International Journal of Advanced Chemistry Research
www.chemistryjournals.net
Online ISSN: 2664-679X; Print ISSN: 2664-6781
Received: 05-02-2020; Accepted: 20-04-2020; Published: 25-04-2020
Volume 2; Issue 1; 2020; Page No. 33-37

Impact of green manuring and growth stimulants on soil properties of organically grown transplanted rice (*Oryza sativa* L.)

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DOI: https://doi.org/10.33545/26646781.2020.v2.i1a.59

Abstract
The present investigation was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (Maharashtra) during *Kharif* season of 2019. The result of present investigation indicated that, The nitrogen, phosphorus and potassium content, uptake in the grain, straw and availability were significantly higher under the treatment of in situ green manuring with dhaincha followed by green leaf manuring with glyricidia, in situ green manuring with fodder cowpea and control in the descending order of significance. While The nitrogen, phosphorus and potassium content and uptake in the grain and straw were higher under the treatment of spraying of humic acid @ 0.5% (at 30, 45 and 60 DAT) which was followed by spraying of jeevamrut @ 5%, vermiwash @ 5% and control in that descending order of significance. Significantly higher grain, straw yield and total biomass (q ha^{-1}) was found in treatment in situ green manuring with dhaincha and spraying of humic acid @ 0.5% (at 30, 45 and 60 DAT).

Keywords: Green manure, growth stimulants, soil properties, transplanted rice, yield

Introduction
Rice (*Oryza sativa* L.) is the most important staple food grain crop of the world which constitutes the principle food for about 60 per cent of the world's population. Rice contributes 43 percent of the total food grain production and 46 per cent of total cereal production in India. Organic farming is way of conserving the soil, maintaining its fertility, protecting soil flora and fauna thus preventing pollution of ground water, 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 acid play major role in improving growth and yield of crops. Besides they also improve soil 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 nutrient need of crops. The pre-season green manuring of *Sesbania aculeate* (dhaincha) and it's in-situ incorporation improves growth and productivity of succeeding cereals, particularly rice. Balanced use of nutrients through organics like farmyard manure, vermicompost, green manuring, neem cake and biofertilizers are pre-requisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Dahiphale *et al*., 2003) [5]. Jeevamrut is a liquid organic manure popularly used as means of organic farming. It is considered to be an excellent source of 'natural carbon', 'biomass', 'Nitrogen', 'Phosphorous' 'Potassium' and lot of other micro nutrients required for the crops. Humic substances are readily found in soils and influence plant growth both directly and indirectly (Cimrin and Yilmaz, 2005) [4]. They have indirect influences on plant growth because they can improve soil properties such as aggregation, aeration, permeability, water holding capacity, hormonal activity, microbial growth, organic matter mineralization and solubilisation and availability of microelements (Fe, Zn and Mn) and some macro (K, Ca and P) elements. Directly, they affect the processes associated with the uptake and transport of humic substances into the plant tissues (Nardi *et al*., 2002) [12]. Keeping these points in view, the study on effect of green manuring and growth stimulants on properties of soil was carried out.

Materials and Meth-ods
The research was conducted at the Agronomy Department Farm, College of Agriculture, Dapoli, Dist. Ratnagiri during *kharif* 2019. It is situated at 17.1° North latitude and 73.1° East longitude having elevation of 250 m above the mean sea level. The selection of site was considered on the basis of suitability of the land for cultivation of rice crop. The soil of the experimental plot was clay loam in texture, slightly acidic in pH and high in organic carbon content. The climate is tropical, warm and humid which is very much favourable for a crop like rice during kharif season. The field experiment was laid out in strip plot design. The main plot treatments comprised of four types of green manure as in-situ green manuring with dhaincha (*Sesbania aculeate)*, green leaf manuring with *glyricidia sepium*, in-situ green manuring with fodder cowpea (*Vigna unguiculata*) and control and 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 all, there were sixteen plots in each replication with distance of 1.50 m between the plots and replicated thrice. Hence, there were 48 plots of 4.50 m X 3.0 m each. The seed of rice variety Ratnagiri-1 which was treated with 3% brine solution @ 3 g lit^{-1} of water for eradication of seed borne diseases and prevents seed rotting, damping off, Leaf spot diseases. Seed was sown in lines 10 cm apart at 2-3 cm depth. Top dressing of vermicompost @ 1 kg 100 sq. m^{-1} was done 15 days after sowing. Twenty-five days old seedlings were transplanted on 20th July, 2019 with the recommended spacing of 20 cm × 15 cm. Hand weeding was done at 20 and 45 DAT

