INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

ALLELOPATHIC EFFECTS OF INVASIVE WEED (*SOLANUM SISYMBRIIFOLIUM* LAMK.) ON GERMINATION AND SEEDLING GROWTH OF FOUR WIDELY CULTIVATED INDIAN CROPS

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ABSTRACT
Allelopathic potentiality of *Solanum sisymbrifolium* Lamk.; a widely growing invasive weed in India was evaluated on four widely cultivated crops, *Vigna radiata* L., *Amaranthus mangostanus* L., *Oryza sativa* L. cv. Pankaj *and Brassica campestris* L. *var. dichotoma* Wall. A significant effect on the rate of seed germination and seedling growth (Root and Shoot) was observed on all the tested crop plants. Our result showed that aqueous extract strongly inhibits the seed germination, root and shoot growth of *Vigna radiata* L., *Amaranthus mangostanus* L., *Brassica campestris* L. *var. dichotoma*. Whereas, *Oryza sativa* L. was less sensitive in comparing to other tested plant with both the extracts. The present study also showed that the leaf extract was more effective than the flower extract. The germination rate and the seedling growth were decreased over the control with the increase of concentration of the extracts solutions. At 2-4% concentration of the extracts inhibit 80-100% germination rate and root shoot growth of the tested crops, while rice showed the same result when concentration reaches at 8%. This kinds of concentrations dependent response of the tested plants suggested that the extracts of the *Solanum sisymbriifolium* might contain allelochemical(s). This result may be utilized for the conservation of indigenous biodiversity and management of agricultural crop.

KEY WORDS: Weeds management, invasive species, allelopathy.

INTRODUCTION
Invasive species create the worldwide negative impacts on biodiversity (McGeoch *et al*. 2010, Wilcove *et al.* 1998). Once an invader reaches to any new ecosystem they reside in large area and creating copious problems to local flora and fauna (Nikki and Scott 2010), resulted, significant economic losses (Pimentel *et al.* 2005). Therefore, due to their destructiveness on ecosystem it is necessity to concern about the invasive species and understanding their ecology (Mack *et al.* 2000, Huston 2004). Allelochemicals are water soluble secondary metabolites, that produced at a mature stage on the plants as a defense mechanism (Inderjit 1996) and inhibits the growth of the newly emerges propagules and young plants (Alam and Islam 2002). It may directly effects to the neighboring seedlings or by dispersing chemicals into the soil that may inhibits seedlings emergences, its growth and yielding capacity. But allelopathic effects may be species specific (McEwan *et al.* 2010) or conditions such as life stage (Barto *et al.* 2010) and nutrients (Cipollini *et al.* 2008). The spiny invasive weed *Solanum sisymbriifolium* L. is a native of Central America and introduced in all most all continents. In India it is invaded within so many state and altering the local vegetation and fettering local ecosystem functioning. It is found throughout the state in almost all ecosystems (Moumita and Datta 2013) and very common along roadside, in waste places and in the dry crop lands. The plant also has hazardous effects on grazing livestock. The phytochemical, antioxidant and anti-microbial activity also revealed from the plant (Gupta *et al.* 2014), but the compound responsible for the inhibition of the other's growth not yet determined. While, there was no evidence of allelochemical(s) and no comprehensive research on allelopathic effects of the species. Therefore the objective of the present study was to determine, for the first time, the allelopathic effects of aqueous leaf and flower extracts of the species *Solanum sisymbriifolium* on germination and seedling growth of four widely cultivated crops.

MATERIALS & METHOD
Collection and preparation of extract
Leaves and flowers of vigorously growing invasive spiny weed S*olanum sisymbriifolium* were collected from certain agricultural field of West Tripura District (Tripura, India) during February to June 2015. Leachates and flower extract were prepared by soaking 500 mg of shade dried powdered leaves and flower in 100 ml of sterile distilled water for 48 hours in a mechanical shaker. Filtrates were taken in a volumetric flask which served as 0.5% leachate. Likewise, 1%, 2%, 4% and 8% leachates were prepared separately for leaf and flower.

