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Influence of NPK, vermicompost and biofertilizer on soil properties, growth and yield of cowpea (*Vigna unguiculata* L.) var kashi kanchan

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Abstract

The present investigation entitled “Influence of NPK, Vermicompost and Biofertilizer on Soil Properties, Growth and Yield of Cowpea (*Vigna unguiculata* L.) var. Kashi Kanchan” was conducted during the kharif season to evaluate the influence of different levels of NPK, vermicompost and biofertilizer on physical and chemical properties of soil, growth and yield attributes of cowpea. The experiment was conducted in a randomized block design (RBD) with three replications consisting of nine treatment combinations. The treatments comprised different levels of NPK, vermicompost and Azotobacter. T₀ (NPK @ 0% + Vermicompost @ 0% + Azotobacter @ 100%), T₁ (NPK @ 0% + Vermicompost @ 50% + Azotobacter @ 50%), T₂ (NPK @ 0% + Vermicompost @ 100% + Azotobacter @ 0%), T₃ (NPK @ 0% + Vermicompost @ 100% + Azotobacter @ 0%), T₄ (NPK @ 50% + Vermicompost @ 50% + Azotobacter @ 50%), T₅ (NPK @ 50% + Vermicompost @ 100% + Azotobacter @ 0%), T₆ (NPK @ 100% + Vermicompost @ 0% + Azotobacter @ 100%), T₇ (NPK @ 100% + Vermicompost @ 50% + Azotobacter @ 50%) and T₈ (NPK @ 100% + Vermicompost @ 100% + Azotobacter @ 0%)

The results revealed that the different levels of NPK, Vermicompost and Biofertilizer significantly influenced the physical and chemical properties of soil, growth and yield attributes of cowpea. The lowest bulk density (1.13 Mg m⁻³), highest pore space (51.17%) and water holding capacity (55.00%) were recorded under T₅ (50% NPK + 100% vermicompost + 0% Azotobacter). The maximum available nitrogen (286.12 kg ha⁻¹), available phosphorus (34.00 kg ha⁻¹) and available potassium (186.99 kg ha⁻¹) were recorded under T₈ (100% NPK + 100% vermicompost + 0% Azotobacter). The same treatment also recorded maximum plant height (75.33 cm), number of leaves per plant (38.01), number of pods per plant (10.90), pod weight per plant (24.00 g) and pod yield (73.34 q ha⁻¹). Thus, the integrated application of NPK and vermicompost was found effective in improving soil fertility, growth and productivity of cowpea var. Kashi Kanchan.

Keywords: NPK, vermicompost, azotobacter, soil properties, growth, yield, cowpea

Introduction

Soil is a vital natural resource that serves as the medium for plant growth and plays a crucial role in sustaining agricultural productivity (Lal, 2015) [9]. The physical and chemical properties of soil directly influence nutrient availability, water retention, root development, and microbial activity, which ultimately affect crop growth and yield (Leskovar, *et al.*, 2016). Soil health is increasingly recognized as a key component of sustainable agriculture, as it determines the capacity of soil to function effectively as a living ecosystem (Sahu, *et al.*, 2019). Nitrogen (N), phosphorus (P), and potassium (K) are primary macronutrients essential for plant growth and development. Nitrogen is involved in protein synthesis and vegetative growth, phosphorus plays a key role in energy transfer and root development, while potassium regulates enzyme activation, water balance, and stress tolerance. Adequate and balanced application of NPK fertilizers is therefore essential for achieving optimum crop growth and productivity (Brady and Weil, 2017; Fageria, 2014) [3]. Vermicompost is an important organic manure that contains essential plant nutrients and organic matter in readily available forms. Its application improves soil structure, aggregation, porosity, water holding capacity and microbial activity, while also contributing to the gradual release of nutrients. The combined use of organic manures and inorganic fertilizers can improve nutrient availability and soil fertility and may result in better crop growth and productivity compared

with the use of either source alone (Kannan *et al.*, 2005; Chettri and Bandhopadhyaya, 2005) ^[4, 8]. Biofertilizers also play an important role in sustainable nutrient management. *Azotobacter* is a free-living nitrogen-fixing microorganism that can contribute to biological nitrogen availability and produce growth-promoting substances. The use of biofertilizers in combination with organic and inorganic nutrient sources may improve nutrient use efficiency and support better plant growth. Integrated nutrient management involving chemical fertilizers, organic manures and beneficial microorganisms has therefore been considered an important approach for maintaining soil fertility and achieving sustainable crop productivity (Rajkhowa *et al.*, 2002; Ramesh *et al.*, 2006) ^[13,14]. Cowpea has a high potential to respond to improved nutrient management, particularly under conditions where soil fertility is limiting. The integration of NPK, vermicompost and biofertilizer may therefore provide a suitable approach for improving both soil health and crop productivity. However, the response of cowpea to different combinations and levels of inorganic, organic and biological nutrient sources may vary according to soil and environmental conditions. Hence, the present investigation was undertaken to study the influence of NPK, vermicompost and biofertilizer on soil properties, growth and yield of cowpea (*Vigna unguiculata* L.) var. Kashi Kanchan.

