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Effect of Different Cultural Practices and Fertilization on the Regeneration of Degraded *Lasiurus sindicus* Grassland in Extreme Arid Conditions of Jaisalmer, India

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Abstract: A field trial was conducted in factorial randomized block design with three cultural practices of till, no-till and burning in the main plot and two levels of fertilization viz. control and 40 kg N + 20 kg P ha^{-1} in subplots on the degraded *Lasiurus sindicus* (Sewan) grassland to ascertain the regeneration behavior of the grass at Jaisalmer, Rajasthan during the summer 2010. The results of the study revealed that cultural practice of no-till recorded 94.46 and 100.47 higher green and dry fodder yield than the tilling practice. The root volume, dry weight of rhizome and roots were also 38.63, 92.89 and 49.57% higher with no-till practice than the tilling practice. Application of fertilizer increased the fresh and dry fodder yield, dry crown weight, dry root weight and fresh root volume per tussock by 85.93, 125.63, 75.51, 67.36 and 63.02% more than the control, respectively. The practice of no-till recorded maximum numbers of tillers/tussock, tiller height, nodes/tillers, leaves/tussock and spikes/tussock compared to till and burning practices. The tussock diameter of Sewan grass was double in size at all the stages under no-till compared to till treatment. The effect of fertilization was more on tillers/tussock that was 93.16, 83.91, 77.37 and 78.49% higher than the control at 15, 30, 45 and 60 days after treatment of cultural practices and fertilization, respectively application. The protection of the degraded grassland and supply of nutrients sufficed for the revival of Sewan grassland in the Jaisalmer conditions.

Key words: Burning, fertilizer, regeneration, Sewan, till.

The agriculture of seventies in the hot arid zone of India (western Rajasthan) was chiefly towards subsistence farming involving rearing of livestock in association with rainfed cultivation of clusterbean, moth bean and pearl millet. Grassland covers dominate among different land use systems and provide main support to the huge livestock population of the region (Kar *et al*., 2009). *Lasiurus sindicus* Henr locally known as Sewan is one of the dominating grass of the Jaisalmer, Bikaner, Barmer and Jodhpur districts of the western Rajasthan where it provides fodder to the livestock. Extensive patches of this grass can be seen in Jaisalmer district from Lathi onwards on Pokran-Jaisalmer route and from Devikot to Jaisalmer on Barmer-Jaisalmer route. Hummocky sandy plains of Bikaner district also supported extensive Sewan grasslands (Gupta and Saxena, 1970). It is endemic to dry regions of north-west India (Bor, 1960) and is capable of resisting extreme drought conditions as is evident by its distribution. The climatic conditions prevailing in the zone of Sewan grass lands are arid, roughly following an isohyte of about 250 mm and in terms of aridity index the number of physiologically dry days in Barmer, Bikaner and Jaisalmer are 250 (Gupta and Saxena, 1970), while the Thornthwaite's moisture index is below -40. The soils of Sewan rangelands are generally light textured and belong to the desert soil group (Roy and Sen, 1968). A well-established stand of *Lasiurus sindicus* lasts for 8-10 years with proper management (Yadav and Rajora, 1995). Studies conducted on the productivity of *Lasiurus sindicus* at Jodhpur showed that under a total rainfall of 178.80 mm, the production of dry matter was 3.99 g $plant^{-1}$ day^{-1}, which later decreased to 2.74 g $unit^{-1}$ day^{-1} in 60 days time (Gupta and Saxena, 1970). If calculated on a carrying capacity basis it comes to about three hectare per adult cattle on year long basis (Ahuja *et al*., 1968). Unfortunately,

