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Full Length Research Paper

Allelopathic potential of selected rice varieties

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Two experiments, one in the laboratory and the other in the greenhouse, were carried out at the Bangladesh Agricultural University, Mymensingh, to evaluate the allelopathic potential of nine rice (*Oryza sativa* L.) varieties/lines (BR-5331-93-2-8-4, BR-5620-9-1-2, BRRI Dhan27, BR-5615-3-1-2, Lalparija, BR11, BR21, BR23 and BR25). Under laboratory condition, relay seedling technique was followed using lettuce (*Lactuca sativa* L.) as indicator plant. Average percent inhibition (API) in lettuce due to allelopathic effect of different rice varieties/lines was estimated. Under greenhouse conditions, double-pot technique was followed using barnyard grass (*Echinochloa crusgalli* L.) as indicator plant. The changes in barnyard grass plant charcters due to allelopathic effect of rice varieties/lines in comparison with the control were determined. Correlation between API values of the two experiments was studied. The API values of rice varieties/lines ranged for 22 to 40% under laboratory conditions and 30 to 35% under greenhouse condition. The ranking of rice varieties on the basis of API values under laboratory conditions was as follows: BR23 (40.51%) > BR21 (39.48%) > BR25 (39.42%) > BR11 (34.76%) > BR-5331-93-2-8-4 (34.50%) > BR-5620-9-1-2 (34.05%) > Lalparija (33.92%) > BR-5615-9-1-2 (28.87%) > BRRI dhan27 (22.76%). Under greenhouse condition, the highest API value was noticed in BR 25 (35.13%), followed by BR-5615-9-1-2 (34.50%) and the lowest API was found in BR-5331-93-2-8-4 (30.57%). The API values of rice varieties/lines under laboratory condition were positively related to the API values under greenhouse condition.

Key words: Rice cultivars, allelopathy, average percent inhibition, relay seeding technique, double-pot technique.

INTRODUCTION

Allelopathy is any direct or indirect harmful or beneficial effect of one plant on another through the production of chemical compounds that escape into the environment (Rice, 1984). Allelopathy can be used in weed management either by selecting an allelopathic crop variety or by incorporating an allelopathic character into a desired crop variety or by applying residues and straw as mulch (Rice, 1995; He et al., 2012). The potential of allelopathy may vary in different varieties of an individual rice species (Bansal and Singh, 1986; Rajangam, 1997; Oudhia and Tripathi, 1999; Jadhav et al., 2011).

Therefore, the effects of different rice varieties on seed germination and growth of weeds are important to be acquainted with. A number of weeds grow in rice field, which compete with crop and reduce the crop yield (Ampong-Nyarko and de Datta, 1991). Generally, the weeds hamper the growth and development of crops due to competition for nutrient and light but when the rice plant show allelopathic effect the qualitative and quantitative damage of crop may be less. If the allelopathic effect of specific rice varieties on specific weeds can be known, weed management becomes economically more effective for the crop grower (Azania et al. 2003).

The present study was, therefore, undertaken to examine the influence of allelopathic rice varieties on seed germination and growth of lettuce and barnyard grass, and thereby evaluate the allelopathic potential of selected nine rice varieties/lines.

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Abbreviation: API, Average percent inhibition.

MATERIALS AND METHODS

Two experiments, one in the laboratory and the other in the greenhouse were conducted at the Department of Agronomy, Bangladesh Agricultural University, Mymensingh, during the period of August, 2010 to November, 2010 to evaluate the allelopathic potential of nine rice varieties/lines against the growth and development of lettuce (*Lactuca sativa* L.) and barnyard grass (*Echinochloa crusgalli* L.). The nine rice varieties/lines used in the experiment were BR-5331-93-2-8-4, BR-5620-9-1-2, BRRI Dhan27, BR-5615-3-1-2, Lalparija, BR11, BR21, BR23 and BR25. These rice varieties/lines were screened out as allelopathic rice in previous study under simple laboratory conditions (Islam, 2010). The experiment was laid out in completely randomized design. Relay seeding technique was followed in the laboratory experiment. Twenty non-dormant rice seeds of each variety were placed in Petri-dishes lined with 9 cm Whatman no. 1 filter paper. Seven milliliter of distilled water was added to each Petri-dish. Petri-dishes were then put in the Seed Laboratory for germination at 27°C temperature and 12 h light period. Seven days after seed placement, while the rice seeds were germinated, twenty lettuce seeds were placed adjacent to the rice seedlings in the same Petri-dishes. The theme of the trial was that the germinating rice seedlings will release allelochemicals in the Petri-dish environment and that will affect the germination and growth of lettuce seed and seedlings. The experiment was continued for another 10 days after which data were recorded (Navarez and Olofsdotter, 1996). Number of seed germinated, shoot length, root length and dry matter weight of lettuce were recorded. Average percent inhibition (API) was calculated taking the average of percent reduction in seed germination, shoot length, root length and dry matter weight of lettuce seedlings.

