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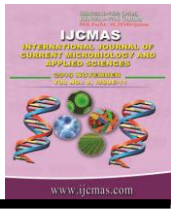

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Enhanced Effect of Nitrogen and Phosphorus on Growth and Yield of Capsicum: A Review

Yugalkishor Lodhi[1]*, Sangeeta[2], Snehasish Chakravorty[3] and B.V.G. Prasad[3]

[1]Department of Vegetable Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur-492012 (C.G.), India
[2]Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur-492012 (C.G.), India
[3]Department of Vegetable Science, Visva-Bharati, Sriniketan (West Bengal), India

**Corresponding author*

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A B S T R A C T

This review article is based on complete articles and abstracts. The nutrition status of any plants plays a vital role in determining its growth, yield and quality of fruits. An optimal fertilization is contributive in obtaining high yield of good quality and high biological value. Both macro and micro-nutrients are well known to ameliorate plant growth, yield and quality. Application of nutrients especially macronutrients like nitrogen, phosphorus and potassium etc. is well known to enhance the crop growth and development for optimum yield and to improve quality of produce. It is evident from literature, that nitrogen and phosphorus affect growth, yield and quality of fruits and vegetables. The available literature on effect of nitrogen and phosphorus application on growth parameters, yield components and quality of capsicum and other fruits or vegetable crops are reviewed and presented below.

Introduction

Capsicum is one of the most popular vegetable crops, also known as Bell pepper, Sweet pepper or Green pepper or Shimla Mirch. It belongs to family Solanaceae and is native to Mexico with secondary centre of origin at Guatemala and Bulgaria (Safford, 1926). Sweet pepper is relatively non-pungent or less pungent with thick flesh. Chilli is the third important crop of family Solanaceae after tomato and potato (Naz, 2006). It is cultivated throughout the world, mostly in temperate regions of Central and South America and European countries, tropical and subtropical regions of Asian continent mainly in India and

China. India contributes one fourth of world production of Bell pepper with an average annual production of 327 thousand tons from an area of 46,000 hectare with a productivity of 7108.70 kg per hectare from open as well as protected cultivation (Anonymous, 2017). It is extensively cultivated in hills of Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir and Nilgiri hills during summer months. As an autumn crop, it extends up to winter months in Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh, Bihar, West Bengal and Madhya Pradesh (NHB, 2016-17).

Capsicum is consumed as cooked vegetable or as raw salad. Juroszek and Tsai (2009) reported that sweet pepper fruits are good sources of many essential nutrients, including vitamins A, C, and E, carotenoids, minerals (e.g., calcium and iron), and other secondary plant compounds. It is highly nutritious with abundant source of vitamins A and C, minerals like phosphorus, potassium, calcium and magnesium. A 100 g fresh weight of bell pepper contains vitamin A (3131 IU), vitamin C (283 mg), protein (1.29 mg), calcium (13.4 mg), magnesium (14.9 mg), phosphorus (28.3 mg) and potassium (263.0 mg) (Arya, P.S., 1999 and IIHR, 2000).

The mineral nutrients, N, P and K are known to affect growth and yield of the capsicums. Stroehlein and Oebker (1979) reported that N applications to chili peppers showed a significant increase on plant growth characteristics, color and nutrient content of leaves and yield. Crucial role of nitrogen for being main constituent of all amino acids in proteins and lipids, the structural compounds of cells and chloroplast made it the most essential macronutrient for good plant establishment and expected growth (Uddin and Khalequzzaman, 2003). Therefore, its deficiency shows negative impact on growth and development of plants which is ultimately reduces plant yield. Reports of various investigations indicated its significant role in stimulating the plants for uptake of potassium and phosphorus through its synergistic effect (Qawasmi *et al.,* 1999). Bell pepper requires heavy nitrogen application for higher yield as it imparts good vegetative growth necessary for good development of fruit.

Phosphorus is also one of the important macronutrients play a vital role in crop growth as it is involved in several key plant cellular activities like energy transfer, photosynthesis, transformation of sugars and starches and transfer of genetic characteristics from one generation to the next. It also promotes root proliferation that increases root volume and improves soil nutrient exploration. Phosphorus shortage restricted the plant growth and remains immature (Hossain, 1990). The effect of phosphorus on the formation and translocation of carbohydrates, roots development, nodulation, growth and other agronomic characters are well recognized. Phosphorus induces earliness in flowering and fruiting including seed formation (Buckman and Brady, 1980). Again, secondary mechanism of interference was the absorption of phosphorus from the soil through luxury consumption, increasing the tissue content without enhancing smooth biomass accumulation (Santos *et al.,* 2004). To attain considerable production and quality yield for chilli it is necessary to proper management including ensuring the availability of essential nutrient components in proper doses.

