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Screening of Allelopathic Potential Bangladesh Rice Cultivars by Donor-Receiver Bioassay

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Abstract: To identify allelopathic rice, 102 Bangladesh rice cultivars (42 high yielding and 60 traditional cultivars) were screen out using laboratory donor-receiver bioassay. Cress (*Lepidium sativum* L.), lettuce (*Lactuca sativa* L.), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) and *Echinochloa colonum* (L.) Link were used for bioassay as test plants. High yielding rice cultivars, BRRI dhan37, BRRI dhan30, BR26 and BRRI dhan38, respectively, had the most significant inhibiting effect on the growth of cress, lettuce, barnyardgrass and *E. colonum*. Traditional rice cultivars, Goai and Jogly, respectively, showed the highest inhibition on the growth of cress and lettuce. Kartikshail had the most significant inhibition on the growth of barnyardgrass and *E. colonum*. Although none of the rice cultivar had strong inhibitory activity on all of the test plant species, several rice cultivars inhibited the root and hypocotyl/shoot growth of all the four test plant species and a high yielding rice cultivar, BR17 marked the greatest inhibitory activity with an average of 39.51% of the growth inhibition on roots and hypocotyls/shoots of cress, lettuce, barnyardgrass and *E. colonum*. The present research suggests that BR17 is the most allelopathic in 102 Bangladesh rice cultivars and may be one of the candidates for research programme of Bangladesh rice allelopathy for isolation and identification of allelochemicals.

Key words: Allelopathy, Bangladesh rice, cress, lettuce, barnyardgrass, *E. colonum*, donor-receiver bioassay, screening

INTRODUCTION

Maximizing the world agricultural efficiency depends largely on controlling a variety of disease and pests, especially weeds. Weeds are the major constraint in crop production. This problem has traditionally been solved by hand-weeding. Presently, access to herbicides is helping in decreasing the weed problem. However, increasing farm labour costs and environmental concerns about pesticide usage make it increasingly important to find alternative and sustainable weed management methods. One of the ecological strategies of weed control, allelopathy, has drawn a great deal of attention. Allelopathy is defined as any process involving allelochemicals produced by plants, algae, bacteria and fungi, which influence the growth and development of plants, including positive or negative effects. Many weed scientists have attempted to explore allelopathy directly as a weed management strategy through screening for allelopathic traits in germplasm of crops. Furthermore, the application of rice allelopathy in integrated weed control will enhance the competitive ability of the rice crop and thereby reduce or delay the need for applying herbicides (Lin *et al*., 2000; Lin and He, 2003).

The first observation of allelopathy in rice was made in field examination in Arkansas, USA in which about 191 of 5,000 rice accessions inhibited the growth of *Heteranthara limosa* (Dilday *et al*., 1991). This finding led to a large field screening program. Similar attempts have been made in some other countries and many rice varieties were found to inhibit the growth of several weed species (Hassan *et al*., 1994; Tamak *et al*., 1994; Chou, 1995; Olofsdotter *et al*., 1995; Navarez and Olofsdotter, 1996; Chung *et al*., 1997; Dilday *et al*., 1998; Mattice *et al*., 1998; Ahn and Chung, 2000; Rimando *et al*., 2001). In addition, allelopathic potential has been also reported from numerous crops like barley (Lovett and Hoult, 1975), cucumber (Putnam and Duke, 1974), oats (Fay and Duke, 1977), rice (Kato-Noguchi *et al*., 2002), sorghum (Nimbal *et al*., 1996), sunflower (Leather, 1983) tobacco (Patrick *et al*., 1963) and wheat (Wu *et al*., 1999).

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Rice is the principal food crop of Bangladesh but yield of rice is low in comparison to other rice producing countries due to various reasons of which severe weed infestation is one of the major reasons (Mamun, 1988). In Bangladesh paddy weed is controlled by mostly hand pulling and infrequently Japanese rice weeder. However, labour cost is very high and weed control is often imperfect because of limited budgets for hiring labour and unavailability of labour during peak periods. Since Dilday *et al.* (1991) and Kato-Noguchi *et al.* (2002) reported some rice accessions possess allelopathic activity in weed suppression, rice allelopathy may play an alternative to control weed in paddy ecosystem. The present research was, therefore, undertaken to screen out the allelopathic potential rice cultivars of Bangladesh by using laboratory bioassay.

MATERIALS AND METHODS

This research was conducted in the Laboratory of Biochemistry and Food Science, Department of Applied Biological Science, Faculty of Agriculture, Kagawa University, Japan during the period from November 2006 to April 2007. Forty two high yielding and 60 traditional cultivars of Bangladesh rice (*Oryza sativa* L.) were selected for screening out of their allelopathic activities (Table 1). High yielding rice cultivars are short stature, leaves are dark green and vertical. All leaves receive sunlight and their productivities are high. Grain yield is almost equal with straw weight. Traditional rice cultivars are long stature and lodge easily. Their leaves are light green and horizontal and lower leaves are covered by upper leaves. Thus lower leaves do not receive enough sunlight and their productivities are low. Grain yield is half of straw weight. The seeds of these rice cultivars were collected from Genetics Resource Division (GRS), Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh and farmers of Patuakhali and Dinajpur districts of Bangladesh. All the rice cultivars used in this study were non-sticky and indica rice. Cress (*Lepidium sativum*), lettuce (*Lactuca sativa*), barnyardgrass (*Echinochloa crusgalli*) and *Echinochloa colonum* were used as test plants since cress and lettuce are often used as model plants for bioassay and barnyardgrass and *E. colonum* are important paddy weeds.

For breaking dormancy rice seeds were kept in drier at 45-48°C for 7 days. Then the seeds were soaked in distilled water. After 24 h soaking the seeds were sown on a sheet of moist filter paper (No. 2; Toyo Ltd, Tokyo, Japan) at 25°C in dark. After 48 h the seeds were transferred to a growth chamber with a 12 h photoperiod. After another 48 h, the uniform germinated rice seedlings were transferred (six rice seedlings per Petri-dish) to 55 mm Petri-dishes each containing a sheet of filter paper moistened with 2.5 mL 1 mM phosphate buffer (pH 7.0) and grown for further 48 h. Then ten seeds of cress, lettuce or ten germinated seeds of barnyard grass or *E. colonum* were sown on the filter paper in each Petri-dish, allowed to grow with the rice seedlings under the conditions as describe above. Each treatment was replicated two times. After 48 h, the lengths of the hypocotyls/shoots and roots of cress, lettuce, barnyardgrass and *E. colonum* were measured with a ruler. Control seedlings were incubated without rice seedlings in the same way. Percentage inhibition was then determined by the formula (Lin *et al.*, 2004):

$$\text{Inhibition (\%)} = \left(\frac{\text{Control plant length - Plant length incubated with rice}}{\text{Control plant length}}\right)\times 100$$

A t-test was performed between control and treatments (Li *et al.*, 1993).

