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Effect of humic acid based bio-stimulant on growth, yield and yield attributing characters of kharif rice (*Oryza sativa* L.)

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Abstract
Field experiment was conducted during *kharif*, 2021 at Instructional Farm, Department of Agronomy, College of Agriculture, Dapoli, Ratnagiri, Maharashtra in lateritic soils of Konkan to study the effect of humic acid based bio-stimulant on growth, yield and yield attributing characters of *kharif* rice. The treatments comprise of various levels of bio-stimulant *viz*., 0, 2.5, 5, 10, 15, 20 kg ha-1 and tricontanol @ 25 kg ha^{-1} along with RDF which are applied on rice under transplanted condition. Significantly positive effects and higher values were observed on plant height, number of tillers hill^{-1}, number of functional leaves hill^{-1} and dry matter production at 60 DAT (Days after transplanting) and 90 DAT of rice crop with the application of bio- stimulant @ 20.0 kg ha^{-1} (T_5) whereas, least values were recorded with untreated control or RDF only (100: 50: 50 NPK kg ha^{-1}) treatment. Significantly higher grain yield (4753.33 kg ha^{-1}) and straw yield (6156.63 kg ha^{-1}) were observed when bio-stimulant @ 20.0 kg ha^{-1} (T_5) was applied over other treatments and lower grain and straw yields were observed with respect untreated T_7 (applied RDF only) treatment.

Keywords: Bio-stimulant, rice (*Oryza sativa* L.), RDF, growth

1. Introduction
Rice (*Oryza sativa* L.) is the world's single most important crop, a primary food source for half of the world's population. A total of 49 per cent calories consumed by the world human population come from rice, wheat, and maize, where 23 per cent are provided by rice, 17 per cent by wheat and 9 per cent by maize. Thus almost 25 per cent of the calories consumed by the entire world human population come from rice. Rice cultivation needs urgent emphasis regarding its revamp in productivity. The concernment of uplifting rice productivity is more prominent under the scenarios of increasing food demand in response to consistent population growth as well as agricultural land shrinkage. Moreover, in the present context of changing climate, unsatisfactory performance of rice crop is a major challenge which needs to be addressed with competent agro- technological interventions. India is the largest producer of rice in terms of area (43.79 million hectare) in the world with production.
India has the largest area of land under rice cultivation in the world. In India the area occupied under rice cultivation is 44 million hectares with production of 102.32 million tonnes and an average productivity of 2550 kg ha^{-1} (Anonymous, 2020a) [1]. In Maharashtra area under rice is 1.53 million hectares with production of 3.51 million tonnes with average productivity of 1873 kg ha-1 during 2019-2020. The average productivity of the Maharashtra state is low as compared to other rice growing states viz., West Bengal, Uttar Pradesh, Punjab, Odisha, Tamil Nadu, Haryana, Andhra Pradesh etc. West Bengal is highest rice producing state in India (Anonymous, 2020b) [2]. In Konkan rice is cultivated over an area of 0.39 million hectares with an annual production of about 1.52 million tonnes with average productivity around 2930 kg ha-1. The area, production and average productivity of the Konkan region is more as compared to Western Maharashtra, Marathwada and Vidarbha. The Konkan region comprises five districts *viz*., Palghar, Raigad, Thane, Ratnagiri and Sindhudurg. The area under rice in Raigad districts is 0.11 million hectares with a production of 0.31 million, which is the highest in Konkan region.
Bio-stimulants have increasingly been considered as valuable advanced farming techniques used in worldwide agricultural production. They enhance crop health, quality and grower profitability and can effectively contribute to overcome the challenges posed by the increasing demand for food by the world's population in continuous growth.

