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Allelopathic Potential of Rice Varieties against Spinach (*Spinacia oleracea*)

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ABSTRACT

Two laboratory experiments were conducted to investigate the allelopathic effects of rice varieties on spinach (*Spinacia aleracea* L.). Fifteen rice varieties were included for evaluation. Two methods viz. Sandwich method and Relay seeding method were used to observe the allelopathic effects of rice varieties on seed germination, mean germination time, shoot and root length and dry matter production of spinach as a test crop. Average inhibition in spinach growth was calculated to evaluate the allelopathic potential of the rice varieties. All the selected varieties of rice were more or less detrimental to studied characters of spinach. WITA12 resulted in about 48% average percent inhibition of spinach growth. On the basis of average percent inhibition rice varieties ranked in order of WITA12>Dular>WITA3>BR26>BRRI dhan42>BRRI dhan39>BRRI dhan31>BRRI dhan44>BRRI dhan40>BR19>BRRI dhan43>BRRI dhan46>BRRI dhan47>BRRI dhan45>BRRI dhan28. Both the evaluation methods were positively correlated in determining percent reduction in most of the parameters of spinach due to allelopathic effects of rice. © 2010 Friends Science Publishers

Key Words: Allelopathy; Spinach; Sandwich method; Relay seeding method

INTRODUCTION

Allelopathy refers to any direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds. Exploring allelopathy for weed management in agricultural systems is an emerging area in science. Since mechanical control is very expensive and chemical control leads to environmental pollution and development of herbicide-resistant weeds, biological control using allelopathic rice variety is the alternate option to manage the weed problem in rice field. Allelopathic rice may also reduce the herbicidal dose if chemical control of weed is really needed (Christensen, 1995; Iqbal *et al.*, 2009). Screening of allelopathic rice varieties is, therefore important to plan a sustainable weed management programme in rice. Allelopathy in rice was first observed in 1980's in the seed production plots, which were naturally infested with duck salad (*Hetheranthera limosa*) at Arkansas Rice Research Institute, USA (Dilday *et al.*, 1989). Later allelopathic potential in rice has been reported in many countries such as, Japan (Fujii, 1992), Philippines (Olofsdotter & Navarez, 1996), Korea (Kim & Shin, 1998) and Egypt (Hasan *et al.*, 1998).

Allelopathic weed management options include either selecting an appropriate crop variety or incorporating an allelopathic character into a desired crop variety and/or applying residues and straw as mulches or growing an allelopathic variety in a rotational sequence that allows residues to remain in the field (Rice, 1995). Growing allelopathic rice may lead to reduction of weeding cost to a great extent. Moreover, due to reduction in herbicidal dose in controlling weeds in crop fields, it helps to reduce environmental pollution. Most allelochemicals are released during germination and early growth (Dekker & Meggitt, 1983). The allelopathic effect of rice on paddy weeds had a higher growth inhibition of root than shoot. Allelopathic accessions had six to nine times heavier root dry weights than non-allelopathic accessions (Dilday *et al.*, 1989).

Resource competition is difficult to separate from allelopathy under field conditions. To overcome this problem, various laboratory screening techniques have been developed to measure allelopathy without the interference of resource competition. Among several methods, sandwich method (Fujii *et al.*, 2003), agar medium selection (Fujii, 1992; Wu *et al.*, 1999), plant box method and relay seedling method (Navarez & Olofsdotter, 1996) have been reported and tested for bioassays. Because of proper seed germination and good response to allelochemicals, lettuce (*Lactuca sativa*) has been used as test species in allelopathic studies (Chou & Lin, 1976; Fujii, 1992).

The overall aim of this study was to evaluate 15 rice varieties and to screen out highly allelopathic variety of rice. To fulfill this aim the study was conducted to (i) observe the effects of root exudates of rice on the seed germination,

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plant growth and dry matter accumulation of spinach, (ii) find out the average inhibition in spinach growth due to allelopathic effects of rice varieties and (iii) compare two methods (Sandwich method & Relay seeding method) in determining the allelopathic potential of rice varieties.

MATERIALS AND METHODS

Plant material: Fifteen rice varieties used in the study with their important characteristics are presented in Table I. The selected rice varieties were collected from the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur and the spinach seeds were collected from the local market. The initial germination of the collected seeds was more than 80%. Two methods as Sandwich method and Relay seeding method were used to investigate the allelopathic potentials of rice varieties. However this Sandwich method has been modified from that of Fujii *et al.* (2003).

