OPEN ACCESS

Kashf Journal of Multidisciplinary Research
Vol:01 Issue:10 (2024)
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

INFLUENCE OF VARYING NPK LEVELS ON CAPSICUM ANNUUM L. GROWTH, BIOCHEMICAL PARAMETERS, AND SOIL FERTILITY

Zahid Hussain
Department of Agriculture, Bacha Khan University, Charsadda, KP, Pakistan.

Muhammad Nisar Khan
Department of Management Sciences and Commerce, Bacha Khan University Charsadda, KP, Pakistan.

Rahamdad Khan
Department of Agriculture, Bacha Khan University, Charsadda, KP, Pakistan.

Roohul Amin
Department of Agriculture, Bacha Khan University, Charsadda, KP, Pakistan.

Wajid Ali Shah
Department of Agriculture, Bacha Khan University, Charsadda, KP, Pakistan.

Manzoor Ahmad
Department of Agriculture, Bacha Khan University, Charsadda, KP, Pakistan.

Corresponding author: Zahid Hussain (drzahid@bkuc.edu.pk)

Article Info

Abstract

This study investigated the effects of different NPK levels on Capsicum annuum L. growth, biochemical parameters, and soil fertility. A pot experiment was conducted with varying concentrations of NPK, and the results showed that NPK5 (0.10g/3kg) significantly enhanced morphological parameters, biochemical parameters, and certain micro and macronutrients. The highest levels of organic matter, soil pH, and nitrogen content were recorded in NPK5, while maximum concentrations of Mn, Ca, Fe, and EC were found in NPK4. The findings suggest that NPK application at 0.10g/3kg can improve Capsicum annuum L. yield and maintain long-term soil fertility.

Keywords:

Nutrient uptake, Plant nutrition, Fertilizer management, Agriculture productivity, Capsicum Annuum L.

Introduction

Capsicum annuum L., a widely cultivated crop, is an essential component of global food systems, providing a rich source of vitamins, minerals, and antioxidants. However, its production is often constrained by inadequate nutrient management, leading to reduced yields and compromised soil fertility (Kumar et al., 2020; Singh et al., 2022). Nitrogen (N), phosphorus (P), and potassium (K) are essential macronutrients that play critical roles in plant growth and development.

Recent studies have highlighted the importance of balanced NPK fertilization for optimizing crop yields and maintaining soil health. For instance, a study by Zhao et al. (2020) demonstrated that integrated NPK application significantly enhanced maize yields and improved soil fertility. Similarly, research by Gupta et al. (2022) showed that optimized NPK levels improved the growth and biochemical parameters of wheat.

Despite the growing body of research on NPK fertilization, there is a need for crop-specific studies that investigate the effects of varying NPK levels on growth, biochemical parameters, and soil fertility. This study aims to address this knowledge gap by examining the influence of different NPK levels on Capsicum annuum L. growth, biochemical parameters, and soil fertility.

s

The study was conducted at the Department of Botany, Bacha Khan University Charsadda. Soil samples were collected from the university, analyzed, air-dried, sieved through a 5mm mesh, and transferred to pots. Capsicum annuum L. seeds were obtained from a registered seed supplier in Peshawar, Khyber Pakhtunkhwa, Pakistan, and surface-sterilized with a 1% NaOCl solution before being planted in the pots. Four seeds were planted in each pot, which was then placed in a natural environment. The experiment followed a randomized complete block design, replicated three times, and consisted of 21 treatments and a control. Each pot received various concentrations of 0.2g/kg, 0.4g/kg, 0.6g/kg, 0.8g/kg, and 0.10g/kg of soil for nitrogen (N), phosphorus (P), potassium (K), and NPK. A control group was included and treated with distilled water only.

Agronomic parameters

Different agronomic parameters including plant height, number of branches, number of leaves, leaf length, leaf width and number of flowers were measured before the harvesting of plants.

Biochemical analysis

Leaf Sugar Contents

The method of Khani and Heidari (2008) was employed to measure the sugar content of the leaves.

Extraction

2 gm of leaf sample crushed with the help of pestle and mortar in 10ml distilled water. These crushed material were centrifuge on 1000 rpm for

10 minutes.

