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Prospects and study of soil seed bank in India

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Abstract
Soil seed bank plays a vital role in long term survival of an individual species, as well as plant communities in all agro-ecosystem of the world. In a case study over Thar desert, it was observed that a total number of seed per m^2 at fully protected rangeland site was significantly higher than controlled and open grazing sites for all four soils layers: 0-3 cm, 3-6 cm, 6-9 cm, and 9-12 cm. A total of sixteen plant species was identified (major species; *Lasiurus sindicus, Cenchrus biflorus, Cenchrus ciliaris, Cenchrus setigerus, Panicum antidotale*) in the collected samples irrespective of the type of rangelands, soil depth, and the time period of observation. Amount of seed stock (number/m^2) in collected soil samples during the month of May was found significantly higher (30.6 % for fully protected; 34.5% for controlled and 44.5 % for open grazing) than rest of the periods. Soil environmental status in the different profile viz., 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm in soil seed study area, it was found that an average organic carbon content of the profile was observed higher in the bottom layer of the soil (1.80 g kg^{-1}). Water retention both at 1/3 bar and 15 bar increased with increase in soil depth. Steady state infiltration rate was observed as 5.11 mm min^{-1}. Regarding vegetation coverage, it was observed that the seasonal vegetation coverage was 15.2% in fully protected, 14.6% in controlled grazing and 8.2% in open grazing rangeland of Indian arid ecosystem. Therefore, soil seed bank study is an indicative major of the future vegetation in any agro-ecosystem.

Keywords: Soil seed bank, rangeland, *Lasiurus sindicus*, agro-ecosystem

Introduction
The soil seed bank is the natural seed reservoir, often dormant, within the soil of most of the ecosystems and plays a vital role in long term survival of an individual species, as well as plant communities in the soil over the world (Sinha, et. al., 2014) [8]. The seed emergence in the soil seed bank is influenced by the conducive factor of temperature, humidity, and air held in the different strata of the soil (Sinha, et. al., 2009) [5]. The variation in the factors affected seed germination in the soil surface causing degradation of vegetation (Sinha and Santra, 2011a) [6]. The germination strategy used by a particular plant species is a part of the complementary set of adaptation made to suit the particular habitat (Went, 1949; Gutterman, 2002) [9, 2]. During the period of seed development and maturation, seed germination is affected by environmental factors as well as maternal factor whose influences may increase the phenotypical plasticity of seed germination. Therefore, only a small portion of the seed of the plant species in the seed bank may be ready for germination after a particular rainfall event. The phenomenon of phenotypical plasticity of the seed germination was observed in the seeds of certain plant species with dispersed by wind as well as by rain (Gutterman, 2002) [2]. Wind regime is yet another characteristics feature of the ecosystem, especially during summer besides extreme dry condition prevails. Together these two, results in the occurrence severe wind erosion and dust storm. Dusting facilitates sand movement from unstabilized sand dunes (Ramakrishna *et al.*, 1990) [3] causes the deposition of seed in form of sand flux for years as seen in the specific environment of the Thar desert of India.

Present status
Human management practices such as deforestation, extensive grazing or hay cutting or species rich grassland was transformed into arable land as a result of large areas have undergone threatened. In order for natural vegetation to return a viable seed bank would have to exist within the upper soil horizon. Seasonal variation in soil seed bank has also been seen due to variation in vegetation coverage (Sinha and Santra, 2011b) [7]. Seed bank are vital to ecosystem where seed can survive in the soil for many years and germinate when the conditions are suitable. Hence, the species accumulation
process in the restored communities depends to a large extent on the presence of viable seeds in the soil (Bakker et. al. 1996) [1]. Therefore, to obtain an assessment of the probable role of seed bank in community assembly it is essential to gain the knowledge of species composition

of the seed bank before starting a restoration programme.

In present scenario of climate change, it has observed an erratic and irregular rain fall. It is found that the when land bears a good rainy season (may be called as normal rainfall year) bears good flowering and fruiting in the normal rainfall year. The seed formed in this period may have some survival mechanism to combat drought lying within the years.

