



EFFECT OF NPS COMPOST AND FOLIAR SPRAY OF HUMIC SUBSTANCES ON YIELD AND NUTRIENT UPTAKE OF BRINJAL (*SOLANUM MELONGENA* L.) GROWN IN VERTISOLS

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ABSTRACT

Integrated nutrient management is essential for sustaining productivity and soil health in vegetable-based systems. A field experiment was conducted during summer 2022-23 at Dr. PDKV, Akola, to evaluate the combined effect of NPS compost and foliar-applied humic acid on yield, nutrient concentration, and nutrient uptake of brinjal (*Solanum melongena*) grown in Vertisols. The experiment was laid out in randomized block design with nine treatments and three replications. The nine treatments consists of a 100% recommended dose of fertilizer (100:150:100 kg N, P₂O₅ and K₂O ha⁻¹) (T₁), 100% RDF+ FYM @ 5 t ha⁻¹ (T₂), 100% RDF+ NPS compost @ 2.5 t ha⁻¹ (T₃), 100% RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 0.5% (T₄), 100% RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 1% (T₅), 100% RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₆), 100% RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 0.5% (T₇), 100% RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1% (T₈), 100% RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉). Organics (NPS compost and FYM) were applied at transplanting. Results revealed that integrated application of RDF, NPS compost @ 2.5 t ha⁻¹ and four foliar sprays of humic acid @ 1.5% significantly enhanced fruit yield (41.01 t ha⁻¹) and straw yield (47.55 q ha⁻¹) compared to RDF alone. The same treatment also recorded the highest concentrations and uptake of nitrogen, phosphorus, potassium, and sulphur in both fruit and plant. Total nutrient uptake reached 271.57, 68.70, 284.70, and 45.58 kg ha⁻¹ for N, P, K, and S, respectively, indicating improved nutrient use efficiency. The superior performance of combined treatments may be attributed to enhanced nutrient availability, improved root growth, and increased metabolic activity induced by humic substances and compost enrichment. The findings demonstrate that integrating NPS compost with foliar humic acid application is an effective strategy for improving brinjal productivity and nutrient uptake under Vertisol conditions, thereby supporting sustainable vegetable production systems.

Key words: Humic acid, NPS Compost, Brinjal, Content and Uptake of nutrients.

Introduction

Brinjal (*Solanum melongena* L.) is one of the most widely cultivated vegetable crops in tropical regions and is extensively grown across India. It is a versatile crop often referred to as a “poor man’s vegetable” because of its affordability and adaptability to diverse agro-climatic conditions, allowing year-round cultivation. Although botanically a perennial, it is commercially cultivated as an annual crop. Brinjal is valued for its nutritional composition, providing essential minerals such as iron,

phosphorus, and calcium, along with vitamins A, B-complex, and C. The immature fruits are primarily consumed as a vegetable, while they are also used in the pickling and dehydration industries. In traditional systems of medicine, brinjal is considered beneficial for managing liver disorders, improving appetite, and supporting the management of diabetes. It is also regarded as having cardiogenic, laxative, anti-inflammatory, and therapeutic properties. India’s vegetable demand has been projected to rise substantially to meet the needs of a growing

population. Brinjal accounts for a significant share of vegetable cultivation, covering about 1.0 million hectares, with production of 1.87 million tonnes and an average productivity of 17.96 t ha⁻¹ (Anon., 2018-19).

Humic acids constitute the principal fraction of humic substances and represent some of the most biologically active components of soil and compost organic matter. As naturally occurring organic biostimulants with charged functional groups, humic acids play an important role in regulating plant growth and development, ultimately contributing to improved crop productivity (Nardi *et al.*, 2004). Humic acid is well known for controlling soil-borne diseases and improving soil health, plant nutrient uptake, mineral availability, and fruit quality (Mauromicale *et al.*, 2011). Humic acid-based fertilizers increase crop yield (Bakry *et al.*, 2009).

The use of a single manure source or chemical fertilizer alone is insufficient to maintain long-term soil health and stable crop yields. Therefore, integrating with compost and fertilizers is essential for sustainable nutrient management, crop yield and quality. (Youssef and Eissa, 2017; Aktar *et al.*, 2018). Sustainable agriculture requires the use of organic fertilizers for a steady nutrient supply and improving soil organic matter, soil physical and chemical properties and crop productivity (Rekaby *et al.*, 2020).

