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Allelopathic Potential of *Eucalyptus* on Germination and Early Seedling Growth Performance of Agricultural Crops

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Abstract

Plants may favourably or adversely affect other plants through allelochemicals, which may be released directly or indirectly from living or dead plants (including microorganisms). This research was undertaken in the nursery of Areka Agricultural research centre that crops grown in a pot experiment laid in a completely randomized design. Water extracts of young and fresh Eucalyptus- camaldulensis and *Eucalyptus-globulus* leaves were used as a treatment. Four agricultural crops (haricot-bean, faba-bean, wheat and maize) were used as recipients of the extracts, with the objective to evaluate the effects of water leaves extracts on the germination and early seedling growth of the crops. Results suggested that both tree species induced inhibitory effects on germination and growth of all crops compared to the control treatments except for some independent parameters of some crops. Eucalyptus globulus has more inhibitory effect on all crops than Eucalyptus camaldulensis. Thus, it is recommended that these crops should not be planted very close or not to *Eucalyptus* trees or seed rate of the crops should increase one to two times this is due to the likely adverse effects of Eucalyptus on seed germination and other seedling growth parameters.
Keywords: Allelopathy; Eucalyptus camaldulensis; Eucalyptus globulus; Agricultural crops; Germination; Seedling growth.

1. Introduction

Nowadays many people in Ethiopia are dependent on *Eucalyptus* for fuelwood, construction wood and income generation [1]. The sale of *Eucalyptus* poles and products has substantial potential to raise farm incomes, reduce poverty, increase food security, and diversify smallholder-farming systems in less-favoured areas [2]. The other greatest positive contribution of *Eucalyptus* is perhaps in replacing indigenous species for firewood. Thereby, preventing further denudation of natural forests [3]. Generally, *Eucalyptus* in Ethiopia is highly favoured for planting and it is common to see the species in most of the agro-ecological zones of the country. *Eucalyptus* species are known to have allelochemicals 1, 4-and 1, 8-cineole.

Whilst *Eucalyptus* have such and many other benefits, including fast growth and the ability to coppice, of all widely used plantation species they have attracted by far the most criticism [3]. Some of the critics associated with it are: the species do not provide organic matter and depletes soil nutrients needed by agricultural crops, it depletes water resources and competes with agricultural crops, it suppresses ground vegetation and resulting unsuitability to soil erosion control, the leaves of *Eucalyptus* are not palatable and cannot be used as fodder species, and finally people raise issues related to its allelopathic effect [2].

By having such unjustified fears of its negative aspects, some countries have restricted or banned planting of *Eucalyptus* [4]. Even in Ethiopia, some administrative regions have banned the planting of *Eucalyptus* on farmlands. The blame continues without discriminating the 600 *Eucalyptus* species, which differ in their inherent growth rates, environmental adaptations, and nutrient and water uptakes [5].

Not all *Eucalyptus* species may have equally negative effects on the environment, on undergrowth vegetation, soil fertility etc. Their effect may vary within different geographical areas, rainfall regimes and within species. So to discourage or promote the planting of *Eucalyptus* and to use them for agroforestry purposes, sufficient scientific evidence on the ecological impact, on undergrowth vegetation, soil fertility, and the quality of the product should be further investigated [6].

The harmful effect of forest trees on agricultural crops growing near it through release of allelochemicals in to the crop environment has assumed a great importance in the recent past with the recognition of agroforestry as an independent discipline [7, 8], and evaluation of the allelopathic potential may, hence, be important for the assessment of the ecological impact of exotic tree species. The information may encourage farmers to select promising tree and food crop combination to develop a productive, sustainable, and ecologically stable agroforestry system. The objective of the present study was to assess the effects of aqueous leaf extracts of two *Eucalyptus* species on the germination and early seedling growth of maize, wheat, faba bean and haricot bean, and, to contribute to the knowledge of proper management of *Eucalyptus* for the benefit of the farmers.

2. Methodology

2.1. Description of the Study Area

The study was conducted at Areka Agricultural Research Center, which is located in Southern Nations Nationalities and People's Regional State (SNNPRS), Wolita zone. It is found at 410km south of Addis Ababa and 3km from Areka town, at 7°04.196'N and 37°41.330' E and altitude of 1790 meters above sea level (masl). The soil of the centre is formed from pyroclastic rocks and is clayey in texture (Abayneh, 2003). The mean annual rainfall is 1460 with a bimodal pattern, which extends from March to September. The peak rainy months are April, July, August and September. The mean minimum and maximum temperatures are 15°C and 26°C, respectively. November and December were the coldest months, whereas February was the hottest.

