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SOIL PROPERTIES AND SEED YIELD AS INFLUENCED BY ORGANIC AMENDMENTS IN MUSTARD-CLUSTERBEAN CROPPING SEQUENCE

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SUMMARY

The different organic amendments which were tested during investigations included direct incorporation of mustard and clusterbean crop residues in the field, green manuring, use of vermicompost and FYM prepared for mustard residue and cattle dung in 1 : 1 ratio. All the three soil amendments viz., vermicompost, crop residue and farm yard manure @ 10.0 t/ha at 50 and 75 per cent RDF significantly increased seed yield in both the crops–clusterbean as well as rapeseed mustard during 2nd and 3rd years of experimentation. Nutrients uptake in terms of N, P and K was also positively affected by soil amendments in both the crops. Physical properties like bulk density (BD), water holding capacity (WHC) and infiltration rate numerically but non-significantly increased in organically amended plots when compared with the control or with initial values. Bulk density decreased from 1.47 to1.44 g/cc, while the water holding capacity and infiltration rate increased from 23.4 to 23.7 per cent and 2.76 to 2.79 cm/h, respectively, in organically amended plots. There was slight decline in soil pH in the plots amended with soil amendments, but this decline was non-significant. EC was not affected by treatments. Organic carbon (OC%), available N and available P were significantly affected by organic amendments. Biological properties in terms of dehydrogenase activity (DHA), alkaline phosphatase activity and viable microbial count significantly varied in treated plots as compared with 50 per cent RDF/75 per cent RDF alone or over with initial values. Increase in seed yield of mustard due to organic amendments was non-significant during first year of investigation. However, these values were found to be significant over respective doses of fertilizers in 2nd and 3rd years of investigations.

Key words : Organic amendments, soil properties, mustard residue, clusterbean, dehydrogenase

Decrease in soil fertility and imbalanced nutrient supply due to intensive agriculture are some of the main causes of deterioration of soil health and decrease in crop yield over the years. Poor soil fertility is one of the important factors limiting crop yield. The injudicious and indiscriminate use of chemical fertilizers causes deterioration of soil health, which affects the quality and quantity of agricultural produce. Indian soils are also low in organic content due to intensive cultivation and solarization. For sustainability and soil quality, reliance on integrated plant nutrient supply (IPNS) systems has become more important. It not only increases the crop productivity, but improvement in soil fertility is also achieved. The continuous and indiscriminate use of chemical fertilizers has adversely affected sustainability of agricultural production and has caused a lot of environmental pollution. About 92 per cent of the soils in Haryana are low and 8 per cent are medium in organic content, which is an index of nitrogen availability (Kumar, 2002). About 400 million tonnes of crop residues are produced every year in the country, which have potential of about 7.3 million tonnes of N and P along with major chunk of other major and minor elements. Rapeseed-mustard is the major oilseed crop of southern Haryana and major parts of Rajasthan. It is cultivated in **rabi** season under fallow-mustard rotation system. Its residue which is about three times of its yield generally goes waste. Under such cropping system, there is also possibility of having clusterbean-mustard rotation. Soil can also be enriched by incorporating crop residue of these crops or by use of vermicompost/FYM prepared from their residues and cattle dung in 1:1 ratio.

Clusterbean (*Cyamopsis tetragonoloba*), commonly known as guar, is grown for animal feed, fodder and vegetable purposes under semi-arid and arid zones of India. It occupies an important place in Indian economy because of its industrial importance and gum production. India is the largest producer of clusterbean. In India, this crop is grown in about 3.5 million hectares having about 10-11 lakh MT production per year *(www.nmce.com/files/study/guar seed)*. Major chunk of guar is produced in Rajasthan followed by Haryana. Crop wastes of clusterbean, grown in rotation with mustard, can be harnessed by incorporating them directly into the field or may be composted with cattle dung to form FYM or vermicompost. Hence, the present investigations were undertaken to study the impact of different alternatives in clusterbean-rapeseed mustard crop sequence.

