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Effect of potassium humate on growth, yield and quality of transplanted rice (*Oryza sativa* L.)

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Abstract

A field experiment was conducted during the Kharif season of 2024 at the Dusty Acre Research Farm, JNKVV, Jabalpur, to evaluate the effect of potassium humate on growth, yield, quality, and economics of transplanted rice. The soil was clay loam with neutral pH and low nitrogen content. The experiment consisted of six treatments (five potassium humate doses: 5-25 kg/ha + 100% RDN, and a control with 100% RDN alone) laid out in an RBD with four replications. Potassium humate significantly improved growth parameters such as plant height, tillers per hill, leaf area index, and chlorophyll content. The highest values were recorded with 25 kg/ha potassium humate + 100% RDN, closely followed by 12.5 kg/ha potassium humate + 100% RDN. Yield attributes—including effective tillers m², panicle length, grains per panicle, and filled grains per panicle—also increased significantly with higher doses of potassium humate, although the 1000-grain weight remained unaffected. The maximum grain (4296.25 kg/ha) and straw yield (6406.30 kg/ha) were obtained with 25 kg/ha potassium humate + 100% RDN, followed by 12.5 kg/ha potassium humate. Economic analysis revealed that, although 25 kg/ha resulted in the highest gross return, the most profitable and cost-effective treatment was 12.5 kg/ha potassium humate + 100% RDN, which gave the highest net return and B:C ratio (3.01). Overall, potassium humate application, particularly at 12.5 kg/ha, enhanced growth, yield, quality, and economic returns in transplanted rice. Further studies over multiple seasons and with varied nutrient combinations are suggested to validate and refine these results.

Keywords: Potassium humate, humic acid, nutrient uptake, spad, lai

1. Introduction

Rice (*Oryza sativa* L.), a self-pollinated short-day crop of the Poaceae family, is the world's second most important cereal after wheat and a staple food for millions, with 90% of global production concentrated in Asia. (Vasudevan *et al.*, 2014)^[1]. It grows best in humid subtropical to moist tropical climates, under submerged lowland conditions with an optimal temperature range of 21-37 °C and acidic soils (pH 4-6). Globally, Rice is the second most widely grown cereal next to wheat and it has occupied an area of 168 M ha with production and productivity of 532.66 mt and 4.7 tons ha⁻¹, respectively (USDA, 2021)^[2]. In India, rice occupies 47.8 million ha with 145.28 million tons production, While Madhya Pradesh grows it on 2.11 million ha with lower productivity. (Agriculture statistics at a glance, 2023). Rice cultivation commonly involves transplanting in puddled, waterlogged soil, but practices vary with agroclimatic conditions. (Gupta *et al.*, 2015)^[3]. Weeds remain a major challenge in both irrigated and rainfed systems. Biostimulants, including humic substances, enhance plant growth by influencing gene expression, hormone-like activity, and nutrient uptake. (Kumar *et al.*, 2018)^[4]. Potassium is a vital nutrient for cereals, improving yield, quality, stress tolerance, and carbohydrate metabolism. (Zorb *et al.*, 2014)^[5]. Due to intensive cropping and imbalanced fertilization, potassium deficiency has increasingly become a limiting factor.

Potassium humate, a potassium salt of humic acid derived from lignite, contains about 50% humic substances and 12% potassium. It is highly soluble, environmentally safe, and improves soil fertility, nutrient mobility, antioxidant defence, and microbial activity.

Humic acids act as natural chelators, reduce nutrient losses, stimulate root growth, enhance photosynthesis, and help plants tolerate abiotic stress. It enhanced the intake of water and nutrients and stimulated plant growth by increasing cell division. Additionally, HA promoted the growth and activities of the soil microbes (Chen *et al.*, 2004) [6]. Although beneficial, its use in cereal crops remains limited due to low awareness. Overall, humic substances, especially potassium humate, have strong potential to enhance soil health, nutrient availability, and crop performance. Therefore, keeping in view all above facts the present investigation entitled “Effect of potassium humate on growth, yield and quality of transplanted rice (*Oryza sativa* L.)” has been conducted.

