Range Mgmt. & Agroforestry 40 (1) : 150-155, 2019
ISSN 0971-2070

Nutritive value of pearl millet stover as influenced by tillage, crop residue and sulphur fertilization

Mukesh Choudhary[1, 2]*, K.S. Rana[1] and Pramod Kumar[1]
[1]ICAR-Indian Agricultural Research Institute, New Delhi-110012, India
[2]ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, India
*Corresponding author e-mail: selmukesh@gmail.com
Received: 31st January, 2018 Accepted: 16th February, 2019

Abstract
A field experiment was conducted during rainy (*kharif*) seasons of 2013 and 2014 to find out the effect of tillage practices, crop residue and sulphur fertilization on nutritive value of pearl millet (*Pennisetum glaucum*) stover. Five tillage practices *i.e.* conventional tillage (CT) with 0, 2 and 4 t/ha crop residue; zero tillage (ZT) with 2 and 4 t/ha crop residue were allocated to main plots and four sulphur levels (0, 15, 30 and 45 kg S/ha) in sub-plots. Study showed that ZT with 4 t/ha crop residue recorded significantly higher N, P, K and S content in pearl millet stover which remained at par with CT at same residue level. Furthermore, maximum uptake of N, P, K and S was recorded in CT and ZT with 4 t/ha crop residue during 2013 and 2014, respectively. Incremental supply of sulphur fertilizer from 0 to 45 kg/ha had significantly improved N, S and crude protein content and crude protein yield and decreased acid detergent fibre and neutral detergent fibre contents in stover. CT or ZT with 4 t/ha crop residue improved N, P, K, S and CP content and uptake. Similarly, application of 30 kg S/ha in pearl millet improved nutritive quality of stover.

Keywords: Crop residues, Pearl millet, Stover quality, Sulphur, Tillage practices

Introduction

Crop residues are major source of livestock feed and constitute about 40–60% of total dry matter intake in livestock. At present, India faces a net deficit of 10.9% dry crop residues. The demand of dry fodder will reach to 631 mt by the year 2050 and at the current level of growth in forage resources, there will be 13.2% deficit in dry fodder in the year 2050 (IGFRI, 2013). In India, the crop residues are traditionally utilized as animal feed as such or by supplementing with some additives. In the dry months, particularly 2–3 months prior to the onset of next monsoon, only crop residue fed to animal by resource poor farmer. However, crop residues, being unpalatable and low in digestibility, cannot form a sole ration for livestock. Crop residues are low-density fibrous materials, low in crude protein, soluble carbohydrates, minerals and vitamins with varying amounts of lignin which acts as a physical barrier and impedes the process of microbial breakdown. One potential avenue for improving feeding systems is to enhance the nutritive value of these crop residues.

Sulphur is one of the essential elements required for the normal growth of plants and it plays an important role as a constituent of many plant processes and deficiency of this nutrient causes basic metabolic impairment, which will not only reduce crop yield but also the quality of produce. When there is not a sufficient supply of S, the application of high rates of other nutrients (N, P, and K) may not result in increased yields, due to imbalances in the N/S and P/S ratios in the plants (Crusciol *et al*., 2006). Application of sulphur in deficient soil increases crude protein while decreases crude fibre in fodder crops (Kumar *et al*., 2015a)

Pearl millet (*Pennisetum glaucum*) is the important crop of India and it is mostly cultivated for food and fodder in the north-western states of the country. It is grown in 9.3 m ha area and generates about 15.8 mt crop residue (Kumar *et al*., 2015b).

In recent years, interest of farmers in conservation tillage has increased because of escalation of capital and production costs. In general, zero tillage system required lower operational costs and gave greater economic returns compared with conventional tillage (Choudhary *et al*., 2017). Permanent crop cover with recycling of crop residues is a pre-requisite and integral part of conservation agriculture. Due to less biomass productivity and competing uses of crop residues, the scope of using crop residues for conservation agriculture is limited in dryland ecosystems. Further, costs are also incurred in their application. Optimizing residues use that can be retained for conservation agriculture without affecting the crop- livestock system, particularly for the regions where residues are the main source of fodder. Therefore, it is necessary that suitable amount fertilizer nutrient should be applied to enhance crop productivity in a cost-effective manner. Keeping these aspects in view an experiment was undertaken to study the effect of tillage, crop residue and sulphur fertilization on nutritive value of pearl millet stover.

