



## RESEARCH ARTICLE

# Plant specific responses of *Imperata cylindrica* leaves extracts (in-vitro) on selected forest tree species

Rafia Rahman\*, Mohammed Jashimuddin, Sudipta Sen Gupta and Mohammed Kamal Hossain

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### ABSTRACT

*Imperata cylindrica*, a widespread invasive weed, is significantly disrupting plantations and degraded hill forests in Bangladesh through the release of allelopathic chemicals that inhibit the growth of other plants. To assess its allelopathic impact, an experiment was conducted using six concentrations of *Imperata cylindrica* leaves extract (prepared at 28–30°C) to evaluate effects on seed germination and seedling growth of four forest tree species: *Syzygium fruticosum* (Puttiam), *Albizia procera* (Silkeroi), *Azadirachta indica* (Neem), and *Ficus hispida* (Dumur). The extracts' lower concentrations (<20 g/L) stimulated germination in *S. fruticosum* and *A. indica*, while concentrations above 20 g/L inhibited germination of all species. Increasing concentrations negatively affected shoot growth, particularly of *F. hispida*, and root growth of *A. indica*. Among the tested species, *A. procera* showed the highest vigor index for both root and shoot growth at the 50 g/L concentration, indicating a higher tolerance to *I. cylindrica* allelopathy. In contrast, *F. hispida* was the most adversely affected. These findings suggest that *A. indica* and *A. procera* are more resilient to the allelopathic effects of *I. cylindrica* and could be promising candidates for reforestation or afforestation in areas heavily infested with *Imperata cylindrica*. However, greenhouse studies and field studies are needed for drawing definitive conclusions.

**Keywords:** Allelopathy, *Albizia procera*, *Azadirachta indica*, *Imperata cylindrica*, Invasive weed, Forest trees

### INTRODUCTION

Allelopathy is one of the well-known mechanisms by which interactions between organisms detrimentally influence the structure and functions of ecosystems (Powell *et al.* 2013). A species will be deemed invasive when it expands beyond its normal range and has the potential to affect the native variety, ecosystem structure, and general function (Thiébaud *et al.* 2019). Multiple studies have demonstrated evidence of detrimental allelopathic effects on germination, growth, development, survival, reproduction, nitrogen fixation, and/or selective mycorrhizal fungi by the release of allelochemicals via leaching, decomposition of litter, exudation of roots, and/or direct volatilization (Kundra *et al.* 2023, Schulz and Tabaglio 2025) though these interactions vary species to species, dose to dose, and under different weather conditions.

*Imperata cylindrica* (L.) P. Beauv. also known as cogon grass, japgrass, blady grass, sungrass, speargrass, alang-alang, and lalang-alang, is a C4 rhizomatous perennial weed under Poaceae family with culms that grow upright to ascending and

normally reach heights of 1.2m but can reach heights of 3 m (Holm *et al.* 1977, MacDonald 2004). This species is recognized as one of the top ten most notorious invasive weeds among the world's 100 worst invasive alien species, noted for its significant disruptive impact across diverse ecosystems (Kato-Noguchi 2022) that harms the ecosystem and causes significant economic loss in both natural and agricultural settings. Like globally, *I. cylindrica* shows its invasiveness by growing abundantly in the hills (Kato-Noguchi 2022, Mukul *et al.* 2021), and can hamper or even destroy the growth of different natural vegetation. *I. cylindrica* has a high phenotypic plasticity, which means it can do well in a wide range of conditions (MacDonald 2004, Bryson *et al.* 2010). Invasive plants have phytotoxic chemical substances that disrupt the physiological and biochemical processes of other plants. 72 chemical components have been extracted and identified from *I. cylindrica* including the main constituents are saponins, flavonoids, phenols, and glycosides (Jung and Shin 2021). All those available phytochemicals in *Imperata cylindrica* are also found in some other species that show negative impact on its surrounding species in forest and agroforestry ecosystems. Invasive alien species are a major factor in the reduction of biodiversity. As the species invade hills and there is a

Institute of Forestry and Environmental Sciences, University of Chittagong, Chattogram 4331, Bangladesh

\* Corresponding author email: rafiarahman.cu38@gmail.com

high possibility that it might have some impact on the hill forest vegetation. However, this impact has not been assessed yet in the climatic conditions of Bangladesh. Moreover, *Imperata cylindrica*'s allelopathic inhibition/stimulation effects on hill tree species was not studied. Therefore, a study was conducted to quantify the impact of the leaves extracts of *I. cylindrica* on seed germination and initial growth of four common trees under in-vitro conditions.

