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# Consequence of nitrogen, phosphorus and potash efficiency on the growth and yield attributes of sweet pepper (*Capsicum frutescens*)

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## Abstract

A field experiment was conducted at the farmers field in village sable, district Tehari Garhwal, during the Kharif season on 2013 to find out the consequence of optimum levels of fertilizer on growth and yield attributes of capsicum, consisting three levels of nitrogen (40, 80 & 120 kg ha$^{-1}$), two levels of phosphorus (40 & 70 kg ha$^{-1}$) and two levels of potash (35 & 60 kg ha$^{-1}$) along with control on sweet pepper in randomized block design with three replications. Number of fruits plants$^{-1}$, plants height at harvesting (cm), fruits length (cm), fruits width (cm), fruits weight (g), fruits maturity, fruits yield g plant$^{-1}$, fruits yield kg plot$^{-1}$ and fruits yield quintal hectare$^{-1}$. Plant height at harvest, fruits length, fruits width, number of fruits per plant, fruits maturity, fruits weight and fruits yield increased significantly with $T_{19}$ treatment (nitrogen, phosphorus and potash 120:40:60 kg ha$^{-1}$) level.

**Keywords:** Sweet pepper, nitrogen, phosphorus, potash, growth, yield.

## Introduction

Bell pepper (*Capsicum annuum* L. var. *grossum* Sendt.), commonly known as sweet pepper or capsicum or Shimla mirch, sweet pepper botanically referred to as the genus *Capsicum* is the member of *Solanaceae* family. It is the native to the Tropical South America and Brazil (Shoemaker *et al.*, 1955). The genus *Capsicum* consists of about 20 species and only four species are under cultivation, out of which *C. pendulum* and *C. pubescens* are restricted to the South and Central America. The other two species such as *C. annum* and *C. frutescens* are commonly cultivated throughout the world. *C. annum* is the most commonly cultivated species and all green chilies in the market and most of the dry chilies belong to this species. 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). Sweet pepper is also known as bell pepper, green pepper or *capsicum*. 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). It was introduced in India by the Britishers in the 19$^{th}$ century in Shimla hills. In India, bell pepper occupies an area of 5,50,000 hectares with a production of 51,000 tonnes (including hot pepper) (FAO 2009). It is commercially grown in Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Arunachal Pradesh and Darjeeling district of West Bengal during summer months and as autumn crop in Maharashtra, Karnataka, Tamil Nadu and Bihar. In Himachal Pradesh, it is extensively grown as cash crop in open environment and covers an area of 2,447 hectares with production of 31,810 metric tonnes. It is an important off-season vegetable of western Himalayas and offers potential for boosting economy of farmers of hilly regions. It is a warm season and chilling sensitive crop. At present, bell pepper growers in hilly regions are facing several challenges in the open field cultivation like vagaries of weather *viz.* fluctuating temperature, unprecedented rains and frequent hail storms which affect the yield and quality of the produce, thereby reducing the profit margin of producers. Due to these challenges, the scenario of bell pepper production has been changing significantly. The protected cultivation is getting preference over open field cultivation for off-season quality production by extending availability of the quality produce, higher productivity and improved nutritional attributes of the polyhouse produce. Bell peppers (*Capsicum annum L.*) originate from central and South America where numerous species were used centuries before Columbus landed on the continent. The cultivation of peppers spread throughout Europe and Asia after the 1500's. Although perennials, they grow as annuals in temperate climates. They are sensitive to low temperatures and are relatively slow to establish. As there is little field production of bell peppers in Alberta, greenhouse production provides most of the local source of this product. Greenhouse production of peppers is based on indeterminate cultivars in which the plants continually develop and grow from new meristems that produce new stems, leaves, flowers and fruit. In comparison, field pepper cultivars are determinate, the plant grows to a certain size, produces fruit and stops growing and eventually dies. Indeterminate cultivars require constant pruning to manage their growth. In order to optimize yield, a balance between vegetative (leaves and stems) and generative (flowers and fruit) growth must be established and maintained.

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), the results of a large number of experiments on inorganic and organic fertilizers conducted in several countries reveal that inorganic fertilizer alone can 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. Therefore, the present investigation was undertaken to study the effect of nitrogen and phosphorus fertilizers on growth and yield of sweet pepper and to find out the optimum dose of fertilizer for successful growth and yield of sweet pepper.

Adetula and Olakojo (2006) suggested that the best way of fertilizer application is once and 3 weeks after planting and the amount should be 140 kg per ha nitrogen and 25 kg per ha phosphorus in 75 × 40 cm distance. Dimitrov and Chevenkova (1978) obtained the best yield by using 180 kg per ha nitrogen in 2 stages. Peivast (2005) proposed 150 kg per ha nitrogen in 3 stages. Gopinath *et al* (2009) and Abu-Zahra (2012) on pepper plant showed that conventional fertilizer increased plant growth characters and significantly higher number of pepper fruits per plant and total yield plot per kg.