Sandwich method: An amount of 8 ml of 2% (w/v) of agar solution were poured in the sterilized Petri dish. The Petri dishes with agar solution were kept undisturbed for solidification. Fifteen smashed rice seeds of each variety were uniformly placed on the solidified agar medium in each Petri dish. Again the agar solution of same concentration was poured over the smashed seeds of rice in each Petri dish. After solidification of second layer of agar solution 15 clean and scarified spinach seeds were placed on agar medium in each Petri dish. In case of control treatment only agar media were used without smashed rice seeds. All the Petri dishes were placed in an incubation chamber at room temperature (20±2^{o}C). The experiment was continued up to 17 days after seed placement. The treatment was replicated four times in a completely randomized design (CRD). The theme of this method was that the smashed rice seeds released allelochemicals in the agar medium, which ultimately affected the spinach seed germination and seedling growth.

Relay seeding method: Fifteen rice seeds were placed on the Petri dishes lined with 9 cm Whatman No. 1 filter paper. Seven milliliter of distilled water was poured in each Petri dish. Then the Petri dishes were kept at the Agronomy Seed Laboratory, BAU, Mymensingh at room temperature (20±2^{o}C) and with 12 h light period. Fifteen clean and scarified seeds of spinach were placed in each Petri dish after 7 days of placement of rice seeds. In control treatment, 15 seeds of spinach were placed in Petri dish lined with filter paper and soaked with 7 mL distilled water only without rice seed. The experiment was continued for another 10 days in the Seed Laboratory. The treatments were replicated four times in CRD. Three mL of distilled water was poured to each Petri dish every 2 days to maintain sufficient moisture for germination. The theme of this technique was that the rice seedlings released allelochemicals in the germination media and the growth of the neighboring test plant (spinach) seedlings were affected due to allelochemicals.

Data collection: The number of germinated spinach seeds was counted daily from the 4th day (beginning of germination) of seed placement and was continued up to completion of seed germination. Mean germination time (MGT) was calculated using the data of daily germination as per the formula described by Nicolis and Heydecker (1968):

$$MGT = \frac{\Sigma nt}{\Sigma nt}$$

Where, n = number of newly germinated seed at 't' time and t = days from sowing.

After 17 days of seed setting, the root length and the shoot length of five randomly selected spinach seedlings were measured in both methods. The sample seedlings were placed in paper bags and then kept in an electric oven at 80^{o}C for 72 h. The weights of oven dried specimens were recorded. The percent reduction in germination, mean germination time, root length, shoots length and dry matter accumulation was determined by using the following formula:

$$\text{Percent reduction} = \frac{C-T}{C} \times 100$$

Where, C = value under control treatment (without rice) and T = value under treatment with rice.

The overall effects of rice varieties on the growth of spinach were determined on the basis of average percent inhibition (API) as API = (percent germination reduction + percent mean germination times reduction + percent root reduction + percent shoot reduction + percent dry weight reduction)/5, where 5=number of parameters included. The value of API was used as the indicator of allelopathic potentials of rice varieties. Higher value of API indicates higher allelopathic potential of the varieties and *vice versa*. Correlation between API and percent reduction in all growth parameters of spinach seedlings were done. Correlation between two methods in determining allelopathic potential of the rice varieties was also made. The collected data on different parameters of the indicator plant were statistically analyzed by using the statistical package MSTAT and the mean differences were adjudged using DMRT (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Effects on seed germination of spinach: Spinach seed germination was significantly affected by the allelopathic effect of all the test rice varieties under Sandwich method. The highest spinach seed germination (53.3%) was observed under control treatment (without smashed rice seeds) and the lowest (33.3%) was found in three rice varieties such as ITA12, BRRI dhan31 and BRRI dhan40 (Table II). Oppositely the highest percent reduction in

Table I: The origin, varietal type and morphological characteristics of test rice varieties

Variety	Origin of variety	Type	Maturity (days)	Culm height (cm)	Yield (t ha-1)
WITA12	Africa	Foreign	113	70	2.18
Dular	Bangladesh	Local	110	92	2.16
WITA3	Africa	Foreign	110	85	3.85
BR26	Bangladesh	Modern	115	115	4.40
BRRI dhan42	Bangladesh	Modern	100	100	3.50
BRRI dhan39	Bangladesh	Modern	122	106	4.50
BRRI dhan31	Bangladesh	Modern	140	115	5.00
BRRI dhan44	Bangladesh	Modern	145	130	6.50
BRRI dhan40	Bangladesh	Modern	145	110	4.50
BR19	Bangladesh	Modern	170	110	6.00
BRRI dhan43	Bangladesh	Modern	100	100	3.50
BRRI dhan46	Bangladesh	Modern	124	105	4.70
BRRI dhan47	Bangladesh	Modern	150	105	6.10
BRRI dhan45	Bangladesh	Modern	145	100	6.50
BRRI dhan28	Bangladesh	Modern	140	90	5.00

