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Allelopathic effects of parthenium weed debris in soil on the emergence and development of rice

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Abstract: An investigation was made to assess the allelopathic effects of parthenium weed debris (*Parthenium hysterophorus* L.) on the emergence and seedling development of rice. Parthenium fresh leaves and plants were air-dried for one week in the greenhouse. The cut samples (4-6 cm) were further dried in an electric oven at 70 °C for 3 days. The oven-dried plant samples were then cut into smaller pieces (0.5-1 cm) and mixed with field soil. Four concentrations of weed debris (e.g. 0, 0. 25, 0.5 and 1.0 g dry weight per 100g soil) were included. Twenty five non-dormant seeds of rice were put on the soil surface of pots. The pots were watered regularly with equal amount of water. The number of emerged seedlings was counted daily up to 12 days of seed placement. Plant height, leaf numbers and leaf area of rice were measured after 30 days of seed placement. The dry weight of randomly selected 10 seedlings was recorded after being dried at 72°C in an electric oven for seven days. The weed debris at different concentrations of Parthenium reduced the seed emergence, plant height, leaf numbers, leaf area and seedling dry weight of rice. Seedling emergence, plant height, leaf number, leaf area, and dry weight were reduced by 25.40%, 20.98%, 20.02%, 33.85% and 22.78% respectively. Among all the parameters were considered, leaf area was most affected than other parameters. The inhibitory effects on rice were positively related to the concentration of parthenium weed debris in soil.

Key words: Allelopathy, parthenium weed, rice.

Introduction

The term allelopathy denotes the toxic effect of chemicals which are produced by one plant to another. Rice (1974) defines allelopathy as any direct or indirect harmful effect by one plant to another through the production of chemical compounds that escape into the environment. Some of the weed exerts chemical stress on some crops by their phytotoxic root exudates and other plant leachates which are accumulated into the soil. As a result the growths of other plants in the proximity are adversely affected (Lall and Savongdy, 1981). Most allelochemicals are released during germination and early growth stages (Dekker and Meggilt, 1983). Allelopathic potential may also vary in different parts of an individual weed species (Bansal and Singh, 1986). Allelopathic substances are commonly found in plant extracts and in plant residues in soil, in live plant exudates and as volatile gases liberated from leaves and rhizome (Keeley, 1987). It has been known that plants can be influenced by each other, in the mechanism of allelopathy. Boonitee and Ritdhit (1984) stated that usually the effects are harmful, but there are occasional reports of beneficial effect (Newman and Andrews, 1973). The inclusion of parthenium as green manure and their compost increased the availability of micronutrients (Fe, Mn, Zn and Cu) under submerge condition (Murthy *et al.*, 2007).

Parthenium (*Parthenium hysterophorus* L.) is a newly introduced highly invasive weed in Bangladesh. It is a herbaceous annual and member of the Asteraceae family which is capable of flowering within 4 to 5 weeks of germination (Navie and McFadyen, 1996). A preliminary survey was made in Jessore, Dhaka, Faridpur, Magura and Patuakhali districts, and it was noticed that a vast area of land especially in roadsides are heavily infested by this weed. Some plants were also available in the Sher-E-Bangla Agricultural University campus, Dhaka. Recently parthenium weed has also found in Bhaluka upazila, Mymensingh, Natore and Rajshahi district (Karim, 2009).

A number of weeds grow in rice field. Parthenium weed is one of them, which compete with crop and reduce the crop yield (Karim and Forzwa, 2010). In India, parthenium weed had been found in upland rice. The invasive weed *Parthenium hysterophorus L.* spread to almost every part of India (Kohli and Rani, 1994). In Bangladesh, although the weed has not been observed in crop field yet, but it was found to grow in the leevy of rice fields and winter crops in Faridpur (Karim, 2009). When the weeds show allelopathic effect, the qualitative and quantitative damage may be severe on the basis of allelochemicals present in the species. If the allelopathic effects of specific weed species on specific crops are known, weed management becomes economically more effective for the crop grower. By knowing the potential of allelopathy in specific weed, we can remove those species from the crop field before they contribute allelopathy to crop suppression. All these information emphasize the study on allelopathy of different weed species on rice production including parthenium.