Bioassay and experimental design

Four important agricultural crops *Vigna radiata*, *Amaranthus mangostanus*, *Oryza sativa*, *Brassica campestris* were selected for the allelopathic bioassay. Healthy seeds of that species were surface sterilised with 0.5% sodium hypochlorite solution for 2 min and washed thoroughly with distilled water in such a way that the residue of sodium hypochlorite should not contaminate the inner cotyledons of the seeds. After that, sufficient numbers of autoclaved Petri dishes were prepared; each containing a single layered of (No.1 What man) filter paper. Each Petri dishes is wetted with 5 ml of test solutions of different concentrations of leaf and flower separately. The Petri dishes wetted with distilled water were taken as control and considered to be set 0. In each Petri dish, 75 number of surface sterilized seeds were placed separately for each tested species. A total of 5 replications of all the sets for both leaf and flower leachate were kept undisturbed at room temperature (28±2°C) in the laboratory for 5 days. The numbers of germinated seeds, length of radical and plumule of each set were recorded for both the extracts at 5th days. The emergence of a radical approximately 1 mm in length was taken into consideration as germination.

Statistical analysis

Percentage of inhibition of germination and radical/plumule growth were estimate by using Microsoft excel, 2007 and IC_{50} values were calculated by using linear regression calculator.

RESULTS

The aqueous leaf and flower extracts of invasive weed *Solaum sisymbriifolum* suppressed the germination and seedling growth of the four selected crop species at different concentrations tested in the laboratory. While the flower extract showed less allelopathic potentiality than the leaf extract in all the experimental species (Fig. 1).

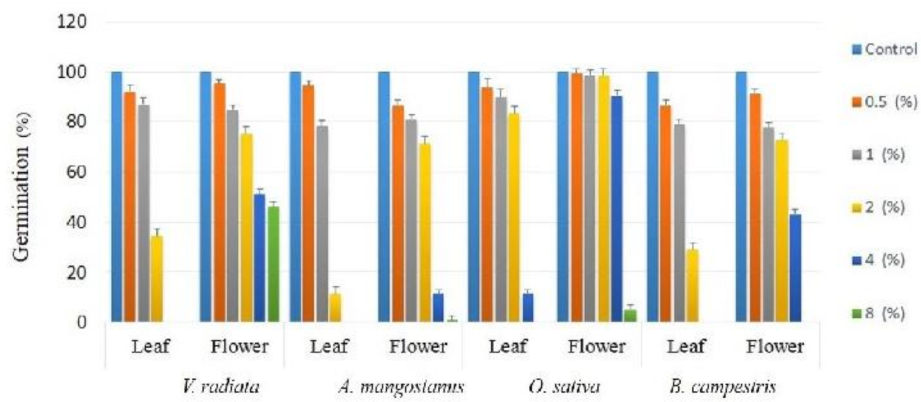

FIGURE 1: Effect of aqueous leaf and flower extracts of *Solanum sisymbriifolium* on seed germination of four common crops

TABLE 1: Inhibition (%) of seed germination of four common crops treated with aqueous leaf and flower extracts of *Solanum sisymbriifolium*

Conc. (%)	Inhibition (%)							
	Vigna radiata		*Amaranthus mangostanus*		*Oryza sativa*		*Brassica campestris*	
	LF	FL	LF	FL	LF	FL	LF	FL
Control	0	0	0	0	0	0	0	0
0.5	7.8	4.8	5.6	13.6	6.4	0.8	5.6	8.8
1	13.2	15.2	21.6	19.2	10.4	1.6	20.8	22.4
2	65.6	24.8	88.8	28.8	16.8	1.6	71.2	27.2
4	100	48.8	100	88.8	88.8	9.6	100	56.8
8	100	53.8	100	99	100	95	100	100
IC_{50}	2.75	6.25	2.51	3.1	3.38	5.34	2.51	3.91