Table 1: Bangladesh rice cultivars used in this research

Traditional cultivar				High yielding cultivar		
Badshabhog	Deshibalam	Jhingashail	Manikjour	BR1	BR17	BRRI dhan35
Baron	Dhepa	Jogly	Marichbati	BR2	BR19	BRRI dhan36
Bashful	Dhepa2	Jotabalam	Matiagorol	BR3	BR20	BRRI dhan37
Bashiraj	Dudhkalam	Kachamota	Mohanbhog	BR4	BR21	BRRI dhan38
Bashmoti	Dudhlaki	Kalamanik	Motaman	BR5	BR22	BRRI dhan39
Binnaful	Dudshor	Kalizira	Nizershail	BR6	BR23	BRRI dhan40
Biroi	Dular	Kartikshail	Pajam	BR7	BR26	BRRI dhan42
Buta	Gabura	Kataribhog	Pashushail	BR8	BRRI dhan27	BRRI dhan43
Chandon	Gangasagor	Kazliboro	Patnai31-675	BR9	BRRI dhan28	BRRI dhan45
Chikon aman	Ganjia-3	Khoiyaboro	Pusur	BR10	BRRI dhan29	Binadhan-4
Chiniatop397	Goai	Kumari	Rajashail	BR11	BRRI dhan30	Binadhan-5
Chiniatop398	Gobolshail	Lakkhidigha	Sadajira19-287	BR12	BRRI dhan31	Iratom-24
Chinigura	Gobrijoshua	Lalaman	Shakkhorkona	BR14	BRRI dhan32	
Chinisagor	Hashikalmi	Madhabjota	Shorna	BR15	BRRI dhan33	
Choiyamura	Jamainaru	Maliabhangor	Tepiboro	BR16	BRRI dhan34	

RESULTS AND DISCUSSION

One hundred and two Bangladesh rice cultivars were divided into two groups such as the high yielding (42 cultivars) and the traditional rice (60 cultivars) and their allelopathic effects were determined by using laboratory donor-receiver bioassay. Laboratory bioassay is useful and necessary for the first stage of allelopathic investigation in rice cultivars, since laboratory bioassays are the most convenient, effective and simplest way to estimate the allelopathic potential of rice and various rice cultivars can be examined in a limited time and space all year round (Khanh *et al*., 2007).

Out of 102 rice cultivars, 22 high yielding cultivars and 29 traditional cultivars inhibited cress root growth at 1% level of probability. Three high yielding rice cultivars, BRRI dhan37 (53.25% inhibition), BR5 (53.24% inhibition) and BR20 (53.23% inhibition) showed more than 50% growth inhibition on cress roots. Nine high yielding rice cultivars inhibited the cress root by 40 to 50% and 14 high yielding rice cultivars inhibited the cress root by 30 to 40%, respectively. Five traditional rice cultivars, Goai (55.79% inhibition), Kachamota (53.36% inhibition), Kazliboro (51.48% inhibition), Dudhlaki (51.20% inhibition) and Manikjour (50.57% inhibition) showed more than 50% growth inhibition on cress roots. Moreover, 13 traditional cultivars exhibited 40 to 50% inhibition on cress root and 17 traditional cultivars had 30 to 40% inhibition on cress root. Eleven high yielding rice cultivars and two traditional rice cultivars inhibited the growth of cress hypocotyl at 1% level of probability being BRRI dhan37 the highest (34.40%). The growth inhibition on cress roots by rice was relatively greater than that on cress hypocotyls. High yielding rice cultivar, BRRI dhan37 had the greatest activity with an average of 43.83% of the growth inhibition on cress roots and hypocotyls (Table 2, 3).

Three high yielding cultivars, BRRI dhan30 (94.02% hypocotyls, 90.00% root inhibition), BR22 (83.33% hypocotyl and 90.32% root inhibition) and BR17 (56.52% hypocotyl and 58.42% root inhibition) and one traditional rice cultivar, Dhepa (88.89% hypocotyl and 47.62% root inhibition) had highest inhibitory activity on lettuce seedlings. Three high yielding rice cultivars, BRRI dhan28 (41.18% hypocotyl and 56.73% root inhibition), BRRI dhan32 (50.00% hypocotyl and 47.69% root inhibition) and BR2 (44.44% hypocotyl and 64.79% root inhibition) and two traditional rice cultivars, Baron (63.64% hypocotyl and 65.43% root inhibition) and Buta (50.00% hypocotyl and 60.12% root inhibition) had the second highest inhibitory activity on lettuce seedlings. High yielding rice cultivar, BRRI dhan30 had the highest activity with an average of 92.01% of the growth inhibition on lettuce roots and hypocotyls (Table 2, 3).

Two high yielding rice cultivars (BR14 and BR26) and three traditional rice cultivars (Dular, Kazliboro and Patnai31-675) inhibited the shoot growth of barnyardgrass more than 20% (Table 2, 3). Four high yielding rice cultivars (BR17, BR26, BR9 and BR14) and three traditional rice cultivars (Kazliboro, Dular and Lalaman) inhibited the root growth of barnyardgrass more than 40% (Table 2, 3). Traditional rice cultivar, Kartikshail (70.53% inhibition), showed the highest inhibitory activity on the root growth and had the greatest activity with an average of 42.04% of the growth inhibition on barnyardgrass roots and shoots (Table 3).

Seven high yielding rice cultivars, BR17, BRRI dhan29, BR20, BRRI dhan34, BR9, BRRI dhan40 and BR7 and two traditional rice cultivars Badshabhog and Chinigura inhibited the shoot growth of *E. colonum* seedlings and 11 high yielding rice cultivars, BRRI dhan38, BR15, BR21, BR26, BR17, BRRI dhan29, BR2, BR16, BRRI dhan43, BR9 and BR11 and five traditional rice cultivars Kartikshail, Badshabhog, Lakkhidigha, Buta and Shorna inhibited the root growth of *E. colonum* seedlings at 1% level of probability (Table 2, 3). Two high yielding rice cultivars, BRRI dhan38 and BR15 inhibited the root growth of *E. colonum* more than 50% and two traditional rice cultivars (Kartikshail and Chiniatop397) inhibited the root growth of *E. colonum* more than 50%. BRRI dhan38 (75.31% inhibition) showed the greatest inhibitory activity on the root growth and had the greatest activity with an average of 42.94% of the growth inhibition on *E. colonum* roots and shoots (Table 2, 3). Considering the root growth inhibition of test plant species Iratom-24, BRRI dhan30, Kartikshail and BRRI dhan38, respectively, had the highest inhibition on the root growth of cress, lettuce, barnyardgrass and *E. colonum* (Fig. 1). However, rice cultivar BR17 had the highest average growth inhibition (39.51%) on the test plants species followed by BRRI dhan28 (33.70%), BR22 (33.08%), BR26 (31.94%), Kartikshail (30.96%) and BR23 (30.85%) among the 102 rice cultivars (Fig. 2, 3).

