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Productivity, Forage Quality and Economics of Guinea Grass and Caribbean Stylo Intercropping Systems

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Abstract: A field experiment was conducted on sandy loam soil for four consecutive years (2003-04 to 2006-07) at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi, to study the effect of row ratios (grass sole, legume sole, 1:1, 2:2, 3:3 and 4:4) and fertility levels on growth, productivity, quality and monetary return of Guinea grass – *S. hamata* intercropping system under rainfed conditions. Intercropping of Guinea grass with *S. hamata* in 2:2 row ratio produced significantly higher dry forage (5.01 t ha^{-1}) and crude protein yields (438.8 kg ha^{-1}) as compared to sole crop or alternate rows of both grass and legumes, and it was at par with 3:3 and 4:4 row ratios. The dry matter yields of the recommended dose of fertilizer was reduced by 28.32% over 75% of RDF + 5 t ha^{-1} FYM. Intercropping of Guinea grass with *S. hamata* in all the row ratios resulted in land equivalent ratio greater than 1, indicating intercropping to be beneficial. The maximum values of the relative crowding coefficient (RCC) was recorded in 2:2 row ratio of grass-legume intercropping, which indicated comparative yield advantage of this system over other intercropping treatments. The maximum net returns (Rs. 5,103 ha^{-1}) as well as net return/Re. invested (0.72) was obtained in paired row (2:2) of grass-legume intercropping. Among fertility levels, highest net returns (Rs. 5,276 ha^{-1}) and net return/Re. invested (0.55) were achieved with application of 75% of the RDF in combination with 5 t ha^{-1} FYM.

Key words: Fertility levels, *Panicum maximum*, productivity, row ratios, *Stylosanthes hamata*.

In India livestock rearing is one of the main occupations of the farmers in arid and semi-arid regions. Livestock population is increasing every year and there is ever increasing demand for quality forage. The major feed sources are by-products (rice and wheat straw/crop residue) or less nutritious grasses that result in low production and productivity of livestock. Feeding livestock with high priced concentrates increase the production cost. Poor farmers cannot easily supply concentrates to their livestock. It is therefore, important that community lands, village grazing lands and marginal lands owned by the farmers should be put under pasture from both the economic and resource conservation point of view (Yadav and Rajora, 1995). This may reduce the hazards of soil erosion and adverse effect of drought on animal population in arid and semi-arid regions. In this context, Guinea grass (*Panicum maximum* Jacq.) and Caribbean Stylo (*Stylosanthes hamata)* are main pasture species suitable for higher forage production from these areas. Guinea grass is a high yielding perennial forage grass that performs well in 900 to 1500 mm rainfall range, but can survive even when rainfall is less than 400 mm. It has profuse tillers, quick regeneration and high leaf-stem ratio provides highly nutritious, digestible and palatable forage. It can be easily propagated both by seeds and vegetative means and performs well under shade of trees and saline sodic soil conditions. *S. hamata* is a perennial forage legume provides cheaper source of quality feed and enhances animal productivity when grown with grasses in the tropics (Thomas *et al.*, 1997). Being a legume, it enriches the soil fertility and benefits the associated grasses. Row ratios and fertilizer management in intercropping have important bearing on the component crops and their productivity. The nutrient management based on inorganic and organic fertilizers could provide a viable option for sustainable forage production. Therefore, the present experiment was under taken to study the effect of row ratios and fertility levels on growth, productivity, quality and economics of Guinea grass-*S. hamata* intercropping system under rainfed conditions.

Materials and Methods

A field experiment was conducted during July 2003-2007 at Central Research Farm (25°27′ N latitude, 78°37′ E longitude and 275 m above mean sea level) of Indian Grassland and Fodder Research

