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Influence of nitrogen and potassium on growth and yield of chilli (*Capsicum annuum* L.)

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Abstract

The present investigation was conducted during 2019-20 and 2020-21 to study the effect of nitrogen and potassium on growth, yield of chilli. The experiment was conducted in randomized complete block design and replicated thrice. The experiment comprised twelve treatments combination of four nitrogen doses (0, 75, 100 and 125 kg/ha) and three potassium (0, 30 kg /ha as basal and KNO_3 @ 2% as spray). Two equal splits of nitrogen i.e., one at the time of transplanting and remaining at first picking were applied in case of 75 kg/ha N. However, for 100 and 125 kg N/ha application was applied in three equal splits i.e., first at the time of transplanting, second and third at first and third picking of chilli. Foliar application of KNO_3 was applied thrice i.e., at the time of flowering, first and third picking of chilli. Potassium nitrate (KNO_3) @ 2% along with nitrogen 100 kg/ha and potassium 30 kg/ha was proved to be significantly higher in growth and yield contributing parameters such as plant height, leaf area index, days to 50% flowering, average fruit weight, and number of fruits/plant. There was higher green and red ripe fruit yield of 8-18 % and 20-22 % respectively in chilli during both seasons. So, 100 kg nitrogen per hectare in three splits and 30 kg potassium per hectare along with three foliar sprays of KNO_3 @ 2% in chilli was proved suitable for production of chilli under North Indian conditions.

Keywords: Chilli, Nitrogen, Potassium, Foliar Application, Days to 50% flowering

Introduction

Chilli also known as hot pepper (*Capsicum annuum* var. *annuum* L.) is an important vegetable as well as cash crop in India. It belongs to family Solanaceae and originated in the tropics and subtropics of America (Dhaliwal 2015). Chilli is famous for its nutritional value, medicinal effects and therapeutic uses; in addition it is being used as an organic coloring and flavoring agent in food industry. The fresh green chilli fruits are outstanding source of vitamin A and C (292 IU /100g and 67 mg / 100g) due to several carotenoid viz- chlorophyll, pro-vitamin A, carotene and oxygenated carotenoids such as capsanthin and cryptocapsin (Deepa et al. 2007). The green chilli contain moisture, protein, mineral, fiber, fat, carbohydrate, energy, Ca, P, Fe, thiamine, carotene, Capsaicin, niacin, riboflavin, Nordihydrocapsaicin and Dihydrocapsaicin as well as large number of polyphenolic compounds or flavonoids. It has annual trade of almost 17% of overall spice trade in the world and become most important spice crop of the world (Ahmed et al. 2000).

Nutrients play an indispensable part in plant growth and development. Different nutrients have different physiological and biochemical roles in plant system. Nutrients in the soil can be supplemented through the application of fertilizers or manures. Crop yield reduces over time if soil is not replenished with nutrients. Among plant nutrients, nitrogen and potassium have a great effect in this respect. Nitrogen is essential for building up proteins and protoplasm which encourage initial meristematic activity and cell division when applied in ideal quantity (Singh and Kumar 1999). Nitrogen application to chilli peppers exhibited an important role for rise in plant growth parameters, color and nutritive value of leaves and yield (Hussein 2017). Crucial role of nitrogen for being the integral part of all amino acids in proteins and lipids, the structural complexes of cells and chloroplast made it the most important macronutrient for better plant formation and proper growth (Uddin et al. 2003).

On the other hand, Potassium is one of most essential nutrients, supplying 6% of plant dry weight (Hartz et al. 1998). In spite of, potassium is not a component of any organic molecule or plant part, it plays a chief role in various biochemical and physiological processes (Chauhan 2012). It affects different fruit characters such as shape, taste, colour, size and shelf life. Potassium

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also plays a main role in crop quality, size of fruit and stimulates root growth. It is also called quality nutrient because it has important effects on quality traits of plants. Potassium nitrate is a water soluble potassic fertilizer containing 44% K_2O and 13% N suitable for foliar fertilization. The foliar spray of potassium nitrate in chilli considerably increases the growth and yield parameters by influencing various physiological and biochemical activities namely water uptake, root growth, turgor pressure, transpiration and stomatal behavior. Attempts have been made through the present investigation to determine the optimum levels of nitrogen and potassium which would be best for the growth and yield of chilli.