2.2. Experimental Design and Treatments

A pot experiment was conducted at Areka research centre using CRD. The fresh green leaves from 3 years old young *E.globulus* and *E.camaldulensis* plantation were collected from midland agro-ecology (Areka, Wolita) and highland agro-ecology (Doyogen, Kembata Tembaro), and then washed with water. These leaves were chopped manually and again thoroughly mixed. The chopped leaves were soaked in water using plastic tubes in the ration of 1:5 (leaves: water) for 72 hours [9]. The soaked leaves were stirred frequently after every 8 hours to maintain the O_2 level and to avoid the anaerobic condition. 5 seeds of each crop were sown in each pot filled with soil. The soil in the pot was kept moist throughout the duration of the experiment by aqueous extract and with tap water to the respective control pots.

Treatment arrangements were; Control (only tap water application), *E.camaldulensis* extracts application on maize, wheat, haricot-bean and faba-bean independent pots, and, *E.globules* extracts application on maize, wheat, haricot-bean and faba-bean independent pots.

2.3. Data Collection

Faba-bean, wheat, Haricot bean and maize seeds germination percentage, Shoot length (cm), root length (cm), Shoot fresh and dry weight (g), Root fresh and dry weight (g) and Collar diameter (cm) were measured accordingly:

The germination percentage was calculated following Rho and Kil [10], Bewley and Black [11] and Saxena, *et al.* [12] as GC (%) = (No of germinated seeds/Total No of seeds sown) x 100.

The following length and weight measurements are followed by Khan [13] as For shoot length (cm) two plants in each treatment were measured with meter rod and the measurements were taken from the stem joint to the tip of the terminal leaf; for root length (cm) two plants in each treatment were measured with meter rod and the measurements were taken from the root joint to the tip of the tap/main root. All the measurements were summed up and divided by the number of plants measured to find out the single plant average shoot and root length. Collar diameters (mm) of both crops were determined using a calliper.

After the different organs were separated to shoot and root biomass, they were kept in paper bags and tagged properly. Wet and dry weights of the biomass were measured using scientific electrical balance. For shoot and root fresh weight (g), two fresh plant shoots and roots were destructively removed and weighed and the total weight was averaged to determine single plant shoot and root fresh weight. For shoot and root dry weight (g), the two fresh plants shoots and roots were air dried then weighed, and the total was averaged to determine single plant shoot and root dry weight.

2.4. Data Analysis

The analysis of variance (ANOVA) was conducted using the general linear model (PROC GLM) procedure in Statistical Analysis System (SAS) program version 9. Means were compared for all significant parameters using a Least Significant Difference (LSD) test at the 5% level of significance.

3. Results and Discussion

Table-1. Response to the allelopathic effect of *Eucalyptus* on haricot bean

Treatments	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Collar diameter (mm)	Germination (%)
Control	11.53 a	16.75a	5.75a	2.25a	0.21a	0.18a	3.51a	100 a
E.Camaldulensis	10.28 ab	16.5a	4ab	0.6 b	0.18a	0.15a	2.55b	90.0 ab
E.globulus	9.3b	9 b	2 b	0.5 b	0.15a	0.15 a	2.88b	85.0b
LSD @ p=0.05	*1.39*	*3.02*	*2.24*	*0.56*	*0.09*	*0.06*	*0.49*	*14.10*
CV	*8.42*	*13.44*	*35.80*	*31.36*	*30.82*	*26.64*	*10.27*	*9.62*

*Means in the same column followed by the same letter are not significantly different according to LSD at a probability level of 0.05.

The mean value (Table 1) indicates that *E.globules* has a more inhibitory effect on seed germination and seedling growth of haricot bean than *E.Camaldulensis* and control values. There is also a significant difference between *E.globules* treatment on all crop growth parameters except for Shoot dry weight and Root dry weight as compared to the control treatment. It has been shown that *E.camaldulensis* reduces significantly the root fresh weight and collar diameter of Haricot bean. These findings are confirmed by the work of Ahmed, *et al.* [9] who reported that leaf litters of *L. leucocephala* induced inhibitory effects on germination, growth and collar diameter of Falen (*Vignaunguiculata*), Chickpea (*Cicerarietinum*) and Arhor (*Cajanus cajan*). Anwar (1991) observed greater allelopathic effects of the fresh leaves extracts of *Eucalyptus alba*, *E. deglupta* and *E. robusta* on the growth of maize seedlings. Padhy *et al* (1992) tested the leaches of senescing and freshly fallen leaves of *Eucalyptus globulus* for their allelopathic effect on an improved cultivar of finger millet in the laboratory. Germination, seedling shoots, and root growth were inhibited with the effects increasing with leachates concentration.

