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RESEARCH ARTICLE

ALLELOPATHIC EFFECT OF SIAM WEED DEBRIS ON SEED GERMINATION AND SEEDLING GROWTH OF THREE TEST CROP SPECIES

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ABSTRACT

Allelopathy is important for agricultural practices as has gained attention in sustainable agriculture management. Therefore, an experiment was conducted to assess the allelopathic effect of siam weed (*Chromolaena odorata* L. King and Robinson) debris on the germination and seedling growth of rice, mustard and groundnut at four concentrations of weed debris (e.g., 0, 0.25, 0.5 and 1.0 g dry weight per 100 g soil). The weed debris at different concentrations reduced the seed germination, plant height, leaf numbers, leaf area and seedling dry weight of the test crop species. The inhibitory effects of the test crop were positively related to the concentration of siam weed debris in soil. On the basis of average percent inhibition (API), mustard (24.47%) was mostly affected by the siam weed debris followed by groundnut (20.10%) and rice (17.10%). From the results of the study, it is observed that weed debris of siam weed had inhibitory effect on the seed germination and seedling growth of rice, mustard and groundnut. Therefore, the allelopathic activity of the siam weed may play an important role in the management of sustainable agriculture.

KEYWORDS

Weed allelopathy, *Chromolaena odorata*, field crop, average percent inhibition, sustainable agriculture.

1. INTRODUCTION

Allelopathy is a mechanism mediated by the release of secondary metabolites "allelopathic compounds" from a donor plant into the surrounding environment (Rice, 1984). Allelopathic plants and/or allelopathic compounds has an influence on the growth and development of other plants in multiple mode of actions depending on bioactive compounds and the sensitivity of target plants and it is considered to be one ecological strategy of weed control. A number of plants, including crops, weeds and trees, have been reported to have allelopathic properties. It has been reported that some of the weed exerts chemical stress on some crops by their phytotoxic root exudates and other foliage leachates which are accumulated into the soil (Nakano et al., 2003). As a result the growth of other plants in the proximity is adversely affected. Most allelochemicals are released during germination and early growth stages. Considerable research work has been done on the allelopathic effect of weeds on natural plant communities viz, abandoned field or old fields (Dongre and Rajeev Mishra, 2007; Shetty et al., 2007). Therefore, many researchers have attempted to study the allelopathic phenomenon with the purpose to utilize such effects in designing appropriate management strategies for sustainable agriculture.

The weed species siam (*Chromolaena odorata* L. King and Robinson), belonging to the family Asteraceae, is a troublesome weed of arable fields, roadsides and plantation crops such as oil palm, coffee and cashew (Eze and Gill, 1992). It easily takes over plantations of cocoa, plantain, oil palm, rubber and other long season crops. Observations reveal that in areas where siam weed grows, growth of other plants is always hampered. Chemical investigations of *C. odorta* have shown that it contains phenolic, alkaloids and amino acid, which may retard the growth of crop plants (Ambika and Jayachandra, 1984). Tijani-Eniola and Fawusi reported allelopathic activities of crude methanol extract of siam weed on seed germination and seedling growth of tomato (Tijani-Eniola and Fawusi, 1989). In another experiment, Ambika (2002) observed that the leaves of siam weed contained a large amount of allelochemicals, which might retard the growth of crop plants. Hills and Ostermeyer have reported allelopathic activities of siam weed on seed germination and seedling growth of rice (Hills and Ostermeyer, 2000). Although information on the allelopathic effects of this weeds on some temperate crop plants is available, such information is lacking for some tropical crop plants. Moreover, the work has not yet been done on the effect of plant debris of Siam weed on the growth of rice, mustard and groundnut. Therefore, the present study was undertaken to evaluate the allelopathic effect of Siam weed debris on the seed germination and growth of rice, mustard and groundnut and to identify the appropriate concentration of Siam weed debris at which considerable growth inhibition occurs for seed germination and seedling growth of rice, mustard and groundnut.

