Bangladesh J. Bot. 46(1): 473-480, 2017 (March) Supplementary

INHIBITING EFFECTS OF SIAM WEED (*CHROMOLAENA ODORATA* (L.) KING & ROBINSON) ON SEED GERMINATION AND SEEDLING GROWTH OF FOUR CROPS

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Keywords: Allelopathic effect, Siam weed, Crop inhibition, Average per cent inhibition

Abstract

Siam weed (*Chromolaena odorata* (L.) King & Robinson) usually grows in plantations, agricultural fields, pasture lands, wastelands and roadsides, where it leaves a lot of plant residues that are used either directly to crop fields for composting or for compost preparation. Authors hypothesized that plant debris of siam weed in the field soil might be detrimental to seedling emergence of crop species. The aqueous extracts of siam weed was tested on seed germination and seedling growth of four field crops namely, rice (*Oryza sativa*), groundnut (*Arachis hypogea*), chickpea (*Cicer arientinum*) and mustard (*Brassica campestris*). The effects of various plant parts of the weed (leaf, stem and root) at different concentrations (2.5, 3.5 and 4.0%) of the extracts on seed germination, patterns of root and shoot growth, and dry matter accumulation of selected crops were determined in a laboratory bioassay. Results revealed that all crops were significantly reduced in their growth by the allelopathic effects of the weed, average percent inhibition (API) ranged from 13.36 to 24.72%. Groundnut and rice were the mostly affected crops with 24.7% inhibition. Among the plant parts, leaf was most inhibitory (API = 24.39%) and the least effect was noticed by stem extract (API = 17.20%). The inhibitory effects were concentration dependent. A 4.0% extract of siam weed leaf extract was enough to reduce the growth of the crops by about 42%. Therefore, the presence of siam weed in crop field or incorporation of leaves of siam weed in the fields must be avoided.

Introduction

Siam weed (*Chromolaena odorata* (L.) King & Robinson, Fam.: Asteraceae) is an invasive weed usually infesting nurseries, plantations, agricultural fields, pasturelands, wastelands and roadsides in humid tropics including Bangladesh and Malaysia (Karim 2010). It is reported as highly invasive weed in Bangladesh and is also found throughout the country especially in hilly areas (Ahmed *et al.* 2008), where the people practice slash-and-burn agriculture (Karim 2010). Agricultural losses due to siam weed can also be massive. In India, siam weed caused yield losses up to 45% in several crops probably due to competition and allelopathic effects (Ghosh *et al*. 2000, Ambika 2002). It is reported to reduce forage production by up to 80% (Hills and Ostermeyer 2000). Siam weed is a serious problem in perennial grasslands leading to reduced beef production by as much as AU$ 15 million annually in Australia (Burton 2001).

In the developing countries, the rural farmers usually collect the fallen leaves of siam weed and put them in the field soil for composting. In slash-and-burn agricultural system, this weed is also incorporated in the soil after burning the dried plants. But there are reports that the farmers face difficulty in crop establishment in the siam weed treated fields (Koutika and Kamga 2006). Recently, increased interest has been given to enhance the crop emergence under the slash-and-burn agriculture in many countries (Koutika *et al*. 2002). Thus studies evaluating the effects of

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siam weed extracts on seed germination and seedling growth of field crops might be be helpful in designing appropriate management strategies for sustainable agriculture. Insufficient information on the impacts of siam weed on the emergence and establishment of field crops in humid tropics especially in Bangladesh are available. Therefore, the study was undertaken to evaluate the effects of siam weed on seed germination, development of root length, shoot length and dry matter production of four field crops, and to identify the plant parts of the weed which may cause sufficient crop suppression.

