Biofertilizers, Nitrogen and Phosphorus on Yield and Nutrient Economy in Forage Sorghum Affected by Nutrient Management in Preceding Mustard

A. V. Ramanjaneyulu[1*], G. Giri[2] and S. R. Kumar[3]

[1]Regional Agricultural Research Station (ANGRAU), Palem, Mahaboobnagar, Andhra Pradesh (509 215), India
[2]Indian Agricultural Research Institute (IARI), New Delhi (100 012), India
[3]Directorate of Sorghum Research (ICAR), Rajendranagar, Hyderabad, Andhra Pradesh (500 030), India

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Correspondence to
E-mail: avr_agron@rediffmail.com

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Abstract

The results of field experiment conducted during 2003-04 and 2004-05 revealed that green and dry fodder yield of sorghum were highest when the crop received recommended dose of fertilizer (RDF) at 60 kg N+30 kg P_2O_5 ha^{-1}, but the crop yielded comparable green and dry fodder when it received half RDF (30 kg N+15 kg P_2O_5 ha^{-1}) +biofertilizers (*Azotobacter*+phosphate solubilizing bacteria). Further, RDF and half RDF+biofertilizers enhanced the dry fodder yield by 45.8 and 41.2%, respectively over control. The highest agronomic efficiency (57 kg dry fodder kg^{-1} N applied), net return (INR 5190 ha^{-1}) and benefit-cost ratio (1.45) were also obtained with half RDF+biofertilizers. On the contrary, the crop removed significantly greater amount of N and P when supplied with RDF, while RDF and half RDF+biofertilizers were at par and significantly superior to half RDF and control in respect of K uptake. RDF (80 kg N+40 kg P_2O_5 ha^{-1}) applied to preceding mustard significantly out yielded all other treatments in respect of green fodder yield of sorghum barring residual half RDF+biofertilizers. Residual RDF and half RDF+biofertilizers enhanced dry fodder yield by 31.6 and 27.0%, respectively.

1. Introduction

Among the forage crops, sorghum *(Sorghum bicolor* L.) is very popular in semi-arid zones particularly more in drought-prone regions of the world (Wenzel and Van Rooyen, 2001) due to its short duration, fast growing nature, high productivity and wider adaptability to varied agro-climatic conditions. Because of such inherent advantages, it is potentially suitable for mustard based cropping systems in some of the drought-prone areas of north-west India. As the improved and hybrids varieties of sorghum respond well to the nutrients application, unless the nutrients are replenished, higher yields from succeeding crop can not be expected. An integrated use of inorganic and biofertilizers should be opted for maximizing economic yield and to improve soil health (Syed Ismail et al., 2001). Importance of the use of organic sources of nutrients along with chemical fertilizers for maintaining soil health has been emphasized by Katyal (2000). The use of chemical fertilizer or biofertilizer has advantages and disadvantages in the context of nutrient supply, crop growth and environmental quality. The advantages need to be integrated in order to make optimum use of each of the fertilizers to achieve balanced nutrient management for crop growth (Jen-Hshuan Chen, 2006). The present work was an attempt to study the impact of biofertilizers and chemical fertilizers (nitrogen and phosphorus) on yield and nutrient uptake in forage sorghum.

