Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.19, 2015

Invasion of Prosopis Juliflora in Salabani Location Kenya is Soil a Factor

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Abstract
Invasive species occur outside their adaptive and dispersal range. They are tolerant to climatic and edaphic variations and have adapted to harsh conditions of the dryland by their deep rooting system. They are a threat to functioning and structure of ecosystems worldwide. Prosopis is a leguminous plant that fixes nitrogen through symbiosis hence can directly affect soil nitrogen dynamics. This study sot to examine the relationship between spread of Prosopis juliflora and soil characteristics in Salabani Location. The study area was stratified into areas of high density, low density and zero density of P. Juliflora invasion. Soil samples were collected and analyzed for pH, Cation exchange capacity and soil nutrients. Soil analysis established that soil nutrients increased under high density P. juliflora stands than where there was no P. Juliflora. The plant increased soil nutrients through nitrogen fixing and lowered the pH which might have contributed to invasive growth of the plant. Soils under high P. juliflora density had seventeen times total nitrogen content than soils without P. juliflora and had more than four times nitrogen than soils under low P. juliflora density.

Introduction

Invasive alien plants can dominate ecosystems and are a growing threat to the delivery of ecosystem functions and services (Levine *et. al.*, 2003). *P. juliflora* has survived where other tree species have failed and in many cases become a major nuisance. They are tolerant to high saline and alkaline soils, poor physiochemical and biological conditions of the soil. They have deep rooting systems, few stomata, and seed profusely and are allelopathic (Pasiecznik *et. al*., 2001). Livestock scarify the seeds and spread them in the fields through their dung. The seeds can lie dormant for over 14 years and germinate once the soils are disturbed. Prosopis coppices from cut stems and roots. *P. juliflora* continues to invade millions of hectares of rangeland in South Africa, East Africa, West Africa, India, Pakistan, Australia and coastal Asia (Pasiecznik *et. al*., 2001). Affected countries have devoted increasing amounts of time and funds to control invasion with limited success. The first records of propagation of invasive *Prosopis juliflora* in Kenya can be traced to tree species trials carried out in 1973 in Bamburi in Mombasa, Menengai in Njoro, 1983 in Marigat in Baringo, Tana River, and Turkana Districts. Subsequent appraisal of the *P. juliflora* project by the World Bank and FAO led to the formation of Baringo Fuel Wood Afforestation Extension project which intensified the planting programme after finding the tree suitable (Pimentel *et. al*., 2000). This was due to its resilience, drought tolerance, fast growth, source of fodder for livestock, and fuel wood (Meyerhoff, 1991). The Government of Kenya introduced this tree to mitigate desertification, draught conditions and fuel wood shortages in the ASAL areas. The plant was easily imported into Kenya due to the poor phytosanitary regulations and enforcement policies in the 1960s to 1980s. Further planting of the tree was stopped in the early 1990s when the weedy characteristics of the plant were noticed (Choge *et. al.*, 2002).

The study seeks to determine relationship between spread of *P. juliflora* and soil characteristics in Salabani Location. This objective was investigated in view of curiosity surrounding the rapid invasion and spread of *P. juliflora* in Salabani location; the factors influencing such rapid growth of the plant. Indeed it was speculated that the major driver of this invasion may have been the nature and characteristics of the soils in the study area.

Methodology

Stratified systematic sampling method was used in collecting soil samples from areas of high Prosopis density towards Lake Baringo, Low density and zero density towards the Marigat –Kambi Samaki road. Composite samples of top soil and subsoil were collected and mixed thoroughly and stored in brown paper for each sampling stratum and analyzed in the laboratory.

Data Analysis

Soil characteristics were analyzed using ANOVA

Study Area

Salabani Location lies between longitude $0^0$45'N, $0^0$30'N and latitude 35^0 45'E, $36^0$0'E. It is located about 15 km from Endao bridge junction along Marigat - Kambi Samaki road in the Ilchamus (Njemps) plains between Lake

Baringo and Lake Bogoria. The local community relies mainly on pastoralism. Salabani experiences severe soil erosion due to poor vegetation cover and poor soil structure (GoK, 2002). Soils are mainly clay loams with alluvial deposits derived from tertiary / quaternary volcanic and pyroclastic rock sediments that have been weathered and eroded from the Tugen highlands. The soils contain high levels of phosphorous, potassium, calcium and magnesium and low levels of nitrogen and carbon. The soils range from acidic to slightly alkaline (GoK, 2002).

These lowlands receive 600 mm of rainfall annually which is bimodal, low, erratic and unreliable. Long rains start from March to July while short rains between September and November. The mean annual maximum temperature lies between 25°C and 30°C and minimum temperatures from 16–18°C (GoK, 2002). The hottest months range from January to March. The flood plains lie between agro-ecological zone IV and V. The ASAL vegetation is characterized by *P. juliflora* and Acacia woodlots (mainly *A. tortilis*) in association with *Boscia* spp., *Balanites aegyptica* and bushes of *Salvadora persica*. High evapo-transpiration rates and low variable rainfall create water scarcities that limit intensive agricultural land use (GoK, 2002). The population density is relatively low 21 persons per square kilometer, with a total population of 40,985 people in Marigat division and 2000 households in Salabani location (GoK, 2009).