Note: Local varieties are those varieties which have been adapted to our environment and have been using by our farmers for long times, Modern varieties are those varieties which have been developed in Bangladesh Rice Research Institute (BRRI) by different breeding programmes, Foreign varieties are those varieties which have been collected from other countries and kept in germplasm for future research

Table II: Alleopathic effect of smashed rice seeds on percent germination, mean germination time, root length, shoot length and dry matter production of spinach under Sandwich method

Variety	Germination (%)	MGT (No. day^{-1})	Root length (cm)	Shoot length (cm)	Dry matter (mg)
Control	53.33a	2.00a	4.28a	5.97a	78.75a
WITA3	40.00bc	1.07ef	1.05f	3.11g	49.00ef
WITA12	33.33c	1.00f	0.99f	3.03g	43.00e
Dular	40.00bc	1.09def	0.95f	3.07g	46.00g
BR26	40.00bc	1.12def	1.47ef	3.50fg	51.75de
BRRI dhan 39	36.67bc	1.36bc	1.35ef	3.60efg	55.00de
BR19	40.00bc	1.31cd	2.38cd	4.38cd	64.00c
BRRI dhan 28	41.67b	1.55b	3.15bc	5.03b	70.25b
BRRI dhan 31	33.33c	1.38bc	2.43cd	4.11cd	64.75c
BRRI dhan 40	33.33c	1.24cde	1.87f	4.33cd	63.00c
BRRI dhan 42	43.33b	1.36bc	0.78f	4.06def	52.00de
BRRI dhan 43	40.00bc	1.27cde	2.47cd	4.37cd	64.00c
BRRI dhan 44	36.67bc	1.06ef	2.65bc	4.10e	54.25de
BRRI dhan 45	43.33b	1.31cd	3.36b	4.82bc	67.75bc
BRRI dhan 46	38.33bc	1.19cdef	2.99bc	4.43cd	70.75b
BRRI dhan 47	43.26b	1.28cde	2.88bc	4.47bcd	67.00bc
Level of Significance	***	***	***	***	***
CV. (%)	10.94	10.99	12.27	9.16	5.80

NB: *** Indicates Significant at 0.1% level of Probability and MGT indicates Mean germination time

spinach seed germination (37.5%) was obtained from rice varieties WITA12, BRRI dhan31 and BRRI dhan40 and the lowest was (18.8%) under the variety BRRI dhan28, BRRI dhan42 and BRRI dhan45 (Table III). A good number (11) of the varieties caused 25 to 37.5% reduction of germination of spinach.

Different kind of response from rice varieties on the seed germination of spinach was noticed under Relay seeding method. The highest spinach seed germination was observed under control treatment and BRRI dhan47 (Table IV). Comparatively higher percentage of germination of spinach seed in BRRI dhan47 was due to less suppressive allelopathic effect of that variety. On the other hand, spinach germination percentage under varieties WITA12 and BRRI dhan44 were less due to severe phytotoxic effects. The germinating rice seeds might have released different allelochemicals, which affected the seed germination of spinach. Similar inhibitory effect of rice on the seed germination of weed was reported by Sobhana *et al.* (1990), Gaffar *et al.* (1996) and Madhu *et al.* (1995). Among the rice varieties the highest reduction in spinach seed germination (27.09%) was in WITA12 and BRRI dhan44 and the lowest (8.3%) in BRRI dhan47 (Table V). No significant correlation between two methods was noted for the percent reduction of seed germination (data not shown).

