RESEARCH ARTICLE

EFFECT OF WOOL WASTE AND INORGANIC FERTILIZERS ON PRODUCTIVITY OF BOTTLE GOURD (*LAGENARIA SICERARIA*) AND SOIL PROPERTIES OF LOAMY SAND SOIL

Shankar Lal Sunda[1], R.K. Jakhar[2]*, Sushil Kumar Kharia[3] and R.K. Sharma[4]

[1,2,3]*College of Agriculture, Swami Keshwanand Rajasthan Agriculture University, Bikaner*
[3]*College of Agriculture (MPUAT), Udaipur*
Email: rkjakhar33@gmail.com

Received-02.07.2021, Revised-13.07.2021, Accepted-24.07.2021

Abstract: Afield experiment was conducted on effect of wool waste and fertilizers on productivity of bottle gourd (*Lagenaria siceraria*) and soil properties of loamy sand soilat research farm of Agriculture Research Station, SKRAU, Bikaner during *Kharif,* 2018. The experiment consisted ten treatments viz., T_1- Control , T_2- Recommended dose of fertilizer, T_3- wool waste@ 20 t ha^{-1} , T_4- RDF +wool waste @ 20 t ha^{-1}, T_5- RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$, T_6- RDF +wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$, T_7- STCR recommendation fertilizer dose, T_8- STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$, T_9-STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$and T_{10} -STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$.The experiment was laid out in randomized block design with three replications.Wool waste is a biodegradable, rich in nutrients and can be recycled in soil as a fertilizer for maximum benefits. Application of waste wool in soil significantly improved the fertility status of soil, and considerable improvement was also observed in organic carbon, macro and micronutrients. The activities of soil enzymes higher in waste wool treatment as compared to control. Application of waste wool not only improved soil health but produced 50% higher grain and dry fodder yield of barley over control. The improvement in physical properties of soil with waste wool resulted in higher water use efficiency of the system. The results revealed that application of wool waste significantly improved physical properties of soil such as bulk density, hydraulic conductivity and moisture retention etc. in treatments having wool waste @ 20 t ha^{-1}than treatments without wool waste. Addition of wool waste significantly enhanced the availability of nitrogen, phosphorus, potassium, sulphur, zinc and iron in soil as compared to control, RDF without wool waste and STCR recommendation without wool waste. Biological properties of soil such as dehydrogenese and microbial populationalso significantly improved in treatments having wool waste application. Significantly higher dry weight of straw, average fruit weight, vine length, number of inter nodes andyield were found inRDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$.

Keywords: Bottle gourd, Fertilizer, Loamy sand soil

INTRODUCTION

Bottle gourd is one of the important cucurbits commonly grown in both rainy and summer season in various parts of India. The fresh fruit has light green smooth skin and white flesh. They come in a variety of shapes: they can be huge and round, small and bottle shaped or slim and serpentine, some times more than a meter long. The edible portion of fruit contains 96.3 per cent moisture, 2.9 per cent carbohydrates, 0.2 per cent protein, 0.1 per cent fat, 0.5 per cent mineral matter and 11 mg of vitamin C per 100 g fresh weight (Thamburaj and Singh, 2005).The fruit is also known to have a good source of essential amino acids such as leucine, phenyl alanine, theonine, cystine, valine, aspartic acid and proline, along with fair amount of vitamin B complex, especially thiamine, riboflavin and niacin.

India being the second largest producer of vegetable in the world, after China, shares about 15 per cent of the world output of vegetables from about 3 per cent of total cropped area in the country. In India, during 2016-17 bottle gourd was cultivated on 153 thousand hectares with an annual production of 2529 thousand metric tons (Anonymous, 2017). However in Rajasthan, during 2016-17 it was cultivated on 4.50thousand hectares with an annual production of 15.50 thousand metric tons (Anonymous, 2017)

Among the several factors related to vegetable production, nutrient management is one of the key factor for achieving higher yield and better quality of the crop. The use of high yielding crop varieties and chemical fertilizers have resulted in rapid increase in agricultural production system, at the same time indiscriminate use of chemical fertilizers will lead to widespread nutrient deficiency in soils, disturbed soil reaction, development of nutrient imbalance in plant, increased susceptibility to plant diseases, reduced soil organic matter, lesser occurrence of beneficial soil micro organism and increased environmental pollution as well as human health hazards.