Materials and Methods

The present investigation was carried out at the Research Farm of Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, during the Kharif seasons of 2025-26. The experiment was laid out in Randomized Block Design (RBD) with three levels of NPK, vermicompost and four levels of *Azotobacter*. The treatments have been replicated three times. The different treatments were employed randomly in each replication. The treatments comprised of T₀ (0% NPK + 0% vermicompost + 100% *Azotobacter*), T₁ (0% NPK + 50% vermicompost + 50% *Azotobacter*), T₂ (0% NPK + 100% vermicompost + 0% *Azotobacter*), T₃ (50% NPK + 0% vermicompost + 100% *Azotobacter*), T₄ (50% NPK + 50% vermicompost + 50% *Azotobacter*), T₅ (50% NPK + 100% vermicompost + 0% *Azotobacter*), T₆ (100% NPK + 0% vermicompost + 100% *Azotobacter*), T₇ (100% NPK + 50% vermicompost + 50% *Azotobacter*) and T₈ (100% NPK + 100% vermicompost + 0% *Azotobacter*). Soil samples from each experimental plot were collected at two depths (0-15 cm) following crop harvest. The samples were air-dried, finely ground, and sieved through a 2 mm mesh, after which they were stored in polythene bags for subsequent analysis. The processed samples were examined for a range of physico-chemical properties, including bulk density, particle density, Muthuvel *et*

al., 1992) ^[10], pH (Digital pH meter by Jackson, pore space percentage (100 ml measuring cylinder method by 1958), electrical conductivity (Digital EC meter by Wilcox, 1950) ^[22], organic carbon (Wet method by Walkley and Black 1934) ^[21], and available macronutrients like Nitrogen (Alkaline (Calorimetric method by Olsen *et al.*, 1954) ^[11], Potassium permanganate method by Subbiah & Asija 1956) ^[16], Phosphorus (Flame photometric method by Toth and Prince, 1949) ^[19].

Results and Discussion

The application of different combinations of NPK, vermicompost and *Azotobacter* significantly influenced the physical and chemical properties of soil as well as the growth and yield of cowpea. The results are presented and discussed under the following heads.

3.1 Physical properties of soil

The bulk density of soil ranged from 1.13 to 1.22 Mg m⁻³, and the treatment effect was statistically non-significant, although the lowest value was recorded under T₅ (50% NPK + 100% vermicompost + 0% *Azotobacter*), followed by T₁ and T₈ (1.15 Mg m⁻³ each), while the highest bulk density (1.22 Mg m⁻³) was recorded under T₀ (the unfertilised control receiving only *Azotobacter*). The comparatively lower bulk density under vermicompost-based treatments may be attributed to improved soil aggregation and reduced compaction resulting from added organic matter. Particle density varied significantly, from 2.10 Mg m⁻³ (T₁) to 2.90 Mg m⁻³ (T₈, closely followed by T₅ at 2.88 Mg m⁻³). Pore space was also significantly affected, ranging from 42.29% (T₁) to 51.17% (T₅, followed by T₈ at 49.98% and T₇ at 48.19%); the higher pore space under vermicompost-rich treatments is consistent with improved aggregation and structural condition of soil. Water holding capacity followed a similar trend, ranging from 51.00% (T₁) to 55.00% (T₅, followed by T₈ at 54.50% and T₇ at 53.80%), reflecting the greater contribution of vermicompost to soil organic matter and its favourable effect on moisture retention. Overall, the improvement in soil physical properties with vermicompost application may be attributed to the addition of organic matter, which improves aggregation, structure and porosity and enhances the proportion of stable aggregates and micropores responsible for water retention. Similar beneficial effects of organic manures and integrated nutrient management on soil physical condition have been reported by Alabadian *et al.* (2009) ^[1] and Chettri and Bandhopadhyaya (2005) ^[4]. These results indicate that T₅ (50% NPK + 100% vermicompost + 0% *Azotobacter*) was particularly effective in improving the physical condition of soil under cowpea cultivation, even though the full recommended dose of NPK was not required to achieve this benefit.

