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Influence of varieties and cutting schedules of perennial pasture grasses on soil fertility, nutrients content and uptake, productivity and economics in hot arid conditions of Rajasthan

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ABSTRACT

A field experiment was conducted during 2000–04 on coarse sandy soil having low fertility status to study the manipulation of soil fertility with leys, enhancing fodder productivity with improved varieties, cutting schedules and economics of fodder production. The study showed that soil organic carbon, *p*H, electrical conductivity and available NPK were not affected significantly either by perennial pastures [Cenchrus (*Cenchrus ciliaris* L.) or sewan (*Lasiurus sindicus* Henrard]. Different cutting schedules or their varieties, were improved noticeably over the years compared to their initial levels indicating a positive impact of these pasture grasses on soil fertility status. Nutrients contents in dry fodder of cenchrus and sewan were statistically similar but nitrogen content was significantly higher in half-yearly cutting than annual cutting. Among varieties 'CAZRI 75' of cenchrus and 'CAZRI m 30–5' of sewan were found containing significantly higher nitrogen compared to their respective other varieties. Nutrients (NPK) uptake was recorded significantly higher in sewan than cenchrus, in half yearly cutting than annual cutting than their respective other varieties. Dry fodder production was significantly higher by sewan (29.39 tonnes/ha) than cenchrus (25.69 tonnes/ha) on yearly as well as total basis. Half-yearly cutting schedule produced significantly higher dry fodder yield than annual cutting schedule during initial two years but reverse trend was observed in latter years and both were found statistically similar on total basis. Among varieties 'CAZRI 75' (29.62 tonnes/ha) of cenchrus and 'CAZRI m 30-5' (32.75 tonnes/ha) of sewan gave significantly higher dry fodder yield compared to their respective other varieties on yearly and total basis. Higher gross and net returns were recorded in sewan grass than the cenchrus grass, half-yearly cutting schedule than annual cutting schedule, and in 'CAZRI 75' of cenchrus, and 'CAZRI m 30-5', of sewan.

Key words: Cenchrus, Cutting schedules, Dry fodder yield, Economics, Nutrients content and uptake, Sewan, Soil fertility, Varieties

Western part of Rajasthan, the *Thar* desert, is the most thickly populated desert of the World, possessing more than 55 million population each of human and livestock. Aberrant weather conditions and poor soil fertility pose major threats to arable crops cultivation, obviously, animal rearing is the only major and most reliable livelihood of rural folks dwelling in this desert region (Chander *et al*. 2004). Livestock rearing is directly dependent on fodder availability but due to harsh agro-climatic conditions there is severe fodder scarcity causing huge livestock loss through starving and malnutrition every year. Mechanization of agriculture has further aggravated the fodder scarcity problem because most of permanent pastures were vanished from this region due to use of heavy agricultural implements in tilling of pasture lands and converting them to arable lands. Loss of perennial pastures is not only causing fodder scarcity but also severe erosion of loose soil from bare and barren land surface (Faroda *et al*. 2007). Keeping these facts in view, the present study was carried out with objective of manipulation of soil fertility with leys of perennial pastures, enhancing fodder productivity through introduction of improved varieties of perennial pastures under different cutting schedules and to work out the economics of fodder production grown in hot arid region under National Agricultural Technology Project of Arid Agro-ecosystem.

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MATERIALS AND METHODS

This experiment was conducted at research farm of the Central Sheep and Wool Research Institute, Arid Region Campus, Bikaner, Rajasthan in split-plot design replicated