The use of allelopathy was considered as a potential and environmentally friendly means of weed control in agricultural crop production. Rice has been extensively studied with respect to its allelopathy and a large number of rice varieties were found to inhibit the growth of several plant species when those rice varieties were grown together with these plants (Dilday *et al*., 1998; Olofsdotter *et al*., 1999; Azmi *et al*., 2000; Khanh *et al*., 2007). In this experiment, both some of high yielding and some of traditional rice cultivars were found to have allelopathic activity against cress, lettuce, barnyardgrass

Table 2: Effect of high yielding rice cultivars on the growth of hypocotyls, shoots and roots of cress, lettuce, barnyardgrass and *Echinochloa colonum*

	Percent inhibition							
	Cress		Lettuce		Barnyardgrass		*E. colonum*	
Rice cultivar	Hypocotyl	Root	Hypocotyl	Root	Shoot	Root	Shoot	Root
BR1	5.75±4.3^{NS}	23.53±10.0^{NS}	-10.50±0.5^{NS}	-81.40±3.5***	-10.00±4.3^{NS}	10.53±8.6^{NS}	14.29±2.5*	0.70±0.9^{NS}
BR2	20.56±3.2**	26.49±12.7^{NS}	44.44±0.7^{NS}	64.79±3.3***	8.27±5.5^{NS}	35.62±11.7**	4.03±4.0^{NS}	39.87±5.2***
BR3	13.39±7.2^{NS}	24.22±5.6^{NS}	46.67±0.8**	41.86±5.6***	19.38±5.1***	32.43±5.6***	8.79±2.7^{NS}	13.60±10.2^{NS}
BR4	-5.49±4.2^{NS}	-23.67±13.9^{NS}	6.67±0.9^{NS}	-83.33±8.1**	9.86±5.3^{NS}	30.59±6.4*	19.12±4.3*	-9.38±4.3^{NS}
BR5	29.81±4.1**	53.24±12.6***	16.67±0.8^{NS}	5.71±4.9^{NS}	10.67±4.7^{NS}	18.41±11.7*	4.84±4.1^{NS}	14.67±9.6^{NS}
BR6	8.42±3.0^{NS}	4.86±0.9^{NS}	25.00±0.7*	3.33±2.3^{NS}	6.99±4.6^{NS}	26.07±13.5*	1.77±1.5^{NS}	-17.73±9.2^{NS}
BR7	9.89±4.5^{NS}	-1.68±1.3^{NS}	33.33±0.8*	28.28±5.6*	-9.85±5.1^{NS}	21.63±15.6^{NS}	14.40±2.7**	34.81±10.2^{NS}
BR8	21.56±4.5*	29.81±14.2^{NS}	18.18±0.7^{NS}	-4.88±3.3^{NS}	11.76±4.5^{NS}	23.42±13.8^{NS}	12.07±3.6^{NS}	23.08±12.1^{NS}
BR9	18.95±2.5**	35.22±7.2**	21.43±0.7*	48.65±3.0***	15.86±3.5**	43.07±11.1***	16.79±2.7**	30.89±8.6**
BR10	2.94±2.2^{NS}	-23.84±8.9NS	30.77±0.8*	61.86±5.0***	1.59±3.2^{NS}	18.32±13.1^{NS}	6.73±3.5^{NS}	-35.96±11.9^{NS}
BR11	8.06±5.2^{NS}	39.44±9.8**	-6.67±0.5^{NS}	20.50±6.3*	7.25±4.7^{NS}	15.00±4.0^{NS}	8.43±5.0^{NS}	28.57±7.0**
BR12	17.14±5.0^{NS}	49.17±18.0**	-6.25±0.9^{NS}	-9.86±1.1^{NS}	5.29±4.0^{NS}	19.65±8.7**	6.58±4.5^{NS}	4.73±1.5^{NS}
BR14	23.38±3.4*	-7.02±4.2^{NS}	25.00±0.8*	-46.67±4.8^{NS}	21.43±4.0**	40.74±4.3***	15.15±3.6*	0.00±0.6^{NS}
BR15	7.87±2.4^{NS}	33.14±7.4**	15.79±0.4*	22.33±6.2^{NS}	12.74±5.8^{NS}	33.20±9.7**	15.38±2.4^{NS}	51.25±5.1**
BR16	25.56±5.0**	39.91±12.3**	44.83±0.9***	22.52±9.2^{NS}	5.33±5.2^{NS}	19.05±5.1^{NS}	20.12±5.7*	39.82±6.1***
BR17	23.08±3.6**	47.42±6.9***	56.52±0.6***	58.42±3.4***	14.40±5.1^{NS}	46.58±9.7***	26.52±3.7***	43.15±9.4***
BR19	-10.53±3.7^{NS}	15.72±10.4^{NS}	37.50±0.9**	28.13±4.9^{NS}	7.63±5.6^{NS}	25.79±10.3*	10.08±2.7*	29.08±7.8*
BR20	24.42±4.2*	53.23±8.8***	23.08±0.8^{NS}	30.76±5.5^{NS}	4.93±6.4^{NS}	8.91±6.0^{NS}	25.55±3.7***	34.78±12.6^{NS}
BR21	13.27±3.9^{NS}	33.65±10.0*	28.57±3.8^{NS}	18.60±5.3^{NS}	4.35±5.6^{NS}	11.89±7.7^{NS}	8.74±3.4^{NS}	45.03±6.9***
BR22	11.35±3.6^{NS}	38.89±17.8**	83.33±0.9*	90.32±4.9*	16.18±7.6^{NS}	21.99±5.5^{NS}	5.16±2.8^{NS}	-2.60±1.2^{NS}
BR23	28.45±4.1**	49.79±13.9**	39.13±0.9***	62.04±5.7***	19.50±4.8*	26.85±8.3***	1.92±4.6^{NS}	19.13±11.0^{NS}
BR26	21.15±4.4*	35.87±10.1*	37.50±0.9**	40.40±5.9**	20.00±12.4**	45.61±13.1***	11.04±4.1^{NS}	43.94±8.3***
BRRIdhan27	15.38±6.1^{NS}	14.43±14.2^{NS}	5.88±0.8^{NS}	-59.26±6.4**	15.00±3.9	13.31±11.3^{NS}	14.17±3.2*	4.64±9.7^{NS}
BRRIdhan28	26.42±3.4**	48.58±9.7***	41.18±.07***	56.73±4.4***	19.15±5.6*	26.15±12.7*	18.64±3.5*	32.74±10.8*
BRRIdhan29	28.21±5.3*	46.19±13.7**	18.18±1.1^{NS}	-38.30±7.1*	19.88±4.5**	39.67±10.3***	25.60±2.6***	40.89±9.1***
BRRIdhan30	-1.18±6.6^{NS}	-2.92±1.7^{NS}	90.00±0.6***	94.02±3.4***	14.10±5.5^{NS}	19.35±13.8^{NS}	22.84±5.7*	15.25±13.5^{NS}
BRRI dhan31	6.90±5.7^{NS}	40.22±14.5*	5.00±0.5^{NS}	15.98±7.8^{NS}	15.71±7.5^{NS}	38.16±15.9***	2.82±1.7^{NS}	7.78±4.5^{NS}
BRRI dhan32	1.03±3.7^{NS}	21.58±14.0^{NS}	50.00±0.9*	47.69±6.0*	-3.38±0.8^{NS}	-8.86±5.0^{NS}	2.27±1.8^{NS}	4.68±1.4^{NS}
BRRI dhan33	32.26±4.8*	22.82±12.4^{NS}	25.00±0.8*	17.81±4.4^{NS}	17.65±4.3*	25.25±12.7*	13.08±3.9^{NS}	-13.57±10.7^{NS}
BRRI dhan34	14.89±1.9**	33.16±6.7***	0.00±0.6^{NS}	9.80±4.8^{NS}	18.83±4.1**	26.13±9.0***	22.13±3.9**	2.88±1.4^{NS}
BRRI dhan35	14.19±4.3^{NS}	20.00±13.0^{NS}	6.25±1.2^{NS}	-52.17±6.4**	17.69±4.8^{NS}	37.37±8.3***	5.56±2.4^{NS}	9.20±4.2^{NS}
BRRI dhan36	-4.65±3.0^{NS}	37.89±12.0**	14.29±0.4^{NS}	-15.96±3.6^{NS}	1.91±0.7^{NS}	23.99±11.5*	9.49±5.1^{NS}	9.49±4.5^{NS}
BRRI dhan37	34.40±3.4***	53.25±12.9***	-7.14±0.6^{NS}	-26.88±5.7^{NS}	-2.90±1.6^{NS}	1.22±0.5^{NS}	7.87±3.0^{NS}	11.98±10.5^{NS}
BRRI dhan38	23.53±4.0^{NS}	38.15±11.9*	-40.00±1.0^{NS}	12.73±7.8^{NS}	-0.82±0.4^{NS}	38.28±12.6**	10.56±3.3^{NS}	75.31±8.5***
BRRI dhan39	10.68±3.4^{NS}	44.35±8.3***	-33.33±0.5*	-142.31±4.1***	-15.79±4.8^{NS}	20.31±12.5^{NS}	-7.63±3.3^{NS}	19.66±8.5^{NS}
BRRI dhan40	26.21±3.8**	36.59±14.6**	-11.76±0.6^{NS}	-65.38±7.1***	8.28±3.6^{NS}	10.66±1.6^{NS}	15.75±2.7**	20.86±8.4^{NS}
BRRI dhan42	16.50±3.2*	43.32±10.6***	-25.00±0.8^{NS}	-50.79±5.5*	2.88±3.7^{NS}	6.02±1.8^{NS}	13.56±2.9*	3.55±1.9^{NS}
BRRI dhan43	23.60±3.9*	37.36±9.3*	7.14±0.7^{NS}	41.84±4.5***	18.40±3.4**	37.66±12.1**	21.65±3.3*	37.23±6.3**
BRRI dhan45	13.40±2.3*	33.21±12.0**	11.76±0.5^{NS}	-29.09±5.2*	13.38±4.7^{NS}	1.39±1.1^{NS}	5.97±3.7^{NS}	2.21±9.0^{NS}
Binadhan-4	20.22±5.4^{NS}	17.73±4.6^{NS}	77.78±0.5***	58.33±2.7*	5.41±4.0^{NS}	0.00±0.6^{NS}	10.81±2.2^{NS}	-18.60±3.6^{NS}
Binadhan-5	10.11±3.3^{NS}	36.02±9.3**	25.00±0.6^{NS}	33.96±4.6^{NS}	18.00±4.9*	26.38±13.7*	27.50±1.7^{NS}	16.67±3.2^{NS}
Iratom-24	26.26±3.0**	49.77±9.6***	5.56±0.5^{NS}	9.09±5.0^{NS}	1.37±5.6^{NS}	1.83±0.6^{NS}	2.94±1.5^{NS}	13.0±2.8^{NS}

