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Performance of bio-stimulant on growth and yield of rice in *Vertisol* of Chhattisgarh

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Abstract

A field experiment was carried out in research farm, IGKV, Raipur, Chhattisgarh, India during kharif 2023 and 2024 to know the Performance of bio-stimulant on growth and yield of rice in *Vertisol* of Chhattisgarh. It was laid down in a randomized block design (RBD) consisting twelve treatments and three replications. The various treatment combinations included : T_1-RDF (120:60:40), T_2-RDF + Root Dipping with humic acid powder(1 g/L), T_3-RDF + humic acid powder @ 250 g/acre (SA), T_4-RDF + humic acid powder @ 500 g/acre (SA), T_5-RDF + humic acid powder @ 1000 g/acre (SA), T_6-80% RDF + Root Dipping with humic acid powder (1 g/L), T_7-80% RDF + humic acid powder @ 250 g/acre (SA), T_8-80% RDF + humic acid powder @ 500 g/acre (SA), T_9-80% RDF + humic acid powder @ 1000 g/acre (SA), T_{10}-80% RDF + humic acid powder @ 1 g/L (FS), T_{11}-80% RDF + humic acid powder @ 2 g/L (FS) and T_{12}-80% RDF + humic acid powder @ 4 g/L (FS). The results showed that combining humic acid powder with 100% RDF had a positive influence on most of the growth parameters. The treatments with RDF + humic acid powder @ 500 g/acre was able to obtained significantly higher grain yield which is directly comparable to RDF + HP @ 1000 g/acre in both the seasons. Also, the higher B:C ratio was obtained by the application of RDF + HP @ 500 g/acre followed by 80% RDF + HP @ 500 g/acre. The higher B:C ratio in RDF + HP @ 500 g/acre and 80% RDF + HP @ 500 g/acre highlights that moderate to high doses of humic acid under 80 and 100% RDF significantly improve economic returns by enhancing crop productivity.

Keywords: Rice, humic acid, root dipping, soil application, foliar spray and B:C ratio

1. Introduction

Rice is most important cereal crop of India and serves as the primary staple food for more than two-thirds of the population. During 2021-22, national rice production reached 130.29 million tonnes across 45 million hectares (Ministry of Agriculture & Farmers Welfare, 2021) [11]. The Indian state Chhattisgarh is known as the ‘rice bowl of India’ contributes about 5% share in rice production. The production and productivity of rice in Chhattisgarh was 92.49 lakh metric tonnes and 21.3 q ha^{-1} respectively in 2020-21 (Agriculture statistics table, Chhattisgarh government, 2021) [1]. In India the total fertilizer applied to rice crop about 7.5 million tonnes in which 4.9 million tonnes of N, 1.68 million tonnes of P, and 0.88 million tonnes of K, respectively. (International Fertilizer Association and International Plant Nutrition Institute, 2017). However, in order to cope up with the rapid population growth, the requirement of rice production by 2030 is estimated to be 160 million tonnes (Mishra *et al.* 2013) [10] which is not achievable through relying solely on green revolution-based farming methods as it is gradually losing its hope due to excessive and unscientific exploitation of its broods (chemical fertilizers, pesticides, irrigation etc). Yield stagnation, sharp rise of input price, soil health deterioration and environmental footprints (Biswas *et al.* 2019) [3] are some pertinent issues associated with the use of chemical fertilizers and therefore, there is an urgent need for its partial replacement or complete paradigm shift towards modern biotechnological advances. Bio-stimulants have recently gained attention as effective tools for improving nutrient-use efficiency, stress tolerance, and overall crop performance. They enhance plant growth without acting as conventional fertilizers or pesticides and can increase yields while reducing dependency on chemical fertilizers. Among various bio-stimulants, humic substances, particularly humic acid, are notable for their ability to improve soil physical, chemical, and biological properties, thereby enhancing crop growth, nutrient availability, and soil health. Integrating humic substances with inorganic fertilizers supports sustainable and high-productivity rice systems. Although humic acid is not formally classified as a fertilizer, it is widely regarded as an effective supplement when used alongside synthetic or organic fertilizers. Numerous studies have demonstrated that humic substances improve soil structure, enhance microbial activity, and influence key physiological mechanisms related to plant growth stimulation, cell permeability, and nutrient uptake, ultimately contributing to higher crop yields.