MATERIALS AND METHODS

Before start of the experiment, soil samples from five locations were taken with an auger (5.0 cm dia), at soil depth of 0-15 cm, pooled together and mixed. The processed soil samples (<2 mm) were analyzed for various physico-chemical and biological properties. Soil samples were moistened to 50 per cent water holding capacity, incubated at 30^0C for 10 days and subsequently stored at 4^0C. Before microbiological analysis, the soil samples were kept at 30^0C for 48 h. pH and electric conductivity (EC) were determined at soil to water ratio of 1 : 2. pH (1 : 2) and EC (1 : 2) of the soil were 8.34 and 0.17 mmhos/cm, respectively (Table 1). Infiltration rate, water holding capacity (WHC) and bulk density (BD) were recorded as 2.76 cm/h, 23.4 per cent and 1.47 g/cc, respectively.The organic carbon was determined by dichromate oxidation method (Kalembasa and Jenkinson, 1973). Soil dehydrogenase activity was determined by reduction of 2,3,5- triphenyl tetrazolium chloride (TTC) by the method of Casida *et al.* (1964).

TABLE 1
Soil properties of experimental field at the start of experiment

Texture	Loamy sand
EC (1 : 2)	0.17
pH (1 : 2)	8.34
OC (%)	0.20
Total N (kg/ha)	348
Available N (kg/ha)	118
Available P (kg/ha)	10.68
Available K (kg/ha)	214
Infiltration rate (cm/h)	2.76
WHC (%)	23.4
Bulk density (BD) (g/cc)	1.47
Dehydrogenase activity (mg TPF/kg soil/24 h)	2.4
Alkaline phosphatase activity (µg PNP/g soil/h)	4.1
Microbial load (CFUs/g soil)	31 x 10^5

For on-farm trials, field having area of 0.4 ha was selected. The soil texture was loamy sand (Typic Ustochrept). There were four main treatments viz., control, crop residue (CR) incorporation, vermicompost (VC) and farm yard manure (FYM) application; each having two sub-treatments viz., 50 and 75 per cent RDF (recommended dose of fertilizer) of the crop. Five tonnes/ha each of vermicompost, FYM as well as mustard residue was incorporated into plots before ploughing. The treatments were applied in triplicates in RBD design having plot size 6.0 x 6.0 m^2. Nutrient composition of different soil amendments was determined as per standard prescribed procedures (Table 2).

TABLE 2
Nutrient composition of different soil amendments (on dry weight basis)

S. No.	Soil amendments	N (%)	P (%)	K (%)
1.	Clusterbean residue	1.15	0.55	1.05
2.	Mustard residue	0.87	0.20	1.36
3.	FYM	0.66	0.53	1.07
4.	Vermicompost	1.07	0.80	1.35

In this experiment, clusterbean cultivar HG-365 was sown during **kharif** season for the continuous three years and data were recorded in terms of seed yield, straw yield and nutrients uptake. In the **rabi** season of each year, Indian mustard cv. RH 8812 was sown in third week of October after application of vermicompost, farm yard manure (FYM) and crop residue of clusterbean @ 5.0 t/ha as per plan of work. The plot size and site of plot were fixed during all the three years. Generally, thinning was done after 25 days keeping plant to plant distance at 12-15 cm and first irrigation was done at 35 DAS. Data were analyzed in terms of seed and straw yields and nutrients uptake. Soil samples after third year of experimentation were also analyzed for various physico-chemical and biological properties as per standard procedures.