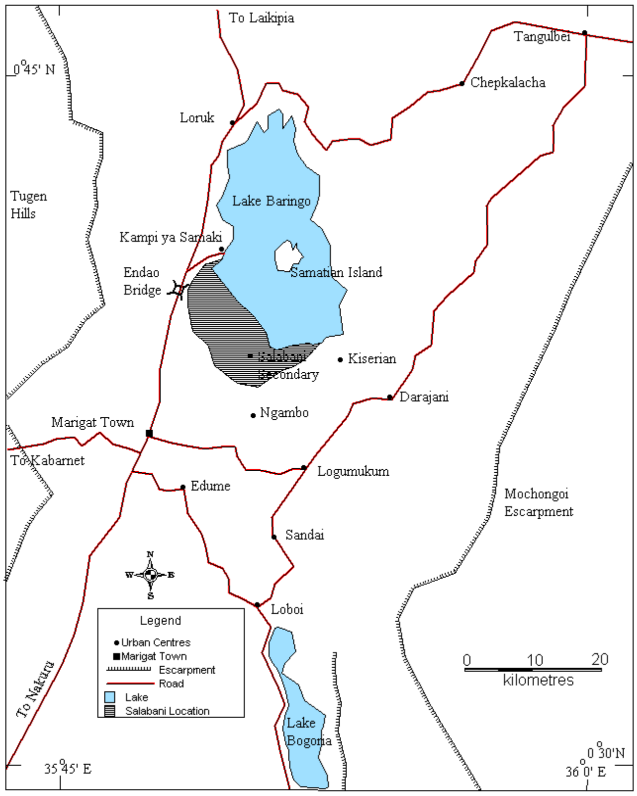

Figure 1: Map of Salabani Location, Kenya
Source: Moi University, Geography Department 2012

Results and Discussion

Table 1 and 2 show the variations in soil characteristics in different densities of invasion of *P. juliflora:* from high density, low density to zero density.

Table 1: Soil characteristics in varying stand densities of *P. juliflora* in Salabani Location.

	***P. juliflora* density**		
Soil characteristics	**None**	**Low**	**High**
pH	7.73 ± 0.14	7.59 ± 0.15	7.4 ± 0.32
E.C	0.11 ± 0.02	0.14 ± 0.02	0.16 ± 0.02
C	0.12 ± 0.04	0.36 ± 0.23	1.5 ± 0.39
Organic matter	0.21 ± 0.004	0.62 ± 0.39	2.43 ± 0.53
TN	0.05 ± 0.01	0.23 ± 0.07	0.89 ± 0.12
TP(ppm)	2.95 ± 0.05	28.63 ± 12.24	38.96 ± 5.67
K(ppm)	232 ± 12.5	343.0 ± 79.7	344.3 ± 56.4
Na(ppm)	74.5 ± 8.51	161.2 ± 44.5	258.3 ± 9.24
Ca(ppm)	2951.5 ± 101.5	4614.3 ± 398.1	4488 ± 306.7

Source: Survey Data, 2009

Table 2: ANOVA of soil characteristics and different Prosopis densities

		Sum of Squares	**df**	**Mean Square**	**F**	**P-value**
pH * density	Between Groups	2.077	2	1.0385	2.642	0.008
	Within Groups	0.786	5	0.393		
	Total	0.863	7			
E.C * density	Between Groups	0.311	2	0.1555	51.833	0.003
	Within Groups	0.006	5	0.003		
	Total	0.01	7			
C * density	Between Groups	2.934	2	1.467	2.360	0.048
	Within Groups	1.243	5	0.6215		
	Total	4.177	7			
OM*density	Between Groups	7.551	2	3.7755	2.862	0.034
	Within Groups	2.638	5	1.319		
	Total	10.189	7			
P (ppm) *density	Between Groups	2587.75	2	1293.875	2.370	0.106
	Within Groups	1091.958	5	545.979		
	Total	2679.709	7			
K(ppm) * density	Between Groups	38706.833	2	19353.4165	2.891	0.005
	Within Groups	13388.667	5	6694.3335		
	Total	82095.5	7			
Na (ppm) * density	Between Groups	51615.708	2	25807.854	4.109	0.026
	Within Groups	12561.167	5	6280.5835		
	Total	54176.875	7			
Ca (ppm) * density	Between Groups	4862762.708	2	2431381.354	3.166	0.043
	Within Groups	1535997.167	5	767998.5835		
	Total	5398759.875	7			

