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Direct and Residual Effect of Organic Manure on Buckwheat (*Fagopyrum Esculentum* Moench) – Fodder Ricebean (*Vigna Umbellata*) Cropping System

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Abstract

The research programme was carried out during early summer seasons of 2012 and 2013 at the experimental farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar to study the direct and left over effect of organics on Buckwheat (*Fagopyrum esculentum* Moench) – fodder Rice bean (*Vigna umbellata*) cropping system. The trial was carried out in Randomized block design with 14 treatments and replicated thrice. Results demonstrate that combined application of vermicompost, poultry manures, mustard cake and farmyard manure improved seed yield of buck wheat by 0.51 and 0.53 t ha^{-1} over 100 % RDF in 2012 and 2013, respectively. Among the sole application of organic manures, application of poultry manure at 5 t ha^{-1} proved its superiority in terms of stem and seed yield of buck wheat. Collective application of vermicompost at 2.5 t ha^{-1} + mustard Cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + Farmyard manure at 4 t ha^{-1} to the preceding buckwheat crop produced 18.67 and 17.20% more fodder yield of ricebean than 100 % chemically treated plot during both the years. Application of vermicompost at 2.5 t ha^{-1} + mustard Cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + Farmyard manure at 4 t ha^{-1} also leave highest amount of available N, P and K in the soil. Economic analysis revelaed that treatment producing highest yield of buck wheat and ricebean fetched lower B: C ratio (0.63 and 0.74 during 2012 and 2013, respectively) as compared to other treatemnts.

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Introduction

Organic manures have traditionally been the important input as sources of plant nourishment. Organic manures directly provided macro and micronutrient and indirectly facilitates in improving the physical, chemical and biological properties of soils[1]. These manures, containing all the essential nutrients when applied to the preceding crop, leave the residual effect and this benefit is harvested by the succeeding crop to a great extent[2]. Organic matter is the heart of fertile soil. It helps in increasing cations and anions holding capacity of soil particularly phosphorus and nitrates. Throughout the crop growth period these adsorbed nutrient ions are slowly available for the benefit of crop. Use of organic matter plays a significant role in improving the use efficiency of applied nutrients and thereby reducing the expenditure of nutrient. Organic manuring has also been reported to improve the efficiency of nitrogenous fertilizers in acidic soils[3]. Buckwheat (*Fagopyrum esculentum* Moench) is a very old Asian crop, extensively grown throughout the globe. It is an important underutilized crop, plays a crucial role in meeting up the food security of the temperate and hilly regions of the countries in East Asia, East Europe and the Himalayan region[4].Though it is not a cereal, but the starchy seeds are generally classified among the cereal grains as of their similar usage. Ricebean (*Vigna umbellata*) is a disease & insect resistant, fast growing legume crop and has the capability to produce huge amounts of healthy animal feed and high quality grain. Its cultivation is mainly confined to the Western, Northern and Eastern India and Nepal. It is broadly grown as an intercrop, predominantly of maize, and was traditionally being grown on residual moisture after rice. Ricebean can grow successfully in the large range of soils. Keeping the above facts in mind present experiment has been carried out to see the, direct and left over consequence of organics on the growth, yield and economics of buckwheat-ricebean cropping sequence.

