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Impact of Various Organic and Inorganic Sources of Fertilizers on Yield, Yield Attributes, and Nutrients Accumulation in Direct Seeded Basmati Rice

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***Abstract*:** A field experiment was carried out at CCS HAU, College of Agriculture, Kaul farm during *kharif* 2019, to study the effects of different organic, inorganic, and integrated sources on yield, yield attributes, nutrients accumulation, and economics of direct seeded basmati rice.The experiment was planned in a randomized block design with ten treatments including NPK, biogas slurry and vermicompost along and in combination. The treatments $N_{37.5} P_{15} K_{15}$ + Vermicompost @ 4 t ha^{-1} and $N_{37.5} P_{15} K_{15}$ + Biogas slurry@ 4 t ha^{-1} were at par in plant height, effective tillers^2, harvest index, grain and straw yields of rice crop, but statistically superior over control. Yield attributes and straw yields, in these treatments were at par with $N_{75} P_{30} K_{30}$. Similar trend was observed in nutrient content (NPK) and their uptake by crop. However, micronutrient's content and their uptake in rice is increased with the application of vermicompost or biogas slurry (2 and 4 t ha^{-1}) alone or with integrated use of inorganic fertilizers. Highest benefit: cost (B:C) ratio was observed in $N_{75}P_{30}K_{30}$ compared to organic manures because of getting higher reruns and lower cost of cultivation.

***Keywords*:** Biogas slurry, Direct seeded basmati rice, Economics, Inorganic sources, Organic sources

India is the 2nd largest producer of rice *(Oryza sati*va L.) in the world with covering area of about 42.94 million hectares. The total production and productivity of rice in the country amounted to 122.27 million tonnes, and 2705 kg ha^{-1}, respectively during 2020-21. In Haryana, rice was cultivated on an area of about 4.59 million hectares with total production and productivity of 17.86 million tonnes and 3891 kg ha^{-1}, respectively during 2019-20 (Anonymous 2020). Basmati rice occupies about 1.94 m ha in the country and the two states viz. Punjab and Haryana account for 72% of total basmati rice produced in India (APEDA 2019). Direct seeding of rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeding avoids three basic operations namely, puddling, transplanting and maintaining standing water (Joshi et al 2013). Repeated puddling adversely affects soil physical properties. As a consequence, following non-rice upland crop in rotation can be adversely affected due to the ill effects of puddling (Kalita et al 2020). To sustain the long-term production of rice, more efficient alternative methods of rice productions are needed. In recent years, water table is running down at a very alarming rate globally, thus, limiting the scope for cultivation of high-water requiring crops. Therefore, there is an immense need of searching alternate method of rice cultivation and direct seeding of rice seems to be such alternative. It is universally accepted that neither use of organic manures alone nor chemical fertilizers can accomplish the sustainability of the crops yield under the modern intensive farming (Kamble et al 2018). However, the use of organic manures alone might not meet the plant requirement due to presence of relatively low levels of nutrients (Timsina 2018). Therefore, in order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is vital to use organic manures in integrated with inorganic fertilizers to obtain optimum yields (Sahu et al 2017). Integrated nutrients management increases the yield and nutrient uptake (Mohanty et al 2013). After going through the above facts in the mind, the present study was initiated to find out the impact of various organic and inorganic sources of fertilizers on yield and yield attributes, nutrient content, and their uptake in direct seeded basmati rice.

MATERIAL AND METHODS

Experimental set-up: A field experiment with direct seeded rice was conducted at CCS HAU, College of Agriculture, Kaul farm during *kharif* 2019. The chemical composition of soil is presented in Table 1. The experiment was laid out in a randomized block design (RBD) with ten treatments (Table 2). The experimental plot size was 4.8 x 3.6 m^2, while the spacing was 20 x 15 cm. Irrigation was applied as per crop requirement. After three weeks of sowing thinning and weeding were done. Organic source (vermicompost or biogas slurry) were applied one day before sowing and incorporated as per treatments. However, the average composition of NPK in vermicompost (1.6, 0.75 and 0.8%) and biogas slurry (1.4, 0.6 and 0.8%) respectively. Inorganic fertilizers were applied as per recommended dose. The recommended dose of N, P_2O_5 and K_2O for direct seeded basmati rice is 75, 30, and 30 kg ha^{-1}. Nitrogen was applied in three split doses whereas P and K were applied as basal dose only. Source of N, P_2O_5 and K_2O was urea, SSP and MOP. Harvesting was done manually and after that plants were dried then threshed manually. Grains were separated manually from straw and weight of grains and straw was recorded for the crop yield estimation. The weights of grains and straw were recorded as per treatments and expressed in kg ha^{-1}.