The use of nutrient-rich organic sources, such as NPS compost, farmyard manure (FYM), vermicompost, and phosphocompost, plays a vital role in sustaining soil fertility and crop productivity. NPS compost, enriched with nitrogen (N), phosphorus (P), and sulphur (S), ensures a balanced supply of essential macronutrients, enhancing nutrient uptake and fruit development. FYM, a traditional organic input made from decomposed animal waste, improves soil structure, moisture retention, and microbial activity. Vermicompost, produced through the action of earthworms, is rich in readily available nutrients and plant growth-promoting hormones, promoting early seedling vigour and improved lint yield. Phosphocompost, fortified with rock phosphate and phosphate-solubilizing microorganisms, enhances phosphorus availability, which is crucial for root development and boll setting in cotton. Collectively, these organic manures improve nutrient use efficiency, soil health, and sustainable cotton production in organic farming systems.

The experiment was carried out with the aim of finding the effect of spraying Humic acid with the combination of FYM and NPS compost at different levels and application of NPS compost on yield and uptake of nutrients by Brinjal.

Material and Methods

Site description, experimental design, and treatments

The study was conducted during the summer season 2022-023 in the research farm, dept of Horticulture, Dr PDKV, Akola. The experimental site, located in the subtropical region at latitude 22.421°N and 77.021°E, at an altitude of 307.42m above mean sea level (MSL), has a hot and dry summer from March to May, a warm and rainy monsoon from June to October, and mild cold from November to February. The experimental soil was shallow black soil, slightly alkaline reaction (pH 7.97), with electrical conductivity (0.25 dSm⁻¹) and organic carbon content (4.34 g kg⁻¹). The available N, P and K contents were 174, 13.5 and 307 kg ha⁻¹, respectively. The available sulphur (10.3 mg kg⁻¹). The experiment was laid out in randomized block design with nine treatments and three replications. The nine treatments consists of a 100% recommended dose of fertilizer (100:150:100 kg N, P₂O₅ and K₂O ha⁻¹) (T₁), 100%RDF+ FYM @ 5 t ha⁻¹ (T₂), 100%RDF+ NPS compost @ 2.5 t ha⁻¹(T₃), 100%RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 0.5% (T₄), 100%RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 1%(T₅), 100%RDF+ FYM @ 5 t ha⁻¹ + 4 sprays of HA @ 1.5%(T₆), 100%RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 0.5%(T₇), 100%RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1% (T₈), 100%RDF+ NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉). Organics (NPS compost and FYM) were applied at transplanting. The basal doses were applied as NPS compost (1.78% N, 1.12% P, and 0.79% K) and FYM (0.53% N, 0.28% P, and 0.41% K). 1/3 of nitrogen and full doses of Phosphorus and Potassium were applied as urea, single super phosphate (SSP), and Muriate of potash (MOP), respectively, at the time of transplanting; the remaining 1/3 N was applied at 30 days after transplanting, and the remaining 1/3 N at 60 days after transplanting. Humic acid was extracted from dried vermicompost in the laboratory using the alkaline extraction method. Liquid humus formulations of different concentrations (0.5%,

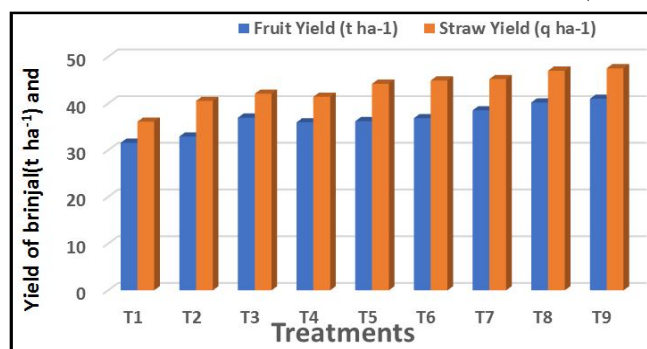


Fig. 1. Effect of NPS compost and foliar spray of humic acid on yield of brinjal

1.0%, and 1.5%) were made based on the vermicompost's recovery of humic acid. Application of humic acid as foliar spray with different concentrations like 0.5%, 1% and 1.5% at different growth stages of brinjal, first spray at 20-25 days after transplanting, second spray at flowering, third spray at fruit setting and fourth spray at 10-15 days after 1st picking.

