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Effect of Water Soluble Fertilizer, Micronutrients, Humic Acid and Seaweed extract on Growth and Yield of Rice

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ABSTRACT: A field experiment was undertaken at Agricultural College and Research Institute, Killikulam during late pishanam season (Dec 2021 - Apr 2022) to determine the effect of water soluble fertilizer, micronutrients, humic acid and seaweed extract (*Sargassum wightii*) on growth and yield of rice (var.ASD 16). The experiment was laid out in a randomized block design with 10 treatment combinations and 3 replications. The results revealed that the soil application of STCR-NPK with humic acid @ 10kg/ha along with foliar spray of 1% liquid micronutrients, 1% WSF (19:19:19), and seaweed extract @2.5 ml/l (T_{10}) thrice at 15, 30, 50 DAT recorded significantly highest growth attributes such as plant height (108), number of tillers per m^2 (376), number of productive tillers per m^2 (345), grain yield (6123 kg ha^{-1}) and straw yield (7242 kg ha^{-1}) of rice followed by STCR- NPK with foliar application of 1% liquid micronutrients, 1% WSF, (19:19:19), 1% humic acid and seaweed extract @ 2.5 ml/l thrice with grain yield of 6098 kg ha^{-1} and straw yield of 7125 kg ha^{-1}. The grain yield was 9.84% higher than the STCR-NPK treatment. The highest uptake of N (85.2 kg ha^{-1}), P (10.83 kg ha^{-1}), K (108.2 kg ha^{-1}), Cu (8.05 g ha^{-1}), Mn (32.1 g ha^{-1}), Fe (77.3 g ha^{-1}), Zn (48.3 g ha^{-1}) and highest agronomic efficiency of N, P, K (18.9, 53.2, 133) respectively were recorded in the same treatment. However the highest net return (Rs. 71401 ha^{-1}) and B:C ratio (2.21) was recorded by the latter treatment *viz*. soil application of STCR- NPK with foliar spray of 1% liquid micronutrients, 1% WSF (19:19:19), 1% and humic acid and seaweed extract @ 2.5 ml/l thrice and could be recommended to get higher grain yield and economic returns of rice cultivation in Tamiraparani command area.

Keywords: Water soluble fertilizer (19:19:19), Micronutrients, Humic acid, Seaweed extract (*Sargassum wightii*).

INTRODUCTION

Rice is the most significant and dominant cereal food crop in India with one-fourth of the total area under cultivation. It can be grown successfully in a hot, humid area as a main food crop. India is among the top ten producers of rice. In India, 122 million metric tonnes of rice were produced, (Anonymous 2021), with more than 11.0 percent of the global production share. India is the second-largest producer of rice after China. To meet the global requirement of rice, efficient nutrient management should be practiced.

The water-soluble fertilizers (19:19:19) (WSF) supply to crops with the ideal rates of nutrients throughout the growth cycle in the most efficient way possible without endangering soil and water resources. They do this by being highly soluble, having a low salt index, and having a high concentration of primary nutrients. Foliar nutrition of WSF provides effective nutrition for correcting deficiencies, especially in short-duration crops, and aids in the resolution of problems including nutrient immobilisation, fixation, and leaching (Bharaani *et al.*, 2020). Nutritional deficits in plants can be quickly recovered by foliar nutrition. It encourages a number of processes that influence crop output potential, including nitrogen metabolism, protein consumption, chlorophyll formation, carbonic-anhydrase activity, stress tolerance, and oxidative damage prevention (Kulhare *et al.*, 2017).

Humic acid augments the physical, chemical and biological properties of the soil and influences plant growth by inducing the growth of roots. Initiation of root enhancement and increased root growth may be observed by the application of humic acids and fulvic acids to the soil (Pettit, 2004). Nutrient elements are bound to humic acid molecules in a form that can be readily utilized by various living organisms. As a result

humic acids (HAs) function as important ion exchange and metal complexing (chelating) systems thus improve the nutrient uptake by plants. The study is focused on the management of nutrient application by progressively adding STCR- NPK, humic acid and sea-weed granules as soil application and water soluble fertilizer, liquid micronutrient, humic acid and sea-weed extract as foliar spray.

