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Effect of different rejuvenation techniques and fertilization on *sewan* (*Lasiurus sindicus*) pasture in hot arid region of Rajasthan

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ABSTRACT

A field experiment was conducted during 2005 and 2006 at Bikaner to evaluate the different rejuvenation techniques and sources of nutrient supplementation on the productivity of old *sewan* (*Lasiurus sindicus* L.) pastures. Stubbles burning treatment proved superior, recording maximum growth attributes, viz. number of tillers/tussock, tiller height and tussock diameter, green fodder (7.75 and 9.49 t/ha), dry matter (2.78 and 3.26 t/ha), crude protein (230.0 and 276.1 kg/ha), NPK uptake, energy ratio (10.98), energy productivity (679 g/MJ), net returns (Rs 2,563/ha), benefit : cost ratio (1.51), and residual soil available P (8.86 and 9.14 kg/ha), and available K (174.3 and 167.1 kg/ha) compared with other treatments. Among fertilization sources, 50% each through organic and inorganic source of plant nutrients (20 kg each NPK + 5 t/ha sheep manure) being on a par with 100% inorganic sources recorded higher growth attributes, *viz.* green fodder (7.66 and 9.37 t/ha), dry matter 2.81 and 3.24 t/ha, crude protein 243.7 and 281.3 kg/ha, NPK uptake, energy output (48,833 MJ/ha) gross returns (Rs. 7,573/ha) and available N, P and K status. However, maximum net returns (Rs 3,035/ha) were given by 100% application of inorganic sources. Rejuvenation of old sewan pastures through stubble burning and fertilized with 50% each organic and inorganic source of plant nutrients gave maximum biomass yield. However, 100% application of inorganic sources (40 kg each NPK/ha through chemical fertilizers) gave the most economical pasture-grass production.

Key words: Economics, Energy relationship, Fertilization, Fodder yield, Rejuvenation techniques, Sewan grass

Amongst pasture-grass species, *sewan* (*Lasiurus sindicus* L.) is a most suitable perennial grass for hyper arid climate and available land resources of western Rajasthan. It has high palatability, good fodder quality and most prominent drought resistance capacity to bear long dry spells and drought situations. After a few years of *sewan* pasture establishment, its forage productivity decreases due to death of the tillers of tussocks if proper care is not taken. A well established sewan pasture in arid habitat is likely to remain productive for 6 to 10 years (Yadav and Rajora, 1995). To maintain good growth of desirable grass species in grassland, it is important to eradicate the unwanted plants and follow rejuvenation techniques. Burning has been an important tool in grassland management (Chatterjee and Das, 1989), but burning at large scale may harm the environment. Moreover, such a practice has not been tested so far in hot arid condition pastures. Practical experience with sewan pastures shows that removal of above-ground hardy portion of old tussocks and disturbing the tap root system are essential at a certain interval for better new sprouting and growth of tussocks of old sewan pastures. Further, there is need to supply adequate plant nutrients to sewan grass which is associated with efficient source to sink relationship, leading to higher forage productivity. Various experiments conducted on manures and fertilizers in different crops proved that neither the chemical fertilizers nor the organic sources exclusively can achieve the production sustainability of soil and crop. Thus, conjoint use of organic manure and chemical fertilizers can help in enhancing the productivity of pastures. In view of this, the present experiment was conducted.

MATERIALS AND METHODS

A field experiment was conducted for 2 years during rainy (*kharif*) season of 2005 and 2006 at Research Farm of Central Sheep and Wool Research Institute, Arid Region Campus, Bikaner (Rajasthan). The soil was sandy with pH 8.57 and EC 0.63 dS/m, being low in organic C (0.24%), available N (158.4 kg/ha) and available P (8.54

