Chemical Science Review and Letters ISSN 2278-6783

Research Article

HCN Content and Forage Yield of Multi-Cut Forage Sorghum under Different Organic Manures and Nitrogen Levels

N. Karthika[1]* and R. Kalpana[2]

[1]Department of Agronomy, TNAU, Coimbatore-641003, Tamil Nadu
[2]Department of Agronomy, AC & RI, Vazhavachanur, Thiruvannamalai-606753, TNAU, Tamil Nadu

Abstract

A field experiment was carried out at Department of Millets, AC and RI, Coimbatore during *rabi* season 2015 to study the HCN content and forage yield of multi-cut forage sorghum under different organic manures and nitrogen levels. The experiment was laid out in randomized block design with three replications. The treatments consisted of application of different organic manures *viz*., farmyard manure, goat manure and vermicompost along with 100% N (90 kg ha^{-1}) or 125% N through fertilizer nitrogen. In addition, recommended application of FYM @ 25 t ha^{-1} + 100% N was adopted for comparison. The results of this study showed that the higher HCN content was recorded under application of vermicompost 2.5 t ha^{-1} + 125% N and the lower HCN content was recorded under application of FYM 10 t ha^{-1} + 100% N. Higher level of green and dry fodder yield were recorded with application of FYM 10 t ha^{-1} with 125% N applied through fertilizer (38.7 and 16.9 t ha^{-1}, respectively).

Keywords: HCN, Forage sorghum, yield

***Correspondence**
Author: N. Karthika
Email: karthikan36@yahoo.com

Introduction

Global trend in animal production indicates a rapid increase in the consumption of livestock products. India supports nearly 20 per cent of the world livestock population on a land area of only 2.3 per cent. It is a leader in cattle (16 per cent) and buffalo (55 per cent) population and has world's second largest goat (20 per cent) and fourth largest sheep (5 per cent) population, respectively. But, the country has only 4.4 per cent of the cultivated area under fodder crops with an annual total forage production of 833 m t (390 m t green and 443 m t dry). In Tamil Nadu, the area under fodder crops is 1.72 lakh ha producing 340 lakh tonnes of fodder annually as against the requirement of 486 lakh tonnes (Season and Crop Report, 2013-14). It is estimated that the deficit will increase over 64.2 and 24.8 per cent of green and dry fodder, respectively by 2020 [1].

Amongst the annual forage crops, sorghum occupies nearly 2.5 m ha area. Cultivation of sorghum over other forage crops is widely practiced due to its high tolerance and suitability to wide variation in soil and climatic conditions and having many advantages like quick growth, high biomass accumulation, high dry matter content and wide adaptability besides drought withstanding ability. It is also suitable for silage and hay making. The green fodder availability from single cut sorghum is seasonal while multi-cut sorghum helps to supply green fodder throughout the year. Multi-cut forage having shorter cutting interval of 40-45 days, requires adequate nutrients in available form to produce sufficient foliage in a limited period of time.

Among the nutrients, nitrogen is vital for plant growth and is the most limiting nutrient in Indian soils. It promotes shoot elongation, tillering regeneration, leaf to stem ratio, succulency and palatability of fodder crop [2]. Sorghum is considered to be a good feed in ordinary conditions but when its normal growth is constrained by drought [3] or imbalanced soil nutrients, hydrocyanic acid (HCN) content may develop to such an extent that the toxic level may reach lethal level when fed to animals. Cyanide occurs in the leaves of sorghum as cyanogenic glucoside dhurrin. Degradation of dhurrin yields equimolar amount of hydrocyanic, glucose and P-hydroxybenzaldehyde (P-HB) [4]. It is observed that when HCN is readily absorbed into the blood stream of grazing ruminants, it causes cellular asphyxiation leading to illness of cattle eventually resulting in the death of animals and even at doses as little as 0.5 g are sufficient to kill a cow. The safe limit of HCN in green forage for livestock is 500 ppm on fresh weight basis and 200 ppm on dry weight basis. Hydrocyanic acid content is heritable and subjected to modification through selection and breeding, as well as by climate, stage of maturity, stunting of plant, type of soil and fertilizer. Nitrogen application is considered to be essential for growth and regrowth during growing season. However, higher level of nitrogen application may increase prussic acid contents of forage sorghum and ultimately poisoning to animals. Nitrogen application is essential requisite to utilize the available soil and environmental resources effectively.

