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Suman kumar Das
M.Sc.(Horti) Vegetable Science Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, Uttar Pradesh, India

Vijay Bahadur
Associate Professor and Head Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, Uttar Pradesh, India

Devi Singh
Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Suman kumar Das
M.Sc.(Horti) Vegetable Science Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, Uttar Pradesh, India

Effect of different quantities of NPK and plant spacing on plant growth, yield and quality of chilli (*Capsicum annum* L.)

Suman Kumar Das, Vijay Bahadur and Devi Singh

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Abstract
A present investigation was carried out at the central research farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during Rabi season, 2023-24 with a view to identify the effects of different level of NPK and its role in growth, yield and quality of Chilli variety Ghoomar F1. The experiment was laid in the randomized block design with 3 replications and 10 treatment. Different quantities of fertilizer used of NPK(120:80:80) recommended and I increased the quantity N:P:K 15:15:15 kg/ha, N:P;:K 20:20:20 kg/ha and N:P:K 25:25:25 kg/ha. From the above experimental finding it may be concluded that the treatment (T8) N:P:K 25:25:25 kg/ha and spacing (60x45 cm).was found to be best in the terms of growth, plant height, days to first flowering, days to 50% flowering, number of fruits per plant and in terms of yield, average fruit weight, Yield per Hectare and in terms of quality, TSS and Ascorbic acid.

Keywords: Achari chilli, NPK, Spacing

Introduction
Chilli can be grown on a wide range of soils but well drained loamy soil rich in organic matter is best suited for its cultivation. It can not withstand water-logged conditions for more than a day. Although chilli can be grown on soils with a pH range of 5.0 to 8.0 but it performs best at a soil pH of about 6.5.

Chilli is famous for its pleasant aromatic flavor, pungency and high coloring substance. It is vegetable as well as spice and one of the most important cash crops of India. It is used for industrial purpose due to extraction of oleoresin. Green fruit of Chilli and sweet peppers are one of the richest sources of anti-oxidants, vitamins such as Vitamin-A, C and E, these anti- oxidants in food protect occurrence of cancer and instant pain relief. One of the most expensive commercial annual spices grown in India is this one. Capsaicin is the compound that gives chillies their pungency. Despite the fact that chili is a highly prized item. Chilli has a great nutritious value. Oleoresins, which allow for a greater distribution of color and flavor in food than chili powder, have also grown in relevance in the food and beverage industries. In addition to being used as a culinary ingredient, chilli is also used for a number of medical conditions. The regular use of chillies promotes salivation, which aids in healthy blood circulation and efficient digestion. Pharmaceutical preparations and medications for heart disorders use the capsaicin derived from ripe dried fruits.

Chilli pepper (*Capsicum annuum* L.) is an important spice and cash crop in many countries of the world. Growing vegetable demand could be achieved through bringing additional area under cultivation crops, using hybrid crops and adoption of improved agrotechniques. Protected cultivation of vegetables could be used to improve yield, quantity and quality3&13. Vegetables grown under field conditions are exposed to abiotic and biotic stress which affects productivity and quality. Protected cultivation has the potential to reduce biotic and abiotic stress. A low tunnel structure can modify environmental conditions with reduced labor. Understanding the impact of NPK fertilizers on chilli is not only crucial for farmers and growers but also for consumers.

The quality and nutritional composition of chilli can be directly influenced by the application of NPK fertilizers, ultimately affecting its taste, texture, appearance, and overall market value. Therefore, this research contributes to both agricultural practices and consumer 4 preferences, providing valuable knowledge for sustainable and efficient chilli production. Therefore, this thesis aims to investigate the effect of different levels of NPK fertilizers on the growth, yield, and quality of chilli. The study will evaluate the impact of varying concentrations of NPK fertilizers on the plant's physiological parameters such as height, leaf area, chlorophyll content, and biomass production. Additionally, the research will investigate the influence of NPK fertilizers on the quality and yirld of chilli, including its vitamin and mineral content. The findings of this study will provide valuable insights into the optimal use of NPK fertilizers for chilli production, allowing growers to maximize their yield and quality while minimizing environmental impact and production costs. In conclusion, investigating the effect of different levels of NPK fertilizers and plant spacing on chilli growth, yield, and quality is essential for optimizing agricultural practices, meeting consumer demands for nutritious food, and maintaining environmental sustainability. This thesis intends to bridge the existing knowledge gap, providing valuable insights into the application of NPK fertilizers in chilli production and serving as a foundation for further research in this field.