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these grasslands are in a bad shape and in a depleted condition due to over-grazing and lack of management practices based on scientific principles. With the advent of Indira Gandhi Canal and commencement of tube-well irrigation in 1985, livestock based economy saw a change in the land use and large tracts of Sewan grassland came under the plough. Further, in arid zone as a whole, the density of livestock increased from 50 animal per 100 hectares of grazing land in 1951-52 to 154 during 2012. According to Livestock Census 2012, the number of animals in the arid zone increased by 41% between 1951 and 1961 and by 15% between 1995 and 2012. In terms of adult cattle units (ACU) the livestock pressure was 9.58 million in 1983, which increased to 11.27 million in 2001 (Tewari and Arya, 2006) and 11.65 in 2012 (Rajasthan Livestock Census 2012). Local grazing pressures are surpassing the recommended stocking rates of the rangelands at an enormous pace. The pressure was 0.87 ACU ha^{-1} in 1981 increased to 1.02 ACU ha^{-1} in 2001 and 1.55 in 2012 against the optimum desirable density of 0.2 ACU ha^{-1} (Tiwari and Arya, 2006; Misra and Kumawat, 2016). The Sewan grasslands of arid Rajasthan face two threats: one from land coming under water-intensive agriculture, and the other from indiscriminate use of water from the canal to irrigate these pastures. The increase in grazing pressure and shrinkage of grazing area resulted in severe degradation of the Sewan grassland with productivity as low as 0.1 t ha^{-1} yr^{-1} (Roy and Roy, 1996). Since the economy of the hot arid zone is livestock based and improvement in the productivity of the animal husbandry is directly correlated with the improvement in native degraded pasturelands (Sharma, 2013a) feasibility of various agro-techniques have been assessed. Burning was recognized as one of the important tools for the grassland management (Chatterjee and Das, 1989), but burning at large scale was found environmentally unsafe. Further, burning may be a standard technology for other perennial grasses but very little information is available for Sewan grass on this aspect. Bai *et al*. (2010) observed rhizome severing on overall improvement of root lifespan and revival of the perennial grasses. Practical experience with Sewan pastures shows that removal of above-ground hardy portion of old tussocks through tilling are essential at a certain interval for better new sprouting, uniform distribution of the tap root system and growth of tussocks of old Sewan pastures (Sharma and Chander, 2007). However, in the Thar desert, scarcity of rainfall limits the tilling operation required for the practice as this may lead to loss of soil moisture. Some studies on rejuvenation were conducted by the Sharma (2013b) on Sewan grass through N-fertilization only. But there is need to supply adequate plant nutrients to Sewan grass that are associated with efficient source to sink relationship, leading to higher forage productivity. Thus, present study was conducted to find out the effect of different cultural practice and fertilization on the rejuvenation behavior of degraded Sewan grassland at Jaisalmer, Rajasthan (India) during summer 2010.

Materials and Methods

The experiment was conducted at Chandan Farm, ICAR-CAZRI Regional Research Station, Jaisalmer, Rajasthan, India (latitude 26°59′31.32″N and longitude 71°20′29.59″E) having elevation of 196 meters during March to April 2010. The soils of the experimental site was sandy with $CaCO_3$ concretions below 50 cm, having 0.09% organic carbon, 72.80 kg ha^{-1} available N, 6.45 kg ha^{-1} P and 215.78 kg ha^{-1} K with pH 9.2. The experiment was laid out in Factorial Randomized Block Design with two factors and four replications. In main plots three cultural practices viz., burning, no-till and till were taken while in sub-plots two levels of fertilizer viz., control and 40 kg N + 20 kg P ha^{-1} were taken. The practices of burning and tilling were done on March 2010. The whole tussock was dried and above ground dead material was burnt in the treatment of burning. The levels of fertilizers were applied through broadcasting in all the three treatments of cultural practices on next day after irrigating the field. Nitrogen was applied through urea while phosphorus was given through di-ammonium phosphate (DAP). Three irrigations were given through sprinkler during the experimentation. The geometry of the plants was 60 cm x 50 cm in the experimental field accommodating on an average more than 33.2 Sewan plants 10 m^{-2}. Morphological observations were taken from randomly selected five plants in each treatment at regular interval of 15 days after treatments (DAT). Dry root weight, root volume, fresh fodder yield, dry fodder yield and seed yield/ tussock was recorded from the five uprooted plants at the end of experiment in April 2010. Plant parts were separated into crown, root and aerial parts (fodder) and fresh fodder yield was averaged to estimate per plant green fodder yield. Root volume of freshly uprooted plants was measured by water displacement method through a measuring cylinder and expressed as cubic centimeter (cc) per plant. Leaf area was calculated by multiplying the length of the leaf with maximum width and then by a factor of 0.75 (Montgomery, 1911). All the plant parts were dried at 65°C for four days in hot air oven and weight of crown, root and fodder was measured for expression as g plant^{-1}. The tussock size was 0.16 to 0.25 m^2 in the experimental field with radius of 20 to 25 cm and circumference of the tussocks was greater than 100 cm. The dry matter yield reported in the study was on per plant basis since the population was not uniform over the entire area. In the present study all the spikes from the five randomly selected plants were harvested manually and dried to get average seed yield per tussock. The data were analyzed statistically using the SPSS 13.0 software package. All data were subjected to an analysis of variance (ANOVA). Means were compared at 5% level of significance and when a significant ($P \leq 0.05$) F ratio occurred for treatment effects, critical difference (CD) between treatments mean were calculated for comparison.

