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Effect of Potassium humate fertilizers on soil nutrients and productivity of Rice crop in vertisols of Southern India

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ABSTRACT

Humic acid is an eco-friendly product needed in lesser quantity when compared to other chemical fertilizers and manures.A field experiment was conducted for three *Kharif* seasons (2019, 2020 and 2021) at Regional Agricultural Research Station, Nandyala, Andhra Pradesh to study the effect of potassium humate fertilizers on soil quality and productivity of Rice crop in scarce rainfall zone of Andhra Pradesh, India. Applications of potassium humate with different doses of fertilizers showed a significant effect on selected soil characteristics. The levels of available N, P, K, and micronutrients likeFe, Zn, Cu and Mn in soil increased with different humic treatments. Significantly highest plant height, productive tillers per hill, panicle length and number of grains per panicle was observed with treatment (T_4) 100% RDF + Soil application of humic acid @ 30 kg ha^{-1} at tillering, panicle initiation and at harvest stages of crop over other treatments. Highest grain and straw yield of 6074 & 8374kg ha^{-1} respectively, was recorded with treatment T_4 (100% RDF+30 kg ha^{-1} Humic acid as soil application) which was on par with T_2 and T_3 treatments. The lowest yield was recorded with T_1 (Control) 2453 kg ha^{-1} in all three years.

Key words : *Paddy crop, Potassium humate fertilizers, Grain yield and straw yield.*

Introduction

Humic substances are generated through organic matter decomposition and employed as soil fertilizers in order to improve soil structure and soil microorganisms. Soil organic matter has been fractionated on the basis of solubility in dilute mineral acid and alkali in to three groups' viz., fulvic acid, humic acid and humin. Fulvic acids are soluble in both acid and alkali, humic acids are soluble in alkali but insoluble in acids and humins are insoluble in both. Humic acids occupy an intermediate position between these three groups and persist in the soil for a prolonged period so as to be useful to the crop plants (Ravichandran, 2011). Rice (*Oryza sativa* L.) is known as staple food for one third of the world's population (Zhao *et al.,* 2011). Asia accounts for over 90% of the world's production of rice, with China, India and Indonesia producing the most. In India, it is grown in an area of 43.9 m.ha with a production of 99.24 m t and productivity of 2494 kg ha^{-1}. In Andhra Pradesh, it is grown in an area of 2.152 m ha with a production of 8.05 m.t and productivity of 3741 kg ha^{-1}. (Ministry of Agriculture, Govt. of India, 2018-19).

Humic acid is an eco-friendly product, needed in lesser quantity when compared to other chemical fertilizers and manures. Humic acid based commercial products are developed and widely available in the market considering the potential of humic acid in agriculture. The humic acid products are usually available in the form of inexpensive soluble salts, referred to as potassium humate (Fong *et al.*, 2007). Potassium humate has been reported recently (Turgay *et al*. 2011; Kumar *et al*. 2013) as the potential to improve soil properties and nutrient dynamics. Potassium humate is a very concentrated form of humus in the naturally occurring lignite which is the brown coal that accompanies coal deposits. Humic acid (HA) consists of chemical conglomerate reactive functional groups, including carboxyls, phenolic, and alcoholic hydroxyls with pH dependent properties (Alvarez-Puebla, 2005). Remarkable response of cereals, pulses, cash crops, vegetables to humic acid application is observed by various scientists. Although several research studies had been carried out on the use of humic acid in various crops, there are hardly any studies focussing on the use of humic acid on soil properties and yield of rice. In view of all these, a field study was conducted in *kharif* 2019, 2020 and 2021 at Regional Agricultural Research Station, Nandyal to study the effect of Potassium humate fertilizers or humic acid on soil quality and productivity of Rice crop.

