The Pharma Innovation Journal 2022; 11(11): 1788-1791

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 1788-1791

www.thepharmajournal.com
Received: 16-09-2022
Accepted: 20-10-2022

GV Mitkar
M.Sc. (Agriculture) Scholar, Department of Agronomy, College of Agriculture, DBSKKV, Dapoli, Maharashtra, India

VV Sagvekar
Officer In charge and Agronomist, Agricultural Research Station, Palghar, Palghar, Maharashtra, India

TN Thorat
Associate Professor, Department of Agronomy, College of Agriculture, Dapoli, Maharashtra, India

SG Mahadik
Vegetable Breeder, Vegetable Improvement Scheme, Central Experiment Station, Wakavali, Ratnagiri, Maharashtra, India

NH Khobragade
Assistant Professor, Department of Soil Science and Agril. Chemistry, College of Agriculture, Dapoli, Maharashtra, India

PS Bodake
Head, Department of Agronomy, College of Agriculture, DBSKKV, Dapoli, Maharashtra, India

VA Rajemahadik
Assistant Professor, Department of Agronomy, College of Agriculture, Dapoli, Maharashtra, India

GK Mote
M.Sc. (Agriculture) Scholar, Department of Agronomy, College of Agriculture, DBSKKV, Dapoli, Maharashtra, India

SS Ghodake
M.Sc. (Agriculture) Scholar, Department of Agronomy, College of Agriculture, DBSKKV, Dapoli, Maharashtra, India

Corresponding Author:
GV Mitkar
M.Sc. (Agriculture) Scholar, Department of Agronomy, College of Agriculture, DBSKKV, Dapoli, Maharashtra, India

Effect of foliar application of bio stimulants on growth, yield attributing characters and yield of *Kharif* rice (*Oryza sativa* L.) under lateritic soils of Konkan

GV Mitkar, VV Sagvekar, PS Bodake, TN Thorat, SG Mahadik, NH Khobragade, VA Rajemahadik, GK Mote and SS Ghodake

Abstract
The response of foliar application of bio-stimulants on the growth, yield attributing characters and yield of *kharif* rice were studied. Application of various types of bio-stimulants such as SeaGrow, triacontanol, humic acid and Panchagavya were foliar applied at different concentrations in comparison to see variation in growth, yield and yield attributing characters of *kharif* rice. The RDF (100: 50: 50 NPK kg ha^{-1}) was applied common for all the treatments of the experiment. The application of bio-stimulants showed positive effect on growth, yield and yield attributing characters of *kharif* rice. Significantly higher values of growth parameters were recorded at 60 DAT, 90 DAT and at harvest with the application of humic acid @ 0.5 per cent. Whereas, significantly maximum grain yield (5036.47 kg ha^{-1}), straw yield (6155.58 kg ha^{-1}) and biological yield (11192.05 kg ha^{-1}) was recorded with the application of humic acid @ 0.5 per cent along with 100 per cent (100: 50: 50 NPK kg ha^{-1}) RDF. The percent increase in grain yield was to the tune of 27.59 % in T_5 treatment over control (T_7) treatment.

Keywords: Rice, bio-stimulants, growth, yield, RDF etc.

1. Introduction
Rice (*Oryza sativa* L.) is one of the most important cereal staple food crops in the world in terms of the number of acres cultivated and the amount consumed. In India, rice is grown on 45.07 million hectares, with a production of 122.3 million tons and an average productivity of 2713 kg ha^{-1} (Anonymous, 2021a) [1]. In Maharashtra, rice is grown on 15.61 lakh hectares with a production of 32.91 lakh tonnes and an average productivity of 2109 kg ha^{-1} in 2021-22 (Anonymous, 2021b) [2]. Maharashtra has a low rice productivity in comparison to other rice growing states, such as West Bengal, Uttar Pradesh, Punjab, Odisha, Tamil Nadu, Haryana, Andhra Pradesh, etc. (Anonymous, 2021b) [2]. In Konkan, rice is cultivated on an area of 3.57 lakh hectares, producing about 8.52 lakh tonnes annually, with an average productivity around 2386.01 kg ha^{-1}. As compared to Western Maharashtra, Marathwada and Vidarbha, Konkan has a more production and a higher average productivity.

