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# Allelopathy effect of *Prosopis juliflora* on selected grass species (*Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans*)

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## ABSTRACT

*Prosopis juliflora* growing frightening rate of invasiveness had affected the livelihood of the pastoral communities in the Amibara rangeland of Afar National Regional State. Therefore, the aim of this study was to investigate the allelopathy effect of aqueous leaf, bark, and root extracts of *Prosopis juliflora* on selected grass species such as *Cenchrus ciliaris*, *Paspalidium desertorum*, and *Lintonia nutans*. A total of 10 soil samples were collected from the Amibara rangeland of Afar National Regional State. The collected soil samples were mixed in a plastic bag to get composite soil. Further, the composite soil sample was subjected to analysis of physico-chemical characters (pH, soil organic matter, phosphorus, and nitrogen content). The aqueous extracts prepared from powdered leaf, bark, and root of *Prosopis juliflora* at different concentration levels (0%, 1%, 2.5%, 5%, and 10%) were subjected to analysis of seed germination percentage and seedling growth of selected grass species such as *Cenchrus ciliaris*, *Paspalidium desertorum*, and *Lintonia nutans*. *Prosopis juliflora* showed a significant inhibitory effect on seed germination of *Cenchrus ciliaris*, *Paspalidium desertorum*, and *Lintonia nutans* grass species. Among the leaf, bark, and root aqueous extracts, the leaf showed the highest inhibitory effect on seed germination percentage *Prosopis juliflora* aqueous extracts of leaf, bark, and root of were exhibited significant inhibition on the fresh shoot biomass weights of *Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans* when compared to the control. While the fresh shoot biomass weight of *Cenchrus ciliaris* and *Paspalidium desertorum* was highly deteriorated at 5% and 10%. And the fresh shoot biomass weight of *Lintonia nutans* momentarily retarded at 1% and 5% as compared to the control.

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## INTRODUCTION

The introduction of *Prosopis juliflora* into Ethiopia took place in the late 1970s in Dire-Dawa. Introductions in the north of the country, in Afar, are believed to have been undertaken by workers of the Middle Awash irrigation project in the late 1970s and early 1980s, with seeds either from Dire-Dawa, from Kenya, or from Sudan. Meanwhile, *Prosopis* is continuously invading areas of the pastoralists of the Afar and Isa groups in the Afar National Regional State (ANRS) and has infested areas that are hundreds of kilometers away from its original introductions (Shiferaw *et al.*, 2004). Other introductions over large areas in Ethiopia took place as part of the Food for Work Programme, which lasted until 1988. Even today, *Prosopis* spp. are planted as shade trees and for living fences (Sertse and Pasiecznik, 2005).

*Prosopis juliflora* reduces the grass cover of grazing lands and consequently affects stocking density. The invasion is also a major problem for agricultural lands. Mesquite is accused of diminishing groundwater with the help of its long taproot system. The leaves showed allelopathic effects by preventing under canopy growth (Nakamo *et al.*, 2003) the pollen grains also source to allergic reactions (Pasiecznik *et al.*, 2004). Moreover, thorns are very toxic to humans as well as animals. These features are enabled mesquite to affect the livelihoods of the rural poor.

*Prosopis juliflora* creates a physical barrier against seedlings of other plant species and therefore, it makes establishment is very difficult. This may lead to negative impacts on local farmlands and pasturelands. Since *Prosopis juliflora* branches are many, dense, and have evergreen leaves, sunlight will not reach the ground, and under the canopy. This may result in

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the death of plants under the canopy of *Prosopis juliflora* (Pasicznik, 2001).

There are few studies on the allelopathic effects of *Prosopis juliflora*. However, these studies do not clearly demonstrate that such effects are due to Allelopathy alone or competition. The main problems of *Prosopis juliflora* invasions on the indigenous plant species are interfering with germination, growth, and performance of the associated plant species. Such effects might contribute to the shrinkage of indigenous plant biodiversity and contribute to the shortage of fodder to the livestock population in the study area thus affecting the livelihood of the pastoral community. Therefore, this research was initiated to study the effect of *Prosopis juliflora* on selected grass species in Amibara Rangeland of Afar Regional State, Ethiopia.