Therefore, the present investigation was undertaken to evaluate the Performance of bio-stimulant on growth and yield of rice in *Vertisol* of Chhattisgarh which aims to preserve the environment and reduce the cost of plant production.

2. Materials and Methods

The experiment was conducted at research farm of Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh, India during Kharif season of the year 2023 and 2024 to investigate the Performance of bio-stimulant on growth and yield of rice in *Vertisol* of Chhattisgarh. The soil of the experimental area was clayey in nature falling under the category of *Vertisol*, which is a fine, hyperthermic, montmorillonitic chromustert soil. Locally, the soil is known as Kanhar and is classified under Arang II series. The experimental soil was clayey in texture, neutral in reaction (7.50) and non-saline in nature (0.19 dS m^{-1}). The organic matter (0.49%) and available nitrogen (215 kg ha^{-1}) were low in status. On the other hand, the available phosphorus (17.5 kg ha^{-1}) was found medium and available potassium (495 kg ha^{-1}) was found at higher status in the soil. Rice (variety-Rajeshwari) was used as test crop in the experiment. The experimental land was prepared thoroughly by ploughing twice with the help of cultivator and divided into plots of size 4 x 5 m. The plots were cleaned up by collecting and removing weeds and stubbles of previous crop. The plots were labelled uniformly and were laid down as per the design of the experiment. The trial was laid down in a randomized block design (RBD) corresponding to 12 treatments and three replications. The treatments were T_1-RDF (120:60:40), T_2-RDF + Root Dipping with humic acid powder(1 g/L), T_3-RDF + humic acid powder @ 250 g/acre (Soil application), T_4-RDF + humic acid powder @ 500 g/acre (Soil application), T_5-RDF + humic acid powder @ 1000 g/acre (Soil application), T_6-80% RDF + Root Dipping with humic acid powder (1 g/L), T_7-80% RDF + humic acid powder @ 250 g/acre (Soil application), T_8-80% RDF + humic acid powder @ 500 g/acre (Soil application), T_9-80% RDF + humic acid powder @ 1000 g/acre (Soil application), T_{10}-80% RDF + humic acid powder @ 1 g/L (Foliar spray), T_{11}-80% RDF + humic acid powder @ 2 g/L (Foliar spray) and T_{12}-80% RDF + humic acid powder @ 4 g/L (Foliar spray). All the treatments consisted a common dose of 80 and 100% recommended dose of N, P and K. Urea, Single super phosphate (SSP), Muriate of potash (MOP) and Humic acid powder were used as fertilizers. One third of N (Urea) and full recommended dose of P and K fertilizers were applied at the time of transplanting. Remaining equal two splits (1/3rd of Urea) of nitrogen were given at tillering and panicle initiation stage of rice. The roots of seedlings were dipped for two hours in humic acid powder solution as requirement of the treatment. After that, the plants were transferred into the treatment (T_2 and T_6). Humic acid powder was given 2 times (at tillering and panicle initiation stage, respectively) through foliar application, as per the treatments. The initial and after harvest soil samples were analyzed using standard protocols to determine the physico-chemical properties of soil. For agronomic observations, five hills at random from each plot were selected and their mean was noted as the final reading of the respective plot. The gross return $hectare^{-1}$, net return $hectare^{-1}$ and benefit cost ratio were recorded as per the formulas given by Tomar and Tiwari, 1990(16). The yield data collected from field and those recorded in the laboratory were subjected to statistical analysis. The analysis of variance approach was used to examine the analytical data in this experiment as described by Gomez and Gomez (1984) [4].

