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Allelopathic potential of needle litter extracts of *Pinus roxburghii* on germination and early growth of *Zea mays* and *Echinochloa crus-galli*

KEYWORDS

allelopathy, needles, weed management, Pinus roxburghii,

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ABSTRACT The needle litter of *Pinus roxburghii*, a common conifer of Himalayan region was investigated for allelopathic potential against crop plant *Zea mays* and weed *Echinochloa crus-galli*. The aqueous extracts from litter enhanced the growth of *Z. mays* slightly at lower concentrations but showed inhibitory effect at higher concentrations. However, the effect on *E. crus- galli* was inhibitory at all the concentrations. Overall, the effect on the weed species was more pronounced as compared to the crop species. The findings suggest that the litter of *P. roxburghii* possesses allelopathic potential and can serve as an important bioresource for management of weeds by utilizing the principles of allelopathy. However, further detailed field studies are needed.

Introduction

Allelopathy refers to the direct or indirect harmful or beneficial effects that a plant exerts on seed germination, growth and development of another plant through the production and release of chemicals compounds in the environment (Rice 1984). It plays an important role in regulating plant diversity. The allelochemicals are released from the plants through the processes of- volatilization, leaching, root exudations or by decomposition of litter. The litter decomposition is claimed to be the most important source of allelochemical release (Reigosa *et al.*, 1996).

During last few decades there is growing concern about the negative impact of commercial herbicides which have many adverse effects on environment and human health and has led to the emergence of herbicidal resistant weeds. So, the need for alternate strategies for weed management is being felt. Of late, the allelopathy is being proposed as a tool for sustainable weed management and as an alternative to commercial herbicides (Weston, 1996; Duke *et al.*, 2002; Owen and Zelaya, 2005; Batish *et al.* 2007a, 2007b; Belz, 2007; Bhadoria, 2011; Chen *et al.* 2013). Many allelochemicals have been identified which are active against weeds (Harper *et al.* 1981, Putnam, 1988) For utilizing the principles of allelopathy in weed management, the allelopathic plants should be evaluated for their effect on crops as well as on weeds.

Pinus roxburghii Sargent (Family- Pinaceae) is native to Himalayas and widely planted. The tree is observed to have sparse understorey vegetation. The litter in the form of fallen leaves (called needles) accumulates on the forest floor and decomposes slowly. The dried needle litter is potential source of forest fires. However it may prove to be a useful bioresource for weed management. So the present study was undertaken to evaluate the allelopathic effect of aqueous extracts of litter of *P. roxburghii* and possibility of using it for weed control. The extracts were tested on the crop plant *Zea mays* L. and associated weed *Echinochloa crus-galli* (L.) P. Beauv.

Materials and methods

Collection of Plant Material

The freshly fallen needle litter of *P. roxburghii* was collected from a forest of Mandi district of Himachal Pradesh. The seeds of *Z. mays* (var. GA-95) were procured from local market and that of *E. crus-galli* were collected from fields and surrounding areas.

Preparation of aqueous extracts

The needles were shade dried, chopped and then grinded and sieved to powder form. Aqueous extract of needle powder was prepared by soaking 4 grams powder in 100 ml. distilled water (4% w/v) for 18 hours in a conical flask and then filtering it through Whatman no. 1 filter paper. Extracts of concentration 2%, 1% and 0.5% were prepared by further dilutions with distilled water. Pure distilled water served as control. Seeds were dipped in distilled water for 12 hours for imbibitions. 7 seeds of *Z. mays* and 15 seeds of *E. crus-galli* were placed in 15 cm diameter Petridish, lined with filter paper and moistened with 10 ml of respective extract or distilled water (control). For each treatment, 5 replicates were maintained. The replicates were kept in completely randomized manner. Germination (radicle length 2mm and beyond) and the growth in terms of root length, shoot length and biomass of seedlings was recorded after one week.

Statistical analysis

Data were analyzed by one- way ANOVA at $p \leq .05$ applying post-hoc Tukey's test. The statistical analysis was performed using SPSS /PC software ver. 16.0 (SPSS Inc., Chicago,IL).

