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Effect of wool waste in combination with farm yard manure and fertilizer on soil properties in aridisol of Bikaner, Rajasthan, India

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Abstract

Aim : The objective of the present study was to assess the impact of conjunctive use of wool waste, farm yard manure and chemical fertilizer on soil properties of *Aridisol* of Bikaner, Rajasthan, India.

Methodology : After harvest of cabbage crop, soil samples were collected from the respective experimental plot of crop field by adopting the standard procedure. Bulk density, particle density, pH, electrical conductivity, organic carbon, available N, P, K, S, Zn, Cu, Mn, Fe, microbial count and dehydrogenase activity were estimated following the standard protocol.

Results : Application of wool waste @ 7.5 t ha⁻¹ along with FYM @ 7.5 t ha⁻¹ (W₁) significantly increased organic carbon and plant available nutrients (N, P, K, S, Zn, Cu, Mn, Fe) over control and rest of the treatment. but W₁ and W₂ (Wool waste @ 5 t ha⁻¹ along with FYM @ 10 t ha⁻¹) treatment was found at par with respect to nitrogen. Treatment W₁ also gave significant performance of microbial count and dehydrogenase activity during experimental season over rest of the treatment. Application of each increasing level of recommended dose of fertilizer significantly enhanced all chemical and biological properties of soil. Application of wool waste @ 7.5 t ha⁻¹ along with FYM @ 7.5 t ha⁻¹ increased available macronutrients and micronutrients over control.

Interpretation : It can be concluded that conjunctive use of wool waste, farm yard manure and inorganic fertilizer proved better nutrient management option for improving soil properties.

Key words: Aridisol, Enzyme activity, Farm yard manure, Macro & Micronutrients, Wool waste

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Introduction

Low and erratic rainfall, high evaporation demand and less fertile soil severely restrict the vegetable production in arid ecosystems. Majority of soils in arid region are low in organic carbon and nitrogen, low to medium in phosphorus and medium to high in potassium. Hence, a balanced fertilization is necessary to increase the productivity of vegetable. Low productivity of cabbage arises due to imbalanced use of chemical fertilizer and minimum use of organic sources of nutrients which makes the soil not only deficient in nutrients but also deteriorates the soil health. As compared to compost and manure, wool waste have high organic nitrogen (>5%) and carbon (>30-50%) (Baker, 1991). Their elemental analyses shows fairly similar percentages of carbon (around 50 mass %), hydrogen (7 mass %), oxygen (22 mass %) and nitrogen (16 mass %) (Popescu and Hocker, 2007). Govi *et al.* (1998) reported that hydrolyzate sheep wool enhance plant growth by improving the nutrient contents like total nitrogen, carbon, phosphorus in soil and also improves seed emergence and plant growth (Nustorova *et al.*, 2006; Choudhary *et al.*, 2018; Zhelijazkov *et al.*, 2005).

Rajasthan, especially Bikaner district is one of the highest sheep and wool producing area in the country. There are about 163 Woollen Mills in Bikaner, manufacturing 1.5 lakhs kg of carpet woollen yarn per day during processing period and releasing a huge quantity of wool waste, approximately 4-5 % of total woollen production. Wool waste is mainly generated from 'Opener Section' of woollen mill. Biodegradability is one of the prime quality of wool which means when applied into soil, it is degraded by soil organisms and release appropriate nutrients essential to the crop growth. Wool is less resistant to attack of soil organisms, which is breakdown under hydrophilic conditions and slowly decomposes in soil. Hence, it can be used as a slow release fertilizer and act as a good source of nitrogen and sulphur for longer period as compared to chemical fertilizer. Low grade wool waste can be used for soil reclamation. Non woven form of wool can be used as mulch, that restrict the growth of many weeds after decomposition in soil release many essential nutrients required for the normal growth of crop (Forcella *et al.*, 2003). Wool fibres absorb and retain moisture effectively, and reduce runoff of contaminants such as pesticides (McNeil *et al.*, 2007). The productivity can be sustained through integration of organic and chemical fertilizer. Organic manures not only act as nutrient source and organic matter, but also enhance microbial activities and physio-chemical, biological properties of soil (Albiach *et al.*, 2000). In view of the above, the aim of this study was to assess the combined effect of wool waste, farm yard manure and chemical fertilizer in relation to soil properties.

Materials and Methods

The present field experiment was laid down during Rabi season of 2015-16 at the Agriculture Research Station, SKRAU, Bikaner, Rajasthan. It comes under hyper arid partial irrigated zone with an annual average rainfall of about 200 to 300 mm.