The farmers are generally not familiar with the optimum growth stage of forage sorghum that should be fed to the livestock. They apply either over or under dose of nitrogen fertilizer to get the higher forage yield of sorghum and harvest at any growth stage without having the knowledge of HCN poisoning and its relation with these practices. Different varieties of sorghum develop varying levels of HCN when grown under different environmental conditions. The present recommendation of FYM is 25 t ha^{-1} which is considered to be higher in the context of high cost of the manure and its non availability everywhere. High nitrogen fertilization also leads to increased HCN poisoning in forage sorghum. Hence, it was felt necessary to optimize the dose of FYM and nitrogen application and to study the effect of different organic manures on HCN content and yield of multi-cut forage sorghum.

Materials and Methods

A field experiment was conducted during *rabi* season 2015 at New Area farm, Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The study area is geographically situated at 11˚N latitude and 77˚E longitude with an altitude of 426.7 m above mean sea level. The soil of the experimental site was clay loam in texture having alkaline pH (8.33) and medium organic carbon (0.67%). The nutrient status of the soil during start of the experiment was low in available nitrogen (229.6 kg ha^{-1}), high in available phosphorus (32.52 kg ha^{-1}) and high in available potassium (632.0 kg ha^{-1}).

The experiment was laid out in randomized block design and replicated thrice using Co (FS) 31 as the test variety. The treatments consisted of application of FYM @ 25 t ha^{-1} + 100% N (T_1), FYM @ 10 t ha^{-1} + 100% N (T_2), FYM @ 10 t ha^{-1} + 125% N (T_3), Goat manure @ 5 t ha^{-1} + 100% N (T_4), Goat manure @ 2.5 t ha^{-1} + 125% N (T_5), Vermicompost @ 5 t ha^{-1} + 100% N (T_6), Vermicompost @ 2.5 t ha^{-1} + 125% N (T_7). Recommended dose of 90: 40: 40 N, P_2O_5, K_2O kg ha^{-1} was applied treatment wise in the form of urea, single super phosphate and muriate of potash. Fifty per cent of the recommended dose of 45 kg N ha^{-1} and full dose of P_2O_5 and K_2O were applied at sowing. Remaining dose of 45 kg N ha^{-1} was top dressed at 30 DAS followed by the application of half the dose of 45 kg N ha^{-1} after every cut. After 4th cut, 100 % dose of PK fertilizer along with 50% dose of N is recommended to be applied. In order to evaluate the HCN content and forage yield of multi-cut forage sorghum under different organic manures and nitrogen levels, the data were statistically analyzed using “Analysis of variance test”. The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other [5]. The HCN content of forage sorghum was estimated as per the standard procedure.

Determination of HCN

The method used for estimation of HCN content suggested by [6] and presented in **Figure 1**. A quantity of 0.15 g of green plant material was cut into short pieces with a scissor and dropped in a test tube and 3 to 4 drops of chloroform was added. A strip of moist filter paper saturated with sodium picrate solution was suspended above the moist sample. Then saturated filter paper was held in place with a cork stopper which serves to seal the test tube and it was incubated at room temperature (20˚C) for 12 to 24 hours. The sodium picrate which prevailed in the filter paper was reduced to a reddish compound in proportion to the amount of hydrocyanic acid which evolved from the sample. The colour produced was dissolved by placing the filter paper in a clean test tube containing 10 ml of distilled water after which the colour of the sample was matched with colour standards and concentration of HCN content was measured in spectrophotometer and then expressed in ppm.

