Research Article

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Allelophatic effects of selected exotic tree species on germination and root length of Maize and Wheat in North Eastern Amhara, Ethiopia

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Abstract

Background: *The selected tree species Gravellia robusta, Eucalyptus camaldulensis and Casuarina equisetifolia are the wide spread exotic species in Eastern Amhara. Allelopathy have either stimulatory or inhibitory effect on the germination percent and the radicle length of the crop, by the release of chemicals from plant parts in both natural and agricultural systems.*

Objective: *This study was conducted to identify inhibitory or stimulatory effect using bark and leaf leachates of selected exotic species on the germination and radicle length of test crops.*

Methods*: The experiment was conducted in sirinka agricultural research center under the laboratory. Aqueous bark and leaf extracts were prepared by soaking 25gm powder for each selected species in 500ml distilled water for 48 hrs. and used the extract for the study. The effect of the leachates was tested by placing 100 seeds of maize and wheat separately in three replicate using complete randomized design (CRD). The data were using SAS software version 9.0.*

Results: *Leaf leachate of Eucalyptus camaldulensis showed inhibitory effect. While, Gravellia robusta and Casuarina equisetifolia showed stimulatory effect for on the germination and radicle growth of tested crops.*

Conclusion: *This result implies to conclude in removing excess Eucalyptus camaldulensis leaf from the crop land should be done to reduce the alleophatic effect & to enhance production of crops.*

Keywords: Allelopathy, ANOVA, Leachate. Inhibitory, Germination percent, Radicle growth

1. Introduction

The alarming rate of human population in Ethiopia exerts huge pressure for the decline of forest for fuel, timber and fodder and on agricultural land for food grains, thus to meet these demands agroforestry had been introduced [1]. Due to the nature of Agroforestry, crops productivity depends on the growth resources (sunlight, soil moisture, nutrients) and allelopathic interactions. Therefore, it is essential that the Eucalyptus species and allelopathic tree species compatibility with crops should be determined before planting in the agroforestry systems [2, 3, 4, and 5].

Allelophatic interactions are an important factor in determining species distribution and abundance within plant communities [6]. Eucalyptus species have proven with their allopathic. It exerts allopathic effects through auto toxicity, its leaf, stem& root extracts /leachates reduce seed germination & seedling growth of test crops like Vigna unguiculata, Hibiscus esculentus and Lycopersicon esculentum, Mungu bean except Zea mays [7, 8]. Eucalyptus showed negative effect for the sustainable cropping, soil and water conservation system as also confirmed by [9]. The cultivation of Eucalyptus on neighboring food crops is not recommended because of their adverse effects (competition of moisture, shade effect on crop productivity in Amhara and Benishagul Gumuz regions, Ethiopia respectively [10, 11]. The allelophatic effect exerted by the leaf leachate of Eucalyptus has also retarding effect on the germination and growth of vegetables like Tomato [4]. While other research on Eucalyptus globulus leaves incorporated as Green Manure to Weed Control in Maize and found that for incorporation of E. globulus residues to soil could be a feasible practice to reduce the reliance on synthetic herbicides in maize-based cropping systems [2]. Similar species of Gravelia known as Grevillea banksii allelophatic has positive effect on the germination of bean and maize seeds as well as the seedling length development of all crop species but inhibit rice seeds germination [12]. Germination, root length and dry matter production of Sorghum, Cow pea and Sunflower is affected due to alleophatic effects of phenolic,trepenodes, and

organic cyamide present at leaf leachate of Casurina equstifolia [13]. The allelophatic of Casurina equstifolia on the contrary has a positive effect using spraying the leaf extract to reduce weed biomass and increase the wheat biomass on the farmers' field [3]. Eucalyptus globulus leaves also can be used as green manure for weed control in Maize based cropping system [2]. Allelopathy can occur also on monocot and dicot species under conditions in which crop weed competition interaction for all resources [14].

