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ALLELOPATHIC EFFECTS OF RICE STRAW EXTRACT ON DIFFERENT CROPS AND WEEDS

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ABSTRACT

A lab experiment entitled “Allelopathic effects of rice straw extracts roots and shoots on different crops and weeds” was conducted at Weed Science Laboratory, Institute of Plant Environmental Protection, National Agricultural Research Center (NARC), Islamabad during 2007 with a factorial arrangement (species and extract concentration) to evaluate the allelopathic effect of various concentrations of rice straw extract on various growth parameters of different test plants. The ANOVA revealed statistically significant ($P \leq 0.01$) differences for extracts, test species and their two and three-way interactions. The whole experiment was repeated once to confirm the findings. Data were recorded during the course of studies on root and shoot length, fresh and dry biomass. The rice plants (Basmati super) were collected from experimental fields of NARC, Islamabad Pakistan to obtain the extracts. Only stems and leaves of rice plants were used for the extraction. The concentrations of 0, 50 and 100% were used for the bioassay. A total of 90 Petri dishes were sterilized in autoclave at 110-120°C for 1 hour. Two filter papers and ten seeds of each test plant were placed in each Petri dish, kept at room temperature of 20°C for 15 days. It was inferred from the results that 100% rice straw extract significantly decreased the germination and growth of test plants as compared to 0 and 50% rice straw extracts. *Gossypium hirsutum* from the crop species and *Ipomoea batatas, Rumex dentatus* and *Convolvulus arvensis* from the weed species were most affected by the rice extracts; whereas *Helianthus annuus*, *Zea mays, Oryza sativa* and *Vigna radiata* were somewhat resistant to the extracts. Therefore, allelopathy of rice straw can be utilized as an alternative environment friendly bio-herbicide for weed management in future.

Keywords: *Oryza sativa*, allelopathy, crops, rice straw extracts, root, shoot, weeds.

INTRODUCTION

Allelopathy is derived from the Greek words *allelon* "of each other" and *pathos* "to suffer" (Rizvi *et al*., 1992). Allelopathy refers to the effects of one plant on another plant in crop and weed species, by the release of chemicals from plant parts and also through the release of compounds into the environment via root exudation, leaching by dews and rains, and volatilization or decaying plant tissue. In most cases, the compounds inhibit the germination or growth of neighboring plants although sometimes the compounds stimulate their growth (Rice, 1984). Allelopathic effects can include poor germination, impaired root growth and stunted shoot growth. Neighbor plants are affected through leaching, root exudation, residue decomposition and other processes. Myriad of chemical compounds including gases to multi-ringed compounds have been identified as being allelopathic. These chemical compounds can be toxic gases, organic acids, aromatic acids, unsaturated lactones, couramins, quinones, flavonoids, tannins, alkaloids, terpenoids and steroids, miscellaneous and unknown (Rice, 1984).

Rice (1984) found allelopathic effects in accessions of maize (*Zea mays* L.), wheat (*Triticum aestivum* L.), oat (*Avena sativa* L.), pea (*Pisum sativum* L.), barley (*Hordeum vulgare* L.), and cucumber (*Cucumis sativus* L.). Putnam and Duke (1974) screened a total of 538 accessions of cultivated and wild cucumber screened through pot and field tests, in which several accessions inhibited the growth of weeds. Out of more than 3000 accessions of oat with the help of a fluorescent microscope, Fay and Duke (1977) found several to exude a large amount of an allelo-chemical called, scopoletin.

On the other hand, several weed species have been reported to show allelopathic properties including couch grass, creeping thistle and chickweed (Rizvi *et al*., 1992); when they occur together they may have a synergistic negative effect on crops (Putnam and Duke, 1974). These chemicals/analogs could provide important new sources of agricultural chemicals for the future. Allelopathy has two approaches for weed control i.e., production of crops that suppress associated weeds and as natural herbicides. Considerable evidence suggests that some of the more aggressive perennial weed species including *Cirsium arvense*, *Sorghum halepense* and *Cyperus rotundus* that impose allelopathic influences particularly through toxins released from their residues. Extracts of several important weed species e.g. *Digit aria sanguinalis* inhibit the nodulation of legumes (Rizvi *et al*., 1992).

Keeping in view the importance of allelopathy in agro ecosystems an experiment was conducted at NARC Islamabad Pakistan with the objectives to study the allelopathic effects of rice straw, to utilize allelopathic materials for control of weeds, to quantify the relative tolerance of different weeds and crop species to the extracts, and to decipher the interaction of different extract concentrations and various crop and weed species.