3. Results and Discussion

The treatments comprising of incorporation of different combinations of bio-stimulants in soil as well as foliar application along with 80 and 100% RDF significantly influenced the total number of tillers per hill during both the years (Table 1). The data on total number of tillers ranged from 7.7 to 8.9 (in kharif 2023) and 7.8 to 9.0 (in kharif 2024). The highest number of tillers per hill was recorded under RDF + HP @ 1000 g/acre (T_5), which remained statistically at par with RDF + HP @ 250 and 500 g/acre (T_3 and T_4). These soil-applied HP treatments significantly outperformed all other HP combinations. Under reduced fertilizer levels, 80% RDF + HP @ 500 and 1000 g/acre (T_8 and T_9) recorded higher tiller numbers than the lower HP dose and were comparable to each other in both seasons.The RDF + RD (T_2) treatment produced tiller numbers similar to 100% RDF (T_1) across years, while 80% RDF + RD (T_6) performed better than 80% RDF + foliar HP @ 1 g/L (T_{10}) but remained significantly inferior to their respective RDF treatments. Similar results were found in the case of effective number of tillers per hill which varied significantly from 6.4 to 7.3 (kharif 2023) and from 6.5 to 7.4 (kharif 2024). The data on number of grains per panicle ranged from 136 and 149(in kharif 2023) and 138 to 151 (in kharif 2024). The maximum number of grains per panicle were observed with RDF + HP @ 500 g/acre (T_4), followed by RDF + HP @ 250 and 1000 g/acre (T_3 and T_5) respectively whereas, minimum grains per panicle was recorded in HP @ 1 g/L (T_{10}). Furthermore, the test weight was influenced non significantly by different combinations of bio-stimulants in soil as well as foliar along with 80 and 100% RDF (Table-2). The range in which the test weight lied was from 30.43 to 31.04 g in kharif 2023 and 30.28 to 31.21 g in kharif 2024. The highest test weight was recorded under RDF + HP @ 500 g/acre, while the lowest was observed with 80% RDF + humic acid @ 1 g/L during 2023 and 2024. The results clearly indicates that the application of humic acid in different doses both as foliar and soil application has a pronounced influence on plant growth and ultimately the final production. Humic acid encourages the development of yield components of rice crop like plant height, productive tillers per hill, and number of grains per panicle at harvest, and ultimately grain and straw yield. It was also reported that the application of humic acid increased the synthesis and activity of IAA, which played a significant role in promoting the plant growth. Present results are concomitant with the findings of Mohammadipour, (2012) [10], Saha *et al.* (2013) [15], Arun *et al.* (2019) [2], Karennavar *et al.* (2022) [5]

and Kumar *et al.* (2023) [8].

The incorporation of different combinations of bio-stimulants in soil as well as foliar along with 80 and 100% (RDF) resulted in a significant increase in grain and straw yield in both the seasons (Table 3). The grain yield ranged from 54.6 and 56.6 q ha^{-1} in 80% RDF + HP @ 1 g/L to 62.7 and 65.3 q ha^{-1} in RDF + HP @ 500 g/acre during 2023 and 2024, respectively. The highest grain yield was recorded under RDF + HP @ 500 g/acre (T_4), which was statistically comparable with RDF + HP @ 1000 g/acre (T_5) and RDF + HP @ 250 g/acre (T_3) across individual years, indicating the consistent superiority of soil-applied HP at higher doses. Under reduced fertilizer levels, 80% RDF + HP @ 500 g/acre (T_8) and 80% RDF + HP @ 1000 g/acre (T_9) resulted in significantly higher grain yield than the lower HP dose (T_7) and remained comparable to each other. The RDF + RD (T_2) treatment produced grain yields similar to 100% RDF (T_1), while 80% RDF + RD (T_6) performed better than 80% RDF + HP @ 1 g/L (T_{10}) but remained inferior to the corresponding RDF-based treatments. Among foliar applications, 80% RDF + HP @ 4 g/L (T_{12}) and 80% RDF + HP @ 2 g/L (T_{11}) recorded higher yields than HP @ 1 g/L (T_{10}), which consistently exhibited the lowest grain yield across years. A similar trend was observed for straw yield. Straw yield ranged from 58.2 to 68.6 q ha^{-1} during 2023 and 59.4 to 70.4 q ha^{-1} during 2024. The highest straw yield was obtained under RDF + HP @ 1000 g/acre (T_5), followed closely by RDF + HP @ 500 g/acre (T_4), both of which were statistically at par and markedly superior to all other treatments during kharif 2023. However, in kharif 2024, the highest straw yield was obtained in RDF + HP @ 500 g/acre(T_4) followed by RDF + HP @ 1000 g/acre (T_5), and significantly superior to the others, while the minimum straw yield was recorded in the 80% RDF + HP @ 1 g/L(T_{10}) during both the years. The higher grain and straw yield might be obtained because the yield is a function of complex inter relationships of its components, which are determined from the growth rhythms in vegetative phase and its subsequent reflection in the reproduction phase of the plant. Nardi *et al.* (1988) reported that humic substances exhibited auxin, gibberellin and cytokinin-like activities. The positive effect of humic acid on yield could be mainly due to hormone-like activities through their association in photosynthesis, cell respiration, protein synthesis, oxidative phosphorylation and various enzymatic reactions. These results were in line with findings of Manjeera *et al.* (2020) [9] and Kumar *et al.* (2023) [8] in rice.