Result and Discussion
Effect of green manures
Data furnished in Table 1 revealed that, the application of in situ green manuring with dhaincha resulted into 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 attribute which further ended in higher yield of rice than other manurial treatments. Hemalatha *et al.* (2000) [9] revealed that *in situ* incorporation of dhaincha at 12 t ha^{-1} remarkably increased the grain yield 6374 kg ha^{-1} (18%) and straw yield 8411kg ha^{-1} (16%) of rice over no organic manure. These observation are in agreement with the findings of Hargilas and Sharma (2015) [8], Chanda and Sarwar (2017) [3], Natarajan and Guru (2019) [13], Suryanvanshi and Singh (2019) [15].

Scanning of data of Table 2 and 3 revealed that nitrogen, phosphorus and potassium content in the grain and straw as well as their total uptake by the crop showed marked variation due to the different green manuring treatments and their extraction capability of nutrients from the soil. Significantly the highest N, P, K content and uptake in the grain, straw and their total uptake by the crop were recorded in treatment in situ green manuring with dhaincha over rest of the treatments. Among the different GM crops, dhaincha have higher accumulation of major and micro nutrients on account of more biomass production and better nutrient composition compared to food legumes. The slow release of N from decomposing GM residues may be better synchronized with plant uptake than sources of inorganic N, possibly increasing N-uptake efficiency and crop yield while reducing N leaching losses (Aulakh *et al.* 2013) [2]. Deshpande and Devasenapathy (2010) [6] also reported that incorporation of dhaincha as a green manure recorded higher N (88.70 kg ha^{-1}), P (19.02 kg ha^{-1}) and K (89.26 kg ha^{-1}) uptake than the without green manure incorporation. These results were supported by Hargilas and Sharma (2015) [8].

The available nitrogen (N), phosphorus (P) and potassium (K) in the soil after harvest of the rice were also found to be significantly higher under different green manuring treatments. However, significantly the higher available of nitrogen, phosphorus and potassium after harvest of the rice was recorded by the treatment (G1) in situ green manuring with dhaincha over rest of the treatments. Webi *et al.* (2016) [16] observed that sesbania rostrata when plowed under at 34-42 days after sowing, can add 90 to 150 kg N ha^{-1} and 7.4 t ha^{-1} of biomass to the soil also found that S. rostrate, supplied as a green manure, can double rice yields after one rice cultivation cycle. Singh *et al.* (2006) [14] also observed that incorporation of 40 and 50 days old sesbania as green manure added 1.94 and 4.05 t ha^{-1} dry biomass to the soil, which contributed 46.5 and 96.6 kg N ha^{-1} respectively, to rice crop as compared with no green manure. Similar finding were reported by Deshpande and Devasenapathy (2010) [6].

Effect of growth stimulants

The data presented in Table 1 revealed that the study in respect to grain, straw and biological yield of rice indicated that spraying of humic acid @ 0.5% (S_3) recorded significantly higher grain, straw as well as biological yield over rest of the growth stimulants treatments. Thus application of humic acid considerably improves soil physical properties and nutrient uptake resulting in greater growth, yield components and yield. These effects are largely attributed to improve soil organic matter, soil physical and chemical properties as well as increased nutrient availability. These results are in line with those reported by Kumar *et al.* (2014) [11], Inamullah and Naeem Ali (2014) [10].

Scrutiny of the data presented in Table 2 and 3 of N, P, K content in grain and straw and N, P and K uptake in the grain and straw was significantly influenced due to the different growth stimulants treatments. However, higher N, P and K concentration in the grain and straw and N, P and K uptake in the grain and straw was recorded by the treatment (S_3) spraying of humic acid @ 0.5% as compared to other treatments. These results are in conformity with that of Saha *et al.* (2013), humic acid are especially beneficial in freeing up nutrients in the soil so that they are made available to plant as needed. Humic acid also especially important because of their ability to chelate micronutrients, thus increasing their bio-availabilty. Similar findings reported by Arjumend *et al.* (2015) [1], Eshwar *et al.* (2017) [7].