2. MATERIALS AND METHODS

An experiment was conducted at the net house of the Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh to

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evaluate the allelopathic effect of Siam weed debris on seed germination, plant height, leaf numbers, leaf area and dry weight of rice, mustard and groundnut. Three test crop species viz., BRRI dhan29 (*Oryza sativa* L.), BINA Sarisha4 (*Brassica campestris* L.) and BINA Cheenabadam2 (*Arachis hypogaea* L.) were used in the study. The treatments included in the experiment were four concentrations of siam weed debris viz., 0%, 0.25%, 0.5% and 1% by dry weight. The experiment was laid out in a completely randomized design with four replications. Pot without Siam debris was considered as control. The selected crop species were collected from the Bangladesh Institute of Nuclear Agriculture (BINA) and Agronomy Field Laboratory of BAU, Mymensingh. The Siam weeds were collected from Botanical Garden, BAU campus, Mymensingh. After collection of Siam weed, fresh leaves and plants were air-dried for one week in the net house. The culm and leaves of the weeds were cut into small (4-6 cm) pieces and put into paper bags. The samples were dried further in an electric oven at 70 °C for 3 days. The oven-dried plant samples were then cut into smaller (0.5-1.0 cm) pieces and then mixed with field soil.

Four concentrations of weed debris (e.g. 0, 0.25, 0.5 and 1.0 g dry weight/100g soil) were included. After addition of adequate amount of water to weed debris with the soil it was kept for 7 days for decomposition (Karim and Forzwa, 2010). Twenty non-dormant seeds of each of the three field crops (i.e. rice, mustard and groundnut) were put in the soil of pots and were watered regularly (two times a day) with more or less equal amount of water. Data were collected on seed germination, plant height, leaf number, leaf area and leaf dry weight. Plant height of the test crops was measured after 30 days of seed placement. Leaf numbers of randomly selected ten plants of three crop species were counted. Leaf area was measured at 30 days after seed placement. Dry weight of randomly selected 10 seedlings was recorded after being placed in an electric oven for seven days at 70°C temperature. Percent reduction of plant height, leaf number, leaf area and leaf dry weight due to different concentrations of Siam weed debris was also estimated according to the equation described by Islam and Kato-Noguchi (2012) with slight modification as follow:

Reduction (%) = [1- (treatment / control)] × 100

The overall effects on the crops based on average percent inhibition (API) was determined according to the equation described by Karim et al. (2014) with slight modification as bellow:

API = [G (%) + PH (%) + LN (%) + LA (%) + DW (%)] / 5

Where, G = percent reduction in seed germination, PH = percent reduction in plant height, LN = percent reduction in leaf number, LA = percent reduction in leaf area, DW = percent reduction in dry weight.

The collected data on different parameters of the crops were statistically analyzed and the mean differences were adjudged using DMRT (Gomez and Gomez, 1984).

3. Results

3.1 Effect of Siam weed debris on seed germination and seedling growth of rice

Seed germination, plant height, leaf number, leaf area and dry weight of rice plant were significantly affected ($p < 0.01$) by different concentrations of Siam weed debris (Figure 1 and Table 1). The highest seed germination (91.25%), tallest plant (38.94 cm), highest number of leaves (5.60), highest leaf area (13.14 cm^2) and highest seedling dry weight (2.36 g/10 plants) were observed in control treatment whereas the lowest performance of these parameter was in 1% concentration of Siam weed debris. Two other concentrations of Siam weed debris showed intermediate results of these studied parameters (Table 1). At 1% concentration of Siam weed debris, the percent reduction of seed germination, plant height, number of leaves, leaf area and seedling dry weight over control was 16.44%, 34.26, 42.86, 39.12 and 43.64%, respectively (Figure 2 and Table 2). In addition, the API value of Siam weed on the growth of rice was 17.10% (Figure 3).

A B C

Figure 1: Comparison among control, 0.25%, 50%, and 1% concentrations of Siam weed debris on seedling growth of (A) rice, (B) mustard and (C) groundnut.

PTC0 = Control (no plant debris of Siam weed), PTC1 = 0.25% concentration of Siam weed debris, PTC2 = 0.50% concentration of Siam weed debris and PTC3 = 1% concentration of Siam weed debris.