The cost and time required for the development of new formulations may be even less than that required for the development of new bio-stimulants. Current resources are directed toward the development of safer bio-stimulants, for the worker and for the environment, as well as toward more efficient application and formulation technologies. Recently, bio-stimulant market globally has grown rapidly and, to fulfil crop requirements and to increase productivity, industries and research institutes have effectively incorporated various innovative products and ingredients. Further, demand from farmers and consumers for organic products that provides alternatives to synthetic inputs are also boosting the growth of the market. Increasing agronomic production demands is also expected to boost demand for bio-stimulants across the globe. The global bio-stimulants market is projected to reach $ 4.14-4.9 billion by 2025. Hence there is a need for progressive efforts in growing the crop without use of chemical fertilisers and rely on organic inputs like use of bio-stimulants which not only improve quality but also quantity of the produce. Our assumption is use of bio-stimulant may trigger the production in limited land under ecologically secure way.

2. Materials and Methods

The field experiment was conducted at Instructional Farm, Department of Agronomy, Collage of Agriculture Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during *kharif*, 2021 with the rice variety of Ratnagiri-1 (cross between IR-8 and Ratnagiri-24). The site was selected on the basis of suitability of soil for growing early varieties of rice. Topography of the plot was fairly uniform with a slight gradient towards the west. The soil analysis indicated that, the experimental plot was sandy loam in texture, medium in available nitrogen (242.3 kg ha-1), phosphorus (13.3 kg ha-1) and potassium (238.2 kg ha-1), very high in organic carbon (13.8 g kg-1), acidic in reaction (pH 6.28) and 0.10 dS m-1 electrical conductivity.

The experiment was laid out in Randomized Block Design (RBD) with seven treatments and replicated three times. The treatments are as given in table 1. The following seven treatments (Table 1) are included in the study. The recommended dose of fertilizers (100: 50: 50 kg N, P and K kg ha-1) and other package of practices for rice were imposed uniformly for all the treatments including control treatments.

Table 1: Treatment details for the field experiment

Symbols	Treatments
T1	Bio-stimulant @ 2.5 kg ha-1 (Laatu)
T2	Bio-stimulant @ 5 kg ha-1 (Laatu)
T3	Bio-stimulant @ 10 kg ha-1 (Laatu)
T4	Bio-stimulant @ 15 kg ha-1 (Laatu)
T5	Bio-stimulant @ 20 kg ha-1 (Laatu)
T6	Tricontanol bio-stimulsnt @ 0.05% GR @ 25 kg ha^{-1}
T7	Untreated control.
Method of application: Broadcasting (Two applications) 1st Application: 2-3 weeks after transplanting 2nd Application: At panicle initiation stage.	

Note: Bio-stimulant made from humic acid, vitamins and fermented product.

3. Results and Discussion

In rice (*Oryza sativa* L.) var. Ratnagiri-1, the plant growth and yield attributes as well as crop yields were highly influenced by application of bio-stimulant.

3.1 Effect on growth parameters

There was significance difference between treatments for the plant height, number of functional leaves per hill, number of tillers per hill and dry matter production of rice crop at 60 DAT (Days after transplanting) and 90 DAT of rice crop but no significant difference at 30 DAT.