Materials and Methods

This research trial was undertaken at the Research Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India. The farm is located at $26^0$19'86" N latitude and $89^0$23'53" E longitude and at an elevation of 43 meters above mean sea level. The soil of the research plot was sandy loam in texture and acidic in nature having pH of 5.5. The initial organic carbon 0.639%, available nitrogen 107.59 kg ha^{-1}, available phosphorus 15.36 kg ha^{-1} and available potash 71.68 kg ha^{-1} were recorded before buck wheat cultivation in 2012. In the first year buck wheat variety VL-7 was sown during mid January with a row and plant distance of 30 cm X 7-10 cm. Fourteen treatments were allocated in randomized complete block design and replicated thrice. Treatments comprises of T_1 = Control (No manures/no fertilizers), T_2 = RDF (40:20:20), T_3 = Vermicompost @ 2.5 t ha^{-1}, T4 = Vermicompost at 5 t ha^{-1}, T_5 = Mustard Cake @ 2.5 t ha^{-1}, T_6= Mustard Cake @5 t ha^{-1}, T_7 = Poultry Manure @ 2.5 t ha^{-1}, T_8 = Poultry Manure @ 5 t ha^{-1}, T9 = F.Y.M @ 8 t ha^{-1}, T_{10} = RDF +FYM @ 4 t ha^{-1}, T_{11} = Vermicompost @ 2.5 t ha^{-1} + Mustard Cake @ 2.5 t ha^{-1}, T_{12} = Vermicompost @ 2.5 t ha^{-1} + Mustard Cake @ 5 t ha^{-1}, T_{13} = Vermicompost @ 2.5 t ha^{-1} + F.Y.M @ 4 t ha^{-1} and T_{14} = Vermicompost @ 2.5 t ha^{-1} + Mustard Cake @ 2.5 t ha^{-1} + Poultry Manure @ 2.5 t ha^{-1} + F.Y.M @ 4 t ha^{-1}. Nutrient concentration of vermicompost, mustard cake, poultry manure and FYM were N: P: K., 1.15:0.48:0.72, 3.76:0.71:0.76, 2.71:2.31:2.10 and 0.56:0.18:0.52 respectively. After the harvest of buck wheat, ricebean (variety: RBL-6) was sown as a sequence in the end of April on residual soil fertility without disturbing the original layout of main crop. Crop management practices for buck wheat and ricebean are similar during both the year. All the organics, (well decomposed) were incorporated on dry weight basis 20 days before sowing of buck wheat. 20 days after application of organics as per treatment buck wheat were sown during 19th January and 21st January in 2012 and 2013, respectively with a seed rate of 40 kg ha^{-1}. Improved agro techniques were followed for the crops. All the plants from individual plots were harvested at physiological maturity and data on agronomic parameters were recorded. Composite soil sample from each plot were collected after harvesting of both buck wheat and ricebean. The samples were systematically dried up in shade, pulverized, passed through 0.2 mm net and then determined for the available N, P and K. Standard statistical methods were used for comparing the treatment means. Treatments variations were analysed on the basis of F test results and critical differences were calculated at 5% level of probability. Economics was calculated based on the prevailing market price.

Results and Discussion

Stem Yield, Seed Yield and Harvest Index of Buckwheat

The seed and stem yield of buckwheat was, in general more in 2013 than in 2012 irrespective of organic sources for nutrient management (Table 1). Significantly, the highest stem (2.83 t ha^{-1} during 2012 and 2.97 t ha^{-1} during 2013) and seed yield (1.65 t ha^{-1} during 2012 and 1.77 t ha^{-1} during 2013) was observed in integrated use of vermicompost at 2.5 t ha^{-1} + mustard cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + F.Y.M at 4 t ha^{-1} (T_{14}) might be due to more leaf area, dry matter accumulation, crop growth and yield attributes followed by joint application of vermicompost at 2.5 t ha-1 + mustard cake at 5 t ha^{-1} (T_{12}) that was statistically equal with sole appliance of poultry manure at 5 t ha^{-1} (T_8) during both the years of experimentation. The improvement of buckwheat yield due to different organic sources of nutrients could be attributed to the by and large advancement of crop growth, production and translocation of sufficient photosynthate. Unfertilized control (T_1) recorded the lowest stem and seed yield of buck wheat during both the years of investigation. The results confirmed the experimental findings of Dietrych *et al.,*[5,6].

Table 1: Performances of buckwheat as influenced by organic sources of nutrient

Treatments	Seed yield (t ha^{-1})			Stem Yield (t ha^{-1})			Harvest index (%)		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
T_1	0.37	0.48	0.43	1.20	1.41	1.31	23.3	25.3	24.3
T_2	1.14	1.24	1.19	2.59	2.72	2.66	30.9	31.2	30.8
T_3	1.00	1.11	1.06	2.54	2.68	2.61	28.2	29.3	28.7
T_4	1.24	1.33	1.29	2.63	2.72	2.67	32.0	32.8	32.4
T_5	1.13	1.23	1.18	2.60	2.70	2.65	30.2	31.2	30.7
T_6	1.35	1.47	1.41	2.84	2.79	2.81	32.1	34.5	33.4
T_7	1.12	1.22	1.17	2.59	2.69	2.64	30.1	31.1	30.6
T_8	1.41	1.52	1.46	2.79	2.83	2.81	33.3	34.9	34.2
T_9	1.17	1.26	1.22	2.57	2.76	2.66	31.1	31.3	31.2
T_{10}	1.27	1.39	1.33	2.70	2.79	2.75	32.0	33.1	32.6
T_{11}	1.39	1.48	1.43	2.82	2.79	2.80	32.1	34.8	33.7
T_{12}	1.46	1.58	1.52	2.81	2.90	2.86	34.1	35.2	34.7
T_{13}	1.31	1.42	1.36	2.76	2.78	2.77	32.1	33.7	32.9
T_{14}	1.65	1.77	1.71	2.83	2.97	2.90	36.8	37.3	37.0
S.Em(±)	0.08	0.10	0.09	0.08	0.10	0.08	0.94	0.94	0.94
CD (P=0.05)	0.23	0.28	0.25	0.24	0.29	0.24	2.75	2.75	2.74