3. Results and discussion

The seed germination in *Z. mays* was not affected at lower concentration treatments of aqueous extracts of needle litter of *P. roxburghii* (Table 1). However, it decreased slightly at 2% and 4% treatments (not significant at $p \leq .05$). The root length of *Z. mays* was slightly stimulated in response to extracts of concentration 0.5%, 1% and 2% but inhibited at 4% conc. However the increase or decrease was not significant ($p \leq 0.05$).

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The shoot length increased slightly at lowest concentration of the extract but a trend of decline was noticed at concentrations of 1% and above. The decline was significant ($p \leq .05$) for 2% and 4% concentration. The biomass of seedlings enhanced slightly in 0.5% and 1% treatments and but declined in 2% and 4% treatments (significant in 4% at $p \leq .05$).

Table1. Effect of needle litter extracts of *Pinus roxburghii* on germination, root length, shoot length and seedling biomass of *Zea mays*

Conc. (%)	Germ. (%)	Root length (cm)	Shoot length (cm)	Biomass (mg)
0	100±0.00a	22.43±0.75a	9.58±0.38a	116.02a
0.5	100±0.00a	23.00±0.71a	9.74±0.25a	116.75a
1	100±0.00a	23.81±0.80a	8.76±0.26ab	117.63a
2	94.28±3.50a	23.73±0.88a	7.77±0.25b	98.80ab
4	91.42±5.71a	20.71±0.98a	7.68±0.35b	93.04b

Data presented as mean ± standard error;
Different alphabets within a column represent significant difference among treatments at $p \leq .05$ applying post hoc Tukey's test.

The aqueous extracts of needle litter showed inhibitory effect on germination of *E. crus- galli* in all treatments (Table 2). The decrease in percent germination was significant ($p \leq .05$) at 2% and 4% concentrations with a decrease of about 27% and 31% respectively with respect to control. The decrease in root length was significant at 1% and above treatments as compared to control. A decrease of about 21% in 1%, 35% in 2% and 55% in 4% extract treatment was observed as compared to control. A trend of decline was also observed in shoot length in all extract treatments as compared to control. The decrease was significant ($p \leq .05$) in 2% and 4% treatments. A reduction of about 15% and 32% was recorded in shoot length in 2%, 4% treatments respectively as compared to control. The biomass showed significant decline at 1% and above treatments as compared to control with a maximum decline of about 36% in 4% treatment.

Table 2: Effect of needle litter extracts of *Pinus roxburghii* on germination, root length, shoot length and seedling biomass of *Echinochloa crus-galli*

Conc. (%)	Germ. (%)	Root length (cm)	Shoot length (cm)	Biomass (mg)
0	82.66±4.52a	4.48±0.14a	5.15±0.11a	2.83±0.17a
0.5	74.66±3.26a	3.96±0.15ab	4.97±0.12a	2.59±0.12ab
1	69.33±3.39ab	3.53±0.17b	4.83±0.11ab	2.41±0.05bc
2	55.99±3.39bc	2.93±0.16c	4.38±0.12b	2.21±0.09c
4	51.99±2.49c	2.02±0.12d	3.52±0.19c	1.80±0.06d

Data presented as mean ± standard error;
Different alphabets within a column represent significant difference among treatments at $p \leq 0.05$ applying post hoc Tukey's test.

The allelopathic plants can have differential effect on different target species (Rizvi *et al*. 1999). Moreover, the allelochemicals, found to inhibit the growth of a species at a certain concentration may stimulate the growth of the same species or another at a lower concentration (Rice 1984; Putnam and Tang, 1986). Pannacci *et al.* (2013) studied the relative effect of aqueous extracts of sunflower on seed germination and growth of weed species *Sinapsis alba* and *Lolium multiflorum* against *Triticum aestivum*. The extracts were more toxic towards the weed species as compared to *Triticum aestivum*.

In our study, the percent germination of *E. crus galli* seeds declined in all treatments whereas it remained unaffected at lower concentration in *Z. mays* (Fig.1). The decline was about 20 % more at 2% and 22% more at 4% treatment for *E. crus-galli* as compared to *Z. mays*. A slight stimulation in root length of *Zea mays* at 0.5%, 1% and 2% concentrations and shoot length at lowest concentration and biomass at 0.5 and 1% concentration was observed (Fig.2). The phenomenon of stimulus known as hormesis can be exploited to increase the crop production and quality (Pannacci *et al* 2013). The root length declined continuously in *E. crus-galli* extracts. The inhibition of shoot length of *E. crus galli* was more at 4% treatment with a decline of about 32% against 20% decline in *Z. mays* (Fig. 3). Similarly, the decrease in the biomass was more in *E. crus-galli* in all concentrations as compared to *Z. mays* (Fig. 4).