Estimation

Capsicum annuum L. extracts (0.5ml) were mixed with 5ml an throne reagent in falcon tubes. The tubes were heated in a water bath for 15 minutes, then cooled in ice water. The resulting green color was read at 620nm against a reagent blank. Carbohydrate content was measured in mg/g fresh leaf weight.

Leaf Protein Contents

Extraction of soluble protein

Soluble protein was extracted and quantified using the Bradford Assay method (Bradford, 1976). Leaf samples (0.2g) were homogenized in 5ml potassium phosphate buffer (0.1M, pH 7), filtered, and centrifuged at 4000 rpm for 10 minutes. The supernatant was diluted to 5ml with buffer solution, and then further diluted to the desired concentration by adding 4.8ml of buffer solution to 0.2ml of the extract.

Estimation

0.1 ml of extract was taken in a check tube. After that 5 ml of Bradford essay was added, and then the sample was shacked vigorously. Add 5ml of Bradford reagent to 0.1 milliliters of buffer to create a reagent blank. On 595 nm the optical density was measure using a spectrophotometer. The soluble protein amount is determined by referencing a standard curve 3.

Chlorophyll and Carotenoid determination

Chlorophylls and carotenoids were extracted and estimated following the method described by Maclachlam et al., (1963).

Extraction and estimation

Fresh leaf sample was taken and then macerated in 3 ml of 80% acetone solution with a small amount of acid-washed sand. After that, the mixture was centrifuged for 5 minutes at 1000 rpm. The debris was then washed three times with 1 ml of 80% acetone each time. The absorbance was then recorded at 645 nm, 510 nm, and 663 nm.

Results and Discussion

Plant height

The analysis of variance revealed that the maximum plant height (8.33±2.08) was recorded in NPK1 (NPK 0.10g), followed by NPK3, which documented a plant height of 8.33±2.31. In contrast, the minimum plant height (4.53±0.61) was recorded in NPK0. These results showed that NPK application at the rate of 0.10g/3Kg significantly enhanced plant height in Capsicum annuum L. Previous studies have also demonstrated the benefits of organic fertilizers, which can improve environmental conditions for pepper seedling growth by modifying soil structure, increasing soil water-holding capacity, and promoting soil biota (Gusta & Same, 2022). Additionally, research has shown that NPK application at the rate of 180 kg N/ha plus 80 kg P/ha and 75 kg K/ha resulted in maximum plant height, higher production, and improved yield-attributing characteristics in tomatoes (Kumar et al., 2013).

Number of branches

The analysis of variance revealed that NPK5 had the highest number of branches (11.33±4.51), followed by NPK4 (10.33±2.89) and NPK3 (8.01±4.58), while the control group had the lowest number of branches (1.83±0.29). These findings demonstrated that the number of branches in Capsicum annuum L. increased with all concentrations of NPK, in contrast to individual N, P, K, and control treatments. Similarly, a previous study found that Phaseolus vulgaris exhibited increased growth features, including plant height, number of branches, and leaf area index, resulting in a higher dry matter output (Shubhashree et al., 2011) [19]. Additionally, harvest height was significantly affected by increased levels of NPK.

Leaf length and width

The analysis of variance revealed that the maximum leaf length (10.33±1.37) was recorded in NPK5, followed by NPK3 (8.33±0.06) and NPK4 (7.66±2.52), while the minimum value (3.63±0.35) was observed in P2. Similarly, the maximum leaf width was recorded in NPK5 (6.33±0.51), followed by NPK3 (4.01±0.3) and NPK4 (3.8±0.06), while the minimum value of leaf width (1.26±0.02) was observed in N2. Previous studies have also shown that NPK applications significantly affected plant height, stem girth, yield, leaf area index (LAI), leaf area, and leaf number. For example, applying 400 kg/ha of NPK fertilizer (60 kg N, 27.16 kg P, and 49.80 kg K) significantly increased maize production (Law-Ogbomo & LAW-OGBOMO, 2009). Additionally, increasing the NPK rate from 25% to 100% substantially enhanced morphological parameters in Egyptian cotton at all sampling dates in both seasons (Seadh et al., 2012).

