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Effect of bio-stimulants and silicon on nutrient uptake and economics of hybrid rice

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Abstract

An investigation was carried out during *Late Samba* season (Sep, 2022 – Feb, 2023) at Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608 002 to study the effect of increased levels of NPK, bio-stimulants and silica application in hybrid rice. The experiment was laid out in randomized block design, replicated thrice with eleven treatments. Among the different treatments experimented, the application of 125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1} (T_{11}) recorded the highest nutrient uptake, gross income and net income of hybrid rice. On regarding to the benefit cost ratio, the highest benefit cost ratio was achieved by T_9 -125% RDF + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}. Hence, treatment T_{11} achieved the highest nutrient uptake and cost of return of the hybrid rice.

Key Words: Benefit cost ratio, Humic acid, Hybrid rice, Nutrient uptake and Silicon

Introduction

Rice (*Oryza sativa* L.) is the most important staple food for more than half of the world's population. About 90% of the world's rice is grown and consumed by Asian countries, covering 85% of the total rice cultivable area (Shahbandeh, 2022). Rice is cultivated worldwide in an area of 165.25 million hectares with the production of 505.4 million tonnes, having a productivity of 4.66 t ha^{-1} (USDA, 2022). In India, rice is cultivated in an area of 46.37 million hectares which is highest among all rice producing countries with an annual production of about 130.29 million tonnes with a productivity of 2.8 t ha^{-1} (MAFW, 2022). Hybrid rice is considered as the master crop of coastal India as well as in several regions of the eastern India during the summer monsoon rainy season mutually high temperature and heavy rainfall offers ideal circumstances for the cultivation of hybrid rice. It was projected that hybrid rice technology was about another rice revolution in the country (Murugan and Sivagnanam, 2020).

The use of Bio-stimulants in agriculture is a sustainable practice that increases yield without affecting the environment (Rouphael *et al*., 2020). Bio-stimulants substances are products that include seaweed extracts (SWE), protein hydrolysates, and humic substances (HS), which can promote diverse positive effects on plants (Cristofano *et al*. 2021). Silicon (Si) is the second most abundant element constituting about 27.7 per cent of the total weight in the earth's crust after oxygen (47 per cent). Although, silicon is not known to be consider as essential element, but it is a beneficial element for growth of crops, particularly for crops of family *Poaceae* (Garg *et al*., 2020).

It is true that sustainable production of crops cannot be maintained by using only chemical fertilizers and it is not a viable ecological option. Furthermore, organic nutrient management has a significant impact on the soil's physico-chemical characteristics and results in healthier output. Similarly, it is not possible to obtain higher crop yield by using organic nutrient management alone, due to their low nutrient status. To address these issues and enhance crop productivity and sustainability, an integrated approach that recognizes the importance of soil as a storehouse of essential nutrients and promotes its efficient management is necessary. So, Integrated use of organic and inorganic fertilizers may play an important role in sustained soil fertility and crop productivity (Bayu *et al*., 2020).

Thus, the integrated use of inorganic and organic fertilizers, such as increased levels of inorganic RDF, silica, and bio-stimulants like seaweed and humic acid, is used to increase the productivity of hybrid rice and to improve the physical characteristics of the soil as well as physio-chemical reactions, reducing soil pH, and stimulating the soil microorganisms. So, it is necessary to know the potential of nutrient uptake to evaluate the effect of humic acid and silicon in hybrid rice.

Materials and methods

Field experiment was conducted in the Experimental Farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar during *Late Samba* season (Sep, 2022 – Feb, 2023) to study the effect of increased levels of NPK, bio-stimulants and silicon application in hybrid rice. The experiment was laid out in randomized block design, replicated thrice with eleven treatments using hybrid Dhanya MC-13 as the test crop. The experimental farm is geographically situated at 11°24' N latitude and 79°44' E longitude with an altitude of + 5.79 m above mean sea level. The treatments includes *viz*., T_1- control (No fertilizer application), T_2- 100% RDF + soil application of seaweed GR @ 25 kg ha^{-1}, T_3-100% RDF + soil application of humic acid GR @ 25 kg ha^{-1}, T_4- 100% RDF + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}, T_5-100% RDF + soil application of seaweed GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}, T_6- 100% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}, T_7- 125% RDF + soil application of seaweed GR @ 25 kg ha^{-1} , T_8- 125% RDF + soil application of humic acid GR @ 25 kg ha^{-1}, T_9- 125% RDF + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}, T_{10}- 125% RDF + soil application of seaweed GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}, T_{11}- 125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}. The data's were statistically analyzed as suggested by Gomez and Gomez (1991).

Results and discussion

Nutrient uptake (kg ha^{-1})

Application of bio-stimulants and silicon significantly increased the NPK and Si uptake. Among the different treatments, the maximum uptake of NPK and Si was found with T_{11} (125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR @ 25 kg ha^{-1}) (Table. 1).

Among the different treatments tested, the treatment T_{11}-125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1} resulted in higher nitrogen uptake of 144.08 kg ha^{-1}, phosphorous uptake of 25.82 kg ha^{-1}, potassium uptake of 117.31 kg ha^{-1} and silicon uptake of 254.34 kg ha^{-1} by hybrid rice. This was significantly followed by T_{10}-125% RDF + soil application of seaweed GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1} which was on par with T_9-125% RDF + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}. The lowest nitrogen uptake of 81.23 kg ha^{-1}, phosphorous uptake of 9.92 kg ha^{-1}, potassium uptake of 78.01 kg ha^{-1} and silicon uptake of 97.87 kg ha^{-1} was noticed from control (T_1).