Materials and Methods

The investigation was conducted at the Research farm of Vegetable Science, PAU, Ludhiana during 2019-20 and 2020-21. The cultivar 'CH-27' comprises the plant material. The experiment was conducted in randomized complete block design and replicated thrice. The nursery of chilli crop was sown on 16th November 2019 and 13th November 2020 for the production of seedlings which were transplanted on 18th of February 2020 and 10th February 2021 for two seasons respectively. The crop was irrigated by furrow irrigation system. Rest cultural practices were followed as per standard agronomic practices. The experiment comprised twelve treatments combination of four nitrogen doses (0, 75, 100 and 125 kg /ha) and three potassium (0, 30 kg /ha as basal and KNO_3@ 2% as spray). Two equal splits of nitrogen i.e., one at the time of transplanting and remaining at first picking were applied in case of 75 kg/ ha. However, for 100 and 125 kg /ha application was applied in three equal splits i.e., first at the time of transplanting, second and third at first and third picking of chilli. Foliar application of KNO_3 was applied thrice i.e., at the time of flowering, first and third picking of chilli. Pooled data of all seasons was analyzed by CPCSI software. Growth related parameters i.e., plant height after 30, 60, 90, 120 and 150 days of transplanting, leaf area index, days taken to 50% flowering, and yield related parameters i.e., average fruit weight, number of fruits per plant, green fruit yield, red ripe fruit yield were studied during the research for both the seasons.

Results and Discussion

Plant height: Plant height is an important parameter depicting the health of the plant. The data pertaining to the effect of different treatments on plant height of chilli at 30, 60, 90,120 and 150 DAT is presented in Table 1. Data of plant height showed that maximum plant height after 30, 60, 90, 120 and 150 days of transplanting was observed with treatment T_9 (100 kg/ ha of N (Three

Table 1: Effect of different treatments on periodic plant height (cm) of chilli at 30, 60 and 90 days after transplanting

S. No.	Treatment	30 DAT			60 DAT			90 DAT			120 DAT			150 DAT		
		2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean	2019-20	2020-21	Mean
T_1	0 kg/ ha of N + 0 kg/ ha of K	13.4	12.5	12.9	26.9	24.3	25.6	64.1	63.1	63.6	77.3	78.2	77.8	83.0	91.9	87.5
T_2	0 kg/ha of N + 30 kg/ ha of K	14.9	15.2	15.1	30.1	25.7	27.9	65.6	64.1	64.9	80.6	79.3	80.0	85.3	94.7	90.0
T_3	0 kg/ ha of N + 30 kg/ ha of K + 3 foliar sprays of KNO_3@ 2%	15.1	18.2	16.6	30.7	32.3	31.5	65.7	68.6	67.2	81.1	83.8	82.4	86.7	96.8	91.8
T_4	75 kg of N (Two split doses) + 0 kg/ha of K	15.0	17.7	16.3	30.3	28.7	29.5	65.7	66.4	66.0	80.9	81.6	81.2	85.9	96.2	91.1
T_5	75 kg of N (Two split doses) + 30 kg/ha of K	15.1	20.3	17.7	30.7	34.3	32.5	65.7	69.4	67.6	81.5	84.6	83.1	87.7	98.0	92.9
T_6	75 kg of N (Two split doses) + 30 kg/ha of K +3 foliar spray of KNO_3 @ 2%	20.1	20.7	20.4	33.2	39.3	36.3	71.5	75.1	73.3	83.4	90.3	86.9	91.1	105.9	98.5
T_7	100 kg/ha of N (Three split doses) + 0 kg/ha of K	16.5	21.3	18.9	32.0	37.2	34.6	67.1	73.2	70.2	81.8	88.2	85.0	88.8	99.9	94.3
T_8	100 kg/ha of N (Three split doses) + 30 kg/ha of K	17.9	22.2	20.0	32.4	38.5	35.5	68.5	74.2	71.4	82.3	89.4	85.9	89.1	101.9	95.5
T_9	100 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar sprays of KNO_3@ 2%	21.3	25.4	22.3	35.6	42.9	39.2	71.9	79.8	75.9	84.9	95.0	90.0	97.9	113.0	105.4
T_{10}	125 kg/ha of N (Three split doses) + 0 kg/ha of K	16.2	23.4	20.8	31.5	36.1	33.8	66.9	71.2	69.0	81.5	86.4	83.9	87.8	99.2	93.5
T_{11}	125 kg/ha of N (Three split doses) + 30 kg/ha of K	20.8	22.4	21.6	32.1	39.3	35.7	69.8	74.3	72.1	82.7	89.7	86.2	90.3	102.9	96.6
T_{12}	125 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar sprays of KNO_3@ 2%	20.9	22.1	21.5	33.9	40.0	37.0	71.5	76.8	74.2	83.9	92.0	87.9	93.5	107.5	100.5
	CD (P = 0.05)	2.85	2.9	3.5	2.3	3.5	4.3	2.5	5.3	4.5	3.7	3.5	5.4	3.6	4.4	6.5

