and found significant increased with the increase of nitrogen level (Table 4). The highest average fruit weight per plant (99.80) was found with 150 kg N ha^{-1} and at the same time the lowest number of fruit per plant (84.47) was observed in control treatment. Average fruit weight per plant increased gradually with the increase of nitrogen dose. The result is in agreement with Mishriky and Alphonse (1994) who reported that increasing the nitrogen rate significantly increased number and weight of fruits per plant. Average fruit weight per plant increased with the increase of phosphorus of *capsicum* significantly (Table 5). Average fruit weight per plant (91.51) was the highest with 60 kg ha^{-1} of phosphorus fertilizer the lowest (89.74) with in the control treatment. The interaction effect of nitrogen and phosphorus for average fruit weight was significant (Table 6). Average fruit weight per plant (102.50) was the highest in N_3P_1 treatment and the lowest (83.50) in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for increasing average fruit weight per plant. Similar results were found by Shrivastava. (1996). They reported that the highest fresh weight/fruit (128) were in plants treated with 250 kg N + 200 kg P + 200 kg K ha^{-1}.

Fruit yield

Analysis of variance showed that the yield was significantly increased with the increase of nitrogen level (Table 4). The highest amount of marketable fruit yield of *capsicum* (8.34 t ha^{-1}) was found with 150 kg N ha^{-1} and at the same time the lowest amount of yield (4.94 t ha^{-1}) was observed in control treatment. Yield gradually increased with the increase of nitrogen dose. Finally availability of nitrogen and their uptake by plant sequentially increased the amount of yield. Application of 150 kg N ha^{-1} in equal splits, at planting, 30 days and 60 days after planting gave higher yield of sweet pepper cv. 'California Wonder.' This result was found by Hasanuzzaman (1999). With the increase of nitrogen fertilization the fruit yield increased up to a certain level (Hasan, 1978). The N and P treatment, showed that 120 kg N + 60 kg P ha^{-1}gave significantly higher yield than the other combinations (Srivastava *et al.*, 2003). The yield of chilli fruits increased with increasing nitrogen levels and the highest fruit yield was recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}, (Singh *et al.,* 2000). Aliyu (2002) found that significant increases in the yield both per plant and per hectare were obtained up to 240 kg N ha^{-1}. Balakrishnan (1999) reported that plant growth and fruit yield were reduced considerably in nitrogen deficient treatment but was only slightly affected by calcium deficiency. With regard to N application rate, the greatest vegetative growth and fruit yield (5.49 t ha^{-1}) were observed at 120 kg N ha^{-1} (Singh *et al.* 2000). The dry chilli yield increased significantly with increasing N and N at 120 kg ha^{-1}gave 313.8, 103.9 and 24.8% increases in yield, respectively, over 0, 60 and 90 kg ha^{-1} (Das *et al.* 1992).

Yield of sweet pepper (*Capsicum annum*) increased with the increase of phosphorus level significantly (Table 5). The highest yield of chilli (7.18 t ha^{-1}) was observed with 60 kg ha^{-1} of phosphorus fertilizer. It was found that the lowest yield of chilli (6.27 t ha^{-1}) was observed in the control treatment Singh *et al.* (2004) reported that the highest fruit yield of *Capsicum* recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}. However, P at 60 kg ha^{-1}gave higher yields than 120 kg P ha^{-1} (Srivastava *et al.,* 2003). The application of phosphorus increased early and total yields of sweet peppers (Ozaki and Hortenstine, 1963).

The interaction effect of nitrogen and phosphorus on yield was significant (Table 6). Yield of *capsicum* (8.51 t ha^{-1}) was the highest in N_3P_1 treatment. The lowest yield of *capsicum* (4.57 t ha^{-1}) was observed in control treatment (N_0P_0). From these results it was stated that higher dose of nitrogen and phosphorus was influential nutrients for increasing yield of *capsicum*. Among the various N and P combinations, 120 kg N + 60 kg P ha^{-1} recorded the greatest fruit yield (262.30 q ha^{-1}) (Chauhan *et al.,* 2005). Such type of results was found by Chaudhary *et al.* 2007. They stated that maximum fruit yield was obtained with N at 250 kg ha^{-1}, while P application increased yield by increasing fruit number and fruit yield/plant at concentrations up to 150 kg ha^{-1}. Narayan *et al.* (2004) stated that the maximum N, P and K uptake (134.56, 14.91 and 104.46 kg ha^{-1}, respectively), fruit yield (296.63 q ha^{-1}), ascorbic acid content (114.26 mg/100 g) and chlorophyll content (6.50 mg/g) were recorded in 50% poultry manure (PM) +50% NPK application. Singh and Jain (2004) found that the highest fruit yield was recorded with 120 kg N ha^{-1}+ 60 kg P ha^{-1}, followed by 120 kg N ha^{-1} + 30 kg P ha^{-1}. And the lowest fruit yield was recorded in the control treatment where only 60 kg K ha^{-1} was applied as a basal dressing. Sharma *et al.* (1996) concluded that the best treatment to promote yield and profitability was 120 kg N + 30 kg P_2O_5 ha^{-1}. Shrivastava *et al.* (1996) found that the highest yield/plant (637.5 g) and yield ha^{-1} (92.95 q ha^{-1}) were in plants treated with 250 kg N + 200 kg P + 200kgKha^{-1}.

Table 4. Influence of nitrogen on number of fruits per plant, average fruit weight/ plant and yield of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant (g)	Yield (t ha^{-1})
N_0	4.32 c	84.47 d	4.94 d
N_1	6.02 b	86.78 c	6.46 c
N_2	8.23 a	93.28 b	7.57 b
N_3	8.61 a	99.80 a	8.34 a
$LSD_{0.05}$	0.61	0.98	0.56
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.
N_0=Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}

Table 5. Influence of phosphorus on number of fruit per plant, average fruit weight/ plant and yield of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant (g)	Yield (t ha^{-1})
P_0	6.17 c	89.74 b	6.27b
P_1	6.78 b	92.00 a	7.03 a
P_2	7.44 a	91.51 a	7.18 a
$LSD_{0.05}$	0.53	0.85	0.49
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

Table 6. Interaction effect of nitrogen and phosphorus on number of fruits per plant, average fruit weight and yield of *Capsicum*

Treatment	Number of fruits/plant	Average fruit weight/plant (g)	Yield (t/ha)
N_0P_0	3.50 g	83.50 h	4.57 d
N_0P_1	4.95 f	85.00 gh	4.93 d
N_0P_2	4.50 fg	84.90 gh	5.32 d
N_1P_0	5.12 ef	85.01 gh	5.50 d
N_1P_1	6.12 de	86.62 g	6.79 c
N_1P_2	6.82 cd	88.70 f	7.10 bc
N_2P_0	7.40 bc	91.57 e	6.70 c
N_2P_1	8.00 b	95.36 d	7.90 ab
N_2P_2	9.30 a	92.92 e	8.10 ab
N_3P_0	7.20 bcd	97.37 c	8.30 a
N_3P_1	9.50 a	102.5 a	8.51 a
N_3P_2	9.12 a	99.50 b	8.21 a
$LSD_{0.05}$	1.05	1.70	0.97
CV (%)	9.12	9.10	8.40

Figure in column, having same letter(s) do not differ significantly at 5% level.
N_0 =Control (without N), N_1 =50 kg N ha^{-1}, N_2 =100 kg N ha^{-1}, N_3=150 kg N ha^{-1}
P_0 = Control (without P), P_1 = 30 kg P ha^{-1}, P_2 = 60 kg P ha^{-1}

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