RESULTS AND DISCUSSION

Seed Yield

The pooled data of seed yield in clusterbean for

three years indicated that maximum seed yield (13.64 q/ha) was recorded in the treatment having 75 per cent RDF+VC @ 5.0 t/ha followed by 75 per cent RDF+FYM (13.11 q/ha) (Table 3). These values significantly varied with 75 per cent RDF alone (11.66 q/ha). All the three soil amendments viz. vermicompost, crop residue as well as farm yard manure at the rate of 10.0 t/ha showed their positive effect on seed yield at both the doses of the chemical fertilizers. During first year of experimentation, the impact of crop residue was less prominent as compared to other two soil amendments. Similar trends in seed yield of mustard were observed during all the three years of experimentation. Mean value of seed yield of mustard at 75 per cent RDF+ vermicompost (21.57 q/ha) was comparable to those of 75 per cent RDF+FYM (21.12 q/ha) or 75 per cent RDF+CR (20.21 q/ha). The lowest seed yield (18.62 q/ha) was recorded at 50 per cent RDF alone. The integrated use of chemical fertilizers, organic manures and biofertilizers for maintaining soil health and crop productivity showed encouraging results (Anand *et al.*, 1998).

Nutrients Uptake

Seed samples of clusterbean and mustard were analyzed for nutrient uptake in terms of nitrogen, phosphorus and potash and cumulative data have been depicted in Tables 4 to 6. Minimum nitrogen uptake by seed was noticed at 50 per cent RDF during all the three years of observations. The nitrogen uptake values through seed at 50 per cent RDF+vermicompost or farm yard manure were higher than 75 per cent RDF alone. Similar trends were observed with regard to P and K both in seed uptake in both the crops. Nutrient uptake was dependent on seed yield of the crops. N, P and K uptake varied non-significantly when vermicompost treatment values were compared to farm yard manure treatment values at their respective fertilizer applications. Similar were the trends in terms of straw yield as different treatments responded in the same fashion as that of seed yield (data not depicted). Vermicompost treatment was numerically superior over the other soil amendments at their respective chemical fertilizer doses. Similar results were observed by Anand *et al.* (2003) in wheat-pearl millet crop sequences.

Physico-chemical and Biological Properties of Soil

Effect of different soil amendments on physico-chemical and biological properties of soil was observed after harvest of mustard crop of third year of experimentation. Physical properties in terms of bulk density (BD), water holding capacity (WHC) and infiltration rate were recorded. These values were non-significant when compared with the initial values and with the control treatments (Table 7). Maximum infiltration rate i. e. 2.79 cm/h was observed in the

TABLE 3
Impact of different organic amendments on seed yield (q/ha) of clusterbean and mustard in clusterbean-mustard crop sequence

Treatment	Clusterbean				Mustard			
	Years				Years			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RDF	12.40	10.48	9.56	10.93	18.57	20.98	16.32	18.62
75% RDF	13.05	11.72	10.23	11.66	20.24	21.96	17.28	19.82
50% RDF+VC	14.40	12.24	11.32	12.65	20.48	22.58	17.96	20.34
75% RDF+VC	15.07	13.78	12.08	13.64	20.85	24.47	19.41	21.57
50% RDF+CR	13.01	10.89	10.48	11.46	17.94	21.93	17.62	19.16
75% RDF+CR	13.58	12.08	11.29	12.31	19.07	23.08	18.48	20.21
50% RDF+FYM	14.23	11.76	10.86	12.28	20.10	21.85	17.78	19.19
75% RDF+FYM	14.87	12.87	11.59	13.11	20.60	24.23	18.54	21.12
Mean	13.82	11.97	10.93	12.24	19.74	22.63	17.92	20.09
C. D. (P=0.05)	1.10	0.95	0.85	0.96	1.31	1.68	1.36	1.45

RDF–Recommended dose of fertilizer, VC–Vermicompost, CR–Crop residue, FYM–Farm yard manure (cattle dung+crop residue in 1 : 1 ratio), RDF for mustard=$N_{80}P_{30}K_{20}$ and for clusterbean=$N_{20}P_{30}K_{20}$.