split doses) + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) which was significantly higher from all other treatments. On the other hand, minimum plant height after 30, 60, 90, 120 and 150 days was witnessed with control (T_1). Plant height observed in treatment T_6, T_9 and T_{12} has found statistically at par with each other. The findings are in consonance with the observations of Kacha et al. (2008) that higher dose of nitrogen resulted in higher plant height as compared to other lower doses. Similarly, Mavengahama et al. (2003) and Dileep and Sasikala (2009) observed that incorporation of inorganic sources of nitrogen and potassium enhance plant height in chilli crop. Increment in plant height depends upon the rate of production of structural proteins in which nitrogen and potassium play an integral part. Higher the content of applied nitrogen and potassium, increases the production of amino acids which Synthesize proteins and thereby higher the plant height

Leaf area Index: Leaf area index plays an important role to determine the photosynthetically active area and transpiration area as well as acts as a primary trait in plant ecology to depict foliage cover around the plant. The impact of LAI on growth of a plant is prominent through various physiological process and biomass accumulation (Patil et al. 2018). The data pertaining to the effect of different treatments of nitrogen and potassium on leaf area index is presented in Table 2. Maximum leaf area index (3.79 and 3.74) was recorded with treatment T_9 (100 kg/ ha of N + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) during 2020-21 and in pooled data respectively, which was significantly higher from all of other treatments. Treatments T_{11} (3.66) and T_{12} (3.69) was recorded to be statistically at par with each other. But different treatments failed to show any significant effect on Leaf area index of chilli during 2019-20. Whereas, in pooled data, leaf area index with application of recommended dose of fertilizer (T_5) was recorded about 3.23 which was significantly higher from control (3.03). Ahmed and Al-Fraihat (2009) observed the same results where application of nitrogen at 100 kg/ha resulted in maximum leaf area index. Similarly, Akambi et al. (2007) revealed that increment in leaf area index was observed with increase in the dose of nitrogen. As nitrogen facilitates the production of amino acids which build up different structural proteins which in turn cause better growth of plant.

Days to 50 % flowering: Days to 50% flowering is very important for earliness and yield because plants that take minimum days for 50% flowering improve fruit number and fruit yield. Data related to effect of different doses of nitrogen and potassium on days taken to 50% flowering was shown in Table 2. Treatment T_{12} (125 kg/ ha of N (Three split doses) + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) resulted in earlier production of 50% flowering in chilli plants whereas maximum days taken to 50% flowering were observed in control. In this context, Hiremath et al. (2006) monitored positive results of potassium dose on early flowering and quality of flowers. Similarly, Bhuvaneswari et al. (2013) revealed that increment in the dose of nitrogen and potassium decreased the days to flowering. The reason being the promoting effect of potassium on translocation of water and food to flowering site and synthesis of photosynthates with the help of nitrogen.

