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Short Communication

Response of Organically Grown Transplanted Rice (*Oryza sativa L.*) under Lateritic Soils of Konkan

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Rice (*Oryza sativa* L.) is the most important staple food grain crop of the world which constitutes the principal food for about 60% of the world's population. Rice contributes 43% of the total food grain production and 46% of total cereal production in India (Anonymous, 2018). Organic farming is a way of conserving the soil, maintaining its fertility, and protecting soil flora and fauna diversity thus preventing pollution of groundwater, lakes and rivers. It does not utilize non-renewable external inputs and energy. Liquid organic manure such as *beejamrutha, jeevamrutha, panchagavya, amruthpani,* biogas slurry, etc., and humic acids play a major role in improving the growth and yield of crops. Besides they also improve soil's physical, chemical and biological properties and also act as growth-promoting and yield-enhancing substances. Green manuring, which is of organic origin, helps to keep soil quality and fertility enhancement as a whole meeting a part of the nutrient requirement of crops. Pre-season green manuring of *Sesbania aculeate* (*dhaincha*) and its *in-situ* incorporation improves the growth and productivity of succeeding cereals, particularly rice. Balanced use of nutrients through organic like farm yard manure, vermicompost, green manuring, neem cake and bio-fertilizers are pre-requisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Dahiphale *et al.,* 2003). The key factors affecting consumer demand for organic food are health consciousness and the willingness of the public to pay for high-priced produce. Organic foods are getting a fast boost up in the world export market, and the potential of pure organic farming can be exploited (Sharma and Sharma, 2002). Day by day, the demand for organic rice is also increasing. Hence, optimization of the dose of green manuring and growth stimulant for rice is one of the main objectives of the present study.

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The research was conducted at the Agronomy Department Farm, College of Agriculture, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, in the state of Maharashtra during *kharif* 2019. It is situated at 17.1º North latitude and 73.1º East longitude having an elevation of 250 m above the mean sea level. The selection of the site was considered based on the suitability of the land for the cultivation of rice. The soil of the experimental plot was clay loam in texture, slightly acidic (pH = 6.02) and high in organic carbon content (13.79 g kg^{-1}). The climate is tropical, warm and humid which is very much favourable for a crop like rice during the *kharif* season. The field experiment was laid out in a strip plot design. The main plot treatments comprised four types of green manure, *in-situ* green manuring with *dhaincha*, green leaf manuring with *gliricidia, in-situ* green manuring with fodder cowpea and control while the sub-plot treatments consisted of four types of growth stimulants spray namely foliar spraying of *jeevamrut* @ 5%, foliar spraying of vermiwash @ 5%, foliar spraying of humic acid @ 0.5% and control at 30, 45 and 60 DAT. In total, there were sixteen (16) plots in each replication with a distance of 1.5 m between the plots and replicated thrice. Hence, there were 48 plots of 4.5 m x 3.0 m each. The seed of rice variety Ratnagiri-1, treated with 3% brine solution @ 3 g L^{-1} of water, was sown in lines 10 cm apart at 2-3 cm depth. Top-dressing of vermicompost @ 1 kg 100 m^{-2} was done 15 days after sowing. Twenty-five (25) days-old seedlings were transplanted on 20th July 2019 with the recommended spacing of 20 cm × 15 cm.

Experimental data were analyzed statistically by applying the technique of analysis of variance as applicable to strip plot design. The significance of the treatment differences was tested by variance ratio test (F-value), the critical difference (C.D.) at 5% level of

probability for comparison and statistical interpretation of the significance was done based on treatment means (Panse and Sukhatme, 1967).

The data presented in Tables 1 and 2 revealed that significantly more plant height, dry matter production hill^{-1} and the maximum number of tillers hill^{-1} was associated with the treatment *in-situ* green manuring with *dhaincha* during all stages of crop growth and it was observed to be at par with the green leaf manuring with *gliricidia* and *in-situ* green manuring with fodder cowpea at 30 DAT. Similarly, the treatment *in-situ* green manuring with *dhaincha* also produced a significantly higher total number of productive tillers hill^{-1} than the remaining manurial treatments. *Dhaincha* is one of the best N-fixing plant species, as N-fixing bacteria nodulate on both stem and root. In addition to that the plant itself grows fast, has high N-fixation rates and tolerates water-logged soils. Consequently, a sufficient amount of N supplied through *dhaincha* having a narrow C:N ratio might have helped in mineralization and release of nutrients in adequate amounts. This has contributed to promoting crop growth as nitrogen is a very important nutrient element for plant growth. The observed data corroborates the finding of Hargilas and Sharma (2015) and Islam *et al.* (2015).