## MATERIAL AND METHODS

### Analyses of soil physico-chemical properties

Ten soil samples were collected from Melka- Werer in Amibara district. After this, collected soil samples were mixed in plastic bags to form a composite sample (Lisanework and Michelsen, 1993). The composite soil samples were further subjected to physicochemical analysis following standard techniques. Determination of Soil pH was done with a pH meter with a ratio of 1: 2.5 w/v soil: distilled water). Soil organic matters (SOM) were measured using the  $K_2Cr_2O_7-H_2SO_4$  oxidation method (Nelson and Sommers, 1996). The phosphorus (P) content was determined by using the colorimetric (Olsen and Sommers, 1982). The Kjeldahl digestion method was used for the determination of total nitrogen.

### Preparation of leaf, bark and root aqueous extract of *Prosopis juliflora*

Fresh leaves, bark, and root from several mature stands of *Prosopis juliflora* were collected from Melka-Werer in Amibara District, air-dried, and mixed. The dried plant materials were ground to a fine powder in a Tecator Cyclotec 1093 Sample Mill and were used for bioassay and pot experiment studies. *Prosopis juliflora* aqueous leaf, bark, and root extracts were prepared by the method proposed by Heisey (1990). Ten grams of each leaf, bark, and root powder were dissolved separately in 100ml of distilled water in conical flasks and shaken for four hours. Following extraction, the solution was filtered through double layers of cheesecloth and filter paper, the volume was made up to 100ml with distilled water and kept at 4° C until application. The aqueous extract of the leaves, bark, and roots has been prepared at 0%, 1%, 2.5%, 5%, and 10% concentrations (Lisanework and Michelsen, 1993). All extracts were used for the germination bioassay and seedling growth assessment.

### Seed germination bioassay study

The three most important and predominant pastoral types of grass before the *Prosopis* invasion in the study area were purposely selected and the seeds of grasses were collected from

the Gene Banks of Werer Agricultural Research Centre. Seeds of three grass species such as *Cenchrus ciliaris*, *Paspalidium desertorum*, and *Lintonia nutans*. The selected weed species were subjected to seed germination (Heisey, 1990). The filter paper was moistened with 5ml of the aqueous extracts (1% 2.5%, 5%, and 10% concentration) of leaf, bark, and root of *Prosopis juliflora* and with distilled water in case of the control. In the Petri-dishes twenty-five seeds were spread out on filter paper. There were three replicate for each type of extract concentration and recipient species. The Petri-dishes have been randomized and incubated at 20 °C in darkness in sealed plastic bags. Germination percentages were calculated after the onset of germination. Germination % = Number of seeds germinated/ Number of seeds placed for gemination × 100.

### Greenhouse experiment

The seeds of selected grass species were sown in earthen pots. The soil consisted of a mixture of river sand, silt, and humus in the ratio of 1:1:2. The seedlings were thinned to three plant/pot. The treatment was started after the 3<sup>rd</sup> leaf has emerged. Before sowing, the seeds were surface sterilized with 15% sodium hypochlorite. All the experimental plants were grown under outdoor conditions in sunlight in the greenhouse of Haramaya University. The pots were watered with different concentrations of aqueous extracts of *Prosopis juliflora* (1% 2.5%, 5%, and 10%) of the test plants on alternate days. Control plants were irrigated with normal water. There were three replicates for each treatment and the pots were arranged completely randomized. The biomass production was determined after three months.

### Data analysis

The data collected on germination bioassay and greenhouse experiment were subjected to analysis of variance using SAS (version 9) software program. Simple descriptive statistics, one-way ANOVA, and Duncan's multiple range tests were used for data analysis. All data were tested at  $p < 0.05$  level in order to investigate if significant differences existed among treatments.