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kg P/ha), and medium in available K (155.4 kg K/ha). The total rainfall received during 2005 and 2006 was 245.8 and 152.4 mm in 19 and 11 days, respectively. The trial was laid out in split-plot design with three replications. The experiment comprising 20 treatment combinations of 5 levels of rejuvenation techniques in main plots, viz. the control (without any rejuvenation technique), burning of stubbles (light burning, at least 75% of above-ground portion of hardy grass leaving out after grazing, to remove it for giving adequate space for good sprouting and growth of new plants), pruning of stubbles (removal of $^{2}/_{3}{}^{rd}$ part of old tussocks mechanically to loosen the soil, disturbing the below-ground root system and to give space for better sprouting and growth of newly emerged plants and tillers), shaving of stubbles (complete removal of above-ground portion of old tussocks to give sufficient space for better activation of below ground apical bud of sewan grass, for better sprouting and growth of plant and tillers) and cultivator ploughing (running of cultivator in pasture to loosen the soil for better moisture absorption, disturbing the root system and increase the new germination of buried sewan seed); and 4 fertilization sources treatments in sub-plots, viz. control (without fertilization), 100% application of organic source of plant nutrients (10 t sheep manure/ha), 100% inorganic sources (recommended dose of 40 kg each of NPK/ha) for sewan grass through chemical fertilizers and 50% application of each organic and inorganic sources (5 t/ha sheep manure + 20 kg each of NPK through chemical fertilizers). The old sewan pasture established in 1996 at the institute farm was utilized for the trial. The sizes of experimental plot were: main plot 6 x 24 m, subplot 6 x 5 m and net plot 5 x 4 m. All the rejuvenation techniques were followed on 15 June and 18 June and fertilization sources, viz. half the dose of nitrogen through urea and full dose of phosphorus through single superphosphate and potassium through muriate of potash, and sheep manure were applied on 4 and 1 July in the first and second years respectively. The remaining N was applied on 29 July in 2005 and on 28 July in 2006. The crop was raised with recommended package of practices and the grass was harvested once on 2 October in 2005 and 6 October 2006 at complete flowering stage. The second-year trial was followed in the same block but different place to avoid the residual effect of previous-year treatments.

RESULTS AND DISCUSSION

Growth and fodder yield

All the rejuvenation techniques, viz. burning, pruning, shaving and cultivator ploughing, significantly increased the growth attributes and grass yields compared with the control during both the years (Table 1). The highest values of growth attributes, viz. number of tillers/tussock, tiller height and tussock diameter, were recorded with the stubbles burning in both the years, except tiller height in 2005; whereas, maximum tiller height was observed with shaving treatment. Green-fodder yield recorded with stubbles burning (7.75 t/ha in 2005 and 9.49 t/ha in 2006) was significantly higher than the rest of the treatments except shaving and pruning treatments in 2005, where the differences were non-significant. The magnitude of increase in green-fodder yield was of 71.1, 8.39, 2.92, and 34.5% during 2005, and 127.6, 12.3, 16.1 and 14.1% during 2006 over the control, pruning, shaving and cultivator ploughing, respectively. Similarly, the differences in green-fodder yields recorded with pruning and shaving in 2005 and pruning, shaving and cultivator ploughing during 2006 were statistically non-significant but significantly higher over the control. Almost similar trend was observed for dry-matter yields during both the years. In spite of higher growth attributes during 2006 in the control plots compared with previous years, the green-fodder and dry-matter yields recorded with the control plots were lower than these observed in 2005. It was due to thinner and less compact tillering in the second year in the control plots compared with the rejuvenation techniques, resulting in lower grass yield. It was also noted that in spite of higher annual rainfall (245.4 mm) during 2005, the values of grass-growth attributes and yields were better during 2006, except in the control. It may be due to the combined effect of stage of occurrence of rainfall (28.0 mm) in the last week of June during 2006 and lower mean sunshine hours of 6.67 hr/day compared with 7.27 hr/day in 2005 during the experimental period, which might have favoured better growth of grass, resulting in higher biomass production. The higher fodder yield with different rejuvenation techniques was the function of higher growth attributes. Maximum yield of sewan grass with the burning of stubbles treatment could be attributed to the deposition of that ash provides P, K, Ca and Mg, which is favourable to regrowth and revival of grass soon on receipt of moisture (Paulsamy, 1992). Paulsamy *et al.* (2003) also reported that surface firing increased the importance value index and higher forage yields of grasses and legumes. In case of fertilization of crop, 50% each application of organic and inorganic plant nutrients significantly increased the growth attributes, viz. number of tillers/tussock, tiller height and tiller diameter, and fodder yield compared with the control, and 100% organic fertilization in both the years. However, it remained statistically on a par with 100% application of inorganic source of plant nutrition. Similarly, the green-fodder and dry-matter yields recorded with 100% inorganic sources were significantly higher than the control and 100% source of organic manure application. Yadav and Rajora (1995) also reported similar results. The