Materials and Methods

The field experiments were conducted during the kharif seasons of crop years, 2019, 2020 & 2021at Regional Agricultural Research Station, Nandyala, Andhra Pradesh, under Irrigated conditions. The soil of experimental site was medium deep black, low in organic carbon (0.24 %), low in Nitrogen (116 kg/ha), high in available P_2O_5 (69.5 kg ha^{-1}) and available K_2O (536 kg ha^{-1}). A composite soil sample was collected from 0-20 cm depth during the study years, processed and analysed in laboratory for pH and Electrical Conductivity(EC) (1:2 soil : water suspension), by pH and Ec meters, respectively (Jackson 1973). Organic Carbon percentage (OC) was estimated by rapid titration method (Walkley and Black method 1934). Available nitrogen was estimated by alkaline permanganate method (Subbaiah and Asija, 1956). Available phosphorus by Olsens method (Olsen *et al*., 1954). Available potassium by ammonium acetate extraction method (Jackson 1973). The experiment was laid out in randomized block design with 7 treatments and replicated in three times. The details of treatments were T_1-Control (No Humic acid application), T_2- 10 kg ha^{-1}Humic acid as soil application, T_3- 20 kg ha^{-1}Humic acid as soil application, T_4- 30 kg ha^{-1}Humic acid as soil application, T_5- 0.2% of foliar application of Humic acid at 30 & 60 DAT, T_6- Root dipping in 0.2 % Humic acid and T_7- 100% RDF. Rice (NDLR-7) was sown during second week of July, transplanted in second week of August by adopting 15x15cm spacing with three seedlings per hill and fertilizers applied as per the treatments protocol. Humic acid at the levels chosen were applied basally and incorporated as per treatments mentioned. The crop cultural practices were carried out according to the standard practices in the rice fields and harvested at 145 days after sowing. The grain and straw samples were collected at harvest, oven dried at 70 ^{0}C processed and analysed for total content of N, P, K, Zn, Cu, Fe and Mn following standard procedures. The data related to plant height and yield attributes was recorded on ten randomly selected plants in each plot. Net grain and straw yield were recorded for net plot and computed as kg ha^{-1}. Soil and plant samples were collected in each treatment and analysed by following standard procedures. All the data were subjected to statistical analysis.

Results and Discussion

Effect on soil properties

After close observation of the study, soil available nutrients content is presented in Table 1 which revealed that there was significant difference between the treatments that received different levels of humic acid in major available nutrients status but pertaining to micronutrients status in three years that received different levels of humic acid and inorganic fertilizers was found to be non significant in all three years of study of paddy crop.

Data pertaining to soil fertility status after harvest of the crop revealed that available soil Nitrogen, Phosphorous and potassium (259, 55.5 and 488 kg N, P_2O_5 and K_2O ha^{-1}) were significantly high in treatment (T_4-100% RDF + 30 kg ha^{-1} Humic acid as soil application). The increase in soil available nitrogen might be attributed to the enhanced microbial activities induced by humic acid. The observed increase in the available nitrogen also might be due to the nature of humic substances to slow down the urease activity (Kumar and Singh, 2017) and also to inhibit the nitrification processes, thereby preventing the loss of N through major avenues such as leaching and volatilization. The increase in available nitrogen could also be ascribed to the addition of N from mineralization of native N on account of enhanced microbial activity. Similarly, Nandakumar *et al.* (2004) found that application of potassium humate in combination with NPK increased soil nutrient availability at all growth stages (tillering, flowering, and harvest) of rice in soil. The favorable effect of organic sources in conjunction with chemical fertilizers in enhancing the availability of nitrogen in soil has also been reported by Bandyapadhyay and Puste (2002). The increase in the availability of P could be attributed to the favorable effect of humic acid on chemical and biochemical processes involved. The humic acids might have helped in solubilizing P from insoluble to soluble form resulting in its increase. David *et al.* (1994) found that, humus would form protective coating over sesquioxides and thereby reduce the fixation of any phosphate, which made them available in the soil. Sangeetha and Singaram (2007) found that available P content were significantly higher in the treatments that received 100% recommended dose of NPK along with 20 kg HA ha˝1 as soil application. Humic acids stimulate fixation and release of K in soil by dissolving K-bearing minerals or blocking interlayer and adsorbing K (Chenghua, Lei, and Liyu, 2005). The present results were parallel to those of these authors, who indicated that depending on their application rate, humic acids accelerated K release from the soil. Similar observation were also made by Bama *et al.* (2003) and reported that combined application of 100% NPK with 20 kg ha^{-1} potassium humate significantly enhanced availability of potassium in soil. Similar results were reported in rice crop by Vanitha *et al*. (2014) and Kumar and Singh (2017). Among micro nutrients data, even though there is no significant difference between treatments, but highest soil iron, zinc, copper and manganese contents were recorded in treatment which received 100% RDF + 30 kg ha^{-1} Humic acid as soil application (T_4). Minimum soil available macro and micronutrients contents were recorded in control plot in all three years.

Effect on rice yield and yield parameters

The results pertaining to yield and yield attributing characters were presented in the Tables 2 and 3 and illustrated in Fig. 1 and 2.

