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EFFECTS OF BARK AND STEM EXUDATES OF EUCALYPTUS ON THREE CROP PLANTS

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ABSTRACT

The present study was conducted to investigate the effect of bark and stem exudates of eucalyptus (*Eucalyptus camaldulensis* L.) on some crops in the research field of HSTU, Dinajpur, Bangladesh. There were three test crops *viz.*, maize, country bean, bottle gourd and four concentrations of bark and stem exudates *viz.*, tap water, 10%, 25% and 50% in laboratory condition and 50% concentration of bark and stem exudates in field condition. The experiment was laid out in completely randomized design (CRD) in the laboratory and randomized complete block design (RCBD) in the field. The results of laboratory experiment showed that the extracts of bark and stem exudates had inhibitory effects to all the tested crops and inhibition rate increased with the increase of concentrations. It also indicated that inhibition by stem exudates was less compared to bark exudates of all crops except bottle gourd. In case of field experiment, both bark and stem exudates of eucalyptus also inhibited the germination of the tested crops. Unlike laboratory condition, stem exudates showed less germination than bark exudates in the crops at field condition. Morphological parameters like plant height (cm), collar diameter (mm), central root length (cm), first order lateral roots, shoot dry weight (g), root dry weight (g) showed significantly better growth in control at the laboratory and field experiments. From the overall results it might be concluded that bark and stem exudates of eucalyptus have allelopathic effects on the crops that may be minimized by removing the fallen bark and stem residues in agroforestry field.

Key words: Agroforestry, bark and stem exudates, bottle gourd, bioassay, country bean, maize

INTRODUCTION

Agroforestry has attracted a great attention in recent years because of its potential to reduce poverty, improve food security, reduce land degradation and mitigate climate change (Luedeling *et al.* 2016). In this system, competitive interactions between trees and crops cause decrease in productivity and the economic yield of intercropping system (Cao *et al.* 2012). Many researchers found the allelopathic effect of trees on crops (Zhang and Fu 2010). Some trees contain chemicals, which have harmful effects on the crops resulting in the reduction, delaying of germination, increase mortality of seedling and reduction in growth (Ghafar *et al*. 2000). *E. camaldulensis* have been introduced into many countries, owing to their fast growth and their rising demand for paper and plywood (Cossalter and Pye-Smith 2003). Presently *Eucalyptus* is grown on more than 20 million ha of plantations around the world (Booth 2013). In Bangladesh, like many other developing countries, *Eucalyptus* was introduced in the 19th century (Hossain and Hoque 2013). To fill the widening gap between supply and demand of forest raw materials, many *Eucalyptus* species are grown in homesteads, road sides and cropland agroforestry (Malik 2004) for fast growth, wider adaptability and high productivity. But also, there is continuing controversy about the ecological functions of *Eucalyptus*; it reduces the diversity and productivity of under storey species because of its negative effects (May and Ash 1990). Aqueous extracts of Eucalyptus are known to exert phytotoxicity on many weeds and crops, but there is also experimental

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evidence of the relative tolerance of maize (Carolina et al. 2013). Very few research projects have yet been undertaken to verify objections of *E. camaldulensis* under Bangladesh conditions. In some cases, it is assumed that the effects in Bangladesh are the same as those in India (Hossain and Hoque 2013). Certain phenolic acids and volatile oils released from the leaves, bark, stem and roots of certain *Eucalyptus* species act as allelopathic agents and are harmful to other plant species (Florentine and Fox 2003). As *E. camaldulensis* is now an integral part of the agroforestry systems in Bangladesh, people sometimes are experiencing crop yield loss due lack of knowledge of allelopathy. Allelopathic effects of trees including *Eucalyptus* leaves have been studied on different plant species by many researchers (e.g. Sasikumar *et al.* 2001; Blanco 2007; Zhang and Fu 2009; Kikuchi *et al.* 2009). But little studies have been reported on live stem and bark exudates (Zhang and Fu 2010). Maize (*Zea mays*), Country bean (*Lablab purpureus*), bottle gourd (*Lagenaria siceraria*). These crops were selected due to their common practice in the farmer's agroforestry fields with *E. camaldulensis* trees. Beside these, the species are locally available. Maize is used as a food for human consumption and also as a feed grain for animals. In a field study, Igboanugo (1988) found that beans could be incompatible with *Eucalyptus*, while maize may be compatible with Eucalyptus for agro-silvicultural practices. country bean and bottle gourd also used as a food for human consumption. Therefore, the present study was an attempt to assess the effects of bark and stem exudates of *E. camaldulensis* on germination, growth and biomass allocation of maize, country bean and bottle gourd in both laboratory and field condition.