Double-pot technique was followed in the greenhouse study. There were two types of pots, one is small and another is big. Each of the small pots (25 cm diameter × 20 cm depth) had a pore at the bottom but the bigger pot had no pore. After filling up the pots with field soil, smaller pots were placed at the top of the bigger pots. The top pots were provided with the rice plants at the rate of three plants per pot. Weed seedlings were raised on the surface of bigger pot around the base of smaller pots. The theme of the trial was that the allelochemicals from the rice plants will drain out through the pore of the smaller pots which will be deposited in the bigger pots. The indicator weeds raised on the bigger pots will be affected due to the effects of allelochemicals released from the rice plants (Mridha, 2007). Regular watering was done to ensure normal growth of rice and weed plants. Plant heights, number of tillers/plant, leaf area/plant and dry weight/plant were recorded after 40 days of seed sowing. The API was calculated using the average of percent reduction in plant height, number of tillers, leaf area and dry weight according to Kabir et al. (2010). The collected data on different parameters of the indicator plant were statistically analyzed and the mean differences were adjusted using Duncan's new multiple range test (Gomez and Gomez, 1984).

RESULTS

Among the nine rice varieties, the highest reduction in seed germination of lettuce was found with BR 5615-9-1-2 (40%) followed by BR23 (30%) and the least reduction was marked with Lalparija (5%). The highest shoot length reduction (37.18%) in lettuce occurred with BR-5331-93-2-8-4 and the least shoot length reduction (11.72%) was seen with BRRI dhan27. The ranking of the nine varieties on the basis of shoot length reduction was BR-5331-93-2-8-4 (37.18%) > BR25 (34.47%) > BR21 (34.16%) > BR23 (31.07%) > BR11 (27.35%) > BR-5620-9-1-2 (21.50%) > Lalparija (20.80%) > BR-5615-9-1-2 (13.33%) > BRRI dhan27 (11.72%) (Table 1). The highest root length reduction (38.81%) of lettuce was with BR-5615-9-1-2 and the least root length reduction was with BRRI dhan27 (19.89% reduction). The ranking of the nine varieties on the basis of root length reduction was BR-5615-9-1-2 (38.81%) > Lalparija (36.83%) > BR-5620-9-1-2 (30.30%) > BR-5331-93-2-8-4 (30.26%) > BR25 (26.45%) > BR 11 (23.95%) > BR23 (19.23%) > BR21 (21.02%) (Table 1). The effects on shoot and root length of lettuce have been reflected in the reduction of dry matter accumulation by the lettuce plants. The highest dry weight reduction in lettuce was noticed with rice variety BR11 and BR23 (77.78%) and the lowest dry weight reduction was found with Lalparija and BR-5615-9-1-2 (33.33%) varieties. The ranking of the nine varieties on the basis of dry weight reduction was BR11 (77.78%) > BR23 (77.78%) > BR25 (77.77%) > BR21 (77.76%) > BR-5331-93-2-8-4 and BR-5620-9-1-2 (55.56%) > BR27 (44.45%) > Lalparija and BR-5615-9-1-2 (33.33%) (Table 1).

When the effects of rice varieties on germination, shoot length, root length, dry matter accumulation of lettuce were combined in calculating API, it was observed that more than 40% API occurred with rice variety BR23. The lowest API was noticed in BRRI dhan27 (22.8%). The ranking of the varieties on the basis of API values was as follows: BR23 (40.51%) > BR21 (39.48%) > BR25 (39.42%) > BR11 (3476%) > BR-5331-93-2-8-4 (34.50%) > BR-5620-9-1-2 (34.05%) > Lalparija (33.92%) > BR-5615-9-1-2 (28.87%) > BRRI dhan27 (22.76%) (Table 1).

From the greenhouse study, it was noticed that the height of barnyard grass was significantly affected ($P<0.01$) by the allelopathic effect of rice varieties. The average height of barnyard grass was shorter in mix-culture with rice than that in monoculture. On an average, 34.12% barnyard grass height was reduced due to allelopathic effect of rice varieties. The maximum reduction (34.99%) in barnyard grass height was seen with the rice variety BR23, which was identically followed by BR21 (34.98%), Lalparija (34.96%) varieties and comparatively less reduction occurred with the rice variety BRRI dhan27 (29.79%) (Table 2). The leaf area of barnyard grass was also significantly reduced due to allelopathic effect of rice. The allelopathic effect of rice made 33.82% reduction of leaf area of barnyard grass. The highest reduction was with the rice variety BR-5615-9-1-2 (38.73%) and the lowest reduction was with the BRRI dhan27 (30.42%) variety (Table 2). The number of tillers per plant of barnyard grass was significantly reduced due to allelopathic effect of rice varieties. The highest reduction in the number of tillers was observed with the rice variety BRRI dhan27 (35.49%) and the minimum (20.75%) was with Lalparija variety (Table 2).