Table III: Percent reduction in percent germination, mean germination time, root length, shoot length and dry matter production of spinach due to allelopathic effect of smashed rice seeds of different varieties under Sandwich method

Variety	Germination (%)	MGT (No. day^{-1})	Root length (cm)	Shoot length (cm)	Dry matter (mg)	API
WITA3	25.00	46.5	75.47	47.91	37.78	46.52
WITA12	37.50	50	76.87	49.25	45.40	51.70
Dular	25.00	45.5	77.80	48.58	41.59	47.84
BR26	25.00	44	65.65	41.37	34.29	41.94
BRRI dhan 39	31.24	32	68.46	39.70	30.16	40.19
BR19	25.00	34.5	44.39	26.63	18.73	29.86
BRRI dhan 28	21.86	22.5	26.40	15.75	10.79	19.26
BRRI dhan 31	37.50	31	43.22	31.16	17.78	32.05
BRRI dhan 40	37.50	38	56.31	27.47	20.00	35.83
BRRI dhan 42	18.75	32	81.78	31.99	33.97	39.58
BRRI dhan 43	25.00	36.5	42.29	26.80	18.73	29.91
BRRI dhan 44	31.24	47	38.08	31.32	31.11	33.17
BRRI dhan 45	18.75	34.5	21.50	19.26	13.97	21.26
BRRI dhan 46	28.13	40.5	30.14	25.80	10.16	26.82
BRRI dhan 47	18.88	36	32.71	25.13	14.92	25.46

NB: MGT=Mean germination time and API=Average percent inhibition

Effect on mean germination time (MGT) of spinach: The mean germination time (MGT) of spinach seed was significantly affected by the allelopathic effect of rice varieties (Table II). The result showed that a good number (6) of varieties caused 40-50% reduction of mean germination time of spinach and 30-40% reduction caused by rest of the varieties (Table III). Among the rice varieties, the highest percent reduction in MGT of spinach seed was 50% under the variety WITA12 and the lowest reduction was 31% under the variety BRRI dhan31 (Table III).

The effect of rice allelopathy on the MGT of spinach under Relay seeding method was different than the Sandwich method. The highest MGT reduction due to allelopathic rice varieties was 30.8% in case of rice variety WITA3 and the lowest was 11.9% due to rice variety BRRI dhan43 (Table V). Three varieties caused more than 25% of reduction such as, BR26, BRRI dhan45 and WITA12. A good number (7) of varieties caused more than 20% reduction in MGT and the rest 5 varieties caused less than

Table IV: Allelopathic effect of different rice varieties on percent germination, mean germination time, root length, shoot length and dry matter production of spinach under Relay seeding method

Variety	Germination (%)	MGT (No. day^{-1})	Root length (cm)	Shoot length (cm)	Dry matter (mg)
Control	80.00a	1.85a	5.40a	6.71a	76.00a
WITA3	63.33cd	1.28c	2.34efgh	4.00efg	49.25efg
WITA12	58.33d	1.37bc	1.69h	3.15g	40.50g
Dular	60.00cd	1.44bc	2.12fgh	3.67fg	46.75fg
BR26	65.00bcd	1.30c	2.36efgh	4.23def	55.50def
BRRI dhan 39	68.33bc	1.55bc	2.43efgh	4.71cde	56.50de
BR19	66.67bcd	1.47bc	2.89cdef	4.96cd	63.25bcd
BRRI dhan 28	68.33bc	1.41bc	4.27b	5.85b	63.50bcd
BRRI dhan 31	63.33cd	1.45bc	2.02gh	3.79fg	57.75cde
BRRI dhan 40	63.33cd	1.53bc	2.15cde	4.80cde	62.00bcd
BRRI dhan 42	60.00cd	1.53bc	2.48efgh	4.28def	55.25def
BRRI dhan 43	65.00bcd	1.63abc	2.92cdef	4.73cde	61.25bcd
BRRI dhan 44	58.33d	1.41bc	2.77defg	4.76cde	60.00bcd
BRRI dhan 45	68.33bc	1.36bc	3.66bc	4.63bc	67.75ab
BRRI dhan 46	65.00cd	1.42bc	3.53bcd	5.88b	67.00bc
BRRI dhan 47	73.33ab	1.52bc	3.61bc	4.95cd	62.50bcd
Level of Significance	***	*	***	***	***
CV (%)	7.92	13.05	7.23	11.94	10.05

NB: * Indicates Significant at 5% level of Probability, *** Indicates Significant at 0.1% level of Probability and MGT indicates Mean germination time

Table V: Percent reduction in germination percentage, mean germination time, root length, shoot length and dry matter production of spinach due to allelopathic effect of different rice varieties under Relay seeding method