MATERIALS AND METHODS

The experiment was conducted in the research field of the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University (HSTU), Bangladesh. The geographical location field is between 25º 13' latitude and 88º 23' longitude and about 37.5 m above the sea level. The field experimental plot was situated in a medium high land belonging to the Old Himalayan Piedmont Plain Area (AEZ 01). Land was well-drained as drainage system was well developed. The soil texture was sandy loam in nature. The soil pH was 5.1. The climate of the study area was characterized by scanty rainfall during Rabi season (7th October to 15th March). The seeds of test crops were collected from the Bangladesh Agricultural Development Corporation (BADC), Dinajpur. The bark and stem were collected from *E. camaldulensis* trees of nearby area of HSTU. The collected bark and stem of *E. camaldulensis* was chipped and air- dried at room temperature. The air-dried materials were soaked in distilled water for five days and were kept into bottles. The bottles were then brought into laboratory for further use. For laboratory experiment, the treatments were consisted of four factors-(i) Test crops: 3 (country bean, bottle gourd, maize), (ii) Exudates: 2 (bark, stem), (iii) Bark exudates concentration: 3 (10%, 25% and 50%) and (iv) Stem exudates concentration: 3 (10%, 25% and 50%). Three different concentrations of bark and stem exudates (50%, 25%, 10%) were prepared. To prepare 50% concentration 50g air-dried material were soaked in 100ml water. Like 50% concentration, to prepare 25% concentration 25g air-dried material were soaked in 100ml water and 10g air-dried material were soaked in 100ml water to prepare 10% concentration. Finally, treatments were replicated 3 times in completely randomized design in the laboratory experiment. Distilled water was used for control treatment. For field experiment, to prepare 50% concentration 50g air-dried materials were soaked in 100ml water. Finally, treatments were replicated 3 times in randomized complete block design in the field experiment. So, the treatment combinations of field experiment were: T_1= bark (50% concentration), T_2= stem (50% concentration) and T_3= control (only water).

Bioassays: In laboratory**,** the seeds were rinsed in distilled water repeatedly after surface-sterilization with 0.5% mercuric chloride solution. Ten seeds were placed in each sterile petridis (9cm dia) lined with two Whatman No.3 filter papers and 4 ml of test extract was added to each petridis according to treatment. The germination experiment was conducted in laboratory with room temperature.

Seeds were considered germinated when root lengths were 1-2 mm and recorded every 24-hour till seven days. The seedlings of maize, country bean and bottle gourd were removed from the Petridis after 7 days and the length of primary roots and shoots were measured. The effects of extracts on test crops were expressed in percentage (%) of control and were calculated according to T/C, where T is the "treatment" data and C is the "control" data (Zhang and Fu 2010). The effect is stimulatory when the result is greater than 100% and the effect is inhibitory when the result is less than 100%. Germination data were collected on the germination percentage, germination speed, shoot number and days of germination initiation. Germination speed was calculated as under (Chiapusio *et al*. 1997):

$$S = (N_1 * 1) + (N_2 – N_1) * 1/2 + (N_3 - N_2) * 1/3 + \ldots + (N_n - N_{n-1}) * 1/n.$$

Where, N_1, N_2, N_3, …, N_{n-1}, N_n refers to the proportion of germinated seeds on the first, second, third days, …, n-1, n days.

In field, the seeds of test crops were sown into field to see their root-shoot growth parameters and fine root architecture (length, diameter and number) in field condition. The collected seeds were sown in the field by mixing the bark and stem exudates in soil separately.

All statistics were calculated with Statistix 10 Software and the data were analyzed statistically following ANOVA technique and means separation were adjusted by Tukey's Range Test and MS Excel 2007. Statistical difference was determined at $p<0.05$ level of significance.