## MATERIALS AND METHODS

The study was conducted at the Society and Environment Research Lab of the Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU) from May to October 2024.

*Imperata cylindrica* was selected as the donor species due to its ecological characteristics, while selected receptor species include *Syzygium fruticosum* (Putijam), *Albizia procera* (Silkoroi), *Azadirachta indica* (Neem), and *Ficus hispida* (Dumur). The selection of receptor species was guided by the natural availability of mature seeds during the study period and their typical occurrence within the hill forest ecosystems of the Chattogram region.

Fresh and mature *Imperata cylindrica* leaves were gathered from various hill slopes within the University of Chittagong campus. The collected leaves were initially air-dried under ambient conditions to reduce moisture content. Following drying, the leaves were chopped into uniform fragments ranging from 0.5 to 1 cm in length to facilitate efficient extraction of phytochemicals. To assess the potential allelopathic effects (inhibitory or stimulatory) of *Imperata cylindrica* leaf extracts, six concentrations were prepared using 10 g, 20 g, 30 g, 40 g, 50 g, and 100 g of chopped leaf material soaked in 1 L of distilled water and maintained at a temperature between 28°C-32°C for 24 hours. Afterwards the mixtures were filtered through four layers of cheesecloth to remove solid residues. The

resulting aqueous extracts were adjusted to final concentrations of 10 g/L, 20 g/L, 30 g/L, 40 g/L, 50 g/L, and 100 g/L, and subsequently stored under appropriate conditions for use in seed treatment experiments. The treatments included the 20 seeds of receptor plants grown each in 0 g/L (Control *i.e.* distilled water), 10 g/L, 20 g/L, 30 g/L, 40 g/L, 50 g/L, and 100 g/L concentration to study the germination and growth test in-vitro using a 12 cm long sterile petri dish covered with Whatman No. 3 filter paper at room temperature. The Petri-dishes were sterilized by maintaining a temperature of 200 degree Celsius. The experimental setup followed a randomized complete block design (RCBD) replicated thrice. Each day, a small amount of the extract from each concentration was applied to each petri dish of the corresponding treatment, just enough to moisten the seeds, whereas the control was applied only with distilled water. To accommodate the final germination rate and the determination of the shoot and root lengths, the experiment was expanded beyond a period of 30 day.

Analysis of Variance (ANOVA) and Duncan's Multiple Range Test were conducted to evaluate the receptor species' percentage of seed germination (%), height of the root (cm), shoot length (cm), and vigor index of the root and shoot collected throughout the experiment (Table 1).

## RESULTS AND DISCUSSION

### Seed germination (%) of receptor tree species

The seed germination (%) of the four receptor tree species decreased with the increasing concentrations of the *I. cylindrica* extracts (Figure 1). Both the stimulating and inhibiting effects on the germination of receptor species seeds was observed with different concentrations of *I. cylindrica* leaves extracts. Significant inhibiting effects on the seed germination of *Syzygium fruticosum* (100 g/L concentration compared to 10 g/L concentration) and *Ficus hispida* (100 g/L concentration compared to 40 g/L concentration) were recorded. Conversely, there was also a significant stimulating effect on the seed germination of *Azadirachta indica* at 20 g/L

**Table 1. The formulae used during the calculations**

Variable	Equation	Reference
Germination Percentage, G	$\frac{\text{Number of seeds germinated}}{\text{Total Number of seeds sown}} \times 100$	Alemu <i>et al.</i> 2016
Vigor Index, V	Germination percentage x seedling length	Abdul-Baki and Anderson 1973
Inhibition, I	$100 - (E_2 \times 100/E_1)$	Surendra and Pota 1978

[I = % inhibition; E1 = The response of the control plant; E2 = The response of the treatment plant]