-: Indicates promotion of growth, NS: Not Significant, *Significant at 5% level of probability, **Significant at 1% level of probability and ***Significant at 0.1% level of probability, Means from two replications with 20 seedlings for each determination are shown

and *E. colonum*. Inhibitions on root growth were greater than those on hypocotyl/shoot growth in four test plant species (Table 2, 3). It was also reported that allelopathic rice cultivars strongly inhibited the root growth rather than the shoot of paddy weeds (Olofsdotter and Navarez, 1996). In addition, allelopathic activity of rice was cultivar and origin dependents and the Japonica type had higher allelopathic activity than the Javanica type (Khanh *et al*., 2007). In the present research, 102 Bangladesh rice cultivars showed wide range of growth inhibition on test plant species (Table 2, 3), which indicates that genetic variability of the allelopathic trait may be widespread among the cultivars.

Barnyardgrass is one of the most noxious paddy weeds in the world since this weed competes with rice for minerals, light and water and reduces the yield of rice. Some of high yielding and traditional rice cultivars were found to possess allelopathic activity against barnyardgrass and *E. colonum* (Table 2, 3). Traditional rice cultivar, Kartikshail marked the greatest inhibitory activity with an average of 42.04% of the growth inhibition on barnyardgrass roots and shoots. These

Table 3: Effect of traditional rice cultivars on the growth of hypocotyls, shoots and roots of cress, lettuce, barnyardgrass and *Echinochloa colonum*