The gross plot size was 4.5×3.6 m² and the net plot size was 3×2.40 m². The brinjal variety Gaurav (F1 hybrid) was used as a test crop for the present investigation. The seedlings were obtained from the nursery and transplanted in the experimental plot as per the layout. The cultivation practices were followed as per the university guidance.

Sampling and Measurements

Total yield per hectare was calculated from the fruit yield per plot recorded across all pickings and expressed as tonnes per ha. After the final harvest, plants from each replication were carefully uprooted, air-dried in the sun and oven-dried at 80°C for 48 hours. The dry biomass was then measured and expressed in quintals per hectare. Treatment-wise, plant samples were collected by carefully uprooting the entire plant. The plant samples were first rinsed with distilled water. The samples were dried in the shade and then oven dried at 65°C. Then the plant samples were ground and stored in butter paper bags. The samples were analysed for Total Nitrogen by the Kjeldahl method (Piper 1966), Total Phosphorus by the Vanado-molybdate yellow colour method using diacid extract (Kiston and Mellon 1973), Total Potassium by the Flame photometrically using diacid extract (Piper 1966) and Total Sulphur by the Turbidimetric method (Chesni and Yien 1950) content by following standard procedures.

Statistical analysis

As per the standard statistical procedure by Gomez and Gomez (1984), the data were submitted to Analysis of Variance (ANOVA) in Randomized Block Design with nine treatments and three replications.

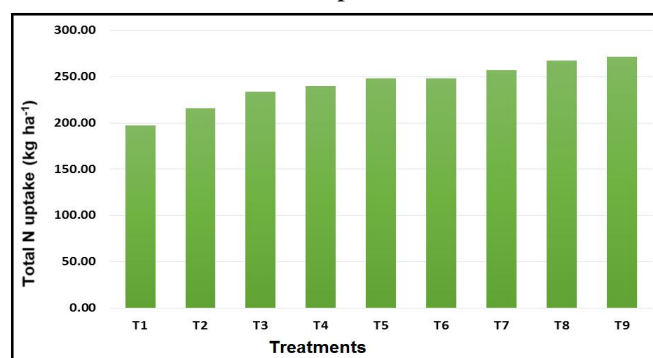


Fig. 2: Total N uptake by brinjal as influenced by different treatments.

Table 1. Effect of NPS compost and foliar spray of humic acid on yield of brinjal.

Tr	Treatment Details	Fruit Yield (t ha ⁻¹)	Straw Yield (q ha ⁻¹)
T ₁	100% RDF	31.59	36.11
T ₂	100% RDF + FYM @ 5 t ha ⁻¹	32.92	40.55
T ₃	100% RDF + NPS compost @ 2.5 t ha ⁻¹	36.98	42.09
T ₄	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 0.5 %	35.98	41.45
T ₅	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1 %	36.22	44.23
T ₆	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1.5 %	36.87	44.92
T ₇	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 0.5 %	38.55	45.22
T ₈	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1 %	40.22	47.02
T ₉	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1.5 %	41.01	47.55
	SE(m)	0.60	0.74
	CD at 5%	1.79	2.22

Results and Discussion

The results of the present investigation, as well as the discussion, have been summarised under the following headings.

Effect of NPS compost and foliar spray of humic acid on the yield of brinjal

The results for fruit and straw yields of brinjal, influenced by NPS compost and foliar application of humic acid, are presented in Table 1. Fruit yield varied from 31.59 to 41.01 t ha⁻¹ and showed significant differences among treatments. The highest yield (41.01 t ha⁻¹) was obtained with the application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ along with four sprays of humic acid at 1.5% (T₉), followed by 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid at 1% (T₈), which produced 40.22 t ha⁻¹. The lowest yield (31.59 t ha⁻¹) was recorded under 100% RDF alone (T₁). The stimulating effect of humic substances on plant growth and yield may have related to enhanced uptake of mineral nutrients (Padem and Ocal, 1998; Adani *et al.*, 1998; Dursun *et al.*, 2002) and the plant hormone-like activity of humic substances (Nardi *et al.*, 2002).

Straw yield was also significantly influenced by the treatments, ranging from 36.11 to 47.55 q ha⁻¹. The highest straw yield (47.55 q ha⁻¹) was recorded with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid at 1.5% (T₉), followed by T₈ (47.02 q ha⁻¹), while the

Table 2. Effect of NPS compost and foliar spray of humic acid on nutrient content of brinjal fruit and plant.

