International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; SP-7(6): 160-163
Received: 10-04-2024
Accepted: 22-05-2024

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Effect of Humic acid and silicon on growth characteristics of hybrid rice: Dhanya MC 13

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sc.834

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 silicon GR (soil conditioner) @ 25 kg ha^{-1} (T_{11}) recorded the highest growth attributes and growth analysis *viz*., plant height (71.06, 106.20, and 118.73 cm at active tillering, panicle initiation and at harvest stages), number of tillers hill^{-1} (15.89 at maximum tillering stage), dry matter production (7323, 11892 and 14735 kg ha^{-1} at active tillering, flowering and at harvest stages), LAI (3.82 and 5.96 at active tillering and flowering stages), CGR (15.23 and 9.48 g m^{-2} day^{-1} at active tillering to flowering and flowering to harvest), RGR (16.16 and 7.15 mg g^{-1} day^{-1} at active tillering to flowering and flowering to harvest), AGR (304.60 and 189.53 mg plant^{-1} day^{-1} at active tillering to flowering and flowering to harvest) of hybrid rice, respectively. Hence, treatment T_{11} remarkably increased the growth attributes and growth analysis of the hybrid rice.

Keywords: Growth attributes, growth analysis, humic acid, hybrid rice, RDF, 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) [19]. 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) [21]. 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) [7].

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. Approximately the entire parts of India are appropriate for raising hybrid rice during the summer season. Consequently, hybrid rice is raised even in western Uttar Pradesh, Punjab and Haryana in low level areas such as waterlogged during the summer and monsoon rainy season (Pandey *et al*., 2021) [14]. It was projected that hybrid rice technology was about another rice revolution in the country (Murugan and Sivagnanam, 2020) [10].

A sustainable method of increasing production in agriculture that doesn't harm the environment is the use of biostimulants (Rouphael *et al*., 2020) [18]. Products known as bio-stimulants include humic substances (HS), protein hydrolysates, and seaweed extracts (SWE), all of which have a variety of advantageous effects on plants (Cristofano *et al*., 2021) [1]. After oxygen (47 percent), silicon (Si) is the second most prevalent element in the earth's crust, making up around 27.7% of its total weight.

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) [3]. Silica strengthens the plant, protects the plants against insect and pests. It increases crop production, increases plant nutrition and neutralizes heavy metal toxicity in acid soils (Mali *et al.*, 2008) [9]. Hence, silicon management is essential for increasing and sustaining rice productivity (Singh *et al.*, 2020) [20].

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 graded 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) [4].

Results

Growth attributes and growth analysis

The results of the field experiment involving increased levels of inorganic NPK fertilizer combined with bio-stimulants and silica exhibit an impact on the growth attributes and growth analysis of hybrid rice (Table 1 & 2) (Figure 1). Among the different treatments experimented, 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}) registered the highest growth attributes and growth analysis *viz*., plant height (71.06, 106.20, and 118.73 cm at active tillering, panicle initiation and at harvest stages), number of tillers hill^{-1} (15.89 at maximum tillering stage), dry matter production (7323, 11892 and 14735 kg ha^{-1} at active tillering, flowering and at harvest stages), LAI (3.82 and 5.96 at active tillering and flowering stages), CGR (15.23 and 9.48 g m^{-2} day^{-1} at active tillering to flowering and flowering to harvest), RGR (16.16 and 7.15 mg g^{-1} day^{-1} at active tillering to flowering and flowering to harvest), AGR (304.60 and 189.53 mg plant^{-1} day^{-1} at active tillering to flowering and flowering to harvest) of hybrid rice, respectively. The lowest growth attributes and growth analysis was observed under the treatment T_1 (control).

Discussion

An increase in crop growth was observed with increasing recommended levels of fertilizer at all stages of growth. The application of higher nutrients provides an adequate amount of nutrients in a balanced proportion to the crop plant resulted in the good establishment of roots and various metabolic processes (Nagarjuna *et al*., 2020) [12]. And also, a larger concentration of nutrients in the cell-sap promotes rapid cell division, a differentiation that performed better nutrient mobilization, which resulted in maximum stem elongation, faster growth and the cumulative effect of photosynthesis. These results were in agreement with the findings of Nagappa *et al*. (2002) [11], Maiti *et al*. (2006) [8].

Table 1: Effect of humic acid and silicon on growth attributes of hybrid rice

Treatment	Plant height (cm)			No. of tillers hill^{-1}	Dry matter production (kg ha^{-1})		
	Active tillering	Panicle initiation	At Harvest	At maximum tillering stage	Active tillering	Panicle initiation	At Harvest
T_1	34.55	61.38	70.23	7.81	3461	5091	5859
T_2	42.75	68.98	77.33	10.88	5453	8350	9833
T_3	46.95	74.61	81.43	11.49	5768	8882	10512
T_4	51.17	81.74	88.06	12.41	6170	9603	11495
T_5	57.17	90.99	98.36	13.71	6565	10412	12629
T_6	60.37	95.09	104.66	14.35	6831	10924	13311
T_7	49.85	79.84	85.76	12.10	6048	9396	11205
T_8	54.07	86.39	93.16	13.06	6342	9970	12017
T_9	65.67	99.39	110.96	14.97	7044	11332	13879
T_{10}	66.90	101.41	113.61	15.28	7113	11472	14099
T_{11}	71.06	106.20	118.73	15.89	7323	11892	14735
S.Em ±	0.62	0.85	1.08	0.16	54.87	77.78	107.94
CD (P=0.05)	1.82	2.62	3.19	0.48	161.88	229.48	318.42