Rice cultivar	Percent inhibition							
	Cress		Lettuce		Barnyardgrass		*E. colonum*	
	Hypocotyl	Root	Hypocotyl	Root	Shoot	Root	Shoot	Root
Badshabhog	15.89±3.9^{NS}	36.53±8.5**	35.29±0.7***	51.11±2.6***	7.34±3.1^{NS}	6.55±2.9^{NS}	33.04±4.1***	40.99±8.1**
Baron	10.42±4.0^{NS}	-24.00±9.5^{NS}	63.64±0.8**	65.43±8.3^{NS}	-9.24±3.8^{NS}	-3.03±1.3^{NS}	2.86±1.2^{NS}	24.06±7.7^{NS}
Bashful	6.67±2.8^{NS}	45.67±8.6***	15.38±0.8^{NS}	51.06±5.8**	-3.85±4.8^{NS}	24.44±9.0**	24.39±5.1^{NS}	12.31±5.8^{NS}
Bashiraj	-8.64±2.2^{NS}	28.06±8.6*	29.41±0.6**	40.54±6.5**	-4.76±3.7^{NS}	10.59±5.6^{NS}	14.63±3.7^{NS}	7.94±4.6^{NS}
Bashmoti	3.41±2.7^{NS}	31.84±10.4^{NS}	0.00±0.5^{NS}	-129.41±3.2**	10.34±4.5^{NS}	13.33±10.2^{NS}	7.14±3.5^{NS}	4.31±1.4^{NS}
Binnaful	-6.98±5.0^{NS}	-19.71±10.1^{NS}	16.67±0.7^{NS}	30.99±4.4*	-6.47±6.3^{NS}	14.46±11.7^{NS}	6.87±3.7^{NS}	6.41±1.9^{NS}
Biroi	-2.13±4.8^{NS}	39.72±12.0**	21.05±0.6*	61.96±4.6***	-2.04±4.7^{NS}	13.53±9.9^{NS}	-4.96±3.3^{NS}	15.53±9.1^{NS}
Buta	10.67±3.7^{NS}	27.09±6.3^{NS}	50.00±9.4**	60.12±6.5***	15.51±5.5*	15.80±4.2*	12.99±3.6^{NS}	33.45±7.5**
Chandon	9.78±1.9*	34.12±5.9***	27.93±0.8^{NS}	48.94±3.4^{NS}	4.76±2.7^{NS}	33.86±11.9**	-11.42±2.9^{NS}	32.76±6.2^{NS}
Chikon aman	-23.96±5.4^{NS}	-13.55±10.2^{NS}	57.14±0.8**	57.14±4.9***	8.96±4.8^{NS}	25.51±12.4*	8.13±3.6^{NS}	13.19±11.7^{NS}
Chiniatop397	4.21±4.5^{NS}	32.88±10.4**	-57.89±1.2***	-20.00±7.8^{NS}	11.67±4.7^{NS}	27.16±10.4**	9.68±2.8^{NS}	53.25±10.9^{NS}
Chiniatop398	8.43±2.2^{NS}	32.14±6.1**	-13.33±0.7^{NS}	-38.10±1.9**	2.68±1.3^{NS}	22.96±7.2**	-9.30±2.0^{NS}	18.97±9.8*
Chinigura	15.83±3.0*	42.30±10.2**	5.56±0.5^{NS}	9.73±4.7^{NS}	8.63±6.6^{NS}	21.85±10.3**	18.58±4.3**	-7.07±2.0^{NS}
Chinisagor	-2.22±1.4^{NS}	14.37±4.4^{NS}	0.00±0.7^{NS}	-18.38±7.4^{NS}	9.58±4.7^{NS}	24.20±10.2**	9.52±2.2^{NS}	30.30±3.7*
Choiyamura	9.28±3.9^{NS}	34.13±11.8*	11.76±07^{NS}	-12.78±4.7^{NS}	10.90±4.4^{NS}	30.37±11.9**	12.59±5.7^{NS}	20.81±9.2^{NS}
Deshibalam	6.90±2.7^{NS}	16.59±8.5^{NS}	5.88±0.6^{NS}	-16.67±7.4^{NS}	4.73±3.4^{NS}	12.37±11.2^{NS}	16.42±2.8^{NS}	24.21±5.8^{NS}
Dhepa	-2.33±2.8^{NS}	16.17±12.1^{NS}	88.89±0.7***	47.62±2.7***	7.63±3.9^{NS}	20.15±8.0**	3.06±1.5^{NS}	-19.01±7.0^{NS}
Dhepa2	5.88±5.1^{NS}	41.49±10.9*	0.00±0.6^{NS}	-1.88±1.7^{NS}	-6.25±6.3^{NS}	15.41±4.5^{NS}	10.00±3.3^{NS}	42.86±6.4^{NS}
Dudhkalam	12.79±4.0^{NS}	29.23±10.0*	11.11±0.6^{NS}	14.09±6.1^{NS}	4.14±3.0^{NS}	25.53±5.0*	4.88±1.8^{NS}	12.86±3.1^{NS}
Dudhlaki	19.27±3.3*	51.20±12.5***	5.56±0.7^{NS}	3.85±1.9^{NS}	9.22±5.4^{NS}	18.30±11.9^{NS}	4.46±4.2^{NS}	29.14±8.1*
Dudshor	-4.05±2.9^{NS}	-19.27±9.6^{NS}	0.00±0.7^{NS}	-21.43±3.0^{NS}	6.33±3.6^{NS}	13.74±5.2^{NS}	7.56±3.5^{NS}	16.08±11.9^{NS}
Dular	19.15±2.8*	45.45±8.1 ***	6.67±0.9^{NS}	27.91±5.4^{NS}	25.18±4.4**	43.96±10.2***	9.23±3.6^{NS}	29.91±7.6^{NS}
Gabura	7.07±2.0^{NS}	40.61±11.8***	0.00±0.8^{NS}	11.00±6.3^{NS}	6.67±5.5^{NS}	39.30±12.0***	0.00±0.9^{NS}	12.70±6.6^{NS}
Gangasagor	-1.35±0.9^{NS}	-20.19±10.9^{NS}	-6.25±0.8^{NS}	-8.77±7.9^{NS}	5.80±4.9^{NS}	8.21±1.5^{NS}	-6.90±3.3^{NS}	-17.11±7.4^{NS}
Ganjia-3	-2.27±1.1^{NS}	-34.85±10.2^{NS}	0.00±0.5^{NS}	-85.14±6.0***	0.97±1.1^{NS}	-13.66±9.9^{NS}	6.06±4.2^{NS}	14.97±10.3^{NS}
Goai	22.47±4.1*	55.79±10.2***	9.09±0.5^{NS}	-17.65±3.4^{NS}	9.02±5.6^{NS}	27.76±8.4**	-17.14±2.9^{NS}	0.00±0.8^{NS}
Gobolshail	10.87±3.7^{NS}	40.00±9.6**	11.11±0.5^{NS}	-7.34±5.0^{NS}	6.76±5.6^{NS}	23.60±5.6^{NS}	12.50±1.5^{NS}	2.38±2.1^{NS}
Gobrijoshua	6.82±2.8^{NS}	42.65±8.1***	0.00±0.7^{NS}	36.94±5.8**	7.69±7.0^{NS}	26.72±11.2*	8.51±2.1^{NS}	2.90±3.1^{NS}
Hashikalmi	9.80±3.6^{NS}	39.81±10.8**	26.32±0.9*	31.11±7.4*	7.75±5.2^{NS}	30.63±11.6**	-2.56±2.8^{NS}	-11.45±9.2^{NS}