The economic performance of different treatment combinations was evaluated through economic analysis and the data of the two seasons were pooled for the final results (Table 4) revealed that the highest cost of cultivation (Rs 47,152 ha^{-1}) was incurred in RDF + HP @ 1000 g/acre, followed by (Rs 47,114 ha^{-1}) under 80% RDF + HP @ 4 g/L. The lowest cost of cultivation (Rs 43,552 ha^{-1}) was observed in 80% RDF + RD with HP @ 1 g/L. The increased cost in RDF + HP @ 1000 g/acre and 80% RDF + HP @ 4 g/L might be due to the higher dosage of humic acid and associated labour costs for its formulation, preparation and application. The highest gross return (Rs 1,46,055 ha^{-1}) was obtained in RDF + HP @ 500 g/acre followed by RDF + HP @ 1000 g/acre (Rs 1,45,388 ha^{-1}) and 80% RDF + HP @ 500 g/acre (Rs 1,40,530 ha^{-1}). In terms of net returns, highest (Rs 99,829 ha^{-1}) was obtained in RDF + HP @ 500 g/acre followed by RDF + HP @ 1000 g/acre (Rs 98,236 ha^{-1}) and 80% RDF + HP @ 500 g/acre (Rs 95,790 ha^{-1}) might be due to better yield performance despite their higher cultivation costs. The lowest net return (Rs 83,025 ha^{-1}) was observed in 80% RDF + of HP @ 1 g/L. The benefit cost ratio, was calculated by dividing the net returns with the total cost of cultivation for distinct treatments and the maximum benefit cost ratio (2.16) was recorded in RDF + HP @ 500 g/acre indicating the best profitability among all treatments, followed closely by 80% RDF + HP @ 500 g/acre (2.14) and RDF + HP @ 250 g/acre (2.11). Treatments RDF (120:60:40), 80% RDF + RD with HP(1 g/L) as soil applicaton, and 80% RDF + HP @ 1 g/L as foliar application recorded comparatively lower Benefit cost ratios of 2.05, 2.00, and 1.85, respectively. The higher benefit cost ratio in RDF + HP @ 500 g/acre and 80% RDF + HP @ 500 g/acre highlights that moderate to high doses of humic acid under 80 and 100% RDF significantly improve economic returns by enhancing nutrient uptake and crop productivity. Conversely, foliar application of humic acid, especially at lower concentrations, resulted in relatively less economic advantage. There findings are in agreement carried out by with the investigation Karennavar *et al.* (2022) [5], Osman *et al.* (2013) [14], Kumar *et al.* (2016) [7] and Khan *et al.* (2019) [6].