Table 2: Effect of humic acid and silicon on growth analysis of hybrid rice

Treatment	Crop Growth Rate (g m^{-2} day^{-1})		Relative Growth Rate (mg g^{-1} day^{-1})		Absolute Growth Rate (mg $plant^{-1}$ day^{-1})	
	Active tillering to flowering	Flowering to harvest	Active tillering to flowering	Flowering to harvest	Active tillering to flowering	Flowering to harvest
T_1	5.43	2.56	12.91	4.71	108.67	51.20
T_2	9.65	4.94	14.20	5.45	193.13	98.87
T_3	10.38	5.43	14.39	5.62	207.60	108.67
T_4	11.44	6.31	14.75	5.99	228.87	126.13
T_5	12.82	7.39	15.37	6.43	256.47	147.80
T_6	13.64	7.96	15.65	6.59	272.87	159.13
T_7	11.16	6.03	14.69	5.87	223.20	120.60
T_8	12.09	6.82	15.08	6.22	241.87	136.47
T_9	14.29	8.49	15.85	6.76	285.87	169.80
T_{10}	14.53	8.76	15.93	6.87	290.60	175.13
T_{11}	15.23	9.48	16.16	7.15	304.60	189.53
S.Em ±	0.11	0.10	0.04	0.05	2.52	2.90
CD (P=0.05)	0.34	0.30	0.11	0.14	7.43	8.56

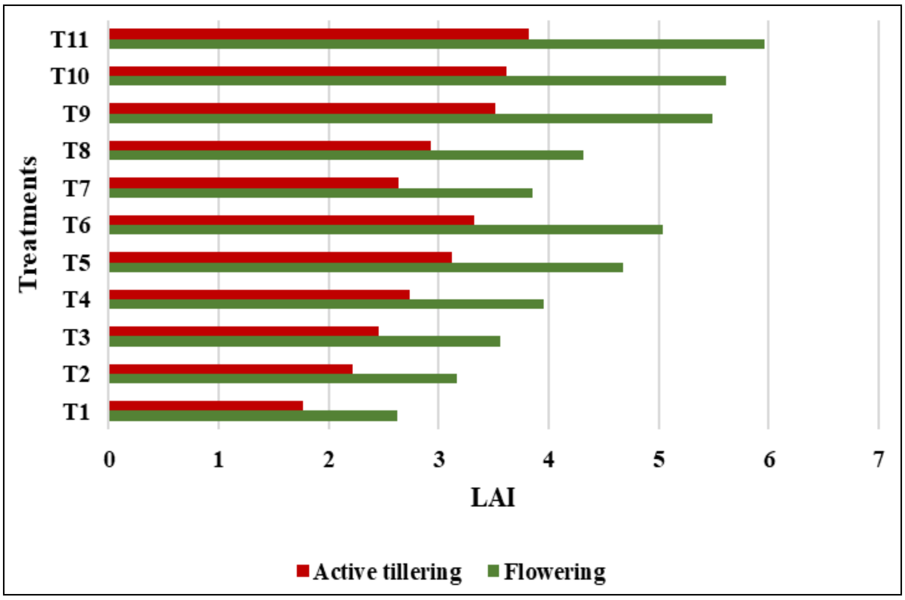

Fig 1: Effect of humic acid and silicon on leaf area index of hybrid rice

Furthermore, the combined application of inorganic fertilizer and organic substances releases nutrients slowly throughout the crop's growth. Application of humic acid granules helps to produce more photosynthates and translocation from source to sink, increasing the soil's physical properties. This was in conformity with the findings of Warren (2006) [23]. Application of silicon enhances the uptake of essential nutrients involved in metabolism of paddy, which is directly related with cell division, vigorous root growth and formation of chlorophyll resulting in higher photosynthesis which leads to increased growth attribute and growth analysis character. These results are in conformity with the findings of Fallah (2012) [2], Nagula *et al.* (2016) [13].

Silicon application significantly increased the plant height. This might be due to deposition of silicon on the plant tissues causing erectness of the leaves, increase the culms and thereby increasing photosynthetic capacity. Similar inferences were also documented by Prakash *et al.* (2011) [17]. Further, improvement of plant growth might be also due to increased uptake of nutrients on application of humic acid. Humic acids are especially beneficial in freeing up nutrients in the soil so that they are made available to the plant as needed and hence increase the plant height (Khaled, 2011) [6]. Tillering is the production of expanding auxiliary buds which is clearly depends upon the nutritional condition of mother culm So, that silicon improves the nutritional condition of mother culm, by this mother culm automatically plant produces more number of tillers $hill^{-1}$. Similar findings were reported by Patil *et al.* (2018) [16].

The beneficial effect of silicon on dry matter production (DMP) was mainly due to the leaf erectness, better penetration of solar energy leading to higher photosynthetic activity and reduction in the incidence of insects and pests. Silicon induced erectness of leaves results in increased photosynthesis, improves water usage and decrease transpiration which eventually accumulated more dry matter. The present results were in agreement with the findings of Jinger *et al.* (2018) [5].

Leaf area is an important parameter which influences the growth and yield of a crop and is mainly responsible for photosynthetic activity of the plant. Silicon nutrition improves interception of light by keeping leaves erect, thereby stimulating canopy photosynthesis, leaf area of rice is increased. Balanced and gradual release of nutrients facilitated the plants to have maximum cell elongation and cell division rendering better size of leaves. The results were in agreement with Patil *et al.* (2015) [15].

The increase in Crop growth rate (CGR), Relative growth rate (RGR) and Absolute growth rate (AGR) might be due to enhanced dry matter production, high leaf area index and with application of silicon with increased levels of NPK. These results were in confirmation with the findings of Wader *et al.*

(2013) [22].

Conclusion

Based on the experimental results, it can 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 growth attributes and growth analysis of the hybrid rice.

Acknowledgement

The authors are thankful to the Department of Agronomy, Faculty of Agriculture, Annamalai university for the help and support during this research work.

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