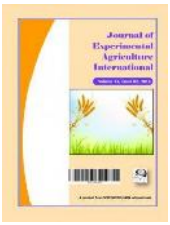

Journal of Experimental Agriculture International

30(4): 1-12, 2019; Article no.JEAI.43100
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Allelopathic Effect of *Eucalyptus globulus* Labill. on Seed Germination and Seedling Growth of Highland Teff (*Eragrostis tef* (Zuccagni) Trotter)) and Barely (*Hordeum vulgare* L.)

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Authors' contributions

This work was carried out in collaboration between two authors. Author FN conducted the experiment, managed the literature searches and wrote the first draft of the manuscript. Author TBG designed the study, wrote the protocol, managed data quality and performed the statistical analysis. The two authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2019/43100
Editor(s):
(1) Dr. Mohammad Reza Naroui Rad, Department of Horticulture Crops Research, Sistan Agricultural and Natural Resources Research and Education Center, Iran.
Reviewers:
(1) Fábio Henrique Portella Corrêa de Oliveira, Universidade Federal Rural de Pernambuco, Brazil.
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(4) Ana Maria Arambarri, National University, Argentina.
Complete Peer review History: http://www.sdiarticle3.com/review-history/43100

Original Research Article

Received 06 June 2018
Accepted 23 August 2018
Published 08 February 2019

ABSTRACT

The phenomenon of allelopathy, whereby a plant species chemically interferes with the germination, growth or development of other plant species has been known and documented for over 2000 years. Allelochemicals are secondary metabolites of plants, released into the environment through volatilization, leaching, root exudation and decomposition of residues. This study was aimed to examine the allelopathic effect of *Eucalyptus globulus* on seed germination and early growth of highland teff (*Eragrostis tef*) and barely (*Hordeum vulgare* L.) conducted at Kulumsa Agricultural Research Center. Fresh leaf, juvenile stems, root and mixtures of these aqueous extracts at 0%,

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5%, 10%, 15%, 25% and 50% concentrations respectively were used to run the experiment under Laboratory condition. The employed research design was Complete Randomized Design with three replications and two factorials as: plant parts and concentrations. The quantitative data was collected, coded and then subjected to SAS Version 9.1 procedure following two ways ANOVA. The means were compared by using least significance difference test (LSD) at $P \leq 0.05$ probability level. It was noted that aqueous extracts at a concentration of 10%, 15%, 25% and 50% had an inhibitory effect on both crops seed germination and seedling growth. The effect was found in much higher than the control treatment. The inhibitory effects were increased as the extract concentration increased and more pronounced in fresh leaf aqueous extract compared to the rest extract sources. This finding indicates allelochemials in the *Eucalyptus globulus* plant parts adversely affect seed germination and early seedling growth of teff and barely. The Phytotoxicity of *Eucalyptus globulus* fresh leaf aqueous extract showed the highest impact affecting early root growth of barely and shoot growth of teff under the highest level of concentration (50%) of the extracts.

Keywords: Allelopathic; barely; Eucalyptus globules labill.; highland teff; seed germination; seedling growth.

1. INTRODUCTION

The term allelopathy is derived from the Greek-compound words allelo and pathy (meaning “mutual harm” or “suffering”) and was first used in 1937 by Austrian scientist Hans Molisch [1,2]. Allelopathy is defined as the beneficial or harmful influence of chemical substances released by plants that can alter the growth and development of nearby plants or microorganisms [3]. The phenomenon of allelopathy, whereby a plant species chemically interferes with the germination, early growth or development of other plant species has been known and documented for over 2000 years [4]. Allelochemicals or phytochemicals are plant secondary metabolites normally released into the environment through volatilization, leaching root exudation and decomposition of plant residues in the soil [5]. The action of allelochemicals can affect the respiration, photosynthesis, enzyme activity, water relations, stomatal opening, hormone levels, mineral availability, cell division and elongation, and structure and permeability of cell membranes and walls [6-9].

Discharge of allelochemicals into the environment occurs by exudation of volatile chemicals from living plant parts, by leaching of water soluble toxins from aboveground parts in the response of action of rain, by exudation of water soluble toxins from below ground parts, by the release of toxins from non-living plant parts through leaching of litter decomposition. Many invasive plant species alter natural ecosystems and reduce vegetable diversity causing plant displacement by the allelopathic inhibition of germination or growth via phytotoxic chemical release [9,10]. *Eucalyptus globulus is* one of such invasive plant species posing greater challenges to the economic, food security and sustainable development of many developing countries whose livelihood is of totally or partially depend on agriculture [11].

Germination and seedling growth are the screening criteria which are widely used to investigate the effects of allelopathy. Morphological changes, in response to allelochemicals, could be due to effects on cellular or molecular level [12]. Allelochemicals may be present in the leaves, barks, roots, flowers and fruits. Therefore, leaves, juvenile stem, root and mixture of all these parts were selected to accomplish the extract bioassays in this research. Allelochemicals restrict plant growth through negative interactions with some physiological processes such as suppression of cell division, changes in cell wall structure and activity of some enzymes. The effect of allelochemicals action was detected at molecular, structural, physiological, biochemical and ecological levels of plant organization [9].