MATERIALS AND METHODS

An experiment was conducted at the Weed Science Laboratory, National Agricultural Research Center (PARC) Islamabad Pakistan during September 2007. Rice plants (Basmati super) were collected from experimental fields of NARC Islamabad. The samples were cleaned, dried, ground and then put into water for 48 hours to obtain the extract. The stems + leaves of rice were used for extraction. The aqueous extract was prepared by adding 100g of ground rice straw (stem + leaves) into 1 L distilled water for 48 hours.

The extracts were filtered through muslin cloth and finally through Whatman No. 1 filter paper; 0 (untreated check), 50 and 100% aqueous extracts were used for the bioassay. For testing, 90 Petri dishes were washed and dried which were then sterilized in autoclave at 110 -120^{o}C for 1 hour. Two filter papers were kept in each Petri dish and ten seeds of each test plants were placed. All the experimental Petri dishses were kept at room temperature of 20°C for 15 days.

Test plants

Crops	Weeds
Zea mays (maize)	*Rumex dentatus* (Broad leaf dock)
Gossypium hirsutum (cotton)	*Sorghum halepense* (Johnson grass)
Vigna radiata (mungbean)	*Echinochola crusgalli* (Barnyard grass)
Helianthus annuus (sunflower)	*Convolvulus arvensis* (Field bind weed)
Oryza sativa (cultivated rice)	*Ipomoea batatas* (Ipomoea)

The following concentrations of the extract were used in the experiment.

a) = 0 percent (Distilled Water)
b) = 50 percent rice straw extract
c) = 100 percent rice straw extract

Each treatment was replicated three times in completely randomized design with a factorial arrangement (species and extract concentrations). The whole experiment was repeated once to confirm the findings. Data on root length shoot length, fresh biomass plant^{-1} (g), and dry biomass plant^{-1} (mg).

Statistical analysis

The data for each parameter were subjected to the analysis of variance technique and the significant means were separated by Duncan's Multiple Range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSIONS

Root length (cm)

The analysis of variance revealed highly significant ($P \leq 0.01$) differences for rice straw extracts, test species, experimental runs and their two and three-way interactions (Table-1a). The mean values exhibited that maximum (5.1cm) root length was recorded in untreated check while minimum (1.9cm) root length was recorded in 100% rice straw extract. Among the test plants the maximum (4.7cm) root length was recorded in *V. radiata* while minimum (2.2cm each) root length was recorded in *G. hirsutum* and *R. dentatus*. Among Extracts x Species interaction the maximum root length was recorded in untreated check x *V. radiata* (7.0cm) while minimum (0.4cm each) root length was recorded in 100% rice straw extract x *G. hirsutum* and *R. dentatus*. Variability was exhibited among the Runs, as far as their interactions are concerned. The higher (3.8cm) mean of the root length was recorded in Run2nd while lower (3.2cm) mean of the root length was recorded in Run1st. Among Runs x Species interactions the maximum root length was recorded in Run 2nd x *V. radiata* (5.06cm) while minimum root length was recorded in Run 1st x *R. dentatus* (1.99cm) it was however statistically comparable with the *G. hirsutum* under the First (2.20cm) and the Second Run (2.22cm) respectively. The mean values (Table-1c) indicated that 100% rice straw extract affected/decreased more root length as compared to untreated check in most of the test plants. Among Runs x Species x Extract interactions maximum root length was recorded in untreated check x *V. radiata* (7.2cm), which shared statistical significance with *V. radiata* under the First Run (6.72cm) while minimum (0cm) root length was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis* test plants, respectively under the same Run. This study shows that 100% of rice straw extract inhibited the growth and development of some of the test plants i.e., *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis*.

The results are in agreement with those of Smith (1989) who concluded that plant extracts negatively affected the seed germination and/or the plant growth. Similarly, *Acacia* species retarded the plant growth and development (Velu *et al*., 1996; Ahn and Chung, 2000). A reduction in *Z. mays* root growth by *Eucalyptus* extracts has also been reported (Khan *et al*., 1999; Sanginga and Swift, 1992).

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Table-1(a). Effect of rice straw extract on extract x Species means for root length (cm).