RESULTS AND DISCUSSION

Germination speed: In laboratory, bark exudates of all concentrations of *E. camaldulensis* significantly inhibited the germination speed of maize, country bean and bottle gourd. The inhibition increased with increasing concentration and the 50% concentration of *E. camaldulensis* significantly inhibited the germination speed of tested crops, while the 10% extracts of *E. camaldulensis* less inhibitory to the germination speed (Figure 1). However, among the tested crops, the germination speed of maize was higher than country bean and bottle gourd (Figure 1).

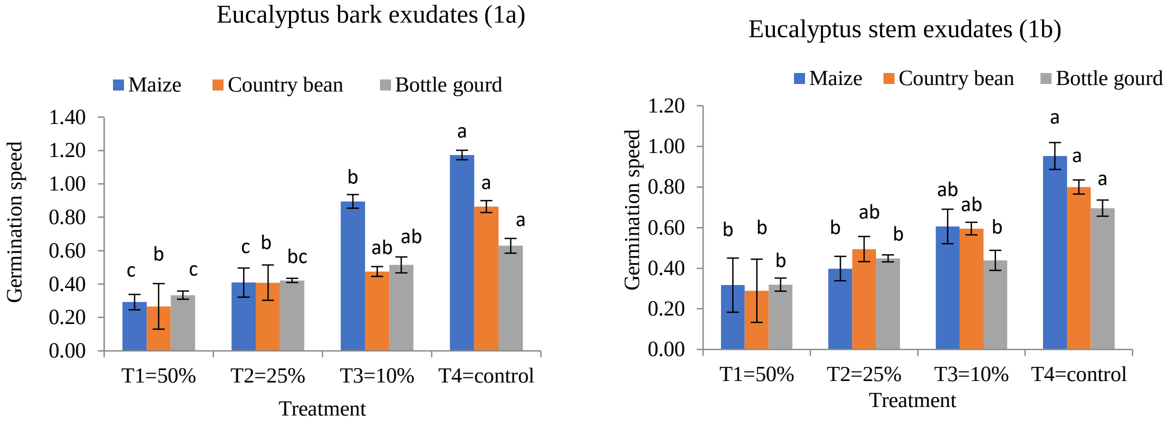

Figure 1: Effects of bark exudates (1a) and Stem exudates (1b) of *E. camaldulensis* on germination speed of three test crops in laboratory. Error bars represent the standard error of mean (different letters on the bars are significantly different).

Similarly, stem exudates of all concentrations of *E. camaldulensis* also inhibited the germination speed of all tested crops. The comparison between bark exudates (50%) and the stem exudates (50%) showed that the effect of stem exudates was more inhibitory in bottle gourd than bark exudates while the same was less inhibitory in maize and country bean in laboratory condition (Figure 1b).

Morphological traits

Morphology of maize: Plant height, collar diameter, central root length and number of first order lateral roots of maize varied statistically among the different treatments due to bark exudates application in laboratory condition. The tallest plant was recorded in control (T_4) and the short was in 50% concentration (T_1) treatments (Table 1). Similar trends of results were recorded in stem exudates application (Table 2). In case of field condition, plant height, collar diameter, central root length and number of first order lateral roots of maize varied significantly among the different treatments. The values were the highest in control (T_3) and the lowest in stem exudates (T_2) (Table 3).

Table 1. Effect of different concentrations of bark exudates of *E. camaldulensis* on the plant morphological characteristics of maize under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	20.50(±0.28) c	2.29(±0.03) d	18.67(±0.20) c	6.339±0.60) b
T_2	20.83(±0.31) c	2.4(±0.0) c	18.78(±0.21) c	7.44(±0.33) b
T_3	23.12(±0.11) b	2.56(±0.02) b	20.79(±0.14) b	7.7(±0.21) b
T_4	24.78(±0.14) a	2.76(±0.02) a	23.13(±0.12) a	10(±0.23) a
C.D.at 0.05%	0.9	0.1	0.7	1.6

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter (s) show statistically significant at P≤0.05 by Tukey's Range Test.Values in the parameter indicate ±SE.*

