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Effect of planting geometry and cutting management on productivity, quality and economics of mixed pasture under rainfed conditions

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ABSTRACT

A field experiment was conducted on sandy-loam soil for 5 years (1997–98 to 2001–02) at Jhansi, Uttar Pradesh, to study the effect of planting pattern and harvest intervals on yield, quality and monetary return of pasture under rainfed semi-arid conditions. Four methods of planting geometry of grasses, viz. *Pennisetum* trispecific hybrid [(*Pennisetum americanum* × *Pennisetum purpureum*) × *Pennisetum squamulatum*], *Pennisetum pedicellatum, Chrysopogon fulvus* and *Andropogon gayanus* and legumes, viz. *Stylosanthes hamata, Stylosanthes scabra, Macroptillium atropurpureum, Clitoria ternatea* and *Atylosia scarabaoides* (1:1–50 cm, 1:2–50 cm, 1:1–75 cm and 1:2–75 cm apart), and four harvesting intervals (45, 70, 95 and 120 days) in mixed pastures were studied. Planting of grasses and legumes in 1:1 row ratio at 50 cm distance resulted in significantly higher green forage (22.0 t/ha) and dry-matter yield (5.41 t/ha) compared with 1:2 row ratio at 75 cm distance (green forage 19.31 t/ha and dry matter 4.61 t/ha) during all the 5 years. Total green forage (23.2 t/ha) and dry-matter yield (5.62 t/ha) was also significantly increased with the harvesting of pasture at 70–day interval than other harvest intervals. The highest net returns (Rs 5,717/ha) and benefit : cost ratio (0.76) were obtained in 1:1 row ratio at 50 cm distance. Among harvesting treatments, highest net returns (Rs 6,793/ha) and benefit : cost ratio (1.95) were achieved with 70-day harvest interval. The significant improvement in crude-protein content (grasses 6.55% and legumes 11.4%) and reduction in neutral detergent fibre (grasses 67.87% and legumes 52.81%) and acid detergent fibre (grasses 47.72% and legumes 36.69%) in forage was recorded in 1:2 row ratio of grass–legume intercropping than 1:1 row ratio at 75 cm distance. Harvesting of pasture at 45 days interval resulted in significantly higher crude protein content (grasses 6.98% and legumes 11.35%) and lower neutral detergent fibre (grasses 64.25% and legumes 48.18%), acid detergent fibre (grasses 45.26% and legumes 33.42%) compared with 70 days, 95 days and 120 days harvest intervals, respectively in all the 5 years.

Key words : Economics, Forage quality, Forage yield, Harvest intervals, Mixed pasture, Planting geometry

Improvement of degraded grazing lands for sustainable forage production is a necessity at present to meet the ever-increasing demand for quality forage to feed growing livestock population of India. In such a situation, introduction of suitable grass + legume mixture and cutting management practice would be helpful in improving the productivity, quality and distribution of the forage (Basak *et al.,* 2003; Ramamurthy and Vinod Shankar, 1998). Legume-usually maintain their quality better than grasses even at maturity and being rich in protein, enhance the forage value and, also add substantially the much-needed nitrogen to the soil. The mixture also checks soil erosion, resists the encroachment of weeds and withstands the vagaries of weather better than pure stand. Farmers in general are reluctant to cutting management practice, as a result most of the grass species are overmatured, which deteriorates the quality of the forage. The dry-matter content increased with delay in harvesting from 35 to 49 days intervals, while crude protein content decreased with delay in cutting (Singh *et al.,* 2000). Thus forage grasses should be harvested at an appropriate growth stage to obtain green forage with acceptable dry matter content and nutrient, particularly protein. Hence the present study was conducted with the aim to find out the effect of planting pattern and harvest intervals on yield and quality of mixed pasture.