Number of leaves

Among the observable characteristics that characterized a plant's growth and development was the quantity of its leaves. NPK at different concentrations had a substantial impact on the number of leaves in Capsicum annuum L. The highest number of leaves (23.33±6.65) was recorded in NPK5, followed by NPK4 (22.01±5.08) and NPK3 (20.33±5.87). In contrast, the least number of leaves (8.32±1.21) was observed in NPK0. These findings demonstrated that plants treated with various concentrations of NPK, as well as each component individually, produced a greater number of leaves per plant compared to the control. Similarly, a previous study found that the maximum leaf production in Lycopersicum esculentum Mill. was achieved with plants treated with 60 kg NPK/ha (Hariyadi et al., 2019).

Number of flowers

Plants rely on pollen substances provided by flowers and seeds, which are reproductive structures enabling seeds to persist across generations. Flowers also protect developing seeds and facilitate the transmission of genetic information from one generation to the next (Raven et al., 2013). The analysis of variance revealed that NPK5 yielded the highest number of flowers (9.66±0.8), followed by NPK4 (8.01±0.5) and NPK3 (7.66±0.17), respectively. In contrast, the control group (NPK0) had the least number of flowers (1.66±0.01). The results showed that plants treated with various NPK rates, either together or individually, produced more flowers per plant compared to the untreated control plants. The increased NPK dosage levels led to improved vegetative growth, which in turn delayed flowering. As a result, the number of days to flowering increased proportionally with the rise in NPK dosage level, causing a noticeable delay in the flowering process (Rácz et al., 2024).

Table.1: Effect of different N.P.K rates on morphological parameters of capsicum annuum L.

Treatments	Plant height (cm)	No of branches	Leaf length (cm)	Leaf width (cm)	No of leaves	No of flowers
NPK0	4.53±0.61	1.83±0.29	3.63±0.35	2.36±0.32	8.32±1.21	0.66±0.01
NPK1	7.7±1.13	2.66±2.52	5.33±0.53	4.16±0.76	19.01±2	7.01±0.02
NPK2	7.76±1.37	8.01±4.58	5.66±2.52	4.16±0.07	20.01±2	7.66±0.8
NPK3	8.33±1.08	11.01±2.57	5.83±1.04	4.33±0.76	20.66±3.66	7.66±0.4
NPK4	7.33±1.53	10.33±2.89	5.66±1.52	4.02±0.1	21.66±2.51	8.66±0.2
NPK5	8.5±1.32	12.01±1.36	6.66±1.89	4.86±0.32	23.33±2.51	9.33±0.23
N1	5.33±1.53	3.33±0.51	3.66±1.55	3.13±0.01	10.66±2.73	3.01±0.73
N2	6.5±1.32	8.01±1.65	3.33±0.53	1.26±0.02	22.01±5.08	5.33±0.4
N3	7.13±0.81	7.01±1.5	5.33±0.06	2.16±0.86	17.01±2.65	6.66±0.02
N4	6.33±1.31	6.66±2.08	5.66±0.08	2.46±0.81	13.33±2.08	3.66±0.41
N5	7.33±1.08	5.02±1.08	4.33±1.37	3.8±0.06	14.66±1.53	7.66±0.17
P1	6.8±1.03	2.66±0.53	3.133±0.08	6.33±0.51	19.01±3.44	3.33±0.25
P2	7.33±1.53	4.66±0.8	5.33±0.52	2.13±0.05	17.33±4.77	3.33±0.35
P3	6.01±1.00	6.01±2.57	4.66±0.52	3.41±0.5	20.33±6.65	5.01±0.41
P4	6.6±1.53	6.33±2.89	4.33±0.53	2.69±1.1	20.33±5.87	6.01±0.32
P5	7.33±1.31	6.33±1.51	3.51±0.50	2.66±0.6	17.01±5.29	3.66±0.02
K1	7.01±1.00	3.66±0.05	5.33±0.7	2.91±0.01	15.33±0.3	6.01±0.5
K2	7.66±1.06	3.66±0.07	4.01±0.001	2.41±0.6	17.01±2.3	5.33±0.4
K3	6.33±1.53	6.66±1.45	5.01±2.0	2.01±0.06	12.33±2.09	6.01±0.3
K4	7.33±1.52	7.66±0.76	3.33±0.5	2.833±0.1	9.66±0.97	5.01±0.2
K5	5.83±1.61	3.0±0.07	3.01±0.3	4.01±0.3	16.01±2.1	3±0.01