Plant analysis: At crop harvest, grain and straw samples each from each plots were collected, dried plant parts were chopped down using a chopper machine.The grain and straw samples were digested separately in di-acid mixture of sulphuric acid (H_2SO_4) and perchloric acid ($HClO_4$) in ratio 9:1 for nitrogen (N), phosphorus (P) and potassium (K)analysis, while the micronutrients were analysed in di-acid mixture of nitric (HNO_3) and perchloric acid ($HClO_4$) in ratio 4:1 with the help of AAS (Atomic absorption spectrophotometer) by the following standard methods (Antil et al 2002).

Data analysis: The crop data subjected to statistically analysis using the OPSTAT statistical software package.

RESULTS AND DISCUSSION

Yield and yield attributes: The plant height, number of effective tiller, grain yield, straw yield and harvest index increased significantly in all the treatment compared to control (Table 3). The higher plant height, number of effective tiller, grain yield, straw yield and harvest index was attained under T_9 which was statistically at par with T_6. The application of organic manures (vermicompost or biogas slurry) alone or in combination of with chemical fertilizers improved the yield and yield attributes of direct seeded rice over control treatment, where no fertilizers were added. These results are in corroborate with the findings of earlier researchers (Borah et al 2016, Nagaraj et al 2018, Kakkar et al 2020). The highest yield thus obtained might be ascribed to improved physico-chemical and biological properties of soil, which have led to better plant growth and increased nutrient use efficiency under integrated nutrient supply system, and ultimately led to increased yield and improved yield attributes characters of rice.

Nutrient N, P and K content and uptake: The significantly highest N, P and K content and their uptake in grain and straw of rice crop was observed under integrated application of organics (T_9, T_6) over organics or chemical fertilizers alone (Table 4). This may be attributed to the addition of organics and fertilizers as a more readily available source of nutrients in the soil for the rice crop. Similar results have also been reported by Gill and Aulakh (2018) and Sharma et al (2015). The presence of chemical fertilizer along with organic manure might have fasten the decomposition of manures and have led to release of more nutrients in the soil (Ankush et al 2021). The higher nutrient uptake is related to increased nutrient availability and better root growth of the crop (Malav and Ramani 2017). However, among organics, highest nutrient content and uptake was recorded with vermicompost as compared to biogas slurry due to its nutrient composition. The increase in N uptake might be linked to a steady supply of nutrients, along with lower N losses by denitrification or leaching, which could have boosted the cognition between plant N requirement and soil supply (Tilahun et al 2013). Inorganics alone resulted in lower N uptake due to poor availability and higher nutrient loss (Selim 2020). The application of organic manures reduced P fixation and increased its availability in the soil thereby enhanced uptake under application of organics alone or in combination with chemical fertilizers (Tilahun et al 2013).

Table 1. Initial soil chemical properties

Parameter	Value
pH	8.66
EC (dS m^{-1})	0.11
Organic carbon (%)	0.50
Available nitrogen (kg ha^{-1})	115
Available phosphorus (kg ha^{-1})	21.47
Available potassium (kg ha^{-1})	360
DTPA-Fe	14.75
DTPA-Mn	2.95
DTPA-Cu	1.34
DTPA-Zn	1.80

