The Pharma Innovation Journal 2021; 10(8): 903-907

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(8): 903-907

www.thepharmajournal.com
Received: 07-06-2021
Accepted: 18-07-2021

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Influence of wool waste on nutrient content and uptake of bottle gourd (*Lagenaria siceraria*) in Western Rajasthan

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Abstract
A field experiment was conducted on influence of wool waste on nutrient content and uptake of bottle gourd (*Lagenaria siceraria*) in western Rajasthan at research farm of Agricultural 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. Application of recommended dose of fertilizer with wool waste @ 20 t ha^{-1} and foliar spray of 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ had significant effect on bottle gourd yield. Significantly higher nitrogen, potassium, sulphur, zinc and iron in fruit and straw was recorded with the application of RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ as compared to control, whereas, phosphorus content was significantly influenced with RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$. Similarly, application of RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ had significant effect on nutrient uptake by fruit and straw of bottle gourd.

Keywords: Bottle gourd, wool waste, nutrient content and nutrient uptake

Introduction
Organic matter plays a key role of achieve sustainability in agricultural production because it possesses many desirable properties such as high water holding capacity, cation exchange capacity, beneficial effects on the physical, chemical and biological characteristics of soil. Wool is a biodegradable fiber, rich in nutrients and can be recycled in soil as a fertilizer for maximum benefits. 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) [16]. Waste wool is light, voluminous and proteinaceous in nature.
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) [14].
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 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) [9].
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) [1]. However in Rajasthan, during 2016-17 it was cultivated on 4.50 thousand hectares with an annual production of 15.50 thousand metric tons (Anonymous, 2017) [1]

Organic manures supply important plant nutrients, both macro and micro. Apart from supplying plant nutrients, they favor aggregation of fine soil particles, thereby promoting good soil structure and also essential for healthy development of soil micro-organisms which further carry out biochemical transformations, play active role in decomposing organic matter and help in releasing some of the essential plant nutrients (Sureshkumar and Karuppaiah, 2008) [18]. Besides, addition of NPK, organic manures is a potential source of micronutrients and increase water holding capacity and improves buffering capacity of soils. Although release of nutrients are slow but steadily for longer duration thus preventing their losses by leaching and other means and improves nutrient use efficiency of the crop. The nutrients supplementation through organic sources also has been found to be a good carrier for flourishment of microbes resulting into sustained soil productivity and enhanced enzymatic activities of soil which play a vital role in the transformation of unavailable form of nutrient into available form and gives rise an organic recycling process along with improving soil health.

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) [16]. 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) [22]. Keeping in view the above an experiment was planned under the entitled influence of wool waste on nutrient content and uptake of bottle gourd (*Lagenaria siceraria*) in western Rajasthan.

Material and Methods

The experiment was conducted at the research farm of Agricultural Research Station, 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 Agro-climatic zone Ic (Hyper arid partially irrigated western plain) of Rajasthan. The zone is characterized with extremes of hot. The temperature ranged between 9.9^0 C and 39.5^0 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 24^{th} 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. Fruit of pre selected plants were collected from each plot. Five fruit per vine selected, and their mean weight expressed as fruit weight (gm). Fruits in each plot were collected at each picking. Yield of each plot recorded by sum of each picking.

Representative straw and fruits samples were taken from each plot at the time of harvesting for estimation of nutrients content. Further, samples were oven dried and grind separately in fine powder with grinder, and nutrients content determined by using standard methods.

The uptake of N, P, K, S and micronutrients by fruit and straw was estimated by using the following formula.

$$\textit{Nutrient uptake } (kg\ ha^{-1}) = \frac{\textit{per cent nutrient content in friut/straw x fruit/straw yield } (kg\ ha^{-1})}{100}$$

$$\textit{Micronutrient uptake}(g\ ha^{-1}) = \frac{\text{Nutrient content}(\text{mg ha}^{-1})\text{x dry yield}(\text{kg ha}^{-1})}{1000}$$

Experimental data recorded in various observations were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950) [4]. 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.

