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Effect of Different Grazing Management Practices on Soil Health in *Lasiurus sindicus* Grasslands of Arid Western Plain

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Abstract: Maintenance of optimal levels of fodder production from grasslands and rangelands require higher importance as in the arid zone, forage species grow under hostile climatic conditions and also bear high grazing pressure. Therefore, a study was undertaken to assess the effect of different grazing management practices in *Lasiurus sindicus* grasslands on soil chemical and biological properties and carbon management. Silviculture systems, managed pastures and natural grassland with control grazing had significantly higher values for SOC, CMI, MBC and DHA in comparison to the reference soil (undisturbed soil). The grazing management in *Lasiurus sindicus* based grassland is highly favourable to soil carbon management and soil health improvement. Silvipasture system and controlled grazing in grasslands had a beneficial role in restoring soil health in arid western Rajasthan.

Key words: Grazing practices, *Lasiurus sindicus*, arid western plain, soil health, CMI.

Grasslands form major land use of Arid Western plains of India and support livestock based economy of the region. Grassland covers dominate among different land use systems and provide main support to the huge livestock population of the region (Kar *et al*., 2009). The protection of the degraded grassland and supply of nutrients sufficed for the revival of Sewan grassland (Kumawat *et al*., 2017). *Lasiurus sindicus* is one of the dominant grass species of the region and found to have higher water and energy use efficiency among the palatable desert grasses. Maintenance of optimum levels of forage production from rangelands assumes importance as in the arid zone, forage species grow under unfavorable climatic conditions and also bear high grazing pressure (Bawa, 1984). Due to increasing human/livestock population, degradation of the grasslands is rampant thereby making management and preservation of the remaining natural resource essential. Degradation of soil habitat is closely associated with soil health thus understanding soil chemical and biochemical properties becomes critical for better management of ecosystem, these properties were ultimately controlled by various labile pools of soil carbon. Management interventions, such as grazing, cutting, fertilisation, reseeding or irrigation have been found to affect SOC to some extent (Conant *et al*., 2017; Rumpel *et al*., 2015). The carbon management index (CMI) encompasses both SOC pool and C lability, which can be a useful indicator to assess the ability of management practices to improve soil quality (Blair *et al*., 1995) under different agricultural systems. Soils with higher CMI improve soil C and nitrogen (N) concentrations (Kumar *et al*., 2019). Changes in the organization of microbial biomass with land management influences soil fertility and productivity, helping in grassland restoration. Therefore, a study was undertaken to assess the effect of different land uses of *Lasiurus sindicus* (LS) on chemical and biological properties of soil.

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Materials and Methods

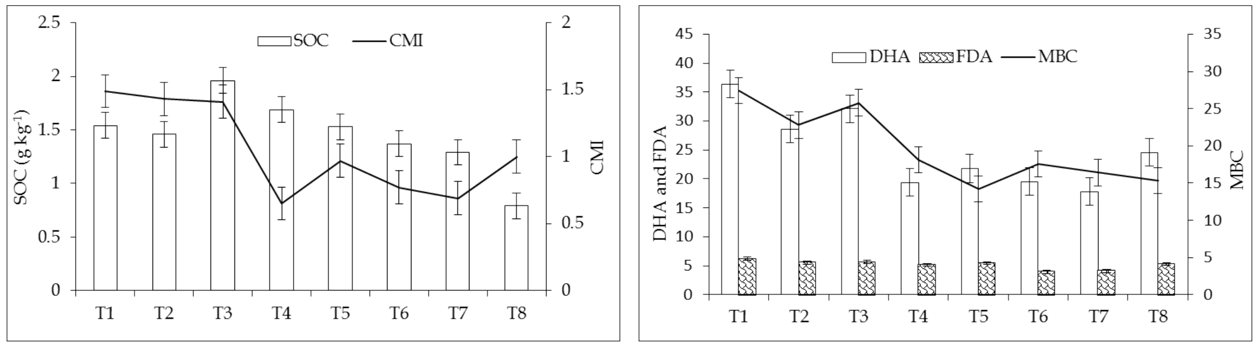
The experiment was conducted at Chandan Farm and Regional Research Station Farm, ICAR-CAZRI, Regional Research Station, Jaisalmer, Rajasthan, India during active phases of grass growth starting from 26^{th} to 50^{th} metrological week (July to December) in 2012. Eight *Lasiurus sindicus* land uses (1: Silvipasture - LS + Mopane; 2: Managed pasture; 3: Natural grassland - Controlled grazing; 4: Natural grassland - Over grazed; 5: Cropped area; 6: Rangeland - protected, 7: Rangeland - unprotected and 8: Reference - undisturbed soil) were selected based on their management and degradation levels.

