Indian Journal of Agronomy **52** (2) : 139–142 (June 2007)

Effect of nutrient and weed management on forage sorghum (*Sorghum bicolor*) under rainfed condition

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Received : February 2007

ABSTRACT

A field experiment was conducted during 2000–01 to 2003–04 at Pali-Marwar, Rajasthan to study the effect of nutrient and weed management on yield of forage sorghum [*Sorghum bicolor* (L.) Moench] under rainfed condition. The experiment was laid out in split-plot design with 3 replications. Application of 5 t FYM/ha + 50% recommended dose of fertilizer 30 kg N and 8.75 kg P/ha significantly increased green and dry fodder yields of sorghum by 35.1 and 35.7% over the control. This treatment also caused highest uptake of N and P by sorghum. The effect of FYM-treated plots on water-use efficiency was significantly higher over the control. Pre-emergence application of atrazine @ 0.5 kg/ha + 1 hoeing or interculture with peg tooth-weeder at 35 days after sowing, being on a par among themselves, caused least weed population and weed dry weight and significantly increased green and dry fodder yields of sorghum by 66–67%. Application of 5 t FYM/ha + 50% recommended dose of fertilizer resulted in the highest mean net return over the control. Pre-emergence application of atrazine alone or atrazine + interculture with peg tooth-weeder at 35 days after sowing gave high net returns and benefit : cost ratio.

Key words : Arid fringes, Atrazine, Dry-fodder yield, Inorganic, Organic, Sorghum

Availability of nutritious fodder in the dry period of the year is a limiting factor for development of livestock in semi-arid regions. Forage sorghum cultivation is emphasized owing to its drought-tolerant characteristics and high production potential. It is a heavy feeder of nutrients, and soils poor in fertility and low in organic matter content are constraints to plant productivity in arid fringes. Therefore judicious use of organic manure in combination with inorganic fertilizer has become imperative for sustained crop production and maintenance of soil heath. Sorghum being a rainy-season crop is severely infested by large number of weed species that compete with the crop for nutrient and soil moisture, resulting in decline in productivity. Integration of chemical weed control with mechanical method will be more effective and economically viable. Keeping this is view, and the higher nutrient requirement of sorghum and its limited supply and higher cost involved in weed control, the present study was undertaken to find out suitable weed-control measure in relation to varying fertility regime for improving the productivity of forage sorghum in arid fringes.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 2000–01 to 2003–04 at Regional Research Station, Pali-Marwar, Central Arid Zone Research Institute. The soil was sandy clay-loam, having 30-45 cm depth and highly calcareous C-horizons, with 8.1 pH, 0.37% organic C, and 213.0, 12.6 and 203 kg/ha available N, P and K content. The experiment was laid out in split-plot design with 3 replications. The treatment comprised 4 combinations of nutrient supply, viz. no farmyard manure (FYM) as control, 5 t FYM/ha + 50% RDF (recommended dose of fertilizer, 60 kg N and 17.5 kg P/ha), 10 t FYM/ha + 50% RDF and 100% RDF in main plots; and 4 weed-management practices, viz. unweeded check (control), pre-emergence (PE) application of atrazine at 0.5 kg/ha, atrazine (PE) at 0.5 kg/ha + 1 hoeing at 35 DAS and atrazine (PE) at 0.5 kg/ha + 1 interculture with peg tooth-weeder at 35 DAS were kept in subplots. Farmyard manure (having 0.45% N, 0.087% P and 0.35% K on dry-weight basis) was mixed in soil 2 weeks before sowing. A total of 244.6 mm, 462.7 mm and 396.5 mm rainfall was recorded during pendency of crop growth in 2000, 2001 and 2003 respectively. Sorghum variety 'CSV15' was sown with the onset of monsoon rains during all the 3 years. Entire dose of P and half of N were applied basal as per treatments through diammonium phosphate and urea, and remaining half N was applied at 35 DAS.

Herbicide was sprayed a day after sowing of the crop in ear marked plots with knapsack sprayer using spay volume

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of 600 litres/ha. The weeds were collected from an area of 0.5% m^2 quadrate from 3 places in each treatment plot and weed population was recorded and classified in different species 60 days after sowing. The crop was harvested at 50% flowering stage. Dry-matter yield of weeds and sorghum were estimated by drying the samples in hot-air oven at 70° C. Nutrient uptake by weeds and crop were calculated by multiplying the dry-matter yield with the nutrient content. Data on weed count and weed dry weights were subjected to square-root transformation to normalize their distribution. The data for individual year were pooled and statistically analysed.