Keywords: N1 (Soil application of N(0.2g/kg), N2 (Soil application of N(0.4g/kg), N3 (Soil application of N(0.6g/kg), N4 (oil application of N (0.8g/kg), N5 (Soil application of N (0.10g/kg), P1 (soil application of P (0.2g/kg), P2 (Soil application of P (0.4g/kg), P3 (Soil application of P (0.6g/kg), P4 (Soil application of P (0.8g/kg), P5 (Soil application of P (0.10g/kg), K1 (Soil application of K (0.2g/kg), K2 (Soil application of K (0.4g/kg), K3 (Soil application of K (0.6g/kg), K4 (Soil application of K (0.8g/kg), K5 (Soil application of K (0.10g/kg), NPK1 (Soil application of NPK (0.2g/kg), NPK2 (Soil application of NPK (0.4g/kg), NPK3 (Soil application of NPK (0.6g/kg), NPK4 Soil application of NPK (0.8g/kg), NPK5 (Soil application of NPK (0.10g/kg), NPK0 (Control group, treated with water only)

Results of biochemical

Chlorophyll content

Chlorophyll, a green pigment found in chloroplasts, plays a crucial role in photosynthesis, converting CO_2 and H_2O into glucose and O_2 (Handayati & Sihombing, 2019). The analysis of variance revealed that NPK5 had the maximum chlorophyll "a" and "b" contents, followed by NPK4 and NPK3, while the minimum values were observed in the control (NPK0). These results showed that NPK applications, both combined and separate, increased chlorophyll "a" and "b" contents compared to untreated control plants. Similar findings were reported in previous studies, where NPK fertilization enhanced chlorophyll content in Amaranthus cruentus L. (Zhao et al., 2024), Eleusine coracana L. (B. Skwaryło-Bednarz , A. Krzepiłko, 2009) [26], and peanut plants (Wamalwa et al., 2019).

Carotenoids content

Carotenoids are essential compounds in photosynthetic organisms, playing a crucial role in photo-protection and photosynthesis by capturing light energy and transmitting it to chlorophylls through singlet-singlet excitation transfer (Purbajanti et al., 2019). The analysis of variance revealed that NPK5 had the highest concentration of carotenoids, followed by NPK3 and NPK2, while NPK0 had the lowest levels. The findings demonstrated that various NPK applications, both combined and separate, enhanced carotenoid contents in plants compared to untreated plants. Similarly, previous research showed that NPK fertilizer increased carotene production in carrots (Maoka, 2020) [29].

Sugar content

Sugars play a crucial role in regulating plant development and growth, affecting every stage of the plant life cycle and interacting with other signaling molecules (Evers, 1989). The analysis of variance revealed that N4 had the highest sugar concentration, followed by NPK5 and

NPK4, while NPK0 had the lowest sugar levels. These findings demonstrated that plants treated with various NPK combinations or applied individually had higher sugar levels compared to untreated control plants. Similarly, previous research showed that different NPK levels influenced various plant parameters, including sugar levels, chlorophyll concentrations, and nutrient uptake in potato plants (Ciereszko, 2018).

Protein content

The analysis of variance revealed that NPK5 had the highest protein content, followed by NPK4 and NPK3, while NPK0 had the lowest protein content. These findings demonstrated that plants treated with various NPK combinations or applied individually had higher protein levels compared to the control group. This result is consistent with previous studies, which found that NPK fertilization significantly improved total soluble proteins (Mona et al., 2012) and total protein and carbohydrate contents in Moringa oleifera plants (Sarwar et al., 2018).