2. Materials and Methods

A field experiment was conducted on sandy loam soil at Agronomy Research Farm of Indian Agricultural Research Institute (IARI), New Delhi, India for two consecutive years (2003-04 to 2004-05). The soil at the experimental site was slightly alkaline, low in available N (135.5 kg ha^{-1}) and medium in P (18.5 kg ha^{-1}) and K (225.5 kg ha^{-1}). The experiment was laid out in a randomized block design (RBD) for forage sorghum with four treatments, viz. control, recommended dose of fertilizer (RDF) 60 kg N+30 kg P_2O_5 ha^{-1}, half RDF (30 kg N+15 kg P_2O_5 ha^{-1}), and half RDF+ biofertilizers. For mustard a split plot design (SPD) was followed with six treatments, viz control, 40 kg N ha^{-1}, 80 kg N ha^{-1}, half RDF (40 kg N+20 kg P_2O_5 ha^{-1}), RDF (80 kg N+40 kg P_2O_5 ha^{-1}) and half RDF+biofertilizers, and three replications. Single cut sorghum variety PC-9 was sown at the rate of 30 kg ha^{-1} with a spacing of 30 x 10 cm^2 (9 rows $plot^{-1}$) on 27 June 2003 and 26 June 2004. During post rainy season, mustard variety Pusa Jagannath was sown at the rate of 5 kg ha^{-1} with a spacing of 45 x l0 cm^2 (6 rows $plot^{-1}$) on 20 October during both the years of experimentation. Nitrogen and phosphorus were applied as per the treatments through urea and single super phosphate (SSP), respectively. Biofertilizers, viz. *Azotobacter chroococcum* and phosphorus solubilizing bacteria (PSB) were used for seed treatment of sorghum as well as mustard just before sowing. Other cultural operations and plant protection measures were followed as per the recommendation. At 70 days after sowing (DAS), green fodder yield from net plot was recorded. Later, a representative green fodder sample from each net plot was oven dried and then dry fodder yield was calculated based on loss of moisture percentage. Before harvest, five plants were

removed and used for chemical analysis after oven drying. N, P and K concentrations in plant sample were determined by micro-kjeldahl method, sulphuric-nitric-perchloric acid digest method and flame photometer method, respectively as per the procedure suggested by Prasad (1998). The N, P and K uptake were calculated dividing the nutrient concentrations by 100 and multiplying with dry fodder yield. The crude protein percentage was obtained by multiplying N% with 6.25. The data were subjected to statistical analysis of variance technique proposed by Gomez and Gomez (1983). The critical difference (CD) values were worked out at 5% level of probability wherever F values were found significant. The CD values were used for comparing treatments and drawing conclusions. Agronomic efficiency (AE) was calculated using the following formula as suggested by Crasswell and Godwin (1984).

$$AE = \frac{\text{Dry fodder in fertilized plot (kg ha}^{-1}\text{)-Dry fodder in control plot (kg ha}^{-1}\text{)}}{\text{Quantity of N applied (kg ha}^{-1}\text{)}}$$

3. Results and Discussion

3.1. Fodder and crude protein yield and monetary returns

The results revealed that green and dry fodder yield of sorghum were highest when the crop received RDF, but produced comparable green and dry fodder yields when it received half RDF+biofertilizers. The superior performance of sorghum with RDF was mainly due to ready availability of N and P nutrients. Comparable performance of forage sorghum with half RDF+biofertilizers might be due to utilization of N and P supplied through inorganic fertilizers in the initial stages, and N and P were fixed and mobilized by *Azotobacter* and PSB, respectively in the later phases by sorghum crop (Kumar and Sharma, 1999). Similar results were earlier published by Subha and Giri (2003) in spring sunflower and fodder sorghum sequence at IARI, New Delhi. It reveals that application of half RDF+biofertilizers not only saves half the dose of N and P but also improves soil health by producing growth hormones, antifungal substances (Sheoran et al., 2000) and vitamins (Das et al., 2004) to sustain the crop productivity. RDF and half RDF+biofertilizers enhanced the dry fodder yield by 45.8 and 41.2%, respectively over control (Table 1). Rizwan et al. (2008) in both pot and plot studies indicated that biofertilizer, supplemented either with 88 or 132 kg N ha^{-1} significantly increased the growth and yield of maize over full dose of N fertilizer. The highest agronomic efficiency (57 kg dry fodder kg^{-1} N applied) was also obtained with half RDF+biofertilizers. On the contrary to the fodder yield, crude protein content and yield were significantly higher due to application of RDF. However, net return (INR 5190 ha^{-1}) and benefit-cost ratio (1.45) was highest with the application of half RDF+biofertilizers mainly because of cheaper cost of biofertilizers besides saving half the cost of recommended dose of N and P. These results are in conformity with the results of Magare et al. (2009) in cotton-sorghum sequence at Akola, Maharashtra, India. While Ghulam et al. (2007) found that biofertilizers helped reduce the use of inorganic fertilizers by minimizing production cost and thus maximizing the net returns in fodder maize.