It was observed that application of humic acid significantly increased the plant height, productive tillers per hill, panicle length and number of grains per panicle at harvest compared to control and 100% RDF. Significantly highest plant height (91.9 cm), highest panicle length (19.2 cm), more no of productive tillers per hill (19) and no of grians per panicle (198) were recorded in T_4 (100% RDF + HA @30 kg

Table 1. Soil fertility status after harvest of rice crop from 2019 to 2022

Treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	Available Fe (mg kg^{-1})	Available Zn (mg kg^{-1})	Available Cu (mg kg^{-1})	Available Mn(mg kg^{-1})
T_1: Control	188	33.8	367	14.16	3.34	2.69	5.54
T_2: 100% RDF+ 10 kg ha^{-1}Humic acid as soil application	225	53.4	461	14.22	3.43	2.73	5.86
T_3: 100% RDF+ 20 kg ha^{-1}Humic acid as soil application	241	52.2	452	14.76	4.05	2.97	6.22
T_4: 100% RDF + 30 kg ha^{-1}Humic acid as soil application	259	55.5	488	16.03	5.06	4.97	7.26
T_5: 100% RDF + 0.2% of foliar application ofHumic acid at 30 & 60 DAT	214	47.5	422	15.10	4.17	3.02	6.28
T_6: 100% RDF+ Root dipping in 0.2 % Humic acid	235	37.9	418	15.37	4.21	3.04	6.35
T_7: 100% RDF	204	44.0	429	14.49	4.04	2.84	6.09
SE.m=/-	11.6	3.2	22.2	0.50	0.21	0.11	0.20
CD at 5%	32.6	9.0	62.2	NS	NS	NS	NS
C. V. (%)	9.0	12.0	8.9	5.8	10.2	9.8	5.5
Soil initial properties	242	56.4	483	14.25	4.36	3.08	6.12

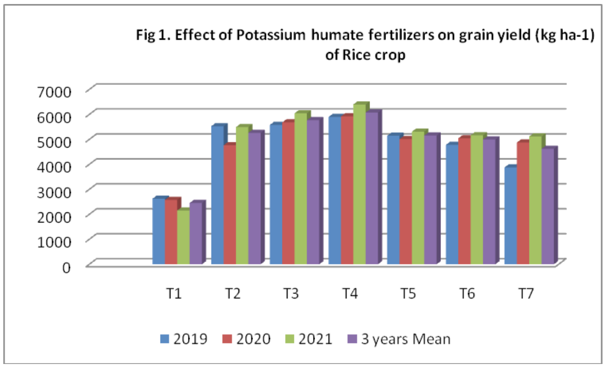

Fig. 1. Effect of Potassium humate fertilizers on grain yield of Rice crop

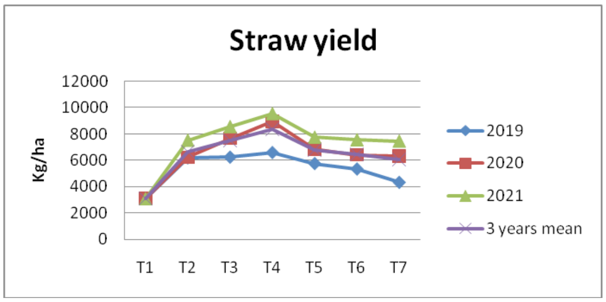

Fig. 2. Effect of Potassium humate fertilizers on straw yield of Rice crop

ha^{-1}) and the lesser plant height (55.6 cm), highest panicle length (16.0 cm), more no of productive tillers per hill (9) and no of grians per panicle (139) were recordedin T_1 (control). The treatments receiving 100% NPK and HA @ 20 kg ha^{-1} (T_3) was statistically on par with 100% NPK + HA @30 kg ha^{-1}(T_4).

There is a significant increase in yield attributes, up to a HA dose of 30 kg ha^{-1} combined with 100% NPK. Application of humic acid in different doses both as foliar and soil application influences 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, panicle length and number of grains per panicle at harvestand 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. Mohammadipour, (2012) showed that the application of humic acid improved the plant growth parameters. Panicle length is a very important parameter because of its association with other important yield components such as number of grains and 1000 grain weight. Potassium humate significantly affected panicle length at 30kg ha^{-1} in all three years (Table 2). Bama and Selvakumari (2005) also reported that application of potassium humate @ 20 kg/ha recorded higher panicle length of rice crop. Sarir *et al.* (2005) suggested that application 200 g humic acid per hectare as soil spray along with basal dose of NPK had great potential to improve maize yield. These results were in agreement with the findings of Baskar *et al.* (2002) and Kumar *et al.* (2014). Retnosuntari *et al.* (2015) reported that highest no. of panicles were obtained with the application of (100%) urea-humic acid in rice.