It would further be seen from the said table that the highest harvest index (36.8 % and 37.3 % during 2012 and 2013, respectively) was recorded under the collective use of vermicompost at 2.5 t ha^{-1} + mustard cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + F.Y.M at 4 t ha^{-1} followed by joint use of vermicompost at 2.5 t ha^{-1} + mustard cake at 5 t ha^{-1} (34.1 % during 2012 and 35.2 % during 2013) which was statistically equal with sole appliance of poultry manure at 5 t ha^{-1} (33.3 % and 34.9 % during 2012 and 2013, respectively). Unfertilized control (T_1) recorded significantly the lowest harvest index of 23.3 % and 25.3 % during 2012 and 2013, respectively.

Growth Attributes and Fodder Yield of Rice Bean

Combine application of poultry manures, mustard cake vermicompost and FYM to previous buckwheat crop significantly increased fodder yield of rice bean by 4.0 and 4.5 t ha^{-1}, during 2012 and 2013, respectively, over 100 % RDF (Table 2) might be due to higher residual fertility for greater nutrient uptake and availability. Similar significant increases on plant

height (115.6 and 117.8 cm), number of branches plant^{-1} (5.2 and 5.3) and number of leaves plant^{-1} (77.7 and 78.3) were also observed in T_{14} followed by joint use of vermicompost at 2.5 t ha^{-1} + mustard cake at 5 t ha^{-1} (T_{12}) which was statistically equal with the sole application of poultry manure at 5 t ha^{-1} (T_8) during both the years of experimentation. As soil of terai region is sandy loam with light textured, prevailing with high rainfall, causes leaching down of nutrients, that's why combined application of all the organic manures was added in treatment T_{14}. All the treatments comprised organic sources of plant nutrient exhibited positive left over consequence in terms of yield traits and fodder yield of rice bean than chemically treated and control plot. Chemically treated plot left insufficient amount of nutrient for the succeeding crop as most of the nutrients was utilized by the preceding crop and some portion was lost from the soil as compared to organically amended plots, as a result performance of rice bean was not at par with the organically amended plots. These results are in accordance with the findings of Iqbal *et.al.,*[7,8,9].

Table 2: Residual effect of organics on the performance of rice bean grown after buck wheat

Treat-ments	Plant height (cm)			Number of branches plant^{-1}			Number leaves plant^{-1}			Fodder yield (t ha^{-1})		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
T_1	98.1	102.5	100.3	3.3	3.7	3.5	29.7	31.0	30.4	11.00	11.20	11.10
T_2	113.2	105.3	109.3	3.6	4.2	3.9	40.3	52.4	46.4	12.20	13.00	12.60
T_3	114.2	102.9	108.5	3.4	3.8	3.6	32.7	34.3	33.5	11.50	11.40	11.50
T4	113.4	123.1	118.3	3.9	4.2	4.1	48.3	55.3	51.8	13.10	14.00	13.60
T_5	114.2	113.6	113.9	3.5	4.0	3.7	38.7	40.0	39.4	12.00	12.30	12.20
T_6	102.4	115.7	109.1	4.2	4.6	4.4	57.7	61.4	59.5	14.10	14.70	14.40
T_7	112.7	114.4	113.5	3.5	3.9	3.7	35.7	37.2	36.4	11.70	12.00	11.90
T_8	110.2	115.5	112.9	4.2	4.8	4.5	67.6	72.0	69.8	14.50	15.40	15.00
T_9	114.6	115.3	114.9	3.9	4.2	4.1	45.7	53.6	49.6	12.30	13.50	12.90
T_{10}	100.3	128.3	114.3	4.1	4.5	4.3	54.8	56.6	55.7	13.60	14.20	13.90
T_{11}	113.5	114.9	116.7	4.2	4.8	4.5	60.7	66.9	63.8	14.30	15.00	14.70
T_{12}	112.3	115.7	114.2	5.0	5.0	5.0	73.3	75.3	74.3	14.70	15.50	15.10
T_{13}	115.3	116.5	114.0	4.2	4.5	4.3	55.7	56.7	56.2	13.70	14.50	14.10
T_{14}	115.6	117.8	115.9	5.2	5.3	5.2	77.7	78.3	78.0	15.00	15.70	15.40
S.Em(±)	6.75	7.31	7.01	0.156	0.15	0.147	2.76	2.96	2.82	0.76	0.84	0.93
CD (P=0.05)	19.74	21.35	20.48	0.456	0.438	0.431	8.06	8.66	8.24	2.23	2.47	2.73