Many studies have evaluated the allelopathic activity of *Eucalyptus* species and reported strong inhibitory effects of eucalyptus extracts on germination and growth of various plant crops such as cucumber, sorghum, rice, tomato, eggplant and black gram [13-16]. However, there is no research finding indication on allelopathic effect of *Eucalyptus globulus* on highland teff *(Eragrostis tef* (Zuccagni) Trotter)) and barely. Therefore, this study is aimed to examine the allelopathic effect of *Eucalyptus globulus* extracts from fresh leaves, juvenile stem, root exudates and mixture extracts of these plant parts on seed germination as well as the seedling growth of barely and highland teff.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The study was conducted at Kulumsa Agricultural Research Center (KARC), central Ethiopia. It is relatively located to the North of Assela twon (167 km from Addis Ababa), to the left side of main road from Addis Ababa to Assela. Kulumsa Agricultural Research Center was established in 1966 by the government of Ethiopia and the Swedish International Development Agency (SIDA). The research Center is mandated to wheat, malt barley and highland pulse crops research nationally and serve as Wheat Center of Excellence for East Africa (Ethiopia, Kenya, Uganda, Tanzania), regionally. KARC is situated at latitude 08°01'10" N and longitude 39°09'11" E, with annual average maximum and minimum temperature of 23.2°Cand 10.5°C respectively, the altitude of 2200m.a.s.l. and an average annual rainfall of 823 mm. Soil type clay soil (Luvisols) and soil pH 6.0. The Research Center carries out research on crop production, animal breeding, on soil and nutritional issues [17].

2.2 Experimental Materials

Eucalyptus globulus plant parts such as fresh leaves; juvenile stem and root were collected from the farmers' farm land around KARC and rinsed thoroughly with sterile distilled water [18]. Seeds of most popular highland teff of variety Felagot (Dz. Cr.442) collected from Bishoftu Agricultural Research Center and seeds of barely variety called Holker were collected from KARC. Bare land local top soil was collected from depth of 0-30 cm as of [19] from KARC.

2.3 Research Procedure

Fresh leaves and juvenile stem collected by cutting and root collected through digging and cutting from a tree of 10 years old, purposively the mid age of harvesting [20] of *Eucalyptus globulus* and chopped in to pieces, open air dried under shade for fifteen days; the samples then put in oven with a temperature of 50°C for 48 hours [21]. All the samples collected prepared powder to fine particles using electric grinder separately. The grinded plant materials were mixed in distilled water at (5%, 10%, 15%, 25%, and 50%) w/v ratio separately [22]. The mixtures then soaked for about 12 hours at room temperature and blended with blender for 24 hours. Then after, the mixtures were centrifuged at 100 × 100 rpm for twenty minutes and the aqueous solutions of each plant part was filtered using What man filter paper Number 1 poured into flat bottomed 250 ml volumetric flasks, well covered and preserved in refrigerator set to -5°C until it was used in a test experiment [10]. For the preparation of mixture extract of the three plant parts, 30ml of each of plant parts with the respective concentrations (5%, 10%, 15%, 25%, 50%) were shared equally mixed well and poured into flat bottomed 250 ml volumetric flasks.

Bare land local top soil from depth of 0 – 30 cm as of [19] collected from three different quadrant of (2x2) meter square from KARC, then mixed well and then equal amount filled to every plastic pot having 3.5 inch depth, 3.5 inch top and 3 inch bottom diameters provided with drainage holes; moisten with 80 ml of tap water and left for one day. Seeds of both crops with germination percentage of 85% and purity of 99% were thoroughly washed with distilled water and surface sterilized with 90% ethanol for 2 minutes, followed by soaking for 5 minutes in a solution of 5.25% sodium hypochlorite, then rinsed four times with distilled water [10].

2.4 Research Design

The research has two laboratory-based experimental parts. **Experiment I**: For seed germination of teff and barely. **Experiment II**: For seed germination and early seedling growth of both crops. Both experiments were laid down in factorial Randomized Complete Design (RCD), with three replications. The research has also two factors namely plant parts as sources of extract as Factor A: at four levels; juvenile stem (A1), root(A2), fresh leaf (A3) and mixtures of (juvenile stem, root &fresh leaf) (A4) and extract concentration levels as Factor B: at six levels; 0%w/v (B1), 5%w/v (B2), 10% w/v (B3), 15% w/v (B4) 25% w/v (B5) and 50% w/v (B6) were used as of [10].

Experiment I: for clearly monitoring seed germination of both crops, nine seeds of both crops were sown sparsely in a filter paper covered glass Petri dish having 9 cm diameter [23] and 5 ml aqueous extract of eucalyptus plant parts at 5%, 10%, 15%, 25%, and 50%) ratio were applied to each glass Petri dish separately and 5 ml distilled water applied in the case of control treatment [18]. The seed planted Petri dishes were placed in greenhouse and arranged in rows for both crops independently and fairly labeled. Seed germination data for both crops

collected on daily basis after planting [22]. The experiment was continued for ten days for seed germination test and 21 days for seedling growth.