Result and Discussion

Yield

Yield and dry weight of straw of bottle gourd were significantly affected application of RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ (Table 1). 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}.

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). 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)] [3, 2, 13].

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

Treatments	Dry weight of straw (q ha^{-1})	Yield (q ha^{-1})
T_1-Control	17.2	170
T_2-RDF	34.0	271
T_3-Wool waste @ 20 t ha^{-1}	43.8	295
T_4-RDF +Wool waste @ 20 t ha^{-1}	49.6	351
T_5-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$	51.9	386
T_6-RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$	54.3	404
T_7-STCR recommendation	37.4	280
T_8-STCR recommendation + Wool waste @ 20 t ha^{-1}	46.7	341
T_9-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$	48.5	378
T_{10}-STCR recommendation + Wool waste @ 20 t ha^{-1}+ 1 per cent $FeSO_4$+ 0.5 per cent $ZnSO_4$	50.9	385
SEm±	0.979	7
CD	2.9	21

Nutrient content of fruit and straw

Data depicted in table 2 revealed that RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ had significant effect on nitrogen, potassium, sulphur, zinc and iron content in fruit and straw content at harvest of bottle gourd (Table-2), whereas, phosphorus content was significantly influenced with RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ but at par with T_6. Nitrogen content was ranged from 1.34% to 1.54% under different treatments. Nitrogen content in treatments T_6 was significantly higher as compared to control but at par with STCR + wool waste treatments. Application of RDF + Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ resulted a significant increase in potassium content in fruit and straw (1.75 per cent and 3.10 per cent, respectively).

Table 2: Effect of wool waste and fertilizers on nutrient content (%) in fruit and straw

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc		Iron	
	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw
T_1	1.34	2.12	0.203	0.197	1.30	2.18	0.101	0.092	12.5	15.1	144	233
T_2	1.43	2.50	0.243	0.217	1.45	2.49	0.118	0.103	15.0	17.8	189	273
T_3	1.46	2.82	0.270	0.237	1.60	2.73	0.147	0.108	18.5	21.1	226	306
T_4	1.49	2.92	0.290	0.267	1.63	2.90	0.163	0.112	21.1	23.5	241	327
T_5	1.53	2.95	0.323	0.300	1.73	2.95	0.164	0.113	24.9	27.5	287	338
T_6	1.54	2.96	0.303	0.282	1.75	3.10	0.167	0.114	24.9	27.6	296	341
T_7	1.46	2.53	0.253	0.233	1.47	2.53	0.123	0.107	16.1	19.3	191	275
T_8	1.49	2.88	0.273	0.243	1.55	2.81	0.153	0.111	20.9	23.2	232	321
T_9	1.51	2.89	0.300	0.277	1.57	2.83	0.160	0.113	23.0	25.6	277	326
T_1	1.51	2.91	0.287	0.260	1.57	2.91	0.164	0.113	23.3	25.9	282	326
S.Em±	0.007	0.06	0.005	0.004	0.025	0.052	0.003	0.001	0.023	0.069	1.5	3.4
CD	0.02	0.19	0.014	0.012	0.07	0.15	0.009	0.004	0.07	0.2	4.4	10

Data presented in table- 2 showed that application of wool waste with RDF and foliar spray of iron and zinc had significant effect on zinc content (24.9 ppm) of fruit at the time of harvest of bottle gourd but at par with treatment T_6. Similarly, significantly higher iron content was recorded with RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ as compared to rest treatment. 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) [5], K, Na, P, Mg, Fe, Mn, and Zn (Zheljazkov *et al*., 2008) [20] and it can be a more balanced organic fertilizer for plants. 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.

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) [19]; 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) [6].