Results and Discussion

Morphological attributes

Results presented in Table 1 indicated that tillers tussock^{-1}, tiller height, nodes tiller^{-1} and tussock diameter affected significantly with the cultural practices and use of fertilization in the Sewan grass. Tillers tussock^{-1} increased consistently with time in terms of growth and reached maximum at 60 days after treatment (DAT) application. There was a marked increase in sprouting of tussocks in terms of tillers under the no-till and burning treatment. It is nature of Sewan grass that after first monsoon rainfall, tussocks become lush green in five days. In summer, irrigation too caused sprouting from the rhizome and prevailing high temperature in the March caused initial growth of the tillers at fast rate. Maximum number of tillers tussock^{-1} was recorded under no-till which was 87% higher than the till (93.4) at 60 DAT. The tiller height was non-significant at early stage i.e. 15 DAT but was maximum at 30, 45 and 60 DAT under no-till treatment. The decrease in the height of tillers from 45 to 60 DAT in all the cultural practices was due to falling of matured spikelets because in Sewan grass the maturity pattern of spike is basipetal. Nodes tiller^{-1} was also maximum at all the four intervals under no-till treatment but at harvest (60 DAT) maximum numbers were recorded under till treatment which was 13% higher than the burning treatment (4.70). The tussock diameter of Sewan grass increased considerably during the first 30 days and thereafter ratio of increase slowed though its value was invariably about double at all the stages under no-till compared to till treatment. The circumference of the tussocks was more than 100 cm at the start of experiment and there was no abrupt increase in tussock circumference. Tussock radius increased from 19.90 cm to 21.34 cm from 15 to 30 DAT for tussock circumference of 125.5 cm and 134.5 cm at respective periods (Table 1). The result of the study corroborates with those of Mertia *et al.* (2006). The shearing of the rhizome with the action of tilling may be the sole reason attributed to lower growth parameters in the study as also evident from the burning and no-till treatments. Application of 40 kg N + 20 kg P ha^{-1} recorded maximum number of tillers and tiller height at all the four intervals. The effect of N and P on the nodes tiller^{-1} and tussock circumference was more up to 30 DAT but, thereafter there were no consistency in the values. Fertilization increased tillers tussock^{-1} that was 93, 84, 77 and 78% higher than the control at 15, 30, 45 and 60 DAT, respectively. The supply of nutrients through N and P fertilizers and their utilization might have caused better growth as observed in this grass. Sewan grass normally reaches grand growth stage after 45 days and spike starts falling thereafter due to basipetal maturity pattern. In the present study, application of N and P might have elongated the growth period for few days by maintaining proper supply of nitrogen in the leaf and hence maturity of spike is delayed. Additionally, the marginal increase in height of tillers at 60 DAT with fertilizer treatment may be due to some short of extended period of maturity consequently resulting in less or non-falling of mature spikelets.

All the cultural practices and fertilization had considerable effect on the leaf attributes in

Table 1. Effect of cultural practices and fertilization on growth attributes of Lasiurus sindicus at Jaisalmer

Treatments	Tillers/Tussock				Tiller height (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
Cultural practices								
Burning	93.5	103.5	116.2	116.3	76.1	86.4	96.3	91.2
No till	137.5	153.0	167.0	173.0	77.0	89.0	101.0	98.0
Till	71.0	77.0	90.0	93.4	70.5	79.5	91.3	89.0
CD at 5%	15.1	15.5	15.3	16.9	NS	8.1	5.3	5.4
Fertility								
No fertilizer	68.7	78.3	89.7	91.6	68.1	79.0	96.0	88.7
Fertilizer	132.7	144.0	159.1	163.5	81.0	90.9	96.4	96.8
CD at 5%	12.4	12.7	12.5	13.8	5.6	6.6	NS	4.4

Treatments	Nodes/tiller				Tussock circumference (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
Cultural practices								
Burning	3.20	4.10	4.70	4.70	110.0	115.5	131.3	119.5
No till	3.30	4.00	5.10	5.10	125.5	134.5	143.5	146.5
Till	2.50	3.80	4.60	5.30	56.0	64.5	66.8	59.6
CD at 5%	0.12	0.27	0.27	0.27	9.3	9.8	9.8	10.8
Fertility								
No fertilizer	2.60	3.73	4.73	5.00	89.7	103.0	118.3	109.7
Fertilizer	3.40	4.20	4.87	5.07	104.7	106.7	109.4	107.4
CD at 5%	0.10	0.22	NS	NS	7.6	NS	8.0	NS

DAT = Days after treatment; NS = non-significant.