Materials and Methods

The present investigation entitled “Effect of different level of NPK and plant spacing on growth, Quality and yield of chilli (*Capcicum Annuum* L). will be carried out. The details of the materials to be used and methodology to be adopted during the course of study are mentioned below:-

Experimental Site

The experiment was conducted during kharif season of the year 2023–24 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj. The experimental site is located in the sub–tropical region which is located at 250. 271 N latitude, 810. 561 E longitude and 98 m above the mean sea level.

Climate

Prayagraj is situated at an elevation of 78 meters above sea level at 25.870 North latitude and 81.150 E longitudes. This region has a sub- tropical climate prevailing in the South-East part of U.P. with both the extremes in temperature, i.e., the winter and the summer. In cold winters, the temperature sometimes is as low as 2 °C in December – January and very hot summer with temperature reaching up to 50 °C in the months of May and June. During winter, frosts and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4 (cm) with maximum concentration during July to September months with occasional showers in winters

Table 1: Details of treatment combination

Treatment Symbol	Treatment Combination
T_0	CONTROL (RDF) NPK (120:80:80 kg/ha)
T_1	NPK 15:15:5 kg+ RDF and plant spacing (55x40 cm)
T_2	NPK 15:15:15 kg+RDF and plant spacing (60x50 cm)
T_3	NPK 15:15:5 kg+RDF and plant spacing (65x55 cm)
T_4	NPK 20:20:20 kg +RDF and plant spacing (55x40 cm)
T_5	NPK 20:20:20 kg+RDF and plant spacing (60x45 cm)
T_6	NPK 20:20:20 kg+RDF and plant spacing (65x50 cm)
T_7	NPK 25:25:25 kg+RDF and plant spacing (55x40 cm)
T_8	NPK 25:25:25 kg+RDF and plant spacing (60x45 cm)
T_9	NPK 25:25:25 kg+RDF and plant spacing (65x50 cm)

Note: RDF (Recommended dose of fertilizer), N (Nitrogen), P(Phosphorus),k(Potassium).

Statistical analysis: the statistical analysis of the data was carried out using STATISTICA (7.0) software.

Results and Discussion

Plant height (cm)

The fastest availability of nutrients, notably nitrogen, the primary nutrient of protein for the synthesis of protoplasm, which results in cell division and cell enlargement, may be the cause of the greatest plant height seen in the treatment T_8 NPK (145:105:105 kg/ha and spacing 60x45 cm). When NPK is applied to chilli plants, it is absorbed by the leaves and moves through the plant’s vascular system, where it acts on the plant cells by stimulating cell elongation and division. This can result in an increase in plant height, stem diameter, and leaf area. Similar findings were reported by Das *et al.* (2017). The influence of different NPK doses and spacing on the plant height shows statistically significant outcomes. That is much better from recommended RDF.

Number of primary branches

A significant difference was observed when various levels of NPK were applied to different treatment. The mean performance of the number of branches 6, 8 and 13. ment T_8 NPK (145:105:105 kg/ha and spacing 60x45 cm) had the most branches, with 13 followed by T0 -NPK (120:80:80 kg/ha), with 2,3.33and 7.67, respectively. When NPK is applied to chilli plants, it is absorbed and increase the metabolic activities which further increases the number of branches by promoting the formation of new lateral shoots and inducing the formation of floral buds. Similar findings were reported by Sharma *et al.* (2017) [11]. There were influenced by treatment shows that proper spacing and fertilizer dose make huge difference in the number of branches of chillii crop.

Numbers of fruits per plant

The significant effect of application of various quantities of NPK, a substantial change in the number of fruits per plant was seen. The range of the mean fruit per plant performance was 9.2 to14.4. The highest recorded number of fruits was 14.4 for treatment T_8 NPK (145:105:105 kg/ha and spacing 60x45 cm) and T_0 Control as shown in while the remaining treatments were moderate. NPK improve the chances of successful fruit set by increasing the amount of pollen produced by the plant and improving pollination efficiency. Similar findings were reported

Khan *et al.* (2014) [7]. The influence by the treatment shows that if we maintain the production technology and add the treatment difference in our production method it will change the the number of fruit per plant also influence the yield.

Fruit length

When various quantities of NPK were applied, a substantial change in fruit length was seen. Fruit lengths varied in length on average from 13.3 cm to 19 cm. The longest fruit was measured under treatment T_8 - NPK (145:105:105 kg/ha and spacing 60x45 cm) at 19 cm, The shortest fruit was measured under treatment T_0 - Control at 9.2 cm as shown. Similar findings were seen in Length of the fruit directly influenced the weight of chilli. Directly affect the cost benefit ration of the crop and treatment T_8 was recommended as per the research.