Results and Discussion

HCN content

The cyanogenic glycoside, dhurrin found in sorghum can be hydrolysed in the rumen and liberate deadly hydrocyanic acid. Hydrocyanic acid content in excess of 500 ppm (on wet weight basis) in the forage sorghum is toxic to the animal health. Stage wise HCN content was estimated and presented in **Table 1**.

In the present study, At 20 DAS, the HCN content was statistically not significant but numerically higher values were recorded in the range of 484.3 to 568.9 ppm which was exceeding the critical level. This might be due to increased level of dhurrin correlated with the activity of two biosynthetic enzymes, CYP 79 A1 and CYP 76 E1 in initial growth stage of forage sorghum [7]. At 30 DAS, the lowest HCN content was recorded under application of FYM @ 10 t ha^{-1} + 100% N. This might be due to less uptake of nitrogen because of lower soil available nitrogen. The results are in agreement with the findings of [8]. Moreover, due to continuous and slow release of nutrients from FYM and increased plant age, the HCN content ultimately decreased [9].

Figure 1 HCN analysis

Table 1 Effect of organic manures and N levels on HCN content (ppm) of multi-cut forage sorghum at first and second cut

Treatment	First cut					Second cut		
	20 DAS	30 DAS	40 DAS	50 DAS	65 DAS	30 DAFH	40 DAFH	50 DAFH
T_1	489.3	378.4	408.1	188.0	145.6	230.3	209.1	88.5
T_2	484.3	209.1	272.6	156.2	103.3	204.9	156.2	72.6
T_3	568.9	213.4	293.8	166.8	145.6	272.6	219.7	92.7
T_4	496.2	219.7	314.9	272.6	130.8	336.1	198.5	71.6
T_5	568.9	236.6	336.1	251.5	166.8	293.8	200.7	82.1
T_6	526.6	230.3	441.9	336.1	236.6	255.7	160.4	103.3
T_7	547.8	312.8	463.1	378.4	251.5	304.4	149.9	124.5
SEd	52.5	26.5	35.9	24.2	16.6	26.6	19.0	9.1
CD (P=0.05)	NS	57.7	78.2	52.8	36.2	57.9	41.4	19.9

At 40 DAS, the lowest HCN content was recorded by application of FYM @ 10 t ha^{-1} + 100% N but compared to 30 DAS it was high. This might be due to 50% nitrogen top dressed at 30 DAS. Increased soil nitrogen availability might have increased nitrogen uptake which led to increased the HCN content of forage sorghum. Similar observation was also made by [10]. At 50 and 65 DAS, the lowest HCN content was recorded by application of FYM @ 10 t ha^{-1} + 100% N might be due to enzyme activity (CYP 79 A1 and CYP 76 E1) which gradually decreased at 50% flowering stage. This is supported by [9].

The HCN content was lowest in the application of FYM @ 10 t ha^{-1} + 100% N at 30 days after first harvest (DAFH). At 40, 50 DAFH the lowest HCN content was recorded through application of vermicompost @ 2.5 t ha^{-1} +

125% N and goat manure @ 5 t ha^{-1} + 100%. This might be due to decreased soil nitrogen availability which decreased nitrogen uptake this leads to lowest HCN content of forage sorghum.

Forage Yield

Forage yield is a function of genetic as well as environmental factors which plays a vital role in plant growth and development (**Table 2**). Higher green and dry forage yield was recorded by application of FYM @ 10 t ha^{-1} + 125% N during first and second cut of forage sorghum. Green forage yield obtained in this treatment was 19% higher over application of FYM @ 25 t ha^{-1} + 100% N for both first cut and second cut. Dry forage yield was also higher by 18 and 16% over FYM @ 25 t ha^{-1} + 100% N for first and second cut respectively. This might be attributed to sustained nutrient supply, which increased all the growth parameters like plant height and leaf stem ratio of the crop and the enhanced growth reflected on yield. It also showed that organic manure has stimulatory effect on efficiency of chemical fertilizer and this resulted in higher availability of N and accelerating the process of cell division, enlargement and elongation. This in turn showed luxuriant vegetative growth and resulted in higher green and dry forage yield. Similar results were also obtained by [11] and [12].