Table 1: Effect of bio-stimulants on total numbers of tillers per hill, Effective number of tillers per hill and Number of grains per panicle of rice at harvest in 2023 and 2024

Treatment s		Total numbers of tillers per hill		Effective numbers of tillers per hill		Number of grains per panicle	
		2023	2024	2023	2024	2023	2024
T_1	RDF (120:60:40)	8.4^{abcde}	8.5 ^{abcd}	6.91 ^{abcd}	7.0 ^{abcd}	141^{bcde}	145^{abcd}
T_2	RDF + RD with HP (1 g/L)	8.5^{abcd}	8.7^{abcd}	7.0^{abc}	7.1^{abc}	144^{abcd}	147^{abc}
T_3	RDF + HP @ 250 g/acre (SA)	8.8^{ab}	8.9^{ab}	7.2^{a}	7.3^{ab}	147^{abc}	148^{ab}
T_4	RDF + HP @ 500 g/acre (SA)	8.9^{a}	8.9^{ab}	7.2^{a}	7.3^{a}	149^{a}	151^{a}
T_5	RDF + HP @ 1000 g/acre (SA)	8.9^{a}	9.0^{a}	7.3^{a}	7.4^{a}	148^{ab}	150^{a}
T_6	80% RDF + RD with HP(1 g/L)	7.9^{de}	8.0^{de}	6.5^{cd}	6.6^{cd}	138de	140^{cd}
T_7	80% RDF + HP @ 250 g/acre (SA)	8.1^{bcde}	8.3^{bcde}	6.8^{abcd}	6.9^{abcd}	140^{cde}	142^{bcd}
T_8	80% RDF + HP @ 500 g/acre (SA)	8.7^{abc}	8.8^{abc}	7.1^{ab}	7.2^{ab}	145^{abcd}	147^{ab}
T 9	80% RDF + HP @ 1000 g/acre (SA)	8.6 ^{abc}	8.7 ^{abc}	7.0 ^{abc}	7.1^{abc}	144^{abcd}	147^{abc}
T_{10}	80% RDF + HP @ 1 g/L (FS)	7.7^{e}	7.8^{e}	6.4^{d}	6.5^{d}	136^{e}	138^{d}
T_{11}	80% RDF + HP @ 2 g/L (FS)	8.0^{cde}	8.1^{cde}	6.6^{bcd}	6.7^{bcd}	140^{cde}	142^{bcd}
T_{12}	80% RDF + HP @ 4 g/L (FS)	8.3^{abcde}	8.5^{abcde}	6.8^{abcd}	7.0^{abcd}	141^{bcde}	144^{abcd}
	SEm (±)	0.2	0.2	0.2	0.2	2	2

	C.D. (P = 0.05)	0.7	0.7	0.5	0.6	7	7

RD = Root dipping, HP = Humic acid powder, SA = Soil application, FS = Foliar spray

Table 2: Effect of bio-stimulants on test weight of rice after harvest in 2023 and 2024

Treatment s		Test weight (g)	
		2023	2024
T_{1}	RDF (120:60:40)	30.79	30.17
T_{2}	RDF + RD with HP (1 g/L)	30.84	30.87
T_{3}	RDF + HP @ 250 g/acre (SA)	31.00	31.13
T_{4}	RDF + HP @ 500 g/acre (SA)	31.04	31.30
T_{5}	RDF + HP @ 1000 g/acre (SA)	31.02	31.21
T_{6}	80% RDF + RD with HP(1 g/L)	30.40	30.44
T_{7}	80% RDF + HP @ 250 g/acre (SA)	30.63	31.63
T_{8}	80% RDF + HP @ 500 g/acre (SA)	30.95	31.11
T_{9}	80% RDF + HP @ 1000 g/acre (SA)	30.90	31.99
T_{10}	80% RDF + HP @ 1 g/L (FS)	30.43	30.28
T_{11}	80% RDF + HP @ 2 g/L (FS)	30.50	30.54
T_{12}	80% RDF + HP @ 4 g/L (FS)	30.70	31.64
	SEm (±)	0.9	0.9
	C.D. (P = 0.05)	NS	NS

RD = Root dipping, HP = Humic acid powder, SA = Soil application, FS = Foliar spray

Table 3: Effect of bio-stimulants on grain and straw yield of rice in 2023 and 2024