Table 1: Effect of different concentrations of Siam weed debris on seed germination and seedling growth of rice, mustard and groundnut

Test crop Species	Concentration (%)	Germination %	Plant height (cm)	Leaf number	Leaf area (cm^2)	Dry weight (g/10 plants)
Rice	0	91.25a	38.94a	5.60a	13.14a	2.36a
	0.25	86.25ab	32.00b	5.00b	12.50b	1.98b
	0.50	81.25bc	28.80c	4.40c	9.89c	1.71c
	1.0	76.25d	25.60d	3.20d	8.00d	1.33d
	$S_{\bar{x}}$	0.123	0.712	0.123	0.167	0.063
	Level of significance	**	**	**	**	**
	CV%	4.66	3.94	4.66	2.66	5.95
Mustard	0	86.25a	53.70a	7.30a	50.88a	15.76a
	0.25	71.25b	46.60b	6.00b	45.87b	13.06b
	0.50	66.25bc	31.87c	4.70c	29.29c	11.33c
	1.0	63.75c	24.20d	2.80d	20.27d	9.26d
	$S_{\bar{x}}$	0.370	0.538	0.356	0.354	0.237
	Level of significance	**	**	**	**	**
	CV%	4.44	2.39	11.89	1.68	3.33
Groundnut	0	87.5a	32.00a	92.80a	9.37a	27.64a
	0.25	73.75b	28.00b	80.80b	8.53b	22.93b
	0.50	68.75b	22.20c	68.60c	6.94c	20.73c
	1.0	63.75b	15.28d	55.00d	5.19d	16.30d
	$S_{\bar{x}}$	0.578	0.723	1.25	0.211	0.404
	Level of significance	**	**	**	**	**
	CV%	6.83	5.14	2.94	4.88	3.20

In a column figures having common letter(s) do not differ significantly as per DMRT

**= Significant at 1% level of probability

3.2 Effect of Siam weed debris on seed germination and seedling growth of mustard

Different concentrations of Siam weed debris had significant inhibitory effect on seed germination, plant height, leaf number, leaf area and dry weight of mustard (Figure 1 and Table 1). The highest seed germination (86.25%), tallest plant (53.70 cm), highest number of leaves (7.30), highest leaf area (50.88 cm^2) and highest seedling dry weight (15.76 g/10 plants) were recorded in control treatment where no Siam weed debris was added in mustard crop. The lowest seed germination (63.75%), shortest plant (24.20 cm), lowest number of leaves (2.80), lowest leaf area (20.27 cm^2) and lowest seedling dry weight (9.26 g/10 plants) of mustard were recorded in 1% concentration (Table 1). At 1% concentration of Siam weed debris, the percent reduction of seed germination, plant height, number of leaves, leaf area and seedling dry weight of mustard over control was 26.09, 54.93, 61.64, 60.16 and 41.24%, respectively (Figure 2 and Table 2). In addition, the API value of Siam weed on the growth of mustard was 24.47% (Figure 3).

3.3 Effect of Siam weed debris on seed germination and seedling growth of groundnut

Seed germination, plant height, leaf number, leaf area and dry weight of groundnut plant were significantly affected by different concentrations of Siam weed debris (Figure 1 and Table 1). The highest seed germination (87.50%), tallest plant (32.00 cm), highest number of leaves (92.80), highest leaf area (9.37 cm^2) and highest seedling dry weight (27.64 g/10 plants) were observed in control treatment whereas the lowest performance of these parameter was observed in 1% concentration of Siam weed debris. Two other concentrations of Siam weed debris showed intermediate results of these studied parameters (Table 1). At 1% concentration of Siam weed debris, the percent reduction of seed germination, plant height, number of leaves, leaf area and seedling dry weight over control was 27.14, 52.25, 40.73, 44.61 and 41.03%, respectively (Figure 2 and Table 2). The API value of Siam weed on the growth of groundnut was 20.10% (Figure 3).