Soil seed bank: A case study over Thar desert

The climatic situation of Thar desert regions of the western Rajasthan is characterized by sparse vegetation and highly variable precipitation, extreme of temperature, high wind speed, high insulation and thus very high evapotranspiration. Soil fertility level of the region is very low and the soils sandy in texture with low water holding capacity. The monsoon season is very short and could supply good soil moisture regime for not more 90 cumulative days. Thus, plant species that could survive are very limited. However, Indian Thar desert is full of many biological activities. Many annual and perennial plant species has adapted to such situations. They complete their life cycle in such short period and provide fodder for large animal population of the region. The important perennial grass species of the extreme desert are: *Lasiurus sindicus*, *Panicum antidotale* and *Cenchrus ciliaris*. However, *Lasiurus sindicus* pre dominates the scenario among the grasses present in the region. It is one of the principal species of *Dichanthium – Cenchrus – Lasiurus* grass cover which may grow in less than 125 mm rainfall. It is one of the most nutritious grass species of the region and thus one of the first to disappear under the impact of the grazing. Over a period of time, it was observed that *Lasiurus sindicus* is slowly disappearing from the rangelands and replaced by non-climaxed and presently uneconomic vegetation. It might be due to excessive grazing pressure and low regeneration through seeds. The seed of the annual and perennial vegetation get buried in the soil for years and emerge with the conducive situation and maintain the vegetation. Thus, the seeds buried in the soil are keys to the conservation of vegetation in the region.

Due to changes in desert environments and species dynamics some variation in seed bank status is also expected. The phenomenon is conspicuous by poor tussock density in the range land. Considering these points, it become imperative, to know status and quality of soil seed bank so that proper corrective measure could be taken to maintain sufficient regeneration in rangeland. Further, establishment of selected species in degraded rangeland would possibly change the plant community structure of the area thereby improving the productivity of rangeland. Emerged mathematical model might be great importance to policy maker in reclamation of degraded rangeland. Therefore, the focus was also on generating a reference database on seed bank for arid rangeland which may be used in future to study the changes in scenarios.

A study was carried out at the typical rangeland located at CAZRI experimental area; hence studies are needed in wider area and also it is needed to quantify the *in situ* germinable seed. It is also needed to study the influence of rainfall and temperature on soil seed bank status of arid rangeland of Thar desert.

Sites identification of different categories of rangelands

A study was carried out at the typical rangeland of ICAR-Central Arid Zone Research Institute, Regional Research Station, Jaisalmer located in extremely arid environment of Thar desert during 2009-11. The study was conducted in three major categories of rangeland: fully protected rangeland located at Chandan Experimental Area of CAZRI (Site-I), controlled grazing rangeland located at Chandan Experimental Area of CAZRI (Site-II), open grazing rangeland located at the outside Chandan Experimental Area of CAZRI (Site-III). All the three study sites; fully protected, controlled and open rangelands, under extremely arid western Rajasthan of India is characterized by sparse vegetation, meager amount of annual rainfall with erratic behavior (<160 mm with coefficient of variation > 80%), extreme of temperature (-4°C to 48°C), high wind speed during hot summer months (mean daily wind speed 18 km hr^{-1}) and very high rate of evapotranspiration (10-15 mm day^{-1} during summer months). The soils are sandy in texture and hence have low water holding capacity. More than 80 per cent of total annual rainfall of the region occurs during monsoon season (July–September) in 7-8 rain fall events.

Observation periods

The field observations in all three rangelands were taken at different season of the year. Six different observation periods were chosen: April/May, June/July, September/October, and post seed fall periods viz., Nov/Dec and Feb/March. Accordingly, observations on seed bank were recorded during March, May, July, October, and December of the year 2009, 2010 and 2011.

Vertical sampling & collection of soil samples from different layers rangelands

In each rangeland site, ten quadrates of 10 m × 10 m size was earmarked in a diagonal transect in one hectare field. Within each quadrate, a single quadrate of 1 × 1 m size was earmarked at the corner.