This preliminary study suggests that the litter of *P. roxburghii* has the allelopathic potential and can be exploited for management of weed, *E. crus-galli*. The needle litter can be used as mulch in *Z. mays* fields as there are a number of reports of inhibitory effect of the plant mulch against weeds (Singh et al 2003; Batish *et al* 2007a). However, detailed field studies are needed as the allelochemicals, upon release, can undergo a variety of changes such as sorption, transformation, toxification and / or detoxification (Cheng, 1992; Blum *et al*. 1999) and their effect depends greatly upon a variety of biotic and abiotic factors, soil type, presence of microorganisms and soil conditions (Blum *et al.*, 1999).

Fig.1. Effect of aqueous extracts of *Pinus roxburghii* on the seed germination of *Zea mays* and *Echinochloa crus-galli*.

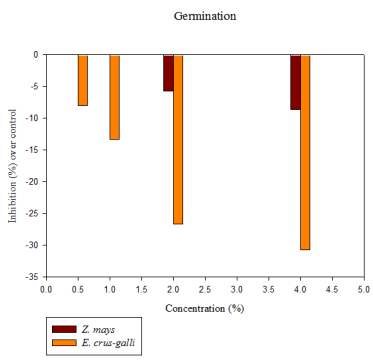

Fig.2. Effect of aqueous extracts of *Pinus roxburghii* on the root length of *Zea mays* and *Echinochloa crus-galli*.

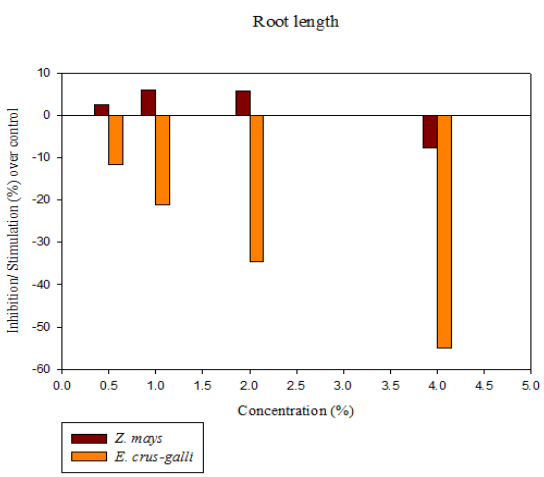

Fig.3. Effect of aqueous extracts of *Pinus roxburghii* on the

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shoot length of *Zea mays* and *Echinochloa crus-galli*.

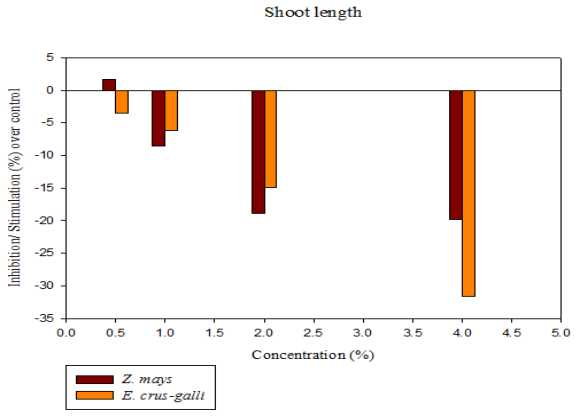
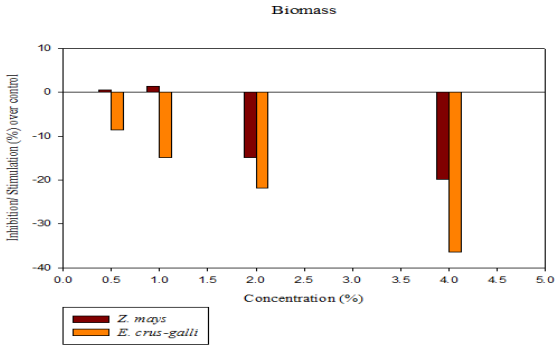


Fig.4. Effect of aqueous extracts of *Pinus roxburghii* on the biomass of *Zea mays* and *Echinochloa crus-galli*.



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