RESULTS AND DISCUSSION

Weed growth

The dominating weeds in sorghum were *Digeria muricata* (L.) Mart. syn. D. *arvensis* Forsk., *Amaranthus spinosus* L., *Amaranthus viridis* L., *Trianthema portulacastrum* L., *Euphorbia hirta* L., *Tribulus terrestris* L. among the broad-leaf weeds; *Setaria glauca* L., *Digiteria sanguinalis* (L.) Scop. *Dactyloctenium aegyptium* (L.) Willd. and *Panicum repens* L. among the grassy weeds; and *Cyperus rotundus* L. in sedges. Among them, *D. arvensis*, *A. spinosus* and *A. viridis* were the most predominant weed species with the average density of 30, 25 and 15%, respectively.

Fertility levels had no significant effect on weed population and weed dry weight. Among the weed-control treatments, maximum weed population and weed dry weight were recorded in unweeded control (Table 1). Application of Atrazine at 0.5 kg/ha as pre-emergence spray significantly reduced the weed population and weed dry weight over the control on pooled basis. Application of Atrazine + 1 hoeing or interculture with peg tooth-weeder at 35 days, being on a par among themselves, caused further reduction in weed population and weed dry weight significantly compared with atrazine application. Highest weed-control efficiency (84.2%) was obtained with atrazine + 1 hoeing, followed by atrazine + 1 interculture with peg tooth-weeder (82.4%) and atrazine alone (76.7%).

Effect of fertility levels varied significantly on N and P uptake by weeds. Though N and P uptake by the weeds under 100% RDF treatment were at par with FYM-treated plots, these were significantly lower than unfertilized control plots. Weed-control treatments being at par among themselves significantly reduced N and P uptake by weeds compared to unweeded control. The significant reduction in weed dry matter from unweeded control led to reduction in uptake of N and P by weeds. The result confirms the findings of Kaushik and Shaktawat (2005).

Sorghum growth and green-fodder yield

Nutrient management in forage sorghum significantly improved plant height and leaf-area index (LAI) 60 days after sowing and green-fodder yield over the control (Table 2). Application of 5 t FYM/ha + 50% RDF (30 kg N and 8.75 kg P/ha) significantly increased the LAI by 37.3% and green-fodder yield by 35.0% over the respective control, on pooled basis. Further, FYM 10 t/ha + 50% RDF and 100% RDF being on a par with above treatment, also increased LAI and green-fodder yield significantly over the control. Such elevated conducive effect was owing to combined influence of organic and inorganic nutrients which have provided the balanced nutrition to satisfy

Table 1. Effect of nutrient and weed management on weed count, weed dry weight, N and P uptake by weeds and weed-control efficiency (3 years' pooled data)

Treatment	Weed count* (no./m^2) at 60 DAS	Weed dry weight* (g/m^2) at 60 DAS	Uptake by weeds (kg/ha) N	Uptake by weeds (kg/ha) P	Weed-control efficiency (%)
Fertility level					
Control	7.87 (60.9)	6.60 (42.6)	6.06	1.57	53.44
5 t FYM/ha + 50% RDF	7.37 (53.3)	6.13 (36.5)	5.20	1.35	60.11
10 t FYM/ha + 50% RDF	7.02 (48.3)	6.01 (35.1)	5.00	1.30	61.64
100% RDF	6.25 (38.0)	5.48 (29.1)	4.14	1.08	68.20
SEm ±	0.31	0.44			
CD (P=0.05)	NS	1.29			
Weed control					
Unweeded control	12.37 (152.0)	9.62 (91.5)	13.03	3.37	
Atrazine 0.5 kg/ha	4.96 (23.6)	4.72 (21.3)	3.03	0.79	76.75
Atrazine 0.5 kg/ha + 1 hoeing	3.45 (10.9)	3.93 (14.4)	2.05	0.54	84.23
Atrazine 0.5 kg/ha + 1 IC with weeder	3.87 (14.0)	4.13 (16.1)	2.28	0.60	82.44
SEm±	0.28	0.17	0.40	0.10	
CD (P=0.05)	0.80	0.52	1.12	0.29	

DAS, days after sowing; IC, inter-culture; *Square-root transformed and original values are given in parentheses;

the need of vigorously growing sorghum plants. Kumar and Gautam (2004) also reported similar results.