Soil Samples were collected from five spots at each 1 × 1 m quadrate using core sampler of 5 cm diameter from four depth (0-3, 3-6, 6-9, and 9-12 cm depth). Soil samples from five random spots within each quadrate were pooled depth-wise to represent a single sample of each quadrate for each depth. During collection of soil samples, it was also kept in mind to keep a minimum separation distance of 20 cm between sampling pairs.

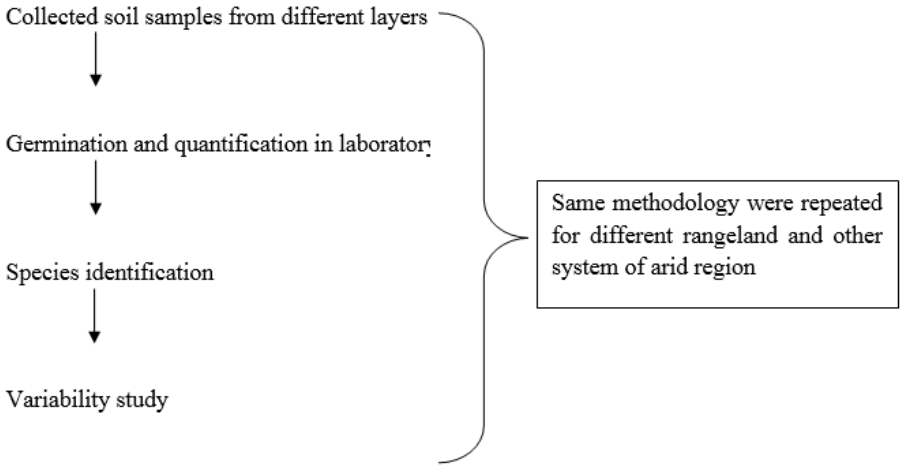
Study would be comprised with; i. present status (vertical and horizontal) of soil seed bank in *Lasiuras sindicus* climax land utilization type of arid region, ii. dynamics of seed of soil seed bank and biotic-abiotic factors influencing it, and; iii. temporal changes in quality of soil seed bank.

Action plan and activities

The study will require laboratory as well as field experimentation under different land utilization types viz., a) fully protected; b) controlled; c) open grazing land.

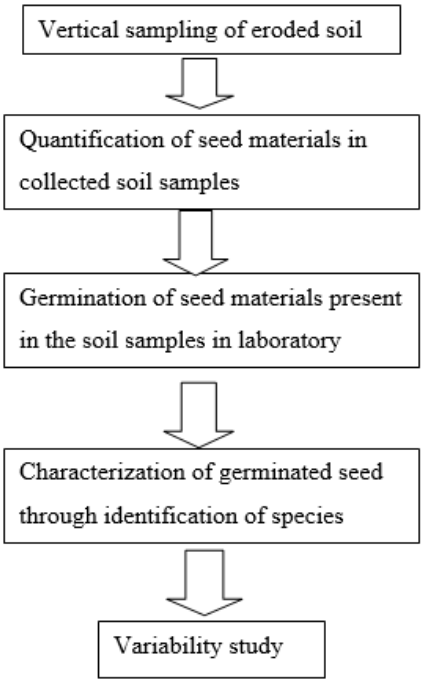
Activity 1

Soil samples was collected month wise after the onset of monsoon. Collected soil samples was kept in petri plate saturated with tap water and then put in growth chamber pre adjusted at 25±1°C. after the germination of seed, species wise identification would be done for variability study. The same methodology was repeated for different rangelands and other systems of arid region.



Activity 2

Vertical sampling of seed disposed by air will be done using sample collector. Collected soil samples were kept in petri plate lined with filter paper. The petri plates were saturated with water and put under growth chamber for germination, quantification, characterization and variability study.



Activity 3

Earmarked all sampling locations by visit and re-visit for the study of soil environment viz., soil temperature at different depths at different weather situations, soil moisture regime, terrain features and existing vegetation densities. This may be repeated for all selected rangeland ecosystem.

