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Organic amendments influence on rice-based cropping system in coastal salt affected soils of south Gujarat

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Abstract
A field experiment was conducted during 2017-18 to 2019-20 at Coastal Soil Salinity Research Station, NAU, Danti-Umbharat, Gujarat to study the effect of organic amendments on growth and yield of different rice-based cropping system under coastal salt affected soils. The experiment was laid out in split-plot design with four replications. The treatments consisted of three levels of organic manure *viz*., O_1: No organic manure, O_2: Bio-compost @ 10 t/ha and O_3: Green manuring with dhaincha applied before *kharif* season crop in main plot and four different cropping sequences *viz*., C_1: Paddy-Fallow, C_2: Paddy-Sugar beet, C_3: Paddy-Gram and C_4: Paddy-Sorghum in sub-plots. The results of the study revealed that applications of organic manure have positive effect on rice crop and have residual effect on sugar beet, gram and sorghum crop. Application of bio compost @ 10 t/ha to rice crop recorded the highest value of all the growth, yield attributes and yield of rice crop in *kharif* season followed by green manuring with dhaincha. The residual effect on sugar beet, gram and sorghum in respect to all growth, yield attributes and yield was higher with bio-compost followed by green manuring with dhaincha. Similar trend was observed in paddy grain equivalent yield. In case of cropping sequences, treatment C_2 (Paddy-Sugar beet) recorded significantly higher paddy grain equivalent yield as compared to rest of the cropping sequences. The present study suggests that for achieving higher yield from rice based cropping sequence under coastal salt affected soils of South Gujarat, to adopt rice (*kharif*) - sugar beet (*rabi*) cropping sequences and apply bio compost @ 10 ton/ha to rice crop.

Keywords: organic manure, Rice-based cropping sequence, coastal salt affected soil

Introduction
Rice (*Oryza sativa* L.) is the staple food for more than 65% of the people and it provides employment and livelihood security to 70% of Indian population. India grows rice in highly diverse conditions starting from below sea levels to hill as high as > 2000 meters. Major share of rice is cultivated during *kharif* season. Indian rice production largely depends on monsoon rains and only 59% rice area has assured irrigation. India ranks first in area with about 43.79 million ha under rice and second in production with 116.42 million tonnes with an average yield of 2659 kg/ha (*Anon*, 2020) [4]. In Gujarat state, rice occupies 7 to 8% of the gross cropped area of the state and accounts for around 14% of the total food grain production. It is grown an average about 6.5 to 7.25 lack hectares of land comprising nearly 55 to 60% low land (Transplanted) and 40 to 45% of upland (Drilled) rice. The total production of rice in the state is about 9.0 to 10.5 lakh tonnes with a productivity of 1500 to 1800 kg/ha (*Anon*, 2020) [4]. Rice is a nutritional staple food which provides instant energy as its most important component is carbohydrate (starch). On the other hand, rice is poor in nitrogenous substances with average composition of these substances being only 8% and fat content or lipids only negligible, i.e., 1% and due to this reason, it is considered as a complete food for eating.
Rice-Fallow-Rice cropping system is the dominant in south Gujarat as well as in coastal area of south Gujarat. However, continuous cultivation of rice for longer periods and often under poor soil and crop management practices, results in the loss of soil fertility as indicated by the emergence of multi-nutrient deficiencies (Singh and Singh, 1995) [13] and deterioration of soil physical properties (Tripathi, 1992) [17]. This decline in soil quality results in a decrease in factor productivity and overall crop productivity (Yadav, 1998) [18].
Crop diversification has been recognized as an effective strategy for achieving food and nutritional security, income growth, employment generation, judicious use of land and water resources, sustainable agriculture development and environmental improvement. Organic amendments (biocompost and green manuring) improve physical, chemical and biological properties of soils under salt affected soils.

Sustainable and profitable productions of crops in salt-affected areas are possible if appropriate soil management is made. So, usage of the organic manures in rice-based cropping system has the potential for improving physical, chemical as well biological properties of the salt affected soil and crop productivity. Hence, to study the effect of organic manure in rice based cropping sequences under salt affected soil, present experiment was conducted.

