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Productivity of forage-based farming systems with farm-boundary plantations of shisham (*Dalbergia sissoo*) under rainfed condition

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 1993-94 to 1995-96 at the Indian Grassland and Fodder Research Institute, Jhansi to study the different food-fodder cropping systems and manurial schedules under rainfed conditions. Significantly higher grain and stover yields of sorghum were obtained in sorghum + pigeonpea/*Cenchrus setigerus* intercropping system compared with that in sorghum + cowpea intercropping system. Sorghum + cowpea intercropping produced significantly more green fodder and dry-matter yields of fodder crops than sorghum + grass strips plots. Sorghum grain-equivalent yield was more in sorghum + pigeonpea followed by sorghum + cowpea and sorghum + grass strips plots. Among the different manurial schedules, combined application of organic and inorganic sources of plant nutrients produced significantly higher grain and stover yields of sorghum, green fodder and dry-matter yields of fodder crop as well as sorghum grain-equivalent yield compared with 100% through inorganic fertilizers application. The survival of trees under rainfed condition was 84.3% after 20 months of their establishment. The tree attained 103.4 cm height and 1.33 cm collar diameter under rainfed condition.

Key words : Shisham, Farming system, Farm boundary, Rainfed, Agroforestry, *Cenchrus setigerus*, Pole tree, Manurial schedules

Under dryland condition of Bundelakhand region, monocropping is commonly practiced. Inclusion of short-duration fodder crops in the existing system increases the possibility of double cropping. This system is aimed at increasing the productivity per unit area and assuring against total crop failure, especially under aberrent weather conditions. The productivity and sustainability of food-fodder system could be stabilized by the judicious use of organic sources of plant nutrients through farmyard manure (FYM) and leaf green-manuring. Multipurpose tree species are planted on

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the boundary of agricultural land. The lopped material of trees from hedge rows of alley cropping could be utilized either as feed supplements for feeding to the animals during lean period or as mulch to conserved soil moisture under dryland condition and substituting the inorganic fertilizers (N) to the extent of 10-30 kg/ha through use to leaf green-manuring. To impart stability and provide sustainability of different manurial schedules and food-fodder intercropping in agroforestry systems under rainfed conditions this experiment was undertaken.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 1993-94 to 1995-96 at the Indian Grassland and Fodder Research Institute, Jhansi to study the performance of different cropping systems and manurial schedules in farm-boundary plantations of *Delbergia sissoo* under rainfed condition. The treatment combinations comprised three cropping systems, viz. sorghum ('CSH 5') + cowpea ('EC 4216') (additive series of 1:1), sorghum + pigeonpea ('Bahar') (replacement series of 2 : 1) and sorghum + grass strips of *Cenchrus setigerus* 4 : 1 metres apart; and three manurial schedules, viz. 100% recommended dose (60 kg N + 40 kg P_2O_5/ha) through inorganic fertilizers, 50% through inorganic fertilizers + 50% through organic manure (FYM @ 6 t/ha), and 50% through inorganic fertilizers + 50% through leaf manuring (3 t *Leucaena* dry leaves/ha). The experiment was laid out in randomized block design with three replications. The soil texture was gravelly coarse with pH 7.25. It was low in organic matter (0.38%), available N (166.0 kg/ha) and available P (6.7 kg/ha) and medium in available K (158.0 kg/ha). The crops were sown in the second week of July, and fodder crop of cowpea was harvested in the first week of September, grass in the last week of September and pigeonpea in the first week of April in the respective year of experimentation. The experimental plot was kept 18 × 16 m^2 (gross) and 16 × 14 m^2 (net). Recommended seed rates were used and fertilizer doses were applied as per treatment. Sorghum, cowpea, pigeonpea and grass were kept 50 cm apart, and spacing of farm-boundary plantation of *Dalbergia sissoo* was maintained 4 m plant-to-plant. One cutting of grass was taken during the first and second years, whereas in the third year two cuttings were taken. During 1994-95 there was no grain formation of sorghum and pigeonpea, because of low amount of rainfall received during the entire crop-growth period. From the standard meteorological week 33 (13-19 August) onwards very little (< 20 mm/week) or no amount of rainfall was received due to 'break' in south-west monsoon. This critical dry period coincides with the vegetative growth period of the crop under experimentation. Therefore flowering and grain formation could not take place. Rainfall received during the crop-growth season was 668, 456 and 787 mm during 1993-94, 1994-95 and 1995-96 respectively.