Wool waste of sheep's are mostly deposited in landfills and nutrients contain can no longer be exploited. More environmentally friendly alteration is to use it as manures. The productivity could be sustained through integrated use of organic and inorganic fertilizers. Applied hydrolyzed wool also improved seed emergence and plant growth (Nustorova*et al*., 2006).

Wool is an important textile fiber in the world. It is used for wool manufacturing, clothes and carpets. Rajasthan specially the Bikaner district is one of the

*Corresponding Author

highest sheep and wool producing areas in the country. There are about 163 Woolen Mills in Bikaner, manufacturing 1.5 lakh kg of Carpet Woolen per day and releasing a huge quantity of wool waste, approximately 4-5 % of Mainly the wool waste is generated from 'Opener Section' of woolen industry. Low grade raw wool or wool waste can be used as agricultural amendments, layed directly in the bottom of the planting pits, or added to the compost mixture, to improve the nitrogen content and water retention. Wool in non-woven form can be also used as weed mats, which initially inhibit weed growth but then slowly break down to release nutrients for the crops (Hempe, 2014).

The majority of European Union's members consider sheep wool a waste. Despite its physical and biochemical characteristic and availability in large quantities, the wool remains almost unused. By being a 100% natural, durable, recyclable and biodegradable material, the sheep wool represents a non-toxic substance. There for it is not able to seep into surface or underground waters, minimizing the level of heavy metals or water eutrophication (Maria and pacurar, 2015).

Globally, India ranks seventh in wool production (1.8%), especially coarse wool with a productivity of 0.600 kg/sheep/year. In wool processing industries, nearly 10–15% wool is considered as waste obtained during processing and discarded or dumped as such on ground (Sharma et al., 2019). Waste wool is light, voluminous and nutrient rich in nature. Though wool is biodegradable, air floating fine particles of waste wool is harmful for human health and may cause serious environment hazards. Therefore, the need of the hour is to have efficient environment friendly wool waste disposal system to overcome this problem (Zoccola et al., 2015). Keeping in view the above an experiments was planned under the entitled Effect of Wool Waste and Fertilizers on Productivity of Bottle Gourd (*Lagenariasiceraria*) and Soil Properties of Loamy Sand Soil.

MATERIALS AND METHODS

The experiment was conducted at the research farm of ARS, SKRAU, Beechwal, Bikaner during *kharif*season of 2018. It is situated at 28˚ 10' N latitude, 73˚ 18' E longitude and 223.88 meters above mean sea level in Agroclimatic zone Ic (Hyper arid partially irrigated western plain) of Rajasthan. The zone is characterized with extremes of hot.The temperature ranged between 9.9^{o}C and 39.5^{o}C during crop growing season. The minimum and maximum relative humidity of the locality fluctuates in between 19.7 to 89.1 per cent. The bright sunshine hours in *Kharif*season of 2018 was recorded from 4.0 to 9.7 Hrs throughout the experiment. The total rainfall was 68.4 mm with 4 rainy days from 23 July 2018 to 2 December 2018.

The soil of the experimental field was characterized as Loamy sand in texture, having pH (8.65), EC (0.10 dSm^{-1}), organic carbon (0.15 per cent) , available nitrogen (125 kg ha^{-1}), available P_2O_5 (26.2 kg ha^{-1}), available potassium (169 kg ha^{-1}), available sulphur (23.9 kg ha^{-1}), zinc (0.86 ppm), iron (5.69 ppm), bulk density (1.55 Mg m^{-3}) and Hydraulic conductivity (12.31 cm hr^{-1})

The experiment comprised ten treatments viz., T_1- Control , T_2- Recommended dose of fertilizer, T_3- wool waste@ 20 t ha^{-1} , T_4- RDF +wool waste @ 20 t ha^{-1}, T_5- RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$, T_6- RDF +wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$, T_7- STCR recommendation fertilizer dose, T_8- STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$, T_9-STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$and T_{10} -STCR recommendation + wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$. The experiment was laid out in randomized block design with three replications.Wool waste @ 20 t ha^{-1} (28 kg $plot^{-1}$) was applied as per plot treatment combination before one month of sowing. Nitrogen @ 100 kg ha^{-1} was applied.

