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Effect of green manuring and residue incorporation on soil properties and seed yield of rapeseed mustard

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ABSTRACT

The different organic amendments which were tested during investigations included direct incorporation of mustard crop residue in the field and green manuring at 50 and 75 per cent RDF. These amendments significantly increased seed yield in 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 were numerically but non-significantly increased in organically amended plots when compared to the control or to initial values. BD decreased from 1.47 g/cc to 1.44 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 but organic carbon, 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 to 50 or 75 per cent RDF alone or over with initial values.

Keywords: Green manuring; residue; soil; rapeseed mustard

INRODUCTION

The continuous and indiscriminate use of chemical fertilizers has adversely affected sustainability of agriculture production and has caused a lot of environmental pollution. 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 (Mohuiddin et al 2000). About 92 per cent of the soils in Haryana are low and eight per cent are medium in organic content which is an index of nitrogen availability (Kumar 2002). About 400 MT of crop residues are produced every year in the country which have potential of about 7.3 MT 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 *Sesbaenia*-mustard rotation as mustard is generally grown as fallow-mustard rotation. Soil can be enriched either by incorporating mustard crop residue or by green manuring before cultivation of mustard crop.

Hence the present investigations were undertaken to study the impact of crop residue incorporation and green manuring on soil properties and seed yield in rapeseed mustard.

MATERIAL and METHODS

Before start of the experiment soil samples from five locations were taken with an auger (5.0 cm dia) at a soil depth 0-15 cm pooled together and mixed. The processed soil samples (<2 mm) were moistened to 50 per cent water holding capacity, incubated at 30°C for 10 days and subsequently stored at 4°C and then analyzed for various physico-chemical and biological properties. Before microbiological analysis the soil samples were kept at 30°C 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 was 8.34 and 0.17 mmhos/cm respectively. Infiltration rate, water holding capacity (WHC) and bulk density were recorded as 2.76 cm/h, 23.4 per cent and 1.47 g/cc respectively (Table 1). 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). Nutrient composition of two soil amendments was determined as per standard prescribed procedures (Table 2).

Mustard residue @ 10.0 tons/ha was incorporated into the plots as per layout of the experiment. *Sesbaenia* sp as green manure was chopped and incorporated in the soil at 42 DAS. Plot size was 8 x 8 m^2 and each treatment had three replications. The experiment was conducted following RBD design. Indian mustard cv Luxmi was sown either in the second or third week of October. Weeding and thinning were done at 25 DAS and first irrigation was given after 35 days of sowing. Fifty per cent of chemical fertilizer dose was applied at the time of sowing while the rest was applied at first irrigation. This experiment was conducted continuously for three years in the fixed plots at CCSHAU, Regional Research Station, Bawal, Haryana. For on-farm trials field having area of 0.4 hectare was selected. The soil texture was loamy sand (typic ustochrept). The soil was analysed for various properties before start of the experiment. There were three main

Table 1. Soil properties of experimental field at the start of experiment

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

treatments viz control, crop residue (CR) incorporation and green manuring each having two sub-treatments viz 50 and 75 per cent RDF (recommended dose of fertilizer) of the crop. Ten tons/ha mustard residue was incorporated into plots before ploughing. The treatments were applied in triplicates in RBD design having plot size 8.0 x 6.0 m^2. Mulching of green manure was done at 40 days of *Sesbaenia* growth. Soil samples were analysed for various physico-chemical and biological properties at the end of 3rd year of experimentation.

RESULTS and DISCUSSION

Biological yield: During first year of investigations maximum seed yield (24.04 q/ha) was recorded at 75 per cent RF + GM although it was non-significant when compared to 75 per cent RF alone (23.77 q/ha) (Table 3). However during the second year seed yield at 75 per cent RF both green manuring treatment (25.31 q/ha) as well as crop residue treatment (24.76 q/ha) significantly varied over 75 per cent RF alone (22.12 q/ha). Similar trends were followed during the third year of experimentation though in general there was reduction in seed yield due to hailstorm in the month of February. Straw yield was directly co-related to the seed yield in all the treatments during all the three years of investigations.