MATERIALS AND METHODS

A field experiment was carried out for 5 years (1997-98 to 2001-02) at Central Research Farm of Indian Grassland

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and Fodder Research Institute, Jhansi, Uttar Pradesh. The soil was sandy loam, low in available N (268 kg/ha) and P (5.46 kg/ha) and medium in available K (226 kg/ha) and organic carbon (0.62%). The total rainfall of 828, 990, 905, 1,118 and 1,174 mm was received in 52, 42, 52, 37 and 51 rainy days during 1997, 1998, 1999, 2000 and 2001 respectively. Sixteen treatment combinations were imposed in factorial randomized block design in plot size of 5.25 × 4.5 m. The treatments comprised four planting geometry of grasses and legumes, viz. 1:1 (50 cm apart), 1:2 (50 cm apart), 1:1 (75 cm apart) and 1:2 (75 cm apart), and four harvest intervals, viz. 45, 70, 95 and 120 days. Four grasses, viz. *Pennisetum* trispecific hybrid [(*Pennisetum americanum* × *Pennisetum purpureum*) × *Pennisetum squamulatum*], *Pennisetum pedicellatum* (perennial Dinanath), *Chrysopogon fulvus* and *Andropogon gayanus*; and 5 legumes, viz. *Stylosanthes hamata, Stylosanthes scabra, Maroptillium atropurpureum, Clitoria ternatea* and *Atylosia scarabaoides,* were sown together in separate rows in a mixed pasture. Rooted slips of old tussock of four grasses were mixed together as per their recommended rates and transplanted in July. The seeds of five legumes were also mixed together as per their recommended seed rates and were sown in lines between 2 rows of grasses. Recommended doses of N (30 kg/ha), P (17.5 kg/ha) and K (25 kg/ha) were applied to the experimental plots. Forage was harvested as per cutting treatment plot-wise and green forage was recorded. The plant samples were oven-dried at 80 °C to record dry-forage yield. The plant samples were analysed for crude protein content according to AOAC (1995), and neutral detergent fibre (NDF) and acid detergent fibre (ADF) by the methods of Georing and Vonsoest (1970). The sale price of green-forage yield of grasses (Rs/q) harvested at 45, 70, 90 and 120 days interval were Rs 45, 40, 35 and 30 during 1997 and 1998; Rs 50, 44, 38 and 33 during 1999 and 2000; and Rs 50, 45, 40 and 35 during 2001 respectively. However, the sale price of green-forage yield of legumes (Rs/q) were Rs 50 during 1997 and 1998; Rs 55 during 1999 and 2000; and Rs 60 during 2001.

RESULTS AND DISCUSSION

Green- and dry-forage yields

Planting geometry and harvest intervals significantly affected the green- and dry-forage yields of mixed pasture (Tables 1, 2). Planting of grasses and legumes in 1:1 row ratio at 50 cm distance resulted in significantly higher green-forage and dry-matter yields of grasses than planting in 1:2 row ratio, both at 50 cm and 75 cm distance and it was on par with 1:1 row ratio at 75 cm distance. However, significantly higher green-forage and dry-matter yields of legumes were obtained when these were intercropped with grasses in 1:2 row ratio both at 50 cm and 75 cm distance. The total green-forage and dry-matter yields were also significantly increased with intercropping of grasses and legumes in 1:1 row ratio at 50 cm distance compared to 1:2 row ratio at 75 cm distance, and it was significantly at par with 1:2 row ratio at 50 cm distance and 1:1 row ratio at 75 cm distance during all the 5 years. The higher total green-forage and dry-matter yield owing to planting of grasses and legumes in 1:1 row ratio might be due to better utilization of space, light, nutrient, moisture etc. than other planting geometry.

Green-forage and dry-matter yields of grasses were significantly increased with 70 days harvest interval than 45 days and 120 days intervals and it was at par with 95 days harvest interval (Tables 1, 2). However, significant increase in green-forage and dry-matter yields of legumes were recorded with harvest of grasses at 45 days interval compared to 70, 95 and 120 days intervals during all the years. This might be due to less competitive effect of grasses over legumes because of early harvest of grasses.

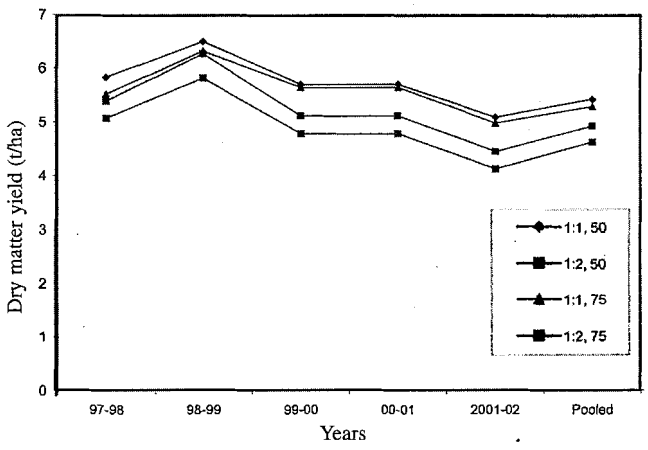

Figure 1. Effect of planting geometry and harvest intervals on total dry-matter yield of mixed pasture