The beneficial effect of *in-situ* green manuring with *dhaincha* treatment in enhancing the growth through increased height, leaves, number of tillers and dry matter production ultimately reflected in higher yield attributing characters *viz.*, number of panicles hill^{-1}, length of panicle, number of filled grains panicle^{-1}, less number of unfilled grains panicle^{-1} and test weight. This ultimately led to an increase in the grain yield of rice which is a function of the yield attributes as reported by Hargilas and Sharma (2015) and Islam *et al.* (2015).

Higher growth and yield attributes obtained due to the application of *in-situ* green manuring with *dhaincha* resulted in the production of significantly higher grain, straw and biological yield as compared to the other manurial treatments. It might be owing to increased biomass production and nutrient recycling through *dhaincha,* which resulted in higher yield attributes and yield of rice than other manurial treatments. Mrudhula *et al.* (2020) reported that green manuring with *dhaincha* significantly increased the grain yield and nutrient uptake in rice and can lead to savings of 15 kg fertilizer P. Similar findings were also observed by Chanda and Sarwar (2017) and Natarajan and Guru (2019).

A perusal of the data presented in Tables 1 and 2 revealed that the growth attributes such as plant height, number of functional leaves hill^{-1}, number of tillers hill^{-1}, dry matter accumulation hill^{-1} and effective tillers hill^{-1} were influenced significantly by the treatments at all the growth stages except at 30 DAT. Significantly higher yield attributes were recorded with humic acid @ 0.5%. This might have resulted from better root growth, more uptake of nutrients, better physiological activities, and finally better growth parameters like the number of tillers and dry matter accumulation hill^{-1}. These results conform with those reported by Inamullah and Naeem Ali (2014), Kumar *et al.* (2014) and Rasool *et al.* (2015).

The data presented in Table 2 revealed that the yield contributing characters *viz.,* panicle length (cm), filled grains panicle^{-1} and test weight (g) were significantly higher while unfilled grains panicle^{-1} was significantly lower with humic acid spray @ 0.5% as compared to other growth stimulants. Spraying of humic acid @ 0.5% recorded significantly higher grain, straw as well as biological yield of rice over the rest of the growth stimulants treatments. Humic acid being a natural substance is rich in essential trace elements and its spray on plants as a fertilizer has been demonstrated to have beneficial effects. The increase in yield due to the foliar application of humic acid could be due to the increase in leaf chlorophyll content and greater photosynthetic activity leading to higher assimilation and translocation of the photosynthates to the grains (Nair, 1995; Okasha *et al.,* 2019; Sivakumar *et al.,* 2007) Besides, humic acid also contains cytokinin and other plant growth promoting substances that bring about changes in plant metabolism and cell division leading to increased growth and also stimulates better uptake of nutrients and trace elements (Osman *et al.,* 2013; Zhang and Erwin, 2004). Spraying of humic acid along with fulvic acid has been reported to significantly increase the plant height, 1000 grain weight, grain yield and straw yield of rice (Osman *et al.*, 2013).

The interaction effect among the different green manuring treatments and growth stimulants with respect to growth attributes of *kharif* rice *viz.*, plant height (cm),

Table 1: *Growth attributes of kharif rice as influenced by different treatments*