Materials and Methods

The experiment was conducted at the Agronomy Seed Laboratory, Bangladesh Agricultural University (BAU), Mymensingh during January to April 2011. Seeds of four crop species, namely rice (cv. BRRI dhan29), mustard (cv. BINA Sarisha4), chickpea (cv. BINA Sola3), groundnut (cv. BINA Cheenabadam2) were collected from the Bangladesh Institute of Nuclear Agriculture (BINA) and Agronomy Field Laboratory of BAU. The initial germination of the collected seeds was found as 80 to 90%. Siam weed was collected from the botanical garden of BAU, Mymensingh. Five grams of fresh leaves of siam weed were cut into 2 - 3 cm long pieces and was placed in conical flasks with 100 ml distilled water to make 5% weed extract. The conical flask was agitated for 24 hrs on an orbital shaker (150 rpm, Firstek Scientific Model S102; Hsin Chuang, Taiwan, ROC). The extract was passed through four layers of cheesecloth and two layers of Whatman No. 2 filter paper to remove solid materials. The same procedure was followed to prepare extracts from root and stem of the weed. Three concentrations of aqueous extracts e.g. 4, 3.5, 2.5% along with a control (distilled water only) were prepared by diluting the original extracts properly. Twenty five seeds of rice and mustard, and ten seeds of chickpea and groundnut were placed in separate Petri dishes lined with 9 cm Whatman No. 2 filter paper. Seven milliliters of extract (or distilled water for control) was added to each filter paper. The covered Petri dishes were then incubated at 25^0C in a seed germinator. The number of seeds germinated, root length and shoot length were recorded after 10 days of seed placement. Reduction in germination percentage, shoot length, root length and dry matter accumulation in comparison to control were determined. After length measurement, all the crop seedlings were placed in paper bags and then in an electrical oven, and dried for three days at 80^0C for recording the seedling dry weights.

The overall effects on the growth of the crops was determined on the basis of average percent inhibition (API) as below:

API = [G (%)+RL (%)+SL (%)+DM(%)]/4 (Karim *et al.* 2014)

where, G = per cent reduction in seed germination, RL = per cent reduction in root length, SL = per cent reduction in shoot length, DM = per cent reduction in seedling dry weight.

The experiment was done in CRD with four replications. The collected data on different parameters of the crop were statistically analyzed and the mean differences were adjudged using DMRT (Gomez and Gomez 1984).

Results and Discussion

The effects of siam weed varied in different crop species. The highest loss in seed germination (23.3%) was observed in groundnut and the lowest loss (12.7%) was found in mustard. (Table 1). The highest reduction in root length was in groundnut (37.7%) followed by rice (27.2%) and the lowest reduction in root length was found in in mustard (10.3%) by the allelopathic effect of siam weed. However, the effect on shoot length had a differetn trend. The highest percent reduction in shoot length was in chickpea (37.55%) followed by rice (32.10%) and the least reduction was observed in mustard (16.86%). The effects on root length and shoot length have been reflected on the dry matter weight. The per cent reduction in dry weight was highest in rice (19.8%) similarly followed by groundnut (17.5%) and the least reduction was in mustard (13.6%) (Table 1).

Allelochemicals are secondary metabolites which inhibit the seed germination and seedling growth of the receptor species due to its toxic effects in the germination media. However, the allelopathic interactions between donor and receptor depends on the characteristics of the species. In this study the inhibiting effects of siam weed varied in different crop species. The per cent loss in seed germination was comparatively higher in groundnut and rice than the chickpea, which was due to differences in response to different crops. Seed germination of any species is usually influenced by the environment of the germinating media. Allelochemicals from siam weed extract might affected the crop seed germination due to the toxic effects of allelochemicals (Sahid and Sugau 1993). Germination and emergence of the crops, namely mungbean, chillies, common beans and aubergines were reduced to the greatest extent by leaf extracts of siam weed in Nigeria (Okwulehie and Amazu 2004). Prati and Bossdorf (2004) reported that the degree of allelopathic interference is species-specific and can even vary within species.

Table 1. **Effects of aqueous extract of siam weed (mean effect) on seed germination, root length, shoot length and seedling dry weights of four crops (Cont. = Control, Treat = Treatment).**

Crops	Seed germination (%)			Root length (cm)			Shoot length (cm)			Seedling dry weight (g)		
	Treat. seed	Cont.	% loss	Treat. seeds	Cont.	% loss	Treat. seeds	Cont.	% loss	Treat. seeds	Cont.	% loss
Rice	70.67	88	19.69b	6.91	9.50	27.23b	6.79	10	32.10b	0.073	0.091	19.78a
Groundnut	76.67	100	23.33a	7.18	10.5	31.72a	9.87	13.40	26.33c	2.146	2.601	17.49ab
Chickpea	73.33	90	18.52c	8.17	10.5	22.30c	5.93	9.50	37.55a	4.358	5.160	15.54c
Mustard	87.33	100	12.67d	8.61	9.60	10.30d	7.39	8.90	16.86d	0.019	0.022	13.60d

In a column, same letter(s) indicate that there are no significant difference at $p \leq 0.05$ by DMRT.