Number of fruits per plant: Number of fruits per plant describes the plants' ability of fruit and flower production. Number of fruits per plant has correlation with fruit yield of chilli. Increase in the dose of nitrogen

Table 2: Effect of different treatments on Leaf Area Index and Days to 50% flowering of chilli

S. No.	Treatment	Leaf Area Index			Days to 50% Flowering		
		2019-20	2020-21	Pooled data	2019-20	2020-21	Pooled data
T_1	0 kg/ ha of N + 0 kg/ ha of K	3.0	3.1	3.0	76.5	74.5	75.5
T_2	0 kg/ha of N + 30 kg/ ha of K	3.0	3.1	3.1	76.0	74.5	75.3
T_3	0 kg/ ha of N + 30 kg/ ha of K + 3 foliar sprays of KNO_3@ 2%	3.2	3.3	3.2	75.7	77.2	76.4
T_4	75 kg of N (Two split doses) + 0 kg/ha of K	3.1	3.3	3.2	76.0	70.1	73.1
T_5	75 kg of N (Two split doses) + 30 kg/ha of K	3.2	3.3	3.2	75.5	72.7	74.1
T_6	75 kg of N (Two split doses) + 30 kg/ha of K +3 foliar spray of KNO_3 @ 2%	3.3	3.6	3.5	60.7	63.9	62.3
T_7	100 kg/ha of N (Three split doses) + 0 kg/ha of K	3.2	3.4	3.3	62.8	64.8	63.8
T_8	100 kg/ha of N (Three split doses) + 30 kg/ha of K	3.3	3.5	3.4	63.0	64.9	63.9
T_9	100 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar spray of KNO_3@ 2%	3.7	3.8	3.7	60.5	63.0	61.7
T_{10}	125 kg/ha of N (Three split doses) + 0 kg/ha of K	3.2	3.3	3.2	64.0	64.2	64.1
T_{11}	125 kg/ha of N (Three split doses) + 30 kg/ha of K	3.3	3.7	3.5	62.0	62.3	62.2
T_{12}	125 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar spray of KNO_3@ 2%	3.4	3.7	3.6	60.0	62.4	61.2
	CD (P = 0.05)	NS	NS	0.1	0.2	8.0	7.7

and potassium simultaneously increase the number of fruits per plant. As, minimum number of fruits were obtained with no fertilizer application (T_1). Whereas, maximum number of fruits were witnessed with treatment T_9 (100 kg/ ha of N (Three split doses) + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) which was significantly higher from rest of the treatments. During 2020-21, number of fruits per plant attained with treatment T_9 were 11.2% more than those obtained with recommended dose (T_5) and 21.46 % more than those obtained with no fertilizer application. Data related to this finding is shown in Table 3. Similar findings were observed in experiment of Leghari and Oad (2005) for number of fruits per plant. Kumar et al. (2010) reported that incorporation of nitrogen and potassium in chilli fields resulted in more number of fruits per plant than control, reason being the nitrogen and potassium are essential constituents of protoplasm which is needed for quality fruit set.

Average fruit weight (g): Average fruit weight is directly and positively related with fruit yield. To promote the yield of chilli crop average fruit weight has a major role to play. Increment in average fruit weight also increases the yield. Data pertaining to average fruit weight is shown in the Table 3. Treatment T_9 (100 kg/ ha of N (Three split doses) + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) resulted in maximum average fruit weight which was significantly higher from rest of the treatments but different treatments failed to show any noteworthy effect on average fruit weight of chilli during first year trial i.e., 2019-20. Average fruit weight obtained with treatment T_6, T_9, T_{11} and T_{12} was found to be statistically at par with each other. Fruit weight obtained with control (T_1) was recorded lower than recommended dose. The results are in conformity with the findings Gupta and Sengar (2000) and Satpal and Saimbhi (2013) in which, noteworthy improved average fruit weight was noticed with increased dose of nitrogen and potassium fertilizers. Nitrogen is an integral part of chlorophyll where most of the photosynthesis occurs and all the photosynthates prepared during photosynthesis are translocated with the help of potassium at sink which are generally fruits, resulted in increase in fruit weight.