Significantly higher plant height is depicted for T5 treatment (Bio-stimulant @ 20 kg ha-1) at 60 DAT (78.53 cm) whereas T2, T3, T4 and T6 treatments were found at par with T5 treatment. At 90 DAT, significantly higher plant height of 87.92 cm was observed for T5 treatment (bio-stimulant @20 kg ha-1) whereas T3 and T4 treatments were found at par with T5 treatment (Table 2). This increase might be due to the existence of organic constituents of sea weed extract, humic acid, vitamins etc. which elicit strong physiological responses in lower doses (Pramanick *et al*., 2013) [8]. From the present investigation it was found that, at 30 DAT there was no any significant difference among the treatments for functional leaves per hill but from 60 DAT and 90 DAT number of functional leaves hill-1 were significantly higher for T_5 treatment (49.9 and 48.71 respectively) whereas T_3 and T_4 treatments were found at par with T_5 treatment. Arun *et al*. (2019) [3] reported that, application of bio- stimulant (LBS6-S) along with RDF during time of transplanting and 30 DAT and 60 DAT produced significantly higher number of leaves per hill whereas least number of leaves per hill is produced in recommended dose of fertilizer (without bio-stimulant) treatment for rice crop. At 30 DAT there was no significant difference among the treatments for number of tillers $hill^{-1}$ whereas at 60 DAT and 90 DAT the crop has shown significant difference for number of tillers hill-1. Significantly higher number of tillers hill-1 at 60 DAT and 90 DAT i.e. 15.1 and 16.63 respectively was obtained for T5 treatment (bio-stimulant @ 20 kg ha-1) where as T_3 and T_4 treatments were found at par with T_5 treatment. Similarly, at 30 DAT there was no significant difference among the treatments for dry matter produced hill-1. At 60 DAT and 90 DAT dry matter produced hill-1 was significantly higher (21.93 and 39.77 g respectively) for T5 treatment (bio-stimulant @ 20 kg ha-1) and lowest (17 and 29.23 g respectively at 60 and 90 DAT) for T_7 treatment (control treatment). T_3 and T_4 treatments were found at par with T5 treatment. Deepana *et al*. (2021) [4] reported that, in rice crop higher values of dry matter production (kg ha-1) with the application of sea weed extract gel soil application 12.5 kg ha-1 along with foliar spraying of sea weed extract liquid 0.5 per cent (*v/v*) at tillering and panicle initiation stage of rice crop.

Table 2: Influence of bio-stimulant on growth parameters

Treatments	Plant height (cm)			No. of functional leaves per hill			No. of tillers per hill			Dry weight (g)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T1	28.22	70.19	75.98	29.25	41.21	40.4	8.75	13.17	14.5	7.59	18.49	33.23
T2	29.31	71.45	77.39	29.69	43.17	41.75	8.82	13.45	14.81	7.81	19.15	34.49
T3	28.34	74.32	84.5	29.01	45.71	45.23	8.85	14.2	15.63	7.62	20.01	36.12
T4	28.6	76.71	86.1	29.45	47.7	46.34	8.63	14.6	16.07	8.04	20.8	37.62
T5	28.86	78.53	87.92	30.01	49.9	48.71	8.43	15.1	16.63	7.91	21.93	39.77
T6	28.73	72.81	79.28	29.77	44.65	42.85	8.59	13.5	14.87	7.82	19.67	35.46
T7	28.44	65.31	72.73	28.99	38.22	36	8.5	11.98	13.19	7.34	17	29.23
S.Em. ±	0.98	2.53	2.68	1.02	1.53	1.5	0.26	0.45	0.49	0.27	0.68	1.28
C. D. at 5 %	N.S.	7.79	8.25	N.S.	4.71	4.62	N.S.	1.39	1.53	N.S.	2.09	3.94

3.2 Effect on yield and yield attributing characteristics

Total yield may appraise to be the mirror of all the growth and yield features. Significantly higher yield attributes were recorded under T_5 treatment (bio-stimulant @ 20 kg ha-1) *viz*., Number of panicles hill-1 (11.83), No. of grains panicle-1 (135.88) and Panicle length (24.13 cm) whereas T_3 and T_4 treatments were found at par with T_5 treatment (Table 3). Numerically lesser no. of panicles per hill (9.75), number of grains per panicle (107.33) and panicle length (20.17 cm) found for control treatment (T_7). But there was no significant difference between treatments for 1000 grain weight. Jayanta *et al*. (2016) [9] also reported that, application of bio- stimulant improved the yield attributing characters in rice crop.

Table 3: Influence of bio-stimulant on yield (grain and straw) and yield attributing characteristics

Treatments	No. of panicles hill-1	No. of grains panicle-1	Panicle length (cm)	1000 grain wt. (g)	Grain yield (kg ha-1)	Straw yield (kg ha-1)
T1	10.09	112.69	21.4	27.9	4107.1	5248.41
T2	10.19	119.31	21.43	27.9	4174.93	5399.78
T3	10.52	124.96	22.27	28.8	4398.67	5716.49
T4	11.05	130.03	23.6	28.6	4581.44	5940.05
T5	11.83	135.88	24.13	28.8	4753.33	6156.63
T6	10.31	121.87	21.73	28.2	4220.69	5615.31
T7	9.75	107.33	20.17	28.7	3640	4759.36
S.Em. ±	0.36	3.91	0.59	0.55	148.1	146.13
C. D. at 5 %	1.11	12.05	1.82	N.S.	456.33	450.29