It was first widely studied in forestry system as allelopathy can affect many aspects of plant ecology including occurrence, growth, and plant succession, the structure of plant community, dominance, diversity& plant productivity [15]. There allelophatic effect of tree species and their effect on different agricultural crops show either inhibitory or stimulatory effect. Therefore, a research on allelophatic effect may help us to develop sustainable measures to integrate tree with crops, to diversify crop production and diversity of plant species and to maintain the ecology.

2. Materials and Methods

2.1. Description of the study area: The study was carried out in Sirinka Agricultural research center on station with an altitude of 1850 m a.s.l and at 11045'00''N latitude and 39036'36''E longitude. The mean total annual rainfall (which mainly falls in the cropping season) is 945 mm. The rainfall pattern of the areas is bimodal and its distribution is erratic; the effective rainy period extends from June to September. Mean annual average temperatures are 19.5 [16].

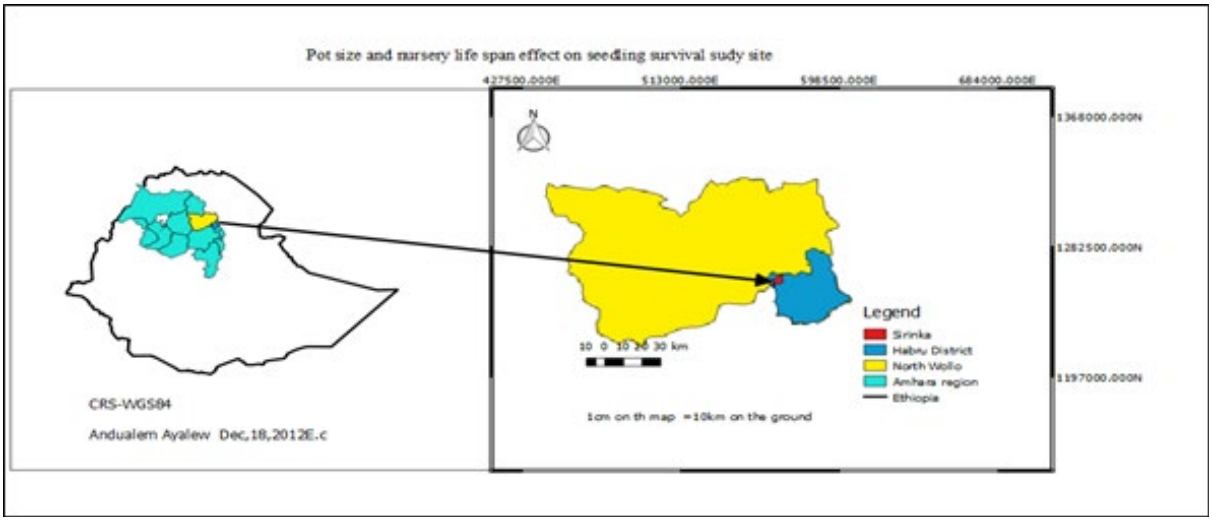

Figure 1: Map of the study area

2.2. Methods and Experimental design

The experiment were conducted in Sirinka agricultural research center with the collection of bark and leaf leachate of the selected tree species and control (with water) effect on wheat and maize in the laboratory. Bark and leaf was dried at room temperature and cut in 0.5-1cm pieces. Bark and Leaf was pounded using electrical stainless material. Aqueous bark and leaf extracts were prepared by soaking 25gm powder for each selected species in 500ml distilled water [17]. Each container was soaked separately for 48 hours at room temperature and the extract were filtrated using Buchner funnel containing Whatman No. 1 filter paper and used for the study. Seeds of wheat and maize (100 seeds each) were put on Glass Fiber Filter Paper placed in a glass Petri-dish (GPD), 12 cm internal diameter. The experiment was conducted with three replication and four treatments using complete randomized design (CRD).

2.3. Data collection

The seeds were examined for germination at three days after initial germination. Moisture in petridish was maintained by adding5ml aqueous extract to the germination of the tested crops. Seeds were considered germinated when the radical growth is greater than or equal to 2mm. Germination percent was calculated by dividing number of seed germinated over the number of seed sown.