TABLE 4
Effect of different amendments on N uptake (kg/ha) in seed by two crops

Treatment	Clusterbean				Mustard			
	Years				Years			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RDF	19.34	16.03	14.34	16.65	55.75	62.94	48.34	55.67
75% RDF	21.40	18.04	15.44	18.29	62.94	68.95	51.32	61.07
50% RDF+VC	23.64	18.97	16.87	19.77	64.92	71.12	53.76	63.26
75% RDF+VC	25.17	22.04	18.36	21.85	68.38	76.08	57.64	67.63
50% RDF+CR	21.04	16.87	15.61	17.84	56.10	68.86	52.20	59.05
75% RDF+CR	22.13	18.96	16.93	19.34	58.73	72.70	54.42	61.95
50% RDF+FYM	23.47	17.58	15.96	19.00	61.70	65.55	52.81	60.02
75% RDF+FYM	24.83	19.84	17.38	20.68	66.53	73.41	54.72	64.88
Mean	22.62	18.44	16.36	19.14	61.50	69.95	53.15	61.69
C. D. (P=0.05)	1.43	1.28	1.17	1.29	3.13	3.84	3.42	3.46

TABLE 5
Effect of different amendments on P uptake (kg/ha) in seed by two crops

Treatment	Clusterbean				Mustard			
	Years				Years			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RDF	6.82	5.76	5.06	5.88	14.12	15.94	12.08	14.04
75% RDF	7.83	6.68	5.52	6.67	15.98	16.90	12.96	15.28
50% RDF+VC	8.35	6.90	6.16	7.13	16.18	17.61	13.68	15.82
75% RDF+VC	9.64	7.46	6.64	7.91	17.09	18.89	14.34	16.77
50% RDF+CR	7.32	5.97	5.78	6.35	13.81	16.88	13.18	14.62
75% RDF+CR	8.01	6.52	5.92	6.81	15.07	18.00	13.96	15.67
50% RDF+FYM	8.53	6.43	5.54	6.83	15.68	16.60	13.24	15.17
75% RDF+FYM	9.37	7.18	6.28	7.61	16.48	18.59	14.06	16.37
Mean	8.23	6.61	5.86	6.90	15.55	17.42	13.43	15.40
C. D. (P=0.05)	0.54	0.50	0.43	0.49	1.27	1.32	1.08	1.22

TABLE 6
Effect of different amendments on K uptake (kg/ha) in seed by two crops

Treatment	Clusterbean				Mustard			
	Years				Years			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RDF	9.67	7.96	7.08	8.23	12.07	13.63	10.28	11.99
75% RDF	10.31	8.79	7.70	8.93	13.56	14.49	11.17	13.07
50% RDF+VC	11.38	8.54	8.32	9.41	15.16	15.12	11.72	14.00
75% RDF+VC	12.21	10.34	9.61	10.72	15.64	17.12	12.68	15.14
50% RDF+CR	10.06	8.38	7.54	8.66	12.02	14.25	11.34	12.53
75% RDF+CR	10.73	9.42	8.36	9.50	13.16	16.15	11.92	13.74
50% RDF+FYM	11.38	8.49	7.96	9.27	14.27	14.63	11.57	13.49
75% RDF+FYM	12.34	9.89	8.70	10.31	15.04	16.96	12.08	14.69
Mean	11.01	8.97	8.15	9.37	13.86	15.29	11.59	13.58
C. D. (P=0.05)	1.01	0.67	0.62	0.76	1.01	1.27	0.78	1.02

TABLE 7
Effect of different organic amendments on physical properties of soil at the end of third year

Treatment	Infiltration rate (cm/h)	WHC (%)	Bulk density (BD) (g/cc)
50% RDF	2.76	23.4	1.47
75% RDF	2.76	23.4	1.47
50% RDF+VC	2.78	23.6	1.45
75% RDF+VC	2.79	23.7	1.45
50% RDF+CR	2.77	23.5	1.45
75% RDF+CR	2.78	23.6	1.44
50% RDF+FYM	2.79	23.7	1.44
75% RDF+FYM	2.78	23.6	1.45
Mean	2.78	23.6	1.46
C. D. (P=0.05)	NS	NS	NS

NS–Not Significant.

treatments having vermicompost and FYM incorporation. There was the numerical increase in infiltration rate when compared with respect to other treatments. Similar trends were observed with regard to WHC and BD. Organic amendments slightly decreased soil pH as compared to the control; although this decrease was non-significant. EC was not affected by soil amendments (Table 8). Available K and total N values varied non-significantly with one another. The lowest values of available N and P were observed in the treatments having no soil organic amendments. OC (%), available N and available P varied significantly in the treatments having organic amendments when compared with the control treatments.