2. Methods and Materials

The field experiment was conducted during Kharif 2024-25 at the Dusty Acre Research Farm, Department of Agronomy, JNKVV, Jabalpur (M.P.), located in the Kymore Plateau and Satpura Hills agro-climatic zone. The region falls under hot sub-humid eco-region number 10 with an average annual rainfall of 1350 mm, mostly from mid-June to September. All required research facilities, inputs, and laboratory support were available at the campus. The study followed a Randomized Block Design (RBD) with six treatments and four replications, using rice variety PB1. The gross plot size was 5.0×4.0 m and net plot size 4.0 × 3.6 m, with spacing of 1.5 m between replications and 1.0 m between treatments. Treatments included 100% RDF alone and in combination with varying doses of potassium humate (5, 7.5, 10, 12.5 kg/ha and 25 g/ha). Data were analyzed using ANOVA as per Gomez and Gomez (1984), and significance was tested through SEM ± and CD at 5% probability. Crop observations were recorded at key growth stages. Plant population (m⁻²) was measured at 20 DAT and harvest from three random rows and converted to square meter values. Plant height was recorded at 30, 60 DAT and harvest from ground level to the top growing point, and the mean was calculated. Tillers hill⁻¹ were counted at 30, 60, 90 DAT and harvest from selected hills. Leaf Area Index (LAI) was assessed at 30, 60 and 90 DAT using a leaf area meter as per Gardner *et al.* (1985) [7]. Chlorophyll index (SPAD) was measured at 30 and 60 DAT from fully expanded middle leaves to assess plant health. Effective tillers were counted from five hills, considering only grain-bearing tillers. Grain yield (kg/ha) was recorded from cleaned produce and converted to hectare basis. Economic assessment was done using the benefit-cost ratio:

$$\text{Benefit cost ratio} = \frac{\text{Gross monetary return (Rs ha}^{-1}\text{)}}{\text{Total cost of cultivation (Rs ha}^{-1}\text{)}}$$

Effect on growth parameters

Although height differences at 30 DAT were statistically non-significant, the numerical increase from 41.2 cm (T₁) to 43.8 cm (T₆) suggests early stimulation of vegetative growth. This can be attributed to the root-stimulating property of humic substances, which promote cell elongation and root biomass development. By 60 DAT, significant differences emerged. Plant height increased progressively from 77.8 cm in T₁ to 86.9 cm in T₆, with the CD (P=0.05) of 5.44 cm indicating a clear treatment effect. Potassium humate application enhances nutrient uptake (especially N, P, K, and micronutrients) through improved membrane permeability and chelation activity. This stage coincides with the rapid vegetative growth phase, where enhanced nutrient absorption directly influences internode elongation and canopy development. At Harvest tallest plants (103.7 cm) were recorded in T₆ (100% RDN + 25 kg/ha K-humate), followed by T₅ and T₄, while the lowest height (94.9 cm) occurred in the control (T₁).

These findings agree with earlier reports that humic acids improve plant morphological traits through. It might be due to the fact that application of potassium humate lies in their ability to enhance nutrient availability to the plant. By improving the uptake of essential nutrients stimulate vital physiological process in plants, ultimately promoting growth and produce taller plant stature. Similar results were reported by Sahu *et al.* (2013), Kumar *et al.* (2022) [8] Gajbhiye *et al* a and b (2024) [9], Gangwar *et al* (2011) [10] and Dwivedi *et al* 2012 [11], tillering Phase (60 DAT) [11] significant effect was observed where tillers/hill increased from 10.02 (T₁) to 12.96 (T₆). Humic substances play a significant role in Enhancing cytokinin activity, which stimulates lateral bud growth, Improving N-use efficiency, leading to vigorous vegetative growth, Activating root branching and enzymatic activity. These physiological improvements support higher tiller production. At 90 DAT, the highest number of tillers (13.19) was found under T₆, significantly superior to the control. Treatments T₄ and T₅ were also close contenders, reflecting the dose-responsive nature of potassium humate. Tiller formation is closely linked to root activity, and humates are known to increase root length, surface area, and number of root tips. This improved root system supports higher nutrient uptake, leading to more tiller development and ultimately higher yield potential. Kumaravel *et al.* (2022) [12] and Ansari *et al.* (2023) [13].

Table 1: Effect of doses of potassium humate on growth parameters at different time intervals

S No.	Treatments	Plant height (cm)			Tillers/hill		
		30 DAT	60 DAT	At harvest	30 DAT	60 DAT	90 DAT
T ₁	100% RDN (Recommended dose of nutrients) (100:60:40 kg/ha N: P: K)	41	77.8	94.9	6.3	10	10
T ₂	100% RDN + 5 kg/ha potassium humate as soil application	42	80.8	96.3	6.4	10.8	11
T ₃	100% RDN + 7.5 kg/ha potassium humate as soil application	43	82.6	98.2	6.51	11.9	12
T ₄	100% RDN + 10 kg/ha potassium humate as soil application	43	83.8	100	6.8	12.2	12
T ₅	100% RDN + 12.5 kg/ha potassium humate as soil application	44	85	101	6.9	12.9	13
T ₆	100% RDN + 25 kg/ha potassium humate as soil application	44	86.9	104	7.02	13	13
	S.Em±	1.5	1.78	1.42	0.45	0.38	0.4
	CD(P=0.05)	NS	5.44	4.31	NS	1.21	1.2

Effect on grain yield kg/ha, straw yield kg/ha, harvest index%.