The availability of nitrogen (N), phosphorus (P) and potassium (K) in soil after harvest of crop was found to be non-significant due to different growth stimulants treatments.

Balance sheet of available soil nitrogen, phosphorus and potassium (kg ha^{-1}).

The data pertaining to the balance of the available nitrogen, phosphorus and potassium in soil after harvest of the rice as influenced by the different treatment combinations are presented in Table 4, 5 and 6. The value of the available soil nitrogen, phosphorus and potassium were higher in the treatment combination of G_1S_3 (294.78, 21.32 and 272.03 kg ha^{-1}) i.e. in situ green manuring with dhaincha (G_1) combined with @ 0.5% humic acid (S_3). The lowest available N, P and K was noticed under treatment combination of G_4S_4 (269.7, 16.93 and 258.08 kg ha^{-1}) i.e. no green manuring (G_4) and no growth stimulants S_4).

Thus, it can be concluded that for growing of organic rice it should be applied with in-situ dhaincha (*Sesbania aculeate*) green manuring and growth stimulants humic acid @ 0.5% foliar application at 30,45 and 60 DAT for obtaining higher nutrient status and yield of rice.

Table 1: Mean grain, straw and biological yield (q ha^{-1}) of rice as influenced by different treatments

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Total biomass (q ha^{-1})
Green manure application			
G_1: In situ green manuring with dhaincha	36.19	45.85	82.04
G_2: Green leaf manuring with glyricidia	31.80	43.89	75.69
G_3: In situ green manuring with fodder cowpea	30.93	43.31	74.24
G_4: Control	25.82	27.66	53.48
SE±	1.18	1.91	2.42
C.D. at 5%	4.08	6.61	8.37
Spraying of growth stimulants at 30, 45 and 60 DAT			
S_1: Spraying of Jeevamrit (5%)	31.56	39.78	71.35
S_2: Spraying of Vermiwash (5%)	30.44	40.90	71.34
S_3: Spraying of Humic acid (0.5%)	35.91	46.25	82.17
S4: Control	26.82	33.78	60.60
SE±	1.07	1.17	2.00
C.D. at 5%	3.71	4.04	6.92

Interaction effect			
SE±	3.70	6.65	8.19
C.D. at 5%	11.00	19.75	24.33

Table 2: Nitrogen and phosphorus content (%) and uptake in grain and straw as influenced by different treatment.

Treatments	Nitrogen content in grain (%)	Nitrogen content in straw (%)	Nitrogen uptake in grain (kg/ha)	Nitrogen uptake in straw (kg/ha)	Total Nitrogen uptake (kg/ha)	Phosphorus content in grain (%)	Phosphorus content in straw (%)	Phosphorus uptake in grain (kg/ha)	Phosphorus uptake in straw (kg/ha)	Total Phosphorus uptake (kg/ha)
Main plot treatments: Green manure application										
G_1: In-situ green manuring with dhaincha	1.21	0.54	43.74	25.76	28.22	0.237	0.094	8.63	4.40	13.03
G_2: Green leaf manuring with glyricidia	1.16	0.50	37.08	22.10	28.23	0.209	0.082	6.66	3.61	10.27
G_3: In-situ green manuring with fodder cowpea	1.16	0.48	35.99	21.02	28.23	0.224	0.084	6.98	3.62	10.65
G_4: Control	1.11	0.42	28.64	11.69	28.13	0.193	0.072	5.01	2.09	7.10
SE±	0.01	0.02	1.33	0.97	0.02	0.003	0.003	0.24	0.22	0.36
C.D. at 5%	0.03	0.08	4.61	3.34	N.S.	0.009	0.009	0.85	0.77	1.26
Sub plot treatments: Spraying of growth stimulants at 30, 45 and 60 DAT										
S_1: Spraying of Jeevamrit (5%)	1.17	0.50	37.01	19.97	28.21	0.210	0.082	6.67	3.35	10.03
S_2: Spraying of Vermiwash (5%)	1.15	0.49	35.24	20.55	28.16	0.216	0.084	6.64	3.48	10.12
S_3: Spraying of Humicacid (0.5%)	1.20	0.56	43.16	26.63	28.24	0.234	0.095	8.52	4.42	12.95
S4: Control	1.12	0.39	30.04	13.41	28.20	0.202	0.072	5.44	2.52	7.95
SE±	0.01	0.01	1.32	0.84	0.02	0.002	0.002	0.23	0.16	0.33
C.D. at 5%	0.02	0.05	4.56	2.92	N.S.	0.008	0.008	0.79	0.55	1.15
Interaction effect										
SE±	0.02	0.05	1.70	0.98	0.05	0.006	0.008	0.81	0.62	1.28
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3: Potassium content (%) and uptake in grain, straw and soil properties as influenced by different treatment.