thrice. Two perennial pasture grasses, viz cenchrus (*Cenchrus ciliaris* L.) and sewan (*Lasiurus sindicus* Henrard), and 2 cutting schedules, namely half yearly (1 cut in 3 months) and annual (1 cut in 6 months) cutting schedules were taken as main plots and 3 varieties each of cenchrus ('CAZRI 75', 'CAZRI 358' and 'CAZRI 1106') and sewan ('CAZRI m 30-5', 'CAZRI 317' and 'CAZRI 319') were taken as sub-plots. The soil was single grained coarse sand having *p*H 8.8 and 8.9, electrical conductivity (EC) 0.24 and 0.27 dS/m, organic carbon 0.147 and 0.112%, available nitrogen 84.67 and 72.13 kg/ha, available phosphorus 9.48 and 4.01 kg P_2O_5/ha and available potassium 57.86 and 67.50 kg K_2O/ha in 0–15 and 15–30 cm depth of soil respectively. The size of each treatment plot was 15 m × 10 m. The seed rate of 6 kg/ha of cenchrus and 8 kg/ha of sewan was used for sowing of these pasture grasses at row spacing of 50 cm with the commencement of rainy season in 2000. First fodder cutting was taken in July 2001 and subsequent cuttings were taken as per the schedule of the treatments. In-half yearly cutting schedule sum total of fodder yield of 2 consecutive cuts and in annual cutting schedule fodder yield of one cut during the same period was compared. Life saving irrigation was applied as and when required to save the pasture grasses from fatal drought during the period of experimentation. Soil samples were collected every year (0–15 cm depth), air dried, grounded, sieved through 80 mesh sieve and analyzed for organic carbon, *p*H, EC and available NPK as per the standard procedures. Plant samples were collected from all the treatments at harvesting of pasture grasses for fodder, air-dried in the shade, oven-dried for 24 hr at 70°C, grounded and analyzed for NPK contents. Dry fodder production was calculated by determining moisture content of green fodder yield. Cost of cultivation was computed by taking into consideration the value of various inputs and operations. Gross and net returns were computed by multiplying the dry fodder yield (tonne/ha) with prevailing market price (Rs 2 000/tonne) and subtracting the cost of production from gross returns, respectively. The data was subjected to appropriate statistical analysis by using MSTAT Software package.

RESULTS AND DISCUSSION

Soil fertility

Growing of cenchrus or sewan, in half-yearly or annual cutting schedule did not bring out any significant change in soil organic carbon, *p*H, EC (Table 1) or available major nutrients (Table 2) in the soil when compared with each other within a year during all the years, ie 2000–04. Similarly, different varieties were also at par among themselves for soil organic carbon, *p*H, EC and available K content, however, available N content was recorded the highest in variety 'CAZRI 317' (124.7 kg/ha) of sewan in 2001 which was significantly higher than other varieties of sewan, in variety 'CAZRI 1106' (161.5 and 168.7 kg/ha) of cenchrus and 'CAZRI 319' (161.0 and 163.4 kg/ha) of sewan in 2002 and 2003, respectively and in 'CAZRI 75' (156.1 kg/ha) of cenchrus and 'CAZRI 319' (153.5 kg/ha) of sewan in 2004. Similar trend was observed in available Phosphorus also. When the year wise overall means of organic carbon, *p*H, EC and available NPK were compared there was successive improvement in soil organic carbon content (0.15 to 0.23%

Table 1 Effect of pasture grasses, their varieties and cutting schedules on soil organic carbon, *p*H and EC (0–15 cm)