Sewan grass (Table 2). The number of leaves tussock^{-1} increased consistently from 15 DAT to 45 DAT and thereafter decreased at 60 DAT. The number of leaves was lowest at 373 tussock^{-1} at 15 DAT with the tilling treatment and highest with no-till treatment. The same trend was observed at other growth stages. Leaf area (product of the leaf length and leaf width) was 198, 147, 147 and 152% higher at 15, 30, 45 and 60 DAT, respectively with no-till than the till treatment. This might be attributed to intact rhizome as it acts as stored food reserve in this perennial tussocky grass (Kathju *et al.*, 1985). The effect of nitrogen and phosphorus was more pronounced on the leaf attributes in the grass. Application of N and P increased the number of leaves/tussock to approximately double the control that did not receive

Table 2. Effect of cultural practices and fertilization on leaf attributes of Lasiurus sindicus at Jaisalmer

Treatments	No of leaf/tussock				Leaf area/tussock				Leaf sheath length (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT
Cultural practices												
Burning	702	737	838	762	6368	8310	13414	9274	5.10	5.90	6.20	5.70
No till	885	957	1024	970	6665	8432	15923	15191	4.25	4.80	5.60	5.60
Till	373	418	447	385	2237	3411	6436	6022	4.80	5.35	5.90	5.90
CD at 5%	61	61	66	66	697	902	1632	1544	0.27	0.28	0.27	0.27
Fertility												
No fertilizer	399	460	505	459	2770	4257	7297	5923	4.60	5.20	5.93	5.53
Fertilizer	908	948	1035	952	7410	9179	16551	14402	4.83	5.50	5.87	5.93
CD at 5%	50	50	54	54	569	736	1332	1261	0.22	0.23	NS	0.22

DAT = Days after treatment; NS = Non-significant.

fertilization. Similarly, the leaf area tussock^{-1} also recorded more than 200% increase with the application of fertilizers over control. However, leaf sheath length, a contributor in the spike photosynthesis, did not show consistency with the fertilization application and was found non-significant at 45 DAT; although at rest of the stages it was found significantly better with use of fertilizers in the grass. Shrama (2013a) also at Bikaner reported similar findings in *L. sindicus* grass with the application of plant nutrients.

Although, spike length did not show any trend with the cultural practices (Table 3), burning practice recorded maximum length of the spike among the cultural practices. The number of spikelets spike^{-1} that determines the seed yield was significantly more with the burning treatment up to 45 DAT. However, at 60 DAT it was higher with no-till practice. Though, spiklets spike^{-1} were higher with burning treatment, the seed yield tussock^{-1} at 60 DAT (harvest) was 12.50 g with no-till practice that was 36% higher than the till practice. The high number of spikelets spike^{-1} might be associated with more number of photosynthetic source (leaves) which were present under no-till treatment. Fertilization did not have significant effect on length of spike except at 30 DAT where it was only 7% more than control. The effect of fertilization was more with respect to number of spikelets spike^{-1} at all the stages. It increased by 9.43, 3.87 and 11.47% at 30, 45 and 60 DAT over control that recorded 16.33, 17.33 and 14.47 spikelets spike^{-1}, respectively. Similarly, maximum seed yield of 17.55 g tussock^{-1} was recorded with the application of fertilizers which was 63% higher than the control. In plants there is a direct relationship between source and sick with leaf number being directly related to the supply of nitrogen also in plants (Evans, 1989). In the present study higher number of leaves and leaf area tussock^{-1} under the no-till treatment might have contributed to more number of spikes, spikelets and higher seed yield compared to control.