Table 1: Fodder and crude protein yield of sorghum as influenced by nutrient management (Pooled over 2003-04 and 2004-05)

Treatments	Fodder yield (t ha^{-1})		Agronomic efficiency (kg dry fodder kg^{-1} N applied)	Crude protein content (%)	Crude protein yield (kg ha^{-1})	Net returns (INR ha^{-1})	Benefit-cost ratio
	Green	Dry					
Control	20.8	4.15	-	5.33	221.5	3343	1.22
Half RDF	24.5	4.85	23	5.69	277.2	3838	1.07
RDF	30.6	6.05	32	6.57	396.6	4835	1.12
Half RDF+biofertilizers	29.4	5.85	57	6.03	353.8	5190	1.45
SEm±	1.1	0.23	-	0.16	11.0		
CD (p=0.05)	3.2	0.64	-	0.49	28.0		

3.2. Uptake of N, P and K and their concentration

On the contrary to the comparable performance of RDF and half RDF+biofertilizers in respect of green and dry fodder yields, the fodder sorghum crop removed significantly greater amount of N and P when supplied with RDF than rest of the treatments (Table 2). However, RDF and half RDF+biofertilizers were at par and significantly superior to half RDF and control in respect of K uptake. Ghulam et al. (2007) indicated highest nutrient uptake by crop recorded as N under half N and P+biofertilizer. The present investigation is found to be in conformity with that of Sundara et al. (2002) who found that the application of PSB increased the P availability thus P uptake by the plant and when used in combination with P fertilizer, it reduced required

Table 2: Removal and concentration of N, P and K by fodder sorghum as influenced by nutrient management (Pooled over 2003-04 and 2004-05)

Treatments	Removal (kg ha^{-1})			Concentration (%)		
	N	P	K	N	P	K
Control	35.3	9.5	55.7	0.85	0.23	1.34
Half RDF	44.2	13.6	69.7	0.91	0.28	1.43
RDF	63.6	21.2	96.0	1.05	0.35	1.58
Half RDF+biofertilizers	56.4	18.6	88.3	0.96	0.32	1.51
SEm±	1.9	0.7	4.5	0.03	0.01	0.05
CD (p=0.05)	6.0	2.4	13.2	0.08	0.03	Non-significant

P dosage by 25%.

3.3. Residual effect of nutrients applied in mustard (first year) on fodder yield of sorghum (second year)

Fodder yield of sorghum was significantly (p=0.05) affected by nutrients applied in preceding mustard grown in 2003-04 (Table 3). RDF (80 kg N+40 kg P_2O_5 ha^{-1}) applied to mustard

Table 3: Residual effect of nutrients applied in mustard on yield of fodder sorghum

Treatments	Fodder yield (t ha^{-1})	
	Green	Dry
Control	23.3	4.50
40 kg N ha^{-1}	24.9	4.98
80 kg N ha^{-1}	25.7	5.10
Half RDF	26.8	5.40
RDF	29.6	5.92
Half RDF+biofertilizers	28.5	5.73
SEm±	0.3	0.07
CD (p=0.05)	1.1	0.22

in preceding season significantly out yielded all other treatments in respect of green fodder yield of sorghum barring residual half RDF+biofertilizers. Residual RDF and half RDF+biofertilizers enhanced dry fodder yield by 31.6 and 27.0%, respectively. Thus the results indicate that application of half RDF+biofertilizers to fodder sorghum saved not only half the dose of RDF but also resulted in highest net return (INR 5190 ha^{-1}) and benefit-cost ratio (1.45). Neeru et al. (2005) observed a net saving of 25-30 kg N using chosen bio-inoculants for wheat crop when rotated with cotton.

Crop rotation studies are important to understand the effect of applied nutrients to the soil and the extant of their utilization by sequential crops. The present study involving mustard and fodder sorghum sequence indicates the positive influence of nutrients applied to mustard crop on the succeeding sorghum crop. Use of biofertilizers in combination with inorganic fertilizers help reduce the dosage thereby help in saving the production costs while maximizing the returns.