Green fruit yield (q/ha): The yield is also an important criterion for comparing the efficiency of different treatments. The data regarding the effect of different treatments on green fruit yield is presented in Table 3. Chilli green fruit yield attained with treatments T_6 and T_9 was statistically similar. Whereas maximum yield was attained with T_9 (100 kg/ ha of N + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) which was significantly

Table 3: Effect of different treatments on number of fruits per plant, average fruit weight, green fruit yield (q/ha) and red fruit yield (q/ha) of chilli

S. No.	Treatment	Number of fruits per plant			Average fruit weight			Green fruit yield (q/ha)			Red fruit yield (q/ha)		
		2019-20	2020-21	Pooled Data	2019-20	2020-21	Pooled data	2019-20	2020-21	Pooled Data	2019-20	2020-21	Pooled Data
T_1	0 kg/ ha of N + 0 kg/ ha of K	665.1	651.5	658.3	4.3	4.1	4.2	206.0	201.4	203.7	188.1	176.5	182.3
T_2	0 kg/ha of N + 30 kg/ ha of K	671.6	655.7	663.7	4.3	4.3	4.3	206.5	213.6	210.1	199.3	187.6	193.4
T_3	0 kg/ ha of N + 30 kg/ ha of K + 3 foliar sprays of KNO_3@ 2%	702.7	680.9	691.8	4.4	4.6	4.5	226.3	229.9	228.1	208.5	204.0	206.2
T_4	75 kg of N (Two split doses) + 0 kg/ha of K	678.7	681.1	679.9	4.4	4.4	4.4	209.3	215.6	212.4	205.9	193.6	199.8
T_5	75 kg of N (Two split doses) + 30 kg/ha of K	707.5	711.7	709.6	4.5	4.7	4.6	231.1	252.7	241.9	210.6	218.7	214.6
T_6	75 kg of N (Two split doses) + 30 kg/ha of K +3 foliar sprays of KNO_3 @ 2%	741.5	751.9	746.7	4.6	4.8	4.7	255.9	265.5	260.7	237.9	252.2	245.1
T_7	100 kg/ha of N (Three split doses) + 0 kg/ha of K	724.0	711.3	717.7	4.6	4.7	4.6	241.0	235.9	238.5	224.9	228.7	226.8
T_8	100 kg/ha of N (Three split doses) + 30 kg/ha of K	725.2	724.5	724.9	4.6	4.6	4.6	243.3	245.9	244.6	225.9	242.9	234.4
T_9	100 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar sprays of KNO_3@ 2%	773.8	791.4	782.6	4.7	5.0	4.9	273.8	273.4	273.6	253.8	263.8	258.8
T_{10}	125 kg/ha of N (Three split doses) + 0 kg/ha of K	718.6	704.5	711.5	4.5	4.5	4.5	232.5	232.7	232.6	213.9	222.5	218.2
T_{11}	125 kg/ha of N (Three split doses) + 30 kg/ha of K	729.8	721.1	725.5	4.6	4.8	4.7	249.0	246.3	247.7	231.6	248.2	239.8
T_{12}	125 kg/ha of N (Three split doses) + 30 kg/ha of K + 3 foliar sprays of KNO_3@ 2%	768.5	759.5	764.0	4.7	4.9	4.8	260.9	251.0	256.0	246.2	253.6	249.9
	CD (P = 0.05)	55.7	55.7	55.7	55.3	NS	0.3	0.2	23.6	17.4	15.2	17.4	21.8

higher than that attained with all other treatments. The results are in conformity with the findings of Sajid et al. (2001) increased dose of nitrogen and potassium up to certain level increased green yield of chilli further increasing dose can adversely affect yield. Similar results were found by Ambare et al. (2005) in okra.