Table-2. Response to the allelopathic effect of *Eucalyptus* on faba bean

Treatments	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Collar diameter (mm)	Germination (%)
Control	28.60 a	19.25a	18 a	7.0 a	0.25b	0.3a	5.61a	100a
E.camaldulensis	22.58 b	16.5ab	16.75 a	7.5 a	0.34a	0.25 ab	5.39 a	95a
E.globulus	20.20b	14b	12.17 a	3.3 b	0.24b	0.21 b	3.3 b	80b
LSD @ p=0.05	*2.78*	*3.60*	*7.01*	*3.18*	*0.04*	*0.06*	*0.82*	*9.23*
CV	*7.30*	*13.59*	*28.02*	*33.59*	*10.53*	*17.03*	*10.78*	*6.29*

*Means in the same column followed by the same letters are not significantly different according to LSD at a probability level of 0.05.

The mean value (Table 2) indicates that *E.globules* has a more inhibitory effect on seed germination and seedling growth of faba-bean than *E.Camaldulensis* and control. There is also a significant difference between *E.globules* treatment as compared to the control treatment on all faba-bean seedling growth parameters except for Shoot fresh weight and Shoot dry weight. *E.camaldulensis* also shows a significant effect on shoot length and shoot dry weight parameters of faba-bean. The mean value of *E.camaldulensis* show that there is the stimulatory effect on root fresh weight and shoot dry weight (also significant) as compared to the control. Sunil and Khara (1991) also reported that water extract of leaves (green, brown and decayed) from 6 years old *Eucalyptus tereticornis* trees and bark were tested for their inhibitory effects on seed germination and primary root and shoot development of *Phaseolus vulgaris* seedling. Srinivasan *et al* (1990) also observed the reduced crop germination and growth of *vigna mungo, vignar adiata*, pigeon pea and soybean, when grown in the topsoil taken from *Eucalyptus tereticornis*.

Table-3. Response to the allelopathic effect of *Eucalyptus* on maize

Treatments	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Collar diameter (mm)	Germination (%)
Control	21.45a	38 a	5.05a	3.05a	0.15a	0.15 a	4.10 a	100a
E.camaldulensis	18.55 ab	33.25ab	3.05b	2.8a	0.15a	0.18 a	4.55 a	85b
E.globulus	16.47b	30.50b	1.8 b	1.18 b	0.16 a	0.20 a	3b	70 c
LSD @ p=0.05	*4.43*	*6.25*	*1.88*	*1.30*	*0.02*	*0.06*	*0.58*	*14.10*
CV	*14.74*	*11.53*	*35.72*	*34.85*	*9.36*	*24.16*	*9.45*	*10.37*

*Means in the same column followed by the same letter are not significantly different according to LSD at a probability level of 0.05.

Table 3 also shows that the mean value of *E.globulus* has a more inhibitory effect on seed germination and seedling growth of maize than *E.camaldulensis* and control. As compared to the control there is also a significant difference between *E.globulusis* treatment on all of the maize measured growth parameters except for Shoot dry weight and Root dry weight. There is also a significant reduction of *E.camaldulensis* treatment on shoot fresh weight and germination as compared to control treatment. The stimulatory effect was also shown on *E.globulus* of shoot dry weight and root dry weight and *E.camaldulensis* of root dry weight and collar diameter. Probable reasons for this could be the elevated amount of allelochemicals and inhibitory effects present in both *Eucalyptus* species water extracts that affected the essential germination and growth processes. These results are also in agreement with those reported by (Lisanework and Michelson, 1993) who noted a decrease in germination of maize due to applied *Eucalyptus globules*, *Eucalyptus camaldulensis* and *Eucalyptus saligna* extract. The results validate the findings of (Ebrahim *et al.*, 1999, Khan *et al.*, 1999 and Khan *et al*., 2007) who reported that leaf extract of *Eucalyptus camaldulensis* and *Eucalyptus microthecia* delayed and inhibited germination of maize. Thakur and Bhardwaj (1992) also reported that leachates from *E.globulus* leave significantly reduce maize germination. Rao and reddy (1984) reported inhibition of germination and other growth parameters in horse gram, green gram, cowpeas and beans due to the leaf extracts of *Eucalyptus camaldulensis***.** Schumann *et al* (1995) also reported that water extracts of *E. grandis* significantly reduced weed establishment. Swaminathan *et al* (1993) evaluated the allelopathic effect of eight multipurpose trees including *Eucalyptus tereticornis* on maize, red gram and sesame. All the trees inhibited germination and growth of all the crops. Khan *et al* (1999) also reported that *Eucalyptus camaldulensis* extracts reduced maize seedling height and fresh root weight. The results from (Khan *et al*, 1999) also showed that aqueous extract of *Eucalyptus camaldulensis* reduced seedlings dry weight, fresh shoot weight and fresh root weight of maize.