Variety	Germination (%)	MGT (No. day^{-1})	Root length (cm)	Shoot length (cm)	Dry matter (mg)	API
WITA3	20.84	30.81	56.67	40.39	35.20	36.56
WITA12	27.09	25.95	68.70	53.06	46.71	44.01
Dular	25.00	22.16	60.74	45.31	38.49	37.99
BR26	18.75	29.73	56.30	36.96	26.97	33.66
BRRI dhan 39	14.59	16.22	55.00	29.81	25.66	27.85
BR19	16.66	20.54	46.48	26.08	16.78	25.06
BRRI dhan 28	14.59	23.78	20.93	12.82	16.45	17.56
BRRI dhan 31	20.84	21.62	62.59	43.52	24.01	34.30
BRRI dhan 40	20.84	17.30	41.67	28.46	18.42	25.15
BRRI dhan 42	25.00	17.30	54.07	36.21	27.30	32.08
BRRI dhan 43	18.75	11.89	45.93	29.51	19.41	24.93
BRRI dhan 44	27.09	23.78	48.70	29.06	21.05	29.80
BRRI dhan 45	14.59	26.49	32.22	16.10	8.22	19.18
BRRI dhan 46	18.75	23.24	34.63	12.37	11.84	20.02
BRRI dhan 47	8.34	17.84	33.15	26.23	17.76	20.37

NB: MGT=Mean germination time and API=Average percent inhibition

20% reduction (Table V). No correlation between two methods in determining the percent reduction in MGT was noticed (data not shown).

Effect on root length of spinach: A significant effect of smashed seeds of different rice varieties on the root length of spinach was observed in the study under Sandwich method. Four varieties namely, BRRI dhan42, WITA12, Dular and WITA3 caused more than 75% reduction of root length of the spinach (Table III). Six varieties caused 65 to 82% reeducation and 21 to 56% root length reduction was caused by other 9 varieties.

More or less similar significant effect of rice allelopathy on the root length of spinach was noticed in Relay seeding method (Table IV). The allelopathic effect of rice varieties caused, on an average, 47.9% reduction in root length of spinach. Three varieties (WITA12, BRRI dhan31 & Dular) caused more than 60% root length reduction (Table V). Four varieties caused more than 50% reduction of root length of spinach and 30-50% root length was reduced by rest eight varieties of rice. On the basis of root length reduction, WITA12 was the most allelopathic variety, while BRRI dhan28 was the least. The detrimental effect of rice exudates caused stunted roots with pruned root tips. In some cases the tip of the spinach became discolored. Kim *et al.* (1999) and Chung *et al.* (1995) also observed similar detrimental effects of rice exudates on the root length of *E. crusgalli*. Recently, Karim and Ismail (2007) observed that rice varieties namely Manik and Makmuer caused more than 80% and 75% reduction of root length of *E. crusgalli*, respectively due to their allelopathic effect. Therefore it is obvious that genotypic diversities existed among the rice varieties with respect to their allelopathic potentialities in inhibiting the root growth of spinach.

Effect on shoot length of spinach: The effect of smashed rice seeds of different varieties on the shoot length of spinach was similar to that on the root length. The variety WITA12 caused the highest (>49%) reduction (Table III). Four varieties namely WITA12, WITA3, Dular and BR26 were found to cause 41-49% reduction of shoot length and other nine varieties caused more than 25% reduction of spinach shoot length (Table III).

The effect of rice root exudates on the shoot length of spinach under Relay seeding method was similar to that Sandwich method. Significant reduction of shoot length of spinach was also caused due to allelopathic effect of the rice varieties (Table IV). The variety WITA12 caused the highest (>53%) reduction (Table V). Three varieties caused more than 40% reduction of shoot length of spinach namely, Dular, BRRI dhan31 and WITA3. Eight varieties namely, BR26, BRRI dhan42, BRRI dhan39, BR19, BRRI dhan40, BRRI dhan43, BRRI dhan44 and BRRI dhan47 were found to cause 25 to 40% reduction of shoot length of spinach and the rest three varieties also caused <20% of reduction of spinach shoot.

Stunting effect of rice allelopathy on the shoot length of spinach was also noted in the study. Therefore allelochemicals might be released from the smashed seeds of rice, or root exudates, which inhibited the shoot growth of the test plant. Similar effect of rice on the shoot growth of *Echinochloa crus-galli* was also found by Karim and Ismail (2007). However, some varieties like BRRI dhan28 and BRRI dhan45 caused very little reduction (<20%) of shoot length. All these variability in effects of rice varieties on the shoot length of spinach also support the fact that rice varieties posses differential genotypic characteristics related

Fig. 1: Correlation between average inhibition and different parameters of spinach growth under Sandwich method; reduction in (a) root length, (b) shoot length, (c) dry matter and (d) germination percentage