The reduction in number of tillers of barnyard grass by other rice varieties was as follows: BR-5331-93-2-8-4

Table 1. Allelopathic effects of rice varieties on growth parameters of lettuce.

Rice variety	No. of seeds that germinated	Reduction (%)	Shoot length (cm)	Reduction (%)	Root length (cm)	Reduction (%)	Dry weight (mg)	Reduction (%)	API
BR- 5331-93-2-8-4	17^{cd}	15	2.69^{bc}	37.18	3.05^{d}	30.26	20^{b}	55.56	34.50
BR- 5620-9-1-2	15^{b}	25	2.33^{d}	21.5	2.95^{bc}	30.31	30^{c}	55.56	34.05
BRRI dhan27	17^{b}	15	3.79^{e}	11.72	3.51^{d}	19.89	25^{b}	44.45	22.76
BR- 5615-9-1-2	12^{f}	40	4.15^{f}	13.33	2.68^{bc}	38.81	30^{c}	33.33	28.87
Lalparija	19^{a}	5	3.40^{e}	20.8	2.77^{bc}	36.83	30^{c}	33.33	33.92
BR 11	18^{cd}	10	2.35^{d}	27.35	2.10^{b}	23.95	10^{a}	77.78	34.76
BR 21	15^{b}	25	2.13^{c}	34.16	2.18^{b}	21.02	10^{a}	77.76	39.48
BR 23	14^{b}	30	2.23^{c}	31.07	2.12^{b}	23.19	10^{a}	77.78	40.51
BR 25	18^{cd}	10	2.12^{b}	34.47	2.03^{b}	26.45	10^{a}	77.77	39.42
CV(%)	4.231	--	5.025	--	1.851	--	4.066	--	
No rice	20.00	--	4.293	--	4.385	--	45.00	--	

API, Average percent inhibition.

Table 2. Allelopathic effect of rice varieties on growth parameters of barnyard grass.

Rice Variety	Plant height (cm)	Reduction (%)	Leaf area (cm^2 $plant^{-1}$)	Reduction (%)	No. of tiller/plant	Reduction (%)	Dry weight (g/plant)	Reduction (%)	API
BR- 5331-93-2-8-4	35.38^{cd}	33.78	35.05^{a}	30.52	2.325^{bc}	30.20	2.95^{b}	27.80	30.58
BR- 5620-9-1-2	37.10^{b}	31.72	36.00^{c}	35.12	2.312^{bc}	29.81	2.92^{b}	31.51	32.04
BRRI dhan27	29.79^{f}	34.66	36.30^{c}	30.42	2.137^{c}	35.49	2.90^{b}	27.09	31.92
BR- 5615-9-1-2	31.50^{e}	34.73	28.75^{d}	38.73	2.312^{c}	30.20	2.80^{c}	34.66	34.51
Lalparija	31.82^{e}	34.96	30.25^{d}	32.56	2.625^{b}	20.75	2.95^{b}	41.60	32.47
BR 11	33.08^{def}	33.59	27.00^{e}	30.45	2.375^{bc}	28.30	3.01^{b}	36.18	32.13
BR 21	35.43^{c}	34.98	41.25^{b}	34.68	2.360^{bc}	28.75	2.89^{b}	37.69	34.03
BR 23	32.50^{e}	34.99	28.50^{d}	33.41	2.180^{c}	34.18	2.83^{b}	31.34	33.23
BR 25	33.68^{cde}	33.71	30.25^{a}	38.54	2.437^{bc}	26.41	2.95^{b}	41.88	35.14
CV (%)	2.308	--	8.89	--	1.815	--	4.006	--	
No rice	43.00	--	51.25	--	3.31	--	3.88	--	

API, Average percent inhibition.

(30.20%), BR-5620-9-1-2 (29.81%), BRRI dhan27 (35.49%), BR-5615-9-1-2 (30.20%), Lalparija (20.75%), BR11 (28.30%), BR21 (28.75%), BR23 (34.18%) and BR25 (26.41%) (Table 2). The effects on plant height, number of tiller per plant, leaf area per plant have been reflected on the dry matter accumulation of barnyard grass. The dry matter weight of barnyard grass was significantly reduced due to allelopathic effect of rice varieties.

