Impacts of Climate Change on Forest Tree Seeds in Sudan: A review

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Abstract
The paper is a short review of most of the research work carried on Sudan tree seeds characteristics and the impacts of climate change on those tree soil seed bank and tree seed productivity. It expressed that seeds acquire their characteristics according to the prevailing environmental conditions in their habitats as a guarantee for the presence and continuity of the parent plants on earth. The paper also showed the adverse impacts of accelerated climate change on tree soil seed bank and tree seed productivity expressed in the poor seed quality and low quantity.

Keywords: climate change, seeds characteristics, seeds quality.

Introduction
Climate change and global warming has its effects on Sudan environment. Temperatures are increasing and rainfall is decreasing, arid and semi-arid areas are expanding as more water is lost to the atmosphere, the land quality is reduced, more of it turns to desert and crop yield falls (WWW.Climatechoices.org.uk). The forest cover declined from 36% to 11.6% during the last 100 years. A number of trees and shrubs are seriously endangered (FNC, 2013).

Plants, as known, cannot move from one place to another like other living organisms. They stay the whole of their life where they are and witness the different seasonal and climatic changes. This of course leads plants to develop tight survival mechanisms to coincide closely with the different environmental changes otherwise plants will suffer and cannot live successfully on earth and undergo their physiological activities completely. This might lead to the extinction of plants, which is in terms a loss of useful resources for human well-being. Successful plants are those, which are adapted to their habitats and encounter even slight changes in their natural homes to arrange their life phases. Tolerant plants are those, which can overcome severe and fragile climatic conditions. Survival mechanisms or adaptations are different from one plant to another in type and the way they work, on which plant distribution on earth is based. Those adaptations are found in every part of the plant, (leaves, stems seeds, Fruit...etc). These mechanisms (adaptations) are revised, changed or amended by the plant by interpreting environmental signals to acquire certain characters that enable the plants to overcome environmental stresses. Those survival mechanisms are not evolved suddenly or in a short time but over a long time that could take decades or centuries

The seed is the mobile phase of the plant and so it is the most important part of the plant responsible for the distribution and continuity of the plant on earth. Accordingly, the seed is quite adapted to its surrounding environment. Seeds have

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physical and/or physiological characters that help the seed to protect itself from being decayed, eaten, or losing viability. In this respect, the National tree seed centre conducted a lot of research work on seed characters in relation to environmental factors (seed ecophysiology or seed ecology) in all seed procurement and testing aspects. This paper is a short review of research work on the impact of climate change on tree seed characteristics, tree soil seed bank and tree seed productivity.

**Impact of climate change on seed characteristics**

Seeds acquire their different characteristics from genetically inherited factors plus prevailing environmental conditions, which are interpreted in the plant genome (Schimdt, 2000). Seeds once detached from the parent plant are well provided with characters that protect them from external factors harmful to the seed (Willan, 1995).

**Seed dispersal:** Tree seeds develop certain characters according to their dispersal mechanisms, seeds dispersed by wind are light and have wings like, members of the Combretaceae (Mamoun, 2012; Mahgoub, 2002). *Mahogany* Seeds are winged and wavy in shape to help being carried by wind (Mahgoub, 2002). Seeds of the dry zone Acacias stick to their thin light fruits, which are blown by wind. Seeds dispersed by animals have hard fruit endocarp around the seed to avoid being crushed or chewed by animals and have a sticky solution around the endocarp to stick to animal body and being distributed *Balanites aegytiaca* (Higlig), *Zizuphus spina-cristi* (sider), *Cordia abyssinia* (gimbeel) (Mahgoub, 2002). Tree seeds dispersed by water have fibrous fruit pulp filled with air to provide buoyancy of fruit carrying the seed like Dome (Salih, 2008 unpublished) like *Faidherbia albida* (Haraz) *Acacia nilotica* (grad).