Materials and Methods

An experiment was conducted at the Agronomy net house, Bangladesh Agricultural University, Mymensingh during of September to December 2009 to evaluate the allelopathic effect of Parthenium weed debris on seed emergence, plant height, leaf numbers, leaf area and dry weight of rice (BR 24). The experiment was laid out in completely randomized design with three replications. Pot without parthenium debris was considered as control. There were 4 concentration of Parthenium weed debris (0%, 0.25%, 0.5%, 1%). Rice seeds were collected from the BINA, Mymensingh. The Parthenium weeds were collected from Jessore. After collection of parthenium weed, fresh leaves and plants were air-dried for one week in the greenhouse. 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 per 100g soil) were included. After mixing weed debris with the soil it was kept for 7 days for decomposition. Twenty five non-dormant seeds of Rice were put in the soil of each of the pots and were watered regularly (two times a day) with more or less equal

amount of water to maintain a moisture content at 80% field capacity.

Data was collected on the selected parameters (seed germination, plant height, leaf number, leaf area and dry weight). The seeds of 2 mm plumule above the soil surface were considered as a germinated seed. Plant height of the test crops was measured after 30 days of seed placement. The leaf numbers of randomly selected ten plants was counted. The leaf area was also measured at the same time. The 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 in all the parameters due to different concentration of parthenium weed debris in comparison to control was also estimated. The collected data on different parameters of the crops were statistically analyzed using MSTAT-C and the mean differences were adjudged using DMRT (Gomez and Gomez, 1984).

Results and Discussion

Seedling emergence: Rice seed emergence was affected significantly ($p < 0.01$) by the different concentrations of Parthenium weed debris. The highest seedling emergence was observed in control (20.33) and the lowest emergence was found under 1% concentration (10.33) (Table 1 and Fig. 1 to 2). The percent reduction in seed emergence over control was 14.76%, 37.68% and 49.14% at 0.25, 0.5 and 1% concentration, respectively (Table 1).

Fig.1. Seedling emergence of rice under different concentrations of parthenium debris (Photograph taken at 12 days after seed placement).

The germination of rice seed was least at 1% concentration due to higher allelopathic effect of *Parthenium hysterophorus*. Therefore, the concentration of parthenium weed debris had strong inhibitory effect on seed germination of rice. Oudhia and Tripathi (2000) also found inhibitory effects of parthenium weed on seed germination of rice.

Plant height: Rice plant height was affected significantly ($p < 0.01$) by the different concentrations of Parthenium weed debris. The highest plant height was observed in control (28.22 cm) and the lowest plant height was found in 1% concentration (18.37 cm) (Table 1, and plates 3 to 4). There was no significant difference among the

Fig. 2. Comparison between control and 1% concentration

Fig. 3. Seedling growth of rice under different concentrations of partheniun debris (Photograph taken after 30 days of seed placement.

Fig. 4. Comparison between control and 1% concentration

concentration of 0.25%, 0.5% and 1% in producing plant height of rice (Table 1). The percent reduction in plant height over control was 22.68%, 24.06% and 34.90% at 0.25, 0.5 and 1% concentration respectively (Table 1). The plant height of rice was less at 1% concentration due to higher allelopathic effect of *Parthenium hysterophorus*. Therefore, the concentration of parthenium weed debris had strong inhibitory effect on plant height of rice. Karim and Forzwa (2010) also noticed similar inhibition in plant

height of field crops, rice, wheat chickpea and mustard due to allelopathic effects of parthenium weed in laboratory bioassay at Bangladesh Agricultural University, Mymensingh.