Materials and Methods

Experimental site and designing: A field experiment was conducted at the Research Farm of Indian Agricultural Research Institute, New Delhi during the rainy (*kharif*) season of 2013 and 2014. The experimental site is situated at 28° 38’ 23” N and 77° 09’ 27” E and 228.6 m above mean sea-level under a semi-arid climatic belt, with annual maximum temperature as high as 45°C in summers and minimum temperature as low as 1°C in winters. The total rainfall received during the cropping season of 2013 and 2014 was 944 and 270 mm, respectively. The soil of experimental site was sandy loam in texture, slightly alkaline in reaction (pH 7.8), low in organic carbon (4.5 g/kg soil) and available nitrogen (139.7 kg/ha) and medium in available P (15.2 kg/ha) and K (178.8 kg/ha) and deficient in available S (8.8 mg/ kg soil). The experiment was laid out in split-plot design with 3 replications having five tillage and residue management practices in the main-plots, (conventional tillage (CT) without residue; CT with 2 and 4 t/ha residue; zero tillage (ZT) with 2 and 4 t/ha residue), and 4 sulphur levels (0, 15, 30 and 45 kg S/ha) in the sub-plots. The gross and net plot size was 5.0 × 3.6 m and 3.00 × 1.80 m, respectively. In conventional tillage, field was prepared with a disc plough followed by two pass of a disc harrow and planking in the last to have a uniform seed bed of fine tilth. No tillage operation was carried out in zero-tilled plot. Crop residues of previous season mustard were applied by spreading the material uniformly on the field just after sowing. Sulphur was applied through agriculture grade gypsum containing 13% S at the time of field preparation as per treatment.

Crop raising: Pearl millet cultivar ‘Pusa 443’ was sown on 12 July 2013 and 20 July 2014 with a spacing of 45 cm × 15 cm. Uniform dose of N, P_2O_5 and K_2O @ 60–40–30 kg/ha were applied. Entire phosphorus and potassium were applied as basal through di-ammonium phosphate (DAP) and muriate of potash, respectively through drilling at the time of sowing, whereas N was applied in two equal split through urea at sowing and 25–30 days after sowing (DAS). In zero-tilled plots weeds were managed by glyphosate @ 0.1% before sowing and atrazine @ 0.5 kg a.i./ha as pre-emergence. Thinning and gap filling were done at 20 DAS to maintain the uniform plant stand. Crop was not irrigated in both years of experimentation and it was not affected by the incidence of major pest and diseases. The crop was harvested on 01 October 2013 and 13 October 2014, respectively from the net plots.

Sampling and laboratory analysis: The stover samples were collected at maturity and dried in hot air oven at 65°C for 48 hours. The oven-dried samples were ground to pass through 40 mesh-sieve in a Macro-Wiley Mill. From each treatment, stover sample was taken for chemical analysis to determine N, P, K and S concentration. Nitrogen was estimated by modified Kjeldhal method, P concentration by Vanado-molybdo-phosphoric yellow colour method, K concentration by flame photometer method and S concentration by turbidimetric method as per the procedure described by Jackson (1973). Thereafter, the uptake of nutrient was calculated by multiplying concentration with their respective yield. Crude protein content in stover was worked out by multiplying the nitrogen content with the factor 6.25. Protein yield (kg/ha) was calculated by multiplying the protein content with stover yield. Acid detergent fibre (ADF) and neutral detergent fibre (NDF) in stover samples were estimated as method described by Van Soest (1963).

Statistical analysis: Statistical analyses were performed using software SAS version 9.3 (Cary, USA). Analysis of variance (PROC MIXED) was performed and means were separated by least significant differences (LSD), when the F-test indicated factorial effects on the significance level of $P < 0.05$.

Results and Discussion

Nutrient content: Tillage practices had significant effect on nutrient content in stover of pearl millet in 2014 while those were statistically similar in 2013 (Table 1). Significantly highest N, P, K and S content were recorded under ZT–CR4 which remained at par with CT–CR4 and ZT–CR2. The improvement in nutrient content under residue applied treatments could be ascribed to favourable moisture condition maintained in the soil for relatively longer period and improvement in available nutrient status of soil through decomposition of crop residues. Thus, the favorable moisture condition and improved nutritional environment led to higher translocation and assimilation of nutrients to plant (Choudhary and Prabhu, 2016).

