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RESEARCH ARTICLE

PROSOPIS JULIFLORA (SWARTZ) DC. ECOLOGICAL IMPACT AND CONTROL IN ETHIOPIA

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ABSTRACT

Biodiversity is one of the key factors which make the planet Earth unique. Unfortunately, there are several threats to these resources. Invasive Alien Species (IAS), next to habitat destruction has been a major cause of extinction of native species. *Prosopis juliflora* (Swartz) DC known as Mesquites elsewhere and in Ethiopia it is called 'Weyane/Dergi-Hara' and 'Biscuit' around Afar and Diredawa respectively. Its first introduction is believed to be in late 1970s at Goro nursery, Dire-Dawa, possibly from India. Even though, the plant has several uses, it becomes out of control and threatens biodiversity of the lowlands of Oromia, Somalia, Tigray, Amhara, Afar and South Nations Nationalities and Peoples (SNNP) Regional States of Ethiopia. In Ethiopia, it has invaded more than 70,000 ha of land. Knowing the physiological background for its hardiness; then by, to find a weak-link in its power of endurance is essential to develop an effective, low cost, environmentally sound and sustainable control measures. Several control measures such as mechanical control, chemical control, prescribed burning and others has been implemented. Considering the potential uses of the plant such as; Medicinal values, charcoal and furniture from its high-quality timber; controlling the plant by its utilization is the best measures and it is better to be conducted in integrated way with the active participation of the local community.

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INTRODUCTION

Biodiversity is one of the key factors which make the planet Earth unique. It is also a common factor that links agriculture, forestry, fisheries and other sectors and provides the raw materials for livelihood, sustenance, trade, medicines and industrial development. Unfortunately, there are several treats to these resources. According to the World Conservation Union (IUCN), Invasive Alien Species (IAS), next to habitat destruction has been a major cause of extinction of native species. This invasion by biological control agents has caused a significant loss of biodiversity. Virtually all ecosystem types on the planet are affected by invasive species and they pose one of the biggest threats to biodiversity worldwide (GISP, 2000). According to the Global Invasive Species Program (GISP), globally the damage caused by invasive species has been estimated to be £1 trillion per year – close to 5% of global GDP (GISP 2000). In developing countries, where agriculture accounts for a higher proportion of GDP, the negative impact of invasive species on food security as well as on economic performance can be even greater. As a developing country, this estimation of damage also applies to Ethiopia's condition, even in a more serious condition; since the country's economy is mainly depend on agriculture. According to the Ethiopian Institute of Agricultural Research (information leaflet), in Ethiopia, *Prosopis juliflora* (Swartz) DC. is one of the six identified major invasive plant species distributed to Oromia, Somalia, Tigray, Amhara, Afar and South Nations, Nationalities and Peoples (SNNP) regional states. This paper presents a review on the invasive alien species, *P. juliflora* (Swartz) DC, its introduction to Ethiopia, uses, ecological impacts, control measures and its drought resistance mechanisms.

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WHAT ARE INVASIVE SPECIES?

According to Lowe *et al.* (2000), "Invasive species are organisms (usually transported by humans) which successfully establish themselves in, and then overcome, otherwise intact, pre-existing native ecosystems". Cork and Fuller (1995), also argue that invasive plants are an alien plants spreading naturally (without the direct assistance of people) in natural or semi-natural habitats, to produce a significant change in terms of composition, structure or ecosystem processes. Even though, the two definitions have differences in the way of the introduction of the species to the new area; the former says transported by humans and the later says without the direct assistance of people; they basically agree on what is mean by

invasive species. In general, invasive species can be plants, animals, and other organisms (e.g. microbes) which are:

- An introduced species which invades natural habitats;
- Non-native (or alien) to the ecosystem under consideration and
- Whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Cork and Fuller, 1995; Heywood and Watson, 1995).

Description of *P. juliflora*

Prosopis juliflora belongs to the family FABACEAE (LEGUMINOSAE), subfamily Mimosoideae and genus *Prosopis*. (Figure 1 and 2 below shows pods and seeds of *P. juliflora* respectively).

Fig. 1 Pods of *P. juliflora*

Fig. 2 Seeds of *P. juliflora*

The genus Prosopis is widespread and consists of 44 species, mostly thorny trees and shrubs. It is armed with stipular spines. Leaves have 1-2 sometimes up to 4 pairs of pinnate; the number of leaflets could be 6-29 pairs with glabrous surfaces. Flowers are yellowish. The pod is pale brown, linear, straight or slightly curved, 8-29 cm x 0.8-1.7 cm, compressed and with a sugary-pulpy mesocarp (Asfaw and Thulin, 1989; Vilayati, 2000).