MATERIALS AND METHODS

The field experiment was conducted at B block of central farm, Agricultural College and Research Institute, Killikulam using the test crop of paddy (ASD 16) during late Pishanam season (Dec – April, 2022). The experimental field was located at 8º42´06.8´´N 77º51´27.1´´E. The soil of the experimental site belonged to Manakkarai series and according to USDA soil taxanomy it was classified as sandy clay loam, fine non-arid kaolinitic isomegathermic family of Typic Haplustalf. Soil samples were collected from experimental site and initial physical and chemical characters were analysed. The soil pH was 7.04 with normal EC (0.23 dS m^{-1}). The available NPK was low (238 kg ha^{-1}), medium (19 kg ha^{-1}) and high (492 kg ha^{-1}) respectively. The experiment was laid out in a randomized block design with 10 treatment combinations and 3 replications. The treatment details were T_1- Absolute control; T_2- STCR- NPK; T_3- STCR-NPK + Humic acid @10 kg ha^{-1}; T_4- STCR- NPK + Sea weed granules @ 15 kg ha^{-1}; T_5-STCR- NPK + Humic acid @ 10 kg ha^{-1} + Sea weed granules @ 15 kg ha^{-1}; T_6 - STCR- NPK + foliar spray of 1% liquid micronutrients + 1% WSF + 1% Humic acid; T_7- STCR- NPK + foliar spray of 1% liquid micronutrients +1%WSF + SWE @ 2.5ml/l; T_8- STCR-NPK + foliar spray of 1% liquid micronutrients + 1%WSF + 1%Humic acid + SWE @ 2.5ml/l; T_9- STCR- NPK + Sea weed granules @ 15 kg ha^{-1} + foliar spray of 1% liquid Micronutrients + 1% WSF + 1% Humic acid; and T_{10}- STCR- NPK + Humic acid @ 10 kg ha^{-1} + foliar spray of 1% liquid micronutrients +1% WSF + SWE @ 2.5ml/l;

The STCR-NPK suggested dose of NPK (175:62.5:25) was administered according to schedule to the experimental plots. Urea, SSP, and MOP were the respective sources of N, P, and K. SSP was used as the basal application, whereas urea and MOP were applied in four equal splits at Basal, Active Tillering (AT), Panicle Initiation (PI), and Heading. Humic acid and seaweed extract (*Sargassum wightii*) were added to the soil during critical rice growth stages *viz*. Basal, AT, PI, Heading stages at 15, 30, and 50 DAT respectively for each treatment. The foliar applications of water-soluble fertilizer, liquid micronutrient, humic acid, and seaweed extract were made at all the three critical growth stages. The plant height, SPAD value, the number of productive tillers m^{-2}, 1000 grain weight, grain and straw yield were recorded. The outcomes of the study such as soil characteristics, biometric observations and the yield data were statistically examined (Snedecor and Cochran 1967). The curves and diagrams were produced using Microsoft Office Word and Excel. The gathered data were subjected to an analysis of variances using the AGRES software to determine the statistical significance of the effect of treatments.

RESULT AND DISCUSSION

A. Growth Parameters

Analyzing the data in Table 1 revealed that the application of humic acid, seaweed extract and other fertilizers in soil and as foliar spray significantly influenced the plant height, SPAD value, number of tillers m^{-2} over STCR-NPK control. The treatment STCR-NPK with soil application of humic acid @10 kg ha^{-1} and foliar spray of 1% liquid micronutrients, 1% WSF and SWE @ 2.5ml/l (T10) showed highest plant height (40.3, 65.3, 108.3 cm), number of tillers m^{-2} (243, 313, 376), SPAD value (42.1, 42.9, 45.2) at three critical stages of active tillering (15 DAT), PI (30 DAT) and Heading (50 DAT) stages respectively. It was on par with treatment STCR-NPK, foliar spray of 1% liquid micronutrients, 1%WSF, 1% Humic acid and SWE @ 2.5ml/l (T8).

The foliar micronutrient spraying greatly boosted plant height, which could be attributed to a sufficient supply of nutrients to sink and thereby accelerated plant metabolism of auxin and enzymatic activity (Sudha and Stalin 2015). It is due to the enhanced photosynthetic rate, induced root development, cell division, and cell enlargement, which led to an increase in plant height and the number of tillers $hill^{-1}$. These findings concur with Rasool *et al*., (2015) conclusion .The application of humic acid along with micronutrient mixture recorded the significantly higher plant height, no.of tillers m^{-2} of transplanted rice was also reported by Vinod Kumar *et al.,* (2019). The foliar application throughout the critical growth stages enhanced the supply of essential nutrients impacting the production of chlorophyll pigments which appeared to increase the chlorophyll content of rice, accelerated the light absorption and speed up the photosynthetic processes. In a related study, Zayed and his associates found that absorption of sufficient nutrients considerably improved the chlorophyll content (SPAD index) as compared to control (Zayed *et al.*, 2011).