Sulphur fertilization had significant effect on N and S content in stover during both the years (Table 1). However, P and K content were similar across sulphur levels. Increasing levels of sulphur enhanced N and S content in stover but lower level (15 kg S/ha) failed to exert any significant effect. The interaction between N and S is generally positive and occasionally additive in sulphur deficient soil (Jamal *et al*., 2010) and S has a role in regulating nitrate reductase - an enzyme that perform the rate- limiting step of the nitrate assimilation pathway. So, N content in plant increased with sulphur fertilization. Increasing sulphur content in plant with sulphur application might be due to increased availability of sulphur in soil (Gupta and Jain, 2008).

Nutrient uptake: Uptake of nutrients (N, P, K and S) by pearl millet stover was influenced significantly with tillage practices during both the years of study (Table 2). Slightly higher uptakes were recorded in first year than second year in spite of low nutrient content in that year. In general, K uptake was twice of N uptake. Furthermore P and S uptake was almost similar but one fourth of N uptake.

Table 1. Effect of tillage practices and sulphur fertilization on nutrient content (g/kg) in pearl millet stover

Treatment	2013			
	N	P	K	S
Tillage practices				
CT–CR0	6.82±0.33	1.94±0.10	13.9±0.47	1.55±0.09
CT–CR2	7.02±0.20	2.03±0.07	14.3±0.60	1.60±0.13
CT–CR4	7.19±0.34	2.07±0.09	14.7±0.69	1.65±0.06
ZT–CR2	7.00±0.40	2.04±0.10	14.1±0.67	1.57±0.09
ZT–CR4	7.15±0.35	2.10±0.09	14.7±0.55	1.62±0.06
SEm±	0.09	0.03	0.2	0.02
LSD (*P*=0.05)	NS	NS	NS	NS
Sulphur levels (kg/ha)				
0	6.80±0.30	1.99±0.12	14.1±0.55	1.53±0.10
15	7.03±0.29	2.04±0.09	14.3±0.68	1.58±0.08
30	7.12±0.32	2.06±0.08	14.6±0.74	1.63±0.07
45	7.20±0.36	2.05±0.12	14.5±0.62	1.65±0.09
SEm±	0.08	0.02	0.1	0.02
LSD (*P*=0.05)	0.24	NS	NS	0.05

Treatment	2014			
	N	P	K	S
Tillage practices				
CT–CR0	6.91±0.31	2.03±0.11	14.4±0.83	1.66 ±0.08
CT–CR2	7.16±0.31	2.11±0.11	15.0±0.59	1.74 ±0.09
CT–CR4	7.32±0.31	2.16±0.10	15.4±0.60	1.81 ±0.08
ZT–CR2	7.20±0.31	2.13±0.10	15.2±0.44	1.76 ±0.08
ZT–CR4	7.32±0.30	2.21±0.10	15.9±0.51	1.84 ±0.08
SEm±	0.08	0.03	0.2	0.03
LSD (*P*=0.05)	0.27	0.10	0.6	0.08
Sulphur levels (kg/ha)				
0	7.02±0.21	2.08±0.13	14.8±0.81	1.70 ±0.10
15	7.15±0.36	2.13±0.13	15.1±0.85	1.76 ±0.08
30	7.24±0.39	2.15±0.10	15.3±0.61	1.78 ±0.10
45	7.30±0.30	2.16±0.11	15.4±0.74	1.81 ±0.09
SEm±	0.07	0.03	0.20	0.02
LSD (*P*=0.05)	0.21	NS	NS	0.05

CT- Conventional tillage; ZT- Zero tillage; CR0- No crop residues; CR2- Crop residues at 2 t/ha; CR4- Crop residues at 4 t/ha

Maximum uptake of N, P, K and S was recorded in CT–CR4 and ZT–CR4 during 2013 and 2014, respectively. Residue application under ZT practices (ZT–CR2 and ZT–CR4) resulted in similar or even better uptake of nutrients than corresponding conventional tillage practices. Furthermore, crop residue at 4 t/ha under ZT significantly improved nutrient uptake in comparison to lower level (2 t/ha) at same tillage system during second year. The higher uptake of nutrients under ZT with residue might be due to improved physical environment favourable for better microbial activity that might have favoured mineralization resulting better availability of nutrients to crops and thus increased the uptake under these treatments (Behera *et al*., 2007; Choudhary *et al*., 2019). Since, uptake of the nutrient is the function of nutrient content and biomass production, the significant increase in nutrient content coupled with increased yield (Choudhary *et al*., 2016) under residue treatment enhanced the total uptake of these nutrients.