**Seed extraction:** Tree seeds have different fruit characters and different extraction methods according to their habitats. Dry seeds of desert and semidesert areas mostly have dehiscent papery thin fruits that are blown by wind carrying the seeds and are extracted by beating or easy crushing to release the seeds like Hashab, Talih, Salum, *Acacia oerota* (laoat) etc (Mahgoub, 1995-2005). Seeds of humid and sub humid areas usually have a thick fruit pulp around the seed that is fermented and dissolved in the humid soil when fruits are dropped from the tree or eaten by animals which spit out the seed with endocarp, examples are (Humaid), *Kaya senegalensis* (mahogni), *Cordia africana* (gimbeel) (Mahgoub, 2002; Mahgoub and Elsheikh, 2005; NTSC data 1999). Seeds in the high rainfall areas or near water sources are usually extracted by water. They mostly have chemicals in the fruits and seeds (tannin, suberin, phenols) which are antiseptics that protect the seed from decay or rotting in the water until the suitable conditions for germination are available such as *Acacia nilotica* (grad), *Tectona grandis* (teak) members of the Combretaceae, Joghan (Mahgoub, 1998 and 2002).

**Seed dormancy and germination:** the phenomenon of seed dormancy is a direct response to environmental conditions. Seeds remain dormant to pass unsuitable environmental condition for a seedling to grow but will perish (Harper, 1977). Tree seeds have impressive dormancy mechanisms very much related to their climatic conditions. Seeds of *Acacia nilotica* and *A. seibera* have very hard seed coats because they are riverine species along the Nile banks and the fruits are
dropped in water when the Nile floods and remain floating for 3 months after which the seed stick to the mud and germinate. On the other hand seeds of the dry zones have soft coats to start germinating after the first rain showers and complete their germination within the first 7 to 10 days like Hashab on sand, like *Acacia mellifera* (Kitir) and *Acacia Senegal* (hashab) (Abdeldafi, 1977; Musa, 2005) and *Adonsonia digitata* (tabaldi), Balanites aegyptiaca (higlig) (Mahgoub, 2002). Seeds, which enjoy plenty of rains, complete their germination within a longer period (4-6 weeks) since they guarantee the presence of water throughout the rainy season like *Acacia senegal* (hashab) on clay (Elfeel, 2009), *Khaya senegalensis* (mahogni) Cordia Africana (gimbeel), *Diospyros mespiliformis* (Joghan) (Mahgoub, 2002) (Figures 1,2 and 3).

![Fig. 1. Germination rate and Percentage of seeds of *Acacia senegal* from different soil types (Elfeel, 2009)](image1)

![Fig. 2. Germination rate and percentage of *Adansonia digitata* and *Balanites aegyptiaca* (semi desert species) over 8 weeks (Mahgoub, 2002)](image2)
Seeds of fruits eaten by animals possess mechanical dormancy represented in the woody endocarp around the seed to protect the seed from damage by animals teeth. These seeds will germinate only when this endocarp mechanically open along certain sutures filled with soft tissue as the case in Balanites aegyptiaca (higlig), Zizuphus spina-cristi (sider), Cordia Africana (gimbeel), Grewia tenax (geddaim), Sclerocarya birrea (homid), Terminalia laxiflora (sobag) etc. (Mahgoub, 1998, 2002). Seeds of montane areas like Jebel Marra have endogenous dormancy which is not broken unless treated with cold stratification simulating the cold weather of the area as in Cordia Africana (gimbeel) (Mahgoub, 2002). On the other hand seeds produced at the beginning of the rainy season in areas with high rainfall or subjected to regular irrigation, possess no dormancy like Diospyros mespiflorum (Joghan) in the high rainfall savannah and Azadirachta indica (Neem) as an urban plantation (Mahgoub, 2002).

Acacia seeds of the semidesert zone have differential dormancy (Doran et al. 1983) i.e seeds of the same seed lot germinate at different times, the majority of seeds germinate after the early rains, another fraction of seeds remains dormant to capture the late rains and a third fraction is left deeply dormant for the coming seasons.

Therefore, if we assure that seed characteristics are acquired and controlled by genetic and environmental factors, then a gradual change in the seed habitat will call for a gradual change in seed characteristics. Ultimately, an accelerated rate of habitat and climate change could be a hazard to seed life and finally to plant presence on earth if those seed changes can not coincide with environmental changes.