B. Yield Parameters

A significant increase in straw and grain yield was observed with the application of fertilizers, humic acid and sea weed extract (table 2). The highest number of productive tillers m^{-2} (345), 1000 grain weight (24.8 g), straw (7242 kg ha^{-1}) and grain (6123 kg ha^{-1}) yields were recorded in the treatment by the application of STCR-NPK and humic acid @10 kg ha^{-1} in soil along with foliar spray of 1% liquid micronutrients, 1% WSF

and SWE @ 2.5ml/l (T10). This was followed by (T8). The grain yield of rice in treatment STCR-NPK and humic acid @10 kg ha^{-1} + foliar spray of 1% liquid micronutrient + 1%WSF + SWE @ 2.5ml/l (T10) was 9.84% higher than the STCR-NPK control (T2).

Bharaani Sri *et al.* (2020) reported that foliar spray of 1% TNAU Liquid Micronutrient + 2% TNAU water-soluble fertilizers (19:19:19) along with a recommended dose of fertilizers at active tillering, panicle initiation and 50% flowering showed the maximum growth, LAI, SPAD value and straw and grain yield. According to Rathore *et al.* (2009), foliar spray of 15 percent seaweed extract treatment resulted in the highest yield of soybean. Addagarla *et al.*, (2022), stated that bio-stimulants such as humic acid and seaweed extract substantially improve the quality and yield parameters in rice by enhanced enzyme activity, photosynthetic rate. The study conducted by Rahmatullah Khan *et al.* (2006) showed that direct application of micronutrient significantly influenced the grain yield of wheat and rice crop. The number of spikes m^{-2}, number of spikes per plant, spike length, plant height and 1000 grain weight of wheat and rice were significantly increased over control. Saha *et al.*, (2013) showed that the positive trend of humic acid and poultry manure in rice cultivar BRRI dhan 39. The highest grain yield was obtained by the application of humic acid along with poultry manure.

On the basis of above findings, it could be concluded that for obtaining higher grain yield, number of productive tillers m^{-2}, other growth and yield attributes, the treatment STCR-NPK with soil application of humic acid @10 kg ha^{-1} and foliar spray of 1% liquid micronutrients, 1% WSF and SWE @ 2.5ml/l (T10) was found to be the best.

T_1- Absolute control; T_2- STCR-NPK; T_3- STCR-NPK + Humic acid @10 kg ha^{-1}; T_4- STCR-NPK + Sea weed granules @ 15 kg ha^{-1}; T_5-STCR-NPK + Humic acid @ 10 kg ha^{-1}+ Sea weed granules @ 15 kg ha^{-1}; T_6 - STCR-NPK + foliar spray of 1% liquid micronutrients +1% WSF + 1% Humic acid; T_7- STCR-NPK + foliar spray of 1% liquid micronutrients +1%WSF + SWE @ 2.5ml/l; T_8- STCR-NPK + foliar spray of 1% liquid micronutrients +1%WSF + 1%Humic acid +SWE @ 2.5ml/l; T_9- STCR-NPK+ Sea weed granules @ 15 kg ha^{-1} + foliar spray of 1% liquid Micronutrients +1%WSF+ 1% Humic acid; T_{10}- STCR-NPK +Humic acid @10 kg ha^{-1} + foliar spray of 1% liquid micronutrients + 1% WSF + SWE @2.5ml/l.

Table 1: Effect of water soluble fertilizers, micronutrients, humic acid and seaweed extract on growth parameters of ASD 16 rice.

Treatment details	Plant height (cm)			No.of tillers (m^{-2})			SPAD value		
	15 DAT	30 DAT	50 DAT	15 DAT	30 DAT	50 DAT	15 DAT	30 DAT	50 DAT
T_1	27.4	40.6	70.3	154	220	262	33.7	36.8	38.6
T_2	32.1	57.1	95.4	223	243	321	39.1	39.4	40.5
T_3	32.3	56.3	94.6	208	239	303	36.9	37.2	41.6
T_4	30.8	55.7	92.8	195	212	343	40.1	34.3	42.3
T_5	35.2	59.2	97.6	214	246	356	40.3	40.5	43.4
T_6	38.5	60.1	95.7	229	283	354	39.8	38.7	42.2
T_7	37.3	57.8	98.3	203	254	343	35.6	41.1	42.4
T_8	40.1	63.5	106	234	298	367	41.7	41.9	44.4
T_9	37.6	56.9	98.4	197	234	347	39.1	37.9	42.7
T_{10}	40.3	65.3	108.3	243	313	376	42.1	42.9	45.2
SEd	0.78	0.94	1.18	3.84	4.5	5.12	0.52	0.54	0.6
CD (P=0.05)	1.62	1.96	2.62	8.08	9.46	10.76	1.12	1.14	1.28

Table 2: Effect of water soluble fertilizers, micronutrients, humic acid and seaweed extract on yield and yield parameters of rice (ASD 16).