Table 2. Effect of different concentrations of stem exudates of *E. camaldulensis* on the plant morphological characteristics of maize under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	22.43(±0.31) bc	2.44(±0.02) b	21.07(±0.61) b	6.86(±0.26) c
T_2	21.83(±0.36) c	2.43(±0.02) b	21.61(±0.49) b	11(±0.23) b
T_3	23.40(±0.14) ab	2.54(±0.02) a	22.50(±0.14) ab	13(±0.67) b
T_4	24(±0.24) a	2.60(±0.01) a	23.95(±0.41) a	14.50(±0.26) a
C.D.at 0.05%	1.1	0.1	1.5	1.6

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter (s) show statistically significant at P≤0.05 by Tukey's Range Test. Values in the parameter indicate ±SE.*

Table 3. Effect of different concentration of bark and stem exudates of *E. camaldulensis* on the plant morphological characteristics of maize under field condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	108.8(±0.28) b	18(±0.58) b	34(±0.58) b	24.67(±0.33) b
T_2	92.20(±1.1) c	14.74(±0.15) c	23.63(±0.32) c	17(±0.58) c
T_3	117(±1.2) a	25(±0.58) a	41(±0.58) a	36(±0.58) a
C.D.at 0.05%	4.1	2.1	2.2	2.2

**T_1= Bark, T_2=Stem, T_3= Only water (control). In a column, different letter(s) show statistically significant at P≤0.05 by Tukey's Range Test. Values in the parameter indicate ±SE.*

Morphology of country bean*:* Vine length, collar diameter, central root length and number of first order lateral roots of country bean varied statistically among the different treatments due to bark exudates application in laboratory condition. The results were highest in control (T_4) and lowest in 50% concentration (T_1) (Table 4). Same results were recorded in stem exudates application (Table 5). In case of field condition, vine length, collar diameter, central root length and number of first order lateral roots of country bean varied statistically among the different treatments. These were highest in control (T_3) and lowest in stem exudates (T_2) except central root length (Table 6).

Table 4. Effect of different concentrations of bark exudates of *E. camaldulensis* on the plant morphological characteristics of country bean under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	10.64(±0.66) b	2.02(±0.01) c	2.31(±0.09) b	4.43(±0.20) b
T_2	11.12(±0.44) b	2.35(±0.08) ab	2.6(±0.31) b	4.889(±0.39) b
T_3	10. 00(±0.82) b	2.20(±0) bc	2.6(±0.43) b	8.00(±1.04) a
T_4	14.33(±0.830 a	2.48(±0.02) a	4.38(±0.05) a	9.00(±0.44) a
C.D.at 0.05%	3.1	0.2	1.0	2.2

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter (s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Table 5. Effect of different concentrations of stem exudates of *E. camaldulensis* on the plant morphological characteristics of *Lablab purpureus* L. under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	10.17(±0.10) c	2.05(±0.03) b	2.2(±0.09) b	2.83(±0.98) b
T_2	10.17(±0.08) c	2.10(±0.32) ab	3.07(±0.69) b	4.00(±0.75) ab
T_3	10.96(±0.15) b	2.58(±0.23) ab	3.56(±0.01) b	5.12(±.29) ab
T_4	11.67(±0.33) a	3.28(±0.17) a	5.00(±0.00) a	7.00(±0.00) a
C.D.at 0.05%	0.7	1.2	2.0	3.4

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Table 6. Effect of different concentrations of Bark and Stem exudates of *E. camaldulensis* on the plant morphological characteristics of *country* bean under field condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	96.79(±0.64) b	5.34(±0.01) ab	15.33(±0.88) c	5.33(±0.33) c
T_2	74.53(±0.61) c	5.23(±0.11) b	19(±0.58) b	11(±0.58) b
T_3	114(±1.00) a	5.91(±0.19) a	23(±0.58) a	15.33(±0.33) a
C.D.at 0.05%	3.3	0.6	3.0	1.9

**T_1=Bark, T_2=Stem, T_3= Only water (control). In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Table 7. Effect of different concentrations of bark exudates of *E.camaldulensis* on the plant morphological characteristics of bottle gourd under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	10.64(±0.38) c	3.07(±0.04) b	3.21±0.57 c	3.64±0.52 a
T_2	14.66(±0.26) b	3.15(±0.03) ab	5.11±0.18 b	3.67±0.23a
T_3	14.35(±0.21) b	3.18(±0.03) ab	5.05±0.20b	3.60±0.33 a
T_4	17.28(±0.28) a	3.29(±0.05) a	6.78±0.28 a	4.28±0.28 a
C.D.at 0.05%	1.2	0.2	1.3	1.5