2.3. Statistical analysis

The bark and leaf extract allelophatic effect on the germination percent and radicle growth of selected cereals was analyzed using SAS software version 9.4.The data on the radicle growth was recorded at 7 days after sowing and subjected to statistical analysis using ANOVA. The statistical difference was detected using Duncan Multiple Range Test (DMRT) to compare the allopathic effects between treatments. The general impact of allelophatic on agricultural crops was assessed in the laboratory. The allelophatic effect of the selected tree species are investigated by taking bark and leaf leachate in the laboratory in order to see inhibitory or stimulatory effect on crops.

3. Results

3.1. Allelophatic effect of tree species on the germination and radicle growth of wheat

In the present study, the bark leachate of *Eucalyptus camaldulensis showed* significantly stimulatory effect at $P<0.0001$ on the germination of wheat, while significantly inhibitory effect at $P<0.001$ on radicle growth of wheat. However, the leaf leachate

of *Eucalyptus camaldulensis showed* significantly inhibitory effect at P<0.001 on the germination and radicle growth of wheat. *Gravellia robusta and Casuarina equisetifolia* (Bark and leaf leachate) showed significantly stimulatory effect at P<0.0001, and P<0.001 on the germination and radicle growth of Wheat respectively (Table 1 and Table 2).

Tree species	Bark leachate in percent		Leaf leachate in percent	
	Germination	effect level	Germination	Effect level
Eucalyptus camaldulensis	73.2	+1.4	62.6	-9.22
Gravellia robusta	83.72	+11.9	79.52	+7.7
Casuarina equisetifolia	77.3	+5.5	74.7	+2.88
Control	71.82		71.82	
R-square	0.99		0.99	
DMRT (5%)	<0.0001(NS)		<0.001	

Table 1: Allelophatic effect of selected tree species on germination percent of wheat

Values in plus and minus sign under the effect level indicate the reduction/increment percentage in germination and radicle growth as compared to control.

Tree species	Bark leachate in percent		Leaf leachate in percent	
	Radicle growth	effect level	Radicle growth	Effect level
Eucalyptus camaldulensis	4.48	-0.41	3.4	-1.49
Gravellia robusta	5.17	+0.28	5.44	+0.55
Casuarina equisetifolia	6.2	+1.31	5.11	+0.22
Control	4.89		4.89	
R-square	0.99		0.97	
DMRT (5%)	<0.001		<0.001	

Table 2: Allelophatic effect of selected tree species on mean radicle growth of wheat

Values in plus and minus sign under the effect level indicate the reduction/increment percentage in germination and radicle growth as compared to control.CV% is calculated by dividing standard deviation to mean.

2. Allelophatic effect of tree species on the germination and radicle growth of Maize

In the present study, the bark leachate of Eucalyptus camaldulensis showed stimulatory effect on the germination of Maize, while the bark has inhibitory effect on radicle growth of Maize. However, the leaf leachate of Eucalyptus camaldulensis showed inhibitory effect on the germination and radicle growth of Maize. Gravellia robusta and Casuarina equisetifolia (Bark and leaf leachate) showed stimulatory effect on the germination and radicle growth of Maize (Table 3 and Table 4).

Tree species	Bark leachate in percent		Leaf leachate in percent	
	Germination	effect level	Germination	Effect level
Eucalyptus camaldulensis	73.22	+1.4	62.68	-9.12
Gravellia robusta	83.75	+11.93	79.52	+7.72
Casuarina equisetifolia	77.3	+5.48	74.7	+2.9
Control	71.82		71.8	
R-square	0.99		0.99	
DMRT (5%)	<0.0001		<0.0001	

Table 3: Allelophatic effect of selected tree species on the germination percent of Maize

Values in plus and minus sign under the effect level indicate the reduction/increment percentage in germination and radicle growth as compared to control.