Tr	Treatment details	Nutrient content (%)							
		N		P		K		S	
		Fruit	Plant	Fruit	Plant	Fruit	Plant	Fruit	Plant
T ₁	100% RDF	1.50	1.19	0.34	0.23	1.59	1.30	0.21	0.14
T ₂	100% RDF + FYM @ 5 t ha ⁻¹	1.54	1.31	0.36	0.26	1.62	1.39	0.22	0.16
T ₃	100% RDF + NPS compost @ 2.5 t ha ⁻¹	1.57	1.37	0.36	0.24	1.65	1.38	0.24	0.16
T ₄	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 0.5 %	1.63	1.35	0.37	0.26	1.67	1.47	0.23	0.19
T ₅	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1 %	1.64	1.33	0.38	0.27	1.69	1.47	0.22	0.20
T ₆	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1.5 %	1.62	1.35	0.38	0.29	1.70	1.44	0.24	0.22
T ₇	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 0.5 %	1.62	1.41	0.39	0.27	1.72	1.48	0.27	0.20
T ₈	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1 %	1.64	1.38	0.42	0.31	1.73	1.45	0.28	0.19
T ₉	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1.5 %	1.67	1.37	0.44	0.30	1.73	1.49	0.28	0.23
	SE(m)	0.02	0.02	0.01	0.003	0.02	0.01	0.003	0.003
	CD at 5%	0.07	0.07	0.02	0.01	0.07	0.04	0.01	0.01

lowest straw yield (37.22 q ha⁻¹) was observed under 100% RDF (T₁). Humic acid increases soil holding capacity of water and uptake of nutrients which caused increment in the growth of the plant and so that increases yield attribute and components (Zhang *et al.*, 2003).

Effect of NPS compost and foliar spray of humic acid on nutrient content of brinjal fruit and plant

Nitrogen content:

The data pertaining to nutrients content of brinjal fruit and plant were presented in Table 2. The nitrogen content of fruit and plant as effected by the application of NPS compost and foliar spray of humic acid were found to be significant. However, numerically highest nitrogen content in fruit and plant (1.67% and 1.38%) were recorded with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉) whereas lowest nitrogen content was observed with application of 100% RDF (T₁). The superior performance of humic acid-treated treatments may be attributed to its role in improving nutrient availability, enhancing root growth, increasing membrane permeability, and stimulating enzymatic activity. Humic acid also facilitates better nitrogen absorption and translocation within the plant system (Nardi *et al.*, 2022) and Shafeek *et al.*, (2013) reported that optimum humic acid levels found to increase total N uptake by Brinjal. Asik *et al.*, (2009) studied the effects of foliar and soil application of humic substances on plant growth of Brinjal with increased the N uptake.

Phosphorus content:

The results for phosphorus content in brinjal fruit and plants showed a significant difference between the treatments comprising NPS compost and a foliar spray of humic acid. The phosphorus content of brinjal fruit and plant ranged from 0.31 to 0.44% and 0.23 to 0.31%. The significantly highest phosphorus content in fruit were

recorded highest (0.41% and 0.31%) with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉) and 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1% (T₈) which are at par, while significantly lowest phosphorus concentration (0.31%) was recorded with application of 100% RDF (T₁). The significantly highest phosphorus content in plant (0.23%) was recorded with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1% (T₈) and 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉) which is found to be at par with comprising NPS compost and various concentrations of foliar spray of humic acid. Significantly lower phosphorus content (0.23%) was recorded with the application of 100% RDF (T₁).

The increase in phosphorus content may be due to enhanced metabolic activity and vegetative growth, which improve nutrient availability and uptake. Xudan (1987) reported that foliar application of humic substances increased phosphorus uptake in wheat under both pot and field conditions. Similar findings were also reported by Deotale *et al.*, (2017), Noorozisharaf and Kavini (2018), and Rasouli *et al.*, (2022).