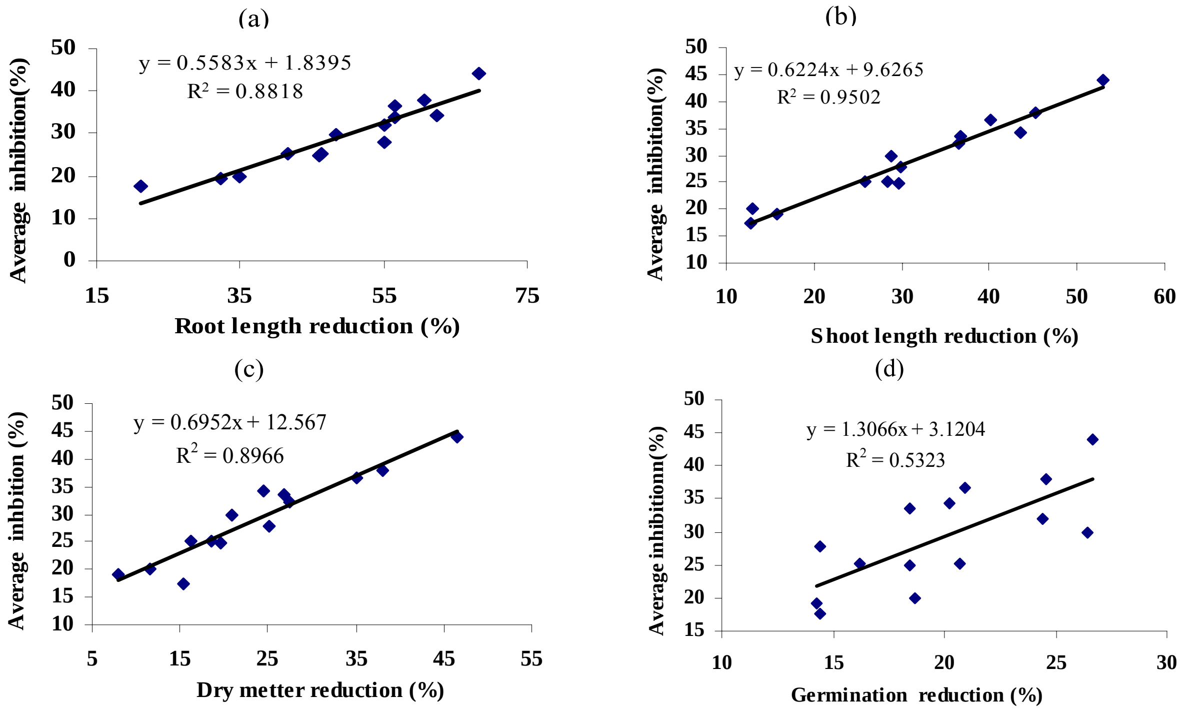
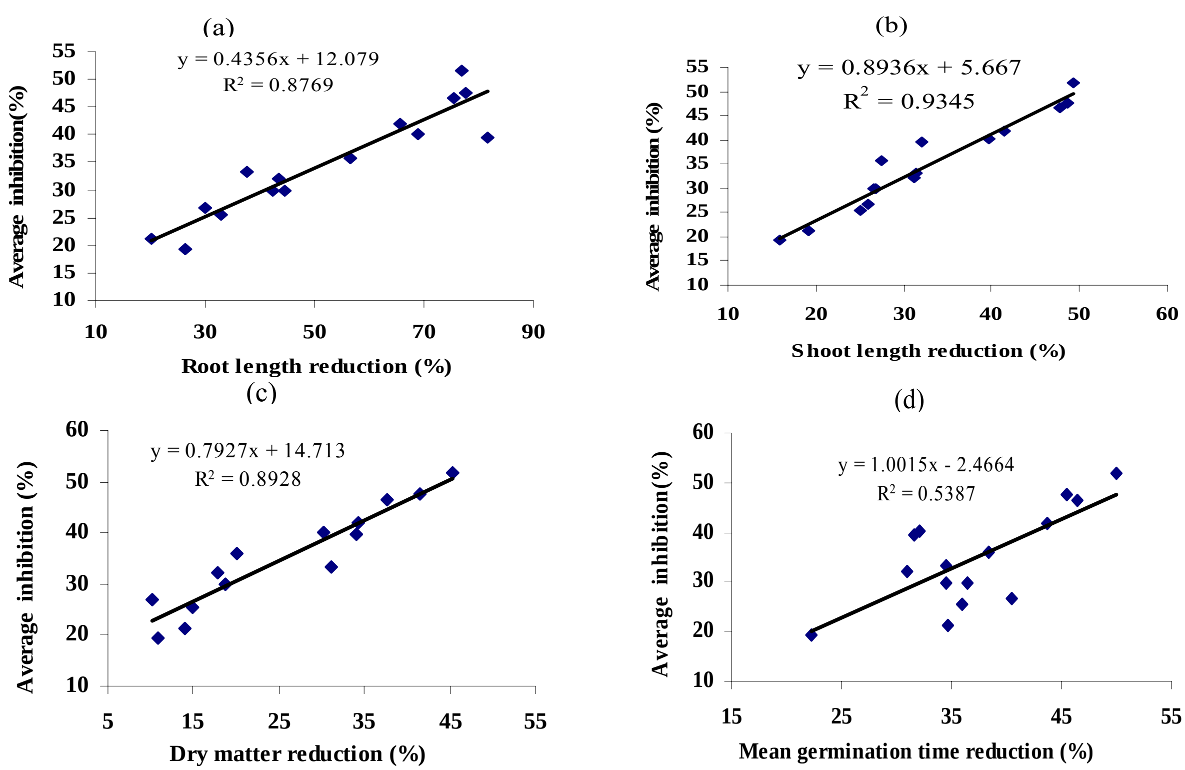