Fertilizers were applied as per the RDF and STCR recommendation. According to the STCR recommendation, different treatment have different fertilizer dose like:

For Nitrogen = 1.1 T* - 0.92 N – 0.82 O**N

For Phosphorus = 0.54T* - 1.32 P_2O_5 – 1.07** P_2O_5

For potassium= 0.52 T* – 0.25 K_2O – 0.55 O** K_2O

*target yield **organic

The wool waste used in experiment contains carbon (17.9 per cent), nitrogen (2.47 per cent),phosphorus (0.473 per cent), potassium (0.755 per cent), sulphur (2.17 per cent), zinc (94.3 ppm), copper (13.4 ppm), iron (915 ppm) and manganese (45.9 ppm) with C:N ratio 8.1. C: P ratio 59.1 and C: S ratio 8.1.

Sowing of bottle gourd was done on 24th August 2018. The distance between row to row as well as plant to plant was kept at 1.0 m and 1.25 m, respectively. Thus, Nine plants were accommodated in each plot. The first irrigation was done after sowing of bottle gourd, later on three days interval. At the time of fruiting, the irrigation was given at three to four days interval depending upon soil moisture conditions using the drip irrigation method.

Nitrogen was supplied in the form of urea. Half dose of nitrogen was applied at the time of field preparation, and remaining does at 60 days after sowing. As per the treatments, phosphorus @ 40 kg ha^{-1} was applied through DAP (46 % P_2O_5) as a basal dose. Potassium was supplied @ 40 kg ha^{-1} through MOP (60% K_2O).

150 g ferrous sulphate was dissolved in 15 liter water, and 3-4 g of citric acid added to avoid the burning effect on the leaf. A small amount of gum was also added as a surfactant. The foliar spray was done at 45 days after sowing.75 g zinc sulphate was

dissolved in 15 liter water, and 3-4 g of citric acid added to avoid the burning effect on the leaf. A small amount of gum was also added as a surfactant. The foliar spray was done at 46 days after sowing.

Five plants were selected randomly in each plot and tagged permanently. Vine length of preselected plants was measured at 50 DAS from the base of the plant to the top of main vine by meter scale, and their mean expressed as vine length (cm). Numbers of nodes per wine of the preselected plants were counted, and there mean value expressed as no. of nodes vine^{-1}. Fruit of preselected plants were collected from each plot. Five fruit per vine selected, and their mean weight expressed as fruit weight (gm). Fruits of each plot were collected at each picking. Yield of each plot recorded by sum of each picking.

Soil samples of each plot were collected at harvest of crop from surface (0-15 cm depth) soil layer. Physico- chemical properties of collected soil samples were analysed by standard procedures..

Biological properties like dehydrogenase activity was assayed by the method given by Tabatabai (1982). The test soil sample was serially diluted, and aliquots of selected dilution were inoculated in nutrient agar media, taken sterilized petriplate. Each colony, developed in the culture media, was assumed to have grown from one viable unit (Serial dilution plate method, Dhingra and Sinclair, 1993). The test soil sample was serially diluted, and aliquots of selected dilution were inoculated in potato dextrose agar media, taken sterilized petriplate. Each colony, developed in the culture media, was assumed to have grown from one viable unit (Serial dilution plate method, Dhingra and Sinclair, 1993) The test soil sample was serially diluted, and aliquots of selected dilution were inoculated in nutrient agar media, taken sterilized petriplate. Each colony, developed in the culture media, was assumed to have grown from one viable unit (Serial dilution plate method, Dhingra and Sinclair, 1993).

Experimental data recorded in various observations were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons were worked out wherever the variance ratio (F test) was found significant at 5% level of significance.