Table 2. **Effects of aqueous extract of different parts of siam weed on seed germination, root length, shoot length and seedling dry weights of four crops.**

Parts of siam weed/ control	Seed germination (%)		Root length (cm)		Shoot length (cm)		Seedling dry weight (g)	
	Treated seeds	% loss	Treated seeds	% loss	Treated seeds	% loss	Treated seeds	% loss
Control	94.5	-	10.035		10.45	-	1.969	-
Root	76.88	18.64b	7.716	23.10b	7.562	27.63b	1.601	18.68b
Stem	81.75	13.49c	8.078	19.50c	7.813	25.23c	1.761	10.56c
Leaf	72.38	23.40a	7.361	26.64a	7.119	31.87a	1.582	19.65a

In a column, same letter(s) indicate that there is no significant difference at $p \leq 0.05$ by DMRT.

Crop seed germination was affected significantly ($p < 0.01$) due to the effect of different plant parts of the weed. The highest reduction in seed germination (23.40%) was noted due to leaf extracts and the lowest reduction (13.49%) was due to stem extracts of the weed (Table 2). The root length and shoot length of the crops were affected significantly ($p < 0.01$) as well by the allelopathic effect of the weed plant parts. The maximum reduction in root length (26.64%) was noted due to application of leaf extracts and the lowest reduction (19.50%) was due to stem extracts of siam weed (Table 2).

Similar pattern of reduction was also noted in the case of shoot length and dry matter accummulation of crop seedlings (Table 2). Allelopathic potential of weed usually varies in different parts of the plant body. The higher reduction in seed germination was noticed due to leaf extracts than that of root or stem extracts. Sahid and Sugau (1993) observed higher reduction of seed germination of four crops e.g. chilli, chinese cabbage, rape and cucumber, due to allelopathic effects of leaf extracts of siam weed. In the laboratory bioassay and field experiments, incorporation of the plant parts of siam weed, especially the leaves had the most adverse impact and roots had the least effect on the seed germination and growth of the test crop. Gill *et al*. (2013) also found most growth inhibitory effect of leaf extract of *Chromolaena odorata* on cowpea (*Vigna uguiculata*).

A significant effect of interaction of crop species and weed plant parts on seed germination was observed in this study. The highest germination (90%) was found in the interaction effect of mustard and weed stem extract and the lowest germination (67%) was found in the interaction of rice and weed leaf extract (Table 3). The highest reduction in root length (35.05%) was noted due to interaction between groundnut and weed leaf extract and the lowest reduction (8.07%) was noted due to interaction between mustard and stem extract of the weed. But in case of shoot length of crops, the highest reduction occurred due to weed leaf extract in chickpea. Seedling dry weight of crops was reduced mostly in mustard due to the leaf extract of the weed.

Table 3. **Interaction effect of aqueous extract of different parts of siam weed on seed germination, root length, shoot length and seedling dry weights of four field crops.**