It was observed that the arid range land bears a good rainy season which falls after every five years and may be called as normal rainfall year. It means the plant of the region bears good flowering and fruiting in the normal rainfall year. The seed formed in this period may have some survival mechanism to combat drought lying within every five years. However, Sinha et. al., (2014) [8] reported the species dynamics of the three land utilization types of rangelands viz., fully protected; controlled and open grazing rangelands. Further, it is highly required to study all other types of prevailing Indian arid rangelands.

Soil environment study

Soil of the experimental site was characterized through digging a soil profile followed by soil sample collection. Soil depth was found about 40 cm below which calcite concretion was observed. Soil properties were determined in the laboratory and are presented in Table 1.

Sand and clay content varied between 83.40-88.63% and 7.77-9.50%, respectively. Generally, sand content decreased with depth and was found maximum in 10-20 cm soil layer. It indicates the eluviations of fine particles from surface along with movement of water through soil profile and deposition of them at the bottom layer. At the top surface (0-10 cm), slightly higher silt and clay content than the 10-20 cm soil layer is due to deposition of fine eroded particles through wind erosion processes. Bulk density was observed maximum 1.64 Mg m^{-3} at 10-20 cm soil layer. Average organic carbon content of the profile was observed 1.50 g kg^{-1} with maximum content (1.80 g kg^{-1}) at bottom layer. Water retention both at 1/3 bar and 15 bar increased with increase in soil depth and were observed to vary from 4.39 to 7.10 % and from 2.62 to 4.84%, respectively. Steady state infiltration rate was observed as 5.11 mm min^{-1}.

Table 1: Soil environmental status at different depths.

Soil depth	Sand (%)	Clay (%)	Bulk density (Mg m-3)	Organic carbon content (g kg^{-1})	Water retention at 1/3 bar (%)	Water retention at 15 bar (%)
0-10 cm	86.27	9.43	1.58	1.50	4.39	2.62
10-20 cm	88.63	7.77	1.64	0.90	5.45	3.07
20-30 cm	84.68	9.50	1.59	1.50	5.98	3.80
30-40 cm	83.40	9.03	1.55	1.80	7.10	4.84

Vegetation dynamics of rangeland

The total coverage of grassland changed significantly in both season wise and category wise and are depicted in Fig.1. The coverage dynamics of plant population in rangeland differ among seasonal plant life forms in different categories of rangeland. *Lasiurus sindicus* which was dominant perennial

grass species in arid region showed different response to grazing. Though, *Lasiurus sindicus* did not show clear relationship between coverage change and grazing intensity. The coverage increased rapidly from 7% to 30 % in fully protected, 9% to 26 % in controlled grazing, 5% to 11% in open grazing rangeland from May to October. However, fully protected rangeland showed higher vegetation coverage in July, October and December but non-significantly differed in July with controlled grazing whereas controlled grazing rangelands showed higher vegetation coverage in March & May than fully protected and open grazing rangeland but differences was non-significant in March with the fully protected rangeland. It is very interesting to note that fully protected rangeland showed at par vegetation coverage performance with the open grazing rangeland in May whereas controlled grazing rangeland showed significantly higher vegetation coverage with fully protected and open grazing rangeland. Over all, it was observed seasonal vegetation coverage of 15.2% in fully protected, 14.6% in controlled grazing and 8.2% in open grazing rangeland of Indian arid ecosystem.