RESULTS AND DISCUSSION

Yield attributes and yield

Vine length and number of interdes, average fruit weight, dry weight of straw, yield and chlorophyll content of bottle gourd were significantly affected by the addition of wool waste (Table 1). Application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ had significant effect on vine length and number of interdes with value of 140 cm and 14.1 respectively. Average fruit weight of bottle gourd was also significantly increased with RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ (961 g fruit^{-1}). Application of wool waste and fertilizers was also significantly increased the dry weight of straw. Maximum fruit yield was recorded as 404 q ha^{-1} in T_6 i.e. RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ as compared to 170 q ha^{-1}. Maximum chlorophyll content (2.66 mg g^{-1} and 2.03 mg g^{-1} at 45 DAS and 90 DAS respectively) were recorded under treatment T_6 (i.e. RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ +0.5 per cent $ZnSO_4$)

The recycling of organic wastes in agriculture can be an important step for sustaining soil health and protecting the environment from unwanted hazards apart from supplying essential plant nutrients. According to, Application of wool waste as a nutrient source for field crops may be an excellent soil amendment for improving yield and quality of produce (Choudhary et al., 2018). All the growth parameters and yield contributing characters were also improved with waste wool. Several researchers were also reported that substrate amendment with waste wool as fertilizer source contributed to increasing yield attributing characters and yield of plant[Das *et al.*, (2015), Baghel*et al.*, (2017), Nagar *et al.*, (2017)].

Similarly, Supply of nitrogen through organic wastes has been resulted in increase in higher crude protein content. Application of organic manures improved the nutrient availability and uptake which builds up amino acids and phosphorus content, which might have contributed to large photosynthetic activity and higher synthesis of protein in fodder. These finding are corroborates with the findings of Kumar *et al.*,(2012), Das *et al.*, (2015), Baghel*et al.*, (2017), Meena*et al.*,(2017), Kadu*et al.*, (2018), Rathod*et al.*, (2018).

Chemical properties of Soil

Application of organic sources such with inorganic fertilizers as a nutrient source into the soil improves chemical properties of soil (Table 2). Results revealed that wool waste application with fertilizer into the soil significantly affected organic carbon. Organic carbon content in soil was ranged from 0.190 % to 0.127 % under different treatments. Maximum organic carbon (0.190 %) was recorded with T_6 followed by T_5.Significantly higher organic carbon content was found under treatments with wool waste as compare to control, RDF without wool waste and STCR recommendation without wool waste treatments. Similar results were also reported by Mubarak *et al.*, (2009) and Gupta *et al.*, (2014).

Similarly, application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ (T_6) had significant influenced on available nitrogen , available phosphorus, available potassium and available sulphur over inorganic treatments but at par with treatment T_5 i. e.RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ (Table- 2).Wool waste contains a good amount of suphur. Therefore, its application will definitely improve the sulphur content of soil. These findings are corroborates with the findings of Tabith*et al.*, (2017) and Gupta and Sharma (2014).

Waste wool surplus is also an organic waste and its use as manure in soil can be a viable option (Sharma et al., 2019). Utilization of protein-rich product such as waste wool and other organic by-products of sheep would offer additional advantages of waste reduction and nutrient enrichment. Waste wool have higher content of C and N than the rest used organic manures, so, its disposal in soil for agriculture production may be good option for its use as a fertilizer apart from safe disposal. Sheep wool is made up of keratin (protein) and contains an adequate amount of essential plant nutrients viz., N, C and S (Gorecki and Gorecki, 2010), K, Na, P, Mg, Fe, Mn, and Zn (Zheljazkov et al., 2008) and it can be a more balanced organic fertilizer for plants.

Application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$significantly increased the amount of available zinc and iron in soil as compare to control, RDF and STCR recommended treatments (Table 2). Available zinc and iron was significantly higher under treatments having RDF + wool waste than treatments having STCR recommendation + wool waste. Similar results were also reported by Gupta and Sharma (2014) and Gupta *et al.*,(2014).Wool waste application into soil reduced the pH and EC of soil as compare to control, RDF without wool waste and STCR recommended without wool waste treatments. Similar results were also reported byDurani*et al.*, (2017) and Gupta and Sharma (2014).

Voncina and Mihelic (2013) and Suruchi et al. (2014) also reported that soil fertility was enhanced by application of wool waste, as it added ammonium-nitrogen (NH4–N) and nitrate-nitrogen (NO3–N), which increased the total N and improved the microbial properties of soil. The addition of waste wool can improve crop production in arid and semiarid regions as soil of these regions are alkaline in nature and sheep wool hydrolyzate contains N and S compounds and their oxidation and mineralization leads to reduction in soil pH (Tiwari et al., 1989); therefore, waste wool provides better growing conditions for crop plants by supplying essential nutrients like N, C, and P in the soil (Govi et al., 1998).