Table 1. Yield attributes, and fodder and crude-protein yields of sewan pasture as influenced by treatment variables

Treatment	No. of tillers/ tussock		Tiller height (cm)		Tussock diameter (cm)		Green-fodder yield (t/ha)		Dry-matter yield (t/ha)		Crude-protein yield (kg/ha)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Rejuvenation technique												
Control	91.2	119.4	77.3	79.3	38.0	42.4	4.53	4.17	1.64	1.45	131.2	113.2
Burning	128.2	147.1	93.7	97.1	48.0	48.0	7.75	9.49	2.78	3.26	230.0	276.1
Pruning	113.7	132.8	93.4	91.3	44.6	46.4	7.15	8.45	2.64	2.92	221.4	240.5
Shaving	125.7	122.7	95.8	89.2	47.6	43.8	7.53	8.17	2.74	2.84	228.0	237.3
Cultivator	102.1	124.9	89.3	90.7	41.6	44.4	5.76	8.32	2.13	2.87	175.4	234.1
SEm±	1.5	1.8	1.38	1.26	0.30	0.20	0.36	0.23	0.13	0.07	12.1	7.4
CD (P=0.05)	3.5	4.1	3.18	2.90	0.70	0.46	0.83	0.52	0.30	0.17	27.9	16.9
Fertilization source												
Control	91.3	108.6	84.0	78.6	37.4	38.0	4.93	4.63	1.80	1.59	127.5	111.9
100% organic	110.4	131.7	88.5	90.7	43.4	45.6	6.43	8.18	2.32	2.83	190.1	230.5
100% inorganic	122.1	136.5	93.0	93.6	47.2	46.6	7.16	8.71	2.61	3.01	227.5	257.2
50% each organic and inorganic	124.6	140.3	94.7	95.2	47.8	47.4	7.66	9.37	2.81	3.24	243.7	281.3
SEm ±	2.4	2.2	1.86	1.83	0.42	0.49	0.34	0.34	0.12	0.11	10.6	9.8
CD (P=0.05)	4.9	4.4	3.79	3.75	0.86	1.00	0.69	0.70	0.25	0.23	21.6	19.9

higher values of green-fodder and dry-matter yields with 50% each organic and inorganic sources was due to improved growth attributes, viz. higher number of tillers/tussock, more tiller height and increased tussock diameter. These were higher for green fodder by 55.4, 19.1 and 6.98% and for dry matter 56.1, 21.1 and 7.12% during 2005; and green fodder 102.4, 14.5 and 7.58% and dry matter 103.8, 14.5 and 7.64% during 2006 over the control, 100% organic sources and 100% inorganic sources of fertilization respectively. It might be due to the fact that organic manure has stimulatory effect of better efficiency of chemical fertilizers and mitigates micronutrient deficiency in addition to supplying major nutrients and improving the physico-chemical properties of soil.

Crude-protein yield

Maximum crude protein (CP) yields (230.0 and 276.0 kg/ha) were recorded with the treatment stubbles burning in both years (Table 1). These yields were equal to the treatment of shaving and pruning during 2005, but significantly higher than the rest of the treatments. Similarly, CP yields recorded with the treatment pruning, shaving and cultivator ploughing were significantly greater than that of control plots. The CP yields recorded with stubbles burning were 75.3, 3.88, 0.88 and 31.1% more during 2005, and 143.9, 14.8, 16.3 and 17.9% more during 2006 than the control, pruning, shaving and cultivator ploughing, respectively. The improved CP yield with stubbles burning and other rejuvenation treatments was due to higher N uptake and increased biomass yield. Regarding fertilization sources, conjoint use of nutrient sources recorded the highest value of CP yield (243.7 and 281.3 kg/ha) in both the years, which were 7.12, 28.2 and 91.1% more during 2005, and 9.37, 22.0 and 151.4% more during 2006 than 100% inorganic, 100% organic sources of plant nutrients and control, respectively.