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	5.5 c	3.8 gh	2.7 i	4.0 c
Oryza sativa	4.2 fg	3.7 gh	2.5 ij	3.5 d
Zea mays	5.3 cd	3.9 gh	2.4 ij	3.9 c
Vigna radiate	7.0 a	4.5 efg	2.7 i	4.7 a
Gossypium hirsutum	3.6 h	2.6 i	0.4 l	2.2 e
Ipomoea batatas	5.7 bc	3.9 gh	1.2 k	3.6 d
Sorghum halepense	6.2 b	4.5 ef	2.7 i	4.4 b
Rumex dentatus	3.8 gh	2.3 ij	0.4 l	2.2 e
Convolvulus arvensis	4.9 de	3.6 h	1.3 k	3.3 d
Echinochola crusgalli	5.2 cd	3.6 h	2.0 j	3.6 d
Extract Means	5.1 a	3.6 b	1.9 c	

LSD $_{0.05}$ for Test species = 0.2952, LSD $_{0.05}$ for Extracts = 0.11617, LSD $_{0.05}$ for Interaction = 0.5112

Table-1(b). Effect of rice straw extract on runs x species x extracts means for root length (cm).

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	5.1 defgh	3.5 lmn	2.5 pqr
	Oryza sativa	3.9 jklm	3.5 lmn	2.6 opqr
	Zea mays	4.7 ghij	3.7 klm	2.4 pqr
	Vigna radiate	6.7 ab	3.7 klm	2.6 opqr
	Gossypium hirsutum	3.4 lmno	3.2 mnop	0.0 u
	Ipomoea batatas	5.2 defg	3.6 lmn	0.0 u
	Sorghum halepense	6.1 bc	4.2 hijkl	2.8 nopq
	Rumex dentatus	3.8 klm	2.2 qr	0.0 u
	Convolvulus arvensis	4.7 ghij	3.6 lmn	0.0 u
	Echinochola crus-galli	4.9 fghi	3.4 lmno	1.9 rs
Run 2nd	*Helianthus annuus*	5.8 cde	4.1 ijkl	2.8 mopq
	Oryza sativa	4.5 ghijk	3.9 jklm	2.5 pqr
	Zea mays	5.9 bcd	4.1 ijkl	2.5 pqr
	Vigna radiate	7.2 a	5.2 efg	2.8 nopq
	Gossypium hirsutum	3.9 jklm	2.0 qrs	0.8 t
	Ipomoea batatas	6.2 bc	4.1 ijkl	2.3 qr
	Sorghum halepense	6.3 bc	4.7 ghij	2.6 opqr
	Rumex dentatus	3.9 jklm	2.5 pqr	1.3 st
	Convolvulus arvensis	5.0 efgh	3.7 klm	2.6 opqr
	Echinochola crus-galli	5.6 cdef	3.9 jklm	2.1 qr

LSD $_{0.05}$ value for Interaction = 0.7230

Shoot length (cm)

The analysis of variance revealed highly significant (P≤0.01) differences for rice straw extracts, test species, experimental runs and their two and three-way interactions (Table-2a). Variability exhibited among the test species, as far as their shoot length is concerned

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(Table-2a). The maximum (11.9cm) mean of the shoot length was noticed in untreated check while minimum (3.6cm) mean of the shoot length was recorded in 100% rice straw extract. Among test plants the maximum (10.6cm) mean of the shoot length was recorded in *Z. mays* while minimum (2.6cm) mean of the shoot length was recorded in *R. dentatus*. Among Extract x Species interactions the maximum shoot length was recorded in untreated check x *Z. mays* (15.9cm), *H. annuus* (15.5cm) and *V. radiata* (15.6cm) while, minimum shoot length was recorded in 100% rice straw extract x *R. dentatus* (0.8cm) and *G. hirsutum* (1.1cm). Among Runs x Species x Extract interactions the maximum shoot length was recorded in untreated check x *Z. mays* (16.6cm) in Run 2^{nd} which was however statistically at par with *V. radiata* (16.0cm) and *H. annuus* (16.2cm) under untreated check and the same Run (Table-2b). While minimum (0cm) shoot length was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis.* In case of 100% rice straw extract showed inhibitory effect on the shoot length as compared to untreated check. It can be concluded from the results that rice straw extract is most harmful extract for *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis* because it has inhibiting allelochemicals to suppress the growth and development of these test plants.

