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Soil Seed Bank and Natural Regeneration of Trees

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Abstract

The current trend of natural resources utilization, such as soils is getting incompatible with the natural, biological, physical and chemical processes of ecosystems. Excessive pressure of increasing agricultural production has exerted a negative impact on soil and its associated resources development. As the agricultural frontiers are getting exhausted in terms of productivity, immediate need has been developed to bring previously considered marginal and peripheral lands under cultivation by clearing forest resources by posing a sever threat to different ecosystems. Forest plantations are generally considered as efficient ways for the sustained development, rehabilitation and protection of land resources. Forest plantations will also provide other ecosystem services like, timber and associated products, control of soil erosion, edible fruits, shelter for wildlife, moderating climate and weather and carbon sequestration. Apart from this, forest plantations will serve a natural medium for the succession of the forest in the understory by moderating the microclimate and by creating the conducive environment for the proper functioning of dispersal agents and the soil seed bank regeneration process. The objective of this article is, therefore, to outline the soil seed bank elements and the natural regeneration process of trees as knowledge about soil seed bank and regeneration process plays a vital role in the proper management of forest development activities and understanding of forest dynamics.

Keywords: soil, seed bank, trees, regeneration

1. Introduction

Forests cover about 31 percent of the earth's surface. The five developed countries (Russia, Brazil, Canada, USA and China) hold more than half of the world's forest. Forest resources provide a range of ecological, social and economic benefits as they contain interestingly diverse plant and animal species (FAO, 2010; Mersha, 2013).

Biologically active ecosystems are the results of plant and animal community interacting with each other and the environment. Ecosystems are also composed of chemical and physical elements, such as water, soil and different forms of nutrient that sustain the wellbeing of life forms. These life forms can vary from large plants and animals to microscopic life forms. Humans are an integral part of the ecosystem and their wellbeing is entirely dependent on the proper functioning of ecosystem services.

Ecosystems provide goods and services which unless and otherwise life forms can't afford to live without it. Clean air, clean water, timber products, moderate climate, etc. are some of the services provided by ecosystems. Among others, ecosystems also help to moderate extreme weather conditions, mitigates flood, recycle nutrients, disintegrate toxic materials and substances, conserve land resources from erosion and helps to maintain biodiversity (ESA, 2015).

Forests do have the natural ability to grow and replace older ones and continue to offer many environmental benefits and ecosystem services. The natural regeneration process boosts the restoration and continuation of biodiversity in forested areas. Many of the forested areas, however, are being cleared than the rate of restoration in order to meet the ever increasing needs of mankind. This anthropogenic interference is presently posing an ecological challenge in many parts of the planet by lowering carbon sequestration, biodiversity losses, obliterations of ecological functions and services and deeply threatening the restoration potential of trees. In addition to this, the clearing of forests is also facilitating for the emergence of invasive species which are not friendly to the environment as it favors the establishment of weeds, pest and diseases (Leonel and Miguel, 2011).

The natural restoration/regeneration of trees is a natural process whereby trees replace themselves from the seed which is present in the soil. This process helps the in-situ conservation of genetic diversity as it is a biological process of the dynamics in the ecosystem.

During this development plant populations which are dominated by trees will develop and evolve, which in turn has a far reaching impact on the structure and composition of forests in the future. Therefore, knowledge on natural regeneration processes of trees along with its dynamics is a vital element to ensure proper planning and development of forest management activities (Yang et al., 2014; Zhang, 2006).

2. Objective

The objective of this article is to outline the soil seed bank elements and the natural regeneration process of trees as knowledge about soil seed bank and regeneration process plays a vital role in the proper management of forest activities.

3. Methodology

To the success of this work, different sources of information such as journals, proceedings and reports were drawn in the form of a critical analysis and discussion. The review also considered a range of knowledge of differing arguments, theories and approaches on soil seed bank research methods. The article attempted to summarize the basic characteristics of soil seed bank and regeneration potential of trees. The review also explored the different biological and physical factors that can affect the quality of seed in the soil.

4. Results and Discussion

4.1 Definition and Scope of Soil Seed Bank and Regeneration

INHF (2001) defined a seed bank as the community of viable seeds present in the soil and Fernando (2009) contented as soil seed bank as all viable seed present under and on the surface of the soil.

Demel (2005) also defined soil seed bank as all viable seeds and fruits present on or in the soil and associated litter/humus.

Seed banks of a forest area have an abundant effect on the succession of plant species since the emerging vegetation that invades an area after a major disturbance will usually rise from them. There are also occasions whereby some plant species that can emerge from disturbed forest areas may not be an element of the mature, revealing as source could be from migrant or seeds buried in the soil (Fernando et al., 2009).

Greene and Waters cited in Mohamed and Mohamed (2008) explained as soil seed banks have a key role in the regeneration and restoration ventures as it helps to initiate a natural rehabilitation of vegetation even after disturbance. Baker (1989) also mentioned as this can reflect the evolutionary changes in plant communities as a consequence of changes in land use besides serving as safeguards for genetic variability.

According to Marco and Raffaello, (2012) regeneration is an ecological process through which forests got renewed in a natural way that is created as a result the emergence of young plants from seeds (seedlings). They also explained as forest trees encounter different phases of life cycle which includes, seedling phase, characterized by intensive competition and high mortality; a juvenile intensive height growth phase, which determines how fast growing trees reach the over-story canopy layer; and finally the maturity phase, which is described by the dominance of canopy and the onset of reproduction and recruitment processes.