Table 1. Effect of concentrations of parthenium weed debris on seed germination and plant height of rice

Concentration (%)	Germination (number)	% Reduction over control	Plant height (cm)	% Reduction over control
0	20.33a	-	28.22a	-
0.25	17.33b	14.76	21.82b	22.68
0.5	12.67c	37.68	21.43b	24.06
1.0	10.33d	49.19	18.37b	34.90
S x ¯	0.332		1.067	
Level of significance	**		**	
CV (%)	3.81		8.23	

**= Significant at 1% level of probability

Table 2. Effect of concentrations of parthenium weed debris on leaf number, leaf area and dry weight of rice

Concentration (%)	Leaf number/ plant	%Reduction over control	Leaf area (cm^2)	% Reduction over control	Dry weight/4 plants (g)	% Reduction over control
0	4.00a	-	3.42a	-	0.45a	-
0.25	3.42b	14.58	2.55b	25.35	0.40b	11.11
0.5	3.17bc	20.83	2.09c	38.89	0.28c	37.78
1.0	2.83c	29.18	0.98d	71.26	0.26c	42.22
Level of sig.	**		**		**	
CV (%)	7.35		0.65		3.22	

**= Significant at 1% level of probability

Leaf numbers: Rice leaf numbers was affected significantly ($p < 0.01$) by the different concentrations of Parthenium weed debris. The highest leaf numbers was observed in control (4.00) and the lowest leaf numbers was found in 1% concentration (2.83). There was no significant difference between the concentration of 0.25% and 0.5% and the concentration of 0.5% and 1% (Table 2). The percent reduction in leaf numbers over control was 14.58%, 20.83% and 29.18% at 0.25, 0.5 and 1% concentration respectively (Table 2). From Table 2 it was observed that the leaf numbers was comparatively higher at control (0% concentration) due to no allelopathic effect and it was less at 1% concentration due to higher allelopathic effect of *Parthenium hysterophorus*. Therefore, the concentration of parthenium weed debris had strong inhibitory effect on leaf numbers of rice. Since the toxic effects of 'parthenin' of parthenium weed affected the physiology of rice plants, the number of leaves was affected accordingly.

Leaf area: Rice leaf area was also affected significantly ($p < 0.01$) by different concentrations of Parthenium weed debris. The highest leaf area was observed in control (3.42) and the lowest leaf area was found in 1% concentration (0.98). The percent reduction in leaf area over control was 25.35%, 38.89% and 71.26% at 0.25, 0.5 and 1% concentration respectively (Table 2). The leaf area of rice was less at 1% concentration might be due to higher allelopathic effect of *Parthenium hysterophorus*. Therefore, parthenium weed debris had strong inhibitory effect on leaf area of rice. Probably the toxic influence of parthenium weed in the leaf physiology of rice hindered the leaf area development of the crop.

Seedling dry weight: Seedling dry weight of rice was affected significantly ($p < 0.01$) by the different concentration of Parthenium weed debris. The highest seedling dry weight was observed in control (0.45g/4 plants) and the lowest seedling dry weight was found in 1% concentration (0.26g/4 plants). There was no significance difference between the concentration of 0.5% and 1% (Table 2). The percent reduction in seedling dry weight over control was 11.11%, 37.78% and 42.22% at 0.25, 0.5 and 1% concentration respectively (Table 2). The seedling dry weight of rice was less at 1% concentration due to higher allelopathic effect of *Parthenium hysterophorus*. Since the allelopathic effects of parthenium reduced the plant height, leaf number and leaf area, finally it rendered significant reduction of seedling dry weight. Therefore, the concentration of parthenium weed debris in soil had strong inhibitory effect on seedling dry weight of rice. A number of authors reported that biomass accumulation of rice and other field crops are reduced due to allelopathic effects of parthenium weed. A notable examples are Dongre and Yadav (2005), Dongare and Yadav (2007), Satsangi *et al.* (2002), Singh *et al.* (2005).

The weed debris of different concentrations of Parthenium reduced the seed germination, plant height, leaf numbers; leaf area and seedling dry weight of rice. The percent reduction in rice parameters were estimated against control. Among the plant parameters, leaf area (33.88%) was mostly affected by the different concentrations of parthenium weed debris. Inhibitory effects of Parthenium weed debris were progressively increased with the increase in debris concentration. Therefore, we should be

careful about incorporation of parthenium weed debris in the soil of rice fields.

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