Experiment II: For seed germination and early seedling growth of both crops uniform pots filled with local top soil from the depth of 0-30 ml prepared were arranged in rows for both crops independently. Nine seeds for both crops were planted separately in each of the plastic pots and 5 ml aqueous extract of eucalyptus plant parts at 5%, 10%, 15%, 25%, and 50%) ratio were applied to each pot separately and 5 ml distilled water applied in the case of control treatment [10,23]. The seed planted pots were placed in green house and fairly labeled. Moistening seeds with equal amount of tap water and data on seed germination for both crops were collected on daily basis after planting. After emergence, seedlings thinned to six plants per pot for both crops and the experiment continued for 21 days in which the final measurement was recorded.

2.5 Data Collection

Seed germination was considered when radicle emergence (≥ 1 mm) and daily counted for 5 days or until the last seed germinated [24]. Final data collection for early seedling growth was effective after 21 days of seed plantation and the data from three randomly selected seedlings of both crop species root and shoot length for each replicate measured and recorded as of [19]. Shoot length (S.L) measured in cm taken from the stem joint to the tip of the terminal leaf and Root length (R.L) measured in cm taken from the root joint to the tip of the tap/main root and data recorded and registered clearly.

2.6 Statistical Data Analysis

The quantitative data was collected, recorded clearly, coded and then subjected to two way ANOVA analysis of variance procedure with SAS Version 9.2 and the means compared by using least Significance difference (LSD) test at the $P \leq 0.05$ level of probability. The seed germination data recorded and seed germination percentage (%) was determined using: the formula as of [10,19,24,25].

$$\text{Germination } \% = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

Percentage phytotoxicity produced by *E. globulus* was by the following formula as used in the research done by Sorecha and Bayissa [10].

$$\text{phytotoxicity } \% = \frac{\text{radicle length of control} - \text{radicle lenght of treated sample}}{\text{Radicle length of control}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Seed Germination

The present study provides the evidence that aqueous extracts of *Eucalyptus globulus* plant parts such as juvenile stem, root, fresh leaf or mixtures of them showed the inhibitory response towards germination percentage and early seedling growth (shoot length and root length) of teff and barely seeds. Interaction in all conditions showed that allelopathic effect becomes more pronounced with increasing doses of *Eucalyptus aqueous* extracts. The same result was reported by the study of Sorecha and Bayissa [10] on seed germination and growth of tomato plant. Even if seed germination count continued for ten days, there was no seed germination, observed starting from the seventh day to the last tenth date for both crop species and both on Petri dish and in pot conditions.

There was direct relationship between allelopathic effect and extract levels of *Eucalyptus globulus* plant parts. This result is in line with the research finding done by [9] on allelopathic activity of *E. globules* leaf aqueous extract on *Hordeum vulgare* growth and cytogenetic behaviour. The seed germination of both crops was delayed for aqueous extract treatments at increasing concentration. At 25% and 50% *Eucalyptus globulus* aqueous extracts of all plant parts, seed germination of both crop species (Teff & Barely) were inhibited under both conditions of germinations (germination on Petri dish & in pot). However, inhibition of germination becomes more pronounced on Petri dish of both crop species. At 50% level of all aqueous extracts of *Eucalyptus globulus* plant parts of both crop species resulted in a significant reduction of germination counts when compared with control. In comparison to all conditions of germination aqueous extract sources of *Eucalyptus globulus* plant parts, fresh leaf aqueous extract exhibited more germination inhibition at 25% and 50% level of concentration compared to other extract sources. For example: comparing *Eucalyptus globulus* plant parts aqueous extracts, it was fresh leaf extract at 50% that highly reduced the germination percentage of Teff in which only 14.4% of seeds were germinated followed by root extract in which only 18.5% of the same seed germination took place.

Table 1. Percentage of teff seeds germination after treated with *E. globulus* plant part extracts under Petri dish

Source of extract	Treatment level in (%)					
	0% (Control)	5%	10%	15%	25%	50%
Juvenile stem	100	96.3	88.8	66.6	44.4	36.6
Root	96.3	92.2	81.1	58.8	40.7	18.5
Fresh leaf	100	85.2	66.6	51.8	36.4	14.4
Mixtures*	92.2	88.8	85.2	58.5	40.7	22.2

**= mixture of juvenile stem, root &fresh leaf each 33%*

The highest percentage value of teff seed germination (36.6%) was obtained by the juvenile stem part of the tree at 50%, Table 1.

The result of the analysis of variance, ANOVA is also presented in Table 2. Significant differences among the mean values were found based on the least significance difference, LSD, test. Seed germination of teff was significantly (at $p \leq 0.05$) responded to the increasing aqueous extracts concentrations for all *Eucalyptus globulus* plant parts both in petri dish and on pot conditions, Tables 2 & 3.

The lowest mean value of teff seeds germination (1.32) in the petri dish, was observed under 50% concentration of fresh leaf extracts (Table 2), whereas on the pot it was stem juvenile extract the least mean value of germination, 3.33, (Table 3) obtained for the maximum concentration. There was a direct relationship between seed germination of both crop species and allelopathic effects of extract level. The seed germination of both crops was delayed for aqueous extract treatments at increasing concentration. Inhibition of teff seed germination more pronounced under fresh leaf extract at 50% level of concentration, followed by root aqueous extract under the same level of concentration. Where about 1.3 and 1.67 teff seeds germinated per Petri dish for fresh leaf and root aqueous extract respectively (Table 2).