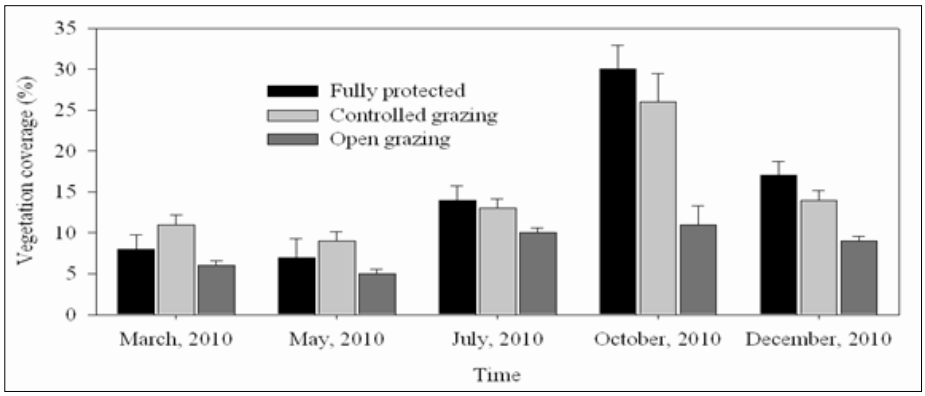


Fig 1: Seasonal change of total grassland coverage in three major categories of arid rangeland.

Mathematical relation between soil seed bank of L. sindicus and vegetation coverage

Mathematical relation between soil seed bank of *L. sindicus* and vegetation coverage was developed. Soil seed bank status and the vegetation coverage of *L. sindicus* was found to have quadratic relationship with each other. Increasing trend in vegetation coverage with increase in soil seed bank up to~50 seeds/m^2 was observed followed by a decreasing trend (Fig. 2). A threshold level was identified after which seed bank status and vegetation coverage negatively influences each other.

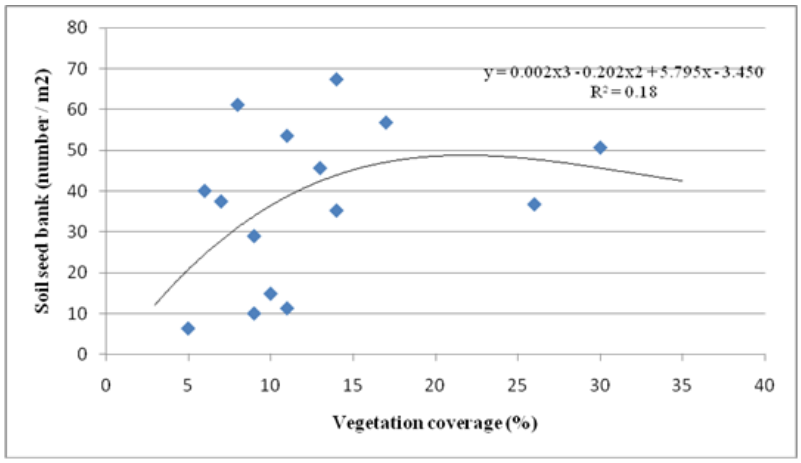


Fig 2: Relationship between soil seed bank of *L. sindicus* and vegetation coverage.

The study revealed that seeds of *L. sindicus* are dominant among composition of soil seed bank in Thar desert as expected from the maximum ground coverage by this grass species in rangelands. In the project, soils at different depth was collected and carried to laboratory condition and suitable environments for germination were maintained for counting the number of seeds. However, the question remains is that whether the same number of seeds as mentioned in the soil seed bank status reported in this project will germinate in nature and expected answer is that it will not. Because, in nature abiotic factors specially soil temperature and soil moisture prevalent in desert soil is highly erratic and may not support good germination of seeds lying below the surface.

Future need

Due to changes in desert environments and species dynamics some variation in seed bank status is also expected (Sinha et. al., 2014) [8]. The phenomenon is conspicuous by poor tussock density in the range land. Considering these points, it become imperative, to know status and quality of soil seed bank so that proper corrective measure could be taken to maintain sufficient regeneration in range land and conservation for future generation. Further, establishment of selected species in degraded range land would possibly change the community structure of the area thereby improving the productivity of rangeland. Therefore, focus should be given on generating a reference database on seed bank for arid rangeland which would be used in future to study the changes in scenarios.

Therefore, the seed bank reported here is an indicative of the amount of potential quality seeds, which may germinate if congenial environment prevails. Attempt to quantify seed bank status under natural condition was also tried by setting experimental conditions of rainfall and temperature situations, which may be strengthened in future study.

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