Soil Nutrient Status

Results showed that available nutrient content of soil depleted after completion of crop sequence as compared to their initial level (before buckwheat). Collective application of vermicompost at 2.5 t ha^{-1} + mustard cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + F.Y.M at 4 t ha^{-1} (T_{14}) witnessed considerably highest values of available nitrogen (161.9 and 168.2 kg ha^{-1}), phosphorus (26.2 and 34.3 kg ha^{-1}) and potassium (124.0 and 127.5 kg ha^{-1}) followed by vermicompost at 2.5 t ha^{-1} + mustard cake at 5 t ha^{-1} and mustard cake at 5 t ha^{-1} during both years of experimentation. Organically treated plots recorded higher values of available nitrogen, phosphorus and potassium than chemically treated plots during both the years of experimentation. The probable reason might be due to losses of nutrients from chemically treated plot. The available nitrogen was higher might be due to the fixation of atmospheric nitrogen by buckwheat. It was also found that whenever, poultry manure was applied either solely or combindly with other organic manures recorded maximum available

potassium in both the years, it might be due to higher potassium content in poultry manure. The result of the present study is in agreement with the result of Singh *et.al.,*[8,9,10].

Economics of Buckwheat-Rice Bean Sequence

The data on economics of buckwheat-ricebean cropping sequence in relation to organic manures and chemical fertilizers have been presented in Table 3 and 4. The economics analysis revealed that maximum gross return of ₹ 91500 and ₹ 97920 ha^{-1} were achieved with collective application of vermicompost at 2.5 t ha^{-1} + mustard cake at 2.5 t ha^{-1} + poultry manure at 2.5 t ha^{-1} + F.Y.M at 4 t ha^{-1} i.e. T_{14} closely followed by ₹81820 and ₹88300 ha^{-1} with vermicompost at 2.5 t ha^{-1} + mustard cake at 5 t ha^{-1} i.e. T_{12} during 2012 and 2013, respectively. Higher gross return was simply due to higher yield of both the crop in the sequence during both the years of experimentation. The results showed that all the organic treatments recorded higher gross returns as compared to chemically treated and control plots.

Among all treatments T_8 (poultry manure at 5t ha^{-1}) registered the highest earnings to the tune of ₹51901 ha^{-1} in 2012 and ₹57941 ha^{-1} in 2013. This was next to T_2 (₹44992 ha^{-1} in 2012 and ₹50351 ha^{-1} in 2013). The net returns were less in first year of experiment as compared to the second year simply due to lesser yield for buckwheat and ricebean in the first year. Among the organic manures mustard cake recoded comparatively lower net returns in both the years might be due to higher unit price (₹ 8.0 kg^{-1}) of mustard cake. The highest benefit: cost ratio (2.33 and 2.59 during 2012 and 2013, respectively) was noticed in T_2 (100 % RDF) followed by T_{10} (2.07 and 2.33 during 2012 and 2013, respectively). This was owing to the less cost incurred by these treatments. The results corroborate with the earlier findings of Panwar and Munda[11] and Jat *et. al.,*[12].

Table: 3 Impact of organic sources of nutrients on soil fertility after harvesting of rice bean