It may be observed from Table 1 that soils under high *P. juliflora* density stands around Lake Baringo had significantly lower pH value which suggests that they are more acidic than soils in open stands towards Marigat Kambi Samaki road. The slight acidity of the soils under high density *P. juliflora* stands could be attributed to leaches and exudates from the litter that falls and rooting of *P. juliflora*. The findings of this study are in agreement with those of Bhatia *et.al.* (1998): He observed a significant reduction in soil pH under the canopies of *P. juliflora.*

Soil nutrients and electrical conductivity increased from low density stands to high density stands of *P. juliflora.* The high electrical conductivity could be attributed to the presence of cations. Organic carbon content and organic matter was significantly high under high density *P. juliflora* stands than in the open areas. The accumulation of organic carbon and organic matter below the tree canopies may be partly due to litter fall and reduced leaching under the tree canopy. Birds and other animals which have found a habitat under *P. juliflora* stands could also be responsible for the higher organic carbon and phosphorous observed and reduced leaching under the tree canopies (Felker 2003). Soils under high *P. juliflora* density had seventeen times total nitrogen content than soils without *P. juliflora* and had more than four times nitrogen than soils under low *P. juliflora* density.

Available phosphorus was significantly higher in the areas of high *P. juliflora* density than areas with low density or none. The high available phosphorus content under *P. juliflora* could be attributed to biological processes that are continuously taking place between the Rhizobium bacteria and the tree roots, since *P. juliflora* is leguminous (Geesing *et.al.* 2000). The phosphorous concentration under *P. juliflora* canopies could also be attributed to pumping of soluble phosphorous from deeper soil layers (Geesing *et.al.* 2000). Legumes have been found to be more efficient in obtaining phosphorous from insoluble sources due to the increased cation exchange capacity of their rooting systems that lowers the calcium activity of the soil solution facilitating the release of phosphorous from insoluble Ca-P compounds (Geesing *et.al.* 2000). The results of this study are consistent with those of Young (1989) who also observed high phosphorus under the tree canopy and attributed it to biological nitrogen fixation by Rhizobium bacteria. Frias - Hernandez, *et.al.* (1999) found phosphorous to be two times greater under *P. juliflora* than in the open. Gadzia and Ludwig (2009) found soils under *P. juliflora* to have higher concentrations of calcium, magnesium, and potassium than those in open areas in southern New Mexico. Klemmedson and Tiedemann (1986) also found more potassium in soils under *P. juliflora* and linked it to higher electrical conductivity. The density of the plant is higher around Lake Baringo where there are more fertile alluvial deposits in the floodplains eroded from the Tugen highlands and availability of water throughout the year in this ASAL conditions (plate 2). The pastoralists in Salabani keep a lot of livestock as a security to persistent droughts. The goats browse on pods from this plant which contain a lot of seeds (plate1). It is estimated that each mature tree produces 630,000 to 980,000 seeds per annum (Harding and Bate1991).

Plate 1: Prosopis pods seed profusely
Source: Survey data 2006

Plate 2: Thickets of Prosopis on shores of Lake Baringo in the background
Source: Survey data 2006

The goats however, do not digest the seeds due to hard seed cover hence they are passed on in there dung which germinate vigorously under pasture land. Such undigested seeds are also washed downstream by floods towards Lake Baringo and rivers in the study area which enhances their dispersal. In areas where the plant has been cut for charcoal production it coppices heavily with each stool producing on average 5 shoots. This also increases the density of the plant in the study area. The Density of prosopis increases as one approaches Lake Baringo where there are alluvial deposits and plenty of water and decreases towards Marigat Kambi Samaki road where soils are generally coarse and stony.

Conclusions

The study therefore concludes that soil characteristics influence the invasion of *P. juliflora* as the density increases towards Lake Baringo where soils are rich in nutrients, organic matter and higher electrical conductivity**.** The plant is leguminous hence it also fixes its own nutrients enriching the soils, lowers the soil pH hence increasing cation exchange capacity. These then contribute to invasiveness of the plant coupled by availability of water from Lake Baringo and Bogoria in this ASAL conditions. The plant fixes its own nitrogen from the Rhizobium bacteria in its nodules whereas leaches and exudates from litter fall increase acidity and organic matter. The deep rooting system is also thought to pump nutrients from deeper soil layers.

Recommendations

The study recommends that the government of Kenya should increase utilization of *P. juliflora* but simultaneously replace it with *P. chilensis* which is spineless and not invasive. KFS and KEFRI should continue training farmers in the field schools established on how to manage the invasion through thinning, pollarding and treating cut stems. The community should stop burning *P. juliflora* as it encourages re-sprouting from damaged stems, scarifies the dormant seeds and removes all valuable native plants from the ground.

Acknowledgement

The authors wish to sincerely thank Egerton University for the opportunity to carry out this research and KEFRI for analyzing the soil samples in Muguga Nairobi.

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