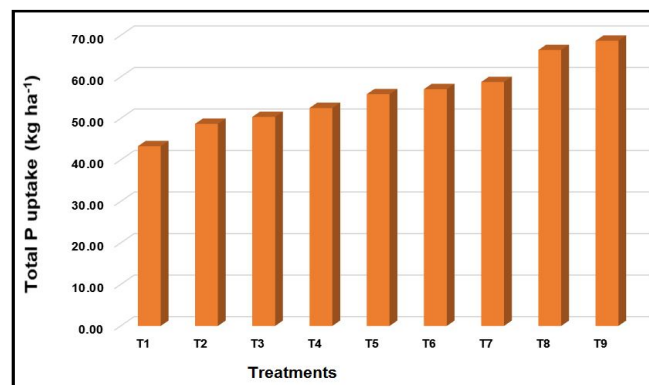


Fig. 3: Total P uptake by brinjal as influenced by different treatments.

Potassium content:

The results for potassium content in brinjal fruit and plants showed a significant difference between the treatments comprising NPS compost and a foliar spray of humic acid. Significantly highest potassium content in fruit (1.73%) was recorded with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1% (T₈) and 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉). Lowest potassium content in fruit (1.59%) was recorded with application of 100% RDF (T₁). The highest potassium content in brinjal plant (1.49%) was observed with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉) while the lowest potassium content in brinjal plant (1.30%) was recorded with application of 100% RDF (T₁).

Sulphur content:

The results for sulphur content in brinjal fruit and plants showed a significant difference between the treatments comprising NPS compost and a foliar spray of humic acid. The sulphur concentration in fruit ranged from 0.21 to 0.28%. The significantly highest sulphur content of fruit (0.28%) was recorded with application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + 4 sprays of HA @ 1.5% (T₉). However, it is found to be statistically at par with treatment (T₇) which comprising of various combinations of NPS compost and foliar spray of humic acid. The significantly lowest sulphur content of fruit (0.21%) was recorded with the application of 100% RDF (T₁). The highest sulphur content in the plant (0.23%) was recorded with the application of 100% RDF + NPS compost at 2.5 t ha⁻¹ and 4 sprays of HA at 1.5% (T₉). The treatment (T₆) comprising NPS compost and various concentrations of foliar spray of humic acid was found to be at par. Significantly lowest sulphur content of brinjal plant (0.14%) was observed with application of 100% RDF (T₁).

Since NPS compost and humic acid contain appreciable amounts of sulphur (1.12% and 1.30%,

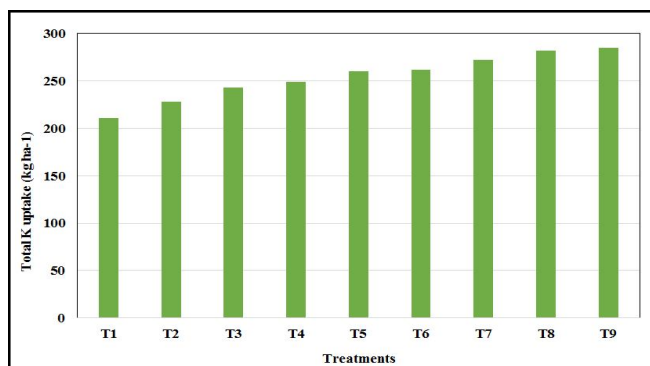


Fig. 4: Total K uptake by brinjal as influenced by different treatments.

respectively), their addition likely contributed directly to enhanced sulphur availability. Moreover, improved nutrient supply may have stimulated biological nitrogen fixation and promoted greater accumulation of above-ground dry matter, thereby enhancing overall nutrient uptake and translocation to leaves and fruits. Comparable findings have also been documented by Singh *et al.*, (2001) and Patel *et al.*, (2014).

Effect of NPS compost and foliar spray of humic acid on total nutrient uptake by brinjal crop

The data related to nutrient uptake as affected by the application of NPS compost and foliar spray of humic acid were presented in Table 3. The application of organics and foliar spray of humic acid significantly influenced the uptake of nitrogen, phosphorus and potassium by the fruit and plant. Application of NPS compost, combined with foliar sprays of humic acid, markedly improved nitrogen uptake compared with RDF alone. The highest nitrogen uptake by fruit (206.48 kg ha⁻¹) and plant (65.09 kg ha⁻¹) was recorded with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉). However, this treatment remained statistically comparable with similar treatments receiving lower concentrations of humic acid (0.5% and 1%). In contrast, the application of 100% RDF alone (T₁) resulted in the lowest nitrogen uptake by fruit (154.32 kg ha⁻¹) and plant (42.97 kg ha⁻¹).

Total nitrogen uptake followed a similar trend, ranging from 197.30 to 271.57 kg ha⁻¹. The maximum uptake was observed in (T₉), while treatments combining RDF, NPS compost, and humic acid were generally comparable and superior to RDF alone.