**Impact of climate change on tree soil seed bank**

The tree soil seed bank is the future forest through natural regeneration if suitable conditions for seed germination (water, temp., and oxygen) are available in the soil. Seeds of the soil seed bank have a life time or seed age that varies between seeds of the different species. The tree soil seed bank of Talih (Acacia seyal var. seyal), Mesquite (Prosopis chilensis) and Seyal (Acacia tortilis Subsp.raddiana)
were found to have a seed age of 2 to 3 years (Mamoun, 2004; Ashria, 2008; Elmagboul, 2009). While that of sunt (Acacia nilotica) was predicted to be 10 years (Elbasheir, 2006). Tropical tree legume seeds possess physical differential dormancy to avoid the germination of all seeds in one season, the non-dormant seed fraction will germinate during the rainy season and the dormant ones will enrich the soil seed bank for the coming seasons (Doran et al., 1983). They could also have different degrees of the seed coat thickness so that every year a certain percentage of the seeds in the soil will germinate until the soil seed bank is depleted. This will guarantee the continuous production of new plants from the soil seed bank even if the parent plant is removed.

The seed in the store (either cold or normal) are different from those in the soil seed bank (Elmagboul, 2009). The latter are subjected to the different habitats and climatic changes that affect their physiological characters and may cause an accelerated loss of viability. The impacts of climate change on tree soil seed bank could affect both seed quality and quantity.

**Impacts on seed quality**

Suffering trees from climatic conditions produce poor quality seeds, empty seeds, abortive, low vigor…etc. Accelerated rate of climate change accelerates soil seed bank aging and vigor like increased warming which raise temperature during the day.

**Impacts on Seed quantity**

Removal or death of trees producing seeds, due to increasing drought conditions, decreases the soil seed bank. Soil erosion by either wind or water affects the soil seed bank quantity by carrying the seeds from one place to another or burying it deep in the soil. Recent studies of the soil tree seed bank in the semi arid region of Elgitaina in the White Nile State and Elrawakeeb – Khartoum State revealed that tree soil seed bank is almost zero and the trees cover become patchy (Mutwali, 2007; Basheir, 2010). This is because the wandering livestock eat the falling fruits with seeds or the fruits are collected by the owners of these animals and taken to them elsewhere. This depleted soil seed bank should be considered a serious situation in the semi desert areas of the Sudan since no natural regeneration is expected in the area and ultimately the loss of the existing tree cover will occur unless seed broad casting or afforestation programmes are set. In this regard, the tree soil seed bank is a useful climatic indicator for area degradation.

**Impact of climate change on seed productivity**

Tropical plants regularly produce seeds (fruiting) in quantity and quality when they are enjoying suitable and sustainable climatic conditions. Recently, the tropical and sub tropical regions are the most regions affected by the global climate change. The drought spells that hit the region followed by increasing desertification and scanty uneven rains have made the region vulnerable (WWW.Unep.org/climatechange/).

Accordingly, plants of the dry tropics are suffering from such drought stresses. Plants suffering bad climatic conditions or environmental hazards produce low quality and quantities of seeds and adverse weather conditions are known to influence fruit and seed production (Whitmore, 1984; Schmidt, 2000). This is
simply because the production of seeds (flowering and fruiting) is one of the serious physiological processes that is very sensitive to environmental changes. A rise in temperature and fluctuations in rains had gradually affected the seed yield of cabbage during the period (1981-2004) (Kumar et al., 2004). Off season flowering and fruiting of plants could occur as a result of an environment or habitat change. Some plants are flowering and fruiting all the year round in their optimum conditions while they lose this character in the dry conditions like Azadirachta indica (Neem) which is flowering and fruiting throughout the year in Thailand while in East Africa this is associated with pronounced wet and dry seasons (Schmidt, 2000). Elrawashda forest in Gadaref State is one of the seed sources of Talih (Acacia seyal var. seyal) for the National Tree Seed Centre since its establishment in 1990. However, during the last decade the trees in this forest are suffering from drought and their seed productivity seriously declined except for trees near water sources (per.com. Manager of regional tree seed centre - Gadaref). This forest is no longer used as a seed source now.

Conclusions
Tree seeds acquire their characteristics according to the surrounding environmental conditions and hence are adversely affected with adverse climatic changes, which are expected to increase in the future, and this necessitates more tree planting and seed conservation.
Accelerated climate change adversely affect the tree soil bank and tree seed productivity both in quantity and quality.

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