Nutrient uptake

All the rejuvenation techniques significantly increased the N, P and K uptake compared with the control. The highest nutrient uptake was recorded with stubbles burning by *sewan* grass (Table 2), giving an increase of 75.2 and 144.2% in N uptake, 79.6 and 137.8% in P uptake, and 71.4 and 128.3% in K uptake over control during the first and second year respectively. Higher nutrient uptake with rejuvenation treatments may be attributed to the increased N content in grass and higher biomass yield compared with the control. Among nutrient sources, 50% application of each organic and inorganic sources recorded the highest values of NPK uptake, which was statistically on a par with 100% inorganic nutrient sources but significantly higher over rest of the treatments. Higher N, P and

K uptake under conjoint use of fertilization sources might be due to better utilization of applied nutrients by improving the microbial activity of soil, leading to improved nutrient content in fodder and higher biomass yield, which recorded increased nutrient uptake.

Energy relationship

Among rejuvenation techniques, maximum energy ratio (10.98) and energy productivity (679.1 g/MJ) were recorded with stubbles burning (Table 2). Energy ratio and energy productivity in burning treatment were respectively 89.3 and 89.2% more than the control, with only additional mere energy input use of 3.65%. Their higher values in burning treatment were due to maximum biomass production and comparatively lower input energy use. Among fertilization sources, 100% organic manure application recorded the maximum value of input energy due to bulk use of sheep manure. Among fertility schedules (other than the control), 100% inorganic nutrient supplementation consumed minimum input energy and recorded the highest energy ratio (9.78) and energy productivity (604.8 g/MJ), followed by 50% each through organic and inorganic sources of nutrient supplementation.

Economics

The economic analysis of different treatments showed that stubbles burning proved superior and recorded the maximum net return (Rs 2,563/ha) and B:C ratio (1.51), followed by cultivator ploughing (Table 2). These higher values were obtained due to higher biomass yield and lower input use compared with other treatments. Among fertilization sources, although maximum gross returns were recorded with 50% each organic and inorganic sources (Rs 7,573/ha), but the highest net returns (Rs 3,035/ha) were given by 100% inorganic source of nutrient supplementation. It may be due to lower cost of chemical fertilizers used than the organic source applied in bulk in the treatments 100% organic source as well as 50% each organic and inorganic sources of plant nutrition. However, in spite of lowest biomass yield, highest B:C ratio (1.87) was observed with control due to the lowest cost of cultivation.

Physico-chemical properties of soil

The total addition of N, P and K through different fertilization sources under different treatments was 216, 106 and 148 kg NPK/ha in 100% organic sources; 40 kg each NPK in 100% inorganic sources; and 128, 73 and 94 kg NPK/ha in 50% each NPK/ha. Soil pH, EC, organic C and the available N, P and K status of soil showed marked variation due to rejuvenation techniques and fertilization sources compared with their initial values (Table 3). The differences in pH and EC values were non-significant. The

Table 2. Nutrient uptake, energy relationships and economics as influenced by treatment variables

Treatment	Nutrient uptake (kg/ha)						Energy relationship				Economics*			
	N		P		K		Input energy (MJ/ha)	Output energy (MJ/ha)	Energy ratio	Energy productivity (g/MJ)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit: cost ratio
	2005	2006	2005	2006	2005	2006								
Rejuvenation technique														
Control	21.0	18.1	3.78	3.51	27.6	25.1	4,291	24,902	5.80	359.0	3,925	3,861	–64	0.98
Burning	36.8	44.2	6.79	8.17	47.3	57.3	4,447	48,833	10.98	679.1	4,995	7,558	2,563	1.51
Pruning	35.4	38.5	5.87	6.63	44.2	49.5	5,701	44,953	7.88	487.6	5,851	6,949	1,098	1.19
Shaving	36.5	38.0	6.36	6.78	46.3	49.0	5,800	45,114	7.78	481.0	6,065	6,973	909	1.15
Cultivator	28.1	37.5	4.76	6.76	34.8	48.8	4,807	40,425	8.41	520.1	4,939	6,308	1,369	1.28
SEm±	1.94	1.17	0.20	0.30	2.28	1.11								
CD (P=0.05)	4.47	2.71	0.47	0.69	5.27	2.57								
Fertilization source														
Control	20.4	17.9	3.65	3.31	29.0	26.0	1,503	27,327	18.19	1124.7	2,300	4,293	1,993	1.87
100% organic	30.4	36.9	5.01	6.23	37.7	47.2	7,709	41,557	5.39	333.4	8,300	6,433	-1,867	0.77
100% inorganic	36.4	41.2	6.44	7.56	45.0	53.2	4,646	45,438	9.78	604.8	3,984	7,019	3,035	1.76
50% each organic and inorganic	39.0	45.0	6.96	8.34	48.4	57.3	6,178	48,833	7.90	488.9	6,035	7,573	1,538	1.25
SEm±	1.69	1.56	0.34	0.32	1.87	2.00								
CD (P=0.05)	3.45	3.19	0.70	0.66	3.82	4.08								