More than 80 per cent rainfall is received during the southwest monsoon. During summers, the maximum temperature may rise up to 48°C while in winter it may fall to 0°C. This region is prone to high wind velocity and soil erosion. The soil of the experimental field was sandy in texture, low in organic carbon (0.16 %), nitrogen (89.24 kg ha⁻¹), phosphorus (27.64 kg ha⁻¹), iron (6.60 ppm) and zinc (0.97 ppm) and medium in potash (224.29 kg ha⁻¹) and alkaline pH (8.55) in reaction. The treatment combinations were setup as per recommended dose of fertilizer for cabbage crop in I-C zone (Experimental area). In this zone the organic matter requirement was 15 t ha⁻¹ for cabbage crop. The treatments consisted four levels of organic material, i.e. control, 7.5 t ha⁻¹ each wool waste and farm yard manure (W₁), wool waste @ 5 t ha⁻¹ + farm yard manure @ 10 t ha⁻¹ (W₂), wool waste @ 3.75 t ha⁻¹ + farm yard manure @ 11.25 t ha⁻¹ (W₃), farm yard manure @ 15 t ha⁻¹ (W₄) and four levels of recommended dose of fertilizer (0, 75, 100 and 125% RDF, i.e., F₀, F₁, F₂ and F₃, respectively). The experiment was replicated thrice in a split plot design. Wool waste and farm yard manure in different combinations were applied as per treatments before one month of transplant. Wool waste was collected from Vijay Woollen Mills, Bikaner and the elemental concentration is depicted in Table 1.

The dose of N, P₂O₅, K₂O and S were applied as urea, diammonium phosphate, murate of potash and elemental sulphur, respectively, as per treatment combination. Half dose of nitrogen, full dose of P and K were applied as basal in the form of urea, diammonium phosphate and murate of potash at the time of transplanting. The remaining nitrogen was applied after 30 days of transplanting. Sulphur was applied as per treatment combination @ 40 kg ha⁻¹ through elemental sulphur before 10 days of transplanting. Cabbage crop (var. *Valina* hybrid) was transplanted in the field during November, 2015 and harvested at maturity stage, i.e., March, 2016. Soil samples were collected after harvesting of crop and analysed by the standard procedures. Fresh soil samples from all experimental plots were collected after harvest and stored at 4°C for microbial biomass

Table 1: Elemental concentration of wool waste and farm yard manure used in field experiment

Parameter	Wool waste	Farm yard manure
Carbon (g kg ⁻¹)	179.2	190.8
Nitrogen (g kg ⁻¹)	23.72	7.38
Phosphorus (ppm)	0.303	0.21
Potassium (g kg ⁻¹)	7.55	4.20
Sulphur (g kg ⁻¹)	21.70	0.20
Zinc (ppm)	94.25	41.26
Copper (ppm)	13.39	4.33
Manganese (ppm)	45.93	54.66
Iron (ppm)	914.96	955.33
C:N ratio	7.55:1	25.85:1
C:P ratio	59.14:1	90.86:1
C:S ratio	8.26:1	954:1

and enzyme activity (Schinner *et al.*, 1996).

Additional soil samples for nutrient and trace element analysis were taken at harvest, air dried at room temperature and ground with wooden pestle to pass through 2.0 mm screen. Physical properties of soil like porosity, particle density and bulk density were determined by specific gravity bottle method (Richards, 1954), chemical parameters like pH and EC were determined by electro conductivity meter; organic carbon was estimated following the procedure of Walkley and Black (1934); available nitrogen, phosphorus and potassium were estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956); sodium bicarbonate by extractable P method (Olsen *et al.*, 1954) and neutral normal ammonium acetate method (Jackson, 1973). Sulphur content was determined following the method of Chesnin and Yein (1952). Zinc and Copper were estimated by atomic absorption spectrophotometer (AAS) (Tandon, 1993). Iron and manganese were estimated Spectrometrically (Jackson, 1973; Chopra and Kanwar, 1991). Fungi and bacterial population (CFU $\times 10^4$ and 10^6 g^{-1}) and microbial activity in terms of dehydrogenase activity ($\mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ h}^{-1}$) were estimated following the method Baron *et al.* (1994) and Casida *et al.* (1964). The experimental data recorded were subjected to statistical analyses using analyses of variance. The critical difference for the comparison of treatments were worked out, wherever the 'F' test was found significant at 5% level of significance. C.D. (I) is to be used when main treatment is at same level and sub-plot treatment at different levels, C.D. (II) is to be used when main treatment is at different levels and sub-treatment at the same level.