Enhanced nitrogen uptake with humic acid application may be attributed to improved lateral root formation and development of finely branched secondary roots, which increase the absorptive surface area. Humic substances also improve membrane permeability and nutrient availability in the soil solution, facilitating greater nutrient

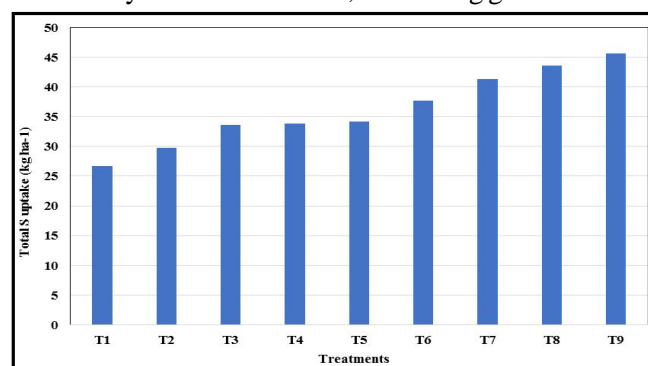


Fig. 5: Total S uptake by brinjal as influenced by different treatments.

Table 3: Effect of NPS compost and foliar spray of humic acid on total nutrient uptake by brinjal crop.

Tr	Treatment details	Nutrient uptake (kg ha ⁻¹)											
		Nitrogen uptake (kg ha ⁻¹)			Phosphorus uptake (kg ha ⁻¹)			Potassium uptake (kg ha ⁻¹)			Sulphur uptake (kg ha ⁻¹)		
		Fruit	Plant	Total	Fruit	Plant	Total	Fruit	Plant	Total	Fruit	Plant	Total
T ₁	100% RDF	154.32	42.97	197.30	34.99	8.31	43.29	163.57	46.94	210.51	21.61	5.05	26.66
T ₂	100% RDF + FYM @ 5 t ha ⁻¹	162.99	53.12	216.11	38.14	10.54	48.68	171.44	56.37	227.80	23.27	6.48	29.76
T ₃	100% RDF + NPS compost @ 2.5 t ha ⁻¹	175.83	57.66	233.49	40.27	10.10	50.36	184.76	58.11	242.87	26.86	6.73	33.59
T ₄	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 0.5 %	183.95	55.96	239.91	41.74	10.78	52.51	188.49	60.93	249.42	25.96	7.87	33.83
T ₅	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1 %	189.25	58.77	248.02	43.88	11.94	55.83	195.07	65.02	260.09	25.35	8.85	34.20
T ₆	100% RDF + FYM @ 5 t ha ⁻¹ + 4 sprays of HA @ 1.5 %	187.57	60.67	248.24	44.02	13.02	57.04	196.90	64.70	261.60	27.79	9.89	37.68
T ₇	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 0.5%	193.27	63.75	257.02	46.55	12.21	58.76	205.19	66.93	272.12	32.23	9.05	41.27
T ₈	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1 %	202.74	64.87	267.62	51.90	14.58	66.47	213.60	68.20	281.80	34.62	8.94	43.55
T ₉	100% RDF + NPS compost @ 2.5 t ha ⁻¹ + 4 sprays of HA @ 1.5%	206.48	65.09	271.57	54.43	14.27	68.70	213.86	70.84	284.70	34.65	10.93	45.58
	SE(m)	4.84	0.01	4.93	0.40	0.30	1.35	4.86	1.36	5.08	0.84	0.20	0.85
	CD at 5%	14.52	3.04	14.77	4.20	0.90	4.04	14.57	4.09	15.22	2.52	0.61	2.55

absorption (Sumathi & Rao, 2007; Bhandari *et al.*, 2002). In addition, foliar application influences plant metabolism and membrane functions, thereby enhancing nutrient uptake efficiency (Eshwar *et al.*, 2017). Shafeek *et al.*, (2013) also reported increased total nitrogen uptake in brinjal with optimum humic acid application.

Phosphorus uptake:

The highest fruit P uptake (54.43 kg ha⁻¹) and plant uptake (14.27 kg ha⁻¹) were recorded with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉), which remained statistically comparable with the 1% humic acid treatment (T₈). The lowest uptake was observed under 100% RDF (T₁), with 34.99 kg ha⁻¹ in fruit and 8.31 kg ha⁻¹ in plant.