Root and shoot yield

Sewan grass has stout woody storage rhizome and its size determines the regrowth potential of the grass (Kathju *et al.*, 1985). Further, an effective root system is also important for the regrowth as the one that occupies sufficient soil volume also imparts better efficiency in terms of utilization of both soil moisture and nutrients. The cultural practices and fertilization also had considerable impact on the dry weight of rhizome and root volume (Table 4). The cultural practice of no-till recorded 49.57, 38.63 and 92.89% higher root weight, root volume and dry weight of rhizome compared to tilling practice. Similarly, cultural practice of no-till had 94.46 and 100.47% higher green and dry fodder than the tilling practice. However, in the earlier studies maximum yield of Sewan grass was reported with the burning of stubbles. It was opined that burning caused the deposition of ash that provides P, K, Ca and Mg, which are favorable for regrowth and revival of grass soon after rainfall (Paulsamy, 1992). The practice of burning was found next best practice in present study with regard to improvement in growth parameters of Sewan. The shearing of the rhizome with the action of tilling may lead to destruction of functional roots and loss of stored food material of the grass that might

Table 3. Effect of cultural practices and fertilization on spike length and spikelets/spike of Lasiurus sindicus at Jaisalmer

Treatments	Spike length (cm)			No of spikelets/spike			Seed yield/tussock (g)
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	60 DAT
Cultural practices							
Burning	10.90	11.60	10.40	18.30	18.80	15.50	9.20
No till	9.30	10.80	9.90	16.20	16.80	15.90	12.50
Till	9.00	10.50	9.60	16.80	17.40	14.50	6.60
CD at 5%	0.55	0.54	0.54	0.82	0.68	0.82	0.62
Fertility							
No fertilizer	9.40	10.87	10.00	16.33	17.33	14.47	10.75
Fertilizer	10.07	11.07	9.93	17.87	18.00	16.13	17.55
CD at 5%	0.45	NS	NS	0.67	0.56	0.67	0.56

DAT = Days after treatment; NS = non-significant.

Table 4. Effect of cultural practices and fertilization on root weight, root volume, rhizome weight and fodder yield of Lasiurus sindicus at Jaisalmer

Treatments	Dry root weight/ tussock (g)	Root volume/ tussock (cc)	Dry weight of rhizome/tussock (g)	Fresh fodder yield/tussock (g)	Dry fodder yield/ tussock (g)
Cultural practices					
Burning	27.26	76.33	312	446	326
No till	38.23	97.50	461	632	431
Till	25.56	70.33	239	325	215
CD at 5%	2.89	8.35	30	36	31
Fertility					
No fertilizer	22.70	61.89	245	327	199
Fertilizer	37.99	100.89	430	608	449
CD at 5%	2.36	6.82	24	30	25

cause reduction in the regrowth of the grass and other associated attributes. The results of the study corroborated with those of Bai *et al*. (2010). In case of fertilization, application of 40 kg N + 20 kg P ha^{-1} was found significantly higher than the control (Table 4). Application of fertilizer increased the fresh and dry fodder yield, dry root weight and fresh root volume per plant by 88.93, 125.63, 67.36 and 63.02% than the control, respectively. From the Table 1, it was evident that tussock size reduced from 45 to 60 DAT in both fertilized and unfertilized treatments. However, the reduction in tussock size was more in unfertilized treatment (118.3 cm to 109.7 cm) compared to fertilized treatment (109.4 cm 107.4 cm). This clearly indicate that the newly emerged tillers in unfertilized treatment dried at faster rate than the fertilized one. Further, the height of tillers was 8 cm more in the fertilized plants than the unfertilized plants that recorded 88.7 cm as tillers height. The number of tillers per tussock was also more in fertilized plants (91.6 in unfertilized compared to 163.5 in fertilized plants at 60 DAT). The cumulative effect of higher number of tillers and tiller height resulted in 2.25 times higher dry matter yield in fertilized plants. Kathju *et al*. (1985) also reported that application of nitrogen increased the rhizome of *Lasiurus sindicus* grass and hence more number of roots and root volume. Yadav and Rajora (1995) also reported similar results at Jodhpur.

Conclusion

The regeneration of degraded *Lasiurus sindicus* varied considerably with different cultural practices and fertility treatments. Among cultural practices no-tilling of the degraded grassland recorded highest yield followed by burning during the initial years under irrigated conditions. Application of 40 kg N + 20 kg P ha^{-1} almost doubled the fresh and dry fodder yield of the grass together with other yield attributing parameters. It is therefore inferred from the study that protection and application of 40 kg N + 20 kg P ha^{-1} is required in the extreme arid conditions of Rajasthan for the regeneration of the degraded grassland of Sewan grass.

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