Introduction of P. juliflora to Ethiopia

Prosopis is known as Mesquites elsewhere and in Ethiopia the plant has different names in different languages. According to Demissew (2005), it is called 'Weyane/Dergi-Hara' and 'Biscuit' around Afar and Diredawa respectively. Caroline, also reported that it is called 'devil tree' in some parts of Ethiopia. Demissew (2005), also described that, the plant came originally from the Americas. Its first introduction to Ethiopia is believed to have been in the late 1970s at Goro nursery, Dire-Dawa, possibly from India. In Afar, it may have been introduced possibly from Dire-Dawa or independently from Kenya or Sudan by foreigners working in the Middle Awash irrigation project in the late 1970s and early 1980s.

Uses of P. juliflora

According to Hartwell (1967), mesquite is used in folk remedies for cancerous condition, colds, diarrhea, stomachache, vulnerary for dysentery, eyes, excrescences, flu, inflammation, itch, measles and pinkeye. Apart from these, it is also used for production of furniture, herbal or modern medicines, charcoal and others (Sharma, 1981).

Propagation of P. juliflora

Prosopis is propagated through its seeds, root suckers, and hardwood cuttings (Hailu *et al.,* 2004). Studies revealed that 12% to 45% of Prosopis seeds ingested by animals could pass unharmed through their digestive tracts. Seeds ingested by livestock typically have higher germination rates. According to Hailu *et al.,* (2004), the number of seeds recovered from one kilogram of droppings of each animal under study (Goat, Camel, Warthog and Cattle) ranged between 760 (Goats) to 2833 (Cattle). The seeds can germinate under considerable moisture stress and temperature that ranges between 20-40 ^{o}C. Seeds retained within intact pods can remain viable for up to 40 years, but exposed seeds dry out or decay more rapidly (Cork and Fuller, 1995).

Negative impacts of *P. juliflora*

Invasiveness

Biologists are still trying to characterize the capability of IAS to invade in the hope that initial invasions can be predicted and stopped. Factors of invasiveness may include: an organism has been relieved of the pressures of predators or parasites of its native country; being biologically "hardy", for example, has short generations and a generalist diet; arriving in an ecosystem already disturbed by humans or some other factor. But whatever the causes, the consequences of such invasions; including alteration of habitat and disruption of natural ecosystem processes are often catastrophic for native species. *P. juliflora* is one of the IAS which becomes a threat globally as well as locally in Ethiopian. In India, it has invaded nearly 5.55 million hectares of land. In Ethiopia Prosopis has become a problematic species expanding at an alarming rate in Afar and Somali regions (Figure 3 and 4 below). From unpublished sources, it says in Ethiopia it has invaded >70,000 ha of land. Prosopis is fast growing, drought resistant and with a remarkable coppicing power. Such unique adaptive traits of the species have got negative impact for local biodiversity and ecosystems. Hailu *et al.* (2004), also describes also describes its fast invasiveness in relation to the role of livestock, deer,

rabbits, and rodents in dispersal of the seeds. Accordingly, livestock trailed at the rate of 15 kms per day would transport Prosopis seeds in their digestive tracts more than 100 kms in a week's time.

Fig. 3 ***P. juliflora*** **blocking the rail road around Metehara town, Ethiopia**

Fig. 4 ***P. juliflora*** **on Tef (*Eragrostis tef*) farm around Metehara town, Ethiopia**

Toxicity

According to Lewis et al. (1977), the thorn from mesquite, on penetrating the eye, causes more inflammation than expected from the physical injury. The irritation may be due to waxes. Injection of cerotic acid is destructive to the eye. Using the wood in a fireplace has caused dermatitis. The gum has irritant properties. Lewis *et al.* (1977), also reported that ingestion over long periods of time will result in death in cattle. Further, they reported that the pollen may cause allergic rhinitis, bronchial asthma, and/or hypersensitivity pneumonitis. Kingsbury (1964), goes into some detail on mesquite poisoning in cattle, including cases where autopsies showed pods and seeds in the rumen nine months after the cattle could have ingested them. Mesquite poisoning may induce a permanent impairment of the ability to digest cellulose. Felker and Bandurski (1979), also provide interesting detail; if Prosopis pods are the sole food source for cattle, ca 1% becomes sick, and some die with a compacted pod ball in the rumen. Death is attributed to high sugar content repressing the rumen-bacterial cellulose activity.

Control methods of *P. juliflora*

The facts that Prosopis has great ecological impact, urges its immediate control but not eradication. So, several control methods such as mechanical control, chemical control, prescribed burning have been employed. To have an effective, sustainable and environmental friendly control measure, knowledge of the physiological basses of its hardiness and its mechanism for tolerance against stress is vital.