Jamainaru	15.73±2.8^{NS}	31.52±9.8*	-43.75±0.8***	-11.72±6.5^{NS}	0.00±1.3^{NS}	25.00±9.3**	-22.50±2.6^{NS}	38.36±4.8*
Jhingashail	1.20±1.1^{NS}	26.92±7.9*	-9.09±0.6^{NS}	16.67±2.0^{NS}	-1.59±0.7^{NS}	24.79±11.7*	-23.26±1.9^{NS}	4.35±4.6^{NS}
Jogly	16.67±3.2*	38.95±9.3**	69.23±0.9***	71.43±3.4***	6.09±3.3^{NS}	27.91±8.9**	-2.00±1.7^{NS}	-13.51±7.3^{NS}
Jotabalam	1.03±3.2^{NS}	22.54±12.6^{NS}	-13.33±0.6^{NS}	-71.15±4.7***	10.08±3.7^{NS}	22.32±11.3^{NS}	-22.47±4.1^{NS}	-27.21±6.9^{NS}
Kachamota	21.51±3.3*	53.36±9.8***	15.79±0.9^{NS}	7.89±5.1^{NS}	0.67±0.2^{NS}	9.57±2.4^{NS}	-8.89±1.7^{NS}	-8.06±5.6^{NS}
Kalamanik	15.96±4.0^{NS}	13.98±12.0^{NS}	50.00±0.9*	45.00±3.9**	-1.61±3.7^{NS}	6.35±3.5^{NS}	7.34±4.0^{NS}	2.04±1.7^{NS}
Kalizira	3.64±3.2^{NS}	-15.92±9.2^{NS}	23.08±1.0*	5.69±3.3^{NS}	6.18±5.6^{NS}	19.0±10.2*	11.90±1.6^{NS}	30.36±1.9*
Kartikshail	10.45±3.4^{NS}	14.81±4.1^{NS}	13.33±0.8^{NS}	42.05±5.6*	13.55±6.3^{NS}	70.53±12.5***	16.88±5.1^{NS}	66.07±8.3***
Kataribhog	21.78±3.1**	40.25±6.1***	-10.53±0.8^{NS}	-30.93±5.9*	1.91±0.7^{NS}	24.75±11.8*	13.33±1.2^{NS}	25.00±3.0^{NS}
Kazliboro	7.60±2.9^{NS}	51.48±11.4***	7.69±0.6^{NS}	22.89±5.2^{NS}	23.57±4.0***	46.75±8.1*	10.81±3.4^{NS}	18.52±5.3^{NS}
Khoiyaboro	13.25±5.1^{NS}	40.11±13.1*	14.29±0.5^{NS}	-33.33±2.1^{NS}	-1.38±0.9^{NS}	30.72±10.5***	20.00±3.9^{NS}	24.14±5.6^{NS}
Kumari	22.00±4.2**	40.56±7.6**	0.00±0.6 ^{NS}	-29.63±6.3^{NS}	-4.79±2.1^{NS}	17.00±4.5^{NS}	9.09±3.7^{NS}	18.60±5.5^{NS}
Lakkhidigha	-10.84±3.5^{NS}	-23.13±9.6^{NS}	0.00±0.5^{NS}	23.16±4.6*	9.09±4.4^{NS}	27.75±12.9^{NS}	12.07±3.5^{NS}	40.00±6.5***
Lalaman	12.12±3.2^{NS}	50.00±10.2***	0.00±0.7^{NS}	-3.27±1.1^{NS}	14.79±4.3*	40.82±7.9***	15.38±4.4^{NS}	47.06±7.2^{NS}
Madhabjota	5.21±3.8^{NS}	37.89±11.9**	18.51±2.0^{NS}	36.59±5.8***	10.12±5.7^{NS}	19.40±4.8^{NS}	-2.63±1.4^{NS}	10.00±5.0^{NS}
Maliabhangor	8.73±3.3^{NS}	35.41±9.3***	4.76±0.8^{NS}	-17.54±6.0^{NS}	11.11±4.6^{NS}	20.89±9.5*	15.15±2.8^{NS}	-12.94±7.4^{NS}
Manikjour	11.00±4.0^{NS}	50.57±13.0***	22.22±0.5*	30.51±2.7*	11.56±5.4^{NS}	30.77±11.5**	3.29±2.7^{NS}	12.71±4.7^{NS}
Marichbati	13.48±2.5*	37.67±11.0**	0.00±0.7^{NS}	4.92±2.3^{NS}	7.14±6.3^{NS}	39.66±10.3***	21.05±2.9^{NS}	27.27±4.6^{NS}
Matiagorol	-2.06±3.0^{NS}	22.08±9.8*	0.00±0.7^{NS}	-29.63±6.4*	7.91±4.2^{NS}	28.63±8.8**	8.62±2.8^{NS}	11.49±9.8^{NS}
Mohanbhog	12.12±3.1^{NS}	5.83±1.4^{NS}	9.09±3.7^{NS}	0.00±0.7^{NS}	4.48±4.4^{NS}	4.80±4.0^{NS}	7.32±3.9^{NS}	-8.24±4.5^{NS}
Motaman	-5.68±4.2^{NS}	-16.89±10.2^{NS}	13.33±0.6^{NS}	-2.38±3.7^{NS}	7.83±4.2^{NS}	17.44±13.0^{NS}	0.00±0.4^{NS}	-15.11±12.4^{NS}
Nizershial	17.05±4.8^{NS}	32.44±7.5^{NS}	7.69±0.7^{NS}	16.83±5.7^{NS}	16.15±3.3**	4.96±1.7^{NS}	-3.88±3.8^{NS}	12.90±9.9^{NS}
Pajam	19.35±2.9*	39.45±9.8**	28.57±0.6^{NS}	-9.02±4.7^{NS}	-1.98±0.8^{NS}	18.63±10.1^{NS}	11.65±2.6*	17.29±8.7^{NS}
Pashushail	18.27±2.9*	31.15±7.0**	-12.50±0.7^{NS}	-15.79±1.4^{NS}	12.23±3.2*	25.43±10.1**	1.82±1.8^{NS}	-13.91±8.9^{NS}
Patnai31-675	3.55±5.0^{NS}	7.91±1.4^{NS}	13.04±0.6*	-14.39±6.7^{NS}	20.74±6.2**	10.99±2.1^{NS}	23.28±7.8*	-26.06±14.2^{NS}
Pusur	17.02±4.2^{NS}	41.74±14.7*	0.00±0.5^{NS}	38.93±5.8***	4.07±4.0^{NS}	26.80±12.1**	11.11±1.8^{NS}	10.96±6.0^{NS}
Rajashail	2.46±1.6^{NS}	-7.17±1.8^{NS}	27.78±0.8*	20.00±5.4^{NS}	4.30±2.2^{NS}	8.98±2.9^{NS}	-1.12±3.5^{NS}	-6.36±4.5^{NS}
Sadajira19-287	-7.53±4.8^{NS}	-52.41±11.2**	21.43±0.8^{NS}	4.86±5.4^{NS}	16.20±5.0^{NS}	5.08±1.9^{NS}	11.81±3.1*	-26.19±11.5^{NS}
Shakkhorkona	-7.92±3.5^{NS}	-10.11±9.4^{NS}	30.00±0.9^{NS}	52.94±6.0*	14.79±5.2^{NS}	38.57±9.8***	3.70±3.8^{NS}	6.94±1.2^{NS}
Shorna	12.77±2.4*	39.81±9.6**	-7.14±0.6^{NS}	3.81±3.4^{NS}	4.51±2.6^{NS}	32.82±8.3***	7.41±3.2^{NS}	27.38±6.8**
Tepiboro	17.14±3.5*	42.28±12.2**	0.00±0.8^{NS}	29.93±7.6*	7.91±4.5^{NS}	20.91±12.9^{NS}	2.70±2.3^{NS}	20.75±8.8^{NS}