Nutrient uptake: Seeds and straw samples were digested and analysed for N, P and K. Nitrogen, phosphorus and potash uptake both by seed as well as straw was calculated during the period of study. The observations are presented for N uptake in Table 4, for P uptake in Table 5 and K uptake in Table 6. Maximum N, P and K uptake was observed at 75 per cent RF + GM in seed as well as straw during the period of investigations. In the year 2005-06 and 2006-07 these values at 75 per cent RF + GM varied significantly over those of 75 per cent RF alone. The values in the treatment having residue incorporation also

Table 2. Mean nutrient composition of different soil amendments used (on dry weight basis)

Soil amendment	N (%)	P (%)	K (%)
Mustard residue	0.87	0.20	1.36
Green Manure (*Sesbaenia* sp)	1.75	0.51	1.11

Table 3. Effect of different soil amendments on biological yield of mustard in mustard-based cropping system

Treatment	Seed yield (q/ha) in year				Straw yield (q/ha) in year			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RF	22.21	21.06	16.60	19.95	64.52	62.54	43.67	56.91
75% RF	23.77	22.12	17.67	21.18	69.47	65.91	46.54	60.64
50% RF + CR	21.96	22.61	18.33	20.96	63.18	68.08	48.38	59.88
75% RF + CR	23.21	24.76	19.67	22.54	67.84	74.28	52.70	64.94
50% RF + GM	22.94	23.50	18.65	21.69	66.45	67.05	50.12	61.20
75% RF + GM	24.04	25.31	20.24	23.19	71.68	73.17	54.20	66.35
Mean	23.02	23.22	18.52	21.58	67.19	68.05	49.27	61.50
CD	1.45	1.54	1.40	1.46	3.49	4.28	3.78	3.85

RF= recommended fertilizer, CR= crop residue, GM= green manure

Table 4. N uptake by mustard crop as affected by different soil amendments in mustard-based cropping system

Treatment	Seed N uptake (kg/ha) in year				Straw N uptake (kg/ha) in year			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RF	68.18	63.18	47.64	59.66	50.97	54.40	38.50	47.95
75% RF	76.30	69.45	52.28	66.01	64.61	59.31	40.84	54.92
50% RF + CR	66.54	67.83	56.82	63.73	50.54	59.22	42.22	50.66
75% RF + CR	75.20	76.57	60.52	70.76	63.77	64.38	45.07	57.74
50% RF + GM	71.11	70.65	57.20	66.32	56.48	62.17	43.29	53.98
75% RF + GM	78.61	77.99	62.68	73.09	68.81	65.36	47.60	60.59
Mean	72.66	70.94	56.19	66.59	59.20	60.80	42.90	54.3
CD	3.98	3.79	3.58	3.78	3.79	3.57	2.54	3.3

RF= recommended fertilizer, CR= crop residue, GM= green manure

Table 5. P uptake by mustard crop as affected by different soil amendments

Treatment	Seed P uptake (kg/ha) in year				Straw P uptake (kg/ha) in year			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RF	16.44	16.00	12.92	15.12	9.67	11.25	7.77	9.56
75% RF	19.25	15.48	13.14	15.95	12.50	12.52	9.38	11.46
50% RF + CR	17.35	17.40	13.78	16.17	12.00	12.93	9.82	11.58
75% RF + CR	9.26	18.96	14.86	17.69	13.57	14.63	10.47	12.89
50% RF + GM	18.35	17.60	14.18	16.17	13.29	13.03	9.58	11.96
75% RF + GM	19.95	19.31	15.41	18.22	15.77	14.85	10.80	13.80
Mean	18.43	17.45	14.04	16.64	12.8	13.20	9.64	11.88
CD	1.23	1.33	0.98	1.18	1.07	1.08	0.57	0.90

RF= recommended fertilizer, CR= crop residue, GM= green manure

Table 6. K uptake by mustard crop as affected by different soil amendments

Treatment	Seed K uptake (kg/ha) in year				Straw K uptake (kg/ha) in year			
	1st	2nd	3rd	Mean	1st	2nd	3rd	Mean
50% RF	13.55	13.68	10.46	12.56	89.68	85.05	59.60	78.11
75% RF	16.40	15.48	11.51	14.46	97.26	90.29	62.48	83.34
50% RF + CR	14.49	14.92	11.94	13.78	9.35	93.26	65.72	56.11
75% RF + CR	16.94	17.01	12.85	15.6	96.33	102.43	70.18	89.64
50% RF + GM	16.06	15.87	12.07	14.66	98.35	94.18	66.43	86.32
75% RF + GM	17.79	17.33	13.18	16.1	108.95	103.99	72.58	95.17
Mean	15.87	15.71	12.00	14.52	96.82	94.86	66.16	85.94
CD	1.41	1.27	0.74	1.14	7.29	6.94	4.02	6.08

RF= recommended fertilizer, CR= crop residue, GM= green manure

showed significant difference to those of 50 and 75 per cent RF alone in two years of study.