LF, Leaf; FL, Flower

Our result showed 100% inhibition of germination for all the species at 2- 4% aqueous extracts of leaf except *Oryza sativa*, which showed same inhibitory result at 8% concentration. Even 8% aqueous extract of flower showed almost 100% inhibition potentiality to *Amaranthus mangostanus*, *Oryza sativa*, *and Brassica campestris* while this concentration (8% aqueous extract of flower) had little effect on germination of *Vigna radiata*. The concentration required for 50% inhibition (IC_{50}) was higher in flower extracts than the leaf extracts (Table 1) in all the species tested. Both the root and shoot growth of all the tested seedlings were strongly inhibited at all the concentration (Fig. 2, 3 Table 2, 3) assayed in the laboratory. Effect on root growth is more than the effect recorded in shoot growth. The 100% inhibition of root and shoot growth were observed at 4% aqueous leaf extract whereas, higher concentration (8%) of flower extract revealed the same results on the experimental species. The IC_{50} values were very low in the experimental sets treated with leaf extract than the aqueous extract of flower.

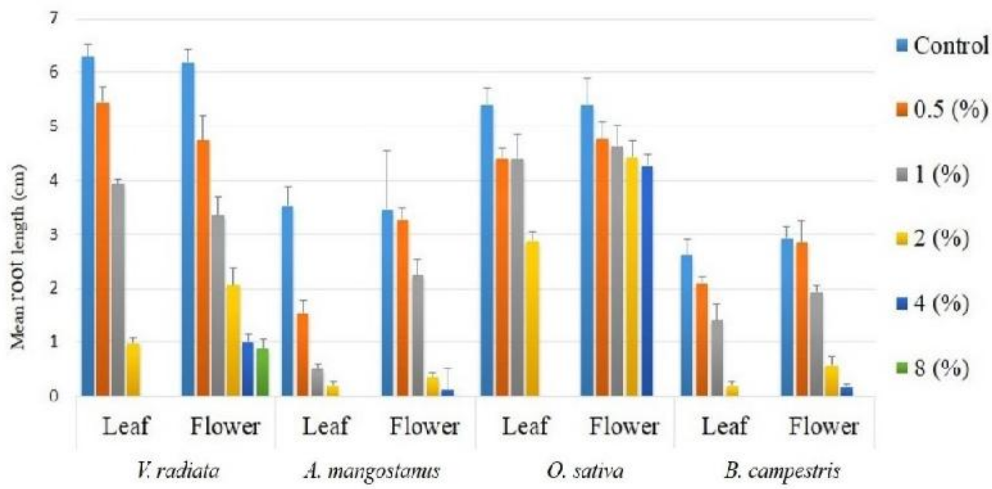

FIGURE 2: Effect of aqueous leaf and flower extracts of *Solanum sisymbriifolium* on root growth of four common crops

TABLE 2: Root growth inhibition (%) of four common crops treated with aqueous leaf and flower extracts of *Solanum sisymbriifolium*

Conc. (%)	Inhibition (%)							
	Vigna radiata		*Amaranthus mangostanus*		*Oryza sativa*		*Brassica campestris*	
	LF	FL	LF	FL	LF	FL	LF	FL
Control	0	0	0	0	0	0	0	0
0.5	13.65	23.30	56.25	5.20	18.14	11.85	19.84	2.73
1	37.46	42.63	85.79	35.26	18.14	14.07	45.80	33.56
2	84.44	66.66	94.31	90.17	46.66	17.77	92.36	80.13
4	100	83.81	100	96.53	100	21.11	100	93.83
8	100	85.76	100	100	100	100	100	100
IC_{50}	2.26	2.56	1.47	2.35	2.76	4.35	2.1	2.49