Fig. 2: Correlation between average inhibition and different parameters of spinach growth under Relay seeding method; reduction in (a) root length, (b) shoot length, (c) dry matter and (d) mean germination time reduction



to allelopathy. In this study no stimulating effect of rice varieties was found although Karim and Ismail (2007) observed the increase in root length and shoot length of *E. crusgalli* in some cases. Rice (1984) stated that stimulatory effects could occur at lower concentration of allelopathic substances, while higher concentration may cause inhibitory effects.

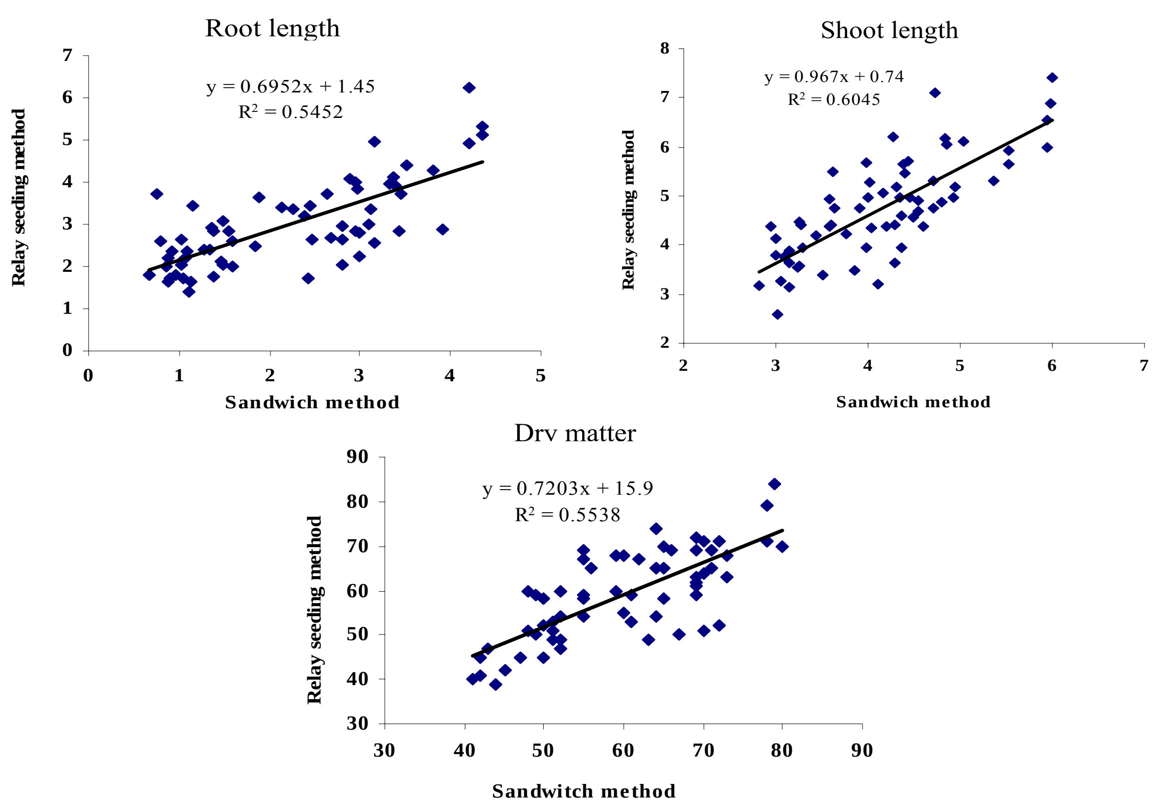
Effect on dry matter of spinach: The effects of smashed rice seeds on the root and shoot length of spinach was reflected on the dry matter production of the spinach. Significant reduction of spinach dry matter was noted due to allelopathic effect of different rice varieties used in the study. The highest reduction of spinach dry matter was caused by the variety WITA12 (45.4% reduction) followed by the variety Dular (41.6%) (Table III). Five varieties caused more than 30% reduction e.g., WITA3, BR26, BRRI dhan42, BRRI dhan44 and BRRI dhan39. Seven varieties caused less than 20% reduction in spinach dry matter. Thus, on the basis of reduction percentage of dry matter, WITA12 was the most allelopathic, while BRRI dhan46 was the least.