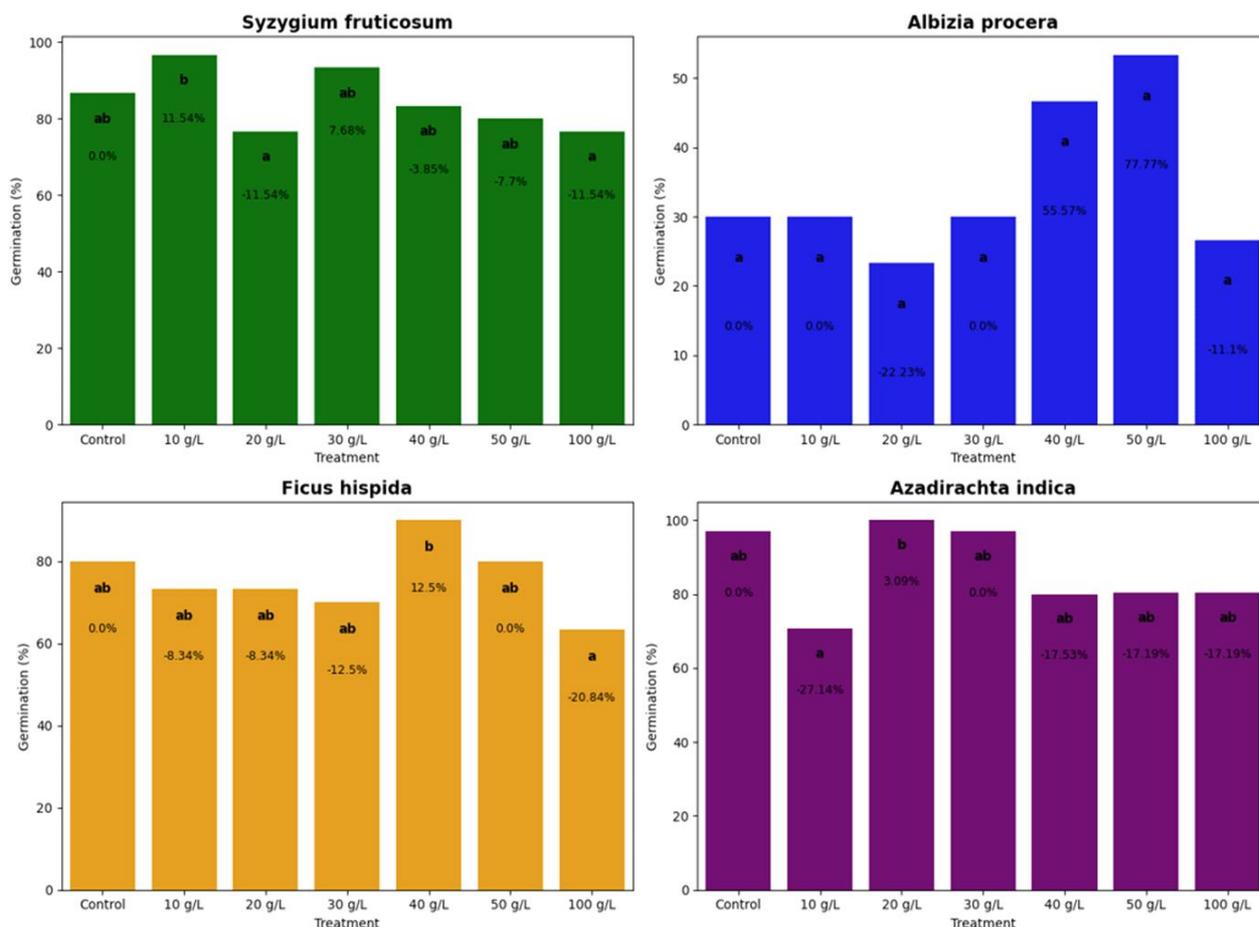


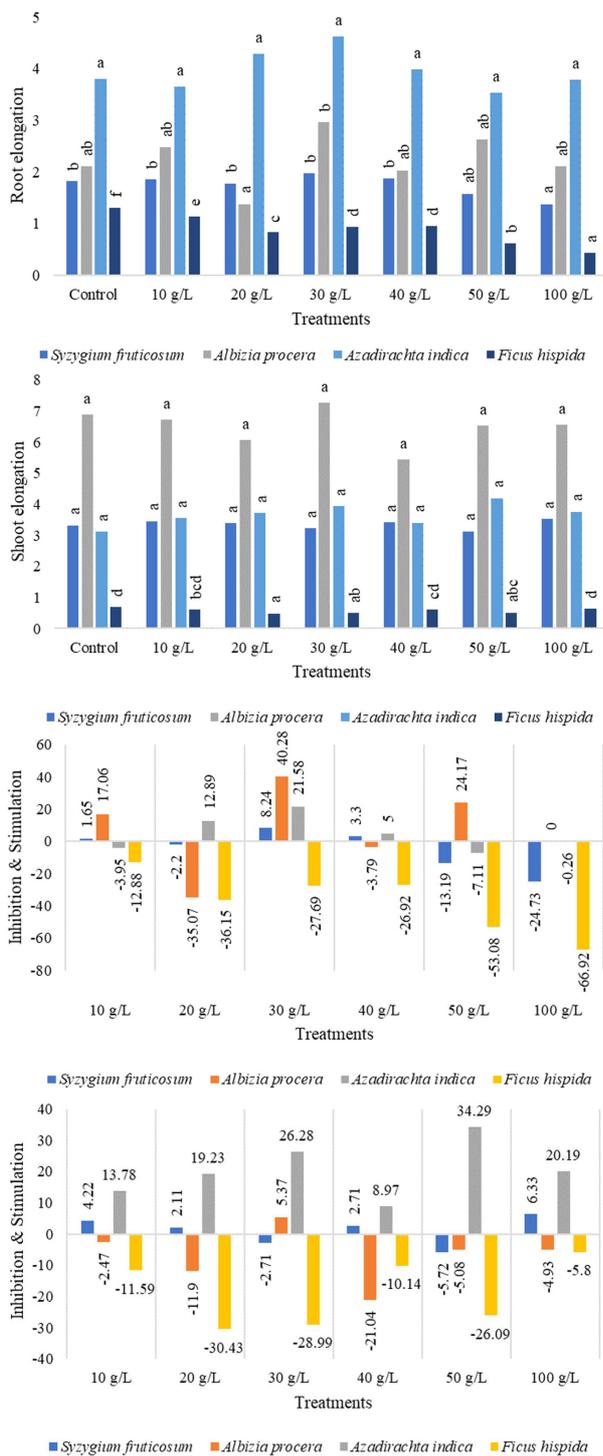
Figure 1. The receptor trees seed germination percentage and inhibition/stimulation by different leaves extract concentrations of *Imperata cylindrica*

concentration compared to 10 g/L (Figure 1).

The highest seed germination (%) with little stimulation at low concentrations was observed in *Azadirachta indica* with 20 g/L and *Syzygium fruticosum* with 10 g/L concentration. Possibly, a lower concentration of the leachate may induce little stress (Subtain *et al.* 2014) that does not significantly affect the germination percentage of the recipient crops, alternatively, leaf with a lower concentration of leachate can serve as an accelerator to enhance germination (Pedrol *et al.* 2006) regarding few instances demonstrating the stimulating effects in *Syzygium fruticosum* and *Azadirachta indica*. For *Ficus hispida*, the inhibition percentage increased with the high concentration of the treatment which was also revealed elsewhere (Moro Cordobés *et al.* 2023) and (Suzuki *et al.* 2018). Except for *Albizia procera*, most species showed seed germination inhibition when treated with higher concentrations. This type of inhibiting germination may result due to the presence of benzoic acids (Hagan *et al.* 2013).