## Materials and Methods

The experiment was conducted at the farmer field in village Sable, district Tehari Garhwal, Uttarakhand during *Kharif* 2013. It has an altitude of about 1900 metre above mean sea level, lying between latitude of $30^0$ 15' North and longitude $78^0$ 02' East under mid hill zones of Uttarakhand. The soil of the experimental block is silty clay loam in texture, low in available nitrogen (210 to 2185 kg $ha^{-1}$) and available phosphorus (11.50 to 13.50 kg $ha^{-1}$) and rich in available potash (408 – 418 kg $ha^{-1}$). The pH of the soil varies from 5.5 to 5.6, electrical conductivity as measured in 1:2 soil water ratio is 0.5 to 0.7 dsm $^{-1}$. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. Three seed beds were prepared for raising the seedlings and seeds were sown in each seed bed on 22 April, 2013. Complete germination of the seeds took place with 5 days after seed sowing under poly house condition. The experiment consisting of twenty treatments of optimum levels of fertilizer on growth and yield attributes of capsicum, consisting three levels of nitrogen (40, 80 and 120 kg $ha^{-1}$), two levels of phosphorus (40 & 70 kg $ha^{-1}$) and two levels of potash (35 & 60 kg $ha^{-1}$) along with control on sweet pepper in randomized block design with three replications. There were twenty treatment combinations. The treatment combinations were as follows:

| | |
|---|---|
| $T_1$ | Control (without NPK and VC application) |
| $T_2$ | 40 kg $ha^{-1}$ Nitrogen |
| $T_3$ | 80 kg $ha^{-1}$ Nitrogen |
| $T_4$ | 120 kg $ha^{-1}$ Nitrogen |
| $T_5$ | 40 kg $ha^{-1}$ Phosphorus |
| $T_6$ | 70 kg $ha^{-1}$ Phosphorus |
| $T_7$ | 35 kg $ha^{-1}$ Potash |
| $T_8$ | 60 kg $ha^{-1}$ Potash |
| $T_9$ | 40:40:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash |
| $T_{10}$ | 40:40:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash |
| $T_{11}$ | 40:70:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash |

$T_{12}$ 40:70:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{13}$ 80:40:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{14}$ 80:40:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{15}$ 80:70:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{16}$ 80:70:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{17}$ 120:40:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{18}$ 120:70:35 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{19}$ 120:40:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash
$T_{20}$ 120:70:60 kg $ha^{-1}$ Nitrogen: Phosphorus: Potash

The land operation was completed on 25 May, 2013. The N, $P_2O_5$ and $K_2O$ fertilizers were applied according to Fertilizer Recommendation Guide (BARC, 1997) through urea, single super phosphate (SSP) and muriate of potash (MP), respectively. One third (1/3) of whole amount of Urea and full amount of MP and SSP were applied at the time of final land preparation for each treatment. The remaining Urea was top dressed in two equal installments at 22 days after transplanting (DAT) and 48 DAT respectively. Healthy and uniform sized 30 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 28 May, 2013 maintaining a spacing of 50 cm and 45 cm between the rows and plants, separately. The seedlings were watered after transplanting. Gaps filling, weeding, irrigation and pest management were done as per requirement. Fruits were harvested at 7 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of size of fruits. Harvesting was started from 8 August, 2013 and completed by 28 September 2013.

## Results and Discussion

Number of fruits $plants^{-1}$, plants height at harvesting (cm), fruits length (cm), fruits width (cm), fruits weight (g), fruits maturity, fruits yield g $plant^{-1}$, fruits yield kg $plot^{-1}$ and fruits yield quintal $hectare^{-1}$ are shown in table 1. Plant height in nitrogen, phosphorus and potash levels $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg $ha^{-1}$) showed the maximum height of the plants (63.47 cm) and the lowest plant height at final harvesting stage (42.93 cm) was found in the control. Plant height varied from 42.60 to 63.93 cm (table 1). While observing the effects of nitrogen and phosphorus levels on capsicum, Khan *et al*, (2010) reported the maximum plant height at 150 kg Nitrogen and 60 kg phosphorus $ha^{-1}$ with the fact that phosphorus with phosphate soubizers attributed to higher translocation of carbohydrates to respective parts during maturity due to better phosphate dose. In chilli, Bhuvaneswari *et al.*, (2013) recorded maximum height with 75 kg nitrogen and 60 kg potash per ha, respectively.

