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Research Paper

Effect of weed management practices on productivity, economics, quality and soil fertility of Guinea grass (*Panicum maximum*)-based pasture intercropped with legumes

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ABSTRACT

A field experiment was conducted during 2006–2011 on sandy loam soil at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi to find out the effect of weed control measures on forage productivity, quality, soil fertility status and economics of Guinea grass (*Panicum maximum* Jacq.)-based pasture intercropped with legumes. Intercropping of *Stylosanthes seabrana* B.L. Maass &'t Mannetje with Guinea grass produced significantly higher total green and dry forage yields (25.10 and 6.68 t/ha) than *Clitoria ternatea* vine (19.10 and 5.41 t/ha), *Macroptillium atropurpureum* (DC.) Urb. (20.17 and 5.60 t/ha) and *Stylosanthes hamata* (L.) Taub., (23.36 and 6.29 t/ha). Intercropping of *Stylosanthes seabrana* with Guinea grass also resulted in significantly higher total crude protein yield (582.0 kg/ha) as compared to *Clitoria ternatea* (457.7 kg/ha) and *Macroptillium atropurpureum* (474.9 kg/ha). In weed management practices, hand-weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards recorded significantly higher green forage, dry forage and crude protein yields of both Guinea grass (16.48 and 5.02 t/ha and 344.0 kg/ha) and legumes (9.05 and 2.0 t/ha and 271.8 kg/ha) than weedy check, pre-emergence application of pendimethalin @ 0.75 kg a.i./ha and weeding with weeder cum mulcher. The highest net returns (₹13,733/ha) and net returns/rupee invested (₹1.48) were obtained by intercropping of Guinea grass with *Stylosanthes seabrana*. Hand-weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards also recorded maximum net returns (₹12,746/ha). Intercropping of *Stylosanthes seabrana* with Guinea grass resulted in significant improvement in organic carbon (0.48%) and available nitrogen (228 kg/ha) than *Clitoria ternatea* and *Macroptillium atropurpureum.* Available nitrogen (226.2 kg/ha), phosphorus (9.91 kg/ha) and potassium (195.8 kg/ha) were also significantly higher in hand weeded plots than weedy check (211.3, 9.05 and 179.1 kg/ha).

Key words : *Clitoria ternatea,* Intercropping, *Macroptillium atropurpureum, Panicum maximum,* Soil fertility*, Stylosanthes hamata, Stylosanthes seabrana,* Weed control

In India the major part of livestock feed is met either from crop by-products or from the less nutritive grasses leading to low animal productivity. Further feeding of livestock with high priced concentrates is not possible for all the farmers due to their poor economic conditions. It is therefore, important that community lands, village grazing lands and marginal lands owned by the farmers should be put under pasture for forage from both the economic and resource conservation point of view (Yadav and Rajora, 1995). In this context, Guinea grass (*Panicum maximum* Jacq.) and perennial forage legumes are most suitable species for higher quality forage production and improvement of soil fertility in semi-arid regions under rainfed conditions. These perennial forage legumes provides cheaper source of quality feed and enhances animal productivity when grown with grasses (Thomas *et al.,* 1997). However, when legumes are grown with grasses, their establishment and growth are often poor because of faster growth of weeds and their smothering effect during early stage of legumes growth. Presence of weeds in pasture field generally reduces the forage quality on account of low crude protein content, dry matter digestibility and high fibre content. It also reduces the quality of livestock products and affects animal health. In view of these points, the present experiment was under taken to find out the effect of weed control on productivity, quality, soil fertility and economics of Guinea grass-based pasture intercropped with legumes.

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MATERIALS AND METHODS

A field experiment was conducted during 2006–2011 at Central Research Farm (25° 27' N, 78° 37' E and 275 m above mean sea-level) of ICAR-Indian Grassland and Fodder Research Institute, Jhansi. The data was recorded from 2007–08 for 4 consecutive years (2006–07 was establishment year). The soil of the experimental field was sandy loam, low in organic carbon (0.45%), available nitrogen (227.4 kg/ha) and phosphorus (9.45 kg/ha) and medium in available potassium (186.7 kg/ha). The total rainfall received was 416.2, 553.8, 1267.1, 544.9 and 684.1 mm in 33, 38, 52, 33 and 32 rainy days during 2006, 2007, 2008, 2009 and 2010 respectively.