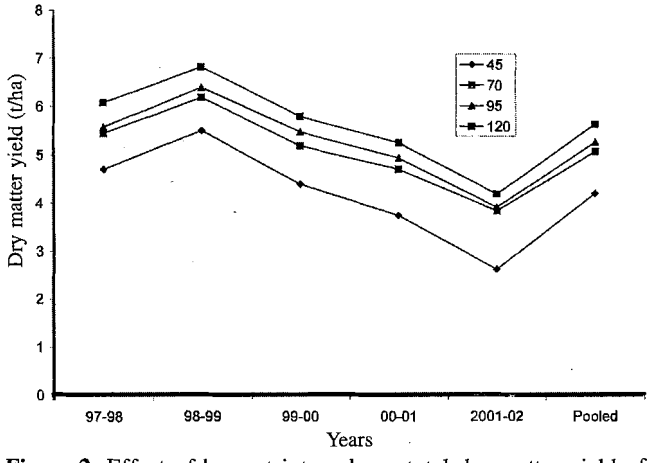

Figure 2. Effect of harvest intervals on total dry-matter yield of mixed pasture

Table 1. Effect of planting geometry and harvest intervals on green-forage yield (t/ha) of mixed pasture

Treatment	1997–98			1998–99			1999–00			2000–01			2001–02			Pooled		
	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total
Grass–legume ratios and spacing (cm)																		
1:1, 50	18.55	5.29	23.84	22.20	4.15	26.35	19.32	3.49	22.80	17.98	2.67	20.65	14.93	1.44	16.37	18.59	3.41	22.00
1:2, 50	16.53	6.45	22.98	20.21	5.66	25.87	15.79	4.81	20.60	15.29	3.60	18.89	12.68	2.05	14.75	16.10	4.51	20.61
1:1, 75	17.49	5.41	22.90	20.94	4.45	25.39	18.32	3.69	22.01	17.09	2.81	19.90	14.20	1.55	15.75	17.61	3.58	21.19
1:2, 75	15.81	6.14	21.95	18.86	5.23	24.09	14.75	4.42	19.17	14.17	3.45	17.62	11.84	1.89	13.73	15.09	4.22	19.31
SEm±	0.48	0.17	0.58	0.58	0.14	0.71	0.53	0.17	0.61	0.45	0.08	0.55	0.39	0.05	0.45	0.52	0.13	0.64
CD (P=0.05)	1.54	0.53	1.86	1.83	0.46	2.26	1.68	0.53	1.94	1.44	0.25	1.75	1.25	0.16	1.43	1.65	0.40	2.05
Harvest intervals (days)																		
45	15.52	6.55	22.07	18.18	5.72	23.90	12.50	4.85	17.35	12.71	3.86	16.57	10.53	2.05	12.58	13.89	4.60	18.49
70	18.54	5.90	24.44	22.59	5.03	27.62	20.22	4.27	24.49	18.75	3.24	21.99	15.65	1.88	17.53	19.15	4.06	23.21
95	17.34	5.59	22.93	20.98	4.59	25.57	18.11	3.86	21.97	17.22	2.81	20.03	14.20	1.58	15.78	17.57	3.68	21.25
120	16.96	5.27	22.23	20.26	4.15	24.41	17.34	3.43	20.77	15.86	2.62	18.48	13.28	1.43	14.71	16.74	3.38	20.12
SEm±	0.48	0.17	0.58	0.58	0.14	0.71	0.53	0.17	0.61	0.45	0.08	0.55	0.39	0.05	0.45	0.52	0.13	0.64
CD (P=0.05)	1.54	0.53	1.86	1.83	0.46	2.26	1.68	0.53	1.94	1.44	0.25	1.75	1.25	0.16	1.43	1.65	0.40	2.05

G, Grasses; L, legumes

Table 2. Effect of planting geometry and harvest intervals on dry-forage yield (t/ha) of mixed pasture