The available literature on the effect of nutrient application on growth, yield components and quality of bell pepper and other fruits or vegetables are reviewed and presented below:

Lodhi *et al.,* (2019) reported that the fruit yield of bell pepper was significantly influenced by nutrients and mulching. The highest fruit yield per plant (739.31g), fruit

yield per plot (12.67 kg) and fruit yield per hectare (21.12 t ha^{-1}) were recorded in treatment T_6 with 200kg N ha^{-1} + 80kg P_2 O_5 ha^{-1} + Paddy straw mulch @ 7 t/ha^{-1}.

Lodhi *et al.,* (2019) conducted a field experiment and observed that the fruiting and fruit characteristics of bell pepper significantly influenced by nutrients and mulching. Highest number of fruits per plant (9.95), highest fruit weight (69.18g), maximum fruit length (9.95cm), diameter (7.37cm) and volume (97.07cm^3) were observed in the treatment T_6 with 200kg N ha^{-1} + 80kg P_2 O_5 ha^{-1} + Paddy straw mulch @ 7 t/ha^{-1}. Control condition indicated significantly lowest result than all other treatments.

Fruit quality of bell pepper was significantly influenced by different levels of nitrogen and phosphorus. The bio-chemical parameters *viz.* TSS, chlorophyll content and Vitamin–C increased with increasing rate of nutrients. Highest total soluble solids (7.410Bx), chlorophyll content (63.28 SPAD) and Vitamin–C (197.64 mg/100g) were observed in treatment T_8 with 200kg N ha^{-1} + 120kg ha^{-1} P_2 O_5 + Paddy straw mulch @ 7 t ha^{-1}. Control condition indicated significantly lowest result than all other treatment (Lodhi *et al.,* 2019).

Islam *et al.,* (2018) investigated the influence of nitrogen and phosphorus on growth and yield of chilli and found that growth and yield contributing parameters significantly influenced by different doses of nitrogen and phosphorus fertilizers. Most of the growth parameters increased with increasing level nitrogen and phosphorus between 120 to 140 kg N ha^{-1} and 45 to 60kg P_2O_5 ha^{-1}. Based on the investigation results, it can be suggested that the combined use of 140 kg N ha^{-1} with 60 kg P_2O_5 ha^{-1}increased plant growth and fruit yield of chilli. A field experiment was conducted by Dubey *et al.,* (2017) and observed that the treatment combination of N.P.K. (175:55:45 kg/ha) was superior overall other treatments in relation to growth parameters but low in production and quality. N.P.K. (155:55:45 kg. /ha) was found superior in terms of yield and N.P.K. (155:55:55 kg/ha) was superior in relation to quality (fruit length, fruit diameter, shelf life, TSS) of capsicum. Thus, application of optimum doses of NPK was found highly beneficial for plant growth, yield and quality of capsicum.

A greenhouse experiment was conducted by Hussein Hussein Alhrout, (2017) and evaluated plant height (cm), leaves number per plant, number of days to 50% flowering, fruit number per plant, fruit length, yield of fruit per plant (kg), and yield of fruit per hectare (t/ha). He concluded that the NPK treatment gives highest plant height (cm), leaves number per plant, fruits number per plant, yield of fruits per plant (kg), and yield of fruits per hectare (t/ha).

A field investigation was carried out by Lodhi *et al.,* (2017) and observed that growth parameters were significantly influenced by different nutrients levels. The highest plant height (62.87cm), stem diameter (12.18mm), highest primary and secondary branches (2.84 and 5.94) were recorded in treatment T_6 with 200kg N/ha + 80kg P_2O_5/ha + paddy straw mulch @ 7t/ha. Appearance of early flowering, 50% flowering and days to first harvest (51.10 days, 84.02 days and 101.00 days respectively) were observed in treatment T_4 with 150kg N/ha + 120kg /ha P_2O_5+ paddy straw mulch @ 7 t/ha.