## RESULTS AND DISCUSSION

### Soil physical and chemical properties

Soil physical and chemical properties were analyzed and the results were indicated in table-1. It revealed that the lowest pH (4.6) noticed under the canopy, away from the canopy showed almost near to neutral pH value (6.43). The edge of the canopy

**Table 1: Physico chemical analyses of soil samples that were taken from the *Prosopis juliflora* invaded sites and the adjacent natural sites**

Soil distance	pH value	SOM (%)	Available P (mg/kg)	Total N%
Under of canopy	4.6±0.30 <sup>b</sup>	2.80±0.06 <sup>a</sup>	14.08±0.93 <sup>b</sup>	0.99±0.26 <sup>a</sup>
Edge of canopy	6.43±0.50 <sup>b</sup>	2.61±0.28 <sup>a</sup>	19.74±0.63 <sup>b</sup>	0.82±0.21 <sup>a</sup>
Out of canopy (1-2m) away	7.51±0.31 <sup>a</sup>	2.53±0.15 <sup>a</sup>	23.88±1.52 <sup>a</sup>	0.34±0.03 <sup>a</sup>

showed a pH value just below the neutral. Moreover, the pH value found to increase with increasing distance from *Prosopis juliflora*.

However, the variation of soil pH slightly showed acidity with the canopy zone. In line with this, Bhatia *et al.* (1998) described a significant reduction in the soil pH due to the accumulation of allelochemicals leach out for the *Prosopis juliflora*. In addition to this, soil organic matter (SOC) and total nitrogen (N) were showed significant differences ( $P>0.05$ ) their values appeared to decrease with increasing distance from *Prosopis juliflora*. However, phosphorus (P) was increased with increasing distance from the under canopy. In the canopy of *Prosopis juliflora* accumulation of high total nitrogen and soil organic matter may be due to the earlier seasonality of leaf litter fall and reduced leaching under the tree canopy. This result of our study corroborated with Watonga (2001) who states the presence of higher concentration nitrogen, phosphorus, and soil organic matter in the soils within the canopy than in soils in the adjacent open area.

**Allelopathy effect of *Prosopis juliflora* on seed germination percentage of selected grass species (*Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans*)**

Effect of *Prosopis juliflora* aqueous leaf, bark, and root extracts on seed germination percentage of selected grass species such as *Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans* were analyzed and the results were summarized in table-2. The results showed that seed germination percentage was decreased with increasing the level of the concentration. Therefore, the effect was concentration dependent. In all the selected grass species seed germination was highly affected by *Prosopis juliflora* leaf extracts compared with bark and root aqueous extracts. Among the selected three grass species, *Cenchrus ciliaris* showed low seed germination by aqueous leaf extract of *Prosopis juliflora*. Moreover, among the selected aqueous extracts bark showed the least inhibitory effect on seed germination percentage. Getachew (2012) reported that inhibitions of seed germination particularly the grasses and seedling growth of all studied species by leaf and root aqueous extracts at higher concentrations of *Prosopis juliflora*. In line with this, aqueous extracts from different parts of *Prosopis juliflora* on the final germination percentages of seeds and early

**Table 2: Effect of *Prosopis juliflora* leaf, bark and root aqueous extracts on seed germination percentage of *Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans***

Grass species	Extract type	Concentration (%)				
		Control	1	2.5	5	10
<i>Cenchrus ciliaris</i>	Leaf	99.33	87.23	75.52	62.35	51.23
	Bark	99.33	90.32	86.56	78.42	63.21
	Root	99.33	89.23	80.43	76.36	62.32
<i>Paspalidium desertorum</i>	Leaf	98.67	90.12	87.52	76.54	65.54
	Bark	98.67	87.45	78.52	75.01	67.52
	Root	98.67	88.54	85.25	78.52	63.35
<i>Lintonia nutans</i>	Leaf	98.00	89.36	85.23	79.32	71.20
	Bark	98.00	91.32	90.52	86.36	81.45
	root	98.00	90.42	87.54	82.36	80.25

growth of seedlings of various test crops after four days of sowing (Omer and Mohammed, 2017). Asrat and Seid (2017) reported that, seed germination of *C. gayana* significantly inhibited by *Prosopis juliflora* leaf extracts. Therefore, it is suggested that leaves had the most Allelopathic effect followed by leaf litter and roots extracts.

Seed germination of *C. ciliaris*, *P. desertorum*, and *L. nutans* were significantly inhibited by leaf, bark, and root aqueous extract concentration all the levels of *Prosopis juliflora* when compared to the control. *C. ciliaris* seed germination was significantly suppressed at all concentration levels as compared with the control. Whereas, *P. desertorum* and *L. nutans* seed germination was retarded from small to high concentration levels as compared to the control but not exhibited highly significant among concentration levels.