Effect of organic amendments on biological properties of soil was also observed after 3rd year of experimentation. Biological properties in terms of

TABLE 8
Chemical properties of soil at the end of third year experiment as affected by different soil amendments

Treatment	pH (1 : 2)	EC (1 : 2)	O. C (%)	Total N (kg/ha)	Available nutrients (kg/ha)		
					N	P	K
50% RDF	8.38	0.17	0.20	332	107	9.33	207
75% RDF	8.42	0.18	0.19	335	106	10.57	205
50% RDF+VC	8.27	0.18	0.21	342	112	11.50	211
75% RDF+VC	8.29	0.17	0.21	346	114	11.67	209
50% RDF+CR	8.30	0.18	0.22	345	116	11.53	212
75% RDF+CR	8.27	0.18	0.21	344	111	11.67	213
50% RDF+FYM	8.27	0.19	0.21	346	114	12.15	211
75% RDF+FYM	8.24	0.18	0.22	349	117	12.00	214
Mean	8.30	0.18	0.20	342	112	11.30	210
C. D. (P=0.05)	NS	NS	0.02	NS	5.6	0.74	NS

NS–Not Significant.

TABLE 9
Effect of soil amendments on biological properties of soil at the end of third year

Treatment	DHA (mg TPF/kg soil/24 h)	Alkaline phosphatase activity (µg PNP/g soil/h)	Microbial No.=x 10^5 CFUs/g soil
50% RDF	1.9	4.3	26
75% RDF	2.2	3.9	22
50% RDF+VC	3.2	6.4	48
75% RDF+VC	3.4	7.8	39
50% RDF+CR	2.9	5.7	32
75% RDF+CR	3.1	7.4	34
50% RDF+FYM	3.3	6.2	51
75% RDF+FYM	3.6	7.8	53
Mean	3.0	6.5	41
C. D. (P=0.05)	0.84	2.2	NS

DHA–Dehydrogenase activity, TPF–Tri phenyl formazone, PNP–P-nitrophenol. NS–Not Significant.

dehydrogenase activity, alkaline phosphatase activity and viable microbial count showed significant improvement in organic amendments when compared with 50 and 75 per cent RDF alone or over initial values (Table 9). Maximum dehydrogenase and alkaline activities were noticed in FYM amendment at 75 per cent RDF (3.6 mg TPF/kg soil/24 h and 7.8 µg PNP/g soil /h, respectively).

Use of different organic manures caused decrease in bulk density, increase in porosity, WHC, OC and DHA (Maheswarappa *et al*., 1999). Katyal *et al.* (2001) observed an increase in organic carbon from 0.24 to 0.38 per cent after six years of residue incorporation. Use of crop residue in different modes may enrich the soil with macro- and micro-nutrients along with the improvement of soil properties. Improvement of physical properties of soil due to long term incorporation of straw was observed by Ocio *et al*. (1991). There are reports that mustard residue improve soil texture and moisture conservation. It contains chemicals like glucosinolates, due to which it acts as natural herbicide/fumigant (*www.asuextension.com*). Seed yield of clusterbean and mustard along with soil properties was positively affected by direct incorporation of their residues (Pathak *et al*., 2005).

CONCLUSION

All the three soil amendments viz., vermicompost, crop residue and farm yard manure @ 10.0 t/ha at 50 and 75 per cent RDF significantly increased seed yield in both the crops–clusterbean as well as rapeseed-mustard during 2nd and 3rd years of experimentation. Nutrients uptake in terms of N, P and K was also positively affected by soil amendments in both the crops. Physical properties like BD, WHC and infiltration rate numerically but non-significantly increased in organically amended plots when compared with the control or with initial values.

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