Table 2. Effect of Potassium humate fertilizers on yield parameters of rice crop in vertisols from 2019-2021

Treatments	Plant height (cm)	Productive tillers/hill	Panicle length (cm)	No. of grains/ panicle
T_1: Control	55.6	9	16.0	139
T_2: 100% RDF+ 10 kg ha^{-1}Humic acid as soil application	67.5	17	17.3	186
T_3: 100% RDF+ 20 kg ha^{-1}Humic acid as soil application	87.3	18	19.0	197
T_4: 100% RDF + 30 kg ha^{-1}Humic acid as soil application	91.9	19	19.2	198
T_5: 100% RDF + 0.2% of foliar application of Humic acid at 30 & 60 DAT	69.7	18	18.3	179
T_6: 100% RDF+ Root dipping in 0.2 % Humic acid	68.6	17	17.9	166
T_7: 100% RDF	63.2	14	17.4	161
SE.m=/-	3.98	0.94	0.99	9.67
CD at 5%	12.27	2.91	3.05	29.78
C. V. (%)	9.59	10.52	9.64	9.61

Table 3. Effect of Potassium humate fertilizers on productivity of Rice crop (Pooled data of 3 years grain yield kg ha^{-1})

Treatments	2019	2020	2021	3 years Mean
T_1: Control	2627	2578	2154	2453
T_2: 100% RDF+ 10 kg ha^{-1} Humic acid as soil application	5528	4765	5492	5262
T_3: 100% RDF+ 20 kg ha^{-1} Humic acid as soil application	5582	5682	6047	5770
T_4: 100% RDF + 30 kg ha^{-1} Humic acid as soil application	5899	5925	6398	6074
T_5: 100% RDF + 0.2% of foliar application of Humic acid at 30 & 60 DAT	5146	5012	5313	5157
T_6: 100% RDF+ Root dipping in 0.2 % Humic acid	4782	5043	5163	4996
T_7: 100% RDF	3879	4876	5118	4624
SE.m=/-	250.8	286.24	332.15	305.8
CD at 5%	702	824.3	1023.46	890.2
C. V. (%)	9.1	12.15	11.29	10.28

Effect of HA on grain and straw yield

The highest grain yield (6074 kg ha^{-1}) and straw yield (8374 kg ha^{-1}) was recorded in T_4(100% NPK + HA @30 kg ha^{-1}) and the lowest grain yield (2453 kg ha^{-1}) and straw yield (3101 kg ha^{-1}) was recorded in T_1 (control) where humic acid and inorganic nitrogen were not applied. The treatments receiving 100% NPK + HA @ 20 kg ha^{-1} (T_3) was statistically on par with 100% NPK + HA @30 kg ha^{-1}(T_4).

Application of humic acid @ 30 kg ha^{-1}combined with 100% RDF recorded 40% more grain yield compared to control. Yield is a function of complex interrelationships of its components, which are determined from the growth rhythms in vegetative phase and its subsequent reflection in the reproduction phase of the plant. The highest grain yield in addition of potassium humate in the present study reveal that humic acid enhanced the availability of the plant nutrients and improved yield components and yield of rice crop. 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 Govindasamy and Chandrasekaran (2002), Sathiyabama (2002), Nandakumar *et al.* (2004), Kumar *et al.* (2014) Manjeera *et al*. (2020) in rice.

Conclusion

The levels of available N, P, K and micronutrients like Fe, Zn, Cu and Mn in soil increased with different humic treatments. There is a significant influence on plant height, productive tillers per hill, panicle length and number of grains per panicle at harvest compared to control and 100% RDF on application of humic acid in combination with inorganic fertilizers. Significantly highest plant height, productive tillers per hill, panicle length and number of grains per panicle was observed with treatment (T_4) 100% RDF + Soil application of humic acid @ 30 kg ha^{-1} at tillering, panicle initiation and at harvest stages of crop over other treatments. There was a significant increase in the grain and straw yield of rice crop with application of 100% RDF + Soil application of humic acid @ 30 kg ha^{-1} and it was on par with treatments T_2 and T_3 . Hence, the result of this study suggest that humic acid extracted from the huge reserves of lignitic coal in India can be used as a low cost natural fertilizer for improving soil physical and chemical condition, microorganism activity, better efficiency of chemical fertilizers and for maintaining sustainable cultivation practices without deterioration of soil health

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