Total phosphorus uptake ranged from 43.29 to 68.70 kg ha⁻¹, with the maximum recorded in (T₉) and the minimum in (T₁). The improved uptake may be attributed to humic acid's role in enhancing phosphorus availability by reducing Ca-P precipitation, competing for adsorption sites, and promoting the chelation of metal ions (Guppy *et al.*, 2005). Additionally, humic substances improve soil

fertility and nutrient availability, thereby increasing phosphorus absorption (Rizk and Mashhour 2008; Bhardwaj *et al.*, 1994).

Potassium uptake:

The highest fruit potassium uptake (213.86 kg ha⁻¹) was recorded with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉), which was statistically comparable with treatments receiving NPS compost and lower concentrations of humic acid. The lowest fruit uptake (163.57 kg ha⁻¹) was observed under 100% RDF (T₁).

Similarly, plant potassium uptake was highest (70.84 kg ha⁻¹) in (T₉) and remained on par with treatments receiving 0.5% and 1% humic acid, whereas the lowest uptake (46.94 kg ha⁻¹) occurred with RDF alone. Total potassium uptake ranged from 210.51 to 284.70 kg ha⁻¹, with the maximum recorded in (T₉) and the minimum in (T₁). Similar results were reported by Ameri *et al.*, (2012) and Taha *et al.*, (2006). An increase in K content and uptake might be due to reduced K fixation, which increased the permeability of bio membranes to

electrolytes with the addition of humic acid, thereby increasing K uptake (Eshwar *et al.*, 2017).

Sulphur uptake:

Significantly higher sulphur uptake by fruit (34.65 kg ha⁻¹) was recorded with the application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉), which was statistically at par with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 0.5% (T₇) and @ 1% (T₈). The lowest sulphur uptake by fruit (21.61 kg ha⁻¹) was recorded with 100% RDF alone (T₁). Sulphur uptake by the plant was also significantly affected by the treatments. The highest uptake (10.93 kg ha⁻¹) was observed with the application of 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉), whereas the lowest uptake (5.05 kg ha⁻¹) was recorded under 100% RDF alone (T₁).

Total sulphur uptake was significantly influenced by the integrated application of NPS compost and humic acid sprays. The highest total sulphur uptake (45.58 kg ha⁻¹) was recorded with 100% RDF + NPS compost @ 2.5 t ha⁻¹ + four sprays of humic acid @ 1.5% (T₉), which was statistically at par with the treatment receiving humic acid @ 1% (T₈). The lowest total sulphur uptake (26.66 kg ha⁻¹) was observed with 100% RDF alone (T₁).

These findings are in agreement with earlier studies reporting improved nutrient uptake due to humic substances and organic amendments. Chen Y and Aviad T (1990) reported that humic substances enhance nutrient uptake by increasing membrane permeability and root growth. Nardi, S. *et al.*, (2002) documented that humic acids stimulate root metabolism and nutrient absorption. Similarly, Sangeetha, M. *et al.*, (2006) observed increased nutrient uptake in crops with humic acid application, while Ramakrishna, A. *et al.*, (2010) reported improved nutrient uptake and soil fertility with organic amendments.

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Conclusion

The findings of the present investigation clearly demonstrate that the integrated application of NPS compost and foliar spray of humic acid significantly enhanced yield, nutrient content, and total nutrient uptake of brinjal (*Solanum melongena*) grown in Vertisols.

Among the different treatment combinations, the application of 100% recommended dose of fertilizers along with NPS compost @ 2.5 t ha⁻¹ and four foliar sprays of humic acid at 1.5% proved to be the most effective in improving fruit yield, straw yield, and uptake of nitrogen, phosphorus, potassium, and sulphur. The superior performance of integrated treatments over the sole application of inorganic fertilizers indicates the positive role of organic amendments and humic substances in enhancing soil fertility, nutrient availability, and plant metabolic activity. The combined application of NPS compost and humic acid not only increased nutrient concentrations in fruit and plant tissues but also led to greater overall nutrient removal, driven by higher biomass production. Therefore, the study highlights the importance of integrated nutrient management practices for sustainable brinjal cultivation. Incorporating NPS compost along with foliar application of humic acid can be recommended as an efficient strategy to achieve higher productivity and improved nutrient use efficiency while maintaining soil health under Vertisol conditions.

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