Mebratu *et al.,* (2014) found that nitrogen had significant effect on yield and quality components of hot pepper (*Capsicum annum* L.). Nitrogen at 100 kg ha^{-1} resulted in the highest total dried pod yield (3.1 t ha^{-1}), marketable yield (2.7 t ha^{-1}) pod length (10.6 cm) and pod width (3.4 cm).Application of

nitrogen at the rate of 100 kg ha^{-1} also improved the physical quality attributes of hot pepper.

The influence of nitrogen and potassium levels on chilli (*Capsicum annuum* L.) was evaluated by Khan *et al.*, (2014). Nitrogen levels showed significant effect on all growth and yield parameters. The maximum plant height (68.3 cm), number of leaves $plant^{-1}$ (294), number of branches $plant^{-1}$ (18.3), stem thickness (2.43 cm), fruits $plant^{-1}$ (59.4), fruit length (6.83 cm), seeds $fruit^{-1}$ (152) and yield (8.803 tons ha^{-1}) were recorded with Nitrogen application at the rate of 180 kg ha^{-1}.

Roy *et al.*, (2011) observed the effect of nitrogen and phosphorus on the fruit characteristics and yield attributing parameters of Capsicum. Length, breadth of fruit and number of fruits per plant were increased significantly with increasing nitrogen doses up to 150 kg N ha^{-1} and average weight of fruit content increased significantly up to 200 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 200 kg N and 30 kg P ha^{-1}.

Roy *et al.*, (2011) Conducted experiment on Nitrogen and Phosphorus Efficiency on the Fruit Size and Yield of Capsicum and identified the highest number of fruits per plant (8.61) was found with 200 kg N ha^{-1} and the lowest number of fruits per plant (4.32) was found in control treatment. Malik *et al.*, (2011) studied on the effect of inorganic fertilizers on Growth, yield and fruit quality of sweet pepper hybrid SH-SP-5 (*Capsicum annuum L.*). Application of 200kg N ha^{-1}, 120kg P_2O_5 ha^{-1}, 60kg K_2O ha^{-1} to capsicum crop recorded maximum plant height (55.65 cm), number of branches (6.61), plant spread (44.50 cm), fruit length (8.30 cm), fruit diameter (8.00 cm) and the highest fruit quality in terms of vitamin-C (243.34 mg/100 g), total chlorophyll content (732.66 mg/100 g), dry matter content (9.93 g/100 g).

Khan *et al.*, (2010) studied the effect of nitrogen and phosphorus on the growth and yield of capsicum. The results revealed that plant height at final harvest and number of branches at first and final harvest increased significantly up to 200 kg N ha^{-1} and, whereas plant height and number of branches at final harvest and number fruits per plant enhanced significantly up to 60 kg P_2O_5 ha^{-1}.

Kacha *et al.*, (2008) reported the effect of different nitrogen level on *Capsicum annuum* cv. S-49).The application of nitrogen at 150 kg/ha significantly improved the yield attributes and green fruit yield compared to the lower level (100 kg/ha), but was on a par with the higher levels (200 and 250 kg/ha). Nitrogen at 250 kg/ha recorded the highest values of nitrogen, phosphorus and potassium content and uptake, and available nitrogen status after harvesting; this treatment was superior to lower levels of nitrogen except 200 kg/ha. However, the capsaicin content was reduced as the nitrogen level increased.

Singegol *et al.*, (2007) studied the effect of different level of nitrogen fertilizer and phosphorus on growth and yield of *Capsicum annuum* cv. Pusa Jwala. The results revealed that among nitrogen levels studied, 200 kg N/ha was significantly better with respect to growth characters like plant height, plant spread, number of primary and secondary branches per plant as well as yield attributing characters like number of fruits per plant and

average fruit weight. Similar was the response of most of characters to higher phosphorus (75 kg/ha) resulting in higher yield.

Chaudhary *et al.,* (2007) reported that the effects of different nitrogen rates on the growth and yield of *Capsicum annuum var. grossum* and observed that maximum fruit yield was obtained with N at 250 kg/ha, while P application increased yield by increasing fruit number and fruit yield/plant up to 150 kg/ha.