From Table 3, it can be understood that the most allelopathic effect was exhibited at highest level of concentration (50%) of *Eucalyptus globulus* on teff seed germination under pot condition. Comparing the extract sources under pot condition, juvenile stem aqueous extract at 50% treatment showed the ultimate allelopathic effect on teff seed germination where only 3.33 germinated seeds were obtained as least mean value of the three replications.

Table 4, indicated that inhibition of barely seed germination under petri dish was more pronounced under 50% of all aqueous extract of *Eucalyptus globulus* plant parts, however more barely seed germination inhibition noticed under fresh leaf aqueous extract at 50% level of extract treatment. Where only about 2.67 seeds of barely germinated per Petri dish, but the highest barely seed germination recorded under control treatment that accounts nine barely seeds germination under the same condition.

Table 2. Mean comparison of teff seeds germinated per Petri dish after treated by *Eucalyptus globulus* extract

Treatment concentration level in (%)	Source of extract			
	Juvenile stem	Root	Fresh leaf	Mixtures*
0% (Control)	9.00^{a}	8.67^{a}	9.00^{a}	8.33^{a}
5%	8.67^{a}	8.33^{a}	7.67^{ab}	8.00^{a}
10%	8.00^{a}	7.31^{ab}	6.00^{b}	7.67^{ab}
15%	6.00^{b}	5.33^{b}	4.67^{bc}	5.31^{b}
25%	4.00^{bc}	3.67^{c}	3.33^{c}	3.67^{c}
50%	3.33^{c}	1.67^{c}	1.32^{c}	2.00^{c}
Mean	6.51	5.82	5.32	5.82
CV%	37.53	54.44	58.03	39.31
LSD	4.32	3.86	4.56	3.86

*Note: means with the same letter in the same column are not statistically significantly differences at alpha level of 0.05 as evaluated by ANOVA. Significant at $p \leq 0.05$, *= mixture of juvenile stem, root &fresh leaf each 33%, CV%= coefficient variation in percentage, LSD= least significant difference*

Table 3. Mean comparison of teff seeds germinated per pot after treated by *Eucalyptus globulus* extract

	Source of extract			
	Juvenile stem	**root**	**Fresh leaf**	**Mixtures)**
0%(control)	8.67 [a]	9.00 [a]	9.00 [a]	8.67 [a]
5%	8.67 [a]	8.67 [a]	8.32 [ab]	8.67 [a]
10%	8.00 [a]	7.67 [ab]	7.31 [ab]	8.00 [a]
15%	6.67 [b]	6.67 [b]	6.3 [b]	6.67 [b]
25%	6.01 [b]	5.31 [b]	5.00 [b]	5.67 [b]
50%	3.33 [c]	4.33 [bc]	4.00 [c]	4.31 [c]
Mean	6.89	6.94	6.65	6.99
CV%	66.64	27.72	33.50	61.32
LSD	3.47	5.06	9.03	11.21

*Note: means with the same letter in the same column are not statistically significantly differences at alpha level of 0.05 as evaluated by ANOVA test. Significant at p≤ 0.05, *= mixture of juvenile stem, root &fresh leaf each 33%, CV%= coefficient variation in percentage, LSD= least significant difference*

Table 4. Mean comparison of barely seeds germinated per Petri dish after treated by *Eucalyptus globulus* extract

Treatment concentration level in (%)	**Source of extract**			
	Juvenile stem	**root**	**Fresh leaf**	**Mixtures**
0%	8.67 [a]	9.00 [a]	8.67 [a]	8.67 [a]
5%	8.33 [a]	8.33 [a]	8.10 [a]	8.33 [a]
10%	7.67 [ab]	7.33 [ab]	7.00 [ab]	8.33 [a]
15%	7 [ab]	7 [b]	6 [b]	7.3 [ab]
25%	5.67 [b]	5.67 [bc]	5 [b]	5.3 [b]
50%	3.33 [c]	4.67 [b]	2.67 [c]	3.3 [c]
Mean	6.76	6.99	6.22	6.86
CV%	66.26	52.07	61.06	59.86
LSD	4.01	6.13	4.81	4.37

Note: means with the same letter in the same column are not statistically significantly differences at alpha level of 0.05 and 0.01 as evaluated by ANOVA test. Significant at p≤ 0.05= mixture of juvenile stem, root &fresh leaf each 33%, CV%= coefficient variation in percentage, LSD= least significant difference*

Table 5. Mean comparison of barely seeds germinated per pot after treated by *Eucalyptus globulus* extract

Treatment concentration level in (%)	**Source of extract**			
	Juvenile stem	**root**	**Fresh leaf**	**Mixture**
0%	9.00 [a]	8.67 [a]	8.67 [a]	9.00 [a]
5%	8.67 [a]	7.67 [ab]	8.67 [a]	8.68 [a]
10%	8.00 [ab]	7.30 [ab]	8.00 [ab]	7.32 [b]
15%	7.00 [b]	7.31 [ab]	6.31 [b]	6.30 [bc]
25%	6.33 [bc]	5.30 [b]	4.67 [bc]	5.00 [b]
50%	4.31 [c]	4.00	3.30 [c]	3.67 [c]
Mean	7.21	6.70	6.60	6.66
CV%	24.17	29.41	33.04	37.46
LSD	1.86	3.40	3.87	4.33