Treatment	Organic carbon (%)					Soil *p*H					Soil EC (ds/m)				
	2000*	2001	2002	2003	2004	2000*	2001	2002	2003	2004	2000*	2001	2002	2003	2004
Grasses															
Cenchrus	0.15	0.18	0.21	0.24	0.24	8.80	8.74	8.38	8.76	8.55	0.24	0.47	0.54	0.42	0.61
Sewan	0.15	0.17	0.20	0.17	0.21	8.80	8.71	8.29	8.77	8.51	0.24	0.49	0.49	0.37	0.53
CD (*P*=0.05)		NS	NS	NS	NS		NS	NS	NS	NS		NS	NS	NS	NS
Cutting schedule															
Half yearly	0.15	0.17	0.20	0.23	0.22	8.80	8.66	8.35	8.75	8.54	0.24	0.48	0.52	0.41	0.59
Annual	0.15	0.17	0.21	0.18	0.23	8.80	8.79	8.32	8.77	8.52	0.24	0.47	0.50	0.39	0.55
CD (*P*=0.05)		NS	NS	NS	NS		NS	NS	NS	NS		NS	NS	NS	NS
Varieties															
Cenchrus															
'CAZRI 75'	0.15	0.17	0.21	0.23	0.23	8.80	8.44	8.33	8.73	8.60	0.24	0.43	0.52	0.43	0.59
'CAZRI 358'	0.15	0.18	0.22	0.25	0.25	8.80	8.80	8.46	8.77	8.53	0.24	0.43	0.51	0.42	0.63
'CAZRI 1106'	0.15	0.18	0.19	0.23	0.25	8.80	8.58	8.36	8.77	8.52	0.24	0.54	0.59	0.43	0.62
Sewan															
'CAZRIm30-5'	0.15	0.16	0.19	0.19	0.23	8.80	8.79	8.30	8.72	8.53	0.24	0.52	0.55	0.43	0.56
'CAZRI 317'	0.15	0.18	0.23	0.17	0.19	8.80	8.62	8.31	8.78	8.51	0.24	0.47	0.46	0.33	0.52
'CAZRI 319'	0.15	0.17	0.19	0.16	0.21	8.80	8.73	8.25	8.80	8.49	0.24	0.48	0.44	0.33	0.51
CD (*P*=0.05)		NS	NS	NS	NS		NS	NS	NS	NS		NS	NS	NS	NS

*Initial status at the start of experiment in June 2000

Table 2 Effect of pasture grasses, their varieties and cutting schedules on available N, P and K of soil (0–15 cm)

Treatment	Available N (kg/ha)					Available P (kg/ha)					Available K (kg/ha)				
	2000*	2001	2002	2003	2004	2000*	2001	2002	2003	2004	2000*	2001	2002	2003	2004
Grasses															
Cenchrus	84.7	109.8	152.4	161.7	152.4	4.1	4.6	7.1	8.8	8.5	48.0	69.4	146.6	211.9	202.2
Sewan	84.7	111.2	143.8	155.1	149.3	4.1	5.8	8.5	9.9	8.6	48.0	68.1	157.9	186.8	196.6
CD (*P*=0.05)		NS	NS	NS	NS		NS	NS	NS	NS		NS	NS	NS	NS
Cutting schedule															
Half yearly	84.7	112.5	149.1	160.1	154.1	4.1	5.0	7.7	9.1	8.8	48.0	70.3	151.6	194.6	200.7
Annual	84.7	108.5	147	156.7	147.6	4.1	5.3	8.0	9.6	8.3	48.0	67.1	152.9	204.1	198.1
CD (*P*=0.05)		NS	NS	NS	NS		NS	NS	NS	NS		NS	NS	NS	NS
Varieties															
Cenchrus															
'CAZRI 75'	84.7	108.2	149.5	160.6	156.1	4.1	4.8	7.0	9.2	8.9	48.0	70.5	148.1	227.4	209.9
'CAZRI 358'	84.7	111.4	146.1	155.8	149.7	4.1	3.5	6.3	7.5	8.0	48.0	69.1	142.3	204.9	198.0
'CAZRI 1106'	84.7	109.9	161.5	168.7	151.4	4.1	5.5	7.9	9.6	8.7	48.0	68.5	149.5	203.4	198.6
Sewan															
'CAZRIm30-5'	84.7	101.9	129.6	145.6	142.1	4.1	5.1	6.5	8.3	8.6	48.0	64.0	165.3	194.1	199.8
'CAZRI-317'	84.7	124.7	140.8	156.3	152.3	4.1	6.4	8.3	9.7	8.5	48.0	72.8	154.7	180.2	192.8
'CAZRI-319'	84.7	106.8	161.0	163.4	153.5	4.1	6.0	11.5	11.4	8.8	48.0	67.4	154.0	186.3	197.3
CD (*P*=0.05)		14.8	13.5	12.9	10.3		2.5	2.6	1.5	NS		NS	NS	NS	NS