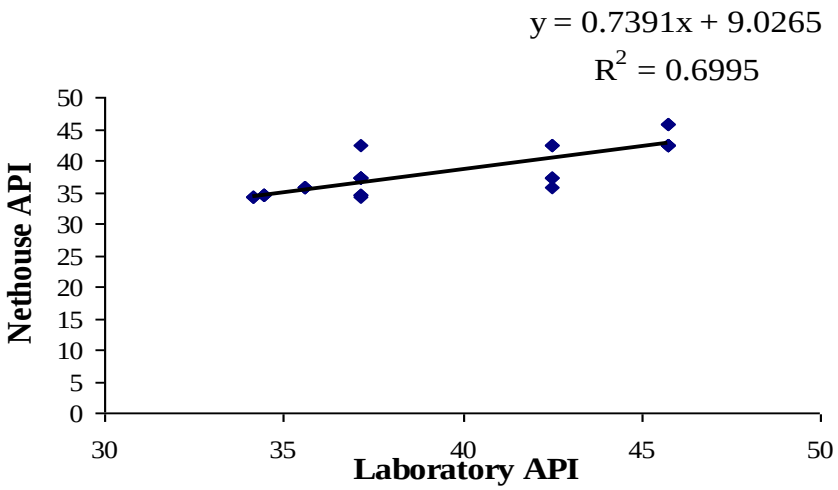

Figure 1. Correlation between API values of laboratory experiment and greenhouse experiments.

On an average, 34.41% reduction in dry matter of barnyard grass was noticed due to allelopathic effect of rice varieties. The maximum reduction of dry matter was noticed in barnyard grass due to the influence of the rice variety BR25 (41.88%) and the minimum (27.09%) reduction was observed due to the influence of the rice variety BRRI dhan27 (Table 2).

When API values were calculated by using percent reduction in root length, shoot length and dry matter accumulation, the highest API value was noticed in the rice variety BR 25 (35.13%), followed by BR-5615-9-1-2 (34.50%) variety and the lowest API was found in BR-5331-93-2-8-4 variety (30.57%).

DISCUSSION

It is obvious in this study that the shoot length of the indicator plants (lettuce and barnyard grass) was reduced due to action of rice allelopathy. Probably, the allelochemicals released by the rice varieties affected the nutrient uptake of neighboring plants, which ultimately interfered with the development of shoot length of the indicator plants. Similar kind of reduction in plant height of barnyard grass due to allelopathic effects of rice varieties was noted by Karim and Ismail (2005). The effect of rice allelopathy on root length of the lettuce or barnyard grass was also similar to that on shoot length.

Since allelochemicals affect the cell metabolism in the root of neighbouring plants, it ultimately reduced the growth of root length of the plant. In some plants, the tip of roots became discolored and inactive. Similar kind of reduction in root length of barnyard grass due to allelopathic effect of rice varieties was noted by Karim and Ismail (2005). Since allelopathic effect of rice varieties affected the growth of shoot and root length, the dry matter accumulation of lettuce or barnyard grass was also affected (reduced) due to released allelochemicals in the germinating environment of indicator plant seeds. Azmi et al. (2000) also noticed that dry matter accumulation of lettuce was significantly reduced due to allelopathic effects of Malaysian rice varieties. Allelochemicals can affect mineral uptake by altering the cellular membrane functions in plant roots. Phenolic acids depolarize the electrical field across membranes and thereby inhibit the absorption of mineral ions (Balke, 1985). However, the mere presence of allelopathic substances in the plant is not sufficient to prove allelopathy. Rather, allelopathic activity is believed to be the joint action of several metabolites that may act synergistically (Galley et al., 2000; Chung et al., 2001).

Li et al. (2004) also reported similar decrease in plant height of barnyard grass due to allelopathic effects of rice varieties. The maximum reduction in the number of tillers was caused by the influence of the rice variety BRRI dhan27 (35.49%) and the minimum (20.75%) was due to Lalparija variety. Similar reduction in tiller number in barnyard grass was also reported by Karim and Ismail (2005) due to allelopathic effects of rice varieties. When the effects of rice varieties on the growth and development of barnyard grass were considered (the effects on plant height, number of tillers plant^{-1}, leaf area plant^{-1} and dry matter plant^{-1}), it was marked that the rice varieties are with sufficient allelopathic potential to reduce the growth of barnyard grass (Table 2). Most of the selected rice varieties are good in allelopathic potential causing 30 to 35% average percent inhibition, which reconfirmed their allelopathic potentials as determined by Islam (2010). This reconfirmation was supported by both laboratory and greenhouse experiments since significant positive correlation was found between the mean API values of rice varieties under laboratory and greenhouse conditions (Figure 1). Mridha (2007) also found positive relationship between weed suppression under laboratory

and greenhouse conditions in summer and autumn season experiments when he evaluated the allelopathic potentials of 149 rice varieties under laboratory and greenhouse conditions.

Therefore, all these varieties/lines of rice can be suggested to farmers for cultivation especially where barnyard grass is a problem. These rice varieties can also be used as source of genes which can be used in rice breeding to develop high yielding and weed-suppressive rice varieties.

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