Soil properties: Physical properties in terms of infiltration rate, bulk density (BD) and water-holding capacity (WHC) were determined. These values were 2.79 cm/h, 1.44g/cc and 23.6 per cent respectively in the treatment having green manuring (Table 7). But these values were statistically at par to other treatments. Physical properties of soil were not much affected by different soil amendments when compared to the initial values; pH was also numerically but non-significantly affected by soil amendments (Table 8). However EC values were not related to different treatments. Maximum organic carbon (0.22%) was observed in GM.

Table 7. Effect of different amendments on soil physical properties at the end of 3rd year in fallow-mustard rotation system

Treatment	Infiltration rate (cm/hr)	WHC (%)	Bulk density (BD) (g/cc)
50% RF	2.76	23.4	1.47
75% RF	2.76	23.4	1.47
50% RF + CR	2.77	23.6	1.45
75% RF + CR	2.78	23.6	1.46
50% RF + GM	2.78	23.7	1.44
75% RF + GM	2.79	23.6	1.45
Mean	2.77	23.5	1.46
CD	NS	NS	NS

RF= recommended fertilizer, CR= crop residue, GM= green manure

Table 8. Chemical properties of soil after harvest of mustard crop as affected by crop residue incorporation and green manuring

Treatment	pH (1:2)	EC (1:2)	OC (%)	Total N (kg/ha)	Available nutrients (kg/ha)		
					N	P	K
50% RF	8.43	0.17	0.20	328	113	9.87	207
75% RF	8.46	0.18	0.20	330	115	10.33	206
50% RF + CR	8.28	0.18	0.21	348	118	11.67	214
75% RF + CR	8.31	0.18	0.21	352	119	11.33	213
50% RF + GM	8.30	0.17	0.22	358	121	11.00	212
75% RF + GM	8.27	0.18	0.22	361	122	12.13	215
Mean	3.34	0.18	0.21	346	118	11.05	211
CD	NS	NS	0.02	2.6	6.4	0.62	NS

RF= recommended fertilizer, CR= crop residue, GM= green manure

Total available N and available P values were positively affected by soil amendments while available K values were statistically at par in different treatments.

Positive and significant differences in biological properties in terms of dehydrogenase and alkaline phosphatase activities were noticed by green manuring and residue incorporation (Table 9). Viable microbial count to the label of 62 $x10^5$ CFUs/g of soil was observed in the treatment having 75 per cent RF + GM followed by 59 x 10^5 CFUs in 50 per cent RF + GM treatment. Maximum dehydrogenase activity (5.2 mg TPF/kg

Table 9. Effect of organic amendments on biological properties of soil after harvest of mustard crop in fallow-mustard rotation system

Treatment	DHA (mg TPF/kg soil/24h)	Alkaline phosphatase activity (mg PNP/g soil/h)	Microbial #= x 10^5 CFUs/g soil
50% RF	2.7	3.4	18
75% RF	2.5	3.8	14
50% RF + CR	3.8	7.2	42
75% RF + CR	4.6	7.4	37
50% RF + GM	4.9	8.9	59
75% RF + GM	5.2	9.2	62
CD	0.68	2.4	NS

DHA= dehydrogenase activity, TPF= triphenyl formazone, PNP= p-nitrophenol
RF= recommended fertilizer, CR= crop residue, GM= green manure

soil/24h) and phosphatase activity (9.2 mg PNP/g soil/h) were observed in the treatment having 75 per cent RF + GM.

Use of different organic manures caused decrease in bulk density, increase in porosity, water holding capacity, 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 micronutrients 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). The soil amendments like vermicompost, crop residues of mustard and cluster bean or farm yard manure (10.0 tons/ha) positively affected soil properties along with significant increase in the seed yield of both the crops during 2nd and 3rd year of experimentation (Pathak et al 2005, Pathak and Yadav 2014). There are reports that mustard residue improves soil texture and moisture conservation. It contains chemicals like glucosinolates due to which it acts as natural herbicide/fumigant (www.asuextension.com).

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