Institute, Jhansi, to study the effect of row ratios and fertility levels on growth, productivity, quality and monetary returns from Guinea grass-*S. hamata* intercropping system under rainfed conditions. The soil of the experimental field was sandy loam, low in organic carbon (0.38, 0.41, 0.43 and 0.46%), available nitrogen (148.4, 158.8, 165.0 and 173.5 kg ha^{-1}) and phosphorus (8.30, 8.46, 8.58 and 8.73 kg ha^{-1}) and medium in available potash (161.3, 165.7, 171.5 and 179.3 kg ha^{-1}) during first, second, third and fourth years, respectively. The total rainfall received was 1187.10, 486.10, 440.7 and 416.2 mm in 37, 30, 31 and 33 rainy days during 2003, 2004, 2005 and 2006, respectively. There were 18 treatment combinations replicated thrice in split plot design. The treatments comprised of six intercropping systems of Guinea grass (*Panicum maximum*) and *S. hamata* viz. (i) grass sole, (ii) legume sole, (iii) 1:1, (iv) 2:2, (v) 3:3 and (vi) 4:4 row ratios of grass-legume and three fertility levels viz. (i) recommended dose of fertilizer (NPK), (ii) 50% of the recommended dose of fertilizer (RDF) + 5.0 t ha^{-1} farmyard manure (FYM) and (iii) 75% of the RDF + 5.0 t ha^{-1} FYM. The recommended dose of NPK for sole Guinea grass, sole *S. hamata* and alternate row of grass-legume intercropping were applied every year @ of 80:30:30, 20:40:30 and 60:40:40 kg ha^{-1}, respectively, and for row ratios 2:2, 3:3 and 4:4 the RDF of sole Guinea grass and sole *S. hamata* were applied in their respective strips. The seedlings of Guinea grass were transplanted in the month of July. The crops were harvested during August to November and observations were recorded at the time of harvest. In this experiment the narrow row ratio means 1:1 row ratio of Guinea grass and *S. hamata* intercropping. The 2:2, 3:3 and 4:4 row ratios are wider row ratios of Guinea grass and *S. hamata* intercropping.

Relative crowding coefficient (RCC) was calculated following De Wit (1960):

RCC = Yield of intercrops/(yield of sole crop – yield of intercrops)

The experiment was laid out in replacement series. Dry matter content was estimated by drying 500 g plant sample of each treatment and replication in hot-air oven at 70°C. The crude protein was estimated by the procedure of AOAC (1995).

Results and Discussion

Growth parameters

Intercropping of *S. hamata* with Guinea grass in 2:2 row ratio recorded significantly higher leaf-stem ratio of Guinea grass as compared to its sole stand (**Table** 1). In *S. hamata* significantly higher plant height and number of branches/plant were observed in its sole stand as compared to alternate row of grass-legume intercropping and it was at par with row ratios of 2:2, 3:3 and 4:4 (Table 1).

Growth parameters viz. plant height, leaf-stem ratio and number of branches/ plant of both Guinea

Table 1. Effect of intercropping row ratios and fertility levels on growth parameters and dry matter yield of Guinea grass and S. hamata (Pooled data of 4 years)

Treatment	Guinea Grass		*S. hamata*		Dry matter yield (t ha^{-1})		
	Height (cm)	Leaf-stem ratio	Height (cm)	Branches/ plant	G	L	Total
Intercropping							
G sole	136.9	0.75	–	–	4.60	–	4.60
L sole	–	–	51.4	5.8	–	2.96	2.96
G+L (1:1)	144.2	0.83	43.3	4.2	3.12	1.29	4.41
G+L (2:2)	145.8	0.86	47.6	5.4	3.21	1.80	5.01
G+L (3:3)	142.3	0.82	49.0	5.4	3.05	1.87	4.92
G+L (4:4)	140.7	0.79	50.3	5.7	2.90	1.92	4.82
CD (P=0.05)	NS	0.09	4.8	0.6	0.49	0.24	0.42
Fertility levels							
RDF (NPK)	133.9	0.74	44.9	4.5	2.97	1.76	4.73
50%RDF+5t FYM	141.0	0.81	47.5	5.1	3.32	1.92	5.24
75%RDF+5t FYM	151.1	0.90	52.4	6.3	3.84	2.23	6.07
CD (P=0.05)	9.2	0.06	3.2	0.4	0.33	0.16	0.40

G: Guinea grass, L: *S. hamata*, Total: Guinea grass + *S. hamata*.

Table 2. Crude protein yield, land equivalent ratio, relative crowding coefficient and economics of Guinea grass and S. hamata as influenced by intercropping row ratios and fertility levels (Pooled data of 4 years)

Treatment	Crude protein yield ($kg\ ha^{-1}$)			Land equivalent ratio	Relative crowding coefficient		Net return ($Rs.\ ha^{-1}$)	Return/Re . invested
	G	L	Total		G	L		
Intercropping								
G sole	298.9	–	298.9	–	–	–	2200	0.32
L sole	–	365.1	365.1	–	–	–	1684	0.27
G+L (1:1)	208.9	155.1	364.0	1.14	2.15	0.80	3203	0.44
G+L (2:2)	219.1	219.7	438.8	1.32	2.36	1.56	5103	0.72
G+L (3:3)	199.5	229.6	429.1	1.29	1.88	1.72	4655	0.67
G+L (4:4)	191.6	237.0	428.6	1.29	1.78	1.86	4866	0.60
CD (P=0.05)	31.6	33.8	34.2	–	–	–	–	
Fertility levels								
RDF (NPK)	193.0	168.0	361.0	1.23	1.95	1.38	4047	0.68
50%RDF+5 t FYM	218.9	234.9	453.8	1.24	1.95	1.46	3703	0.46
75%RDF+5 t FYM	258.9	276.6	535.5	1.30	2.22	1.62	5276	0.67
CD (P=0.05)	20.6	22.4	32.7	–	–	–	–	–