-: Indicates promotion of growth, NS: Not Significant, *Significant at 5% level of probability, **Significant at 1% level of probability and ***Significant at 0.1% level of probability, Means from two replications with 20 seedlings for each determination are shown

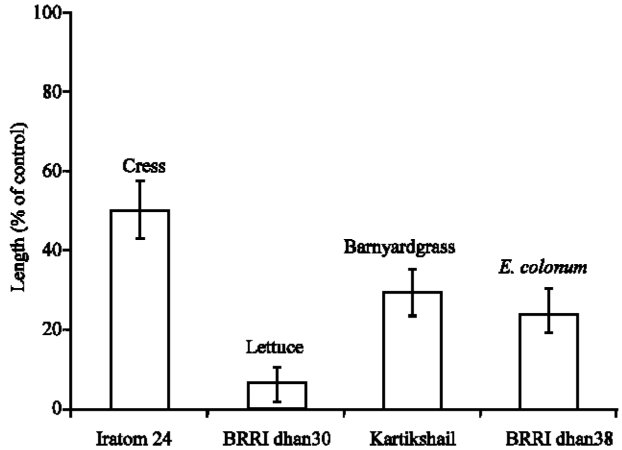

Fig. 1: The highest inhibitory rice cultivars on the root growth of cress, lettuce, barnyardgrass and *E. colonum*. Mean and bar (SE) from 20 seedlings for each determination are shown

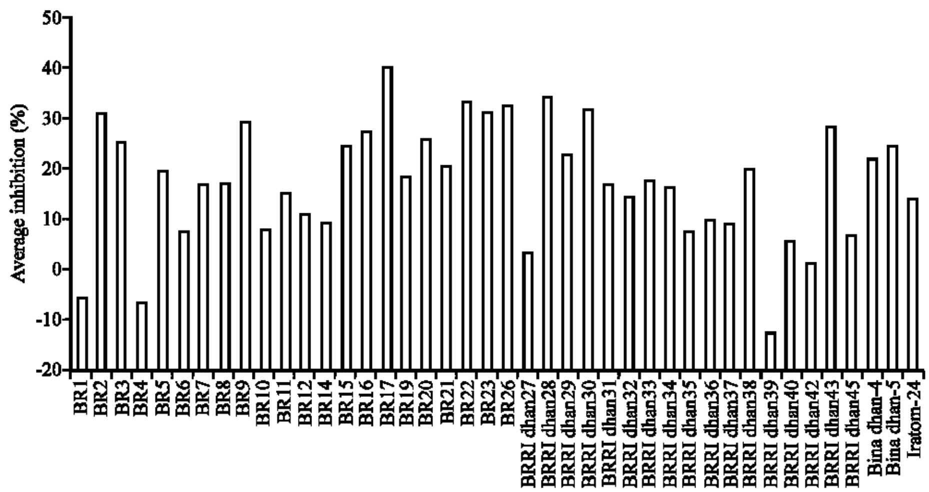

Fig. 2: Average percent of growth inhibition of four test plant species when grown with 42 high yielding rice cultivars of varying allelopathic potential. Means from 20 seedlings for each determination are shown

cultivars may be important in developing allelopathic rice cultivar through breeding programme (Olofsdotter *et al*., 1999).

In this study, BRRIdhan37, BRRIdhan30, Kartikshail and BRRIdhan38, respectively, had the most significant inhibiting effect on the growth of cress, lettuce, barnyard grass and *E. colonum* (Fig. 1). Although several rice cultivars had strong allelopathic effect against one test plant species, none of the rice cultivar had strong inhibitory activity against the four test plant species used in this study (Table 2, 3). Chung *et al.* (1997), Dilday *et al.* (1994, 1998), Hassan *et al.* (1994) and Olofsdotter *et al.* (1999) also found that rice cultivars which were allelopathic against a weed species were not always allelopathic towards another weed species, which suggests that all allelochemicals released from rice plants may not be able to inhibit all plant species. However, in this experiment, there were several cultivars that inhibited the root and shoot growth of all test plant species and high yielding rice cultivar, BR17 marked the greatest inhibitory activity with an average of 39.51% of the growth inhibition on cress, lettuce, barnyard grass and *E. colonum* (Table 2, 3).

The present research suggests that rice cultivar BR17 is the most allelopathic among 102 Bangladesh rice cultivars. This cultivar, therefore, may be one of the candidates for research programme of Bangladesh rice allelopathy for isolation and identification of allelochemicals. Traditional cultivar, Kartikshail might also be important because of great inhibitory activity against

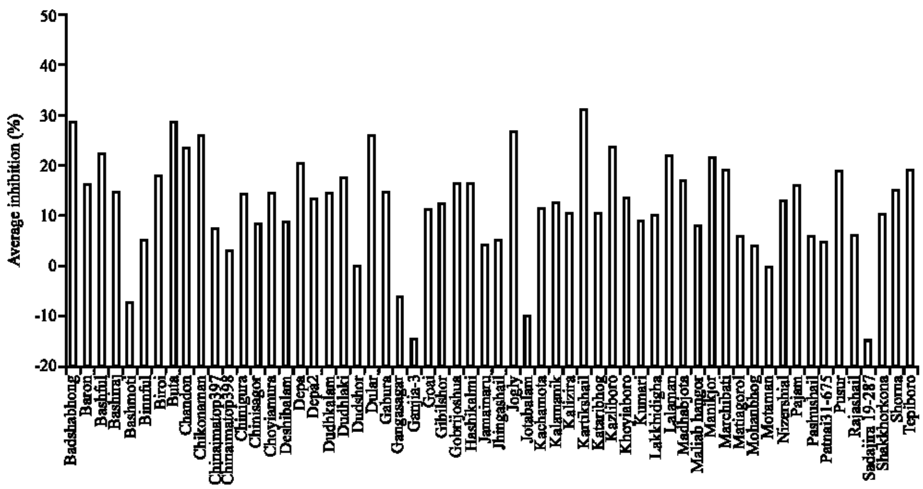

Fig. 3: Average percent of growth inhibition of four test plant species when grown with 60 traditional rice cultivars of varying allelopathic potential. Means from 20 seedlings for each determination are shown

noxious paddy weed barnyardgrass (Table 3). Moreover, these allelopathic rice cultivars may be used for breeding new cultivars having good weed-suppressing ability would benefit farmers in rice producing countries.