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter(s) show statistically significant at $P \leq 0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Morphology of bottle gourd*:* vine length, collar diameter, central root length and number of first order lateral roots of bottle gourd varied statistically among the different treatments due to bark exudates application in laboratory condition. These were highest in control (T_4) and lowest in 50% concentration (T_1) (Table 7). Same results were recorded in stem exudates application (Table 8).

Table 8. Effect of different concentrations of stem exudates of *E. camaldulensis* on the plant morphological characteristics of bottle gourd under laboratory condition

Treatment*	Plant height (cm)	Collar diameter (mm)	Central root length (cm)	No. of First order lateral roots
T_1	10.15(±0.39) c	2.42(±0.20) b	3.36(±0.23) b	3.43(±0.48) a
T_2	11.44(±0.26) b	3.23(±0.05) a	3.74(±0.34) b	3.67(±0.16) a
T_3	11.00(±0.34) bc	3.02(±0.01) a	3.64(±0.14) b	3.85(±0.14) a
T_4	16.06(±0.22) a	3.29(±0.02) a	4.87(±0.22) a	3.87(±0.12) a
C.D.at 0.05%	1.1	0.4	1.1	1.0

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter(s) show statistically significant at $P\leq0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Biomass allocation

Biomass allocation of maize*:* Shoot dry biomass, root dry biomass, total dry biomass and quality index of maize varied statistically among the different treatments due to bark exudates application in laboratory condition. These were the highest in control (T_4) and the lowest in 50% concentration (T_1) (Table 9). Shoot/root ratio did not vary significantly among different treatments. Same results were recorded in stem exudates application and field conditions.

Table 9. Effect of different concentrations of bark exudates of *E. camaldulensis* on the biomass allocation of maize under laboratory condition

Treatment*	Shoot dry weight (g)	Root dry weight (g)	Total dry weight (g)	Shoot/root ratio	Quality Index
T_1	0.47(±0.01) d	0.129(±0.01) c	0.59(±0.01) d	3.97(±0.18) a	0.02(±0.0) b
T_2	0.56± (0.00) c	0.14(±0.01) bc	0.69(±0.02) c	4.29(±0.54) a	0.03(±0.0) ab
T_3	0.83(±0.01) b	0.17(±0.01) ab	1.00(±0.00) b	5.01(±0.29) a	0.04(±0.0) a
T_4	0.87(±0.01) a	0.19(±0.00) a	1.07(±0.01) a	4.53(±0.05) a	0.04(±0.0) a
C.D.at 0.05%	0.0	0.0	0.0	1.5	0.0

**T_1=50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4 = Only water (control). In a column, different letter (s) show statistically significant at $P\leq0.05$ by Tukey's Range Test. Values in the parameter indicate ±SE.*

Biomass allocation of country bean: Shoot dry biomass, root dry biomass, total dry biomass and quality index of country bean varied statistically among the different treatments due to bark exudates application in laboratory condition. These were highest in control (T_4) and lowest in 50% concentration (T_1), shoot dry biomass was also highest in 25% concentration (T_3) (Table 10). Shoot/root ratio did not vary significantly among different treatments. Same results were recorded in stem exudates application.

The results of the present study indicated that the both bark and stem exudates of *E. camaldulensis* inhibited the seed germination and seedling growth of three test crops i.e. maize, country bean and bottle gourd at the laboratory and field conditions. Therefore, both bark and stem exudates of *E. camaldulensis* exerted allelopathic effects which is inhibitory on seed germination of crop species. The results are consistent with the reports on allelopathic effects of leaf and root exudates of *Eucalyptus* on crops (Zhang and Fu 2010, Malik 2004).