Table 1: Influence of NPK, vermicompost and *Azotobacter* on physical properties of soil after harvest of cowpea

Treatment	Bulk density (Mg m ⁻³)	Particle density (Mg m ⁻³)	Pore space (%)	Water holding capacity (%)
T ₀ (0% NPK+0% VC+100% Azo)	1.22	2.42	47.75	52.30
T ₁ (0% NPK+50% VC+50% Azo)	1.15	2.10	42.29	51.00
T ₂ (0% NPK+100% VC+0% Azo)	1.16	2.55	43.56	51.50
T ₃ (50% NPK+0% VC+100% Azo)	1.16	2.28	45.58	52.00
T ₄ (50% NPK+50% VC+50% Azo)	1.19	2.33	48.18	53.20
T ₅ (50% NPK+100% VC+0% Azo)	1.13	2.88	51.17	55.00
T ₆ (100% NPK+0% VC+100% Azo)	1.20	2.66	43.51	51.40
T ₇ (100% NPK+50% VC+50% Azo)	1.21	2.39	48.19	53.80
T ₈ (100% NPK+100% VC+0% Azo)	1.15	2.90	49.98	54.50
F-test	NS	S	S	S
C.D. at 5%	—	0.576	6.818	0.33
S.Em±	1.021	1.089	12.886	1.14

VC = vermicompost; Azo = *Azotobacter*; S = significant; NS = non-significant

3.2 Chemical properties of soil

Soil pH ranged from 6.46 (T₄) to 7.92 (T₇), but the treatment effect was non-significant, indicating that none of the nutrient sources caused any marked alteration of soil reaction over the single crop season. Electrical conductivity varied significantly from 0.23 dS m⁻¹ (T₀) to 0.38 dS m⁻¹ (T₅), but all values remained within a low, non-saline range, indicating no risk of salt build-up from the nutrient sources used.

Organic carbon content of the soil was significantly influenced by the treatments, ranging from 0.42% (T₂) to 0.59% (recorded under both T₅ and T₈), with T₄ close behind at 0.56%. The higher organic carbon under vermicompost-rich treatments reflects the direct addition of organic matter through vermicompost, which is known to improve soil organic matter status and stimulate microbial activity, consistent with the findings of Kannan *et al.* (2005)^[8] and Chettri and Bandhopadhyaya (2005)^[4].

Available nitrogen varied significantly from 259.68 kg ha⁻¹ (T₀) to 286.12 kg ha⁻¹ (T₈, closely followed by T₅ at 283.79 kg ha⁻¹

and T₃ at 283.58 kg ha⁻¹). Available phosphorus followed a similar pattern, from 18.84 kg ha⁻¹ (T₀) to 34.00 kg ha⁻¹ (T₈, followed by T₇ at 29.24 kg ha⁻¹ and T₆ at 28.55 kg ha⁻¹). Available potassium ranged from 147.52 kg ha⁻¹ (T₀) to 186.99 kg ha⁻¹ (T₈, followed by T₅ at 181.72 kg ha⁻¹ and T₇ at 174.72 kg ha⁻¹). The consistently higher availability of N, P and K under T₈ may be attributed to the combined effect of full-dose NPK application and vermicompost, the latter contributing to nutrient mineralisation, improved nutrient retention and reduced fixation. These results agree with the beneficial effects of integrated nutrient management on soil fertility reported by Rajkhowa *et al.* (2002)^[13], Ramesh *et al.* (2006)^[14] and Tanwar *et al.* (2010)^[17], and are consistent with the wider evidence that combining organic and inorganic sources improves nutrient availability more than either source alone (Place *et al.*, 2003^[12]; Vanlauwe *et al.*, 2010)^[20]. Thus, T₈ (100% NPK + 100% vermicompost + 0% *Azotobacter*) proved most effective in improving the available nutrient status of the soil.

Table 2: Influence of NPK, vermicompost and *Azotobacter* on chemical properties of soil after harvest of cowpea

Treatment	pH	EC (dS m ⁻¹)	OC (%)	N (kg ha ⁻¹)	P (kg ha ⁻¹)	K (kg ha ⁻¹)
T ₀	7.00	0.23	0.53	259.68	18.84	147.52
T ₁	7.20	0.31	0.50	262.50	24.81	161.74
T ₂	7.44	0.27	0.42	276.44	26.56	158.33
T ₃	7.29	0.33	0.55	283.58	20.52	162.08
T ₄	6.46	0.37	0.56	280.02	24.80	165.72
T ₅	7.47	0.38	0.59	283.79	25.52	181.72
T ₆	7.75	0.32	0.50	270.18	28.55	170.04
T ₇	7.92	0.34	0.55	274.71	29.24	174.72
T ₈	7.82	0.25	0.59	286.12	34.00	186.99
F-test	NS	S	S	S	S	S
C.D. at 5%	—	0.563	0.539	6.20	3.829	0.56
S.Em±	1.049	1.064	1.019	11.718	7.237	1.058

S = significant; NS = non-significant.