Treatments	Potassium content in grain (%)	Potassium content in straw (%)	Potassium uptake in grain (kg/ha)	Potassium uptake in straw (kg/ha)	Total Potassium uptake (kg/ha)	Available nitrogen (kg ha^{-1})	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
Main plot treatments: green manure application								
G_1: In-situ green manuring with dhaincha	0.355	1.136	12.89	52.36	73.92	291.13	21.21	270.77
G_2: Green leaf manuring with glyricidia	0.337	1.071	10.72	47.18	65.04	286.94	19.98	267.74
G_3: In-situ green manuring with fodder cowpea	0.341	1.051	10.61	45.70	63.71	285.48	18.66	269.42
G_4: Control	0.320	0.900	8.28	24.92	38.81	271.53	17.46	259.71
SE±	0.002	0.005	0.38	1.87	2.21	1.67	0.70	2.16
C.D. at 5%	0.006	0.019	1.32	6.68	7.65	5.78	2.43	7.46
Sub plot treatments: Spraying of growth stimulants at 30, 45 and 60 DAT								
S_1: Spraying of Jeevamrit (5%)	0.339	1.043	10.73	42.00	59.96	284.35	19.68	265.75
S_2: Spraying of Vermiwash (5%)	0.336	1.035	10.23	42.82	60.01	282.85	19.63	267.14
S_3: Spraying of Humicacid (0.5%)	0.353	1.135	12.78	53.17	74.76	285.11	19.23	268.07
S4: Control	0.325	0.944	8.75	32.17	46.74	282.76	18.77	266.68
SE±	0.002	0.007	0.39	1.32	1.49	2.58	0.53	0.55
C.D. at 5%	0.007	0.023	1.33	4.57	5.16	N.S.	N.S.	N.S.
Interaction effect								
SE±	0.007	0.016	1.24	6.83	13.76	6.74	1.62	3.25
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4: Balance sheet of available nitrogen (kg ha^{-1}) as influenced by different treatment combinations after harvest of rice

Treatments	Initial available N (kg ha^{-1})	Addition of N through green manure	Total available N (kg ha^{-1})	Removal of N by crop	Expected balance of available N	Actual balance of available N	Net gain or loss of available N	Actual gain/loss kg h^{-1}
1	2	3	4	5	6 (4-5)	7	8 (7-6)	9(7-2)
G_1S_1	266.64	155.1	421.74	65.12	356.62	291.65	-64.97	25.01
G_1S_2	266.64	155.1	421.74	74.60	347.14	290.6	-56.54	23.96
G_1S_3	266.64	155.1	421.74	90.35	331.39	294.78	-36.61	28.14
G_1S_4	266.64	155.1	421.74	47.92	373.82	287.47	-86.35	20.83
G_2S_1	266.64	138	404.64	63.72	340.92	289.56	-51.36	22.92
G_2S_2	266.64	138	404.64	61.68	342.96	286.42	-56.54	19.78
G_2S_3	266.64	138	404.64	65.51	339.13	284.33	-54.80	17.69
G_2S_4	266.64	138	404.64	45.80	358.85	287.47	-71.37	20.83
G_3S_1	266.64	122.85	389.49	56.81	332.68	286.5	-46.18	19.86
G_3S_2	266.64	122.85	389.49	46.01	343.48	283.63	-59.85	16.99
G_3S_3	266.64	122.85	389.49	75.82	313.67	286.42	-27.25	19.78
G_3S_4	266.64	122.85	389.49	49.40	340.09	285.38	-54.71	18.74
G_4S_1	266.64	0	266.64	42.26	224.38	270.74	45.32	5.06