In present scenario the growing need for food production through sustainable cultivation practices, without reducing crop yield and producer income, is a major objective due to increased environmental pollution, increased use of chemical fertilizers and the gradual degradation of cultivated soils (Russo and Berlyn, 1990) [14]. To avoid such environmental degradation, to reduce use of chemical fertilizers, cost of cultivation and to attain sustainability in production, a promising and environmental-friendly innovation would be the use of natural plant bio-stimulants (PBs) that enhance flowering, plant growth, fruit set, crop productivity and nutrient use efficiency (NUE), and are also able to improve the tolerance against a wide range of abiotic stresses (Colla and Rouphael, 2015) [4]. Bio-stimulants are substances or microorganisms which have positive impacts on plant growth, yield, chemical composition, biotic and abiotic stress tolerance (Shahrajabian *et al*., 2021) [15].

In case of rice foliar application of bio-stimulants is the most cost-effective way of improving nutrient efficiency (Dixit and Elamathi, 2007) [5]. Foliar application of plant's product results in easier absorption of nutrients, which leads to increased yield. Furthermore, foliar spray is much more effective than soil application due to the reduction in losses owing to leaching and fixation. Researchers have shown that bio-stimulants like SeaGrow (seaweed extracts), triacontanol, humic acid and panchagavya which contain a complex mixture of polysaccharides, micronutrients and plant growth hormones, promote plant growth and improve plant resistance to abiotic stresses (Gonzalez *et al*., 2013) [9].

The present study on effect of different bio-stimulants on growth, yield and yield attributing characters of rice in Konkan region was also conducted with the similar vision. Scientific studies have proved that application of bio-stimulants is an effective way of enhancing productivity, profitability and nutrient uptake as well with least environmental pollution. So foliar application of bio-stimulants to rice crop in Konkan region can be effective alternative for farmers in Konkan region as it is not only enhancing productivity but also cost effective while maintaining environmental stability by reducing the use of synthetic fertilizers.

In Konkan region, there is heavy rainfall in monsoon season resulting in high leaching and fixation losses of soil applied bio-stimulants. Under such condition foliar application of nutrients through bio-stimulants can be best alternative. Also, a foliar application of a plant's product (bio-stimulants) results in easier absorption of nutrients, which leads to increased yield. Hence, foliar application of bio-stimulants on rice crop have been selected for present study.

2. Material and Method

In order to study the effect of foliar application of bio-stimulants on growth, yield attributing characters and Yield of *kharif* rice an experiment was conducted at Instructional Farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *kharif*, 2021. Before commencement of experiment, soil samples were taken and analysed in order to determine the physical and chemical properties. The experiment was laid out in randomized block design with seven treatments *viz,* T_1: Bio-stimulant (SeaGrow) @ 0.2%, T_2: Bio-stimulant (SeaGrow) @ 0.3%, T_3: Bio-stimulant (SeaGrow) @ 0.4%, T_4: Bio-stimulant (Triacontanol) @ 0.1%, T_5: Bio-stimulant (Humic acid) @ 0.5%, T_6: Bio-stimulant (Panchagavya) @ 3%, T_7: Control treatment which were replicated three times in which application of bio-stimulant was done by foliar application at 10 to 12 days after transplanting, panicle initiation stage and milking or dough stage. The gross and net plot size were 4.00 m x 4.50 m and 3.60 m x 4.20 m, respectively. The row-to-row distance of 20 cm and plant-to-plant distance of 15 cm was adopted for transplanting of rice. The recommended dose of fertilizer *i.e.*, 100: 50: 50 kg N: P_2O_5: K_2O ha^{-1} was applied uniformly to all the treatments including control treatment.