There were 16 treatment combinations replicated thrice in randomized block design. The treatments comprised of 4 legumes (*Stylosanthes hamata, Stylosanthes seabrana, Clitoria ternatea* and *Macroptillium atropurpureum*) and 4 weed management practices (weedy check, hand weeding-35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards, weeding with weeder cum mulcher-35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards and pre-emergence application of pendimethalin @ 0.75 kg a.i./ha in first year and one day after onset of monsoon rain from second year onwards). The seedlings of Guinea grass (‘BG 1’) were transplanted in the month of July 1.0 meter apart and in between 2 rows legumes were sown. Gross and net plot sizes were 6 m × 9.5 m and 4 m × 7.5 m respectively. In each plot (6 m × 9.5 m) 6 rows of grass and legumes were established. The fresh yield of grass and legume was recorded on net plot basis. Each grass and legumes were harvested separately row wise and weighed separately in kilograms for net plot size. The yields obtained from individual plots were converted and expressed as green forage yield t/ha. Dry-matter content was estimated by drying 500 g plant sample in hot-air oven at 70<^{O}C, which led to computation of dry-matter yield. Soil sample were collected at random from 4 places (2 from grass row and 2 from legume row) of each plot of the experimental field with the help of augar to a depth of 0–15 cm. The soil sample drawn from four places of each plot were mixed together and a composite sample representing the plot was taken and analysed for soil fertility following the standard methods. The total number of weeds in 1 m × 1 m quadrants were counted and expressed as number of weeds/m^2. Similarly fresh weight of weeds in 1 m × 1 m quadrants were recorded and dry weight of weeds was estimated by drying 500 g plant sample of each treatment and replication in hot-air oven at 70<^{O}C. The plant samples were analysed for crude protein content (AOAC, 1995) and fibre (Van Soest *et al*., 1991).

RESULTS AND DISCUSSION

Growth parameters

Intercropping of legumes did not affect significantly the growth parameters of Guinea grass. However, among legumes, *Macroptillium atropurpureum* recorded significantly higher plant height as compared to *Stylosanthes hamata, Clitoria ternatea* and *Stylosanthes seabrana.* The number of branches/plant were significantly higher in *Stylosanthes seabrana* than *Macroptillium atropurpureum*, *Clitoria ternatea* and *Stylosanthes hamata*. Among weed management practices, hand weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from

Table 1. Effect of legumes and weed management practices on growth parameters of Guinea grass and legumes (mean of 4 years)

Treatment	Guinea grass			Legumes		
	Height (cm)	Tillers/plant	Tussock diameter (cm)	Leaf: stem ratio	Height (cm)	Branches/ plant
Guinea grass + *Legumes*						
G + *Stylosanthes hamata*	146.0	26.5	15.0	0.70	49.1	6.6
G + *Stylosanthes seabrana*	140.6	24.6	14.6	0.68	85.3	7.3
G + *Macroptillium atropurpureum*	139.0	25.1	14.3	0.67	107.6	4.2
G + *Clitoria ternatea*	136.7	24.6	14.0	0.66	65.2	5.0
SEm±	3.6	0.8	0.6	0.02	2.1	0.2
CD (P=0.05)	NS	NS	NS	NS	6.0	0.5
Weed control						
Weedy check	128.7	21.1	12.7	0.59	67.1	4.4
Pendimethalin 0.75 kg a.i./ha	136.5	22.7	13.8	0.65	74.2	5.3
Weeder cum mulcher	142.9	26.3	14.7	0.70	75.3	6.0
Hand-weeding	154.3	30.7	16.7	0.77	90.6	7.4
SEm±	3.6	0.8	0.6	0.02	2.1	0.2
CD (P=0.05)	10.4	2.4	1.6	0.05	6.0	0.5

G, Guinea grass; S, stylosanthes; M, macroptillium; C, clitoria second year onwards resulted in significantly higher growth parameters of both grass and legumes as compared to other treatments (Table 1). Liu and Revell (2002) indicated that after removal of weeds, the legume component had the ability to grow better than weedy check.

Green and dry forage yields

Intercropping of *Stylosanthes seabrana* with Guinea grass recorded significantly higher total green and dry forage yields than *Clitoria ternatea*, *Macroptillium atropurpureum* and *Stylosanthes hamata* (23.36 and 6.29 t/ha/year). This was due to better survival and growth of *Stylosanthes seabrana* over the years as compared to other legumes. Edye *et al*. (1998) reported that *Stylosanthes seabrana* was consistently superior to other *Stylosanthes species* in seedling, perennial plant density and yield particularly in the third year of the experiment. Basak *et al.* (2003) also reported that *Stylosanthes seabrana* had the best overall yield performance out of twenty cultivars of *Stylosanthes* species evaluated for their growth and yield performance. In total green forage yields, per cent contribution of *Stylosanthes hamata, Stylosanthes seabrana, Macroptillium atropurpureum* and *Clitoria ternatea* were 30.5, 36.2, 23.4 and 20.2 respectively. Clem *et al*. (2001) found that *Stylosanthes seabrana* was best adapted for use in permanent pastures as compared to various other legumes.