Silicon fertilized plant gained maximum benefits of ample N uptake. The improved N status in the soil which might have hastened the process of mineralization during crop growth period resulting in high accumulation of N in the soil, there by increased the N uptake. Similar results were reported by Meena *et al.* (2014).

The increased phosphrous uptake with silicon application could be due to release of absorbed P by anion exchange. These changes in soil optimize the phosphate fertilizer efficiency and due to this transformation of slightly soluble phosphate, in turn into plant available forms and reduces the phosphate leaching from aerable horizon. This increased solubility of phosphorus, leading to increased efficiency of phosphotic fertilizer. Similar results were registered by Pati *et al.* (2016) and Crooks and Prentice (2017).

Positive response of silicon application towards potassium can be linked to silicification of cell wall. This finding is in line with Chanchareonsook *et al*. (2002) who reported that application of NPK fertilizer in combination with Si significantly increase the total potassium uptake of rice.

Silicon sources favourably influence the uptake of silicon in rice and the supply of plant available silicon (orthosilicic acid) with the application through silicon granules remarkably increase the silicon uptake. Due to the silica fertilizers are silicon rich inorganic substances, that increase the content of plant available silicon compounds (orthosilicic acid) in the soil. Under submerged conditions, monosilicic acid concentration was increase in the soil solution due to application of silicate fertilizer and due to consistent availability of sufficient quantity of plant available silicon in soil, the silicon uptake was increased in the rice crop. These results were in confirmation with the findings of Malav *et al*. (2018).

Table1. Effect of bio-stimulants and silicon on nutrient uptake of hybrid rice

Treatment	Nutrient uptake (kg ha^{-1})			
	N	P	K	Si
T_1	81.23	9.92	78.01	97.87
T_2	107.58	15.29	94.71	151.95
T_3	112.38	16.79	97.21	162.30
T_4	119.88	19.04	101.41	210.57
T_5	128.58	21.65	106.91	220.92
T_6	133.48	22.84	109.81	230.57
T_7	117.28	18.23	100.11	171.95
T_8	123.98	20.35	104.11	184.27
T_9	137.78	24.03	112.71	241.22
T_{10}	139.88	24.75	114.51	245.34
T_{11}	144.08	25.82	117.31	254.34
S.Em ±	**1.14**	**0.28**	**0.78**	**1.68**
CD (P=0.05)	**3.37**	**0.83**	**2.31**	**4.98**

Table 2. Effect of bio-stimulants and silicon on economics of hybrid rice

Treatment	Cost of cultivation (Rs. ha^{-1})		Total cost of cultivation (Rs. ha^{-1})	Income from		Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	BCR
	General COC (Rs. ha^{-1})	Treatment specific VCOC (Rs. ha^{-1})		Grain (Rs. ha^{-1})	Straw (Rs. ha^{-1})			
T_1	44519	-	44519	44700	3878	48578	4059	1.09
T_2	53769	5375	59144	92080	6823	98903	39759	1.67
T_3	53769	3375	57144	95880	7145	103025	45880	1.80
T_4	53769	3000	56769	105340	7697	113037	56268	1.99
T_5	53769	8375	62144	118240	8269	126509	64364	2.04
T_6	53769	6375	60144	125100	8540	133640	73496	2.22
T_7	56081	5375	61456	102080	7495	109575	48119	1.78
T_8	56081	3375	59456	112180	7992	120172	60715	2.02
T_9	56081	3000	59081	131160	8799	139959	80877	2.37
T_{10}	56081	8375	64456	134360	8931	143291	78835	2.22
T_{11}	560811	6375	62456	138500	9200	147700	85243	2.36

Economics

The data on the economics of the cultivation of hybrid rice were furnished in Table 2. Among the various treatments imposed, the maximum gross income of Rs. 147700 ha^{-1}, net income of Rs. 85243 ha^{-1} was achieved by T_{11}-125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}. This was followed by T_{10}-125% RDF + soil application of seaweed GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1} with gross income of Rs. 143291 ha^{-1}, net income of Rs. 78835 ha^{-1}. The lowest gross income of Rs. 48578 ha^{-1}, net income of Rs. 4059 ha^{-1} was noticed under the treatment T_1 (control). On regarding to the benefit cost ratio, the highest benefit cost ratio of 2.37 was achieved by T_9 -125% RDF + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1}. This was followed by T_{11}-125% RDF + soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silica GR (soil conditioner) @ 25 kg ha^{-1} with 2.36. The lowest benefit cost ratio of 1.09 was noticed under the treatment T_1 (control).

Conclusion

From the result of this study, it may be concluded that the treatment, T_{11} (125% RDF + Soil application of humic acid GR @ 25 kg ha^{-1} + soil application of silicon GR (soil conditioner) @ 25 kg ha^{-1}) remarkably increased the nutrient uptake and cost of return in the hybrid rice. Therefore, this treatment can be recommended to the farming community to practise for increasing the nutritional quality and economic benefit in hybrid rice.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could appeared to influence to work reported in this paper.

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