4.2 Characteristics of Soil Seed Bank and Regeneration

The restoration of forest plantations in a natural way is a vital element of conservation and sustained development of forest related services. The regeneration process encompasses a range of process steps which includes the production of seeds, development of seedlings and saplings along with their survival potential. The dispersal of seeds marks the end of the reproductive phase of matured plants as it will be leading to the development of the seedlings and saplings. This stage also has a paramount importance on deciding the structure and composition of the vegetation (Xiaojun *et al*., 2006).

The nature and composition of seed banks is variable. According to Garwood, cited in Christoffoleti and Caetano (1998) seed banks can be categorized as temporary or persistent, whereby temporary banks are those which are composed of seeds of short life, which do not present dormancy and are dispersed in time for short periods during the year. Persistent seed banks are those which are composed of seeds that have more than one year of age and reserves of seeds remain in the soil year after year, generally buried into the soil.

The actual offspring of any plant is its seed, a small breathing embryo having the outline for the creation of the adult plant. As the embryo is a very delicate tissue, the mother plant will build a cover to it and adds food in it, the endosperm, so that the emerging small plant can take up the primary steps of its life, that is, germination and its subsequent growth in to a seedling stage (INHF, 2001).

There are two major categories (FAO, 1987):

1) Orthodox. Seeds which can be dried down to a low moisture content of around 5% (wet basis) and successfully stored at low or sub-freezing temperatures for long periods.

2) Recalcitrant. Seeds which cannot survive drying below a relatively high moisture content (often in the range 20–50% wet basis) and which cannot be successfully stored for long periods.

Table 1. General facts on conditions of storage, initial germination and final germination of some selected tree species

Species	**Conditions of Storage**	**Pre-storage germination %**	**Post-storage germination %**	**Period (years)**
Prosopis juliflora	Dry atmosphere of herbarium in S.W.	-	60	50
Acacia aneura	Closed containers at room temperature (20–25°C)	56	60	13
A. hemsleyi	" " "	96	96	13
A. holosericea	" " "	95	84	14
A. leptopetala	" " "	73	72	18
A. victoriae	" " "	80	60	18

(FAO, 1987)

Research also indicates that the density of seed which is viable to germinate under favorable environmental conditions determines the success of a seed bank. The longevity of seed is also another factor that determines the success of regeneration. Different seeds have different potentials of longevity as it all depends on the nature of the seed, soil depth, factors like rainfall and temperature and the presence of seed dispersal agents (Christoffoleti and Caetano, 1998).

4.3 Some of the Factors Affecting the Quality of Seeds

A number of environmental, edaphic, climatic, biological, etc. factors can affect the longevity and the general regeneration potential of seed banks.

Temperature

Temperature is one of the factors which trigger the germination of seeds in the soil profile. Based on the nature of the plant, maximum and minimum temperatures will prohibit the germination process since it affects the physiological processes. The optimum temperature is however, the range which allows the germination of seeds and emergence of seedlings in a short time (Demel, 2005).

Light

Low ratio of red to far-red radiation (R/FR) normally prevents the germination of seeds since it converts the phytochrome in to an inactive form. According to Demel in a study done on 25 forest species of Ethiopia germination was fully inhibited in darkness for the 28 percent of the species under the study. Whereas, 36 percent of the tree species germinated well both under dark and light conditions.

Seed Maturity

Fully matured seeds will have a longer viability of germination than the immature ones since the earlier will have the basic biochemical elements which are vital for the proper germination of the seeds. However, due to physical and mechanical factors, immature seeds can be detached from the mother plant and get buried in the soil.

Mechanical Damage

Seeds will have the opportunity of being damaged mechanically by wind, water, and other dispersal agents and hence affecting the longevity and viability of seeds to germinate.

Parental Factors

Parental trees can have different genetic make-up and diversity in producing a certain amount of seeds. Some can produce plenty others some, which will in turn have its own impact on the regeneration potential of seeds.

Seed Moisture Content

Germination potential of seeds can easily be affected by the level of moisture content. Moisture can also induce the development of fungal attacks on seeds and lowers down the germination potential.

Table 2. Moisture content with various processes within and around the seed

Seed moisture content % (wet weight)	Processes
Above 45 – 60 %	Germination begins
Above 18 – 20 %	The seed may heat (due to a rapid rate of respiration and energy release)
Above 12 – 14 %	Fungus growth can occur
Below 8 – 9 %	Insect activity much reduced
4 – 8 %	Sealed storage is safe.

(Harrington (1959), cited by FAO (1987))

4.4 Methods of Studying Soil Seed Bank

Examining soil seed bank can at times be a very difficult task as the dynamics of vegetation cover in a specific area can be a cumulative result of actions which took place across years' time whereby a series of events could occur in the process of regeneration and growth stages since trees can have a long life span unless their ecological habitat is modified by human interference.

The method of examining soil seed bank and regeneration involves obtaining a sample of the seed itself and do the identification work or it can also be done by germinating the seed itself and identify the seedlings (INHF, 2001).

Roberts (1981) cited in Christoffoleti and Caetano (1998), mentioned as the best and preferred method of examining soil seed bank and regeneration is to observe the emergence of the seedlings right at the site. He went on saying as the most frequent used method however, involves the physical excavation of soil samples, put them in a conducive environment and examine the number of emerging seedlings or else it can also involve the physical separation of seeds from the soil particles.

5. Conclusion

Many of the natural ecosystems including forests are being degraded by the ever increasing rate of deforestation; land use and land cover change. This action is threatening the biodiversity potential and benefits of forest resources. Many of the natural forests are facing a problem of regeneration due to the same factor which is again leading to the extinction of most valued land resources of the planet. Since forest and ecological restoration is a vital element of sustainable development, the issue of maintaining soil seed bank and natural regeneration potentials needs to be backed by conducive policy, strategy and action plan frameworks.

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