Physical properties of soil

Application of wool waste decreased the bulk density of soil as compare to control, RDF without wool waste and STCR recommended without wool waste treatments had non significant effect (Table -3). Minimum bulk density (1.51 Mg m^{-3}) was recorded with the application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ +0.5 per cent $ZnSO_4$. Application of wool waste increased total porosity soil as compare to control, RDF and STCR recommended treatments.Waste wool is very light and less dense (Shanumugam and Jose, 2019), which may reduce soil bulk density and enhance porosity of the soil (Abdallah et al., 2019). Scotti et al. (2015) reported the addition of organic amendment increases 25–36% organic matter content in soil which reduces the compactness (bulk density) by improving aeration (porosity), water permeability and water holding capacity of soil.

Application of wool waste significantly decreased the hydraulic conductivity of soil as compare to control, RDF without wool waste and STCR recommended without wool waste treatments. Similar results were also reported by Mubarak *et al.*, (2009).

Table 1. Effect of wool waste and fertilizers on yield attributes and yield of Bottle gourd

TREATMENTS	Number of interdes	Vine length (cm)	Dry weight of straw (q ha^{-1})	Average fruit weight (g $fruit^{-1}$)	Yield (q ha^{-1})	Chlorophyll (mg g^{-1})	
						45 DAS	90 DAS
T_1-Control	4.9	26	17.2	492	170	1.39	1.58
T_2-RDF	7.8	57	34.0	600	271	1.40	1.70
T_3-Wool waste @ 20 t ha^{-1}	10.7	94	43.8	743	295	1.80	1.77
T_4-RDF +Wool waste @ 20 t ha^{-1}	11.3	104	49.6	794	351	2.11	1.80
T_5-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	12.7	118	51.9	822	386	2.20	1.98
T_6-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	14.1	140	54.3	961	404	2.66	2.03
T_7-STCR recommendation	8.8	66	37.4	694	280	1.42	1.61
T_8-STCR recommendation + Wool waste @ 20 t ha^{-1}	11.4	97	46.7	750	341	1.70	1.66

T_9-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$	11.9	111	48.5	789	378	1.96	1.81
T_{10}-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	13.2	120	50.9	920	385	2.03	1.82
SEm±	0.44	3.5	0.979	31	7	0.056	0.046
CD	1.3	11	2.9	91	21	0.17	0.14

Table 2. Effect of wool waste and fertilizers on chemical properties of soil

TREATMENTS	**pH**	**EC (dS m^{-1})**	**O.C. (%)**	**N (kg ha^{-1})**	**P_2O_5 (kg ha^{-1})**	**K_2O (kg ha^{-1})**	**S (kg ha^{-1})**	**Zn (ppm)**	**Fe (ppm)**
T_1- Control	8.70	0.087	0.127	115	22.2	161	17.3	0.818	5.173
T_2-RDF	8.68	0.130	0.150	119	26.6	170	23.5	0.953	5.867
T_3- Wool waste @ 20 t ha^{-1}	8.56	0.100	0.177	129	30.9	178	26.2	1.003	6.513
T_4- RDF +Wool waste @ 20 t ha^{-1}	8.54	0.107	0.185	136	32.0	191	30.1	1.050	7.807
T_5 - RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	8.54	0.110	0.187	137	33.5	192	30.5	1.066	7.947
T_6-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	8.52	0.113	0.190	139	34.2	194	30.8	1.103	8.027
T_7-STCR recommendation	8.69	0.140	0.152	122	27.6	172	25.5	0.955	5.967
T_8- STCR recommendation + Wool waste @ 20 t ha^{-1}	8.54	0.100	0.180	130	30.7	186	28.4	1.005	7.700
T_9-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$	8.53	0.107	0.183	131	30.8	187	28.9	1.013	7.853
T_{10}-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	8.53	0.100	0.185	132	31.6	188	29.1	1.017	7.879
SEm±	0.039	0.003	0.005	1.188	0.618	2.492	0.744	0.001	0.113
CD	NS	0.008	0.014	4.00	1.8	7.00	2.2	0.003	0.335