Parts of siam weed × crop spp.	Seed germination (%)		Root length (cm)		Shoot length (cm)		Seedling dry weight (g)	
	Treated seeds	Per cent loss	Treated seeds	Per cent loss	Treated seeds	Per cent loss	Treated seeds	Per cent loss
Rice × no extract	88.00		9.50		10.00		0.091	
Rice × root	68.00	22.72d	6.935	27.00e	6.907	30.93e	0.07258	19.78f
Rice × stem	77.00	12.5i	7.495	21.10h	7.372c	26.28g	0.07575	16.48h
Rice × leaf	67.00	23.86c	6.310	33.57b	6.090	39.10b	0.07025	23.08d
G. nut × no extract	100.00		10.52		13.40		2.601	
G. nut × root	77.50	22.50d	7.160	31.93c	9.963	25.64g	2.075	20.22f
G. nut × stem	82.50	17.50e	7.557	28.16d	10.10	24.62h	2.321	10.77i
G. nut × leaf	70.00	30.00a	6.832	35.05a	9.550	28.73f	2.042	21.49e
Chickpea × no extract	90.00		10.52		9.50		5.160	
Chickpea × root	75.00	16.66fh	8.137	22.65g	5.972	37.13c	4.240	17.85g
Chickpea × stem	77.50	13.88b	8.433	19.83i	6.190	34.84d	4.630	10.27i
Chickpea × leaf	67.50	25.00i	7.928	24.63f	5.633	40.70a	4.204	18.53g
Mustard × no extract	100.00		9.60		8.90		0.025	
Mustard × root	87.00	13.00j	8.632	10.08k	7.405	16.79j	0.01475	40.00b
Mustard × stem	90.00	10.00g	8.825	8.071	7.590	14.71k	0.01725	32.00c
Mustard × leaf	85.00	15.00	8.375	12.76j	7.202	19.07i	0.01400	44.00a

In a column, same letter(s) indicate do not differ significantly at $p \leq 0.05$ by DMRT..

The allelopathic effect of donor species depends on the concentration of the plant extracts. Germination percentage was the highest (95) when no weed extract (only water) was placed in Petri dish and it was linearly decreased with the increase of extract concentration. On an average, more than 34.21% of seed germination was reduced due to 4% concentration of the weed extract (Table 4).

The different concentrations of weed extracts significantly affected the root length, shoot length and dry weight of the crops. On an average, more than 43.76% root length and more than 49% shoot length were reduced due to highest (4%) concentration of the weed extract (Table 4). More or less similar effects of weed extract concentration was noted on the dry weights of crop seedlings (35.5% reduction). The different concentrations of weed extracts significantly affected the seed germination of the crops. Bora *et al.* (2007), Kalita *et al.* (1999) and Ameena and George (2002) noted more or less similar findings. Channappagoudar *et al.* (2005) and Upper *et al.* (2006) found that increasing the concentration of weed extracts increased the degree of inhibition for many plant species, although the lowest rates used had significant positive effects. Einhellig (1986) reported that the biological activity of allelochemicals is concentration dependent with a response threshold below which growth is stimulated in some instances.

Table 4. Effects of concentration of aqueous extract of siam weed (mean of different parts) on seed germination, root length, shoot length and seedling dry weights of four crops.

Concentration (%)	Seed germination (%)		Root length (cm)		Shoot length (cm)		Seedling dry weight (g)	
	Treated seeds	% loss	Treated seeds	% loss	Treated seeds	% loss	Treated seeds	% loss
0	94.50	-	10.03	-	10.45	-	1.97	-
2.5	79.33	16.05c	8.09	19.25c	7.66	26.67c	1.81	7.92c
3.5	72.00	23.80b	7.10	29.20b	6.55	37.31b	1.60	18.79b
4.0	62.17	34.21a	5.64	43.76a	5.33	49.00a	1.21	38.55a

In a column, same letter(s) indicate that there is no significant difference at $p \leq 0.05$ by DMRT.

The API values are the indicators of combined effects on all plant characters of receptor species. The allelopathic effects of weed extracts on the seed germination, root growth, shoot growth and biomass accumulation of the test crop species have been reflected on the API values of the crops. When API was calculated taking the average of all reductions caused in different plant characters of the crops it was observed that rice was mostly affected (API = 24.7) followed by groundnut (API = 24.72), chickpea (API = 23.48), and the lowest inhibition was marked in mustard (API = 13.36) due to allelopathic effect of siam weed (Fig. 1). Among the plant parts, leaf of the weed was most inhibitory to the crop seed germination and seedling growth (API = 24.39) followed by root (API = 22.01) and stem (API = 17.2) (Fig. 2). This indicated that the fallen leaves of siam weed must not incorporate with the soil of crop fields for composting.

Onwugbuta (2001) observed that aqueous extract of siam weed leaf at the concentration of 1 g per 40 ml of water caused significant growth reduction of tomato. Gill *et al*. (2013) also found growth inhibitory effect of the weed on cowpea. The inhibitory effects caused by allelochemicals from siam weed might be due to interfering with physiological processes in receptor plants, resulting in a reduction of plant growth and development (Von Renesse 1997).