RESULTS AND DISCUSSION

Growth attributes

Data pertaining to growth attributes of main crop (sorghum) and intercrops are

Table 1. Growth attributes as affected by different cropping systems and manurial schedules under farm-boundary plantations

Treatment	Plant population/ running metre		Plant height cm		No. of leaves/ plant		Dry-matter accumulation/plant (g)		Root weight/ plant (g)		No. of nodules/ plant
	Main crop	Inter-crop	Main crop	Inter-crop	Main crop	Inter-crop	Main crop	Inter-crop	Main crop	Inter-crop	
Cropping system											
Sorghum + cowpea	8.56	8.10	137.41	82.89	8.85	4.54	17.37	59.46	6.12	0.61	54.28
Sorghum + pigeonpea	10.33	8.10	144.63	124.29	10.85	32.04	20.76	92.36	7.32	15.04	82.35
Sorghum + *Cenchrus setigerus*	10.11	5.67	145.22	75.67	11.74	3.42	20.93	81.67	7.69	0.84	-
CD (P = 0.05)	NS	1.38	3.12	8.40	1.05	3.09	2.16	6.90	1.11	1.68	5.10
Manurial schedule											
100% I.F.	8.44	6.00	129.12	84.58	9.85	10.01	16.22	63.78	6.30	3.56	35.43
50% I.F. + 50% O.M.	9.56	7.33	141.60	94.71	10.56	13.48	20.70	78.48	7.13	6.00	44.85
50% I.F. + 50% L.M.	11.00	8.55	156.54	103.58	11.04	16.50	12.14	91.24	7.71	6.93	56.96
CD (P = 0.05)	1.83	1.38	3.12	8.40	1.05	3.09	2.16	6.90	1.11	1.68	5.10

I.F. = Inorganic fertilizers; O.M. = organic manure (6 t FYM/ha); and L.M. = leaf manuring (3 t *Leucaena* leaves)

shown in Table 1. Sorghum + grass strips of *Cenchrus setigerus* produced significantly taller plant height, more number of leaves/plant, higher dry-matter accumulation/plant and more root weight/plant compared with sorghum + cowpea intercropping system. Sorghum + pigeonpea intercropping also increased significantly more growth attributes and number of nodules/plant than sorghum + cowpea intercropping. Application of 50% recommended dose of inorganic fertilizers + 50% through 3 t/ha *Leucaena* leaves produced significantly more plant population per running metre, plant height, number of leaves/plant, dry-matter accumulation/plant, root weight/plant and number of nodules/plant in main as well as intercrops compared with that of 100% recommended dose through inorganic fertilizers. The increase in growth attributes with the combined use of organic and inorganic sources of fertilizers might be due to the availability of plant nutrients throughout the maturity period.

Grain and stover yields

Results revealed (Table 2) that significantly higher grain (6.86 q/ha) yield of sorghum was obtained in the pooled data in sorghum + pigeonpea intercropping compared with that in sorghum + cowpea intercropping system. Sorghum + grass strips of *Cenchrus setigerus* registered significantly more pooled stover (57.87 q/ha) yields of sorghum than sorghum + cowpea intercropping. Intercropping systems increased the total productivity in addition to stability in production under rainfed conditions (Reddy and Willey, 1980). Umrani (1981) and Jadhav *et al.* (1991) reported that intercropping is more stable and remunerative than sole cropping during *kharif* season. Significantly more pooled grain (6.92 q/ha) and stover (52.59 q/ha) yields over 100% through inorganic fertilizers.

Green-fodder and dry-matter yields

Sorghum + cowpea intercropping gave significantly more green fodder (120.59 q/ha) and dry-matter (32.42 q/ha) yields than sorghum + grass strips of *Cenchrus setigerus,* yielding 47.01 q green–fodder and 12.45 q dry-matter yields/ha. Poor fodder yield of grass during the first and second years was obtained due to its establishment and poor plant stand. Niranjan *et al.* (1998) reported that the intercropping of sorghum/pigeonpea with fodder crops gave significantly more fodder yield than the sole crops without jeopardising the yield of main crops.