Results and Discussion

The result of this study suggests that wool waste is an excellent nutrient source for cabbage crop. Analyses of wool

waste showed that it contains good amount of nutrients required by plants (Table 1) and almost all nutrients showed positive effect, except phosphorus and potassium.

The data presented in Table 2 shows that addition of organic matter decrease bulk density of soil, however significance was not achieved. Compare with different combinations of organic compounds, the minimum bulk density was registered 1.52 mg m^{-3} with W_4 , i.e., farm yard manure @ 15 tha^{-1} . Similarly fertilizer levels did not show any significant effect on bulk density, yet it decreased bulk density from the initial value 1.58 with W_0 , i.e. control. The bulk density of soil decreased significantly with incorporation of wool waste and farm yard manure which might be due to increase in organic carbon content in the soil. The decreased bulk density in the present study might be due to the enhanced microbial population and activity that resulted in the formation of aggregates and increased porosity. The results corroborate with the findings of Dadhich *et al.* (2011), Parewa *et al.* (2014) and Zheljaskov *et al.* (2005). It is discernible from Table 2 that particle density of soil did not show significant effect. Porosity significantly increased in soils treated with organic matter and fertilizer levels as compared to control.

The maximum porosity of 42.04% was recorded in W_4 treatment and F_3 treatment (41.60%). Plots treated with organic and chemical fertilizer showed improved porosity due to formation of soil aggregates and addition of soil microorganisms (Manivannan *et al.*, 2009). The influence of different levels of organic matter and inorganic fertilizer levels showed non-significant effect on pH and EC after harvest of cabbage crop. However, soil pH slightly decreased from its initial value which might be due to the formation of different organic acids during

Table 2: Effect of wool waste in conjunction with farm yard manure and fertilizer levels on some physico-chemical properties of soil after harvest of cabbage crop

Treatments	Physical properties			Chemical properties		
	Bulk density (mg m^{-3})	Particle density (mg m^{-3})	Porosity (%)	pH	EC (dSm^{-1})	OC (%)
Organic materials (t ha^{-1})						
W0	1.58	2.63	39.75	8.55	0.10	0.160
W1	1.54	2.63	41.46	8.40	0.10	0.193
W2	1.53	2.63	41.83	8.44	0.10	0.187
W3	1.53	2.63	41.85	8.47	0.10	0.182
W4	1.52	2.63	42.04	8.51	0.10	0.174
S Em $\pm$	0.002	0.00	0.06	0.034	0.002	0.003
CD at 5%	NS	NS	0.19	NS	NS	0.011
Fertilizer levels (kg ha^{-1})						
F0	1.55	2.63	41.14	8.53	0.10	0.171
F1	1.54	2.63	41.26	8.48	0.10	0.178
F2	1.54	2.63	41.54	8.45	0.10	0.183
F3	1.54	2.63	41.60	8.42	0.10	0.185
S Em $\pm$	0.001	0.00	0.051	0.022	0.001	0.002
CD at 5%	NS	NS	0.15	NS	NS	NS

Table 3: Effect of wool waste in conjunction with FYM and fertilizer levels on available macro and micro nutrients of soil after the harvest of cabbage crop

Treatments	Soil available macronutrients (kg ha ⁻¹)				Soil available micronutrients (ppm)			
	N	P ₂ O ₅	K ₂ O	S	Zn	Cu	Mn	Fe
Organic materials (t ha⁻¹)								
W0	85.06	26.44	217.99	20.95	0.942	0.392	6.87	6.53
W1	129.99	37.33	265.40	25.17	1.097	0.549	10.56	7.94
W2	126.19	35.99	260.70	24.34	1.046	0.499	9.00	7.67
W3	120.03	35.44	252.65	23.94	1.001	0.484	8.15	7.01
W4	114.88	33.28	242.69	22.93	0.984	0.461	7.57	6.73
S Em ±	1.72	0.35	0.76	0.19	0.011	0.015	0.15	0.13
CD at 5%	5.62	1.13	2.47	0.60	0.036	0.048	0.49	0.43
Fertilizer levels (kg ha⁻¹)								
F0	99.67	25.70	227.22	21.22	0.826	0.398	7.54	6.26
F1	112.75	34.20	240.45	23.29	0.998	0.449	8.01	6.77
F2	121.10	36.46	256.00	24.09	1.094	0.504	8.73	7.49
F3	127.39	38.43	267.85	25.26	1.138	0.557	9.44	8.19
S Em ±	1.35	0.37	0.60	0.18	0.021	0.011	0.14	0.11
CD at 5%	3.89	1.06	1.74	0.51	0.061	0.033	0.39	0.33