Weed-control measures exerted significant effect on LAI and green-fodder yield over unweeded control. However, plant height remained unaffected. Pre-emergence application of atrazine at 0.5 kg/ha registered significantly higher LAI by 21.4% and green fodder yield by 51.6% over unweeded control. Addition of either 1 hoeing or interculture with peg tooth-weeder at 35 days to atrazine application caused further significant increase in green-fodder yield of sorghum by 9 to 10%, indicating importance of cultural treatments.

Dry-fodder yield and water-use efficiency

Nutrient management significantly increased dry fodder yield and water-use efficiency over the control (Table 2). Application of 5 t FYM/ha + 50% RDF significantly increased dry-fodder yield by 35.7% over the control and 10.8% over 100% RDF, on pooled basis. The effect of FYM 10 t/ha + 50% RDF though significant over the control, did not cause significant gain in dry fodder yield over 5 t FYM/ha + 50% RDF. The improvement in growth characters like plant height, LAI and green-fodder yield of sorghum with combined application of FYM and inorganic N and P fertilizer might be owing to the improvement in soil health and build up of soil fertility. Kumar *et al.* (2005) reported significantly higher dry matter in forage sorghum with 5 t FYM/ha + 50% RDF (40 kg N + 8.75 kg P/ha) over the control.

The effect of nutrient-management practices on water-use efficiency of sorghum was significant. The effect of FYM-treated plots on water-use efficiency being at par with 100% RDF, was significantly higher over the control. The increase in water-use efficiency under treatments having combined application of FYM and inorganic fertilizer is due to relatively rapid root and shoot growth (Ghosh *et al.*, 2003).

Weed-control measures had significant effect on dry-fodder yield and water-use efficiency of sorghum over unweeded control. Application of atrazine at 0.5 kg/ha as pre-emergence spray significantly increased the dry fodder by 52.2% and WUE by 50.3% over the unweeded control. The application of atrazine + 1 hoeing or interculture with peg tooth-weeder caused further significant increase in the dry fodder over atrazine alone by 9–10%. The increase in WUE was from 16.5% kg/ha-mm under the control to 27.1 kg/ha-mm with above treatments. The increase in dry fodder by atrazine + cultural treatments at 35 days was owing to weed control and soil mulching that might have conserved the precious soil moisture, which ultimately helped increase plant productivity under these treatments (Kaushik and Shaktawat, 2005).

The interaction effect of nutrient management and weed-control measure on green- and dry-fodder yields was significant (Table 3). Application of either fertility levels or weed-control measures is not sufficient to achieve maximum yield of forage sorghum. Maximum yields of green and dry fodder were obtained when fertility levels were supported with suitable weed-control measures. Application of 5 t FYM/ha + 50% RDF along with pre-emergence spray application of atrazine @ 0.5 kg/ha + 1 interculture with peg tooth-weeder produced maximum green fodder of 22.82 t/ha followed 22.72 t/ha under same fertility levels + atrazine application alone.

Table 2. Effect of nutrient and weed management on growth, yield, water-use efficiency (WUE), nutrient uptake and quality, and economics in sorghum (3 years pooled data)

Treatment	Plant height (cm) at 60 DAS	Leaf-area index at 60 DAS	Green-fodder yield (t/ha)	Dry-fodder yield (t/ha)	WUE (kg/ha mm)	Uptake by crop (kg/ha)		Crude protein (%)	Net returns (Rs/ha)	Benefit : cost ratio
						N	P			
Fertility level										
Control	138.1	3.24	15.4	4.45	19.7	31.2	7.62	4.34	3,713	1.73
5 t FYM/ha + 50%	151.9	4.45	20.8	6.04	26.6	47.3	13.91	4.95	4,524	1.62
10 t FYM/ha + 50% RDF	152.2	4.21	19.7	5.71	25.3	42.8	13.25	4.68	2,625	1.30
100% RDF	147.7	4.25	18.8	5.45	24.1	43.1	12.33	4.89	4,256	1.65
SEm±	3.4	0.09	0.7	0.79	1.2	1.8	0.71	0.07		
CD (P=0.05)	10.0	0.28	2.0	0.57	3.5	5.4	2.11	0.21		
Weed control										
Unweeded control	142.1	3.41	12.8	3.70	16.5	23.8	6.73	4.02	1,595	1.27
Atrazine 0.5 kg/ha	148.7	4.14	19.4	5.63	24.8	43.2	12.03	4.82	4,612	1.72
Atrazine 0.5 kg/ha + 1 hoeing	148.2	4.32	21.3	6.17	27.1	49.1	13.77	5.03	3,993	1.48
Atrazine 0.5 kg/ha + 1 IC weeder	150.9	4.28	21.2	6.15	27.1	48.4	14.58	4.99	4,898	1.69
SEm±	2.4	0.07	0.3	0.09	1.1	0.8	0.38	0.06		
CD (P=0.05)	NS	0.21	0.9	0.27	3.2	2.2	1.07	0.18		