LF, Leaf; FL, Flower

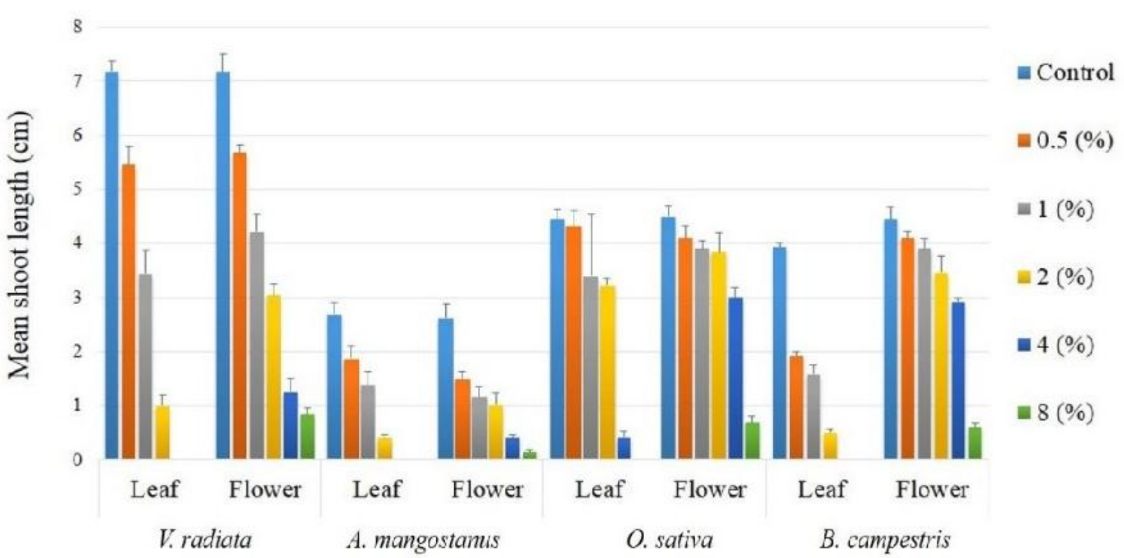

FIGURE 3: Effect of aqueous leaf and flower extracts of *Solanum sisymbriifolium* on shoot growth of four common crops.

TABLE 3: Inhibition (%) of shoot growth of four common crops treated with aqueous leaf and flower extracts of *Solanum sisymbriifolium*

Conc. (%)	Inhibition (%)							
	Vigna radiata		*Amaranthus mangostanus*		*Oryza sativa*		*Brassica campestris*	
	LF	FL	LF	FL	LF	FL	LF	FL
Control	0	0	0	0	0	0	0	0
0.5	23.95	20.67	30.59	42.74	2.70	8.88	51.02	7.65
1	52.08	41.06	48.50	55.72	23.42	13.33	59.69	12.16
2	86.07	57.54	85.07	61.06	27.47	14.66	87.24	22.07
4	100	82.40	100	84.73	90.54	33.33	100	34.23
8	100	88.26	100	94.65	100	84.88	100	86.48
IC_{50}	1.99	2.71	1.96	2.10	3.18	4.90	1.63	4.76

LF, Leaf; FL, Flower

DISCUSSION

The effect of leachate from leaves and flowers of invasive weed *Solanum sisymbriifolium* on the rate of germination, root and shoot growth were more or less similar in *V. radiata, A. mangostanus and B. campestris* while, *O. sativa* is less sensitive than that of remaining three crops when treated with both the extracts. The experimental result also revealed that the rate of inhibition of the root growth was greater followed by the shoot growth and seed germination on both leaf and flower extracts. The 100% inhibition of germination and root-shoot growth were observed when the concentration of the extract reaches at 4% or above in all the treated crops. Our observation are in the agreement with the previous works (Kato-noguchi 2001, Caussanel 1979, Chung and Miller 1995, Babu and Kandasamy 1997) that the activity of the weed residue is directly proportional to the concentrations used in the experiment. Such concentration dependent response of the test plants suggested that the extracts of the leaf and flower of *Solanum sisymbriifolium* may contains allelochemical (s).

CONCLUSION

It is evident from the present investigation that *Solanum sisymbriifolium* has high allelopathic potentiality on *Vigna radiata*, *Amaranthus mangostanus*, *Brassica campestris*, whereas it is less effective on *Oryza sativa*. The present research suggested that, although the experiment was done in the laboratory condition but further investigation in the field is essential. The species may have potent allelochemical(s) and the extracts of the plant inhibit the germination and growth of vegetable crops, which might reduce the economy of the commercial vegetables. Therefore, the management of this weed in agricultural field as well as in the local ecosystem for conservation of biodiversity is strongly require.

ACKNOWLEDGEMENT

Authors are acknowledging UGC, New Delhi for providing research support in the form of Start-Up Grant to corresponding author to carry out this work.

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