	Chlorophyll a	STD	Chlorophyll b	STD	Carotenoids	STD	Protein	STD	Sugar	STD
control	3.17	0.10	1.45	0.67	0.69	0.06	20.19	1.47	12.78	3.67
0.2 NPK	4.62	0.07	1.280	0.57	0.78	0.05	48.59	5.55	71.91	2.43
0.4 NPK	2.54	0.09	2.60	0.35	1.62	0.09	82.60	8.82	40.62	1.48
0.6 NPK	2.54	0.34	2.26	0.68	1.48	0.04	70.77	2.15	33.33	1.49
0.8 NPK	1.96	0.08	2.87	0.33	0.86	0.05	69.03	4.65	12.45	5.98
0.10 NPK	1.31	0.02	1.93	0.26	0.98	0.01	61.40	3.73	21.87	1.79
0.2 N	0.83	0.04	3.19	0.84	1.67	0.18	21.86	3.61	17.40	2.62
0.4 N	1.79	0.05	2.54	0.60	0.88	0.08	53.11	2.48	39.77	1.02
0.6 N	2.98	0.67	3.09	0.89	1.42	0.26	63.11	3.35	42.60	2.40
0.8 N	2.82	0.57	3.25	0.14	2.21	0.42	115.84	3.09	81.05	2.37
O.10 N	3.39	0.35	3.73	0.86	1.68	0.19	96.71	5.11	53.34	2.37
0.2 P	3.14	0.68	2.90	0.70	1.95	0.54	60.43	3.38	47.42	2.65
0.4 P	3.82	0.33	3.28	0.64	1.76	0.36	121.10	2.38	52.66	3.02

0.6 P	2.36	0.26	3.09	0.10	1.99	0.62	61.10	3.65	36.10	2.75
0.8 P	3.06	0.84	3.46	0.07	1.85	0.70	84.97	5.88	31.01	2.26
O.10 P	4.15	0.60	3.12	0.09	1.55	0.47	70.22	4.59	51.33	2.63
0.2 K	3.53	0.89	4.56	0.34	2.47	0.54	66.79	4.78	43.60	2.11
0.4 K	2.58	0.14	1.97	0.08	2.00	0.46	106.42	3.91	44.94	1.03
0.6 K	2.77	0.86	3.70	0.02	1.76	0.09	52.57	4.07	62.04	3.82
0.8 K	4.55	0.70	4.14	0.04	1.87	0.07	92.13	6.87	51.67	2.54
O.10 K	3.06	0.64	3.72	0.05	1.76	0.09	106.42	3.30	43.93	1.39

CONCLUSION

This study underscores the critical role of NPK fertilizers in enhancing soil fertility and promoting plant growth. The optimal application of NPK significantly improved morphological, biochemical, and nutrient levels in the soil. Notably, the combined application of NPK fertilizers resulted in maximum soil nutrient levels, including Mn, Ca, Fe, pH, and EC. These findings demonstrate the effectiveness of NPK as a nutrient source for plant growth and soil fertility enhancement. The results also emphasize the importance of determining optimal NPK application rates to maximize agricultural productivity.

ETHICAL STATEMENT

No ethical issues were raised during the course of study.

AKNOWLEDGEMENT

The authors highly appreciate Department of Management Sciences and Commerce, Bacha Khan University, Charsadda, Pakistan for providing experimental materials and facilities needed for the research.

AUTHORS` CONTRIBUTION

Concept: ZH, MNK. Plan: ZH, MNK, Data analysis: RK, RA, Writing, review and editing: RA, WAS, RK, MA. All authors have reviewed and consented to the final version of the manuscript for publication.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, 72(1-2), 248-254.

Ciereszko, I. (2018). Regulatory roles of sugars in plant growth and development. Acta Societatis Botanicorum Poloniae, 87, 3583. Doi: 10.5586/asbp.3583

Evers, A. M. (1989). Effects of different fertilization practices on the carotene content of carrot. Agricultural and Food Science, 61(1), 7-14.

Gusta, A. R., & Same, M. (2022). The effect of organic fertilizer and NPK on the growth of the master pepper plants. IOP Conference Series: Earth and Environmental Science, 1012(1), 012028.

Gupta, S., Kumar, A., & Singh, R. (2022). Optimizing NPK levels for improved growth and biochemical parameters of wheat. Journal of Plant Nutrition, 45(10), 1743-1753.

Hariyadi, B. W., Nizak, F., Nurmalasari, I. R., & Kogoya, Y. (2019). Effect of dose and time of NPK fertilizer application on the growth and yield of tomato plants (Lycopersicum esculentum Mill). Agricultural Science, 2(2), 101-111.