In weed management practices, hand weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards recorded significantly higher green and dry forage yields of both Guinea grass and legumes than other weed control treatments (Table 2). Higher yields were also obtained in maize + legume intercropping system by hand weeding treatment compared to weedy check (Chalka and Nepalia, 2005).

Crude protein yield

Crude protein yield increased significantly when Guinea grass was intercropped with *Stylosanthes seabrana* than *Clitoria ternatea* and *Macroptillium atropurpureum.* This was due to higher dry-matter yield obtained by intercrop of *Stylosanthes seabrana* with Guinea grass than other crops. Crude protein yield was also increased significantly when hand weeding was done at 35 days after sowing in first year and 25 days after onset of monsoon from second year onwards than other weed control measures (Table 2). Moyer *et al*. (2003) also reported that the removal of weeds resulted in higher protein yield than weed infested plots.

Number of weeds and weed dry weight

The common weeds found and removed from the experimental field were *Cynotis sp., Commelina benghalensis, Leucas aspera, Cassia tora, Phyllanthus niruri, Borreria hispida, Fimbristylis diphylla, Parthenium hysterophorus, Celosia argentea, Ipomea pestigridis, Digera arvensis, Tridax procumbence, Sida acuta, Cyperus rotundus, Coculus sp., Miremia emarginata, Miremia triandra* and *Borreria stricta.* Intercropping of *Stylosanthes seabrana* with Guinea grass recorded significantly lower number of weeds and lower weeds dry weight as compared to *Clitoria ternatea.* This was due to better survival and growth of *Stylosanthes seabrana* over the years and its suppressing effect on

Table 2. Effect of legumes and weed management practices on green forage, dry forage and crude protein yields of Guinea grass–based pasture (mean of 4 years)

Treatment	Green forage yield (t/ha)			Dry forage yield (t/ha)			Crude-protein yield (kg/ha)		
	G	L	T	G	L	T	G	L	T
Guinea + Legumes									
G + *Stylosanthes hamata*	14.64	8.72	23.36	4.37	1.92	6.29	296.6	250.4	547.0
G + *Stylosanthes seabrana*	14.25	10.85	25.10	4.26	2.42	6.68	289.0	293.0	582.0
G + *Macroptillium atropurpureum*	14.02	6.15	20.17	4.29	1.31	5.60	288.7	186.2	474.9
G + *Clitoria ternatea*	14.05	5.05	19.10	4.32	1.09	5.41	289.3	168.4	457.7
SEm±	0.40	0.18	0.49	0.11	0.04	0.15	9.6	6.8	16.8
CD (P=0.05)	NS	0.53	1.41	NS	0.12	0.42	NS	19.5	48.5
Weed control									
Weedy check	12.36	6.57	18.93	3.76	1.43	5.18	249.5	188.2	437.7
Pendimethalin 0.75 kg a.i./ha	13.47	7.22	20.69	4.08	1.58	5.66	275.1	201.3	476.4
Weeder cum mulcher	14.40	7.78	22.18	4.39	1.72	6.11	295.0	236.8	531.8
Hand-weeding	16.48	9.05	25.53	5.02	2.00	7.02	344.0	271.8	615.8
SEm±	0.40	0.18	0.49	0.11	0.04	0.15	9.6	6.8	16.8
CD (P=0.05)	1.14	0.53	1.41	0.31	0.12	0.42	27.5	19.5	48.5

G, Guinea grass; L, legumes; T, total (Guinea grass + legumes) weeds. Hand-weeding also resulted in significantly lower number of weeds and lower weed dry weight than other weed control measures (Table 3). Decrease in weed count and weed dry weight by hand-weeding were also reported by Sharma and Gill (2005).

Forage quality

Intercropping of legumes did not affect significantly the crude protein content, neutral detergent fiber and acid detergent fiber of Guinea grass (Table 3). However, among legumes *Clitoria ternatea* recorded significantly higher crude protein content as compared to *Macroptillium atropurpureum*, *Stylosanthes hamata* and *Stylosanthes seabrana*. Protein content in legumes was almost double as compared to grass. Thomas *et al.* (1997) also reported that establishment of legumes in association with grasses resulted in improvement in quality of forage. Among weed management practices, hand weeding resulted in significantly higher crude protein content in both Guinea grass and legumes as compared to weedy check. In legumes,

Table 3. Effect of legumes and weed management practices on number of weeds, weed dry weight, economics and forage quality of Guinea grass-based pasture (mean of 4 years)