*Initial status at the start of experiment in June 2000

Table 3 Effect of pasture grasses, their varieties and cutting schedules on nutrients content in grasses (on dry weight basis)

Treatment	Nitrogen content (%)				Phosphorus (P) content (%)				Potassium (K) content (%)			
	2001	2002	2003	2004	2001	2002	2003	2004	2001	2002	2003	2004
Grasses												
Cenchrus	1.69	2.03	1.94	1.73	0.19	0.25	0.21	0.20	1.36	1.24	1.13	1.31
Sewan	1.81	2.11	1.96	1.86	0.21	0.26	0.21	0.23	1.42	1.30	1.10	1.42
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cutting schedule												
Half yearly	1.85	2.14	2.00	1.83	0.22	0.28	0.22	0.22	1.33	1.21	1.11	1.39
Annual	1.65	1.99	1.90	1.77	0.19	0.24	0.20	0.21	1.45	1.34	1.12	1.34
CD (*P*=0.05)	0.15	0.11	0.08	NS	0.05	0.07	0.04	NS	NS	NS	NS	NS
Varieties												
Cenchrus												
'CAZRI 75'	1.81	2.13	1.98	1.79	0.20	0.26	0.21	0.22	1.41	1.19	1.14	1.37
'CAZRI 358'	1.61	1.96	1.90	1.71	0.18	0.24	0.20	0.19	1.36	1.31	1.15	1.29
'CAZRI 1106'	1.65	2.00	1.96	1.69	0.19	0.25	0.21	0.20	1.31	1.26	1.11	1.28
Sewan												
'CAZRIm30-5'	1.96	2.16	2.05	1.93	0.22	0.28	0.22	0.25	1.44	1.33	1.04	1.45
'CAZRI 317'	1.76	2.09	1.94	1.80	0.20	0.25	0.21	0.22	1.39	1.27	1.10	1.41
'CAZRI 319'	1.71	2.05	1.90	1.79	0.21	0.26	0.21	0.21	1.43	1.31	1.12	1.40
CD (*P*=0.05)	0.18	0.13	0.09	0.10	NS	NS	NS	NS	NS	NS	NS	NS

from 2000 to 2004, respectively), slightly lowering down of soil *p*H (8.80 to 8.53 from 2000 to 2004), increase in soil EC (0.24 to 0.57 dS/m) and noticeable increase in available N (84.67, 110.49, 148.08, 158.40 and 150.85 kg/ha), available P (9.48 to 19.93 kg P_2O_5/ha) and available K (57.86 to 240.25 kg K_2O/ha) from 2000 to 2004 (Fig 1). This might be due to the addition of organic matter by roots and leaves of growing plants of perennial pasture grasses and increased microbial activity that might have also induced mineralization of fixed soil nutrients. Whitbread (2008) also suggested that grass and legume lays incorporated into farming system can potentially improve soil fertility, crop yields and profitability. Faroda *et al.* (2007) also reported the positive effect of sewan, cenchrus and castor stripes on soils of arid region.