Table 3. Effect of wool waste and fertilizers on physical properties of soil

TREATMENTS	**B.D. (Mg m^{-3})**	**P.D. (Mg m^{-3})**	**Total Porosity (%)**	**Hydraulic conductivity (cm hr^{-1})**
T_1-Control	1.54	2.64	41.6	15.29
T_2-RDF	1.53	2.64	41.9	13.06
T_3-Wool waste @ 20 t ha^{-1}	1.52	2.64	42.3	10.77
T_4-RDF +Wool waste @ 20 t ha^{-1}	1.52	2.63	42.4	8.73
T_5-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	1.52	2.64	42.6	8.73
T_6-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	1.51	2.64	42.7	8.60
T_7-STCR recommendation	1.54	2.64	41.8	12.72

T_8-STCR recommendation + Wool waste @ 20 t ha^{-1}	1.52	2.64	42.3	9.31
T_9-STCR recommendation + Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	1.52	2.64	42.4	9.17
T_{10}-STCR recommendation + Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$	1.51	2.64	42.7	8.95
SEm±	0.005	0.003	0.194	0.102
CD	NS	NS	NS	0.30

Table 4. Effect of wool waste and fertilizers on microbial population

TREATMENTS	**Fungi (c.f.u.10^4)**	**Bacteria (c.f.u.10^6)**	**Actimycetes (c.f.u.10^5)**	**Dehydrogenase (µg TPFg^{-1} soil 24 h^{-1})**
T_1-Control	2.0	50	2.0	36
T_2-RDF	4.0	69	3.1	63
T_3-Wool waste @ 20 t ha^{-1}	5.0	79	4.2	75
T_4-RDF +Wool waste @ 20 t ha^{-1}	5.5	85	4.2	93
T_5-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	5.5	88	4.3	101
T_6-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	6.5	91	5.0	104
T_7-STCR recommendation	4.0	66	3.5	50
T_8-STCR recommendation + Wool waste @ 20 t ha^{-1}	5.3	78	4.0	74
T_9-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$	5.8	80	4.1	88
T_{10}-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	6.0	83	4.6	95
SEm±	0.250	2.811	0.165	1.52
CD	0.74	8.35	0.49	4.5

Biological properties of soil

Application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$had significant effect on population of fungi (6.5×10^4c.f.u.g^{-1}), bacteria (91×10^6 c.f.u.g^{-1}) and actinomycetes(5×10^5 c.f.u.g^{-1}) over other treatments. In the study, the activities of all the soil enzymes were higher under waste wool treatment over control. Soil enzymatic activities was considerably lower in water stress condition might be due to the fact that living biota of soil was more affected by altering soil environment and lack of moisture slows down the enzyme activity and microbial growth. Saha et al. (2008) and Scotti et al. (2015) reported that application of organic amendments to soil provided a better potential for higher enzyme activities mainly by increasing microbial biomass, organic carbon and organic matter contents in soil, however, the response of enzyme activities varied according to organic amendment nature. deMelo et al. (2019) reported that organic matter in soil regulates soil water dynamics by enhancing soil properties like permeability, porosity and water holding capacity and further promotes soil biological activity. Similar results were also reported byNakhro and Dkhar*et al.,*(2010) and Gupta *et al.*, (2014).

Similarly, application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$with micronutrients was significantly increaseddehydrogenase activity in soil as compare to other treatments. Similar findings were also reported by Liu *et al*., (2017).

CONCLUSION

Application of RDF +wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ significantly increased the yield and yield attributes of bottle gourd in loamy sand soils of western Rajasthan. Physical, chemical and biological properties of soil were also significantly influenced by the application of recommended dose of fertilizer and wool waste with foliar spray of Zn and Fe. Application of wool waste, reduced the nutrient leaching by ceasing water movement leading to better crop production

REFERENCES

Abdallah, A., Ugolini, F., Baronti, S., Maienza, A., Camilli, F., Bonora, L., Martelli, F., Primicerio, J. andUngaro, F.(2019).The potential of recycling wool residues as an amendment for enhancing the physical and hydraulic properties of a sandy loam soil. Int. J. Recycl. Org. Waste Agric. 8 (Suppl. 1), S131–S143.https://doi.org/10.1007/ s40093-019-0283-5.