*Note: means with the same letter in the same column are not statistically significantly different at alpha level of 0.05 as evaluated by ANOVA test. Significant at p≤ 0.05, *= mixture of juvenile stem, root &fresh leaf each 33%, CV%= coefficient variation in percentage, LSD= least significant difference*

3.2 Shoot Length and Root Length

The allelopathic potential of eucalyptus plant part aqueous extracts on the inhibition of both shoot and root lengths of the target crop species increased gradually with the increase of the different extracts concentration. The intensity of root length reduction increases with the

increasing concentrations of aqueous extracts of all extract sources as that of shoot length. Significant reduction in root length was recorded at all concentrations compared to control. The length of root values varied from 1.6 cm to 5.2 cm for Teff and 2 cm to 10.1 cm for Barely. The minimum values 1.6 cm and 2 cm were observed for 50% treatment of fresh leaf for teff and barely respectively (Figs. 2 and 4).

Teff seedling root length inhibition was more pronounced under 50% of all aqueous extract of *Eucalyptus globulus* plant parts; however, more teff seedling root length inhibition noticed under fresh leaf aqueous extract at 50% level of extract treatment. Where only about 1.6 cm teff root length recorded compared to control treatment that accounts 5.3cm in length, Fig. 2. Several studies of [10,15] on (sorghum, rice, and black gram), tomato and eggplant had evaluated the allelopathic activity of *Eucalyptus* species and reported strong inhibitory effects of its extracts on germination and growth of various crop plants.

Shoot length of both crops significantly responded to aqueous extracts of *Eucalyptus globulus* fresh leaf, juvenile stem, root and mixtures of them (fresh leaf, juvenile stem & root). However, the response depends on the concentrations and plant parts considered in this particular study. For instance, teff seedling shoot length inhibition is directly proportional to the increase in the concentration of all *Eucalyptus globulus* plant parts juvenile stem, root, fresh leaf and Mixtures of aqueous extract. As it can be observed on Fig. 1, shoot length of teff seedling inhibition was more pronounced under the treatment mixtures (juvenile stem, root &fresh leaf) of extract at 50% level of treatment exhibited, which accounts 8.5 cm (the lowest mean value) compared to control teff seedling shoot length of 18.5 cm long.

The intensity of seedling shoot length reduction increases with the increasing concentration of aqueous extracts of all extract sources. The study indicated that the concentration of all plant parts fresh leaf, juvenile stem, root and mixtures of (fresh leaf, juvenile stem &root) starting from the lowest level of concentration inhibited shoot length of both target crop species (Figs. 1 and 3). This finding is in agreement with results of [26,27].

3.3 Phytotoxicity

The study shows that the phytotoxicity potential of eucalyptus plant parts aqueous extract increases with the increasing concentrations of aqueous extracts of all extract sources.

More phytotoxicity effect pronounced under the highest concentration level at 50% of all *Eucalyptus globulus* plant parts aqueous extract compared to the lower level and control treatment. Compared to both crops plant parts, phytotoxicity effect was more pronounced in root length of both crops. *Eucalyptus globulus* fresh leaf aqueous extract was recognized as the highest impact affecting early root growth of teff and barely at about 69.20% (which is almost the same effect) under the highest level of concentration (50%) of the extract (Figs. 6 & 8), however the highest inhibition of teff shoot length at about 54% and shoot length of barely at about 34.5% pronounced under the treatment of mixed extract and fresh leaf extract respectively (Figs. 5 & 7) under the highest level of concentration (50%).

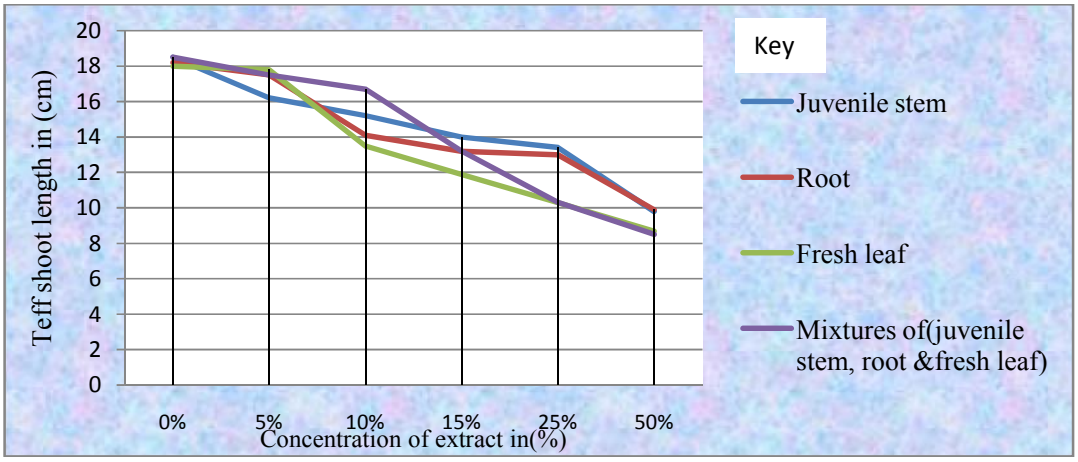

Fig. 1. Effect of *Eucalyptus globulus* plant parts aqueous extract on shoot length of teff