G: Guinea grass, L: *S. hamata,* Total: Guinea grass + *S. hamata.*

grass and *S. hamata* also significantly increased with the application of 75% of the RDF in combination with 5 t ha^{-1} FYM over recommended dose of fertilizer and 50% of the RDF + 5 t ha^{-1} FYM (Table 1). It is evident that pasture receiving 75% of the recommended dose of fertilizer + 5.0 t ha^{-1} FYM was benefited due to favorable soil physical environment in the root zone and availability of nutrients throughout growth period. These findings confirm the observations of George and Pillai (2000), Arya *et al.* (2000) and Sunil Kumar *et al.* (2004).

Dry forage yields

Dry forage yields were significantly influenced with row ratios and fertility levels (Table 1). Intercropping of Guinea grass with *S. hamata* in 2:2 row ratio produced significantly higher total dry forage yield as compared to sole stand and alternate rows of grass and legume and it was at par with 3:3 and 4:4 row ratios. This might be due to more favorable environment for growth of both Guinea grass and *S. hamata* in 2:2 row ratio of grass-legume intercropping system. Higher yields in paired row planting were also obtained by Hazra and Pradeep Behari (1993) and Singh (2000). 28.33% higher dry matter yield of *S. hamata* was recorded in 2:2 row ratio of grass-legume intercropping over alternate row (1.29 t ha^{-1} dry matter yield). Forage yield of *S. hamata* decreased more in narrow row ratios of grass-legume intercropping than in wider row ratios owing to competitive effect of grass, leading to lower growth parameters of legumes.

Combined application of 75% of the RDF and 5 t ha^{-1} FYM gave significantly higher total dry forage yields as compared to RDF and 50% of the RDF + 5 t ha^{-1} FYM. The difference in dry forage yields with the application of RDF and 50% of the RDF + 5 t ha^{-1} FYM was also significant. The dry matter yields obtained from the RDF was reduced by 28.32% over 75% of the RDF + 5 t ha^{-1} FYM (Table 1). The beneficial effects of organic and inorganic fertilizers in terms of sustained production could be related to the enhanced biological activities in the rhizosphere, improved soil structure and increased nutrient availability. These results corroborate with the findings of Arya *et al.* (2000), George and Pillai (2000) and Sunil Kumar *et al.* (2004). The effect of interaction between intercropping having different row ratios and fertility levels was found to be non-significant.

Crude protein yield

The different intercropping row ratios and fertility levels also significantly affected the crude protein yield of pasture (Table 2). Crude protein yield was significantly increased with the intercropping of Guinea grass and *S. hamata* in 2:2 row ratio than sole stand of both grass and legume and 1:1 row ratio and it was statistically at par with 3:3 and 4:4 row ratios. This was due

Table 3. *Effect of intercropping row ratios and fertility levels on N, P and K uptake by Guinea grass and S. hamata (Pooled data of 4 years)*

Treatment	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	G	L	T	G	L	T	G	L	T
Intercropping									
G sole	47.87	–	47.87	15.91	–	15.91	136.64	–	136.64
L sole	–	58.34	58.34	–	4.46	4.46	–	38.39	38.39
G+L (1:1)	35.18	24.78	57.96	10.29	1.86	12.15	88.84	16.02	104.86
G+L (2:2)	34.71	35.11	69.82	10.68	2.62	13.30	91.73	22.48	114.21
G+L (3:3)	32.39	36.69	69.08	10.22	2.73	12.95	87.68	23.51	111.19
G+L (4:4)	30.38	37.78	68.18	9.82	2.85	12.67	84.06	24.50	108.57
CD (P=0.05)	6.42	6.21	12.46	1.98	0.52	2.48	16.42	3.61	20.52
Fertility levels									
RDF (NPK)	30.91	35.98	64.89	10.55	2.56	13.11	84.77	21.93	106.70
50%RDF+5 t FYM	35.09	37.43	72.52	11.84	2.80	14.64	95.59	23.99	119.58
75%RDF+5 t FYM	41.65	44.15	85.50	13.92	3.34	17.26	112.81	28.42	141.23
CD (P=0.05)	4.28	4.06	8.31	1.32	0.34	1.65	10.95	2.36	13.68