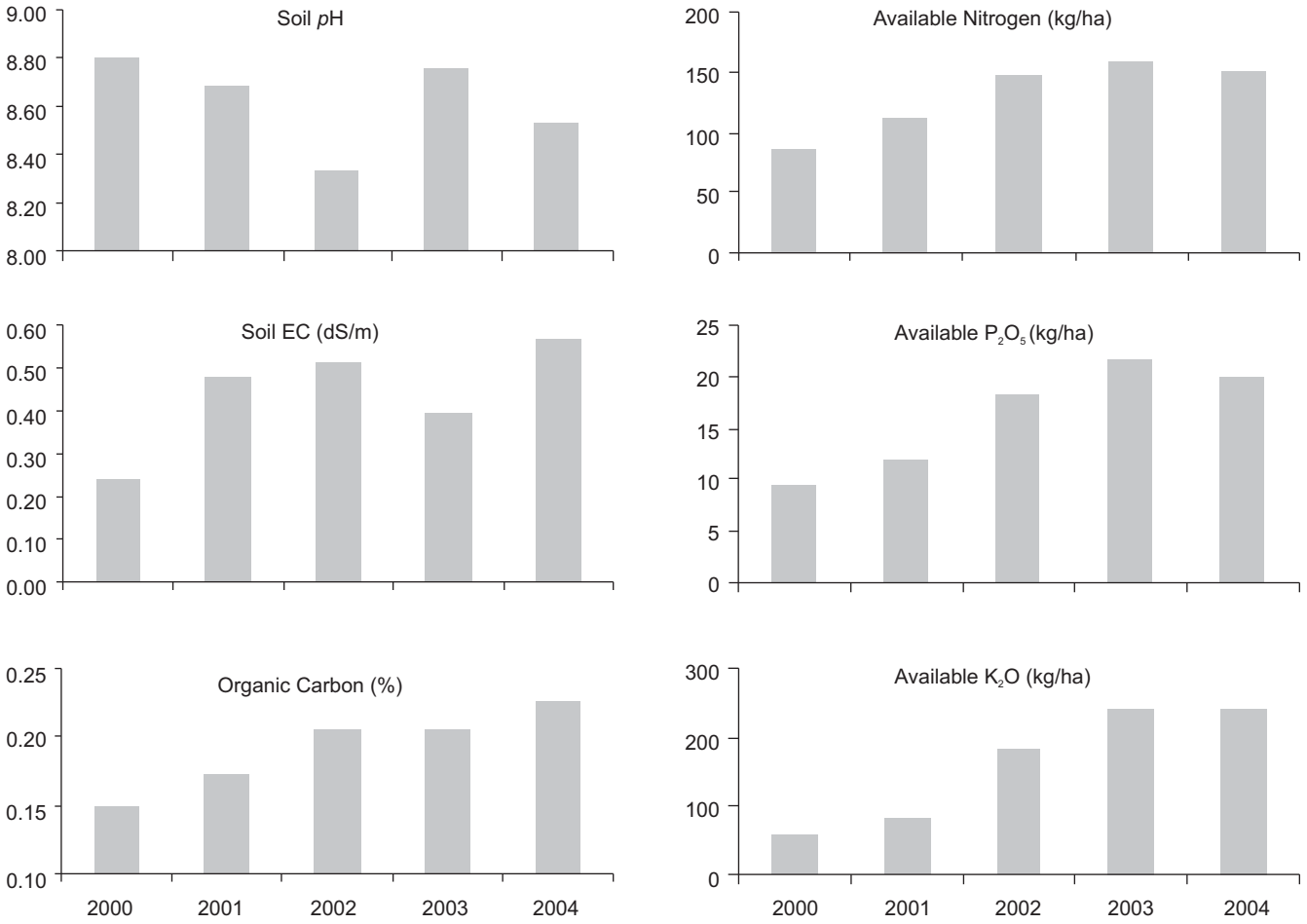

Fig. 1 Soil organic carbon, *p*H, electrical conductivity and available major nutrients content

Nutrients content

NPK content in dry fodder of cenchrus and sewan were found statistically similar to each other during all the years of study (Table 3). N and P contents were found significantly higher in half-yearly cutting than annual cutting schedule throughout the period of study except in 2004 where they were at par in both the cutting schedules. This might be due to the fact that over maturity of plants in annual cutting schedule might have caused quality deterioration and lowering down of N and P content in the fodder of annual cutting schedule. Chander *et al.* (2004) also reported significantly higher protein content in half-yearly than annual cutting schedule of these pasture grasses. Among varieties, 'CAZRI 75' (mean value 1.93%) of cenchrus and 'CAZRI m 30-5' (mean value 2.03%) of sewan recorded the highest nitrogen content in all the years, however, P and K contents were statistically similar in all the varieties of both the pasture grasses during all the years of study (Table 3). Dutta and Sharma (2000) also reported that in grass species, collected from variable habitats falling in 8 arid districts of Rajasthan, *Cenchrus ciliaris* and *C. biflorus* had maximum crude protein value in variety of soils.