Treatment	1997–98			1998–99			1999–00			2000–01			2001–02			Pooled		
	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total
Grass-legume ratios and spacing (cm)																		
1:1, 50	4.78	1.04	5.82	5.65	0.84	6.49	4.92	0.77	5.69	4.51	0.57	5.08	3.69	0.29	3.98	4.71	0.70	5.41
1:2, 50	4.51	1.23	5.38	5.16	1.10	6.26	4.09	1.01	5.10	3.71	0.73	4.44	3.00	0.40	3.40	4.02	0.89	4.91
1:1, 75	4.45	1.06	5.51	5.42	0.89	6.31	4.81	0.82	5.63	4.37	0.60	4.97	3.58	0.32	3.90	4.53	0.74	5.27
1:2, 75	3.88	1.18	5.06	4.78	1.03	5.81	3.83	0.94	4.77	3.41	0.71	4.12	2.89	0.37	0.26	3.76	0.85	4.61
SEm±	0.12	0.03	0.16	0.14	0.03	0.16	0.12	0.02	0.12	0.09	0.02	0.16	0.08	0.01	0.10	0.11	0.02	0.16
CD (P=0.05)	0.37	0.10	0.50	0.45	0.09	0.51	0.37	0.07	0.38	0.28	0.06	0.51	0.26	0.03	0.33	0.36	0.06	0.51
Harvest intervals (days)																		
45	3.39	1.31	4.70	4.33	1.17	5.50	3.42	0.97	4.39	2.92	0.82	3.74	2.81	0.44	2.62	3.25	0.94	4.19
70	4.91	1.61	6.07	5.80	1.10	6.81	4.95	0.84	5.79	4.56	0.68	5.24	3.83	0.35	4.18	4.81	0.81	5.62
95	4.50	1.07	5.57	5.50	0.89	6.39	4.74	0.73	5.47	4.35	0.58	4.93	3.60	0.31	3.91	4.54	0.71	5.25
120	4.46	0.98	5.44	5.39	0.79	6.18	4.54	0.64	5.18	4.17	0.53	4.70	3.54	0.29	3.83	4.42	0.64	5.06
SEm±	0.12	0.03	0.16	0.14	0.03	0.16	0.12	0.02	0.12	0.09	0.02	0.16	0.08	0.01	0.10	0.11	0.02	0.16
CD (P=0.05)	0.37	0.10	0.50	0.45	0.09	0.51	0.37	0.07	0.38	0.28	0.06	0.51	0.26	0.03	0.33	0.36	0.60	0.51

G, Grasses, L legumes

Table 3. Effect of planting geometry and harvest intervals on crude protein content (%) of mixed pasture

Treatment	1997–98		1998–99		1999–2000		2000–01		2001–02		Pooled	
	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes
Grass-legume ratios and spacing (cm)												
1:1, 50	6.50	11.66	6.39	11.55	6.44	11.50	6.37	10.05	5.97	9.98	6.33	10.95
1:2, 50	6.62	11.91	6.67	12.03	6.74	11.96	6.64	10.47	6.26	10.39	6.58	11.35
1:1, 75	6.47	11.62	6.29	11.41	6.37	11.35	6.31	9.93	5.93	9.83	6.27	10.83
1:2, 75	6.57	11.79	6.61	12.06	6.65	11.99	6.56	10.72	6.15	10.64	6.51	11.44
SEm±	0.03	0.07	0.08	0.09	0.07	0.10	0.07	0.11	0.06	0.12	0.07	0.12
CD (P=0.05)	0.10	0.23	0.25	0.29	0.21	0.32	0.23	0.35	0.20	0.38	0.21	0.37
Harvest intervals (days)												
45	7.07	12.14	7.05	12.05	7.11	11.93	7.03	10.37	6.64	10.29	6.98	11.35
70	6.63	11.91	6.63	11.80	6.69	11.67	6.64	10.16	6.26	10.08	6.57	11.12
95	6.12	11.71	6.12	11.60	6.17	11.46	6.16	9.96	5.76	9.87	6.06	10.92
120	5.69	11.55	5.70	11.42	5.74	11.27	5.76	9.78	5.37	9.70	5.65	10.74
SEm±	0.03	0.07	0.08	0.09	0.07	0.10	0.07	0.11	0.06	0.12	0.07	0.12
CD (P=0.05)	0.10	0.23	0.25	0.29	0.21	0.32	0.23	0.35	0.20	0.38	0.21	0.37

Table 4. Effect of planting geometry and harvest intervals on neutral detergent fibre (%) of mixed pasture