Treatments	Available nitrogen (Kg ha^{-1})			Available phosphorus (Kg ha^{-1})			Available potassium (Kg ha^{-1})		
	2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
T_1	80.1	91.1	85.6	7.40	11.2	9.30	21.1	22.6	21.9
T_2	70.2	75.2	72.7	10.2	14.3	12.2	31.2	31.7	31.5
T_3	68.1	73.9	71.0	5.00	8.20	6.60	33.4	39.3	36.4
T_4	75.1	80.1	77.6	14.2	19.0	16.6	66.3	72.8	69.6
T_5	102.6	105.1	103.9	11.3	16.3	13.8	87.9	95.5	91.7
T_6	142.9	156.4	149.7	22.3	26.4	24.3	96.2	101.2	98.7
T_7	80.1	80.2	80.2	24.3	26.4	25.3	98.1	104.7	101.4
T_8	120.1	125.0	122.5	27.1	29.3	28.2	103.0	110.3	106.7
T_9	73.1	75.3	74.2	7.30	12.2	9.70	39.9	43.7	41.8
T_{10}	76.3	77.2	76.7	15.2	21.3	18.2	63.0	72.2	67.6
T_{11}	113.1	118.1	115.6	14.3	20.6	17.4	108.1	115.7	111.9
T_{12}	159.3	165.1	162.2	23.4	26.3	24.8	114.1	120.6	117.3
T_{13}	68.1	70.1	69.1	7.40	14.2	10.8	40.9	44.2	42.6
T_{14}	161.9	168.2	165.1	26.2	34.3	30.2	124.0	127.5	125.7
S.Em(±)	4.81	4.64	3.65	1.26	1.07	0.95	2.26	2.70	1.60
CD (P=0.05)	14.04	13.56	10.68	3.68	3.13	2.78	6.61	7.90	4.69

Table: 4 Cost of production of buckwheat and ricebean as influenced by organic sources of nutrients

	Treatments cost (₹ ha^{-1})		General cost for buckwheat production (₹ ha^{-1})		General cost for ricebean production (₹ ha^{-1})		Total cost of production (buckwheat + ricebean) (₹ ha^{-1})	
Treatments	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
T_1	-	-	15195	15195	2104	2104	17299	17299
T_2	2029	2150	15195	15195	2104	2104	19328	19449
T_3	1000	10000	15195	15195	2104	2104	27299	27299
T_4	20000	20000	15195	15195	2104	2104	37299	37299
T_5	20000	20000	15195	15195	2104	2104	37299	37299
T_6	40000	40000	15195	15195	2104	2104	57299	57299
T_7	5000	5000	15195	15195	2104	2104	22299	22299
T_8	10000	10000	15195	15195	2104	2104	27299	27299
T_9	8000	8000	15195	15195	2104	2104	25299	25299
T_{10}	6029	6150	15195	15195	2104	2104	23328	23449
T_{11}	30000	30000	15195	15195	2104	2104	47299	47299
T_{12}	50000	50000	15195	15195	2104	2104	67299	67299
T_{13}	14000	14000	15195	15195	2104	2104	31299	31299
T_{14}	39000	39000	15195	15195	2104	2104	56299	56299

Input cost of urea, single super phosphate, muriate of potash, farm yard manure, vermicompost, poultry manure and mustard cake were ₹6,8,15,1,4,2 and 8kg^{-1} respectively.

Table: 4 Economics of buckwheat-ricebean sequence as influenced by organic sources of nutrients

Treatments	Return from buckwheat (₹ ha^{-1})		Return from rice bean (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		Benefit: Cost ratio	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**	**2012**	**2013**
T_1	18500	24000	6600	6720	25100	30720	7801	13421	0.45	0.78
T_2	57000	62000	7320	7800	64320	69800	44992	50351	2.33	2.59
T_3	50000	55500	6900	6840	56900	62340	29601	35041	1.08	1.28
T_4	62000	66500	7860	8400	69860	74900	32561	37601	0.87	1.01
T_5	56500	61500	7200	7380	63700	68880	26401	31581	0.71	0.85
T_6	67500	73500	8460	8820	75960	82320	18661	25021	0.33	0.44
T_7	56000	61000	7020	7200	63020	68200	40721	45901	1.83	2.06
T_8	70500	76000	8700	9240	79200	85240	51901	57941	1.90	2.12
T_9	58500	63000	7380	8100	65880	71100	40581	45801	1.60	1.81
T_{10}	63500	69500	8160	8520	71660	78020	48332	54571	2.07	2.33
T_{11}	69500	74000	8580	9000	78080	83000	30781	35701	0.65	0.75
T_{12}	73000	79000	8820	9300	81820	88300	14521	21001	0.22	0.31
T_{13}	65500	71000	8220	8700	73720	79700	42421	48401	1.36	1.55
T_{14}	82500	88500	9000	9420	91500	97920	35201	41621	0.63	0.74

Selling price of buck wheat and faba bean were ₹70 and 40 kg^{-1}, respectively.

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