3.3 Growth and yield attributes

Plant height ranged from 68.05 cm (T₀) to 75.33 cm (T₈, followed by T₆ at 73.80 cm and T₇ at 72.04 cm), the improvement under T₈ being attributable to the adequate and balanced availability of nutrients through combined NPK and vermicompost application, favouring vigorous vegetative growth. The number of leaves plant⁻¹ followed a similar trend, from 27.14 (T₃) to 38.01 (T₈, followed by T₆ at 33.34 and T₇ at 31.47), consistent with improved nutrient availability and soil conditions under integrated nutrient management. The number of pods plant⁻¹ at 45 days ranged from 9.16 (T₀) to 10.90 (T₈, followed by T₆ at 10.84 and T₄ at 10.26), reflecting better vegetative growth and nutrient availability favouring reproductive development. Pod weight plant⁻¹ ranged from 16.00 g (T₀ and T₃) to 24.00 g (T₈, followed by T₆ at 23.00 g and T₇ at 22.00 g), associated with improved

vegetative growth and pod development under adequate nutrition. Pod yield was significantly affected by the treatments, ranging from 54.59 q ha⁻¹ (T₀) to 73.34 q ha⁻¹ (T₈, followed by T₆ at 69.39 q ha⁻¹, T₇ at 66.34 q ha⁻¹ and T₄ at 65.43 q ha⁻¹). The application of 100% NPK with 100% vermicompost (T₈) resulted in 34.35% higher pod yield than the untreated control (T₀), reflecting the cumulative benefit of higher plant height, greater leaf number, more pods per plant and heavier pods under integrated nutrition. These findings are in conformity with the beneficial effects of vermicompost combined with fertilizer application reported by Rajkhowa *et al.* (2002)^[13], and with the improved crop growth and productivity from integrated organic-inorganic nutrient application reported by Ramesh *et al.* (2006)^[14] and Tanwar *et al.* (2010)^[17].

Table 3: Influence of NPK, vermicompost and *Azotobacter* on growth and yield parameters of cowpea

Treatment	Plant height (cm)	Leaves plant ⁻¹	Pods plant ⁻¹ (45 DAS)	Pod weight (g plant ⁻¹)	Pod yield (q ha ⁻¹)
T ₀	68.05	28.30	9.16	16.00	54.59
T ₁	69.47	30.05	9.56	17.00	56.30
T ₂	69.34	28.32	9.96	17.00	56.62
T ₃	70.47	27.14	9.75	16.00	58.42
T ₄	71.70	30.47	10.26	21.00	65.43
T ₅	70.00	29.15	9.83	18.00	60.72
T ₆	73.80	33.34	10.84	23.00	69.39
T ₇	72.04	31.47	10.06	22.00	66.34
T ₈	75.33	38.01	10.90	24.00	73.34
F-test	S	S	S	S	S
C.D. at 5%	2.20	2.337	1.024	1.83	1.92
S.Em±	4.158	4.417	1.935	3.459	3.629

S = significant.

4. Conclusion

Different combinations of NPK, vermicompost and *Azotobacter* significantly influenced the physical and chemical properties of soil and the growth and yield of cowpea (*Vigna unguiculata* L.) var. Kashi Kanchan. Treatment T₅ (50% NPK + 100% vermicompost + 0% *Azotobacter*) was found superior for improving soil physical properties, recording the lowest bulk density (1.13 Mg m⁻³) and the highest pore space (51.17%) and water holding capacity (55.00%). Treatment T₈ (100% NPK + 100% vermicompost + 0% *Azotobacter*) recorded the highest available nitrogen (286.12 kg ha⁻¹), phosphorus (34.00 kg ha⁻¹) and potassium (186.99 kg ha⁻¹), the tallest plants (75.33 cm), the highest number of leaves (38.01 plant⁻¹) and pods (10.90 plant⁻¹), the heaviest pods (24.00 g plant⁻¹) and the highest pod yield (73.34 q ha⁻¹), representing a 34.35% yield gain over the untreated control. It may therefore be concluded that the integrated application of 100% NPK with 100% vermicompost (T₈) is most effective for enhancing soil fertility, growth and yield of cowpea under the agro-climatic conditions of Prayagraj, while a lower NPK level (50%) combined with full vermicompost (T₅) is preferable where improvement of soil physical condition is the primary objective. These findings support integrated nutrient management, combining a reduced dose of chemical fertilizer with organic manure, as a practical strategy for sustaining both soil health and cowpea productivity; further multi-location and multi-season trials are recommended before the treatment can be generalised as a fertilizer recommendation.

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