A nitrogen, phosphorus and potash level also influences the number of fruits per plants (table 1). The maximum number of fruits per plants (23.13) was obtained with $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg $ha^{-1}$) under the present study and number of fruits per plant ranged from 15.20 to 23.13. Bahuguna *et al.*, (2014) also found an increase in fruits increasing per plant with increasing levels of phosphorus and the maximum number being at 20 kg nitrogen, 90 kg phosphorus and 20 kg potash in pea. An increasing trend in fruits length (cm) was observed in capsicum with increasing levels of nitrogen, phosphorus and potash the maximum fruits length (5.59 cm) being under $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg per ha) level, whereas, fruits length varied from 4.60 to 5.59 cm and moderate variation was observed for fruits width (cm) ranged from 3.64 to 4.11 cm (table 1). In chilli, Bhuvaneswari *et al.*, (2013) recorded the highest number of fruits per plant was found with 75 kg nitrogen and 60 kg potash per ha, respectively. Akanbi *et al*., (2007) who also reported that increasing the rate of nitrogen fertilizers increases the average fruit weight and volume of pepper.

Significant increase in fruit weight was observed in $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg $ha^{-1}$) level with 67.59 grams, respectively followed by $T_{16}$ (nitrogen, phosphorus and potash 80:70:60 kg $ha^{-1}$) with 64.25 grams fruit weight. The least fruit weight (48.49 g) was observed in control. The results revealed that by increasing nitrogen, phosphorus and potash levels the fruit weight also started increasing gradually. Our results are in agreement with the previous findings of Ahmed *et al.* (2007) who also reported that fruit weight of cucumber increased linearly with an increase in Nitrogen fertilizer rate. Similarly, Choudhari and More (2002) also observed that 150: 90: 90 kg nitrogen, phosphorus and potash per ha produced maximum fruit weight (g) in cucumber plant. Respectively 50 percent vermi-compost and 50 percent chemical fertilizers that are nitrogen, phosphorus and potash the highest fruits weight of tomato Chanda *et al.*, (2011).

Highly significant data regarding days to fruit maturity (Table I) showed that maximum (91.67) days to fruit maturity were recorded in control, followed by $T_7$ (potash 35 kg $ha^{-1}$) 91.33 days to fruit maturity,

**Table1. Effects of optimum levels of fertilizers efficiency on the growth and yield attributes of sweet pepper (*Capsicum frutescens)* subsequent fruits growth and yield attributes**