Different levels of S also significantly influenced the N, P, K and S uptake during both the years of study. The significant improvement in the nutrient uptake was observed up to 30 kg S/ha during first year and 15 kg S/

Table 2. Effect of tillage practices and sulphur fertilization on nutrient uptake (kg/ha) by pearl millet stover

Treatment	2013				2014			
	N	P	K	S	N	P	K	S
Tillage practices								
CT–CR0	47.3	13.5	96.0	10.79	42.2	12.4	87.8	10.13
CT–CR2	54.1	15.6	110.5	12.37	48.0	14.1	100.2	11.65
CT–CR4	58.0	16.7	118.0	13.31	52.3	15.5	110.0	12.91
ZT–CR2	53.4	15.6	108.0	12.01	47.0	14.0	99.5	11.52
ZT–CR4	55.9	16.4	115.2	12.64	53.8	16.3	116.7	13.47
SEm±	1.7	0.5	3.1	0.36	1.9	0.6	4.1	0.39
LSD (*P*=0.05)	5.4	1.8	10.1	1.16	6.1	1.9	13.5	1.29
Sulphur levels (kg/ha)								
0	46.8	13.7	96.6	10.57	44.0	13.1	93.1	10.63
15	52.5	15.3	107.1	11.88	48.2	14.3	101.6	11.82
30	57.4	16.7	117.5	13.09	50.5	14.9	106.7	12.44
45	58.3	16.6	117.0	13.36	51.9	15.4	110.0	12.86
SEm±	1.5	0.4	3.0	0.31	1.4	0.4	2.8	0.32
LSD (*P*=0.05)	4.3	1.3	8.6	0.88	4.1	1.1	8.0	0.94

CT- Conventional tillage; ZT- Zero tillage; CR0- No crop residues; CR2- Crop residues at 2 t/ha; CR4- Crop residues at 4 t/ha

Table 3. Effect of tillage practices and sulphur fertilization on nutritive value of pearl millet stover (mean data of 2 years)

Treatments	Crude protein (%)	Crude protein yield (kg/ha)	ADF (%)	NDF (%)
Tillage practices				
CT–CR0	4.29	280	41.4	72.6
CT–CR2	4.43	319	41.2	70.2
CT–CR4	4.54	345	41.8	72.4
ZT–CR2	4.44	314	41.7	69.9
ZT–CR4	4.52	343	41.1	73.0
SEm±	0.04	7.9	0.42	0.64
LSD (*P*=0.05)	0.12	23.5	NS	NS
Sulphur levels (kg/ha)				
0	4.32	284	42.0	73.0
15	4.43	315	41.9	71.9
30	4.49	337	41.1	71.1
45	4.53	344	40.8	70.4
SEm±	0.03	6.5	0.32	0.53
LSD (*P*=0.05)	0.10	18.3	0.90	1.50

CT- Conventional tillage; ZT- Zero tillage; CR0- No crop residues; CR2- Crop residues at 2 t/ha; CR4- Crop residues at 4 t/ha; ADF- Acid detergent fibre; NDF- Neutral detergent fibre ha during second year which was significantly higher than the control. The significant increase in yield coupled with nutrient content enhanced the uptake of nutrients. Dixit *et al.* (2017) also reported higher uptake of nutrients with 20 kg S/ha in fodder sorghum based cropping system of Central India.

Stover quality: Crude protein (CP) content in the pearl millet stover at harvest was differed significantly with tillage practices during second year of study (Table 3). Significantly higher value of CP content was recorded under CT–CR4 over CT–CR0 and found at par with all other treatments. Similarly, 23.2% higher CP yield was recorded in CT–CR4 over CT–CR0 (280 kg/ha). Increased N content in stover attributed to increased availability of nitrogen in the soil due to decomposition of crop residue (Choudhary *et al*., 2019). Higher nitrogen in plant is directly responsible for higher CP because it is a primary component of amino acids which constitute the protein.

Incremental supply of sulphur fertilizer had significantly improved CP content and CP yield and decreased acid detergent fibre (ADF) or neutral detergent fibre (NDF) contents. Application of 30 kg S/ha increased CP yield by 18.6% over control (284 kg/ha). Association of higher CP content with sulphur fertilization might be due to role of sulphur in essential amino acids (cystine, cysteine and methionine) that play important role in protein synthesis. Other reason might be positive interaction between S and N. Sulphur application led to higher availability of N to plant that ultimately forms more protein (Jamal *et al*., 2010). The increase in CP yield was attributed to increase in CP content and stover yield. The higher crude protein content and lower value of ADF and NDF in pearl millet with 40 kg S/ha was also reported by Sheta *et al.* (2010) at Anand, Gujarat.