Application of organic sources as a nutrient source into the soil improves nutrient content of plant. These results are corroborates with the findings of Gupta and Sharma (2014) and Shree *et al.*, (2018) [7, 17]. Application of wool waste significantly increases nitrogen, phosphorus, potassium, sulphur, zinc and iron content in plants fruit and straw as compare to control, RDF and STCR recommended treatments. Nutrients content in plants fruit and straw was significantly higher under treatments having RDF + wool waste than treatments having STCR recommendation + wool waste. Similar results were also reported by Zheljazkov *et al.*, (2008a) [20], Gupta and Sharma (2014) [7], Shree *et al.*, (2018) [17].

Nutrient uptake by fruit and straw

Results showed in Table 3 revealed that application of RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ significantly increases uptake of nitrogen, phosphorus, potassium, sulphur, zinc and iron in plants fruit and straw as compare to control, RDF and STCR recommended treatments. The maximum phosphorus uptake by fruit was observed in T_6 with value of 9.2 kg ha^{-1} followed by T_5, T_{10}, T_9, T_4, T_3, T_8, T_2, T_7 and T_1. The maximum sulphur uptake by fruit was observed in T_6 i.e. RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ with value of 5.0 kg ha^{-1} and minimum sulphur uptake was recorded in T_1 i.e. control with value of 1.3 kg ha^{-1}. The zinc uptake was ranged from 15.8 g ha^{-1} to 75.1 g ha^{-1} under different treatments. Similarly, The iron uptake was ranged from 399 g ha^{-1} to 1851 g ha^{-1} under different treatments The maximum iron uptake by straw was observed in T_6 i.e. RDF +Wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ with value of 1851 g ha^{-1} and minimum uptake was recorded in T_1 i.e. control with value of 399 g ha^{-1}. Similar results were also reported by Kandoliya *et al.*, (2018) Gupta *et al.*, (2014) [11, 8].

Table 3: Effect of wool waste and fertilizers on nutrient uptake (kg ha^{-1}) in fruit and straw

Treatment	Nitrogen		Phosphorus		Potassium		Sulphur		Zinc		Iron	
	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw	Fruit	Straw
T_1	16.8	36	2.6	3.4	16.3	37	1.3	1.6	16	26	181	399
T_2	28.3	85	6.8	7.3	29.8	84	2.3	3.5	29	61	374	928
T_3	31.9	124	7.0	10.4	38.0	120	3.2	4.7	40	92	494	1339
T_4	38.6	145	7.2	13.2	45.4	144	4.2	5.6	55	116	626	1619
T_5	42.6	153	8.0	15.6	44.5	153	4.6	5.9	69	143	797	1757
T_6	46.4	161	9.2	15.3	49.8	168	5.0	6.2	75	150	892	1851
T_7	32.6	95	6.1	8.7	34.9	95	2.8	4.0	36	72	427	1028
T_8	37.9	135	7.0	11.4	39.5	131	3.9	5.2	53	108	591	1499
T_9	37.4	140	7.4	13.4	38.0	137	4.0	5.5	57	124	686	1581
T_1	40.1	149	7.6	13.2	41.6	148	4.4	5.8	62	132	750	1662
S.Em±	0.760	5	0.184	0.322	0.978	2.849	0.069	0.140	0.905	2.471	11.5	41.9
CD	2.3	14	0.6	1.0	2.9	9	0.2	0.4	3	7	34	125

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 Das *et al.*, (2015) [3], Baghel *et al.*, (2017) [2], Meena *et al.*, (2017) [12], Kadu *et al.*, (2018) [10], Rathod *et al.*, (2018) [15].

Conclusion

Application of RDF + wool waste @ 20 t ha^{-1} + 1 per cent $FeSO_4$ + 0.5 per cent $ZnSO_4$ significantly increased the fruit and straw yield of bottle gourd in loamy sand soils of western Rajasthan. Nutrient content and uptake in fruit and straw of bottle gourd were also significantly influenced by the application of recommended dose of fertilizer and wool waste with foliar spray of Zn and Fe.

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