The effect of rice root exudates on the dry matter of spinach under Relay seeding method was similar to that of Sandwich method. Significant reduction of spinach dry matter was noted due to allelopathic effects of rice varieties (Table IV). The highest reduction of dry matter was caused by the variety WITA12 and the lowest was caused by the variety BRRI dhan45 (Table V). Seven varieties (Dular, WITA3, BRRI dhan42, BR26, BRRI dhan39, BRRI dhan31 and BRRI dhan44) caused 20-40% reduction, and the rest of the varieties caused less than 20% reduction of dry matter of spinach.

Average percent inhibition (API) of spinach: When the average percentage of inhibition was calculated, it was observed that all the selected rice varieties showed significant spinach inhibition under Sandwich method. The percent inhibition ranged from 19.3 to 51.7% (Table III). The highest percent inhibition of the spinach was under the effects of variety WITA12, which was followed by Dular and the lowest reduction was noticed in the variety BRRI dhan28 (Table III). The average percent inhibition was positively correlated to (a) percent root length reduction, (b) percent shoot length reduction, (c) percent dry matter reduction and (d) percent MGT reduction, but reduction in germination percentage (R2=0.17), was not related to average percent inhibition (API) (Fig. 1).

In case of Relay seeding method similar results were also noticed in respect of API of spinach growth. The highest value of API was found in the variety WITA12 (44.0%), which was followed by Dular (38.0%) and the lowest API (17.6%) was marked in BRRI dhan28 (Table V). The average percent inhibition was positively correlated to (a) percent root length reduction, (b) percent shoot length reduction, (c) percent dry matter reduction and (d) the MGT reduction but percent germination reduction was not related to average percent inhibition spinach (R2=0.07) (Fig. 2). Results of the study were in agreement with those reported

Fig. 3: Correlation between two methods in measuring root length, shoot length and dry matter of spinach



by Dilday *et al.* (1994), Chung *et al.* (1995), Ahn and Chung (2000) and Olofsdotter *et al.* (1995). All those parameters of test weed were reduced by the allelopathic effects of rice. However the authors used different rice varieties in their studies except Dular, which was included in the study of Olofsdotter *et al.* (1995). The variety was also found as allelopathic to Barnyard grass. It is believed that different results among studies are due to different genetic factors and climatic conditions of the experiments. A highly significant positive relationship was noticed between the two methods in measuring shoot length, root length and dry matter reduction of spinach indicating the appropriateness of using both the methods in investigating allelopathic potentiality of rice varieties (Fig. 3).

CONCLUSION

All the tested rice varieties had significant allelopathic influences on spinach growth and the variety WITA12 had the highest allelopathic potential than others. The ranking order of the test varieties on the basis of API values was WITA12 > Dular > WITA3 > BR26 > BRRI dhan42 > BRRI dhan39 > BRRI dhan31 > BRRI dhan44 > BRRI dhan40 > BR19 > BRRI dhan43 > BRRI dhan46 > BRRI dhan47 > BRRI dhan45 > BRRI dhan28. Three varieties namely WITA 12, Dular and WITA3 exhibited more than 40% spinach inhibition. These varieties can be used as gene resources for breeding for allelopathic potentiality and can be incorporated with high yielding rice varieties to generate allelopathic high yielding rice.

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