Fruit girth

The significant effect of application of various quantities of NPK, a substantial change in fruit diameter was seen. Fruit diameters ranged from 1.1 cm to 4.1 cm on an average. Maximum fruit girth was reported during treatment T_8 - NPK (145:105:105 kg/hs and spacing 60x45 cm) at 5.07 cm While the focus might not be solely on fruit girth, it could include observations on fruit size as part of the overall assessment similar results were seen in the impact of N,P,K and spacing allow the crop to meat the maximum fruit grith. When plant spacing maintain properly it will help to plant proper vegetative growth and improve the quality of fruit.

Fruit weight

The application of various level of NPK, a substantial variation in average fruit weight was seen. Fruits ranged in weight from 21.7 g to 26 g. T_8 - NPK (145:105:105 kg/h a and spacing 60x45 cm) had the largest fruit weight, 26 g and minimum fruit weight Treatment T_0 - Control had the fruit length 21.7 g. Similar findings were seen in Sharma *et al.* (2017) [11]. The varying N,P,K doses and plant spacing shows significant affect. This can be explained by different substantial changes in the production technology help to the plant to properly grow and develop it will help maximum fruit bearing capacity of the plant also improve the fruit weight.

Yield/plant

With the application of various NPK levels, a substantial variation in yield and plant was seen. The range of the mean yield performance per plant was 156.3 g to 306.7 g. Treatment T_8 - NPK (145:105:105 kg/ha ans spacing 60x45 cm) recorded the highest yield per plant 306.7 g, Treatment T0 - Control had the lowest yield per plant, 156.3 g. When applied to chilli plants, NPK can stimulate cell division and elongation, promote branching and lateral shoot growth, and delay the ripening of fruits. These effects can increase the overall size and weight of the plant, as well as the number of fruits produced. Similar findings were reported by Akther *et al.* (2016). It **is** similar as fruit weight if the fruit weight influence by the treatment yield per plant also improve. That is help to the farmer to gain maximum return.

Yield/ha

With the application of various level of NPK, a substantial change in yield/ha was seen. The average production per hectare ranged from 56.4 to 115.5 q/ha were T_8 - NPK (145:105:105 gh/ha and spacing 60x45 cm), with maximum value of 115.5 q/ha. The treatments with the lowest yield per hectare were T0 - Control, with a value of 56.4 q/ha. When applied to chilli plants, NPK can stimulate cell division and elongation, promote branching and lateral shoot growth, and delay the ripening of fruits. These effects can increase the overall size and weight of the plant, as well as the number of fruits produced. Similar findings were reported by Basumatary *et al.* (2016). Yield/ha change because of might be associated by the proper utilization of nutrient and spacing improve the growth, yield and quality of chilli.

TSS (0Brix)

When various levels of NPK were applied to TSS, a substantial difference was seen. With a mean of 3.66, the mean performance on TSS ranged from 3 to 6. TSS was reported as having a maximum of 6 for treatment T_8 - NPK (145:105:105 kg/ha and plant spacing 60x45 cm) and a minimum of 3 for treatment T0 - NPK (120:80:80). In terms of TSS there is no huge different in the qualitative parameter influenced by different fertilizer application and spacing.

Table 2: Effect of different quantities of NPK and plant spacing on plant growth, yield and quality of chilli.

Sr no.	Treatments	Days to Germination	Plant height (cm)		
			30DAT	60DAT	90DAT
T_0	CONTROL (RDF) NPK (120:80:80 kg/ha)	7.0	23.69	39.36	60.70
T_1	NPK 15:15:5 kg+ RDF and plant spacing (55x40 cm)	7.1	24.40	40.04	61.04
T_2	NPK 15:15:15 kg+RDF and plant spacing (60x50 cm)	7.1	28.71	44.71	65.71
T_3	NPK 15:15:5 kg+RDF and plant spacing (65x55 cm)	7.2	28.69	44.74	65.41
T_4	NPK 20:20:20 kg +RDF and plant spacing (55x40 cm)	7.2	30.05	48.34	68.06
T_5	NPK 20:20:20 kg+RDF and plant spacing (60x45 cm)	7.3	28.73	48.39	72.03
T_6	NPK 20:20:20 kg+RDF and plant spacing (65x50 cm)	7.3	34.71	52.39	76.07
T_7	NPK 25:25:25 kg+RDF and plant spacing (55x40 cm)	7.4	38.76	54.03	78.73
T_8	NPK 25:25:25 kg+RDF and plant spacing (60x45 cm)	6.9	40.07	56.03	85.05
T_9	NPK 25:25:25 kg+RDF and plant spacing (65x50 cm)	7.7	39	55.03	84.07
F-Test		S	S	S	S
S. Ed. ±		0.11	1.72	2.45	3.16
CD at 5%		0.23	3.62	5.16	6.65
CV %		1.84	6.66	6.22	5.41