Treatment s		Yield (q ha^{-1})			
		Grain		Straw	
		2023	2024	2023	2024
T_{1}	RDF (120:60:40)	58.9^{abcd}	60.4^{bcde}	63.7^{bcd}	65.7^{bcde}
T_{2}	RDF + RD with HP (1 g/L)	59.3^{abc}	61.6^{abcd}	63.5^{bcd}	65.5^{cde}
T_{3}	RDF + HP @ 250 g/acre (SA)	61.2^{ab}	62.6^{abc}	65.6^{abc}	67.3^{abc}
T_{4}	RDF + HP @ 500 g/acre (SA)	62.7^{a}	65.3^{a}	68.0^{ab}	70.4^{a}
T_{5}	RDF + HP @ 1000 g/acre (SA)	62.2^{a}	64.2^{ab}	68.6^{a}	69.7^{ab}
T_{6}	80% RDF + RD with HP(1 g/L)	55.9^{cd}	57.9^{de}	58.8^{e}	60.9^{fg}
T_{7}	80% RDF + HP @ 250 g/acre (SA)	58.4^{abcd}	59.7^{cde}	61.8^{cde}	63.7^{cdef}
T_{8}	80% RDF + HP @ 500 g/acre (SA)	60.8^{ab}	61.4^{abcd}	64.2^{abc}	66.0^{bcde}
T_{9}	80% RDF + HP @ 1000 g/acre (SA)	60.4^{abc}	61.0^{abcde}	65.8^{abc}	66.4^{abcd}
T_{10}	80% RDF + HP @ 1 g/L (FS)	54.6^{d}	56.6^{e}	58.2^{e}	59.4 g
T_{11}	80% RDF + HP @ 2 g/L (FS)	56.8^{bcd}	58.6^{cde}	59.6^{de}	61.9^{efg}
T_{12}	80% RDF + HP @ 4 g/L (FS)	58.8^{abcd}	60.2^{bcde}	62.2^{cde}	63.0^{defg}
	SEm (±)	1.6	1.5	0.2	0.2
	C.D. (P = 0.05)	4.6	4.5	0.5	0.6

RD = Root dipping, HP = Humic acid powder, SA = Soil application, FS = Foliar spray

Table 4: Effect of bio stimulants on economics of rice

Treatment details		Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	Benefit cost ratio
T_{1}	RDF (120:60:40)	45000	137248	92248	2.05
T_{2}	RDF + RD with HP(1 g/L)	45038	138991	93953	2.09
T_{3}	RDF + HP @ 250 g/acre(SA)	45763	142286	96523	2.11
T_{4}	RDF + HP @ 500 g/acre (SA)	46226	146055	99829	2.16
T_{5}	RDF + HP @ 1000 g/acre (SA)	47152	145388	98236	2.08
T_{6}	80% RDF + RD with HP (1 g/L)	43552	130863	87312	2.00
T_{7}	80% RDF + HP @ 250 g/acre (SA)	44277	135756	91479	2.07
T_{8}	80% RDF + HP @ 500 g/acre (SA)	44740	140530	95790	2.14
T_{9}	80% RDF + HP @ 1000 g/acre (SA)	45666	139653	93987	2.05
T_{10}	80% RDF + HP @ 1 g/L (FS)	44864	127889	83025	1.85
T_{11}	80% RDF + HP @ 2 g/L (FS)	45614	132701	87087	1.91
T_{12}	80% RDF + HP @ 4 g/L (FS)	47114	136797	89683	1.90

RD = Root dipping, HP = Humic acid powder, SA = Soil application, FS = Foliar spray

4. Conclusion

The use of humic acid as a soil and foliar application is gaining importance in India, with increasing research efforts being undertaken worldwide to improve crop growth and productivity. This study is one of the maiden attempts to evaluate the Performance of bio-stimulant on growth and yield of rice in *Vertisol* of Chhattisgarh under different modes of application alongside recommended fertilizer doses**.** It can be concluded by the experiments that, the treatments with different combination of soil and foliar-applied humic acid in conjunction with 80 and 100% RDF had a significant effect in improving the yield and yield attributing characters (except test weight) of rice. The soil application of RDF + HP @ 500 g/acre was able to give remarkably high yield which is directly comparable to RDF + HP @ 1000 g/acre. However, other treatments with 80% RDF mixed with soil application of humic acid were also able to give notably high yields. The application of RDF +

HP @ 500 g/acre expressed highest B:C ratio among all the treatments followed by 80% RDF + HP @ 500 g/acre. The higher benefit cost ratio in RDF + HP @ 500 g/acre and 80% RDF + HP @ 500 g/acre highlights that moderate to high doses of humic acid under 80 and 100% RDF significantly improve economic returns by enhancing nutrient uptake and crop productivity. Conversely, foliar application of humic acid, especially at lower concentrations, resulted in relatively less economic advantage.