Treatments	Plant height (cm)				Number of functional leaves hill^{-1}				Number of tillers hill^{-1}				Dry matter accumulation (g) hill^{-1}			
	30 DAT	60 DAT	90 DAT	At harvest 105 DAT	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
Green manuring																
G_1: *In-situ* green manuring with *dhaincha*	19.80	58.66	62.86	64.23	30.72	33.10	27.15	21.13	7.08	8.93	8.34	8.03	8.67	32.42	56.08	56.87
G_2: Green leaf manuring with *glyricidia*	18.75	57.37	58.75	60.11	26.82	28.04	22.75	18.07	6.05	7.13	7.35	7.09	6.75	26.42	48.42	49.38
G_3: *In-situ* green manuring with fodder cowpea	17.94	56.40	58.64	60.81	26.30	28.12	23.18	16.97	5.98	7.26	7.18	7.08	6.46	25.92	46.92	48.18
G_4: Control (no manuring)	15.79	53.95	54.06	56.83	22.38	22.92	17.80	14.23	4.83	5.28	6.39	5.78	6.42	19.42	41.67	42.29
SEm ±	0.41	0.55	0.64	0.90	1.41	1.35	0.72	1.06	0.34	0.31	0.13	0.19	0.36	1.56	1.08	1.14
C.D. at 5%	1.41	1.91	2.22	3.12	4.87	4.68	2.49	3.66	1.19	1.06	0.45	0.67	1.24	5.40	3.75	3.93
Growth stimulant																
S_1 : *Jeevamrit* (5%) spray at 30, 60 and 90 DAT	18.19	56.47	58.76	60.12	27.34	27.87	22.76	17.81	5.99	7.08	7.15	6.92	7.13	26.25	48.42	49.62
S_2 : Vermiwash (5%) spray at 30, 60 and 90 DAT	18.05	56.40	58.28	60.79	26.28	27.28	22.43	17.53	6.16	7.36	7.28	6.93	7.42	25.67	49.17	49.23
S_3 : Humic acid (0.5%) spray at 30, 60 and 90 DAT	18.09	60.16	61.02	63.69	27.12	31.45	24.82	20.94	6.06	8.37	8.38	8.33	7.42	29.58	53.08	53.39
S_4 : Control (no spray)	17.95	53.35	56.26	57.37	25.48	25.58	20.87	14.13	5.74	5.78	6.46	5.80	6.33	22.67	42.42	44.47
SEm ±	0.58	0.40	0.53	0.40	0.73	0.46	0.52	0.74	0.23	0.22	0.17	0.20	0.73	0.84	0.84	0.85
C.D. at 5%	NS	1.39	1.82	1.38	N.S.	1.59	1.81	2.56	NS	0.77	0.57	0.70	NS	2.90	2.92	2.93
Interaction (G × S) effect																
SEm ±	1.33	1.94	1.66	2.12	2.95	2.62	1.77	2.50	0.73	0.62	0.43	0.50	1.02	3.82	4.59	4.35
CD at 5%	N.S.	5.75	4.92	6.31	N.S.	7.79	5.27	7.42	NS	1.83	1.29	1.49	NS	11.36	13.62	12.92

DAT - days after transplanting; NS - non-significant

Table 2. *Yield and yield attributing characters of kharif rice as influenced by the different treatments*

Treatments	No. of effective tillers hill^{-1}	Length of panicle (cm)	No. of filled grains panicle^{-1}	No. of unfilled grains panicle^{-1}	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Total biomass yield (t ha^{-1})
Green manure application								
G_1 : *In-situ* green manuring with *dhaincha*	5.65	19.63	88.60	8.71	28.22	3.62	4.59	8.20
G_2 : Green leaf manuring with *glyricidia*	4.83	19.13	81.85	9.00	28.23	3.18	4.39	7.57
G_3 : *In-situ* green manuring with fodder cowpea	4.92	19.06	82.50	8.83	28.23	3.09	4.33	7.42
G_4 : Control	3.83	18.16	65.43	10.25	28.13	2.58	2.77	5.35
SEm ±	0.21	0.20	1.19	0.25	0.02	0.011	0.019	0.024
C.D. at 5%	0.71	0.68	4.10	0.88	N.S.	0.04	0.06	0.08
Growth stimulant spray								
S_1 : *Jeevamrit* (5%) spray at 30, 60 and 90 DAT	4.92	18.79	77.50	8.73	28.21	31.56	3.98	7.14
S_2 : Vermiwash (5%) spray at 30, 60 and 90 DAT	4.81	18.71	81.83	9.27	28.16	30.44	4.09	7.13
S_3 : Humic acid(0.5%) spray at 30, 60 and 90 DAT	5.33	20.18	88.98	7.68	28.24	35.91	4.63	8.22
S_4 : Control (no spray)	4.17	18.30	70.07	11.12	28.20	26.82	3.38	6.06
SEm ±	0.09	0.06	0.31	0.47	0.02	1.07	0.011	0.02
C.D. at 5%	0.31	0.21	1.07	1.61	N.S.	3.71	0.040	0.07
Interaction effect								
SEm ±	0.37	0.44	1.70	0.98	0.05	3.70	6.65	8.19
C.D. at 5%	1.10	N.S.	N.S.	N.S.	N.S.	11.00	19.75	24.33