Anonymous (2017).Horticultural statistics at a glance.Horticulture statistics division, Department of Agriculture Cooperation & Farmers welfare, Government of India.

Baghel, S. S., Bose, U. S. and Singh, S. S. (2017). Impact of Different Organic and Inorganic Fertilizers on Sustainable Production of Bottle Gourd [*Lagenariasiceraria* L.]. *International Journal of Pure and Applied Bioscience*, **5**(2): 1089-1094.

Choudhary, A., Yadav, S. R and Parewa H. P. (2018).Effect of wool waste in conjunction with FYM and inorganic fertilizer on growth and yield of cabbage (*Brassica oleracea* var. capitata).*International Journal of Chemical Studies*, **6**(4): 3059-3063.

Das, R., Mandal, A. R., Priya, A., Das, S. P. and Kabiraj, J. (2015).Evaluation of integrated nutrient management on the performance of bottle gourd [*Lagenariasiceraria* (Molina) Standl.]. *Journal of Applied and Natural Science*, **7**(1): 18-25.

De Melo, T.R., Figueiredo, A., Machado, W. and Tavares Filho, J.(2019).Changes on soil structural stability after in natura and composted chicken manure application. Int. J. Recycl. Org. Waste Agric. https://doi.org/10.1007/s40093-019-0250-1.

Dhingra, O. D. and Sinclair, J. B. (1993).Basic plant pathology methods. CBS Publisher, New Delhi.

Durani, A., Safiullah, K. and Durani, H. (2017).Effect of long-term application of organic and inorganic fertilizers on maize-wheat cropping system at different forms of nitrogen and soil properties.*International Journal of Applied Research*, **3**(9): 525-532.

Fisher, R. A. (1950). Statistical method for research workers, Oliver and Boyd, Edinburg, London.

Gorecki, R. S. and Gorecki, M. T. (2010).Utilization of waste wool as substrate amendment in pot cultivation of Tomato, Sweet Pepper, and Eggplant. *Polish Journal of Environmental Studies*, **19**(5): 1083-1087.

Govi, M., Ciavatta, C., Sitti, L. and Gessa, C.(1998). Influence of Organic Fertilisers on Soil Organic Matter: a Laboratory Study. 16th World Congress of Soil Science.http:// natres.psu.ac.th/Link/SoilCongress/bdd/symp 40/974-r.pdf.(Accessed 8 May 2017).

Gupta, S. and Sharma, A. (2014). Evaluation of plant yield, macro and micronutrients concentration in spinach (*Spinaciaoleracea* L.) plant tissue as well as in soil amended with hair as fertilizer. *International Journal of Chemical Science*, **12**(1), 73-82.

Gupta, S., Sharma, A., Sharma, S. and Bhogal, N. (2014).Growth, macro and micronutrient concentration in clusterbean (*Cyamposistetragonoloba*), plant tissue as well as in soil when amended with wool as fertilizer. *Journal of Environmental Research and Development*, **8**(3): 607-613.

Hempe, R. (2014). Wool waste could be another value-added product. CELS News (Online). http:cels.uri.edu/news/nwoolmulch.aspx

Kadu, J., Kasture, M., Tapkeer, P., Dhopavkar, R. and Annapurna, M. (2018).Effect of soil application of potassium and foliar spray of zinc and boron on yield, yield contributing character and quality of watermelon [*Citrulluslanatus*(thunb.)] in lateritic soils of Konkan.*International Journal of Chemical Studies*, **6**(3): 07-12.

Kumar, V., Singh, V. K. and Rani, T. (2012).Effect of integretednutientmangement on economics in bottle gourd (*Laginariasiceraria L.*). *Environment and Ecology*, **30**(4A) 1410-1412.

Luo, G., Li, L., Friman, V., Guo, J., Guo, S., Shen, Q. and Ling, N.(2018). Organic amendments increase crop yields by improving microbe-mediated soil functioning of agroecosystems: a meta-analysis. Soil Biol. Biochem. 124, 105–115.

Maria, A. and Pacurar, I. (2015). Study on the use sheep wool in soil and fertilization as the mixture into cubes nutrients.*ProEnvironment*, **8**(22): 290-292.