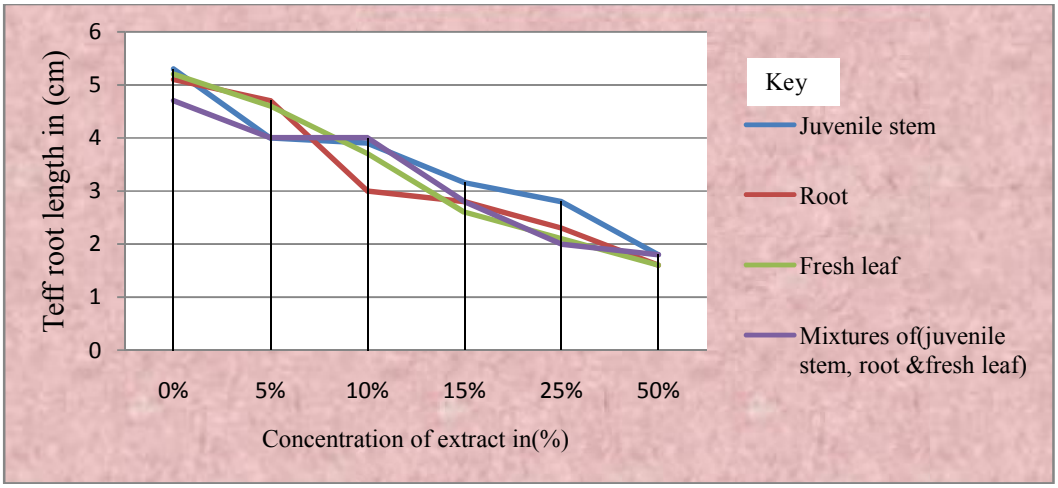

Fig. 2. Effect of *Eucalyptus globulus* plant parts aqueous extract on root length of teff

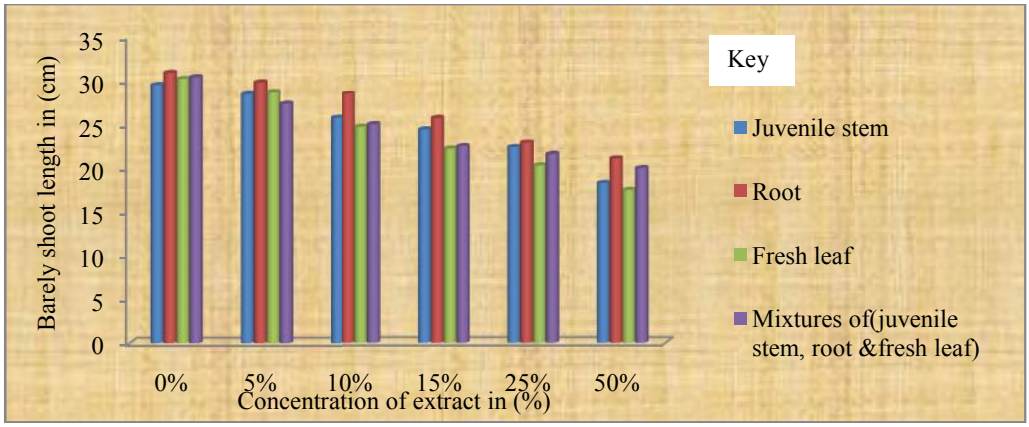

Fig. 3. Effect of *Eucalyptus globulus* plant parts aqueous extract on shoot length of barely

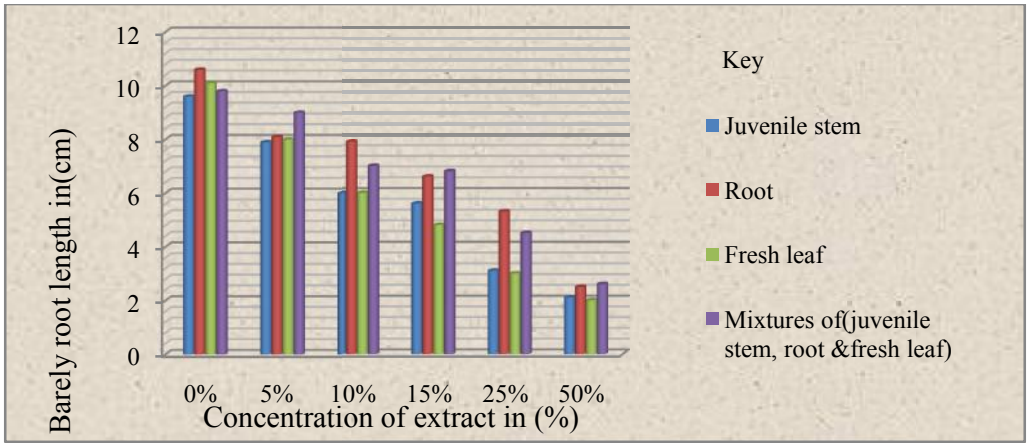

Fig. 4. Effect of *Eucalyptus globulus* plant parts aqueous extract on root length of Barely