Treatment	1997–98		1998–99		1999–2000		2000–01		2001–02		Pooled	
	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	G	L
Gross–legume ratios and spacing (cm)												
1:1, 50	66.98	53.49	68.69	53.94	69.86	54.18	71.14	55.25	72.53	57.23	69.84	54.82
1:2, 50	64.80	51.69	66.35	53.25	67.41	52.67	68.67	53.62	70.17	54.99	67.48	53.01
1:1, 75	67.82	53.93	69.30	54.45	70.58	55.24	72.08	56.45	73.86	58.18	70.73	55.65
1:2, 75	65.58	51.47	67.08	51.80	68.19	52.32	69.46	53.12	70.93	54.31	68.25	52.60
SEm±	0.74	0.60	0.79	0.65	0.83	0.67	0.86	0.67	0.90	0.71	0.88	0.71
CD (P=0.05)	2.35	1.92	2.52	2.06	2.66	2.14	2.73	2.20	2.86	2.26	2.79	2.25
Harvest intervals (days)												
45	61.84	47.03	62.93	47.33	64.11	47.78	65.43	48.73	66.94	50.01	64.25	48.18
70	64.66	49.70	65.76	50.20	67.12	50.95	68.58	52.11	70.24	53.75	67.27	51.34
95	68.42	53.88	69.80	54.42	71.22	55.20	72.80	56.37	74.60	58.04	71.37	55.58
120	70.27	59.12	71.76	59.70	73.26	60.57	74.92	61.88	76.84	63.75	73.41	61.00
SEm±	0.74	0.60	0.79	0.65	0.83	0.67	0.86	0.69	0.90	0.71	0.88	0.71
CD (P=0.05)	2.35	1.92	2.52	2.06	2.66	2.14	2.73	2.20	2.86	2.26	2.81	2.25

Table 5. Effect of planting geometry and harvest intervals on acid detergent fibre (%) of mixed pasture

Treatment	1997–98		1998–99		1999–2000		2000–01		2001–02		Pooled	
	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	G	L
Grass-legume ratios and spacing (cm)												
1:1, 50	47.31	36.94	47.89	37.33	48.75	37.86	49.96	38.66	51.63	39.84	49.11	38.12
1:2, 50	45.89	35.80	46.40	36.12	47.15	36.60	48.22	37.32	49.71	38.40	47.47	36.85
1:1, 75	47.71	37.40	48.35	37.80	49.31	38.39	50.66	39.26	52.51	40.53	49.71	38.68
1:2, 75	46.12	35.56	46.72	35.86	47.59	36.31	49.12	36.97	50.85	37.95	47.97	36.53
SEm±	0.52	0.45	0.54	0.46	0.56	0.48	0.58	0.53	0.67	0.55	0.58	0.51
CD (P=0.05)	1.65	1.42	1.72	1.48	1.80	1.54	1.86	1.68	2.12	1.75	1.86	1.63
Harvest intervals (days)												
45	43.83	32.56	44.27	32.82	44.92	32.16	45.92	33.22	47.38	34.70	45.26	33.42
70	45.49	34.43	46.11	34.78	46.97	35.26	48.13	35.97	49.75	36.98	47.29	35.48
95	48.24	37.24	49.00	37.66	50.00	38.25	51.32	39.10	53.12	40.33	50.34	38.52
120	48.90	41.36	49.82	41.82	51.00	42.48	52.53	43.42	54.54	44.92	51.36	42.77
SEm±	0.52	0.45	0.54	0.46	0.56	0.48	0.58	0.53	0.67	0.55	0.58	0.51
CD (P=0.05)	1.65	1.42	1.72	1.48	1.80	1.54	1.86	1.68	2.12	1.75	1.86	1.63

Table 6. Effect of planting geometry and harvest intervals on economics of mixed pasture (pooled data of 5 years)