Composite soil samples from 0-15 cm were air-dried (25°C), hammered gently to break the clods, extraneous roots, and other foreign materials were removed, and finally passed through a 2 mm sieve. The soils were analyzed for oxidizable SOC by the method of Walkley and Black (1934), available nitrogen was determined using alkaline potassium permanganate method by Subbiah and Asija (1956), available P extracted from soil using a 0.5 M sodium bicarbonate by Olsen *et al*. (1954), and available K after treatment with 1 N ammonium acetate and estimation using a flame photometer (Jackson, 1962). The carbon management index was calculated using method of Blair *et al*., 1995.

A healthy and productive soil exists when its biological and physico-chemical properties contribute to sustain all actions taking place in it. Among these properties the activities of various soil enzymes play a fundamental role because they arbitrate various chemical reactions involved in maintaining ecosystem quality, functional diversity, nutrient cycling, mineralisation and transformation of organic matter within the carbon cycle. To assess the soil biochemical activities influenced by various land uses activity of the following soil enzymes was measured: (a) dehydrogenase, due to its important role in degradation of organic matter and because it is a general indicator of soil enzymatic activity and (b) hydrolysis of fluorescein diacetate (protease, lipase and esterase), due to their role in releasing of inorganic N in the N turnover. Soil dehydrogenase activity (DHA) was estimated by reducing 2, 3, 5-triphenyltetrazolium chloride (Casida *et al*., 1964). Total microbial activity in the soils was measured by monitoring the hydrolysis of fluorescein diacetate (FDA), as described by Green *et al*. (2006). The above analyses were complemented by the determination of microbial biomass carbon content (MBC) in the individual samples using the fumigation-extraction method for measuring soil microbial biomass in accordance with Vance *et al*. (1987). The soils of the experimental site was sandy with $CaCO_3$ concretions below 50 cm, low in soil organic carbon (<0.1%), low in available N (<70 kg ha^{-1}) and P (<10 kg ha^{-1}) and medium in available K (221 kg ha^{-1}) with alkaline pH (>8.0). Data obtained from various observations were analysed statistically by adopting the appropriate "Analysis of Variance" method (Gomez and Gomez, 1984). Critical differences were worked out at 5% level of probability where 'F' test was significant.

Results and Discussion

Soils of these area were low in SOC (<2 g kg^{-1}), available macronutrients (available nitrogen and phosphorous) and medium in available potassium (Fig. 1a and Table 1). Silviculture systems observed higher MBC and DHA (27.4 µg g^{-1}, 10.08 µg TPF g^{-1} soil d^{-1}, respectively) followed by managed pastures (MBC=22.8 µg g^{-1}, DHA=6.12 µg TPF g^{-1} soil d^{-1}) and natural grassland with control grazing (MBC=25.8 µg g^{-1}, DHA=7.21 µg TPF g^{-1} soil d^{-1}) in comparison to the reference soil (Fig. 1a and 1b). The silviculture system and managed pastures reported improved soil health which is due to improved management and addition of organic matter through trees. Maximizing carbon entry, and the flow of organic carbon through a grazing system, could be achieved with proper grazing management as was observed in the soil parameters. Traditionally, small ruminants have been reported to have negative effects on the environment because of browsing in unprotected areas (Oba *et al*., 2000). Significantly higher values were found for silvipasture, protected natural grassland as compared to intensively managed grassland and arable lands. Silviculture systems, managed pastures and natural grassland with control grazing had higher values for SOC, MBC and DHA in comparison to the reference soil.