Treatment details	No. of Productive tillers (m^{-2})	1000 Grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	242	21.1	3298	3918
T_2	299	23.3	5139	6487
T_3	265	22.8	5527	6239
T_4	336	24.0	5125	6423
T_5	338	24.3	5173	6675
T_6	308	23.4	5197	6498
T_7	315	23.6	5600	6813
T_8	340	24.5	6098	7125
T_9	312	23.0	6016	6743
T_{10}	345	24.8	6123	7242
SEd	4.66	0.46	219	323
CD (P=0.05)	9.82	0.94	460	679

C. Nutrient uptake

The increased uptake of NPK and micronutrients with the application of water soluble fertilizers, micronutrients, humic acid and seaweed extract at harvest stage were depicted in Table 3 and Fig 1. Significant increase in NPK uptake (85.2, 10.83, 108.2 kg ha^{-1}) and micronutrients uptake *viz*., Fe, Mn, Cu and Zn (77.3, 32.1, 8.05, 48.3 g ha^{-1}) were observed on STCR-NPK with soil application of humic acid @10 kg ha^{-1} and foliar spray of 1% liquid micronutrients, 1% WSF and SWE @2.5ml/l (T10). This was followed by T8.

Seaweed extract treatments were found to improve uptake of N, P, K, and S (Rathore *et al.,* 2009). Significant amount of N, P and K uptake were recorded with the application of humic acid as foliar spray and soil application (Paramasivan, 2015). Vahap Katkat *et al.,* (2009) investigated the effects of humic material applications in the soil and on the uptake of dry matter yield and nutrient absorption in wheat grown in calcareous soils. The application of 1 g kg^{-1} humic acid treatment resulted in the maximum dry weight and nutrient absorption. The uptake of Mg, Fe, and Mn was statistically significant after foliar application of humic acid. According to Mahmut Yıldıztekin *et al.* (2018) brown sea weed extract and humic acid significantly enhanced the enzyme activity *viz*., peroxidase (POD), catalase (CAT) superoxide dismutase (SOD), in the plant thereby increased macro and micronutrients uptake.

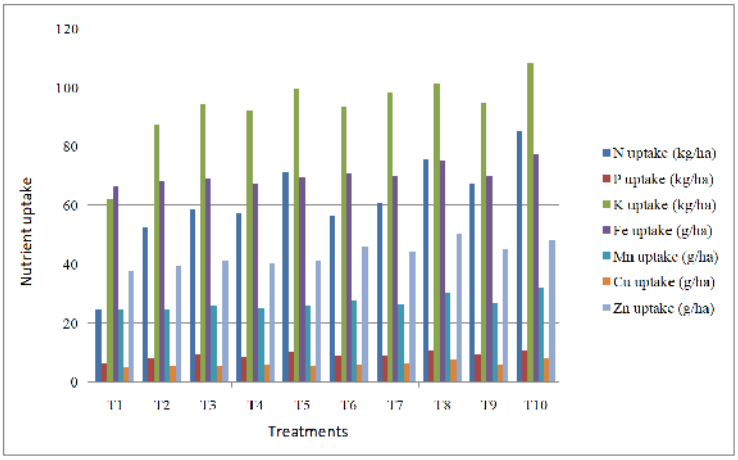

Fig. 1. Impact of water soluble fertilizers, micronutrients, humic acid and seaweed extract on nutrient uptake of rice (ASD 16) at harvest.

Table 3: Effect of water soluble fertilizers, micronutrients, humic acid and seaweed extract on nutrient uptake of rice (ASD 16) at harvest.