4. Conclusion

Integrated use of inorganic N and P fertilizers and biofertilizers is the most efficient way of economizing the fertilizer use and improving agronomic efficiency besides improving physical, chemical and biological properties of the soil. Highest agronomic efficiency (57 kg dry fodder kg^{-1} N applied), net returns (INR 5190 ha^{-1}) and benefit-cost ratio (1.45) were also obtained with half RDF+biofertilizers. Residual RDF and half RDF+biofertilizers applied to mustard crop enhanced the succeeding sorghum dry fodder yield by 31.6 and 27.0%, respectively.

5. References

Crasswell, E.T., Godwin, D.C., 1984. The efficiency of nitrogen fertilizer applied to cereals in different climates. In: Advances in Plant nutrition. (Ed.) Tinker P.B. and Lauchli, Praeger Scientific, New York, 1-55.

Das, A., Prasad, M., Shivay, Y.S., Subha, K.M., 2004. Productivity and sustainability of cotton-wheat cropping system as influenced by prilled urea, FYM, *Azotobacter*. Journal of Agronomy and Crop Science 190, 299-304.

Ghulam, J., Abida, A., Raja, M., Ali, F.Y., Hafeez, I., Shamsi, A.N., Chaudhry, A., 2007. Enhancing crop growth, nutrients availability, economics and beneficial rhizosphere microflora through organic and biofertilizers. Annals of Microbiology 57(2), 120-125.

Gomez, A.K., Gomez, A.A., 1983. Statistical Procedure for Agricultural Research (2nd Edn.). John Wiley & Sons, New York, NJ, 84-101.

Jen-Hshuan Chen, 2006. The combined use of chemical and organic fertilizers and or biofertilizer for crop growth and soil fertility. In: International Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use. Land Development Department, Bankok-10900, Thailand. October, 16-20, 125-130.

Katyal, J.C., 2000. Organic matter maintenance. Journal of Indian Society of Soil Science 48(4), 704-716.

Kumar, S., Sharma, B.L., 1999. Effect of FYM, nitrogen and Azospirillum inoculation on growth parameters of fodder sorghum. Haryana Journal of Agronomy 15(1), 95-97.

Magare, P.N., Matale, S.G., Shendurse, S.M., Nandapure, S.N., 2009. Integrated effect of vegetative barriers and FYM on conservation of soil and nutrient losses, productivity and economics in cotton-sorghum rotation. Green Farming 2(9), 596-598.

Neeru, N., Vivek, K., Baljeet, S., Ranjana, B., Lakshminarayana, K., 2005. Impact of biofertilizers on grain yield in spring wheat under varying fertility conditions and wheat-cotton rotation. Archives of Agronomy and Soil Science 51(1), 79-89.

Prasad, R., 1998. A practical manual on soil fertility. Division of Agronomy, Indian Agricultural Research Institute, ICAR National Agronomy Professor Unit, New Delhi, India, 50-53.

Rizwan, A., Muhammad, A., Azeem, K., Zahir, A., 2008. Effectiveness of organic-bio-fertilizer supplemented with chemical fertilizers for improving soil water retention, aggregate stability, growth and nutrient uptake of maize (*Zea mays* L.). Journal of Sustainable Agriculture 31(4), 57-77.

Sheoran, R.S., Jatasara, D.S., Rana, D.S., 2000. Efficacy of *Azotobacter* incoluation under graded doses of N fertilizer in relation to growth, yield and N utilization efficiency. Acta Agronomica Hungarica 48, 165-170.

Subha, K.M., Giri, G., 2003. INM in spring sunflower and its effect on succeeding fodder sorghum. PhD Thesis, IARI, New Delhi, India.

Sundara, B., Natarajan, V., Hari, K., 2002. Influence of phosphorus solubilizing bacteria on the change in soil available phosphorus and sugarcane and sugar yields. Field Crops Research 77, 43-49.

Syed Ismail, A.P.B., Shinde, G.G., Deshmukh, A.S., 2001. Impact of FYM and fertilizer nitrogen on yield and soil properties of sorghum grown on Vertisol. International Sorghum and Millets Newsletter 42, 29-31.

Wenzel, W.G., Van Rooyen, P.J., 2001. Moisture stress and potential sorghum yield. International Sorghum and Millets Newsletter 42, 28-29.