(a) (b)

T1: Silvipasture - LS + Mopane, T2: Managed pasture; T3: Natural grassland - Controlled grazing; T4: Natural grassland - Over grazed; T5: Cropped area; T6: Rangeland - Protected; T7: Rangeland - Unprotected and T8: Reference (Pristine soil)

Fig. 1. Effect of various Lasiurus sindicus based land uses on (a) SOC (g kg^{-1}) and CMI and (b) MBC (µg g^{-1}), DHA (µg TPF g^{-1} Soil d^{-1}) and FDA (µg Flu g^{-1} Soil h^{-1}).

Table 1. Soil available N, P and K (kg ha^{-1}) as influenced by Lasiurus sindicus based land uses

Land uses of *Lasiurus sindicus*		N	P	K
T1	Silvipasture - LS + Mopane	64.2	5.9	192
T2	Managed pasture	59.6	5.6	217
T3	Natural grassland - Controlled grazing	74.1	6.9	241
T4	Natural grassland - Over grazed	67.8	6.1	263
T5	Cropped area	61.3	9.4	230
T6	Rangeland - Protected	52.4	8.7	224
T7	Rangeland - Unprotected	38.1	8.3	216
T8	Reference (Pristine soil)	54.8	4.6	189
CD (P=0.05)		1.89	0.23	NS

Soil organic carbon is a major determinant for the sustainability of agricultural systems in arid zone. The changes in C pools (active or total) reflect the changes in an agricultural system. The C management index (CMI) can be used to monitor the soil over time, and it also indicated whether a new system or practice is declining or rehabilitating the soil (Sodhi *et al*., 2009). The results of the study clearly showed that the CMI for silviculture system (1.49), managed pastures (1.43) and grassland with managed grazing (1.41) were higher which indicates better management (Fig. 1b). These grazing/management practices are best as they are helping in rehabilitating the soil. Values of CMI was reported below 1.00 for Natural Grassland (Over grazed); Cropped area; Rangeland (Protected) and Rangeland (Unprotected) which shows that these land uses were declining the soil health. In overgrazed grassland C content was reduced which can be attributable to reduction of herbaceous fine root biomass (Liu *et al*., 2014) thereby reducing the CMI of overgrazed grasslands. The overgrazed grasslands face serious degradation in Olesharo Catchment, Kenya which leads to low CMI (Saineop *et al*., 2018). Moreover, according to (Benbi *et al*., 2015) the land use with the higher CMI seems to provide better options for C rehabilitation. The CMI is an important index to determine the soil C build-up and estimate the soil quality to compare and assess the effect of diverse cropping systems and best management practices (Blair *et al*., 1995). It is represented by both labile C and total SOC, thus, it acts as a good indicator of C sequestration and changes in soil with the adoption of cropping systems and management practices (Hazra *et al*., 2019).

Soil available macronutrients (available nitrogen and phosphorous) were observed in low category while available potassium in medium category (Table 1). Among various management practices highest available N (74.1 kg ha^{-1}), P (9.4 kg ha^{-1}) and K (263 kg ha^{-1}) in natural grassland with controlled grazing, cropped area and natural grassland - over grazed, respectively. Livestock grazing distribution considered an important management practice under all climatic condition (Horn *et al*., 2003). Heavy grazing was reported to reduce soil fertility and organic matter content (Steinfeld *et al*., 1996). However, in South Africa's communal grazing lands, significant differences between grazed and protected areas in terms of changes in soil bulk density and nutrients were not found, while differences were related to conditions within individual landscapes (Harrison and Shackleton, 1999). Jusoff (1988) reported greater concentrations of total N and available P in grazed compared to ungrazed areas of Malaysia.

Conclusion

The study indicated the positive role of grazing/management practices in improving soil properties and carbon management indices. Various grazing management practices had an influence on soil organic carbon pools, and consequently on the CMI, the CMI could be used as an indicator for soil degradation or improvement in response to grazing management. The management practices had significant effect on the soil chemical and biological health. Silvipasture system and controlled grazing in grasslands had a beneficial role in restoring soil health in arid western Rajasthan. The grazing management in *Lasiurus sindicus* based grassland is highly favourable to soil carbon management and soil health improvement, and more attention should be paid to improve the soil health and ecosystem sustainability in the arid western plains of Rajasthan.

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