This study showed analogous results with Pawar and Chawan (1999) who reported that some plant extracts including *E. globolus* reduced uptake of Ca, Zn and Mg in *sorghum* resulting in reduced growth and development. Chung *et al*. (2003) also observed that the part of rice plant inhibited/reduced the growth of most test plants. These findings are also in agreement with the work of Khan *et al*. (2004a and b) who found inhibitory role of *Eucalyptus* on wheat crop and some of its associated weeds.

Table-2(a). Effect of rice straw extract on extract x species means for shoot length (cm).

Tested plants	**0**	**50%**	**100%**	**Test plant means**
Helianthus annuus	15.5 a	10.5 cd	5.2 i	10.4 ab
Oryza sativa	13.8 b	6.9 h	4.7 ij	8.5 d
Zea mays	15.9 a	10.8 c	5.2 i	10.6 a
Vigna radiata	15.6 a	9.8 e	5.1 i	10.2 b
Gossypium hirsutum	7.7 g	3.9 k	1.1 n	4.2 f
Ipomoea batatas	13.7 b	9.1 f	2.6 l	8.5 d
Sorghum halepense	9.1 f	5.2 i	4.3 jk	6.2 e
Rumex dentatus	4.4 jk	2.5 l	0.8 n	2.6 g
Convolvulus arvensis	10.0 de	6.3 h	1.8 m	6.0 e
Echinochola crusgalli	13.8 b	9.6 ef	5.1 i	9.5 c
Extract means	11.9 a	7.5 b	3.6 c	

LSD $_{0.05}$ for Test species = 0.3492, LSD $_{0.05}$ for Extracts = 0.1913, LSD $_{0.05}$ for Interaction = 0.6049

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Table-2(b). Effect of rice straw extract on runs x species x extracts means for shoot length (cm).

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	14.8 c	9.2 gh	4.7 stuvw
	Oryza sativa	13.0 d	6.3 mno	3.8 wx
	Zea mays	15.1 bc	9.6 g	4.3 uvwx
	Vigna radiate	15.2 bc	9.6 g	4.3 uvwx
	Gossypium hirsutum	7.2 klm	3.5 xy	0.0 \
	Ipomoea batatas	13.6 d	8.1 ijk	0.0 \
	Sorghum halepense	8.2 ij	4.6 tuvw	4.1 vwx
	Rumex dentatus	4.2 uvwx	2.2 z	0.0 \
	Convolvulus arvensis	9.2 gh	5.7 opqr	0.0 \
	Echinochola crusgalli	12.9 d	8.5 hi	4.9 rstuv
Run 2nd	*Helianthus annuus*	16.2 a	11.8 e	5.6 opqrs
	Oryza sativa	14.6 c	7.5 jkl	5.6 opqrs
	Zea mays	16.6 a	12.0 e	6.2 nop
	Vigna radiata	16.0 ab	10.0 fg	5.9 nopq
	Gossypium hirsutum	8.1 ijk	4.3 uvwx	2.2 z
	Ipomoea batatas	13.7 d	10.1fg	5.3 pqrst
	Sorghum halepense	10.0 fg	5.9 nopq	4.5 tuvwx
	Rumex dentatus	4.6 tuvw	2.8 yz	1.7 [
	Convolvulus arvensis	10.8 f	6.8 lmn	3.5 xy
	Echinochola crusgalli	14.7 c	10.7 f	5.2 qrstu

LSD $_{0.05}$ value for Interaction = 0.8554

Fresh biomass (g)

The analysis of variance revealed highly significant (P≤0.01) differences for rice straw extracts, test species, experimental runs and their two and three-way interactions (Table-3a). The mean values (Table-3a) regarding fresh biomass manifested that maximum (0.3g) fresh biomass was recorded in untreated check while minimum (0.2g) fresh biomass was recorded in both concentrations of rice straw extract. Among test plants the higher (0.5g) fresh biomass was recorded in *Z. mays* while lower (0.1g) fresh biomass was recorded in *G. hirsutum* and *R. dentatus.* Among Extract x Species interactions the maximum fresh biomass was recorded in untreated check x *Z. mays* (0.6g) while minimum (0.1g) fresh biomass was recorded in both rice straw extracts x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis.* Variability existed among the test species, as far as their fresh biomass is concerned (Table-3b). Among Runs x Species x Extracts interaction the maximum fresh biomass was recorded in untreated check x *Z. mays* (0.6cm) while minimum (0g) fresh biomass was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis.* This study revealed that all the rice straw extracts reduced fresh biomass of *G. hirsutum*, *I. batatas, R. dentatus* and *C. arvensis* as compared to untreated check. Rice straw extract might have helped in release of more allelochemicals to affect these test plants. Sanginga and Swift (1992) reported similar findings; whereas Lisanework and Michelson (1993) stated that sunflower extracts reduced the fresh biomass of most of the test plants. James *et al.* (1982) reported that soaked extracts caused more reduction in weed seed germination. Khan *et al*. (2004 a and b) have also demonstrated the inhibition reduction in fresh biomass due to leaf extracts of *eucalyptus* and some other forest species.