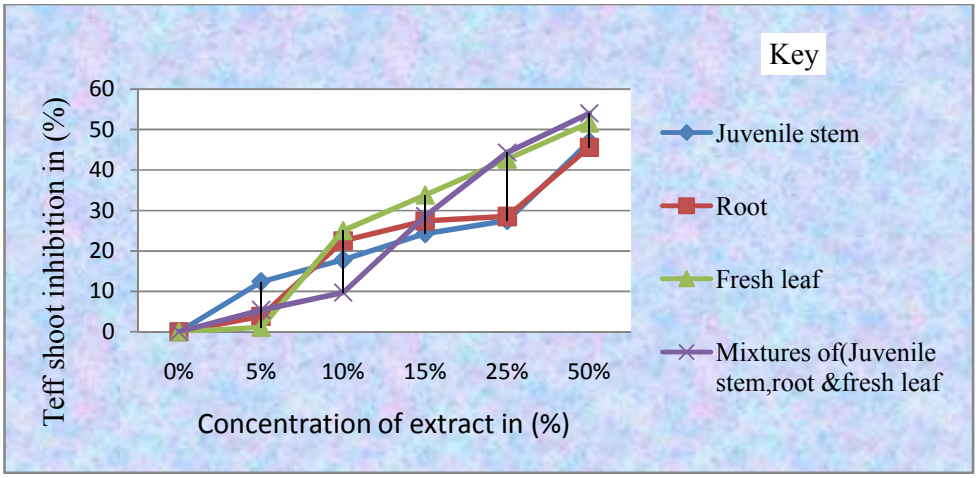

Fig. 5. Inhibitory effect of eucalyptus extract on shoot length of teff

There was direct relationship between teff shoot length and inhibitory effects of *Eucalyptus globulus* plant parts aqueous extract. As the level of *Eucalyptus globulus* plant parts aqueous extract increases, teff shoot inhibition percentage also increases. Teff shoot length inhibition more pronounced under the treatment of mixed extract which accounts for about 54% compared to control treatment, where there was no teff shoot length inhibition exhibited. A similar result was obtained by the authors [15,27]. The intensity of teff root inhibition increases as the level of *Eucalyptus globulus* plant parts aqueous extract increases, almost all plant parts aqueous extract inhibited teff root length in similar manner under the same level of concentration.

It was fresh leaf aqueous extract that pronounced the highest inhibitory (phytototxicity) effect on early root growth of teff at about 69.20% under the highest level of concentration (50%) of the extract, compared to control treatment which almost does not show teff root inhibition.

The study of [26] also explained that aqueous leaf extract of *Eucalyptus globulus* at various levels (doses) inhibited seed germination and early growth of wheat seeds.

There was a direct relationship between barely shoot length and phytotoxicity (inhibitory) effects of aqueous extract level of *Eucalyptus globulus* plant parts. Barely shoot length inhibition