Table-4. Response to the allelopathic effect of *Eucalyptus* on wheat

Treatments	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Collar diameter (mm)	Germination (%)
Control	21.35a	38.5 ab	1.53a	0.80a	0.10a	0.15 a	1.13 a	90 ab
E.camaldulensis	18.41a	39.75 a	1.35a	0.92 a	0.23 a	0.25 a	1.13a	100 a
E.globulus	17.82 a	29 b	0.37 b	0.23b	0.15 a	0.15a	0.66 b	75b
LSD @ p=0.05	*3.63*	*10.68*	*0.58*	*0.35*	*0.17*	*0.18*	*0.27*	*20.65*
CV	*11.85*	*18.68*	*33.67*	*33.67*	*65.66*	*65.66*	*17.44*	*14.61*

*Means in the same column followed by the same letters are not significantly different according to LSD at a probability level of 0.05.

The mean value (Table 4) indicates that *E.globuls* has a more inhibitory effect on seed germination and seedling growth of wheat than *E.Camaldulensis* treatment and control. As compared to the control there is no significant difference between *E.globulusis* treatment on all of wheat seedling growth parameters except for Shoot fresh weight, Root fresh weight and Collar diameter. *E.camaldulensis* shows no significant reduction rather shows the stimulatory effect on all parameters except for shoot length, shoot fresh weight and collar diameter as compared to the control, but there is a significant difference between both trees treatments except for shoot length, shoot dry weight and root dry weight. Shivanna*et al* (1992) also reported the allelopathic effect of *Eucalyptus camaldulensis* on a rag (*Eleusinecoracana*), Cowpeas (*Vignaungnicalanta*) and Sesamum (*Sesmum indicum*). Seed germination and survival of germinated seedlings were also inhibited at closer *Eucalyptus* spacing. Sindhu and Hans (1988) also reported that all wheat plants grown in pots containing *Eucalyptus tereticornis* leaf litter grew significantly less well than control plants. Bhaskar *et al* (1992) observed reduced results of seedling height and number of leaves of finger millet (*Eleusinecoracana*) due to powder leaf litter of *Eucalyptus tereticornis*.

4. Conclusion and Recommendation

The allelopathic compatibility of multipurpose tree species with companion agricultural crops may be crucial to determining the success of an agroforestry practice or system. *Eucalyptus* has claimed that it is notorious for having allelopathic effects on growth of agricultural crops grown in its vicinity. The allelopathic effect of *E. camaldulensis* and *E. globulus* were investigated on the seed germination, and seedling growth of maize, wheat, faba bean and haricot bean growing in the nursery. The fresh green leaf water extract of both *Eucalyptus* species was prepared and applied to the potting soil in which all crops were grown. The effects on seed germination and seedling growth of haricot bean, faba bean, wheat and maize were compared to a control with no water extracts application. It can be concluded from the results that allelochemicals present in the leaves of both *Eucalyptus* species suppressed most of the growth parameters measured and germination in the crop species studied.

Among the two tree species, *Eucalyptus globulus* has a more inhibitory effect on all crop seedlings as compared to *Eucalyptus camaldulensis* and control values, but both *Eucalyptus* species have shown the inhibitory effect on all crops as compared to the control values.

It is recommended that all crops should not be planted very close to or in association with *Eucalyptus* trees due to the likely adverse effects (allelopathy) on seed germination and other seedlings growth parameters of the crops. Thus, there is a need to provide information to farmers about where to plant or not when using this *Eucalyptus* species and their allelopathic effects on agricultural crops. Further studies are suggested to clarify the possible physiological mechanism or by intercropping system related to allelopathic effects of the plants to plant.

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