Materials and Methods

The field experiment was conducted at the Coastal Soil Salinity Research Station, Navsari Agricultural University, Danti-Umbharat in the South Gujarat near the Arabian Sea, India during *kharif-rabi* season of 2017-18 to 2019-20. Geographically, Danti-Umbharat is situated at 20° 83′ N latitude and 72° 50′ E longitude at an elevation of 2.5 m above mean sea level on the western coastal belt of India. The climate of this region is characterized by fairly hot summer, moderately cold winter, humid and warm monsoon. The area receives an annual average rainfall of 1100 mm, most of which occurs from the second week of June to last week of September. The mean minimum and maximum temperatures vary from 13.8 to 27.2 °C and 25.4 to 37.4 °C, respectively. The soil of the experiment plot was clayey in texture, having pH (8.54), electrical conductivity (1.61 dS m^{-1}), organic carbon (0.46%) low in available N (182 kg ha^{-1}), medium in available P_2O_5 (32 kg ha^{-1}) and high in available K_2O (1741 kg ha^{-1}). The test varieties of rice, gram, sorghum and sugarbeet were GNR-5, GG-2, GJ-38 and JK Kuber, respectively. The experiment was laid out in split-plot design with four replications. The treatments consisted of three levels of organic manure *viz*., O_1: No organic manure, O_2: Bio-compost @ 10 t/ha and O_3: Green manuring with dhaincha applied before *kharif* season crop in main plot and four different cropping sequences *viz*., C_1: Paddy-Fallow, C_2: Paddy-Sugar beet, C_3: Paddy-Gram and C_4: Paddy-Sorghum in sub-plots.

The *Sesbania aculeate* (dhaincha) was sown as a green manure (GM) on 50 days before transplanting of paddy seedlings in every year. Fifty days old *Sesbania* crop was harvested, weighted and incorporated into the soil by power tiller and after 2-3 days the rice was transplanted. Bio-compost was incorporated on 15 days before the transplanting of rice crop. The nutrient contents of bio compost and green manure are given in table 1.

Table 1: Nutrient content (%) of organic manure (dry basis) used in the experiments

Organic manure	N	P	K
2017-18			
Green Manuring	2.23	0.29	2.20
Biocompost	1.10	1.30	1.92
2018-19			
Green Manuring	2.51	0.32	1.92
Biocompost	1.05	1.37	1.64
2019-20			
Green Manuring	2.11	0.25	2.14
Biocompost	1.19	1.25	2.05

The sources of chemical fertilizers were urea, superphosphate (SSP) and murate of potash (MOP) for NPK. Dose of NPK for rice, sugar beet, gram and sorghum crop was 120:30:00, 120-60-60, 25-50-00 and 80-40-00 NPK kg/ha., respectively. A full dose of phosphorus and potash were applied as basal dose for all the crops. Nitrogen was applied as per recommendation in different crops. All the crops were grown with the recommended package of practices the under irrigated conditions. Soil samples were collected from the surface layer (0-30 cm) from all the plots before treatment applications and after harvest of Rabi season crops.

Results and Discussion

Growth and yield attributes of rice

Growth and yield attributes of rice crop *viz*., plant height, number of tillers per hill, panicle length, and panicle weight were significantly affected due to organic manure application (Table 1). Treatment O_2 (Bio-compost @ 10 t/ha) recorded significantly higher values of plant height (115.73 cm), number of tillers (8.85) and panicle length (24.99 cm) as compared to treatment O_1 (no organic manure). Treatment O_2 (Bio-compost @ 10 t/ha) recorded significantly higher panicle weight (3.46 g) as compared to treatment O_1 (no organic manure), but it remained at par with treatment O_3 (Green manuring with dhaincha before paddy). All the growth and yield attributes of rice were found to be not significant due to cropping sequences and interaction effect of O × C in pooled results. This might be due to biocompost supplied balanced nutrition to the crop, improved soil physico-chemical properties and thereby resulting in better crop growth and yield attributes of rice. The results are in agreement with Lakhdar *et al*., (2009) [10], khan *et al*., (2014) [8] and Sarwar *et al*., (2020) [12].

Grain and straw yield of rice

The results pertaining to grain and straw yield of rice was found to be significant due to organic manure in pooled results (Table 2 & 3). Treatment O_2 (Bio-compost @ 10 t/ha) recorded significantly higher grain yield (5189 kg/ha) and straw yield (6641 kg/ha) as compared to rest of the organic manure treatments in pooled results. Grain and straw yield of rice was found to be not significant due to cropping sequences and interaction effect of O × C in pooled results. This might be due to the fact that compost plays an important role in improving soil quality, structure, basic infiltration rate and nutrient enhancement which resulted in increased grain and straw yield of rice. The results are in agreement with khan *et al*., (2014) [8], Saied *et al*. (2017) [11] and Sarwar *et al*., (2020) [12].