Conclusion

It was concluded that conventional and zero tillage with crop residue at 4 t/ha maintained higher nutrient (N, P, K and S) content and uptake and CP yield in pearl millet stover. However, acid and neutral detergent fibre contents were not changed due to tillage practices. Application of 30 kg S/ha in pearl millet improved nutritive quality of stover.

Acknowledgement

The first author is grateful to Director, ICAR-Indian Grassland and Fodder Research Institute, Jhansi, and ICAR - Indian Agricultural Research Institute, New Delhi for allowing to carry out this research work under Ph.D. programme.

References

Behera, U. K., A. R. Sharma and H. N. Pandey. 2007. Sustaining productivity of wheat–soybean cropping system through integrated nutrient management practices on the Vertisols of central India. *Plant and Soil* 297: 185–199.

Choudhary, M. and G. Prabhu. 2016. Response of fodder oat (*Avena sativa* L.) varieties to irrigation and fertilizer gradient. *Range Management and Agroforestry* 37: 201–206.

Choudhary, M., K. S. Rana, D. S. Rana and R. S. Bana. 2016. Tillage and crop residue effects in rainfed pearl millet (*Pennisetum glaucum*) in conjunction with sulphur fertilization under pearl millet–Indian mustard (*Brassica juncea*) cropping system. *Indian Journal of Agronomy* 61: 15–19.

Choudhary, M., K. S. Rana, M. C. Meena, R. S. Bana, P. Jakhar, P. C. Ghasal and R. K. Verma, 2019. Changes in physico-chemical and biological properties of soil under conservation agriculture based pearl millet–mustard cropping system in rainfed semi-arid region. *Archives of Agronomy and Soil Science* 65: 911–927.

Choudhary, M., K. S. Rana, R. S. Bana, P. C. Ghasal, G. L. Choudhary, P. Jakhar and R. K. Verma. 2017. Energy budgeting and carbon footprint of pearl millet – mustard cropping system under conventional and conservation agriculture in rainfed semi-arid agro-ecosystem. *Energy* 141: 1052–1058.

Crusciol, C. A. C., R. P. Soratto, L. M. da Silva and L. B. Lemos. 2006. Side dressing sulphur fertilization in common bean crop in no-tillage system. *Bragantia* 65: 459–465.

Dixit, A. K., S. Kumar, A. K. Rai, D. R. Palsaniya and M. Choudhary. 2017. Nutrient management in fodder sorghum + cowpea – chickpea cropping system for higher system productivity and nutrient use. *Range Management and Agroforestry* 38: 82–88.

Gupta, A. K. and N. K. Jain. 2008. Sulphur fertilization in a pearl millet (*Pennisetum glaucum*)-Indian mustard (*Brassica juncea*) cropping system. *Archives of Agronomy and Soil Science* 54: 533–539.

IGFRI. 2013. *Vision 2050*. Indian Grassland and Fodder Research Institute, Jhansi.

Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice Hall Inc., Englewood, Cliffs, U.S.A.

Jamal, A., Yong-Sun Moon and Z. A. Malik. 2010. Sulphur-a general overview and interaction with nitrogen. *Australian Journal of Crop Science* 4: 523–529.

Kumar, A., N. Kumar, P. Baredar and A. Shukla. 2015b. A review on biomass energy resources, potential, conversion and policy in India. *Renewable and Sustainable Energy Reviews* 45: 530–539.

Kumar, R., J. S. Bohra, N. Kumawat and A. K. Singh. 2015a. Fodder yield, nutrient uptake and quality of baby corn (*Zea mays* L.) as influenced by NPKS and Zn fertilization. *Research on Crops* 16: 243–249.

Sheta, B. T., N. K. Kalyanasundaram and K. C. Patel. 2010. Quality parameters and plant nutrient ratios of forage pearl millet as influenced by nitrogen, potassium and sulphur levels in loamy sand soils of Anand. *Asian Journal of Soil Science* 5: 116–121.

Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II - A rapid method for determination of fiber and lignin. *Journal of the Association of Official Analytical Chemists* 46: 829–835.