Application of recommended dose of plant nutrients, 50% through inorganic fertilizers + 50% through 3 t *Leucaena* leaves/ha produced significantly higher green–fodder (58.29 q/ha) and dry-matter (14.34 q/ha) yields than that of 100% through inorganic fertilizers. Combined application of 50% through inorganic fertilizers + 50% through organic manure (FYM @ 6 t/ha) ranked the second-best treatment for producing higher green–fodder (56.71 q/ha) and dry-matter (13.93 q/ha) yields than 100% inorganic fertilizers. Arya and Niranjan (1994) reported that significantly higher fodder yield was obtained with combined use of organic and inorganic sources of N compared with inorganic fertilizers in sorghum + cowpea intercropping under rainfed condition.

Table 2. Productivity of food-fodder cropping systems and manurial schedules with farm-boundary plantations of *Dalbergia sissoo*

Treatment	Yield (q/ha)																			
	Grain			Stover				Green fodder				Dry-matter				Sorghum-grain equivalent				
	1993-94	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled	1993-94	1994-95	1995-96	Pooled	
Cropping system																				
Sorghum + cowpea	7.31	3.72	5.52	46.72	31.61	49.88	44.74	140.08	108.94	112.76	120.59	42.02	21.79	22.55	32.42	22.68	23.35	26.24	22.09	
Sorghum + pigeonpea	9.67	4.06	6.86	43.79	65.66	53.82	54.42	– (2.50)	– (0.54)	– (2.27)	– (1.77)	-	-	-	-	41.70	11.90	21.98	25.19	
Sorghum + *Cenchrus setigerus*	8.34	3.93	6.13	37.88	81.79	53.93	57.87	1.93	19.06	120.05	47.01	0.96	6.38	30.01	12.45	32.69	7.77	25.71	22.05	
CD (P = 0.05)	0.19	0.15	0.27	5.76	6.24	NS	5.30	2.22	1.53	5.68	3.24	1.05	0.46	0.84	1.11	1.44	1.50	1.62	1.98	
Manurial schedule																				
100% I. F.	7.09	3.51	5.30	36.26	51.89	47.68	45.28	44.71	41.27	72.48	52.82	13.53	9.08	16.43	13.01	28.22	12.59	21.79	20.86	
50% I. F. + 50% O. M.	8.62	3.96	6.29	40.39	63.61	53.78	52.59	48.35	43.47	78.31	56.71	14.62	9.56	17.61	13.93	33.23	13.99	25.02	24.08	
50% I.F. + 50% I. M.	9.61	4.23	6.92	51.73	69.56	56.17	59.15	49.16	43.47	82.24	58.29	14.88	9.56	18.57	14.36	35.62	16.45	27.11	26.39	
CD (P = 0.05)	0.19	0.15	0.27	5.76	6.24	5.16	5.30	2.22	1.53	5.68	3.24	1.05	0.46	0.84	1.11	1.44	1.50	1.60	1.98	

Figures in parentheses show grain yield of pigeonpea
I.F. = Inorganic fertilizer; O.M. = organic manure; L.M. = leaf manure

Sorghum grain–equivalent yield

Table 2 shows that significantly highest pooled sorghum grain-equivalent (25.19 and 24.09 q/ha) yield was obtained in sorghum + pigeonpea and sorghum + cowpea intercropping systems respectively compared with that in sorghum + grass strips of *Cenchrus setigerus*. Among the different manurial schedules, combined application of inorganic and organic sources of plant nutrients produced significantly more sorghum grain-equivalent (26.39 and 24.08 q/ha) yield than 100% through inorganic fertilizers (20.86 q/ha) in the respective years as well as on pooled basis. Goyal *et al.* (1991) reported that higher sorghum grain– equivalent yield was obtained in pigeonpea + sesame intercropping system compared with sole pigeonpea under rainfed condition. Incorporation of *Leucaena* leaves available from hedge rows can be a substitute for fertilizer N to the extent of 10-30 kg/ha, thereby reducing the cost of cultivation of sorghum (Subba Reddy *et al.* 1990).

Performance of tree

Growth performance of pole (*Dalbergia sissoo*) trees under rainfed condition was 84.3% after 20 months of their establishment. Since the survival of trees during hot summer decreased to 56.3%, gap filling was done in the monsoon to make uniform tree line. The tree attained 103.4 cm height and 1.33 cm collar diameter under rainfed condition. *Dalbergia sissoo* plantation on field boundary did not have significant effect on the yield of groundnut in *kharif* and wheat in *rabi*. However, rows near to trees showed reduction in yield (Gill and Rai, 1995).

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