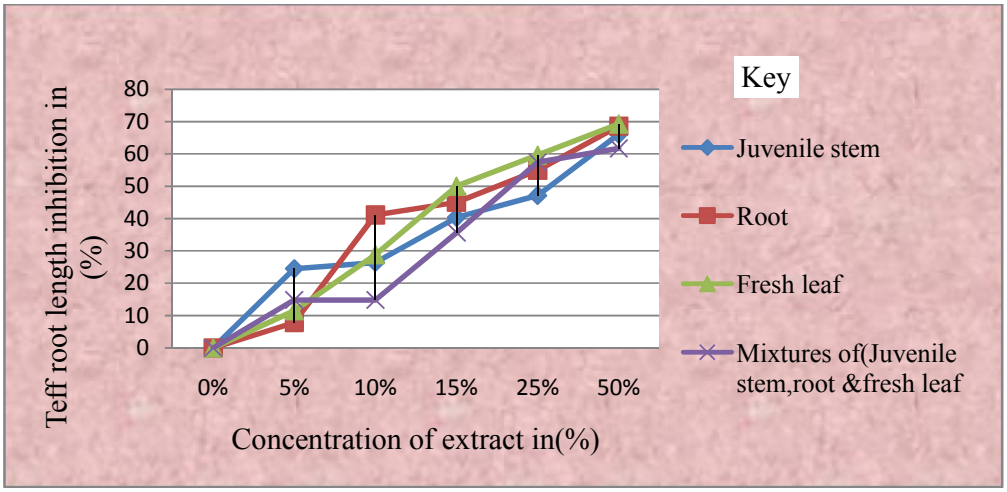

Fig. 6. Inhibitory effect of eucalyptus extract on root length of teff

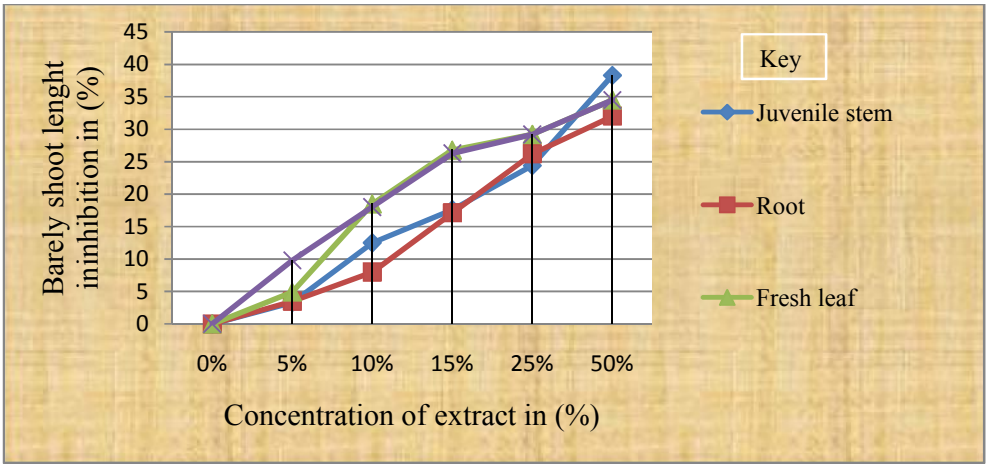

Fig. 7. Inhibitory effect of eucalyptus extract on shoot length of barley

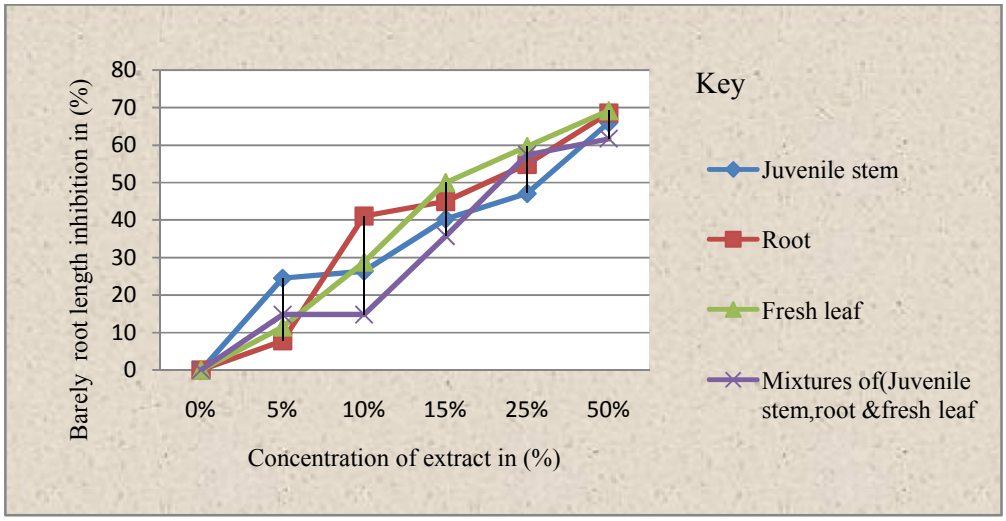

Fig. 8. Inhibitory effect of eucalyptus extract on root length of barely

increases as aqueous extract treatments level increase sunder all treatment level, however barely shoot length inhibition more pronounced under fresh leaf extract at 50% level of concentration. Compared to control which accounts barely root length inhibition at about 34.5% of fresh leaf aqueous extract at 50% level of concentration was exhibited. The study carried out by Yu et al. [27] stated that phytotoxic substances can suppress the growth of many plants by inhibiting seed germination and seedling growth. Barely root length inhibition showed direct proportionality to *Eucalyptus globulus* all plant parts aqueous extract level of concentration, Fig. 8. More barely seedling shoot length inhibition pronounced under 50% of all aqueous extract of *Eucalyptus globulus* plant parts; however compared to all other extract sources more seedling root length inhibition noticed under fresh leaf aqueous extract at 50% level of extract treatment, that exhibited 69.2% root length inhibition (which is almost the same effect root length inhibition to that of teff root length) compared to control treatment that accounts no barely root length inhibition. This result is in agreement with the study carried out by several authors [14,19].

4. CONCLUSION

The result of this study indicates that higher the concentration of *Eucalyptus globulus* plant extracts, the higher the influences on the germination of barely and teff plant species under laboratory condition. Based on the result of this study, the interaction among various levels of

Eucalyptus globulus extract treatment depicted that all extracts at lower level (5%) have lower inhibitory effect as compared to higher level (50%) on both crop species. This gradual decrease in germination (%), shoot and root length were due to allelopathic effects of *Eucalyptus globulus* aqueous extract from the lower level (5%) to higher level (50%) as compared to control. Compared to all aqueous extracts of *Eucalyptus globulus* plant parts of juvenile stem, root, fresh leaf and mixtures of (juvenile stem, root & fresh leaf), fresh leaf aqueous extract pronounced more inhibitory effect on germination percentage (%), shoot length and root length of target crops species. This suggested that there is a variation in phytotoxicity effect or allelocheimical concentration in different plant parts. On the overall findings, it can also be concluded that allelopathy is a concentration-dependent phenomenon whereby its effect increases as the concentration of the extracts increases. Compared with the control (0%), higher concentrations reduced the germination percentage, shoot length and root length in the given average time.

ACKNOWLEDGEMENT

We would like to acknowledge EFDR Ministry of Education and Madda Walabu University for financial support. We also appreciate the cooperation of KARC, during laboratory experiment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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