* Labour wages: Rs 107/manday; and sale price of sewan grass dry fodder: Rs 2.50/kg

Table 3. Physico-chemical properties of soil as influenced by treatment variables

Treatment	pH		EC (dS/m)		Organic C (%)		Available N (kg/ha)		Available P (kg/ha)		Available K (kg/ha)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Rejuvenation technique												
Control	8.48	8.44	0.599	0.569	0.239	0.254	161.2	160.5	8.46	8.75	162.6	160.9
Burning	8.50	8.45	0.533	0.567	0.246	0.247	161.7	157.1	8.86	9.14	174.3	167.1
Pruning	8.50	8.47	0.560	0.563	0.251	0.263	163.6	160.3	8.64	8.82	164.8	160.7
Shaving	8.51	8.50	0.580	0.581	0.227	0.249	162.4	160.0	8.82	9.09	164.5	160.9
Cultivator	8.48	8.49	0.562	0.575	0.240	0.265	163.2	161.1	8.87	9.04	167.6	161.9
SEm±	0.04	0.03	0.015	0.016	0.005	0.006	1.2	0.9	0.09	0.08	3.14	1.11
CD (P=0.05)	NS	NS	NS	NS	0.011	0.015	NS	2.1	0.22	0.18	7.24	2.56
Fertilization source												
Control	8.63	8.58	0.647	0.644	0.227	0.225	156.8	152.1	7.93	8.46	158.4	155.6
100% organic	8.41	8.42	0.537	0.537	0.267	0.279	162.8	161.8	8.93	9.09	169.4	164.3
100% inorganic	8.58	8.54	0.589	0.593	0.234	0.251	161.0	161.7	8.67	8.88	166.5	162.1
50% each organic and inorganic	8.36	8.35	0.511	0.509	0.254	0.269	169.2	163.6	9.40	9.44	172.7	167.2
SEm±	0.33	0.02	0.011	0.011	0.006	0.004	1.0	1.0	0.11	0.11	1.94	1.55
CD (P=0.05)	0.67	0.05	0.023	0.023	0.011	0.008	2.1	2.0	0.23	0.23	3.97	3.17

organic C of the soil, and the available N, P and K status of the soil revealed positive balance due to use of the rejuvenation techniques, except organic C and available N during 2006, where the values recorded with control plots were almost similar to those of other rejuvenation techniques. Comparatively higher values of organic C and available N with the control during 2006 might be attributed to lower biomass production of grass, which resulted in lower nutrient uptake and better organic C and available N status of the soil. Singh (1999) also reported improved available P and K status of the soil after grasses. But the application of organic manure (full as well as half dose) decreased the values of pH and EC, and increased the organic C content and availability of soil N, P and K during both the years. Slight decrease in pH and EC on application of organic manure might be due to decomposition of organic manure, which produces organic acids and increases the cation-exchange capacity of soil (Tan, 1992). Among fertilization sources, 50% each of organic and inorganic sources recorded significantly higher values of available N, P and K status of the soil compared with other treatments in both the years, except available K content in 100% organic sources, where the differences were non-significant.

It was concluded that maximum fodder yield may be obtained by stubbles burning of old *sewan* grass pastures and application of 50% each of organic and inorganic sources of nutrients supplementation. However, 100% inorganic source of nutrients provided energy efficient and economically viable pasture-grass productivity in hot arid region of Rajasthan.

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