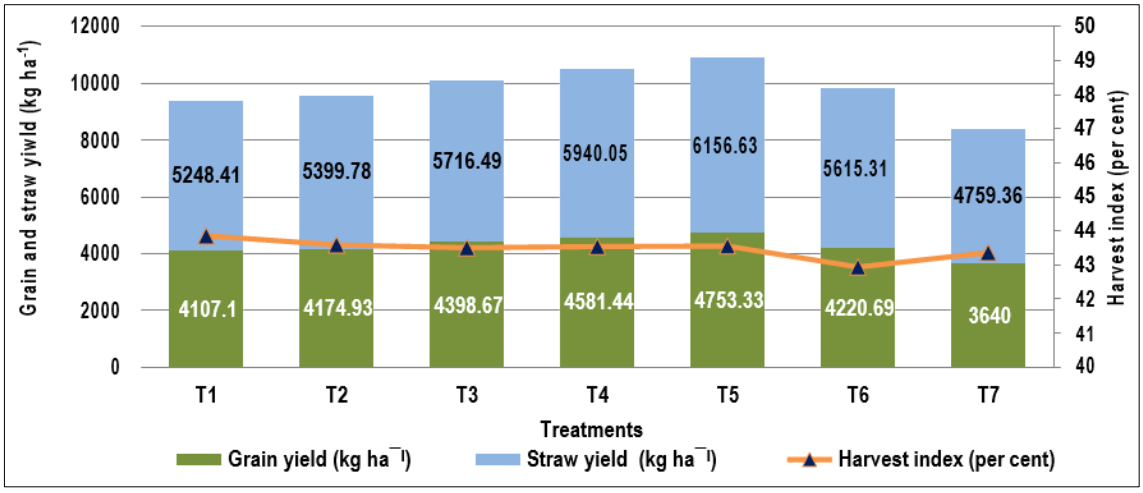

Fig 1: Graph showing grain and straw yield

All these characters contributed positively towards the mean grain, straw yield and biological yield. Application of bio-stimulant @ 20 kg ha-1 (T_5) recorded highest grain yield and straw yield of 4753.33 kg ha-1 and 6156.63 kg ha-1 respectively whereas T3 and T4 treatments were found at par with T5 treatment which is depicted in Table 3 and Fig 1. T5 treatment produced 30.5 percent higher grain yield and 29.35 per cent straw yield then control treatment (T_7). Lower values of grain and straw yield (3640 kg ha-1 and 4759.36 kg ha-1 respectively) are recorded by control treatment (T_7). The results are in line with Dwivedi *et al*. (2014) [6] proved that, in black gram, the foliar application of bio-stimulant @ 15% K sap and RDF resulted in an increase by 49.2 per cent grain yield compared to RDF to control (water spray + RDF). Arun *et al*. (2019) [3] reported that, in rice under the transplanted condition, the application of liquid bio-stimulant LBS6-S obtained higher yield attributes due to effective utilization of native as well as applied nutrients. Deshmukh *et al*. (2013) [5] also showed that, applying seaweed extract @ 1500 g ha-1 in sugarcane and RDF increased cane yield by 14 per cent and sugar yield by 23.1 per cent respectively.

4. Conclusion

The study on the effect of humic-acid based bio-stimulant on growth, yield and yield attributing characters of *kharif* rice (*oryza sativa* L.) concluded that, soil application (broadcasting) of bio-stimulant @ 20 kg ha-1 (at 2-3 weeks of transplanting and at panicle initiation of rice) had higher crop growth parameters *viz*., plant height, number of leaves per hill, tillers per hill and dry weight and yield parameters *viz*., panicle length, no. of panicles per hill, no. of grains per panicle and grain yield and straw yield. The rice grain yield was also increased by 30.5 per cent over control treatment.

5. References

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