Jan *et al.,* (2006) studied the effect of optimum dose of fertilizer and plant spacing on growth and yield of sweet peppers (*Capsicum annuum).* The greatest plant height (29.13 cm), number of fruits per plant (15.36), fruit weight (67.05 g), yield per plant (1040 g) and yield ha^{-1} (43.19 t) were recorded with the application of 125:90:70 kg $N:P_2O_5:K_2Oha^{-1}$. The maximum plant height (28.86 cm) and yield ha^{-1} (45.39 t) were recorded at 60x45 cm spacing. Better performance regarding growth and yield were observed when plants were supplied with 125:90:70 kg N: P: K/ha and spaced at 60x45 cm.

Singh and Jain (2004) the Experiments were conducted to determine the balanced amount of nitrogen, phosphorus and potassium for the higher yield and economics of chilli cv. Pant C-1. The highest fruit yield was recorded with 120 kg N/ha + 60 kg P/ha with highest gross income (Rs. 46 350), net profit (Rs. 26 150/ha) and cost: benefit ratio (1:2.30).

Sarma *et al.,* (2004) An experiment was conducted during 2000-03 in Gossaigaon, Assam, India to determine the optimum level of NPK for *Capsicum annuum*. Plant height (27.25 cm), fruit number per plant (64.33), fruit weight (3.33 g) and yield (27.99 q/ha) of *Capsicum annuum* increased significantly with 200:75:75 kg NPK/ha. The capsaicin contents of green and red ripe fruits were highest at 90:45:45 and 120:60:60 kg NPK/ha. The capsaicin content decreased with further increase in NPK level. The maximum return per rupee invested (3.92) was obtained at 90:45:45 kg NPK/ha, followed by 120:60:60 kg NPK/ha (3.86).

Ramakrishna and Palled (2003) studied the effect of plant geometry and fertilizer levels on growth and yield of chilli (cv. Vietnam-2). A spacing of 60 cm x 45 cm recorded significantly higher fruit yield. Application of 200:75:75 kg N, P_2O_5 and K_2O ha^{-1} with 60 cm x 45 cm spacing recorded significantly higher net returns (Rs.38759 ha^{-1}) and B:C ratio (2.56) over other treatment combinations, except 60 cm x 45 cm with 125:62.5:62.5 kg N, P_2O_5 and K_2O ha^{-1}.

Faiza *et al.,* (2002) reported that the effects of different nitrogen rates on the growth and yield of sweet pepper [*Capsicum*] cv. Yellow Wonder and observed increase plant height (41.60 cm), number of branches (9.13), and yield ha^{-1} (30.82 t) were recorded with the application of 200 kg N/ha^{-1}. Maximum fruiting (18.20) was observed in 100 kg N ha^{-1}. The results showed that better performance in growth and yield were obtained when plants were supplied with 200 kg N ha^{-1}.

Gare *et al.,* (2001) reported that the effect of different spacing and NPK fertilizer application on the yield and yield components of Capsicum *annuum* cv. Phule sai. The results revealed that plant height (53.60 cm) and number of fruits per plant (48) were highest under the 45 x 30 cm spacing, while plant spread (44.53 cm) and fruit length (7.8 cm) was highest under the 60 x 45 cm spacing. The different fertilizer treatments, 200 kg N/ha + 50 kg P/ha recorded the highest values for dry chilli yield (1903 kg/ha), plant height (57.13 cm), plant spread (47.13 cm), number of fruits per plant (51), fruit length (8.1 cm)

and yield of dry chilli per plant (43.1 g). This fertilizer treatment was on a par with the 200 kg N/ha + 37.5 kg P/ha treatment.

Diaz *et al.,* (2001) conducted experiment on effect of fertilization programme on the yield of pimento (*Capsicum annuum* L.*).* The results revealed that an average of 153.7 g/fruit were obtained with 160-197 kg/ha of nitrogen, 42-72kg/ha of phosphorus and 90-168 kg/ha of potassium to the best for pepper production.

Mohanty *et al.,* (2001) An experiment was conducted in Orissa, the response of chilli (C*apsicum annuum* cv. Utkal Rashmi) to N at 0, 40, 80 and 120 kg/ha, and P and K at 0, 30 and 60 kg/ha. N, P and K at 120, 60 and K at 30 kg/ha, respectively, resulted in the tallest plants and maximum number of fruits. N, P and K at 120, 30 and 30 kg/ha, respectively, resulted in the highest yield.