Hossain (2012) remarked that when the plant debris of siam weed at the rate of 1 gm debris per 100 gm of soil was used in pot experiment, it reduced the seedling emergence of rice, mustard, groundnut and chickpea by 16.44, 54.93, 52.25 and 26.73%, respectively. It reduced the accumulation of plant dry matter by 43.64, 41.24, 41.03 and 45.04%, respectively as well. Sahid and Sagau (1993) observed that when the siam weed mulch was added to soil the dry matter accumulation by the chinese cabbage and chillies were reduced by more than 30.0%. Obviously, most of the laboratory studies with the same species are positively correlated to the results of greenhouse or field studies (Karim *et al*. 2012).

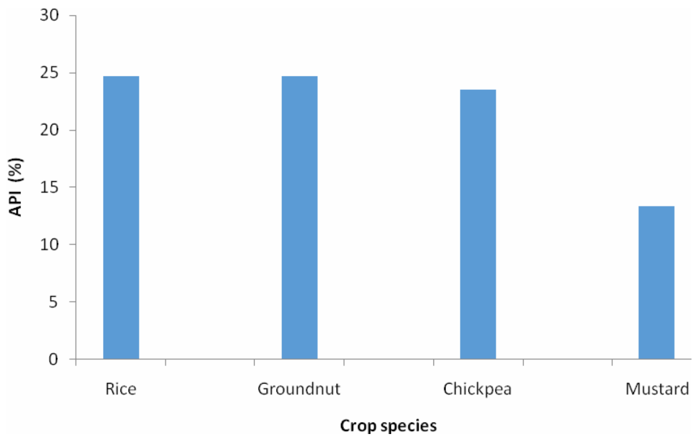

Fig. 1. Mean average per cent inhibition (API) in four crop species due to allelopathic effects of siam weed.

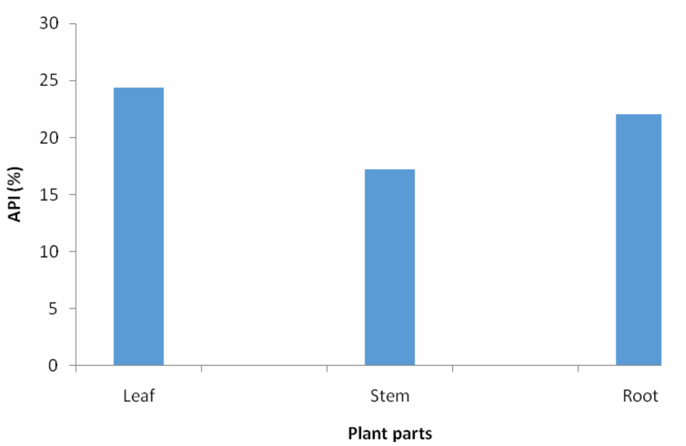

Fig. 2. Mean average per cent inhibition (API) due to leaf, stem and root extractsof siam weed in four crop species.

From the study, it can be concluded that the aqueous extract of siam weed has inhibitory allelopathic effects on the seed germination and seedling growth of rice, groundnut, mustard and chickpea. Among the field crops rice and groundnut growth was mostly affected followed by chickpea and mustard by the allelopathic effects of siam weed. Higher concentration exhibited greater inhibitory effect than lower concentration in aqueous extract and a 4.0% extract of siam weed leaf was enough to reduce the growth of the crops by about 41.3%. The toxic chemicals were probably released from the plant parts of the weed in the germinating media and eventually it affected the seed germination. Similar effects were also observed in the field conditions, which were recorded by other scientists. Therefore, the siam weed cannot be used for compost preparation. If the weed leaves are carried by wind to the crop fields from nearby infested area, care should be taken not to incorporate those in the soil during land preparation.

Acknowledgements

The authors thank the authorities of Bangladesh Agricultural University, Mymensingh, Bangladesh for providing the facilities for carrying out the research and to the Universiti Malaysia Kelantan, Malaysia for providing financial supports for publication of the paper.

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(Manuscript received on 8 December, 2016; revised on 6 March, 2017)