Treatment	Cost of cultivation (Rs/ha)						Net returns (Rs/ha)						Benefit : cost ratio					
	1997–98	1998–99	1999–2000	2000–2001	2001–2002	Pooled	1997–98	1998–99	1999–2000	2000–2001	2001–2002	Pooled	1997–98	1998–99	1999–2000	2000–2001	2001–2002	Pooled
Grass-legume ratios and spacing (cm)																		
1:1, 50	5,894	2,925	3,143	3,406	3,802	3,834	4,516	7,610	6,908	5,709	3,840	5,717	0.76	2.60	2.19	1.67	1.01	1.64
1:2, 50	5,894	2,925	3,143	3,406	3,802	3,834	4,335	7,621	6,183	5,116	3,252	5,301	0.73	2.61	1.96	1.49	0.84	1.52
1:1, 75	5,894	2,925	3,143	3,406	3,802	3,834	4,179	6,732	6,608	5,419	3,597	5,307	0.71	2.11	2.11	1.60	0.96	1.53
1:2, 75	5,894	2,925	3,143	3,406	3,802	3,834	3,909	6,897	5,534	4,568	2,800	4,742	0.66	1.75	1.75	1.33	0.72	1.36
Harvest intervals (days)																		
45	5,894	2,925	3,143	3,406	3,802	3,834	5,171	3,752	5,937	5,304	3,128	4,658	0.97	1.94	1.94	1.62	0.88	1.34
70	5,894	2,925	3,143	3,406	3,802	3,834	5,281	8,759	8,271	6,856	4,798	6,793	0.88	2.62	2.62	2.00	1.26	1.95
95	5,894	2,925	3,143	3,406	3,802	3,834	3,775	6,849	6,025	4,915	3,261	4,965	0.63	1.91	1.91	1.44	0.86	1.43
120	5,894	2,925	3,143	3,406	3,802	3,834	2,639	5,364	4,631	3,499	2,136	3,654	0.43	1.46	1.46	1.01	0.54	1.05

The higher yield of grasses with harvest at 70 days interval could be ascribed to optimum period available for the growth of grasses. Singh and Pradhan (1995) and Ramamurthy and Vinod Shankar (1998) also reported significant increase in yield of different grasses with the increase in harvest interval from 40 to 60 days. The effect of interaction between planting geometry and cutting management was non-significant. Increase in forage yield was recorded up to second year only, after that there was decrease in dry-matter yield by 14.79, 12.26 and 21.72% in third, fourth and fifth years compared to second, third and fourth years respectively.

Economic returns

The maximum net returns as well as benefit : cost ratio were obtained in 1:1 row ratio of grass-legume intercropping at 50 cm distance, followed by 1:1 row ratio at 75 cm (Table 6). Among harvesting treatments, highest net returns and benefit : cost ratio were achieved with harvest of pasture at 70 days interval as compared to 45, 95 and 120 days intervals. *Setaria sphacelata* harvested at 60 days interval also recorded the highest net return (Bora and Thakuria, 2000).

Forage quality

The chemical composition was also significantly influenced by different planting geometry and cutting management patterns (Tables 3, 4, 5). Intercropping of grasses with legumes in 1:2 row ratio at 50 cm distance recorded significantly higher crude protein content and lower neutral detergent fibre and acid detergent fibre than 1:1 row ratio at 75 cm distance. The improvement in quality of forage in 1:2 row ratio of grass–legume mixed pasture may possibly be the result of fixation of higher amount of N, either by direct excretion from the legume nodule root-system or by decomposition of nodule and root debris. The increase in neutral detergent fibre and acid detergent fiber content in forage resulted in decrease in forage quality. Therefore it should be minimum in forage for higher quality.

The interaction effect between cutting intervals and planting geometry was found to be non-significant.

Harvesting of grasses at 45 days interval resulted in significantly higher crude protein content and lower neutral detergent fibre and acid detergent fibre compared to 70, 95 and 120 days harvest intervals. The higher crude protein content and lower neutral detergent fibre and acid detergent fibre with harvesting at 45 days may be ascribed to younger and succulent plants with higher content. Singh and Pradhan (1995), Singh *et al.* (1997) and Bora and Thakuria (2000) found that with the decrease in harvest interval, the crude protein content increased while neutral

detergent fibre and acid detergent fibre decreased. There was no significant interaction between planting geometry and cutting management. Maximum crude protein content in both grasses (6.54%) and legumes (11.75%) was recorded in the first year, after that it decreased to 6.49 and 11.76% in the second year, 6.55 and 11.70% in the third year, 6.47 and 10.29% in the fourth year and 6.08 and 10.21% in the fifth year respectively. However, neutral detergent fibre (grasses 66.30% and legumes 52.65%) and acid detergent fibre (grasses 46.76% and legumes 36.43%) were minimum in the first year, after that there was continuous increase in fibre content over all the years.

It was concluded that for getting higher productivity and monetary returns, grasses should be intercropped with legumes in 1:1 row ratio at 50 cm distance and harvested at 70 days interval in rainfed conditions.

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