Yield of different *rabi* crops

Yield of different *rabi* crops presented in table 3 showed that organic manure treatments to rice crop recorded highest tuber and foliage yield of sugar beet (43986 and 13806 kg/ha, respectively), grain and straw yield of gram (938 and 2210 kg/ha, respectively) and grain and stover yield of sorghum (3032 and 7389 kg/ha, respectively) followed by treatment O_3 (Green manuring with dhaincha before paddy) and O_1 (no organic manure) in pooled results. The residual effect of organic manures on succeeding *rabi* crops was also influenced the sugar beet, gram and sorghum yield and found more residual response from bio-compost @ 10 t/ha followed by green manuring with dhaincha before paddy. Higher availability of nutrient because of favorable effect of organic sources might have improved physiological and metabolic function inside the plant body which in turn laid down the foundation for higher yield of crops. Addition of residues and

subsequent decomposition released nutrients particularly after the first crop in a cycle that helped increase the yield attributes and yield of succeeding crops. Similar results were also reported by Kachroo and Dixit (2005) [7], Singh *et al.* (2006) [14] and Ghosh *et al.*, (2007) [5].

Paddy grain equivalent yield

Paddy equivalent yield was worked out and statistically analyzed (Table 4) show that there was significant effect found of organic manure applied to rice crop and cropping sequences on paddy grain equivalent yield in pooled results. Treatment O_2 (Bio-compost @ 10 t/ha) recorded significantly higher paddy grain equivalent yield (11424 kg/ha) as compared to treatment O_1 (no organic manure) and O_3 (Green manuring with dhaincha before paddy). In case of cropping sequences, treatment C_2 (Paddy-Sugar beet) recorded significantly higher paddy grain equivalent yield (14962 kg/ha) as compared to rest of the cropping sequences. The interaction effect of O × C on paddy grain equivalent yield was found to be significant in pooled results, wherein treatment combination O_2C_2 recorded significantly higher paddy grain equivalent yield (16208 kg/ha) as compared to rest of the treatment combinations (Table 5). Its significant residual effect also contributed to supply nutrients to the succeeding crop. These facts directly reflected on productivity of succeeding crop. This might be reason for getting higher RYE value. Similar reports was reported by Singh *et al.* (2006) [14] and Aruna and Shaik Mohammad (2005) [2].

Physico-chemical properties of soil

Different treatments of organic manure and cropping sequences influenced physico-chemical properties of soil. The effects of organic manure and cropping sequences on soil reaction (pH), soil salinity (EC), organic carbon (OC %), Av. N, Av. P_2O_5, Av. K_2O, CEC, ESP and BD were determined by analyzing soil samples collected after harvest of rabi crops during last year are presented in table 6. The results indicated that organic manures were found to be significant effect on soil parameters *viz.*, pH, EC, OC, Av. N and BD during last year, while Av. P_2O_5, Av. K_2O, ESP and CEC were found non-significant during last year. In case of cropping sequences (C), non-significant effect was found on all the soil parameters at both the depth during all the individual years.

Table 2: Growth, yield of rice and paddy grain equivalent yield as influenced by different treatments (pooled basis)

Treatments	Plant height at harvest (cm)	No. of tillers per hill	Panicle length (cm)	Panicle weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Paddy grain equivalent yield (kg/ha)
Main plot: Organic manure to paddy (O)							
O_1:No Organic manure	106.37	7.76	23.40	3.26	4347	5522	9768
O_2:Bio-compost @ 10 t/ha	115.73	8.85	24.99	3.46	5189	6641	11424
O_3:Green manuring with dhaincha	112.50	8.39	24.22	3.37	4890	6133	10708
S.Em±	1.00	0.14	0.22	0.03	86	106	132
CD (P=0.05)	2.94	0.40	0.63	0.08	251	311	388
CV %	6.75	11.26	6.46	5.75	12.76	13.09	9.47
Sub plot: Cropping sequences (C)							
C_1: Paddy- Fallow	110.56	8.18	24.28	3.37	4854	6113	6077
C_2: Paddy- Sugar beet	111.76	8.32	24.06	3.36	4786	6078	14962
C_3:Paddy- Gram	111.93	8.50	24.19	3.37	4900	6101	10021
C_3:Paddy- Sorghum	111.91	8.34	24.30	3.36	4694	6104	11473
S.Em±	0.93	0.13	0.21	0.04	74	104	129
CD (P=0.05)	NS	NS	NS	NS	NS	NS	363
CV %	5.12	9.05	5.25	4.93	9.32	10.39	6.85
Significant interaction	--	--	--	--	--	--	O x C