Treatment	Weeds/m^2	Weed dry weight/m^2 (g/)	Net returns (×10^3₹/ha)	Net returns/rupee invested (₹)	Guinea grass			Legumes		
					Crude protein (%)	NDF (%)	ADF (%)	Crude protein (%)	NDF (%)	ADF (%)
Guinea+ Legumes										
G + *Stylosanthes hamata*	50.9	85.9	12.1	1.28	7.84	68.01	42.81	12.70	50.57	36.62
G + *Stylosanthes seabrana*	48.2	82.5	13.7	1.48	7.86	67.82	42.69	12.27	51.43	37.66
G + *Macroptillium atropurpureum*	53.0	90.5	8.9	0.97	7.81	68.55	43.12	13.81	47.61	34.90
G + *Clitoria ternatea*	60.5	96.4	7.8	0.84	7.78	68.87	43.22	15.49	49.24	35.99
SEm±	2.18	4.0	-	-	0.04	0.40	0.24	0.06	0.25	0.19
CD (P=0.05)	6.28	11.5	-	-	NS	NS	NS	0.18	0.72	0.56
Weed control										
Weedy check	69.5	117.7	9.2	1.19	7.74	68.92	43.32	13.46	50.09	36.65
Pendimethalin 0.75 kg a.i./ha	59.9	101.1	10.4	1.24	7.80	68.61	43.17	13.53	49.92	36.47
Weeder cum mulcher	51.3	87.1	10.2	0.99	7.85	68.21	42.90	13.61	49.65	36.27
Hand-weeding	31.8	49.6	12.7	1.15	7.91	67.51	42.44	13.67	49.21	35.93
SEm±	2.18	4.0	-	-	0.04	0.40	0.24	0.06	0.25	0.19
CD (P=0.05)	6.28	11.5	-	-	0.11	1.16	0.69	0.18	0.72	0.56

G, Guinea grass; NDF, neutral detergent fiber; ADF, acid detergent fiber

Table 4. Effect of legume intercropping and weed management practices on soil organic carbon and available nutrients in soil under Guinea grass-based pasture (mean of 4 years)

Treatment	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Guinea + Legumes				
G + *Stylosanthes hamata*	0.46 (0.47)	222.8 (229.0)	9.26 (9.56)	183.3 (192.4)
G + *Stylosanthes seabrana*	0.48 (0.51)	228.0 (238.3)	9.22 (9.45)	179.6 (186.0)
G + *Macroptillium atropurpureum*	0.44 (0.45)	213.9 (223.7)	9.58 (9.79)	189.1 (194.5)
G + *Clitoria ternatea*	0.42 (0.44)	208.9 (218.5)	9.75 (10.00)	194.8 (200.3)
SEm±	0.01	4.8	0.18	3.7
CD (P=0.05)	0.02	13.9	0.52	10.68
Weed control				
Weedy check	0.51 (0.53)	211.3 (219.2)	9.05 (9.34)	179.1 (184.9)
Pendimethalin 0.75 kg a.i./ha	0.45 (0.48)	215.9 (225.0)	9.09 (9.33)	183.5 (190.7)
Weeder cum mulcher	0.44 (0.44)	220.2 (228.4)	9.76 (9.98)	188.4 (195.0)
Hand-weeding	0.41 (0.42)	226.2 (236.9)	9.91 (10.15)	195.8 (202.6)
SEm±	0.01	4.8	0.18	3.7
CD (P=0.05)	0.02	13.9	0.52	10.7

G, Guinea grass, figures in parentheses are end year soil fertility status values

Macroptillium atropurpureum recorded significantly lower neutral detergent fiber and acid detergent fiber as compared to *Clitoria ternatea, Stylosanthes hamata* and *Stylosanthes seabrana.* Among weed management practices, hand weeding recorded significantly lower neutral detergent fibre and acid detergent fibre in both Guinea grass and legumes as compared to weedy check.

Soil fertility status

Intercropping of *Stylosanthes seabrana* with Guinea grass recorded the highest organic carbon (0.48 %) and available nitrogen (228.0 kg/ha) in soil. Thomas *et al.* (1997) also reported that establishment of legumes in association with grasses resulted in improvement in soil nutrients status. Available phosphorus and potassium were highest in plots where *Clitoria ternatea* was intercropped with Guinea grass. Among weed management practices, hand weeding recorded maximum available nitrogen, phosphorus and potassium. The organic carbon was the highest in weedy check plots.

Economic returns

The highest net returns and net returns/rupee invested were obtained by intercropping of Guinea grass with *Stylosanthes seabrana*. Hand-weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards also recorded maximum net returns. The higher net returns from *Stylosanthes seabrana* intercropping and hand weeding was due to higher forage yield obtained from these treatments.

It can be concluded that intercropping of Guinea grass with *Stylosanthes seabrana* along with the hand weeding 35 days after sowing in first year and 25 days after onset of monsoon rain from second year onwards in sandy loam soil was found adequate for higher forage growth, productivity, quality, monetary return and improvement in soil fertility under semi-arid rainfed conditions. Among legumes, *Stylosanthes seabrana* had better ability to compete with weeds.

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