Drought stress resistance mechanisms of *P. juliflora*

Water is commonly the most limiting environmental factor for tree survival and growth. Plants have evolved many physiological, morphological and phenological characteristics for responding to and resisting drought stress. Certain characteristics and responses to drought do not occur independently but appear to coincide, leading to the categorization of perennial plants as drought avoiders or drought tolerators (Johnsen *et al.,* 1996).

Drought avoiders have tissues that are very sensitive to dehydration. They tend to have characteristics allowing them to avoid tissue water deficits when soil moisture limitation occurs, e.g. deep roots to maximize water uptake, leaf movements or sensitive stomata to minimize leaf water loss.

Drought tolerators have leaves that can tolerate dehydration and they tend to have poorly developed responses for avoiding dehydration. Tolerators rely on osmotic adjustment to survive drought Ludlow *et al.* (1985). Ludlow *et al.* (1985), has profiled the mechanistically linked characteristics that categorize these two drought resistance strategies. Perhaps the single most important indicator of a drought resistance strategy is the dehydration tolerance of a species, i.e. its tissue capacity for withstanding desiccation.

Elfadl and Luukkanen (2006), had studied the diurnal patterns of gas exchange of *P. juliflora* trees grown under dryland conditions in the Sudan. Maximum photosynthetic rates obtained early in the morning, peaked at 17.6 μmol m^{-2} s^{-1}. Maximum transpiration was 102.4 mg m^{-2} s^{-1}, which corresponded to a maximum stomatal conductance of 0.555 mmol m^{-2} s^{-1}. A marked decrease in photosynthesis was observed before midday together with a reduction in stomatal conductance and transpiration rate. However, water loss was initially high in early morning, continuing throughout the day at a decreasing rate. The decline in photosynthesis was mainly the result of non-stomatal limitations since the percentage decrease in photosynthesis is larger than that of stomatal conductance. These limitations on photosynthetic activity are likely to have been induced by intensive solar radiation and

high temperature and enhanced by the increasing vapour pressure deficit. Stomata were open during the morning to maximize productivity in the favorable period, gradually starting to close towards midday. Stomata did, however, remain slightly open throughout the brief adverse conditions of midday to allow transpiration to protect the photosynthetic apparatus. Elfadl and Luukkanen (2006), concluded that, *P. juliflora* is aggressively invasive only in areas with an abundant supply of water. Kathiresan (2005), also describe that, the most potential invasive feature of *P. juliflora* is, its typical greater assimilate portioning towards root, leading to extraordinary enlargement in the root mass with rich food reserves, aiding rapid and robust regeneration after mechanical lopping or after revival of ecological stress conditions such as drought or inundation. Studies at Annamalai University India, has shown that the root enlargement in Prosopis species is greatly influenced by the temperature regime of the locality. The annual increase in root bio-mass is greater in areas where the mean annual temperature is higher than that in areas of lesser mean annual temperature (Table.1 below).

Table 1. Temperature regimes and root biomass enlargement in *Prosopis* (Kathiresan 2005)

Mean Annual Temperature (°C)	Mean Annual increase in Root biomass (kg)	Mean Annual increase in Shoot biomass (kg)
28	19	42
30	44	47
32	62	56

Increase in shoot biomass due to increasing temperature, though observed is not as significant as that of the increase in root biomass. The increase in root biomass largely contributes for the weed's ability to tolerate climatic extremes such as peak summer associated with high temperature and water scarcity and peak monsoon winter with water inundation and flooding. This adaptation favors the weed to predominate over other native floras that are susceptible to any one of the two extremes.

Conclusion

The facts that *P. juliflora* has great negative impact on biodiversity, urge to put its extensive conquering power under control. Cognizant of the negative impacts of chemical control and burning; it is therefore, important to control the species by exploitation of its actual and potential uses to produce valuable products such as furniture, herbal or modern medicines, charcoal, processed foods and others by participating the local peoples in a well integrated and sustainable manner. Prosopis employed water stress avoidance mechanism, in order to overcome water deficiency; it utilizes the ground water by its well-developed root system. The most potential invasive feature of the species is typical greater assimilate portioning towards root, leading to extraordinary enlargement in the root mass with rich food reserves, aiding rapid and robust regeneration after mechanical lopping or after revival of ecological stress. Knowledge of the physiological process governing its invasive potential is therefore, vital for the development of effective, sustainable and environment friendly control measures. Therefore, control should target to the depletion of its fast-growing roots. Controls targeted only to the above ground part of the plant obviously can't control the robust regeneration after mechanical lopping; rather it encourages its growth.

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