Table 3: Interaction effect of O x C on paddy grain equivalent yield (kg/ha) in pooled

Source (O x C)	Cropping sequences (C)			
Organic manure to paddy (O)	**C_1**	**C_2**	**C_3**	**C_4**
O_1	5571	13701	9171	10627
O_2	6540	16208	10723	12228
O_3	6118	14978	10171	11564
S.Em±	199			
CD (P=0.05)	561			

Table 4: Yield of *rabi* crops as influenced by different organic manure treatments

Organic manure to paddy (O)	Sugar beet		Gram		Sorghum	
	Tuber	Foliage	Grain	Straw	Grain	Stover
O1	37288	11927	838	1817	2823	6891
O2	43986	13806	938	2210	3032	7389
O3	40240	12984	888	2064	2909	7114

Table 5: Soil properties under different treatments

Treatments	Soil pH (1:2.5)	EC (dS/m) (1:2.5)	O.C. (%)	Av. N (kg/ha)	Av. P_2O_5 (kg/ha)	Av. K_2O (kg/ha)	ESP	CEC	BD (g/cm^3)
Initial	8.46	1.58	0.47	184	29.4	1811	11.4	42.8	1.51
O_1: No Organic manure	8.20	1.38	0.68	205	47.4	1635	8.91	43.6	1.38
O_2: Bio-compost @ 10 t/ha	7.99	1.21	0.78	222	52.1	1718	8.83	44.7	1.29
O_3: Green manuring with dhaincha before paddy	8.05	1.29	0.72	234	48.7	1698	8.95	44.0	1.30
SEm±	0.045	0.039	0.020	6.22	1.20	32.3	0.33	1.06	0.014
CD (P=0.05)	0.15	0.13	0.06	21.5	NS	NS	NS	NS	0.04
CV %	2.24	11.88	10.99	11.29	9.73	7.67	15.11	9.63	4.19
C_1: Paddy- Fallow	8.13	1.36	0.70	225	48.1	1651	8.64	43.2	1.34
C_2: Paddy- Sugar beet	8.07	1.27	0.72	211	50.3	1692	9.00	44.6	1.32
C_3: Paddy- Gram	8.10	1.26	0.74	223	51.0	1648	8.63	44.2	1.30
C_3: Paddy- Sorghum	8.03	1.29	0.76	222	48.2	1742	9.31	44.3	1.33
S.Em±	0.070	0.037	0.022	6.32	1.71	44.3	0.34	0.63	0.012
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	3.03	9.81	10.61	9.93	12.02	9.13	13.38	4.96	4.42

Table 6: Economics of different treatments

Treatments	Paddy grain equivalent yield (kg/ha)	Gross income (Rs./ha)	Cost of cultivation (Rs./ha)	Net income (Rs./ha)	BCR
O1C1	5571	83569	58439	25130	1.43
O1C2	13701	205514	128770	76745	1.60
O1C3	9171	137564	98627	38936	1.39
O1C4	10627	159400	102123	57276	1.56
O2C1	6540	98106	69469	28637	1.41
O2C2	16208	243124	139800	103325	1.74
O2C3	10723	160838	109657	51181	1.47
O2C4	12228	183418	113153	70265	1.62
O3C1	6118	91764	62451	29313	1.47
O3C2	14978	224668	132782	91886	1.69
O3C3	10171	152558	102639	49919	1.49
O3C4	11564	173465	106135	67329	1.63

Economics

The interaction effect of organic manure and cropping sequences on paddy grain equivalent yield was found to be significant in pooled results, therefore economics was calculated on combination basis (Table D2.10). Considering paddy grain equivalent yield, maximum net profit realized (Rs. 103325/ha) with BCR (1.74) under treatment O_2C_2.

Conclusions

Based on the paddy grain equivalent yield and economics, it can be concluded that for achieving higher yield and net returns from rice based cropping sequence under coastal salt affected soils of South Gujarat, to adopt rice (*Kharif*) – sugar beet (*Rabi*) cropping sequences and apply bio compost @ 10 ton/ha to rice crop which resulted improve soil condition.

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