Table 2 Effect of organic manures and N levels on green and dry forage yield (t ha^{-1}) of multi-cut forage sorghum at first and second cut

Treatment	Green forage yield		Dry forage yield	
	First cut	Second cut	First cut	Second cut
T_1	32.4	16.5	13.9	8.7
T_2	30.8	15.1	13.2	8.0
T_3	38.7	19.2	16.6	10.2
T_4	32.5	15.6	14.0	8.3
T_5	37.0	16.1	15.9	8.5
T_6	31.6	16.8	13.6	8.9
T_7	36.0	17.8	15.5	9.4
SEd	1.8	1.0	0.8	0.5
CD (P=0.05)	3.7	1.9	1.6	1.0

Conclusion

It can be concluded that FYM was found to be an efficient organic source and when it was applied at 10 t ha^{-1} along with 125 per cent N (112.5 kg N ha^{-1}) as inorganic fertilizer produced higher forage yield and recorded the lowest HCN content in multi-cut forage sorghum.

References

[1] Handbook of Agriculture. 2013. 5th edition Chapter 37, pp. 1353-1356.
[2] Malik, H.P.S., Singh, H. and Singh, O.P. 1992. Response of multi-cut fodder sorghum cultivars to nitrogen and cutting management. Indian J. Agron., 37: 470-473.
[3] Fjell, D., Dale, B. and Gene, T. 1991. Nitrate and prussic acid toxicity in forage causes, prevention and feeding management, Cooperative extension service, Kansas state university, Manhattan, Kansas, USA, pp. 1–4.
[4] Francis, A., Haskins, J., Herman, G. and Hill, R.M. 1988.Colormetric determination of cyanide in enzyme hydrolyzed extract of dried sorghum levels. Agric. Food Chem., 38:775-778.
[5] Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. II Ed., John Wiley and Sons, New York. P- 381.
[6] Hogg, P.G. and Ahlgren, H.L. 1942. A rapid method for determining hydrocyanic acid content of single plant of sudan grass. J. Am. Soc. Agron., 34: 199-200.
[7] Abdel, A. and Gwad, A. 2008. Yield and quality of tunis grass as affected by plant height at cutting and N fertilizer. Animal Agric. Sci., 53: 157-169.
[8] Bahrani, M.J. and Ghenateghestani, A.D. 2004. Summer forage sorghum yield, protein and prussic acid contents as affected by plant density and nitrogen top dressing. J. Agric. Sci.Tec., 73-83.
[9] Kumar, C.V. and Devender, V. 2010. Effect of plant age at harvest and season on the hydrocyanic acid potential of some sorghum cultivars. Indian J. Anim. Nutr., 27: 142-146.

[10] Satpal, B.S., Duhan, Joshi, U.N., Godara, A.S., Arya, S. and Neelam. 2015. Response of yield, quality and economics of single cut forage sorghum genotypes to different nitrogen and phosphorus levels. Forage Res., 41 (3): 170-175.

[11] Duhan, B.S. 2013. Effect of integrated nutrient management on yield and nutrients uptake by sorghum (Sorghum bicolor L.). Forage Res., 39 (3): 156-158.

[12] Sumeriya, H.K. and Singh, P. 2014. Productivity of sorghum (Sorghum bicolor) genotypes as influenced by different fertility levels and their residual effect on succeeding wheat. Ann. Bio., 30: 266-275.

Publication History

Received 30th June 2017

Revised 18th July 2017

Accepted 20th July 2017

Online 30th July 2017