REFERENCES

Ahn, J.K. and I.M. Chung, 2000. Allelopathic potential of rice hulls on germination and seedling growth of barnyardgrass. Agron. J., 92: 1162-1167.

Azmi, M., M.Z. Abdullah and Y. Fuzii, 2000. Exploratory study on allelopathic effect of selected Malaysian rice varieties and rice field weed species. J. Trop. Agric. Food Sci., 28: 39-54.

Chou, C.H., 1995. Allelopathy and sustainable agriculture. In: Allelopathy: Organisms, Process and Application. ACS Symposium Series 582, Inderjit Dakshini K.M.M. and F.A. Einhelling (Eds.) American Chemical Society, Washington, DC, pp: 211-223.

Chung, I.M., K.H. Kim, J.K. Ahn and H.J. Ju, 1997. Allelopathic potential of rice varieties on *Echinochloa crus-galli*. Korean J. Weed Sci., 17: 52-58.

Dilday, R.H., P. Nastasi, J. Lin and R.J. Smith, 1991. Allelopathic activity in rice (*Oryza sativa* L.) against ducksalad (Heteranthera limosa (Sw.) Wild). Symposium Proceedings on Sustainable Agriculture for Great Plains, 1991 USDA, Beltsville, pp: 193-201.

Dilday, R.H., J. Lin and W. Yan, 1994. Identification of allelopathy in the USDA-ARS rice germplasm collection. Aust. J. Expt. Agric., 34: 907-910.

Dilday, R.H., W.G. Yan, K.A.K. Moldenhauer and K.A. Gravois, 1998. Allelopathic activity in rice for controlling major aquatic weeds. In: Proceeding Workshop on Allelopathy in Rice, Olofsdotter, M. (Ed.). IRRI, Manila, Philippines, pp: 7-26.

Fay, P.K. and W.B. Duke, 1977. An assessment of allelopathic potential in *Avena* germplasm. Weed Sci., 25: 224-228.

Hassan, S.M., A.N. Rao, A.O. Bastawisi and I.R. Aidy, 1994. Weed management in broadcast seeded rice in Egypt. Proceedings of the International Workshop on Constraints, Opportunities and Innovations for Wet-Seeded Rice, Bangkok, Thailand, 31 May-June 3, IRRI, Los Banos, Laguna (Philippines), pp: 441-454.

Kato-Noguchi, H., T. Ino, N. Sata and S. Yamamura, 2002. Isolation and identification of a potent allelopathic substance in rice root exudates. Physiol. Planta., 115: 401-405.

Khanh, T.D., T.D. Xuan and I.M. Chung, 2007. Rice allelopathy and the possibility for weed management. Ann. Applied Biol., 151: 325-339.

Leather, G.R., 1983. Sunflowers (*Helianthus annuus*) are allelopathic to weeds. Weed Sci., 31: 37-42.

Li, H.H., M. Inoue, H. Nishimura, J. Mizutani and E. Tsuzuki, 1993. Interactions of trans-cinnamic acid, its related phenolic allelochemicals, and abscisic acid in seedling growth and seed germination of lettuce. J. Chem. Ecol., 19: 1775-1787.

Lin, W.X., K.U. Kim and H.Q. He, 2000. Rice allelopathic potential and its modes of action on barnyardgrass (*Echinochloa crus-galli* L.). Allelopathy J., 18: 247-254.

Lin, W.X. and H.Q. He, 2003. The performance of allelopathic heterosis in rice (*Oryza sativa* L.). Allelopathy J., 12: 179-188.

Lin, D., E. Tsuzuki, Y. Dong, H. Terao and T.D. Xuan, 2004. Potential biological control of weeds in rice fields by allelopathy of dwarf lilyturf plants. BioControl, 49: 187-196.

Lovett, J.V. and A.H.C. Hoult, 1975. Allelopathy and Self-Defence in Barley. In: Allelopathy, Organisms, Processes and Application, Inderjit, K.M., M. Dakshini and F.A. Einhellig (Eds.). American Chemical Society, USA., ISBN: 08-412-30617, pp: 170-183.

Mamun, A.A., 1988. Crop-Ecosystem: Weed Vegetation and Weed Management in Dakshin Chamuria and Jawar. Agricultural and Rural Development in Bangladesh. 1st Edn., JICA, Dhaka, Bangladesh. JSARD Publisher, Dhaka, Bangladesh, pp: 316-342.

Mattice, J., T. Lavy, B. Skulman and R.H. Dilday, 1998. Searching for allelochemicals in rice that control ducksalad. Proceedings of Workshop on Allelopathy in Rice, Nov. 25-27, International Rice Research Institute, Manila, Philippines, pp: 39-44.

Navarez, D. and M. Olofsdotter, 1996. Relay seedling procedure as screening method in allelopathy research. Proceeding of the 2nd International Weed Control Conference, June 25-28, Department of Weed control and pesticide Ecology, Slagelse, pp: 1285-1290.

Nimbal, C.I., C.N. Yerkes, L.A. Weston and S.C. Weller, 1996. Herbicidal activity and site of action of the natural product sorgoleone. Pestic. Biochem. Physiol., 54: 73-83.

Olofsdotter, M., D. Navarez and K. Moody, 1995. Allelopathic potential in rice (*Oryza sativa* L.). Ann. Appl. Biol., 127: 543-560.

Olofsdotter, M., D. Navarez, M. Rebulalan and J.C. Streibig, 1999. Weed-suppressing rice cultivars: Does allelopathy play a role? Weed Res., 39: 441-454.

Patrick, A.Q., T.A. Toussoun and A. Snyder, 1963. Phytotoxic substances in arable soils associated with decomposition of plant residues. Phytopathology, 53: 152-161.

Putnam, A.R. and W.B. Duke, 1974. Biological suppression of weeds: Evidence for allelopathy in accessions of cucumber. Science, 185: 370-372.

Rimando, A.M., M. Olofsdotter and S.O. Duke, 2001. Searching for rice allelochemicals. An example of bioassays-guided isolation. Agron. J., 93: 16-20.

Tamak, J.C., S.S. Naarwal, L. Singh and I. Singh, 1994. Effects of aqueous extract of rice stubbles and straw stubbles on the germination and seedling growth of wheat, oat, berseem and lentil. Crop Res., 8: 180-185.

Wu, H., J. Pratley, D. Lemerle and T. Haig, 1999. Crop Cultivars with Allelopathy Capability. Weed Res., 39: 171-180.