Table 2. Treatments details

Control	:	T_1
N_{75} P_{30} K_{30}	:	T_2
$N_{37.5}$ P_{15} K_{15}	:	T_3
Biogas slurry (4 t ha^{-1})	:	T_4
$N_{37.5}$ P_{15} K_{15} + Biogas slurry (2 t ha^{-1})	:	T_5
$N_{37.5}$ P_{15} K_{15} + Biogas slurry (4 t ha^{-1})	:	T_6
Vermicompost (4 t ha^{-1})	:	T_7
$N_{37.5}$ P_{15} K_{15} + Vermicompost (2 t ha^{-1})	:	T_8
$N_{37.5}$ P_{15} K_{15} + Vermicompost (4 t ha^{-1})	:	T_9
Vermicompost (2 t ha^{-1}) + Biogas slurry (2 t ha^{-1})	:	T_{10}

Micronutrient (Fe, Mn, Zn and Cu) content and their uptake: Micronutrients content and uptake were found to be increased under the application of organic manure (vermicompost or biogas slurry) alone or in combination with chemical fertilizers compared to chemical fertilizer alone (Table 5). Organic materials supply chelating agents, which helps in maintaining the solubility of micronutrients including Fe and Mn. Addition of organic matter (vermicompost or biogas slurry) improves soil structure which provides better soil aeration resulting increased availability of Fe. Readily available Fe released in soil as result of organic matter mineralization might have resulted in its increased uptake by rice. Similar results were reported by Sharma et al (2013) and Basha et al (2017). Nitrogen fertilization increased grain and straw yield and uptake of Fe in rice (Lakshmanan et al 2005). The difference in Mn content between grain and straw may be due to the slow movement of Mn in plants, as reported by Duhan and Singh (2002). Result showed a significant increase in Mn content in rice straw and grain with the application of vermicompost or biogas slurry alone or with their integrated use with NPK fertilizers. Similar results were also found by Basha et al (2017).

Table 3. Effect of organic and inorganic sources of nutrients on yield and yield attributes of direct seeded basmati rice

Treatments	Plant height (cm)	No. of effective tillers (m^{-2})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1	100.07	208.33	1,956.32	3,348.52	36.90
T_2	106.20	244.33	3,031.68	4,265.70	41.55
T_3	103.80	218.67	2,366.16	3,658.30	39.28
T_4	103.07	228.00	2,510.20	3,871.42	39.32
T_5	104.40	237.33	2,873.93	3,934.53	42.22
T_6	107.40	247.33	3,386.31	4,379.90	43.60
T_7	103.13	228.00	2,502.43	3,870.03	39.27
T_8	104.40	234.00	2,848.13	3,957.22	41.85
T_9	107.07	250.00	3,420.20	4,316.78	44.21
T_{10}	103.03	227.00	2,516.16	3,841.95	39.58
CD (p = 0.05)	1.43	5.96	128.24	157.21	1.70

Table 4. Effect of organic and inorganic sources of nutrients N, P and K content indirect seeded basmati rice

Treatments	Nitrogen				Phosphorus				Potassium			
	Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})		Content (%)		Uptake (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	1.10	0.46	21.52	15.50	0.454	0.208	8.88	6.95	0.46	1.46	9.00	48.89
T_2	1.32	0.54	40.02	23.04	0.500	0.260	15.16	11.09	0.52	1.69	15.82	72.09
T_3	1.26	0.48	29.81	17.56	0.460	0.228	10.88	8.34	0.50	1.53	11.91	55.98
T_4	1.28	0.51	32.13	19.79	0.483	0.239	12.13	9.23	0.51	1.57	12.74	60.80
T_5	1.30	0.53	37.36	20.80	0.491	0.249	14.12	9.81	0.52	1.64	14.94	64.55
T_6	1.34	0.56	45.34	24.62	0.516	0.270	17.48	11.84	0.54	1.72	18.28	75.34
T_7	1.28	0.53	32.03	20.40	0.483	0.238	12.09	9.21	0.52	1.57	12.93	60.62
T_8	1.30	0.53	37.03	20.92	0.491	0.250	13.99	9.88	0.52	1.64	14.81	64.90
T_9	1.34	0.56	45.83	24.22	0.515	0.270	17.62	11.66	0.54	1.73	18.47	74.67
T_{10}	1.28	0.53	32.21	20.27	0.482	0.238	12.14	9.15	0.51	1.60	12.92	61.48
CD (p= 0.05)	0.04	0.04	1.71	2.13	0.010	0.008	0.69	0.50	0.03	0.05	1.03	3.76