Cost of input: FYM @ Rs 300/tonne; urea, Rs 250/50 kg bag; DAP, Rs 492/50 kg bag; Atrazine, Rs 202/500 g packet
Price of output: Sorghum dry fodder @ Rs 350, Rs 300 and Rs 150/ 100 kg during 2000, 2001 and 2003, respectively.

Table 3. Interaction effect of nutrient and weed management on green-fodder and dry-fodder yields of sorghum (3-year pooled data)

Treatment	Unweeded control	Atrazine 0.5 kg/ha	Atrazine 0.5 kg/ha + 1 hoeing	Atrazine 0.5 kg/ha + IC with weeder
		Green-fodder yield (t/ha)		
Control	9.92	14.46	18.83	18.30
5 t FYM/ha + 5% RDF	15.61	22.72	22.21	22.82
10 t FYM/ha + 5% RDF	14.70	19.40	22.72	22.06
100% RDF	10.97	21.13	21.60	21.63
SEm±		0.65		
CD (P=0.05)		1.84		
		Dry-fodder yield (t/ha)		
Control	2.86	4.18	5.44	5.30
5 t FYM/ha + 50% RDF	4.51	6.59	6.42	6.62
10 t FYM/ha + 50% RDF	4.26	5.62	6.58	6.40
100% RDF	3.16	6.13	6.25	6.77
SEm±		0.19		
CD (P=0.05)		0.53		

Dry-fodder yield showed the same trend. The interaction effect of year and yield of sorghum was significant. This was caused due to variation in amount and distribution of rainfall. During 2000, rainfall was only 244.6 mm (58% of the average rainfall), during 2001 it was 462.7 mm but its distribution was skewed (73% in July only) and during 2003 normal 396.5 mm rainfall was recorded. Green- and dry-fodder yields of sorghum were positively correlated with amount of rainfall.

Nutrient uptake and crude protein

Nutrient-management practices significantly increased the uptake of N and P (Table 2). Application of 5 tonnes FYM/ha + 50% RDF being on a par with 10 t FYM/ha + 50% RDF and 100% RDF, significantly increased N uptake by 51.6% and P uptake by 82.6% over the control, on pooled basis. The improvement in N and P uptakes was mainly due to higher dry-fodder yield under improved nutrition. The crude-protein content of sorghum dry fodder also showed significant improvement with all the above nutrient-management practices over the control.

Weed-control treatments caused significantly higher uptake of N and P and crude-protein content. Atrazine at 0.5 kg/ha registered significantly higher uptake of N by 81.5% and of P by 78.8% by sorghum over unweeded control. In addition to Atrazine, cultural practices either by hoeing or peg tooth-weeder further increased the uptake of N and P significantly by the sorghum crop. This was mainly owing to higher dry-fodder yield.

Economics

Application of 5 t FYM/ha + 50% RDF/ha gave the maximum net return followed by 100% RDF (Table 2). Khem Chand *et al.* (2002) reported a net return of Rs 1,472/ha from the arable crop of pearl millet under farmer's field condition in arid fringes, where production and life-support system are always constraints due to low and erratic rainfall. Among the weed-control measures, lowest net return and benefit : cost ratio were recorded under unweeded control. These increased remarkably under weed-control treatments. Involvement of labour in conventional hoeing marginalized the net return and benefit : cost ratio from this treatment. Pre-emergence application of Atrazine alone or Atrazine spray+interculture with peg tooth-weeder at 35 DAS gave high net returns and benefit : cost ratio.

It may be concluded that application of 5 t FYM/ha + 50% RDF along with pre-emergence spray application of atrazine @ 0.5 kg/ha alone or in combination with 1 interculture with tooth-weeder at 35 DAS played significant role in enhancing forage-sorghum production.

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