Grain yield kg/ha

The experimental results clearly demonstrate that the integration of potassium humate with the recommended dose of nutrients (RDN) significantly enhances the productivity of rice.

A progressive and consistent increase in grain yield, straw yield, and harvest index was recorded with increasing levels of potassium humate applied as a soil amendment. The lowest grain yield (3679.5 kg/ha) was recorded under T₁ (100% RDN alone). A gradual increase was observed as the dose of

potassium humate increased, with yields ranging from 3815.5 kg/ha in T₂ to 4296.3 kg/ha in T₆. The highest grain yield of 4296.3 kg/ha was obtained under T₆ (100% RDN + 25 kg/ha potassium humate), showing a substantial improvement over control (Jha *et al* 2007 and 2013, Kumar *et al* 2023 and Kumar *et al* 2023, Malviya *et al* 2012,) [14, 17, 15, 16]. The increase in grain yield with potassium humate may be attributed to its beneficial role in improving soil physical properties, enhancing nutrient uptake, stimulating root growth, and boosting microbial activity—all of which collectively contribute to better plant growth and productivity. potassium humate stimulate physiological activities within the plant, viz., photosynthesis, hormone regulation and enzymatic processes, which collectively contribute to increased biomass accumulation and enhanced yields. Similar findings were also reported by Gohary *et al.* (2010) [18], Osman *et al.* (2013) [19] and Barai *et al.* (2022) [28] Shri *et al* 2014 [20] Sahu *et al* 2023 [21].

Straw yield kg/ha

The minimum straw yield (5980.8 kg/ha) was recorded in the control treatment (T₁). Treatments receiving potassium humate

showed steady increments, with yields ranging from 6027.3 to 6406.3 kg/ha. The maximum straw yield (6406.3 kg/ha) was recorded in T₆, indicating improved vegetative growth due to enhanced nutrient availability and better soil health. Higher straw yield reflects improved biomass accumulation, often linked with increased photosynthetic activity and better assimilation of nutrients stimulated by potassium humate (Tiwari *et al* 2013 and Tiwari *et al* 2017, Tomar *et al* a and b 2023, Singh *et al* 2013, Pahade *et al* 2023) [22, 23, 24].

Harvest index%

It is an indicator of the efficiency of the plant to convert its total biomass into economic yield, also showed a gradual improvement with the application of potassium humate. HI increased from 38.09% in T₁ to 40.14% in T₆. The rise in HI suggests better partitioning of assimilates towards grain formation in humate-treated plants. The highest HI in T₆ signifies that potassium humate not only enhances biomass production but also improves crop efficiency in converting this biomass into grain yield (Sairam, *et al* 2023 Yadav *et al* 2023 and Raghav, *et al* 2023) [25, 26, 27].

Table 2: Effect of doses of potassium humate on grain and straw yields (kg/ha) and harvest index

S. No.	Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T ₁	100% RDN (Recommended dose of nutrients)(100:60:40 kg/ha N: P: K)	3679.5	5980.8	38.09
T ₂	100% RDN + 5 Kg/ha potassium humate as soil application	3815.5	6027.3	38.76
T ₃	100% RDN + 7.5 kg/ha potassium humate as soil application	4013.0	6217.9	39.22
T ₄	100% RDN + 10 kg/ha potassium humate as soil application	4112.8	6270.5	39.60
T ₅	100% RDN + 12.5 kg/ha potassium humate as soil application	4250.3	6390.0	40.00
T ₆	100% RDN + 25 kg/ha potassium humate as soil application	4296.3	6406.3	40.14
	S.Em±	64.81	88.23	
	CD(P=0.05)	198.20	268.30	