**Root and Shoot elongation of receptor tree species**

The seed germination test was expanded beyond 30 days to observe the growth of roots and shoots of the receptor seeds. Varying inhibiting growth of roots of different receptor species was observed due to increased concentrations of *Imperata cylindrica* leaves extracts. *Azadirachta indica* showed highest root growth (4.62 cm in 30 g/L concentration) compared to other receptor species in control condition, whereas *Albizia procera* showed highest shoot growth (7.26 cm in 30 g/L concentration) followed by *Azadirachta indica* (4.19 cm in 50 g/L concentration) and *Syzygium fruticosum* (3.53 cm in 100 g/L concentration) under control condition. Significant stimulation in root elongation was observed in *Albizia procera* at 30 g/L concentration compared to 10 g/L, whereas *Azadirachta indica* at 50 g/L concentration compared to the rest. *Syzygium fruticosum* at 100 g/L concentration compared to 30 g/L showed a gradual stimulation in shoot growth as the concentration increased. *Syzygium fruticosum* (100 g/L concentration compared to 20 g/L concentration), and *Ficus hispida* (100 g/L concentration compared to 10 g/L concentration) showed significant inhibiting root growth due to



**Figure 2. Root elongation (cm) and shoot elongation (cm) of receptor tree species and inhibition and stimulation of root and shoot in different concentrations on *Imperata cylindrica* leaves extracts**

increased concentration of *I. cylindrica* extracts. The maximum root inhibition of *Ficus hispida* (67%) followed by *Syzygium fruticosum* (25%) was recorded. On the other hand, highest shoot inhibiting growth of *Ficus hispida* (30%) followed by *Syzygium*

*fruticosum* (6%) was observed with different concentrations of *I. cylindrica* leaves extracts (Figure 2).

**Root vigor index of receptor tree species**

The control exhibits a significantly greater vigor index value for *Ficus hispida* (104 in Control compared to 28 in 100 g/L concentration) and a lower vigor index value for *Albizia procera* (63 in Control compared to 140 in 50 g/L concentration). *Syzygium fruticosum* showed significantly greater vigor index in lower *I. cylindrica* extract concentration (184 in 30 g/L concentration or 180 in 10 g/L concentration) compared to higher concentration (107 in 100 g/L concentration). On the other hand, *Azadirachta indica* showed significantly greater vigor index in lower *I. cylindrica* extract concentration (449 in 30 g/L concentration or 245 in 10 g/L concentration) compared to higher concentration (335 in 100 g/L concentration) (Table 2).

**Shoot vigor index of receptor tree species**

*Azadirachta indica* demonstrated a significantly higher vigor index under the control treatment (Control: 305) compared to treatment 30 g/L concentration (382), suggesting a potential inhibitory effect at higher extract concentrations. In contrast, *Ficus hispida* exhibited a reduced vigor index under 40 g/L concentration (56) relative to 30 g/L concentration (35), indicating species-specific responses. Although these differences were not statistically significant in all cases, a general trend of increasing vigor index with higher concentrations of *I. cylindrica* leaves extract was observed in the remaining species (Table 3), implying a possible stimulatory effect depending on species and treatment level.

Eussen and Niemann (1981), had proven that leaf extract of *I. cylindrica* has growth-inhibitory effects. *I. cylindrica* leaves and underground parts also demonstrated inhibitory effects on seedling growth in a variety of different plant species, including *Sida spinosa*, *Brachiaria ramosa*, *Echinochloa crus-galli*, *Cynodon dactylon*, and *Lolium multiflorum* (Koger et al. 2004). The allelopathic effects of extracts from *I. cylindrica* are determined by allelochemicals such as fatty acids, terpenoids and phenolic acids, and alkaloids that have potential to retard the growth of various other plants e.g. *Sida spinosa*, *Oryza sativa*, *Pinus roxburghii*, etc. (Kato-Noguchi 2022, Salim 2020, Salim et al. 2020).

**Table 2. Vigor index (root) of receptor plants as affected by different concentrations of *Imperata cylindrica* leaves extracts**