Nutrient uptake

Uptake of N and P was significantly higher in sewan than cenchrus and in half-yearly cutting schedule than annual cutting schedule (Table 4) during all the years of study except in 2004 for N and, 2003 and 2004, for P uptake where both cutting schedules were at par, however, K uptake was found significantly higher in sewan than cenchrus in all the years of study and in half-yearly cutting schedule than annual cutting schedule in 2003 only and in other years both cutting schedules were found at par. This might be ascribed to higher dry fodder productivity by sewan grass than cenchrus and by half yearly cutting schedule than annual cutting schedule. Among varieties 'CAZRI 75' of cenchrus and 'CAZRI m 30-5' of sewan recoded the highest nutrients uptake which was significantly higher than their respective other varieties during the period of study. Vyas *et al.* (2003) also reported the superiority of improved varieties of cenchrus compared to indigenous cenchrus varieties grown in hot arid regions of Gujarat.

Dry fodder production

Dry fodder productivity of sewan (total yield 29.39 tonnes/

Table 4 Effect of pasture grasses, their varieties and cutting schedules on nutrients uptake by grasses (on dry fodder yield basis)

Treatment	Nitrogen content (%)				Phosphorus (P) content (%)				Potassium (K) content (%)			
	2001	2002	2003	2004	2001	2002	2003	2004	2001	2002	2003	2004
Grasses												
Cenchrus	48.4	224.8	149.0	70.4	5.44	27.69	16.13	8.14	39.0	137.3	86.8	53.3
Sewan	63.9	264.3	173.3	83.5	7.42	32.57	18.56	10.33	50.2	162.8	97.2	63.8
CD (*P*=0.05)	6.4	7.5	9.2	9.4	1.01	1.55	0.91	0.96	3.5	4.1	3.1	4.2
Cutting schedule												
Half yearly	61.1	266.8	154.0	77.4	7.26	34.90	16.94	9.31	43.9	150.8	85.5	58.8
Annual	51.0	222.1	167.4	76.6	5.87	26.78	17.62	9.09	44.8	149.5	98.7	58.0
CD (*P*=0.05)	3.9	4.2	5.0	NS	0.84	0.90	NS	NS	NS	NS	2.4	NS
Varieties												
Cenchrus												
'CAZRI 75'	56.6	267.4	178.8	87.9	6.25	32.64	18.96	10.80	44.1	149.4	102.9	67.3
'CAZRI 358'	39.7	189.9	137.6	62.8	4.44	23.26	14.48	6.97	33.5	127.0	83.3	47.3
'CAZRI 1106'	49.5	216.0	132.9	61.2	5.70	27.00	14.24	7.24	39.3	136.1	75.3	46.3
Sewan												
'CAZRIm30-5'	76.0	299.5	195.6	105.6	8.53	38.83	20.99	13.68	55.8	184.4	99.2	79.3
'CAZRI 317'	61.9	260.9	171.5	76.0	7.04	31.21	18.56	9.28	48.9	158.5	97.2	59.5
'CAZRI 319'	55.1	233.8	153.9	67.8	6.77	29.66	17.01	7.96	46.1	149.4	90.7	53.1
CD (*P*=0.05)	7.1	7.5	9.0	10.7	1.52	1.62	2.47	1.36	1.7	3.6	4.4	5.1

Table 5 Effect of pasture grasses, their varieties and cutting schedules on dry fodder production of grasses (tonnes/ha) and economics