G: Guinea grass, L: *S. hamata,* T: Guinea grass + *S. hamata.*

to higher dry matter yield with intercropping of grass and legume in 2:2 row ratio. Application of 75% of the RDF + 5 t ha^{-1} FYM also recorded significantly higher crude protein yield than other fertility levels. The gain in crude protein yield was maximum (174.5 kg ha^{-1}) with the application of 75% of the RDF + 5 t ha^{-1} FYM over RDF (Table 2). Sunil Kumar *et al.* (2004) also found improvement in crude protein content and yields of forage crops with the use of FYM. The interaction effect between intercropping row ratios and fertility levels was not significant.

Land equivalent ratio

Intercropping of Guinea grass with *S. hamata* resulted in land equivalent ratio greater than 1, indicating benefit of intercropping. It was higher in 2:2 row ratio (1.32) when compared to alternate row of grass-legume (1.14). In fertility levels, maximum LER was recorded at 75% of the RDF + 5 t ha^{-1} FYM and it was lowest in the treatment where only inorganic fertilizers were applied (Table 2).

Relative crowding coefficient

Guinea grass and *S. hamata* maintained relative crowing coefficient (RCC) values above 1 in all the intercropping systems indicating both grass and legume produced more yield than expected, except in alternate rows of grass-legume (1:1) intercropping where *S. hamata* gave RCC values below 1, as its yield was less than expected. The RCC values were maximum in 2:2 row ratio of grass-legume intercropping, which indicated comparative yield advantage of this system over other combinations. Application of 75% of the RDF + 5 t ha^{-1} FYM gave higher values of RCC of both grass (2.22) and legume (1.62) as compared to RDF and 50% of the RDF + 5 t ha^{-1} FYM during all four years (Table 2).

Nutrients uptake

Nutrients uptake was significantly influenced by crop row ratio and fertility levels (Table 3). Sole crops of Guinea grass and *S. hamata* had significantly higher uptake of nitrogen (47.87 and 58.34 kg ha^{-1}), phosphorus (15.91 and 4.46 kg ha^{-1}) and potash (136.64 and 38.39 kg ha^{-1}), than under intercropping systems. Maximum combined uptake of nitrogen (69.82 kg ha^{-1}), phosphorus (13.30 kg ha^{-1}) and potash (114.21 kg ha^{-1}) were recorded when Guinea grass + *S. hamata* was grown in 2:2 row ratio, mainly due to greater dry matter accumulation in the system.

Combined application of 75% of the RDF and 5 t ha^{-1} FYM resulted in significantly higher uptake of nitrogen (41.65 and 44.15 kg ha^{-1}), phosphorus (13.92 and 3.34 kg ha^{-1}) and potash (112.81 and 28.42 kg ha^{-1}) by Guinea grass and *S. hamata,* respectively. However, the difference in uptake of nitrogen, phosphorus and potash with the application of 50% of the RDF + 5 t ha^{-1} FYM and RDF was not significant (Table 3).

Economic returns

The maximum net returns (Rs. 5,103 ha^{-1}) as well as net return per rupee invested (0.72) were obtained in 2:2 row ratio of grass-legume intercropping. The lowest net returns (Rs. 1,684 ha^{-1}) and net return per rupee invested (0.27) were recorded from sole stand of *S. hamata*. Among fertility levels, highest net returns (Rs. 5,276 ha^{-1}) and net return per rupee. invested (0.55) were achieved with application of 75% of the RDF in combination with 5 t ha^{-1} FYM followed by application of the recommended dose of the fertilizer with net returns Rs. 4,047 ha^{-1} and net return per rupee invested 0.45.

Effect of weather on forage yield during various years

Guinea grass and *S. hamata* are perennial in nature, so their productivity was not only affected by weather but also by their survival, growth and yield in subsequent years as their planting and sowing was only done in first year. In first year the dry forage yield of Guinea grass (2.83 t ha^{-1}) and *S. hamata* (1.77 t ha^{-1}) was lowest. The yields of both Guinea grass (3.82 t ha^{-1}) and *S. hamata* (2.28 t ha^{-1}) were highest in the second year, and declined there after. The decrease in forage yield in third and fourth year was might be due less rainfall during these years.

Thus, intercropping of Guinea grass with *S. hamata* in paired row (2:2 ratio) along with combined application of 75% of the RDF and 5 t ha^{-1} FYM was found adequate for higher growth, productivity, quality and monetary return under rainfed semi-arid conditions.

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