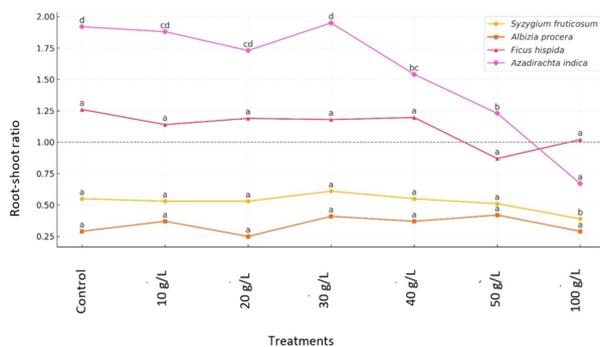
Treatment (Concentration of <i>Imperata cylindrica</i> leaf extracts.)	<i>Syzygium fruticosum</i>	<i>Albizia procera</i>	<i>Azadirachta indica</i>	<i>Ficus hispida</i>
Distilled water only-control	141.33 <sup>ab</sup>	62.67 <sup>a</sup>	369.48 <sup>abc</sup>	104 <sup>d</sup>
10 g/L	180.33 <sup>b</sup>	81 <sup>a</sup>	244.77 <sup>a</sup>	83 <sup>cd</sup>
20 g/L	138.33 <sup>ab</sup>	38.33 <sup>a</sup>	428.79 <sup>bc</sup>	60.33 <sup>b</sup>
30 g/L	183.67 <sup>b</sup>	110.67 <sup>a</sup>	448.21 <sup>c</sup>	66 <sup>bc</sup>
40 g/L	156 <sup>ab</sup>	93 <sup>a</sup>	316.72 <sup>ab</sup>	86 <sup>cd</sup>
50 g/L	127.33 <sup>ab</sup>	139.67 <sup>a</sup>	289.62 <sup>a</sup>	49 <sup>b</sup>
100 g/L	107.33 <sup>a</sup>	55 <sup>a</sup>	334.63 <sup>abc</sup>	27.67 <sup>a</sup>
F-value	2.097	1.302	3.728	13.152

[Note: Different letter(s) beside the mean represent significant differences in different treatments according to duncan’s multiple range test (DMRT) at p=0.05.]

**Table 3. Vigor index (shoot) of receptor plants as affected by different concentrations of *Imperata cylindrica* leaf extracts**

Treatment (Concentration)	<i>Syzygium fruticosum</i>	<i>Albizia procera</i>	<i>Azadirachta indica</i>	<i>Ficus hispida</i>
Distilled water only-control	261 <sup>a</sup>	202 <sup>a</sup>	304.29 <sup>a</sup>	54.67 <sup>ab</sup>
10 g/L	334.2 <sup>a</sup>	206 <sup>a</sup>	263.05 <sup>a</sup>	45.33 <sup>ab</sup>
20 g/L	262.67 <sup>a</sup>	131 <sup>a</sup>	371.42 <sup>a</sup>	35 <sup>ab</sup>
30 g/L	300.33 <sup>a</sup>	267 <sup>a</sup>	381.69 <sup>a</sup>	34.67 <sup>a</sup>
40 g/L	283 <sup>a</sup>	255 <sup>a</sup>	276.25 <sup>a</sup>	56.33 <sup>b</sup>
50 g/L	250 <sup>a</sup>	332.33 <sup>a</sup>	326.08 <sup>a</sup>	41.33 <sup>ab</sup>
100 g/L	271.33 <sup>a</sup>	164 <sup>a</sup>	327.22 <sup>a</sup>	41 <sup>ab</sup>
F-value	0.906	1.214	0.95	1.877

[Note: Different letter(s) beside the mean represent significant differences in different treatments according to duncan’s multiple range test (DMRT) at p=0.05.]



**Figure 3. Root-shoot ratio of receptor plants as affected by different concentrations of *Imperata cylindrica* leaf extracts**

**The root-shoot ratio of receptor tree seedlings**

The root-shoot ratios of tree seedlings indicate their survival probability. Seedlings with a ratio less than 1.0 have a lower survival probability. It is evident from the experiment that, *I. cylindrica* extracts did not significantly affect the root-shoot ratios of *Albizia procera* and *Syzygium fruticosum* compared to control treatment, suggesting they did not significantly impact germinated seed growth. *Ficus hispida* and *Azadirachta indica* had a root-shoot ratio of more than one in control and lower in *I. cylindrica* concentration treatments, suggesting they will survive in control conditions or at low concentrations (Figure 3). However, at higher concentrations, they could influence its survival in the future.

**Conclusion**

The inhibitory impact of *Imperata cylindrica* leaves aqueous extract was higher for *F. hispida* compared to *A. procera* and *A. indica*. Therefore, *A. indica* and *A. procera* may be suggested for planting in the hills infested with *I. cylindrica*. However, green house studies and field studies are needed for drawing definitive conclusions.

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