During the study, growth observation of rice was recorded periodically at an interval of 30 days from transplanting whereas, yield attributing characters and yields were recorded at harvest to evaluate treatment effects. The observations were recorded on growth and development parameters *viz.*, plant population net plot^{-1}, plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1}, dry matter produced (g hill^{-1}), yield attributing characters *viz*., number of panicles hill^{-1}, number of grains panicle^{-1}, panicle length (cm) and 1000-grain weight and yield characters *viz.*, grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (per cent).

3. Result and Discussion

3.1 Effect on growth attributes

Foliar Application of bio-stimulants showed significantly positive effect on growth parameters such as plant population net plot^{-1}, plant height (cm), number of tillers hill^{-1}, number of functional leaves hill^{-1} and dry matter produced hill^{-1} at 60 DAT, 90 DAT and at harvest (Table 1). During the study it was found that, plant population of the rice at both 20 DAT and at harvest stage was unaffected with the application of different bio-stimulants. The mean plant population net plot^{-1} was found to be 465.05 at 20 DAT and 459.33 at harvest stage, respectively. Significantly higher plant height *i.e.*, (61.25 cm, 72.79 cm and 78.37 cm) at 60, 90 DAT and at harvest was recorded with the application of humic acid @ 0.5% (T_5). Whereas, treatment T_3 (SeaGrow @ 0.4%) and T_4 (triacontanol @ 0.1%) were found at par in with treatment T_5 *i.e.*, 58.70 cm, 70.68 cm, 76.27 cm and 58.27 cm, 69.37 cm, 74.57 cm, respectively at 60, 90 DAT and at harvest. The increase in plant height with application of humic acid was due to the improvement in the root zone of crop resulted in greater availability of nutrients (Ayman *et al*., 2009) [3]. The number of functional leaves hill^{-1} were significantly influenced by different treatments (Table 1). The mean number of functional leaves hill^{-1} were found to be increasing with the age of crop up to 60 DAT and then after showed decline trend up to the harvest stage of crop. The application of humic acid @ 0.5% (T_5) produced significantly higher number of functional leaves hill^{-1} followed by SeaGrow @ 0.4% (T_3) and triacontanol @ 0.1% (T_4). Similarly, the number of tillers hill^{-1} went on increasing with the increase in age of the crop up to 60 DAT and later it showed decreasing trend up to the harvest stage of crop (Table 1). The number of tillers hill^{-1} were found to be maximum in treatment (T_5) humic acid @ 0.5% whereas, treatment T_3 (SeaGrow @ 0.4%) and T_4 (triacontanol @ 0.1%) were found to be at par to the treatment T_5. It is a natural phenomenon that productive tillers stabilize with increasing crop age. Humic acid increases nitrogen supply, which is essential for vegetative growth, thus resulting in an increase in number of tillers hill^{-1} and number of functional leaves hill^{-1}. Similar observations were reported by Saha *et al*. (2013) [15], Osman *et al.* (2013) [12] and Rasool *et al*. (2015) [13].

Table 1: Effect of bio-stimulants on growth parameters

Tr.	Plant height (cm)			No. of functional leaves hill^{-1}			No. of tillers hill^{-1}			Dry matter g hill^{-1}		
	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest	60 DAT	90 DAT	At harvest
T_1	52.80	64.27	70.30	44.40	35.60	27.93	9.87	8.60	8.40	24.13	37.47	40.67
T_2	53.93	66.53	72.00	44.73	36.13	27.27	10.13	8.73	8.57	24.51	38.87	41.12
T_3	58.70	70.68	76.27	49.40	42.17	31.60	11.80	9.53	9.37	26.04	43.63	45.17
T_4	58.27	69.37	74.57	49.07	39.83	31.53	11.13	9.27	9.10	25.60	41.73	43.63
T_5	61.25	72.79	78.37	51.83	42.17	33.87	12.07	10.00	9.83	27.11	45.47	47.08
T_6	56.10	67.30	72.97	45.70	36.27	29.60	10.33	8.67	8.50	25.21	41.17	41.83
T_7	50.93	62.27	69.53	39.93	32.23	25.27	9.47	8.00	7.80	23.93	35.93	40.11
S.Em. (±)	1.00	1.62	1.36	0.91	0.79	0.77	0.31	0.26	0.25	0.50	1.33	1.36
C.D. at 5%	3.09	5.00	4.18	2.81	2.45	2.37	0.95	0.80	0.77	1.54	4.11	4.18