Table 5. Effect of organic and inorganic sources of nutrient on Fe, Mn, Zn and Cu content indirect seeded basmati rice

Treatments	Iron (Fe)				Manganese (Mn)				Zinc (Zn)				Copper (Cu)			
	Content (mg kg^{-1})		Uptake (g ha^{-1})		Content (mg kg^{-1})		Uptake (g ha^{-1})		Content (mg kg^{-1})		Uptake (g ha^{-1})		Content (mg kg^{-1})		Uptake (g ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	46.67	65.03	91.32	217.57	6.53	9.50	12.79	31.67	20.07	22.33	39.25	74.54	7.00	4.00	13.70	13.38
T_2	65.00	87.67	197.08	373.87	8.67	11.40	26.28	48.62	21.87	25.50	66.29	108.79	8.07	4.73	24.47	20.19
T_3	59.33	81.67	140.47	299.67	7.33	10.90	17.34	39.89	21.07	24.17	49.85	88.29	7.77	4.57	18.39	16.68
T_4	83.33	120.33	209.21	466.24	10.20	12.93	25.80	50.09	23.13	30.33	58.04	117.58	5.70	3.17	14.31	12.28
T_5	78.33	103.33	225.24	406.48	10.90	12.27	31.34	48.26	22.97	27.37	66.03	107.54	6.83	3.80	19.66	14.95
T_6	94.67	127.33	321.54	557.53	12.37	13.57	41.87	59.41	24.60	31.00	83.31	135.80	6.16	3.40	20.86	14.89
T_7	88.00	115.00	220.38	445.69	10.00	13.97	25.01	54.09	23.17	30.00	57.98	116.15	5.86	3.12	14.68	12.05
T_8	76.67	106.67	218.62	422.49	11.00	12.27	31.37	48.54	22.97	27.17	65.39	107.58	6.73	3.83	19.16	15.18
T_9	91.67	130.00	313.63	561.03	12.40	13.63	42.39	58.84	24.73	31.30	84.62	135.15	6.27	3.43	21.43	14.81
T_{10}	85.67	110.00	215.05	421.87	10.10	12.97	25.40	49.83	23.17	30.17	58.25	116.05	5.73	3.07	14.44	11.79
CD (p= 0.05)	23.73	27.21	71.79	108.42	2.21	1.60	6.47	6.42	2.10	4.21	5.77	17.14	NS	0.80	4.81	3.17

Table 6. Effect of organic and inorganic sources of nutrients on economic of direct seeded basmati rice

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C
T_1	30920	73362	42442	1: 2.4
T_2	33962	113688	79726	1: 3.4
T_3	32441	88731	56290	1: 2.7
T_4	47920	94133	46213	1: 2.0
T_5	40941	107773	66832	1: 2.6
T_6	49441	126987	77546	1: 2.6
T_7	46920	93841	46921	1: 2.0
T_8	40441	106805	66364	1: 2.6
T_9	48441	128258	79817	1: 2.7
T_{10}	47420	94356	46936	1: 2.0

Economics: The cost of cultivation was higher where organic source were applied by combination with chemical fertilizers Table 6. Gross and net return were higher where chemical fertilizers alone or combined with 4 t ha^{-1} of organic manure were applied. The B: C ratio was higher where chemical fertilizers alone was applied because of low cost of cultivation as compared to organics application. Similar results have also been reported by Kumar et al (2014). Baishya et al (2010) reported that crop manured only with organics (100 % RDN through VC/FYM) paid minimum return per rupee invested even lower than that of the control plots.

CONCLUSIONS

Application of chemical fertilizers alone or conjoint use with any of the organics (vermicompost and biogas slurry) gave highest number of effective tiller per m^2, plant height, grain yield, straw yield and harvest index as compare to 100 % RDF. The maximum uptake of macro- and micronutrients by basmati rice were obtained in treatment where @ 4 t ha^{-1} of organic along with 50 % RDF through inorganic fertilizer were applied.

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