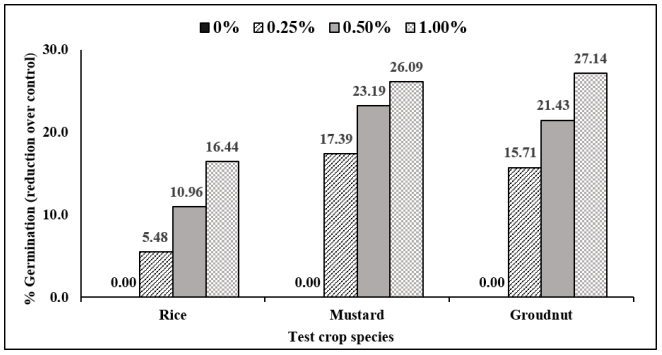

Figure 2: Effect of different concentrations of Siam weed debris on reduction over control of germination of test crop species

Table 2: Effect of different concentrations of Siam weed debris on reduction over control of growth of rice, mustard and groundnut

Test crop Species	Concentration (%)	Plant height (cm)	Leaf number	Leaf area (cm^2)	Dry weight (g/10 plants)
Rice	**0**	0	0	0	0
	0.25	17.82	10.71	4.87	16.10
	0.50	26.04	21.43	24.73	27.54
	1.0	34.26	42.86	39.12	43.64
	Mean	19.53	18.75	17.18	21.82
Mustard	**0**	0	0	0	0
	0.25	13.22	17.81	9.85	17.13
	0.50	40.65	35.62	42.43	28.11
	1.0	54.93	61.64	60.16	41.24
	Mean	27.20	28.77	28.11	21.62
Groundnut	**0**	0	0	0	0
	0.25	12.50	12.93	8.96	17.04
	0.50	30.63	26.08	25.93	25.00
	1.0	52.25	40.73	44.61	41.03
	Mean	23.84	19.94	19.88	20.77

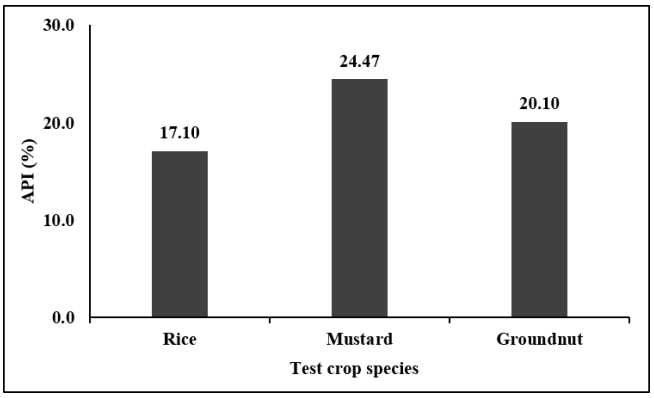

Figure 3: Mean average percent inhibition (API) of siam weed debris on the growth of rice, mustard and groundnut

4. Discussion

The weed debris of Siam had inhibitory effects on the seed germination and seedling growth of rice, mustard and groundnut (Figure 1 and Table 1). The inhibitory activity was proportional to the concentrations of plant debris and higher concentration had stronger inhibitory effect. This type of concentration-dependent inhibitory activity of the Siam weed has been reported (Karikari et al., 2000; Oudhia and Tripathi, 2000; Karim and Forzwa, 2010). In addition, higher concentration (1%) exhibited greater inhibitory effect than lower concentration of weed debris. The seed germination and seedling growth inhibition of the test plants by the Siam weed debris may be due to the inhibitory substances. A number of plants have inhibitory effect on the growth of neighboring plants by releasing phytotoxic chemical into the soil due to decomposition of plant residues (Putnam and Tang, 1986; Chou and Leu, 1972; Li and Wang, 1998; Chaves et al., 2001). The inhibitory effect might be occurred through a variety of mechanisms like reduced mitotic activity in roots and shoots, reduced rate of ion uptake, inhibition of photosynthesis, respiration and enzyme action (Rice, 1974). Moreover, based on the API values of the tested plants, the results of this study showed a variation in sensitivity of the test plant species to the siam weed. These results indicate that different allelochemicals have species-specific inhibition against test plant species (Mushtaq et al., 2018).

5. Conclusion

The siam weed debris exhibited inhibitory effects on the seed germination and seedling growth of three test crop species (rice, mustard and groundnut). These results indicate that this weed possesses strong allelopathic potential and may contain allelochemicals. Therefore, it is important not to leave any plant debris of siam weed in the crop fields, which might affect the seedling emergence and seedling growth of field crops after being incorporated with the soil. However, further isolation and identification is necessary to confirm which allelopathic substances are responsible for the inhibitory activity of siam weed against test crop species.

Conflict of Interest

The authors declare there are no conflicts of interest.

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