Treatment details	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	Fe uptake (g ha^{-1})	Mn uptake (g ha^{-1})	Cu uptake (g ha^{-1})	Zn uptake (g ha^{-1})
T_1	24.5	6.31	62.2	66.7	24.5	4.96	37.8
T_2	52.4	8.13	87.5	68.2	24.7	5.43	39.7
T_3	58.6	9.25	94.3	69.4	26.1	5.54	41.2
T_4	57.4	8.63	92.1	67.3	25.3	5.76	40.5
T_5	71.3	10.18	99.6	69.5	26.2	5.63	41.4
T_6	56.7	8.79	93.4	71.1	27.6	5.82	45.8
T_7	60.9	8.97	98.3	70.2	26.3	6.24	44.3
T_8	75.6	10.52	101.3	75.2	30.4	7.83	50.3
T_9	67.2	9.29	94.7	70.1	27.1	6.07	45.2
T_{10}	85.2	10.83	108.2	77.3	32.1	8.05	48.3
SEd	1.9	0.2	2.2	0.2	2.1	1.5	1.2
CD (P=0.05)	1.4	0.4	4.6	0.4	4.5	3.1	2.6

Agronomic efficiency of NPK. The agronomic efficiency of NPK ranged from 13.3-18.9, 37.1-53.2, 92.8-132.9 respectively (Table 4). The higher agronomic efficiency of NPK (18.9, 53.2, 132.9) were recorded in STCR-NPK, soil application of humic acid@10 kg ha^{-1} along with foliar spray of 1% liquid micronutrients, 1% WSF and SWE @ 2.5ml/l T(10). This was on par with STCR-NPK + 1% liquid micronutrient + 1% WSF + 1% Humic acid + SWE @ 2.5ml/l (18.3, 51.3, 128.3) respectively (T8).

Table 4: Effect of water soluble fertilizers, micronutrients, humic acid and seaweed extract on agronomic efficiency of NPK in rice (ASD 16).

Treatment details		Agronomic efficiency of N	Agronomic efficiency of P	Agronomic efficiency of K
T_1	Absolute control	-	-	-
T_2	STCR-NPK	14.7	41.1	102.8
T_3	STCR-NPK + Humic acid @10 kg ha^{-1}	13.3	37.1	92.8
T_4	STCR-NPK + Sea weed granules@ 15 kg ha^{-1}	14.3	40.1	100.2
T_5	STCR-NPK + Humic acid @ 10 kg ha^{-1}+ Sea weed granules @ 15 kg ha^{-1}	15.8	44.1	110.3
T_6	STCR-NPK + 1% liquid micronutrients +1%Water soluble fertilizer+ 1% Humic acid (FS)	14.7	41.3	103.2
T_7	STCR-NPK + 1% liquid micronutrients +1%Water soluble fertilizer+ Sea weed extract @ 2.5ml/l	16.5	46.3	115.8
T_8	STCR-NPK + 1% liquid micronutrients +1%Water soluble fertilizer+ 1% Humic acid (FS) +Sea weed extract @ 2.5ml/l	18.3	51.3	128.3
T_9	STCR-NPK + 1% liquid micronutrients +1%Water soluble fertilizer+1% Humic acid (FS) + Sea weed granules @ 15 kg ha^{-1}	16.1	45.2	113
T_{10}	STCR-NPK + 1% liquid micronutrients +1%Water soluble fertilizer+Sea weed extract @2.5ml/l+Humic acid @10 kg ha^{-1}	18.9	53.2	132.9

Economics. Utilizing the rice yield and the market price in effect at the time of harvest, the economics reflecting the gross return in rupees per hectare was calculated. The maximum net return was recorded with STCR-NPK + 1% liquid micronutrient + 1% WSF + 1% humic acid + SWE @ 2.5ml/l (T8), as shown in Table 5. (Rs.71401). The afore mentioned treatment, recorded the highest B:C ratio (2.21).

Table 5: Effect of water soluble fertilizers, micronutrients, humic acid and seaweed extract on economics of rice (var. ASD 16).

Treatment details	Total cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1	56066	27770	28296	1.01
T_2	87363	29715	57648	1.94
T_3	93959	32715	61244	1.87
T_4	87125	28877	58248	2.01
T_5	87941	33877	54064	1.59
T_6	100589	31665	68924	2.18
T_7	95200	31315	63885	2.04
T_8	103666	32265	71401	2.21
T_9	102272	34827	67445	1.93
T_{10}	104091	35315	68776	1.95

CONCLUSION

The study found that the application of STCR-NPK along with foliar sprays of 1% liquid micronutrients, 1% WSF, 1% humic acid, and 2% SWE @ 2.5 ml/l (T8) at all crucial stages had boosted rice's growth, yield parameters and yield (9.59% over STCR-NPK control). This method of fertilizer management for farmer fields was determined to be economically viable.

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