In this table we observed that maximum germination are found in (NPK=25 kg:25 kg: 25 kg and S=65 cmx50 cm) (T_9) i.e..7.7. and minimum germination are found in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e.. 6.9.

In this table we also observed that maximum plant height at 30,60 and 90 days is 40.07,56.03and 85.05 cm in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) and minmium plant height at 30,60 and 90 days is 23.69,39.36 and 60.70 cm in T0 control (RDF).

Table 3: Effect of different quantities of NPK and plant spacing on plant growth, yield and quality of chilli.

Sr no.	Treatments	Number of branches		Leaf area index	Days to 1st flowering	Days to 50% flowering
		60 DAT	90 DAT			
T_0	CONTROL (RDF) NPK (120:80:80 kg/ha)	3.33	7.67	93.11	50	54
T_1	NPK 15:15:5 kg+ RDF and plant spacing (55x40 cm)	4.00	8.33	97.65	46	53.7
T_2	NPK 15:15:15 kg+RDF and plant spacing (60x50 cm)	6.67	9.67	102.13	45.7	52
T_3	NPK 15:15:5 kg+RDF and plant spacing (65x55 cm)	6.33	10.67	109.15	46	52
T_4	NPK 20:20:20 kg +RDF and plant spacing (55x40 cm)	6.67	11.33	113.17	47.7	51
T_5	NPK 20:20:20 kg+RDF and plant spacing (60x45 cm)	7.33	12	109.19	48.7	51.7
T_6	NPK 20:20:20 kg+RDF and plant spacing (65x50 cm)	7.33	11.33	116.31	48.7	50.3
T_7	NPK 25:25:25 kg+RDF and plant spacing (55x40 cm)	7.00	12.33	124.89	47.3	50.7
T_8	NPK 25:25:25 kg+RDF and plant spacing (60x45 cm)	8.00	13.00	127.58	41	45.3
T_9	NPK 25:25:25 kg+RDF and plant spacing (65x50 cm)	7.67	12.67	125.27	42	47.7
F-Test		S	S	S	S	S
S. Ed. ±		0.88	1.08	5.88	1.48	1.92
CD at 5%		1.85	2.28	12.36	3.12	4.03
CV %		16.79	12.18	6.44	3.93	4.62

In this table we observed that maximum number of branch are found in (NPK=25 kg,25 kg, 25 kg and s=60 cmx45 cm) (T_8) at 60 and 90days i.e.. 8 and 13 and minimum nuber of branch at 60 and 90 days found in T0 control (RDF) i.e. 3.33 and 7.67.

In this table we also observed that maximum leaf area index found in(NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e..127.58 cm and day to first flowering and 50% flowering at(NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T8) i.e..41 &45.3 days and days to first flowering to 50% flowering maximum found in (T0) control (RDF)i.e.. 50and 54 days.

Table 4: Effect of different quantities of NPK and plant spacing on plant growth, yield and quality of chilli.

Sr no.	Treatments	Fruit length (cm)	Fruit Weight (g)	Fruit Girth (cm)	Fruit Diameter (cm)	No. of fruit/plant
T_0	CONTROL (RDF) NPK (120:80:80 kg/ha)	13.3	21.7	5.07	1.1	9.2
T_1	NPK 15:15:5 kg+ RDF and plant spacing (55x40 cm)	14.7	22	6	1.6	10.3
T_2	NPK 15:15:15 kg+RDF and plant spacing (60x50 cm)	15.5	21.9	6.80	2	10.6
T_3	NPK 15:15:5 kg+RDF and plant spacing (65x55 cm)	16.1	22.5	7.67	2.1	10.2
T_4	NPK 20:20:20 kg +RDF and plant spacing (55x40 cm)	16.1	22.7	7.40	2.9	10.3
T_5	NPK 20:20:20 kg+RDF and plant spacing (60x45 cm)	15.1	23.5	7.67	2.3	10.1
T_6	NPK 20:20:20 kg+RDF and plant spacing (65x50 cm)	16	23	7.13	3.6	10.7
T_7	NPK 25:25:25 kg+RDF and plant spacing (55x40 cm)	16.8	23.2	7.40	2.6	12
T_8	NPK 25:25:25 kg+RDF and plant spacing (60x45 cm)	19	26	10.13	4.1	14.4
T_9	NPK 25:25:25 kg+RDF and plant spacing (65x50 cm)	18	25.3	8.40	2.4	13.5
F-Test		S	S	S	S	S
S. Ed. ±		0.57	0.60	0.38	0.29	0.48
CD at 5%		1.19	1.26	0.79	0.61	1.01
CV %		4.32	3.16	6.27	14.28	5.28