| Treatment kg $ha^{-1}$ | Plant Height at Harvesting (cm) | Number of Fruits $Plant^{-1}$ | Fruits Length (cm) | Fruits Width (cm) | Fruits Weight (g) | Fruits Maturity | Fruits Yield g $Plant^{-1}$ | Fruits Yield kg $Plot^{-1}$ | Fruits Yield Quintal $Hectare^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|
| $T_1$ Control | 42.60 | 15.20 | 4.60 | 3.64 | 48.49 | 91.67 | 599.67 | 10.14 | 264.85 |
| $T_2$ 40 N | 45.47 | 16.93 | 5.20 | 3.78 | 51.19 | 90.67 | 681.67 | 11.13 | 311.00 |
| $T_3$ 80 N | 50.67 | 18.40 | 5.18 | 3.89 | 56.58 | 85.67 | 631.33 | 11.39 | 308.63 |
| $T_4$ 120 N | 48.80 | 16.20 | 5.09 | 3.83 | 55.79 | 84.33 | 675.67 | 11.27 | 308.92 |
| $T_5$ 40 P | 46.47 | 17.40 | 5.04 | 3.83 | 53.32 | 90.33 | 651.00 | 10.64 | 315.59 |
| $T_6$ 70 P | 48.07 | 16.87 | 5.07 | 3.79 | 52.79 | 86.67 | 670.33 | 11.27 | 300.48 |
| $T_7$ 35 K | 43.67 | 16.80 | 5.12 | 3.79 | 50.58 | 91.33 | 626.67 | 10.60 | 285.96 |
| $T_8$ 60 K | 45.27 | 17.87 | 5.15 | 3.79 | 51.85 | 87.33 | 665.67 | 10.69 | 299.00 |
| $T_9$ 40:40:35 N:P:K | 51.53 | 18.73 | 5.30 | 3.82 | 55.99 | 89.33 | 695.33 | 11.45 | 317.67 |
| $T_{10}$ 40:40:60 N:P:K | 54.20 | 19.13 | 5.45 | 3.91 | 54.92 | 88.67 | 689.00 | 11.49 | 313.67 |
| $T_{11}$ 40:70:35 N:P:K | 55.33 | 19.27 | 5.22 | 3.83 | 53.85 | 88.00 | 693.33 | 11.39 | 315.29 |
| $T_{12}$ 40:70:60 N:P:K | 56.33 | 19.60 | 5.30 | 3.94 | 54.99 | 87.00 | 690.67 | 11.27 | 316.63 |
| $T_{13}$ 80:40:60 N:P:K | 59.07 | 20.20 | 5.31 | 3.95 | 57.32 | 85.33 | 695.00 | 11.29 | 316.93 |
| $T_{14}$ 80:40:35 N:P:K | 58.40 | 19.47 | 5.30 | 3.99 | 58.99 | 84.67 | 691.67 | 11.45 | 317.23 |
| $T_{15}$ 80:70:35 N:P:K | 62.20 | 22.13 | 5.55 | 4.07 | 62.45 | 82.67 | 722.33 | 11.65 | 339.29 |
| $T_{16}$ 80:70:60 N:P:K | 62.33 | 22.27 | 5.48 | 4.08 | 64.25 | 81.00 | 725.67 | 12.44 | 344.78 |
| $T_{17}$ 120:40:35 N:P:K | 60.07 | 20.00 | 5.45 | 4.05 | 57.19 | 85.00 | 698.67 | 12.30 | 323.59 |
| $T_{18}$ 120:70:35 N:P:K | 61.13 | 21.93 | 5.51 | 4.06 | 59.99 | 83.67 | 715.33 | 12.16 | 329.00 |
| $T_{19}$ 120:40:60 N:P:K | 63.93 | 23.13 | 5.59 | 4.11 | 67.59 | 79.33 | 789.33 | 13.41 | 370.26 |
| $T_{20}$ 120:70:60 N:P:K | 60.53 | 21.40 | 5.51 | 4.00 | 61.19 | 82.33 | 718.67 | 12.14 | 334.56 |
| CD 1% | 4.16 | 1.47 | 0.71 | 0.61 | 11.24 | 2.47 | 134.64 | 1.02 | 44.33 |
| CD 5% | 3.10 | 1.09 | 0.53 | 0.46 | 8.39 | 1.84 | 100.51 | 0.76 | 33.09 |
| CV | 3.49 | 3.47 | 6.13 | 7.05 | 8.94 | 1.29 | 8.86 | 4.01 | 6.32 |
| GM | 53.80 | 19.14 | 5.24 | 3.91 | 56.81 | 86.25 | 686.30 | 11.48 | 316.67 |
| Sem | 1.08 | 0.38 | 0.19 | 0.16 | 2.93 | 0.64 | 35.11 | 0.27 | 11.56 |

*N= Nitrogen, P= Phosphorus, K= Potash, VC= Vermi-compost, CV= Critical Variance, CD= Critical Deference, Sem= Stender Mean Error, GM= Grant Mean, Control (without fertilizers) respectively where as the minimum 79.33 days taken to fruit maturity was recorded in $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg $ha^{-1}$) treatment. The deficiency of major nutrients stunted the plant growth, resulting in prolonged time taken to fruit setting. The least days taken to fruit maturity are beneficial for obtaining earlier yield of cucumber (Waseem *et al.,* 2008).

Different levels of nitrogen, phosphorus and potash fertilizers have a significant effect on the yield g $plant^{-1}$, kg $plot^{-1}$ and quintal $ha^{-1}$. Fertilizer treatment $T_{19}$ (nitrogen, phosphorus and potash 120:40:60 kg $ha^{-1}$) increased the yield up to 789.33 g $plant^{-1}$, 13.41 kg $plot^{-1}$ and 370.26 quintal $ha^{-1}$, followed by $T_{16}$ (nitrogen, phosphorus and potash 80:70:60 kg $ha^{-1}$) with 725.67 g $plant^{-1}$, 12.44 kg $plot^{-1}$ and 344.78 quintal $hectare^{-1}$, respectively; whereas control has produced the least (599.50 g $plant^{-1}$, 10.14 kg $plot^{-1}$ and 264.85 quintal $ha^{-1}$) nitrogen, phosphorus and potash doses have a significant effect on yield g $plant^{-1}$, kg $plot^{-1}$ and quintal $ha^{-1}$. Naeem *et al.* (2002) reported that different dozes of nitrogen, phosphorus and potash behaved significantly different for total yield. Likewise, Jilani *et al.* (2008) reported that nitrogen application @ 100 kg $ha^{-1}$ significantly increased brinjal yield. Bahuguna *et al.*, (2013) obtained maximum yield of pea of 90 kg phosphorus and 60 kg potash per hectare.

Nitrogen, phosphorus and potash had positive effect on growth and yield of capsicum as it enhanced capsicum production. Amongst different levels of nitrogen, phosphorus and potash, application of nitrogen, phosphorus and potash @120: 40: 60 kg $ha^{-1}$ is the optimum dose for getting maximum production of capsicum per hectare.

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