Table 10. Effect of different concentration of bark exudates of *E. camaldulensis* on the biomass allocation of country bean under laboratory condition

Treatment*	Shoot dry weight (g)	Root dry weight (g)	Total dry weight (g)	Shoot/root ratio	Quality Index
T_1	0.33(±0.00) b	0.23(±0.00) c	0.57(±0.00) d	1.42(±0.01) c	0.05(±0.00) a
T_2	0.37(±0.00) a	0.32(±0.00) b	0.7(±0.00) c	1.17(±0.00) c	0.06(±0.00) a
T_3	0.38(±0.00) a	0.34(±0.00) a	0.72(±0.00) b	1.119±0.01) b	0.06(±0.00) a
T_4	0.38(±0.00) a	0.35(±0.00) a	0.73(±0.00) a	1.08(±0.02) a	0.05(±0.00) a
C.D.at 0.05%	0.0	0.0	0.0	0.1	0.0

**T_1= 50% concentration, T_2= 25% concentration, T_3= 10% concentration, T_4= Only water (control). In a column, different letter(s) show statistically significant at P≤0.05 by Tukey's Range Test. Values in the parameter indicate ±SE.*

Results of laboratory experiment showed that 50% concentration of both bark and stem exudates of *E. camaldulensis* inhibited more in germination of three tested crops compared to other lower concentrations. Bark exudates of *E. camaldulensis* showed germination 24.74% in maize, 31% in country bean and 54.33% in bottle gourd over control. On the other hand, stem exudates of *E. camaldulensis* showed germination 35.36% in maize, 37.33% in country bean and 45.67% in bottle gourd over control. This result is in consistent with the results of many researchers (Prajapati and Tandel 2013, Saberi *et al*. 2013).

Results of field experiment showed that 50% concentration of both bark and stem exudates of *E. camaldulensis* inhibited germination of three tested crops compared to other lower concentrations. Bark exudates of *E. camaldulensis* showed germination 52.0% in Maize, 34.33% in country bean and 50.0 % in bottle gourd over control. On the other hand, 50% concentration of stem exudates of *E. camaldulensis* showed germination 40% in maize, 19.67% in country bean and 40% in bottle gourd over control.

Morphological parameters like plant height (cm), collar diameter (mm), central root length (cm), no. of first order lateral roots showed significantly higher growth in control over bark and stem exudates in all the tested crops at the laboratory and field experiments. Similar results were recorded for biomass allocation like shoot dry weight (g), root dry weight (g), total dry weight (g), shoot/root ratio and quality index. The results showed that the inhibitory effect increased with increasing concentrations. This result is in agreement with many researchers (Fikreyesus *et al*. 2011, Saberi *et al*. 2013). Greater concentration of allelochemicals might inhibit the seed germination by suppressing the synthesis of gibberellins and indole acetic acid (Moradshahi 2003). The inhibitory effect was proportional to the concentrations of the extracts and the higher concentration had the strongest inhibitory effect (Fikreyesus *et al*. 2011). In the field experiment, inhibition by bark exudates is less compared to stem exudates of respective crops. This might be due to more allelopathic effect of stem exudates over bark exudates of *E. camaldulensis* on the tested crops.

It was reported that in addition to the allelopathic effect of leaf and root of *E. camaldulensis*, bark and stem have also allelopathic effect on the agricultural crops which inhibited more in laboratory compared to field condition (Khan *et al*. 2008). As a common practice, if fallen stem, bark and branches of *Eucalyptus* timely collected for fuel wood purposes, it might be a good management strategy to alleviate the allelopathic effects of *E. camaldulensis* on under storey crop species especially in the agroforestry system.

CONCLUSIONS

From the present study it was recorded that germination of maize, country bean and bottle gourd seeds were affected by different concentrations of bark and stem exudates of *E. camaldulensis*. Higher concentrations of exudates had strongest inhibitory effect on the tested crops. Therefore, it may be concluded that if *Eucalyptus* is incorporated with a wider spacing for agroforestry practice, inhibitory effect might be reduced by reducing the concentration of its litter fall. Overall, findings of this study will help farmers and decision makers to choose this tree in the field of agroforestry for higher yield from a piece of land. The allelopathic effect of bark and stem fallen from the *E. camaldulensis* tree may be minimized by regular collection for household purposes. The allelopathic effect can be minimized by planting low- density of *E. camaldulensis* tree. Crops like maize, bean and bottle gourd should not be planted very close to *Eucalyptus* trees to get the maximum germination of the associated crops.

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