Muhammad*et al.,* (2001) noticed a different level of N and P significantly affected in plant height, number of branches per plant, number of fruits per plant and fruit yield of pepper. The tallest plants (65.2 and 64.7 cm), the maximum branches per plant (14.1 and 13.8 branches/plant), and the highest number of fruits per plant (62.6 and 59.2) and fruit yield (9577.726 and 8771.44 kg/ha) were recorded when N and P each were applied at rates of 200 kg/ha, and when N alone was applied at the rate of 200 kg/ha, respectively. N and P each at the rate of 200 kg/ha is recommended for the highest yield of pepper.

Srinivasan *et al.,* (1999) studied response of different levels of fertilizers on growth and yield of hybrid *Capsicum cv.* Bharath and observed the N at 240 kg/ha + P at 180 kg/ha produced the highest mean number of fruits per plant (7.51), N at 180 kg/ha + P at 180 kg/ha produced the highest yield of 52.1, 64.3 and 80.6 q/ha.

Benefit cost ratios were highest (3.25, 4.02 and 4.67) with N at 180 kg/ha + P at 120 kg/ha.

Capsicum annuum var. *grossum* cv. California Wonder was sown at different densities (60x30, 60x45 and 60x60 cm spacing) and was supplied with 4 N rates (0, 50, 100 and 150 kg/ha) and 3 P rates (0, 50 and 100 kg/ha) at Coimbatore, Tamil Nadu, India. The results revealed that total chlorophyll content and harvest index were the highest when 150 kg N/ha + 100 kg P/ha was applied. NAR, RGR and CGR were not affected by N and P rates (Maya *et al.,* 1999).

Revanappa *et al.,* (1998) to study the effect of different nitrogen levels (150, 200 and 250 kg/ha) on the growth and yield of the *Capsicum annum* L cultivars during summer and kharif, season. It was observed that the Plant height (56.07 and 68.67 cm in summer and kharif, respectively) and spread (39.08 and 48.57 cm in summer and kharif, respectively). However, *Capsicum annum* L. cultivars recorded the highest yields (114.51 and 125.70 q/ha in summer and kharif, respectively). The highest N rate produced the maximum growth and yield.

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) in capsicum.

Maya *et al.,* (1997) conducted a trial in Coimbatore to evaluate the effects fertilizers on the yield and growth of sweet pepper (*Capsicum annuum var. grossum*) cv. California Wonder and observed the fruit yield and plant growth generally increased as N and P application rates, the highest yield (12.13 t/ha) and with N and P application rates of 150 and 100 kg/ha, respectively. Manchanda *et al.,* (1988) reported that Increasing rates of N increased plant height, the number of primary branches per plant, leaf area, number of fruits

per plant, fruit length and breadth, and fruit yields. N at 160 kg/ha gave the highest fruit yield (115.4 q/ha).

Prabhakar (1984) recorded higher TSS content with 60 kg P_2 0_5 and 50 kg N ha^{-1} in capsicum.

Ramachandran and Subbiah (1981) conducted trials on Capsicum cv. MDU- 1, received N at 40, 80, 120 or 160 kg/ha. The number of shoots and fruits/plant and the weight of 100 fruits generally increased with rising N rates. The highest yield/ha (2358.33 kg) was obtained from at 120 kg N/ha.

Dry matter content was found to increase at highest concentration of phosphorus (64 kg)/hectare and as well as at highest concentration of nitrogen (100 kg)/hectare. Protein content was found to increase with increasing nitrogen doses and was also found to increase at maximum dose of nitrogen with increasing concentration of phosphorus.

Capsaicin and ascorbic acid content were found to be more at P~ (64 kg)/hectare level at different doses of nitrogen. Maximum uptake of phosphorus and dry matter content was observed at nitrogen (0 kg)/hectare with phosphorus (64 kg)/hectare. Maximum protein, ascorbic acid and capsaicin contents were found at nitrogen (100 kg)/hectare with phosphorus (48 kg)/hectare. [Bajaj *et al.,* (1979)]

After reviewing above research articles and abstracts it can be concluded that application of nutrients like nitrogen and phosphorusis well known to enhance the crop growth and development for optimum yield and to improve quality of produce. It is evident from literature, that nitrogen and phosphorus affect growth, yield and quality of fruits and vegetables. Proper management of fertilizers including ensuring the availability of essential nutrient components in proper doses is also necessary to attain considerable production and quality yield of capsicum.

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