The dry matter produced hill^{-1} showed increasing trend throughout the growth period of crop and it was highest at the time of harvest stage (Table 1). Application of humic acid @ 0.5% (T_5) significantly recorded higher dry matter accumulation hill^{-1} over rest of the treatments followed by SeaGrow @ 0.4% (T_3) and triacontanol @ 0.1% (T_4). That might be due to improved root growth which facilitates more uptake of nutrients and thus better physiological activities. In turn, this resulted in the creation of more leaf area thus more photosynthates which resulted in more dry matter, ultimately resulting in improved plant growth. Also, hormonal effect on catalytic activity and cell permeability was induced by humic acid with its auxin activity which increases the permeability of the plant membranes and intensify enzyme systems which results in more nutrient uptake and higher dry matter yield (Eshwar *et al*., 2017) [7]. Saha *et al*. (2013) [16] reported that the foliar application of humic acid had significant effect on dry weight, number of tillers and mineral uptake by rice crop.

3.2 Effect on yield and yield attributing characters

Data presented in Table 2 revealed that, the yield contributing characters *viz.* number of panicles hill^{-1}, number of grains panicle^{-1} and panicle length (cm) were significantly influenced by different treatments (Table 2). Whereas, application of bio-stimulants was found to be non-significant with respect to the 1000 grain weight (g) during the study. The number of panicle hill^{-1} were significantly higher in treatment T_5 whereas, treatments T_3 and T_4 were statistically at par to T_5. Regarding length of panicle, T_5 (humic acid @ 0.5%) recorded longest panicle length over rest of the treatments whereas, treatments T_3 (SeaGrow @ 0.3%) and T_4 (triacontanol @ 0.1%) were at par to the treatment T_5. Saha *et al*., 2013 [16] reported that, the loss of nitrogen is less in presence of humic acid which helps in vegetative growth such as panicle length of rice crop. However, regarding number of grains panicle^{-1} treatment T_5 (humic acid @ 0.5%) significantly recorded higher number of grains panicle^{-1} whereas, treatment T_3 (SeaGrow @ 0.3%) and T_4 (triacontanol @ 0.1%) were at par to the treatment T_5. Ghasemi *et al*., 2020 reported that, humic acid may improve the morphological and physiological characteristics of cereals and play a role in improving biochemical reactions in plant resulted in increased chlorophyll content and ultimately improved the photosynthesis rate. Therefore, yield and yield components were higher with foliar application of humic acid. The results are in agreement with the findings reported by Saruhan *et al*. (2011) [17], El-Bassiouny *et al*. (2014) [6].

Table 2: Effect of bio-stimulants on yield and yield attributing characters

Treat.	No. of panicles hill^{-1}	No. of grains panicle^{-1}	Panicle length (cm)	1000-grain weight	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})
T_1	8.40	114.53	19.61	26.13	4230.45	5352.70	9583.15
T_2	8.57	116.23	20.34	26.20	4330.48	5462.04	9792.52
T_3	9.37	124.53	21.43	26.40	4873.02	6014.61	10887.63
T_4	9.10	122.43	20.91	26.28	4569.75	5710.68	10280.44
T_5	9.83	126.73	22.03	26.54	5036.47	6155.58	11192.05
T_6	8.50	118.60	20.61	26.07	4458.07	5589.18	10047.25
T_7	7.80	109.07	18.87	26.10	3947.12	5055.27	9002.39
S.Em. (±)	0.25	1.89	0.39	0.34	155.38	194.89	350.26
C.D. at 5%	0.77	5.82	1.21	NS	478.77	600.52	1079.27