**Allelopathy effect of *Prosopis juliflora* on fresh shoot biomass weight of selected grass species under greenhouse experiment**

Fresh shoot biomass weight of *C.ciliaris*, *Pdesertorum*, and *L.nutans* were significantly affected by leaf, bark, and root aqueous extracts at ( $P<0.05$ ) in all concentration levels when compared to the control (Table 3). *C. ciliaris*. Fresh shoot biomass weight was successively reduced by leaf and root aqueous extracts of *P. juliflora* at all concentration levels and the effect was significant when compared to the control. Bark aqueous extracts highly affected the fresh shoot biomass weight of *C. ciliaris* at (10%) when compared with the control. Whereas, bark and root aqueous extracts of *P. juliflora* significantly reduced the fresh shoot biomass weights of *L. nutans* at all concentration levels as compared with the control. While the least significant effect was exhibited on fresh shoot weight of *P. desertorum* at (1%) of bark aqueous extracts when compared with the control. When increasing the level of aqueous extract concentrations, the biomass weights of all grasses species were highly suppressed.

Nakano *et al.* (2001) specified that the growth inhibitory effect of syringin and larciresinol isolated from *P. juliflora* on barnyard grass. In other studies, the *Prosopis juliflora* extract is reported to

**Table 3: Effect of *Prosopis juliflora* leaf, bark and root aqueous extracts on fresh shoot biomass weights of *Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans* under greenhouse experiment**

Grass species	Extract type	Concentration in (%)				
		Control	1	2.5	5	10
<i>C.ciliaris</i>	Leaf	97.00e	44.83j-l	35.37l-r	30.67o-u	23.7t-w
	Bark	97.00e	41.80k-m	29.57p-u	25.37s-w	18.47ww
	Root	97.00e	40.57k-n	34.17m-s	36.17l-q	21.33u-w
<i>Pdesertorum</i>	Leaf	160.75a	112.07c	82.43f	57.23h	41.77k-m
	Bark	160.75a	133.77b	106.50cd	80.38fg	51.97h-j
	Root	160.75a	96.57e	72.23g	59.93h	39.33k-o
<i>L. Nutans</i>	Leaf	55.07hi	31.50n-t	31.67n-t	38.07k-p	46.13i-k
	Bark	55.07hi	36.50l-q	30.00o-u	26.07r-v	16.03w
	root	55.07hi	28.37q-u	28.73p-u	27.90q-v	25.23s-w

cause a maximum reduction in wheat biomass weight (Siddiqui et al., 2009). Inderjit et al. (2008) compared the effects of soils from the rhizospheres of *P. juliflora* and *P. cineraria* and found that soil under *P. juliflora* had higher concentrations of total phenolics, and inhibited total biomass of *Bambusa arundinacea* more than soil from under the native congener.

## CONCLUSIONS

*Prosopis juliflora* aqueous extracts of leaf, bark, and root were exhibited a significant allelopathy effect on seed germination percentage as well as the fresh shoot biomass weights of *C. ciliaris*, *P. desertorum*, and *L. nutans* when compared to the control group. While the fresh shoot biomass weight of *C. ciliaris*, and *P. desertorum* was highly deteriorated at (5% and 10%). Therefore, the present study revealed that the exotic invasive species of *Prosopis juliflora* has toxic substances/allelochemicals and releases it into its ambient surrounding environment and significantly suppressed seed germination, seedling growth as well as biomass production of predominantly covered forage grass species (*Cenchrus ciliaris*, *Paspalidium desertorum* and *Lintonia nutans*) to the livestock of local community in the study area. However, this is likely resulted in a significant reduction of livestock production and adversely affected the livelihood of the pastoral communities of Afar people whose livelihood depends on livestock production. In addition to this, the pastoral community of Afar people in the study area was also complaining and worries about this aggressively invasive alien species *Prosopis juliflora*. This alien species is expected to be poverty driving force in the invaded area because of its aggressiveness and fast-growing degrading native species as well as spreading a large area within the short time period.

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