DAT - days after transplanting; NS - non-significant

number of functional leaves hill^{-1}, number tillers hill^{-1}, dry matter accumulation hill^{-1} and effective tillers hill^{-1} were found to be significant. The *in-situ* green manuring with *dhaincha* in combination with humic acid spray @ 0.5% (at 30, 45 and 60 DAT) recorded significantly higher plant height (cm), number of functional leaves hill^{-1}, number tillers hill^{-1}, dry matter accumulation hill^{-1} and effective tillers hill^{-1} at all growth stages of crop except at 30 DAT. This significant response might be due to enhanced nutrient availability to the crops by the application *in-situ* green manuring with *dhaincha* along with humic acid spray @ 0.5 % (at 30, 45 and 60 DAT). It might further be ascribed to higher nutrient recycling which resulted in higher nutrient availability and better physio-chemical soil properties than other treatment combinations.

The interaction effect among the different green manuring treatments and growth stimulants with respect to grain yield, straw yield and total biomass yield were found to be significant. The *in-situ* green manuring with *dhaincha* in combination with humic acid spray @ 0.5% (at 30, 45 and 60 DAT) recorded significantly higher grain yield (4.10 t ha^{-1}), straw yield (5.57 t ha^{-1}) and total biomass yield (9.67 t ha^{-1}). However, significantly lowest grain yield, straw yield and total biomass yield were found in control plots (no green manuring and growth stimulant spray).

The data presented in Table 4 indicated that the higher cost of cultivation (₹ 114072 ha^{-1}) was recorded under the treatment having green manuring with *gliricidia* along with humic acid spray @ 0.5%. The lower cost was involved in control treatment having no green manuring and growth stimulant spray (₹ 72,480 ha^{-1}).

The highest gross return, net return and B:C ratio (₹ 10,1663 ha^{-1}, ₹ 7,736 ha^{-1} and 1.08, respectively) were obtained in the treatment combination having *in-situ* green manuring with *dhaincha* and humic acid spray @

Table 3. *Effect of different treatment combinations on economics of kharif rice cultivation*

Treatment combinations	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C ratio
G_1S_1	87482	86127	-1355	0.98
G_1S_2	91230	94122	2892	1.03
G_1S_3	93927	101663	7736	1.08
G_1S_4	83163	67793	-15370	0.81
G_2S_1	89539	86539	-3000	0.97
G_2S_2	90172	75844	-14328	0.84
G_2S_3	114072	88561	-25511	0.78
G_2S_4	84072	65401	-18671	0.77
G_3S_1	87553	74217	-13336	0.85
G_3S_2	87955	62134	-25821	0.70
G_3S_3	94625	93508	-1116	0.99
G_3S_4	85689	70606	-15083	0.82
G_4S_1	73526	60155	-13370	0.82
G_4S_2	76619	64223	-12396	0.84
G_4S_3	78665	67853	-10812	0.86
G_4S_4	72480	54643	-17837	0.75

G_1 *In-situ* green manuring with *dhaincha*
G_2 Green leaf manuring with *gliricidia*
G_3 *In-situ* green manuring with fodder cowpea
G_4 Control (No green manuring)

S_1 *Jeevamrit* (5%) spray at 30, 60 and 90 DAT
S_2 Vermiwash (5%) spray at 30, 60 and 90 DAT
S_3 Humic acid (0.5%) spray at 30, 60 and 90 DAT
S_4 Control (no spray)

0.5%. It was followed by treatment having *in-situ* green manuring with *dhaincha* plus vermiwash spray @ 5% (₹ 94122.04 ha^{-1}, ₹ 2,892 ha^{-1} and 1.03, respectively). The lowest gross return was fetched by the control treatment having no green manuring and growth stimulant spray (₹ 54,642 ha^{-1}).

Thus, it can be concluded that *in-situ* green manuring with *dhaincha* in combination with humic acid spray @ 0.5% (at 30,45 and 60 DAT) is effective for obtaining better growth, higher yield and net returns in *kharif* rice production system under lateritic soil in the Konkan coastal region of Maharashtra.

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CONFLICTS OF INTEREST

The authors declare no competing interest.

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