Table-3(a). Effect of rice straw extract on extract x species means for fresh biomass (g).

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	0.4 b	0.3 bc	0.3 bc	0.4 b
Oryza sativa	0.3 bc	0.2 cd	0.2 cd	0.2 d
Zea mays	0.6 a	0.4 b	0.4 b	0.5 a
Vigna radiata	0.2 cd	0.3 bc	0.2 cd	0.2 d
Gossypium hirsutum	0.2 cd	0.1 d	0.1 d	0.1 e
Ipomoea batatas	0.3 bc	0.1 d	0.1 d	0.2 d
Sorghum halepense	0.3 bc	0.2 cd	0.2 cd	0.2 d
Rumex dentatus	0.1 d	0.1 d	0.1 d	0.1 e
Convolvulus arvensis	0.2 cd	0.1 d	0.1 d	0.2 d
Echinochola crusgalli	0.4 b	0.3 bc	0.2 cd	0.3 c
Extract Means	0.3 a	0.2 b	0.2 b	

LSD $_{0.05}$ for Test species = 0.09333, LSD $_{0.05}$ for Extracts = 0.05112, LSD $_{0.05}$ for Interaction = 0.1617

Table-3(b). Effect of rice straw extract on runs x species x extracts means for fresh biomass (g).

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	0.4 abc	0.3 bcd	0.3 bcd
	Oryza sativa	0.3 bcd	0.2 cde	0.2 cde
	Zea mays	0.5 ab	0.4 abc	0.4 abc
	Vigna radiata	0.2 cde	0.1 de	0.2 cde
	Gossypium hirsutum	0.2 cde	0.1 de	0.0 e
	Ipomoea batatas	0.3 bcd	0.1 de	0.0 e
	Sorghum halepense	0.3 bcd	0.1 de	0.1 de
	Rumex dentatus	0.1 de	0.1 de	0.0 e
	Convolvulus arvensis	0.1 de	0.1 de	0.0 e
	Echinochola crusgalli	0.3 bcd	0.3 bcd	0.2 cde
Run 2nd	*Helianthus annuus*	0.5 ab	0.4 abc	0.3 bcd
	Oryza sativa	0.3 bcd	0.2 cde	0.1 de
	Zea mays	0.6 a	0.5 ab	0.4 abc
	Vigna radiata	0.2 cde	0.1 de	0.2 cde
	Gossypium hirsutum	0.2 cde	0.1 de	0.1 de
	Ipomoea batatas	0.3 bcd	0.2 cde	0.1 de
	Sorghum halepense	0.3 bcd	0.2 cde	0.2 cde
	Rumex dentatus	0.1 de	0.1 de	0.1 de
	Convolvulus arvensis	0.2 cde	0.1 de	0.2 cde
	Echinochola crusgalli	0.4 abc	0.3 bcd	0.2 cde

LSD $_{0.05}$ value for Interaction = 0.2286

Dry biomass (mg)

The analysis of variance revealed highly significant (P≤0.01) differences for rice straw extracts, test species, experimental runs and their two and three-way interactions (Table-4a). Variability exhibited among the extracts, as far as their dry biomass is concerned. The highest (134.7mg) dry biomass was recorded in untreated check while lowest (8.0mg) was recorded in 100% rice straw extract. Among test plants the maximum (95.0mg) dry biomass was recorded in *Z. mays* while minimum dry biomass was recorded in *G. hirsutum* (40.0mg) and *R. dentatus* (42.2mg). Among Extracts x Species interactions the maximum dry biomass was recorded in untreated check x *Z. mays* (198.3mg) while minimum (0mg) dry biomass was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis*. The mean values (Table-4b) for Runs x Species x Extracts interactions showed that maximum dry biomass was recorded in untreated check x *Z. mays* (210.0mg) while minimum (0mg) dry biomass was recorded in 100 % rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis*. The highest decrease in 100 % rice straw extract might be due to the presences of higher amount of allelochemicals, which affected all the test plants. It can be inferred from the data that rice straw extract have negative effect on the germination and growth of the test plants. It can be concluded from the results that some test plants have lost their dry biomass due to the negative effect of rice straw extract. Identical results were reported by Rizvi and Rizvi (1992). The highest decrease in dry biomass by rice straw extract may be due to the presence of allelochemicals. These results are corroborated by the work of Sanginga and Swift (1992) and Khan *et al.* (1999) who reported reduction in *Z. mays* shoot dry biomass by *eucalyptus* extracts. Similar findings have been communicated by Ahn *et al.* (2005) who demonstrated the inhibition in dry biomass, leaf area, plant height due to allelopathic potential of rice germplasm for control of *E. crusgalli*.