G_4S_2	266.64	0	266.64	40.85	225.79	270.74	44.95	4.1
G_4S_3	266.64	0	266.64	47.51	219.13	274.92	55.79	8.28
G_4S_4	266.64	0	266.64	30.67	235.97	269.7	33.77	4.1

Table 5: Balance sheet of available phosphorus (kg ha^{-1}) as influenced by different treatment combinations after harvest of rice

Treatments	Initial available P (kg ha^{-1})	Addition of P through Green manure	Total available P (kg ha^{-1})	Removal of P by crop	Expected balance of available P	Actual balance of available P	Net gain or loss of available P	Actual gain/loss kg ha^{-1}
1	**2**	**3**	**4**	**5**	**6 (4-5)**	**7**	**8 (7-6)**	**9(7-2)**
G_1S_1	16.77	47.94	64.71	11.98	52.73	21.26	-31.47	4.49
G_1S_2	16.77	47.94	64.71	14.04	50.67	21.16	-29.51	4.55
G_1S_3	16.77	47.94	64.71	16.68	48.03	21.32	-26.71	4.39
G_1S_4	16.77	47.94	64.71	9.42	55.29	21.1	-34.19	4.33
G_2S_1	16.77	25.5	42.27	11.20	31.07	20.71	-10.36	3.94
G_2S_2	16.77	25.5	42.27	10.03	32.24	20.66	-11.58	3.89
G_2S_3	16.77	25.5	42.27	11.99	30.28	19.38	-10.90	2.61
G_2S_4	16.77	25.5	42.27	7.86	34.41	19.16	-15.25	2.39
G_3S_1	16.77	12.15	28.92	10.24	18.68	18.99	0.31	2.22
G_3S_2	16.77	12.15	28.92	8.99	19.93	18.93	-1.00	2.16
G_3S_3	16.77	12.15	28.92	14.18	14.74	18.82	4.08	2.05
G_3S_4	16.77	12.15	28.92	9.19	19.73	17.89	-1.84	1.12
G_4S_1	16.77	0	16.77	6.68	10.09	17.77	7.68	1
G_4S_2	16.77	0	16.77	7.43	9.34	17.6	8.26	0.83
G_4S_3	16.77	0	16.77	8.93	7.84	17.55	9.71	0.78
G_4S_4	16.77	0	16.77	5.34	11.43	16.93	5.50	0.16

Table 6: Balance sheet of available potassium (kg ha^{-1}) as influenced by different treatment combinations after harvest of rice

Treatments	Initial available K (kg ha^{-1})	Addition of K through green manure	Total available K (kg ha^{-1})	Removal of K by crop	Expected balance of available K	Actual balance of Available K	Net gain or loss of available K	Actual gain/loss kg ha^{-1}
1	2	3	4	5	6 (4-5)	7	8 (7-6)	9(7-2)
G_1S_1	260.52	31.49	292.01	66.42	225.59	269.97	44.38	9.45
G_1S_2	260.52	31.49	292.01	78.48	213.53	270.42	58.50	11.51
G_1S_3	260.52	31.49	292.01	94.01	198.00	272.03	72.42	9.9
G_1S_4	260.52	31.49	292.01	56.76	235.25	270.67	35.42	10.15
G_2S_1	260.52	57.5	318.02	70.64	247.38	266.58	19.20	6.06
G_2S_2	260.52	57.5	318.02	66.00	252.02	267.75	15.73	7.23
G_2S_3	260.52	57.5	318.02	75.26	242.76	269.3	26.54	8.78
G_2S_4	260.52	57.5	318.02	48.25	269.77	267.33	-2.44	6.81
G_3S_1	260.52	101.25	361.77	65.40	296.37	268.37	-28.00	7.85
G_3S_2	260.52	101.25	361.77	54.20	307.57	269.04	-38.53	8.52
G_3S_3	260.52	101.25	361.77	82.28	279.49	271.08	-8.41	10.56
G_3S_4	260.52	101.25	361.77	52.94	308.83	269.17	-39.66	8.65
G_4S_1	260.52	0	260.52	37.40	223.12	259.54	34.96	-2.44
G_4S_2	260.52	0	260.52	41.35	219.17	259.72	40.55	-0.8
G_4S_3	260.52	0	260.52	47.48	213.05	261.49	48.45	0.97
G_4S_4	260.52	0	260.52	29.03	231.49	258.08	28.05	-0.98

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