Red fruit yield (q/ha): Red fruit yield is the measure of total quantity of red fruits produced per hectare of land. It is determined by total fruit length, number of fruits and fruit weight. Fruit yield is the combined effect of many parameters by which effect of those parameters can be detected. It helps us to understand the various factors that limit the adaptability of crop plant. During both seasons and in pooled data the maximum yield recorded with T_9 (100 kg/ ha of N + 30 kg/ ha of K + 3 foliar spray of KNO_3@ 2%) was significantly higher than that attained with rest of the treatments. During 2019-20, treatment T_6, T_9, T_{12} and during 2020-21, treatment T_6, T_8, T_9, T_{10}, T_{11} and T_{12} were found to statistically at par with each other. The reason might be the presence of N and K as a primary nutrient in plant system. Yield of a plant depends upon the amount of biomass produced and translocated through plant system. Here, Nitrogen and potassium both plays fundamental role in all the metabolic and physiological processes to increase yield. The data pertaining to this trait has been shown in Table 3. The findings are in consonance with the observations of Aminifard et al. (2010) and Reddy et al. (2013).

To conclude, application of potassium nitrate (KNO_3) @ 2% along with N @ 100 kg/ ha (Three split doses) and potassium @ 30 kg/ ha was proved to be beneficial in all aspects such as growth and yield. The yield parameters such as number of fruits per plant, average fruit weight and green along with red fruit yield were also at their maximum due to interactive effect of KNO_3. Foliar spray of KNO_3@ 2% showed overall better performance than top dressed fertilizers alone.

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वर्तमान अध्ययन वर्ष 2019–20 और वर्ष 2020–21 के दौरान मिर्च के विकास और उपज पर नत्रजन और पोटैशियम के प्रभाव को ज्ञात करने के लिए किया गया। इस प्रयोग को पूर्ण–रूप से यादृच्छित खण्ड विन्यास में आयोजित कर 3 बार प्रतिकृति किया गया। प्रयोग में 12 उपचारों को शामिल किया गया जिनमें नत्रजन की 4 मात्रा (0, 75, 100 और 125 किग्रा. प्रति हेक्टेयर) और पोटैशियम की 3 मात्रा (0, 30 किग्रा. प्रति हेक्टेयर आधारित और पोटैशियम नाइट्रेट की 2 प्रतिशत का पत्तियों पर छिड़काव) का संयोजन किया गया। कुल 75 किग्रा. नत्रजन प्रति हेक्टेयर को दो बराबर भागों अर्थात् एक पौध रोपण के समय और शेष पहली तुड़ाई के समय प्रयोग किया गया। हालांकि, 100 तथा 120 किग्रा. प्रति हेक्टेयर को तीन बराबर भागों अर्थात् पहली बार पौध रोपण के समय, दूसरी और तीसरी बार की मात्रा को मिर्च की पहली तथा तीसरी तुड़ाई के समय प्रयोग किया गया। पोटैशियम नाइट्रेट के उपयोग को तीन बार– पुष्पन के समय तथा मिर्च की पहली और तीसरी तुड़ाई के समय किया गया। पोटैशियम नाइट्रेट की 2 प्रतिशत का 100 किग्रा. नत्रजन और 30 किग्रा. पोटैशियम के उपयोग से विकास और उपज योगदान मापदंडों जैसे– पौध की लम्बाई, पत्ती क्षेत्र सूचंकाक, 50 प्रतिशत पुष्प आने के दिन, फलों का औसत भार और प्रति पौध फलों की संख्या में बढ़त्तरी पायी गयी। इसके साथ ही हरे और लाल रंग के पके फलों की पैदावार में क्रमशः 8–18 प्रतिशत और 20–22 प्रतिशत, दोनों मौसमों में बढ़ोत्तरी हुयी। इसलिए, उत्तर भारत की परिस्थितियों में मिर्च के उत्पादन हेतु 100 किग्रा. नत्रजन प्रति हेक्टेयर को 3 भागों में तथा 30 किग्रा. पोटैशियम के साथ तीन बार पोटैशियम नाइट्रेट की 2 प्रतिशत का छिड़काव सबसे उपयुक्त पाया गया।

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