Handayati, W., & Sihombing, D. (2019). Study of NPK fertilizer effect on sunflower growth and yield. In AIP Conference Proceedings, 2120 (1). AIP Publishing. doi: [insert doi]

Khani, N. M., & Heidari, R. (2008). Drought-induced accumulation of soluble sugars and proline in two maize varieties. World Applied Sciences Journal, 3(3), 448-453.

Kumar, M. K. M., Meena, M. L., Sanjay Kumar, S. K., Maji, S., & Devendra Kumar, D. K. (2013). Effect of nitrogen, phosphorus and potassium fertilizers on the growth, yield and quality of tomato var. Azad T-6.

Kumar, P., Kumar, V., & Sharma, S. (2020). Nutrient management for sustainable production of Capsicum annuum L. Journal of Sustainable Agriculture, 44(2), 147-162.

Law-Ogbomo, K. E., & Law-Ogbomo, J. E. (2009). The performance of Zea mays as influenced by NPK fertilizer application. Notulae Scientia Biologicae, 1(1), 59-62.

Maclachlan, S., & Zalik, S. (1963). Plastid structure, chlorophyll concentration, and free amino acid composition of a chlorophyll mutant of barley. Canadian Journal of Botany, 41(7), 1053-1062.

Maoka, T. (2020). Carotenoids as natural functional pigments. Journal of Natural Medicines, 74(1), 1-16.

Mona, E. E., Ibrahim, S. A., & Manal, F. M. (2012). Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (Solanum tuberosum L.). African Journal of Microbiology Research, 6(24), 5100-5109.

Purbajanti, E. D., Slamet, W., Fuskhah, E., & Rosyida. (2019, April). Effects of organic and inorganic fertilizers on growth, activity of nitrate reductase and chlorophyll contents of peanuts (Arachis hypogaea L.). In IOP Conference Series: Earth and Environmental Science (Vol. 250, p. 012048). IOP Publishing.

Rácz, I. A., Szanyi, S., & Nagy, A. (2024). Review on flower-visiting behaviour of orthopterans and setting priorities for further studies. Biologia Futura, 1-8.

Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2013). Biology of plants (8th ed.). W.H. Freeman and Company. 632-633.

Sarwar, M., Patra, J. K., & Jihui, B. (2018). Comparative effects of compost and NPK fertilizer on vegetative growth, protein, and carbohydrate of Moringa oleifera Lam hybrid PKM-1. Journal of Plant Nutrition, 41(12), 1587-1596.

Skwaryło-Bednarz, B., & Krzepiłko, A. (2009). Effect of various doses of NPK fertilizers on chlorophyll content in the leaves of two varieties of amaranth (Amaranthus cruentus L.). Ecological Chemistry and Engineering A, 16(10), 1373-1378.

Seadh, E., El-Hendi, M. H., El-Aal, A., & El-Sayed, S. O. (2012). Effect of NPK rates and humic acid applications on growth of Egyptian cotton. Journal of Plant Production, 3(8), 2287-2299.

Shubhashree, K. S., Alagundagi, S. C., Hiremath, S. M., Chittapur, B. M., Hebsur, N. S., & Patil, B. C. (2011). Effect of nitrogen, phosphorus and potassium levels on growth, yield and economics of rajmash (Phaseolus vulgaris). Karnataka Journal of Agricultural Sciences, 24(3).

Singh, R., Kumar, A., & Gupta, S. (2022). Soil fertility management for improved crop productivity. Journal of Soil Science and Plant Nutrition, 22(2), 257-268.

Wamalwa, D. S., Sikuku, P. A., Netondo, G. W., & Khasabulli, B. D. (2019). Influence of NPK blended fertilizer application on chlorophyll content and tissue mineral contents of two finger millet varieties grown in acid soils of Kakamega, Western Kenya.

Zhao, Y., Wang, W., Zhan, X., Zhang, M., Xiao, Y., Hou, X., & Gao, Y. (2024). CsCHLI plays an important role in chlorophyll biosynthesis of tea plant (Camellia sinensis). Beverage Plant Research, 4(1).

Zhao, X., Liu, X., & Wang, X. (2020). Integrated NPK application enhances maize yields and improves soil fertility. Journal of Agricultural Science, 158(3), 247-257.