decomposition of crop residues and organic manure (Sharma *et al.*, 2013). Application of ammonium based fertilizers such as ammonium sulfate, ammonium nitrate and urea aggravated soil acidity (Lungu and Dynoodt, 2008). Soil organic carbon increased after harvest of cabbage crop due to addition of organic matter and chemical fertilizers (Table 2) whereby the highest (0.193%) organic carbon was recorded in plots treated with W₁. Wool waste and farm yard manure levels significantly enhanced organic carbon in soil due to high application of wool waste and farm yard

manure with high organic carbon content and also different rate of oxidation of organic matter by soil microbes. This increase might be due to high application of wool waste and FYM with high organic carbon contents and root residue decomposition of plants grown luxuriously by high rate of compost. These results corroborate the findings (Datt *et al.* (2013) and Parewa *et al.* (2014). Application of inorganic fertilizer found in significant effect on organic carbon content in soil. The order of increase in organic carbon could be depicted as F₃>F₂>F₁> F₀ (control). Available

Table 4 : Effect of wool waste in conjunction with farm yard manure and fertilizer levels on biological properties of soil after the harvest of cabbage crop

Treatments	Microbial count		Dehydrogenase activity (µg TPF g ⁻¹ soil 24 hr ⁻¹)
	Fungi (10 ⁴ cfu g ⁻¹ soil)	Bacteria (10 ⁵ cfu g ⁻¹ soil)	
Organic materials (t ha ⁻¹)			
W ₀	8.99	12.54	82.20
W ₁	16.16	23.41	136.39
W ₂	14.24	20.37	118.30
W ₃	13.21	18.42	109.74
W ₄	12.25	17.41	99.87
S Em ±	0.011	0.006	0.35
CD at 5%	0.037	0.021	1.15
Fertilizer levels (kg ha ⁻¹)			
F ₀	12.76	17.03	124.48
F ₁	12.99	18.13	111.09
F ₂	13.04	19.24	103.30
F ₃	13.09	19.33	98.33
S Em ±	0.008	0.008	0.21
CD at 5%	0.024	0.023	0.61

macro and micro nutrients significantly increased as compared to control (Table 3). The maximum increase in available nutrients were found in W₁ treatment, which could be due to direct addition of nutrients by decomposition of wool waste and mineralization process. It is clear from Table 3 that application of different inorganic fertilizer levels significantly enhanced available N,P,K,S and micronutrients in soil as compared to control. Increased available NPK in soils was observed where soils were treated with enriched compost from different organic wastes, farm yard manure, vermicompost and vermicompost plus NPK after the harvest of rice, ragi and cowpea (Vasanthi and Kumaraswamy, 1999; Srikanth et al., 2000; Chaoui et al., 2003; Abraham and Lal, 2004; Thakur et al., 2011).

Organic material treated plots showed significantly higher microbial population and activity in the soil (Table 4). Incorporation of organic material and composts increased microbial activity and population in soil (Ahmad et al., 2006; Aluko et al., 2005; Obire et al., 2006). The increased fungi, bacterial population in soil might be due to incorporation of organic matter which provides nutrients for microbial growth in the rhizospheric soil (Singh et al., 2012) similarly. Treatment (F3) found significant in total microbial population but was at par to treatment (F2).

The increasing levels of fertilizer enhance microbial population in the rhizospheric soil due to higher biomass, and root exudates (Geethakumari and Shivashankar, 1991; Chand et al., 2010 and Parewa et al., 2014). The maximum dehydrogenase enzyme activity was recorded in treatment W₁. The increased dehydrogenase enzyme activity might be due to higher microbial population and activity in the added manure (Pedrazzini and Mckee, 1984; Masto et al., 2006). The results of this study suggest that application of wool waste @ 7.5 t ha⁻¹ in combination with FYM @ 7.5 t ha⁻¹ and 100 per cent recommended dose of fertilizer lower the bulk density of soil, increase enzyme activity, soil organic carbon and improved nutrient availability of soil for cabbage crop. Thus, it can be concluded that wool waste in combination with farm yard manure and inorganic fertilizer improves fertility status in Aridisol.

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