Meena O. P., Meena R. K., Dhaka R. S., Meena N. K. and Sharma, A. (2017).Effect of nitrogen and phosphorous levels on growth and yield of bottle gourd [*Lagenariasiceraria*(Mol.) Standl.] cv. Pusa Naveen.*International Journal Pure and Applied Bioscience*,**5**(4): 1178-1184.

Mubarak, A. R., Ragab, O. E., Ali, A. A. and Hamed, N. E. (2009).Short-term studies on use of organic amendments for amelioration of a sandy soil. *African Journal of Agricultural Research*, 4(7): 621-627.

Nagar, M., Soni, A. K. and Sarolia., D. K. (2017). Effect of Organic Manures and Different Levels of NPK on Growth and Yield of Bottle Gourd [*Lagenariasiceraria* (Mol.) Standl.]. *International Journal of Current Microbiology and Applied Sciences*, **6**(5): 1776-1780.

Nakhro, N. and Dkhar, M. S. (2010). Populations and biomass carbon in paddy field soil. *Journal of Agronomy*, **9**(3): 102-110.

Nustorova, M., Braikova, D., Gousterova, A. and Vasileva, E. (2006). Chemical, microbiological and plant analysis of soil fertilized with alkaline hydrolysate of sheep's wool waste. *World Journal of Microbiology and Biotechnology*, **22**(4): 383-390.

Rathod, P., Salvi, V. G. and Jadhav, S. (2018). Growth, yield and quality of ridge gourd as influenced by integrated nutrient management in coastal region of Maharashtra.*International Journal of Chemical Studies*, **6**(5): 2357-2360.

Saha, S., Gopinath, K.A., Mina, B.L. and Gupta, H.S.(2008). Influence of continuous application of inorganic nutrients to a Maize–Wheat rotation on soil enzyme activity and grain quality in a rainfed Indian soil. Eur. J. Soil Biol. 44, 521–531.

Scotti, R., Bonanomi, G., Scelza, R., Zoina, A. andRao, M.A.(2015).Organic amendments as sustainable tool to recovery fertility in intensive agricultural systems. J. Soil Sci. Plant Nutr. https://doi.org/10.4067/S0718-95162015005000031.

Shanumugam, N. and Jose, S.(2019). Wool production, quality and waste management. In: Training Manual on A Holistic Approach to Sheep Production, pp. 161–165.

Sharma, S.C., Sahoo, A. and Chand, R.(2019). Potential use of waste wool in agriculture: an overview. Indian J. Small Rumi. 25, 1–12.

Suruchi, G., Anshumala, S., Sarika, S. andNarindra, B.(2014).Growth, macro and micronutrient concent- ration in clusterbean (Cyamopsistetragonoloba), plant tissue as well as in soil when amended with wool as fertilizer. J. Environ. Res. Dev. 8, 607–613.

Tabatabai, M. A. (1982). Soil enzymes. In: A. L. Page, R. H. Miller, D. R. Keeney (eds.) Methods of soil analysis. Part 2.Agronomy 9, *American Society of Agronomy*. Madison, USA. 903-947.

Tabitha, K., Wilson, T. and Joseph, P. C. (2017).Effect of organic and inorganic fertilizer on the soil chemical properties of the rhizosphere in Kiambu County Kenya. *Asian Research Journal of Agriculture*, **7**(4): 1-13.

Thamburaj, S. and Singh, N. (2005).Vegetables, tubercrops and spices.*Directorate of Information and Publications of Agriculture*, ICAR, New Delhi. Pp. 271-272.

Tiwari, V.N., Pathak, A.N. andLehri, L.K.(1989).Response to differently amended woolwaste composts on yield and uptake of nutrients by crops. Biol. Waste 28, 313–318.

Voncina, A. andMihelic, R.(2013). Sheep wool and leather waste as fertilizers in organic production of asparagus (Asparagus officinalis L.). Acta agric. Slovenica 101, 191–200. https://doi.org/10.2478/acas-2013-0015.

Zoccola, M., Montarsolo, A., Mossotti, R., Patrucco, A. andTonin, C.(2015).Green hydrolysis as an emerging technology to turn wool waste into organic nitrogen fertilizer. Waste Biomass Valoriz 6, 891–897. https://doi.org/10.1007/s12649-0.