Treatment	Dry Fodder Yield (tonnes/ha) 2001	2002	2003	2004	Total dry fodder yield (tonnes/ha)	Gross returns (Rs /ha)*	Net returns (Rs /ha)**
Grasses							
Cenchrus	2.87	11.08	7.68	4.07	2.56	513 82	29 482
Sewan	3.53	12.53	8.84	4.49	2.93	58 776	36 876
CD (*P*=0.05)	0.45	1.06	0.53	0.29	1.14	2 674	
Cutting schedule							
Half yearly	3.30	12.47	7.70	4.23	2.77	55 392	33 492
Annual	3.09	11.16	8.81	4.33	2.73	54 780	32 880
CD (*P*=0.05)	0.18	0.52	0.49	NS	NS	NS	
Varieties							
Cenchrus							
'CAZRI 75'	3.13	12.56	9.03	4.91	2.96	59 240	37 340
'CAZRI 358'	2.46	9.69	7.24	3.67	2.30	46 130	24 230
'CAZRI 1106'	3.00	10.80	6.78	3.62	2.42	48 398	26 498
Sewan							
'CAZRIm30-5'	3.88	13.87	9.54	5.47	3.27	65 504	43 604
'CAZRI 317'	3.52	12.48	8.84	4.22	2.90	58 122	36 222
'CAZRI 319'	3.22	11.41	8.10	3.79	2.65	53 036	31 136
CD (*P*=0.05)	0.33	1.32	0.64	0.42	1.72	3 416	

*Price of dry fodder of cenchrus and sewan Rs 2000/tonne

**Total cost of cultivation was worked out to be Rs 21 900/ ha in 4 years

ha) was significantly higher compared to cenchrus (total yield 25.69 tonnes/ha). Half-yearly cutting schedule recorded significantly higher dry fodder yield than annual cutting schedule (Table 5) during initial two years (2001 and 2002) but reverse was true in 2003 and at par in 2004 as well as in total basis. This may be ascribed to the fact that in half-yearly cutting schedule two cuts were taken, while only one cut was taken in annual cutting schedule in the same duration, hence, some total yield of two cuts was higher than one cut yield taken at longer interval. Chander *et al*. (2004) and Patidar *et al*. (2008) also reported higher productivity of sewan than cenchrus.

'CAZRI 75' recorded the highest dry fodder yield on yearly as well as total (29.62 tonnes/ha) basis among cenchrus

varieties, which was significantly better than other varieties of this grass. 'CAZRI m 30-5' recorded the highest dry fodder yield on year wise and total (32.75 tonnes/ha) and was found significantly superior to other varieties of sewan. These findings were in corroboration with the findings of Vyas *et al.* (2003).

Economics

Gross returns from sewan pasture grass (Rs 58 776/ha) were significantly higher than the gross returns from cenchrus pasture grass (Rs 51 382/ha). Net returns were also considerably higher in sewan (Rs 36 876/ha) than cenchrus (Rs 29 482/ha). Similarly, half-yearly cutting schedule brought about higher gross (Rs 55 392/ha) and net returns (Rs 33 492/ha) compared to annual cutting schedule (Rs 54 780 and 32 880/ha gross and net returns, respectively). This is due to higher dry fodder productivity by sewan than cenchrus and half-yearly cutting than annual cutting schedule (Table 5). Sharma *et al.* (2006) also reported fairly good net returns from the cultivation of sewan pasture in arid region. 'CAZRI-75' of cenchrus brought about the highest gross and net returns (Rs 5 924 and 37 340/ha, respectively) that were noticeably higher than other cenchrus varieties. Similarly, CAZRI m 30-5 of sewan also recorded the highest gross and net returns (Rs 65 504 and 43 604/ha respectively) showing its superiority over other varieties of sewan pasture grass. Whitbread (2008) also reported that profitability can be improved by incorporating grass leys into farming system. On the basis of this 4 year study it can be concluded that cultivation of perennial pasture grasses (cenchrus and sewan) with half-yearly cutting schedule and their promising varieties ('CAZRI 75' and 'CAZRI m 30-5') cannot only improve the soil fertility but also brought about higher nutrient contents, their uptake, fodder productivity and profitability. These pasture grasses have a great yield potential and may prove a boon for starving livestock of this hot arid region.

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