Tree species	Bark leachate in percent		Leaf leachate in percent	
	Radicle growth(cm)	effect level	Radicle growth(cm)	Effect level
Eucalyptus camaldulensis	4.5	-0.39	3.3	-1.59
Gravellia robusta	5.2	+0.31	5.45	+0.56
Casuarina equisetifolia	6.17	+1.28	5.1	+0.21
Control	4.89		4.89	
R-square	0.97		0.99	
DMRT (5%)	<0.0001		<0.0001	

Table 4: Allelophatic effect of selected tree species on mean radicle growth of Maize

Values in plus and minus sign under the effect level indicate the reduction/increment percentage in germination and radicle growth as compared to control.

4. Discussions

Allelophatic effect of tree species on the germination and radicle growth of wheat: Similarly other study confirmed that, leaf leachate of Eucalyptus camaldulensis has allelopathic effects on seed germination and seedling growth of wheat (Triticum vulgare L.) [18]. The allelophatic effect of Eucalyptus on the Mung bean and confirmed the leaf leachate of Eucalyptus camaldulensis leaves are not much more harmful for Mung bean growth[19]. Thus, allelopathy could play an important role in weed management for farmers. The present study is in line with [3]. On the contrary, the study is not inconsistent with the allelophatic effect of Casuarina equisetifolia on the germination and radicle growth of Wheat [20].

Similarly the allelochemicals released by Casuarina equisetifolia reduces growth and yield of Sorghum, sunflower and Cow pea [21]. Similarly as wheat germination and root length affected due to the extract of leachate of Casuarina equisetifolia [13].

The present findings corroborate the earlier report by [17]. who found that, the inhibitory effect of leaf extracts of Proposes Juliflora leaf on the seed germination and radicle length of wheat was proportional to the concentration of the extract.

Allelophatic effect of tree species on the germination and radicle growth of Maize Based on the allopathic effects of Eucalyptus species exerts through auto toxicity, its leaf, stem& root extracts/ leachates enhance seed germination & seedling growth of Zea, [7, 8]. While other investigation showed that the effect of aqueous extracts of Eucalyptus camaldulensis L. Reduced seed germination (%) and radicle growth of Maize [18, 22]. On the contrary, the allelophatic effect of Casuarina equisetifolia increase the germination and radicle growth of Maize [20].

Many researchers found that allelochemicals have detrimental effects on the successive crops production which causes ecological and economic threat such as decline in total crop yield [5]. Other Studies show that the actual release of the allelo-chemicals is difficult. This is due to many factors interact with allelo-chemicals in soil can cause inhibitory effects even though the concentrations of individual compounds are below their inhibitory levels [15]. The present study coincides with the study reported by [23]. which confirmed that, leaf leachate has showed more allelophatic effect than Bark. Furthermore, this finding which was done in the laboratory has similar implication to the field work reported by [10, 11]. As this pervious findings on the cultivation of Eucalyptus on neighboring food crops is not recommended because of their allelophatic effect on Agricultural crops in Amhara and Benishagul Gumuz regions, Ethiopia respectively.

5. Conclusion

Based on the result, Eucalyptus camaldulensis showed inhibitory effect on the germination and radicle growth of wheat and Maize. G. Robusta and C. Equisetifolia have stimulatory effect on the germination and radicle growth of Wheat and Maize. This implies growing tested crops far distance from E. Camaldulensis and in close distance with G. Robusta and C. Equisetifolia is possible to remove the inhibitory and stimulatory effect of aliphatic of the species respectively. Removing excess leaf litters from the crop growing areas should be done to reduce the alleophatic effect and to increase the germination, and the growth of the crops grown in the farmlands. It is advisable that growing of tested crops far away from the Eucalyptus plantation is helpful to reduce the allelo-chemical effect and increase the yields of the crops and also to separate the tested crops from Eucalyptus root using isolation trench.

Author contribution statement

Andualem Ayalew: Conceived and designed the experiment; Performed the experiment; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data and Wrote the paper.

Andualem Ayalew and, Zebene Asfaw: edit the manuscript; Analyzed and interpreted the data and Wrote the paper;

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