Table-4(a). Effect of rice straw extract on extract x species means for dry biomass (mg).

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	165.0 b	68.3 h	18.3 l	83.9 b
Oryza sativa	151.7 c	51.7 i	21.7 kl	75.0 c
Zea mays	198.3 a	76.7 g	10.0 m	95.0 a
Vigna radiata	113.3 e	30.0 k	10.0 m	51.1 e
Gossypium hirsutum	100.0 f	20.0 l	0.0 n	40.0 g
Ipomoea batatas	126.7 d	26.7 kl	0.0 n	51.1 e
Sorghum halepense	148.3 c	26.7 kl	10.0 m	61.7 d
Rumex dentatus	116.7 e	10.0 m	0.0 n	42.2 fg
Convolvulus arvensis	113.3 e	21.7 kl	0.0 n	45.0 f
Echinochola crusgalli	113.3 e	43.3 j	10.0 m	55.6 e
Extract Means	134.7 a	37.5 b	8.0 c	

LSD $_{0.05}$ for Test species = 4.588, LSD $_{0.05}$ for Extracts = 2.513, LSD $_{0.05}$ for Interaction = 7.947

Table-4(b). Effect of rice straw extract on runs x species x extracts means for dry biomass (mg).

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	150.0 de	53.3 mn	13.3 stu
	Oryza sativa	130.0 fgh	40.0 op	16.7 rst
	Zea mays	186.7 b	73.3 kl	10.0 tu
	Vigna radiate	113.3 i	26.7 qrs	10.0 tu
	Gossypium hirsutum	100.0 j	20.0 qrst	0.0 u
	Ipomoea batatas	120.0 hi	30.0 pqr	0.0 u
	Sorghum halepense	140.0 ef	23.3 qrst	10.0 tu
	Rumex dentatus	113.3 i	10.0 tu	0.0 u
	Convolvulus arvensis	100.0 j	20.0 qrst	0.0 u
	Echinochola crusgalli	113.3 i	40.0 op	10.0 tu
Run 2nd	*Helianthus annuus*	180.0 bc	83.3 k	23.3 qrst
	Oryza sativa	173.3 c	63.3 lm	26.7 qrs
	Zea mays	210.0 a	80.0 k	10.0 tu
	Vigna radiate	113.3 i	33.3 pq	10.0 tu
	Gossypium hirsutum	100.0 j	20.0 qrst	0.0 u
	Ipomoea batatas	133.3 fg	23.3 qrst	0.0 u
	Sorghum halepense	156.7 d	30.0 qr	10.0 tu
	Rumex dentatus	120.0 hi	10.0 tu	0.0 u
	Convolvulus arvensis	126.7 gh	23.3 qrst	0.0 u
	Echinochola crusgalli	113.3 i	46.7 no	10.0 tu

LSD $_{0.05}$ for Interaction = 11.24

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CONCLUSIONS

This study investigates the allelopathic potential of rice straw extract as a natural bio-herbicide. Rice straw extract reduced the root length, shoot length, fresh biomass and dry biomass of the associated. Rice straw extract activity was due to the synergistic effects of various allelochemicals which inhibited/restricted the germination and growth of the test plants. The identification of rice straw extract as an effective material for the growth inhibition of the test plants implies that it has the potential to be used as an environmental friendly bio-herbicide for control of weeds. Rice straw extract is a natural weed inhibitor, which would reduce the need of chemical herbicides and provide economic benefits. Allelochemicals control the weeds especially at the time of germination. The allelopathic rice varieties could be used for the biological control of weeds in their association. Further research is suggested on the topic to screen out rice varieties for their allelopathic potential and identification of allelochemicals involved in the allelopathic effect.

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