In this table we observed that leaf length (cm) maximum in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 19 cm and minimum leaf length found in (T_0) control (RDF) i.e 13.3 cm.

In this table we observed that fruit weight(gm) maximum at (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 26 gm and minimum fruit weight found in (T_0) control (RDF)i.e 21.7. also observed that fruit girth (cm) maximum at (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 10.13 and minimum found in T0) control (RDF)i.e 5.07.

In this table we also observed that fruit dimeter(cm) maximun in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 4.1 and minimum in (T_0) control (RDF)i.e 1.1 and also observed that number of fruit per plant maximun in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 14.4 and minimum founf in (T_0) control (RDF) i.e 9.2

Table 5: Effect of different quantities of NPK and plant spacing on plant growth, yield and quality of chilli.

Sr no.	Treatments	Yield/plant (gm)	Yield/ha. (q/ha)	Ascorbic acid (mg/100 gm)	TSS (0Brix)
T_0	CONTROL (RDF) NPK (120:80:80 kg/ha)	156.3	56.4	93.11	3
T_1	NPK 15:15:5 kg+ RDF and plant spacing (55x40 cm)	196.7	88.4	97.65	3.3
T_2	NPK 15:15:15 kg+RDF and plant spacing (60x50 cm)	250	71.7	102.13	4
T_3	NPK 15:15:5 kg+RDF and plant spacing (65x55 cm)	190	59	109.15	4
T_4	NPK 20:20:20 kg +RDF and plant spacing (55x40 cm)	213.3	99.3	113.17	4.7
T_5	NPK 20:20:20 kg+RDF and plant spacing (60x45 cm)	243.3	89	109.19	5
T_6	NPK 20:20:20 kg+RDF and plant spacing (65x50 cm)	223.3	69.2	114.99	4.3
T_7	NPK 25:25:25 kg+RDF and plant spacing (55x40 cm)	240	104.4	115.69	5
T_8	NPK 25:25:25 kg+RDF and plant spacing (60x45 cm)	306.7	115.5	116.89	6
T_9	NPK 25:25:25 kg+RDF and plant spacing (65x50 cm)	260	79.4	113.67	5.3

F-Test	S	S	S	S
S. Ed. ±	26.23	1.42	5.11	0.61
CD at 5%	55.10	2.99	10.74	1.29
CV %	14.09	2.09	5.71	16.85

In this table we observed that yield per plant (gm) in maximum in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e 306.7 gm and minimum yield per plant found in (T_0) control (RDF) i.e.. 156.3 and also observed yield/ha maximum yield found in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e..115.5 qt/ha. And minimum yield found in (T0) control (RDF) i.e.. 56.4 qt/ha.

In this table we also observed that ascorbic acid, maximum found in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e..116.89 mg/100gm and minimum found in (T_0) control (RDF) i.e.. 93.11 and in this table we also mention observation of TSS maximum tss found in (NPK=25 kg:25 kg: 25 kg and S=60 cmx45 cm) (T_8) i.e.. 6 and minimum tss found in (T_0) control (RDF) i.e.. 3.

Conclusion

From the results of the aforementioned experiment, it can be inferred that the NPK treatment T_8 (145:105:105 kg/ha and spacing 60x45 cm) was best in terms of growth, including plant height, days until first flowering, days until 50% flowering, pod setting, and number of fruits per plant, as well as yield, including average fruit weight, yield per plant, yield per hectare, and quality, including TSS and fruit color, as well as physiological parameters, including. Economics-wise, the therapies T_8, T_7, T_4, T_5, and T_1 perform better than the remaining T_0, T_1, T_2, T_3 and T_9.

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