References

1. Agriculture Statistics Table. Chhattisgarh Government; 2021. Available from: https://revenue.cg.nic.in/Docs/agriculturaltable2021
2. Arunkumar BR, Thippeshappa GN, Chidanandappa HM, Gurumurthy KT, Basavaraj Naik T, Basavarajappa HB. Effects of biochars on soil carbon pools under aerobic rice cultivation. Journal of Pharmacognosy and Phytochemistry. 2019;8(4):1398-1402.
3. Biswas S, Jana K, Agrawal RK, Puste AM. Effect of integrated nutrient management on growth attributing characters of crops under various oat-lathyrus intercropping system. The Pharma Innovation Journal. 2019;8(9):368-373.
4. Gomez KA, Gomez AA. Statistical procedures for agricultural research. New York: Wiley Inter-Science; 1976. p. 1-680.
5. Karennavar SS, Chavan VG, More VG, Dhopavkar RV, Desai SS, Bodake PS. Effect of humic acid-based biostimulant on growth, yield and yield-attributing characters of kharif rice (*Oryza sativa* L.). The Pharma Innovation Journal. 2022;11(11):319-322.

   Khan OA, Sofi JA, Kirmani NA, Hassan GI, Bhat SA, Chesti MH, Ahmad SM. Effect of N, P and K nano-fertilizers in comparison to humic and fulvic acid on yield and economics of red delicious (*Malus* × *domestica* Borkh.). Journal of Pharmacognosy and Phytochemistry. 2019;8(2):978-981.
6. Kumar U, Gulati IJ, Kumar H, Kumar G. Role of humic acid and salicylic acid on yield attributes, yield, and economics of tomato under saline stress condition. Annals of Plant and Soil Research. 2016;18(2):118-122.
7. Kumar YS, Nayak SB, Reddy CVCM, Kumar KA, Vishnuvardhan KM, Kiranmayi J, Rao EN. Effect of potassium humate fertilizers on soil nutrients and productivity of rice crop in Vertisol of Southern India. Humic Acid. 2018;19:1-10.
8. Manjeera KS, Subbaiah PV, Prasad PRK, Rekha MS. Available nutrient status of soil as influenced by combined application of humic acid and inorganic nitrogen. International Journal of Plant & Soil Science. 2021;33(22):209-217.
9. Mishra MM, Mohanty M, Gulati JML, Nanda SS. Evaluation of various rice (*Oryza sativa*)-based crop sequences for enhanced productivity, profitability and energy efficiency in the eastern plateau and hill zone of India. Indian Journal of Agricultural Sciences. 2013;83(12):1279-1284.
10. Ministry of Agriculture & Farmers Welfare. Agricultural Statistics at a Glance 2021. New Delhi: Government of India; 2021.
11. Mohammadipour E, Golchin A, Mohammadi J, Negahdar N, Zarchini M. Effect of humic acid on yield and quality of marigold (*Calendula officinalis* L.). Annals of Biological Research. 2012;11:5095-5098.
12. Nardi S, Arnoldi G, Dell'Agnola G. Release of hormone-like activities from *Allolobophora rosea* (Sav.) and *Allolobophora* (Sav.) feces. Canadian Journal of Soil Science. 1988;68:563-567.
13. Osman EAM, El-Masry AA, Khatab KA. Effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants. Advances in Applied Science Research. 2013;4(4):174-183.
14. Saha R, Saieed MAU, Chowdhury MAK. Growth and yield of rice (*Oryza sativa* L.) as influenced by humic acid and poultry manure. Universal Journal of Plant Sciences. 2013;1(3):78-84.
15. Tomar SS, Tiwari AS. Production potential and economics of different crop sequences. Indian Journal of Agronomy. 1990;35(1-2):30-35.