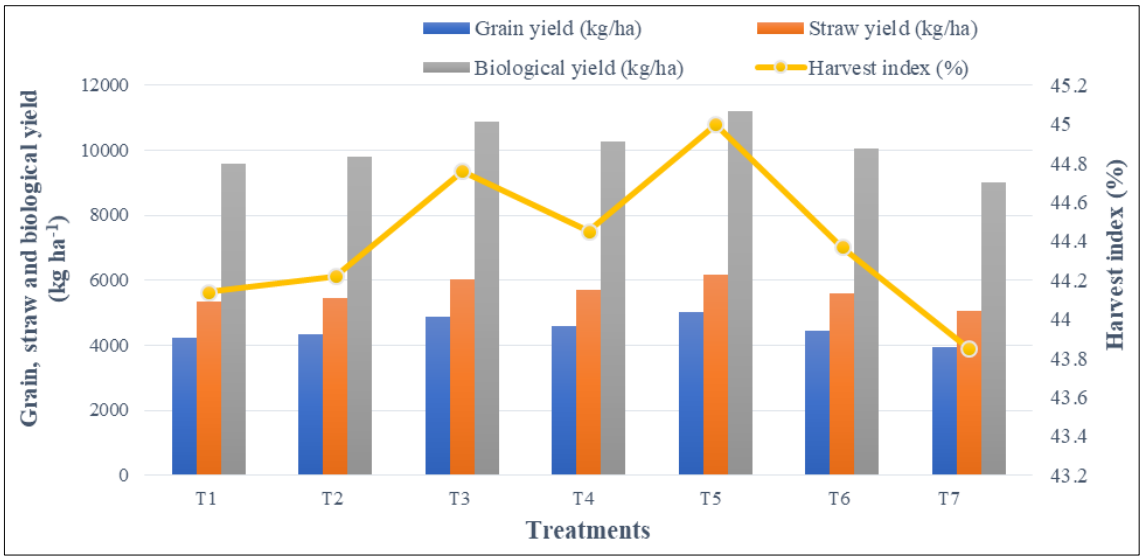

Fig 1: Mean grain, straw, biological yield (kg ha^{-1}) and harvest index (per cent) of *kharif* rice as influenced by different treatments

The application of humic acid @ 0.5% (T_5) resulted in significantly higher grain yield (5036.47 kg ha^{-1}), straw yield (6155.58 kg ha^{-1}), total biological yield (11192.05 kg ha^{-1}) and numerically maximum harvest index (45.00) (Table 2 and Fig. 1). However, application of SeaGrow @ 0.3% (T_3) and triacontanol @ 0.1% (T_4) were found at par with treatment T_5. Mindari *et al*. (2018) [11] stated that, application of humic acid improves physical conditions of soil near root zone of crop, facilitates more uptake of nutrients and improve the photosynthetic rate by regulating biochemical reactions in

plant with its hormonal effect resulting in greater growth, yield and yield components. Haripriya *et al*. (2002) [10] reported that, the increased yield might be due to the efficient utilization of nutrients, improved aeration and water holding capacity in the humic acid applied treatments.

4. Conclusion

The study on the effect of foliar application of bio-stimulants on growth and yield of *kharif* rice concluded that, the foliar application of humic acid @ 0.5% (T_5) at at 10 to 12 days after transplanting, panicle initiation stage and milking or dough stage results in significantly higher growth parameters *i.e*., plant height (cm), number of functional leaves hill^{-1}, number of tillers hill^{-1}, dry matter g hill^{-1}, yield attributes *viz*. number of panicles hill^{-1}, panicle length (cm), number of grains panicle^{-1}, yield (grain, straw and biological yield kg ha^{-1}) of *kharif* rice. The percent increase in grain yield was to the tune of 21.51% in T_5 treatment than control.

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