Effect on Economics

Cost of cultivation

The data indicate that the cost of cultivation was lowest (Rs.40052) under 100% recommended dose of nutrients alone, but increased from Rs.41802 to 48802 with increasing the dose of potassium humate along with the 100% RDN. Whereas, the highest cost of cultivation was (Rs.48802) recorded under the T₆ in which 25 kg/ha potassium humate with 100% recommended dose of nutrients were applied. presents the estimated gross monetary returns get from grain and straw yield based on current market rate. Application of potassium humate @ 25 kg/ha along with 100% RDN fetched highest gross monetary returns of Rs.135293/ha over all the treatments. The next best treatment was potassium humate @ 12.5 kg/ha along with 100% recommended dose of nutrients, which gave gross monetary return of Rs.133897/ha. The lowest gross monetary

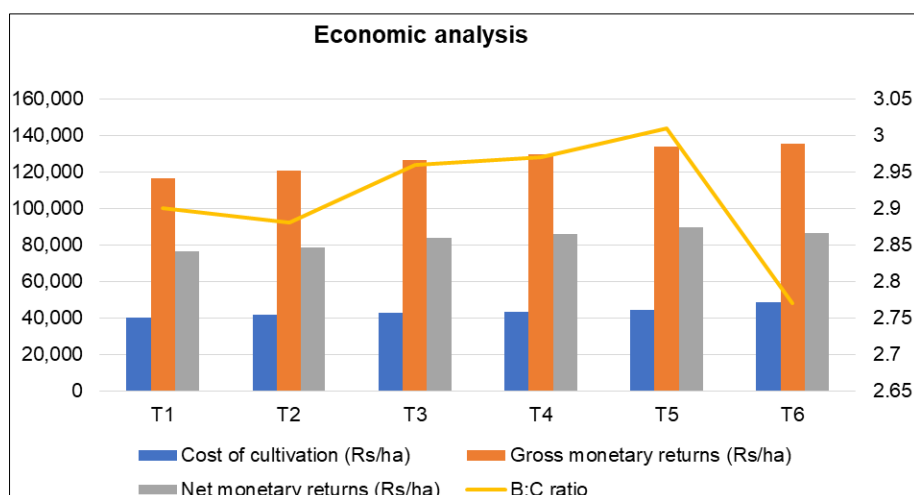
return of Rs.116350/ha was obtained under the 100% recommended dose of nutrients alone.

The net monetary returns (NMR) were computed by subtracting the cost of cultivation from gross monetary returns of individual treatment. Hence, treatment wise computed values are presented in Table 3 and it shows that lowest NMR of Rs.76298/ha was received under 100% recommended dose of nutrients. However it raised with increased doses of potassium humate up to 12.5 kg/ha. The maximum NMR of Rs.89470/ha was recorded with 12.5 kg/ha potassium humate +100% recommended dose of nutrients. Benefit-cost ratio of 2.77 was recorded with 25 kg/ha potassium humate + 100% recommended dose of nutrients while it was highest in 12.5 kg/ha potassium humate + 100% recommended dose of nutrients and seems more remunerative as it fetched 3.01 per rupee investment.

Table 3: Effect of doses of potassium humate on COC, GMR, NMR and B:C ratio in rice

S. No.	Treatments	Cost of cultivation (Rs/ha)	Gross monetary returns (Rs/ha)	Net monetary returns (Rs/ha)	B:C ratio
T ₁	100% RDN (Recommended dose of nutrients) (100:60:40 kg/ha N: P: K)	40,052	1,16,350	76,298	2.90
T ₂	100% RDN + 5 kg/ha potassium humate as soil application	41,802	1,20,492	78,690	2.88
T ₃	100% RDN + 7.5 kg/ha potassium humate as soil application	42,677	1,26,607	83,930	2.96
T ₄	100% RDN + 10 kg/ha potassium humate as soil application	43,552	1,29,652	86,100	2.97
T ₅	100% RDN + 12.5 kg/ha potassium humate as soil application	44,427	1,33,897	89,470	3.01
T ₆	100% RDN + 25 kg/ha potassium humate as soil application	48,802	1,35,293	86,491	2.77

Note:- Current market rates of grain (Rs.30/kg) and straw (1 Rs/kg).



Conclusion

12.5 kg/ha potassium humate with 100% RDN (T₅) proved to be the most economically viable option, whereas 25 kg/ha potassium humate (T₆) maximized biological productivity. Therefore, application of potassium humate at 12.5 kg/ha along with the recommended nutrient dose can be recommended as an optimal and remunerative practice for rice production under the agro-climatic conditions of Jabalpur.

Gajbhiye Mrinali, Agrawal KK, Jha AK and Kumar Narendra 2024. Combined Application of Inorganic Fertilizer and Organic Manure with Nano Urea on Growth and Yield of Scented Rice .International Journal of Plant & Soil Science Volume 36, Issue 5, Page 293-300, 2024

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