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ALLELOPATHIC INFLUENCE OF RICE EXTRACTS ON PHENOLOGY OF VARIOUS CROPS AND WEEDS

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Abstract

In order to study the allelopathic effects of rice straw on different weeds and crops, a lab experiment was conducted at the Weed Science Laboratory, Institute of Plant Environmental Protection, National Agricultural Research Center, Islamabad during 2007 with a factorial arrangement (species and extract concentration) to evaluate the allelopathic effect of various concentrations of rice straw extract on germination percent, mortality percent, and days to germination of different test plants. The rice plants (Basmati super) were collected from experimental fields of National Agricultural Research Center, Islamabad. The samples were put into water for 48 hours after getting them cleaned, dried, and ground for obtaining the extract. The rice stems and leaves were used for the extraction and concentrations of 0, 50 and 100% rice straw extracts were used for the bioassay. A total of 90 Petri dishes were 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 plant were placed in each Petri dish. All the experimental Petri dishes were kept at room temperature of 20°C for 15 days. The results uncovered that 100% rice straw extract convincingly decreased the germination and growth of the test plants, in comparison with the 0 and 50% rice straw extracts. Among the crop plants, *Gossypium hirsutum*; and among the weeds, *Ipomoea batatas, Rumex dentatus* and *Convolvulus arvensis* were mostly affected by the rice straw extracts whereas *Helianthus annuus*, *Zea mays, Oryza sativa* and *Vigna radiata* were somewhat resistant to rice straw extract concentrations. Hence, it has been concluded from the results that rice straw can prove to be a good alternative and environment friendly bio-herbicide for weed management in crops.

Introduction

Allelopathy in crops may act as a biological weed control in the agro-ecosystem. Allelopathic can cause poor germination, impaired root growth and stunted shoot growth, however these symptoms can also have other causes apart from allelopathy. In practice, it is often quite difficult to distinguish true allelopathic effects. Neighbor plants are affected through leaching, root exudation, residue decomposition and other processes. A myriad of chemical compounds include toxic gases, organic acids, aromatic acids, unsaturated lactones, couramins, quinones, flavonoids, tannins, alkaloids, terpenoids and steroids, etc. (Rice, 1984). In 1970s, accessions with an allelopathic effect have been found in crops such as beet, lupine, maize, wheat, oat, pea, barley, rye, and cucumber (Rice, 1984). Putnam & Duke (1974) screened a total of 538 accessions of cultivated and wild cucumber by pot and field tests, and several accessions inhibited the growth of weeds. Several oat accessions were found with a fluorescent microscope to exude a large amount of an allelochemical called scopoletin (Fay & Duke, 1977).

Weed species that are reported by Rizvi *et al*., (1992) showing allelopathic properties are couch grass, creeping thistle and chickweed; in addition where they occur together they may have a synergistic negative effect on crops (Putnam & Duke, 1974). Allelopathy can be utilized in two ways for weed control i.e., in development of crops that suppress their associated weeds and secondly as natural herbicides. Moreover, allelopathy is one of the factors responsible for appearance and disappearance of species and changes in species dominance over time. Thus allelopathy may lead to monoculture but on the other hand, management of allelopathy may lead to biodiversity.

Weed seed longevity is related to allelopathy that happens with two mechanisms, firstly the chemical inhibitors in the seed may prevent seed decay induced by microbes, and secondly the inhibitors keep the seeds dormant but viable for many years. The aggressive perennial weed species that quickly dominate may do so by allelopathic mechanisms (Fay & Duke, 1977). Some of the more aggressive perennial weed species including *Cirsium arvense*, *Sorghum halepense* and *Cyperus rotundus* impose allelopathic influences particularly through toxins released from their residues; *Digitaria sanguinalis* inhibit the nodulation of legumes (Rizvi *et al*., 1992). Zain *et al*., (2013) reported that *Pennisetum purpureum* extracts can be used as natural herbicide for weed management while aqueous extracts of maize possessed allelopathic effects which altered the physiology of soybean plants.

Therefore, keeping in view the importance of allelopathy in agro ecosystems, an experiment was conducted at National Agriculture Research Center (NARC), Islamabad Pakistan with the objectives to study the allelopathic effects of rice straw, to quantify the relative tolerance of different weeds and crop species to rice 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, NARC Islamabad Pakistan during September 2007. Rice plants (Basmati super) were collected from experimental fields of the NARC Islamabad. The samples were cleaned, dried, ground and then put into water for 48 hours to obtain the extract. The stem + leaves of rice were used for extraction. The aqueous extract was prepared by adding 100g of ground rice straw (stem + leaves) into 1L distilled water for 48 hrs. The extract was filtered through muslin cloth and Whatman No 1 filter paper. The treatments of 0 (check), 50 and 100 percent 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°C for 1 hr. 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 crus-galli* (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.

1 = 0% (distilled water)
2 = 50% rice straw extract
3 = 100% rice straw extract

Each treatment was replicated three times in a completely randomized design with factorial arrangement (species and extract concentrations). The whole experiment was repeated once to confirm the findings. During the course of studies data were recorded on germination percentage (for which plants germinated in each treatment were counted and percentages were computed for each treatment), mortality percentage (for which plants killed/affected adversely during the duration of the experiment were counted and the percentage were computed), and germination percentage (for which the first germinated plants in each treatment were counted and the duration was recoded from the date of the start of the experiment till the date of initial germination).

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 & Torrie, 1980).

Results and Discussion

Germination percentage: The analysis of variance revealed highly significant differences for rice straw extracts, test species, and their two and three-way interactions (Table 1a). The mean values exhibited that germination percentage was lowest (12%) in 100% rice straw extracts followed by 50% rice straw extract (21.5%) while in untreated check it was the highest (55.2%). Among the test plants, maximum (40.6%) germination was noticed in *V. radiata* while minimum (21.1%) germination was noticed in *C. arvensis*. Among Extract x species interactions highest germination was recorded in the check x *Z. mays* (69.3%) and *V. radiata* (68.3%); whereas lowest (5.0%) germination was recorded in 100% rice straw extract x *G. hirsutum*, *R. dentatus* and *C. arvensis*. The mean values of the three-way interactions showed (Table 1b) that different concentrations of rice straw extract affected all the test plants. Among Runs x species x Extracts interactions the maximum germination was recorded in untreated check x *V. radiata* (73.3%), while the minimum (0%) germination was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis.* This study shows that different concentrations of rice straw extract inhibited the growth and development of the *G. hirsutum*, *I. batatas, R. dentatus* and *C. arvensis.* The reduction in germination in case of *G. hirsutum, I. batatas, R. dentatus* and *C. arvensis* was more in 100% rice straw extract as compared to untreated check. Ibrahim *et al*., (1999) stated that leaf and litter extracts of *E. camaldulensis* and *E. microthecia* delayed and inhibited germination of the *G. hirsutum* and other crops. Ahn *et al.,* (2005) declared rice extracts as a source of natural herbicide. There may be genetic differences among rice cultivars for allelopathic potential on weeds like barnyard grass etc. Aamer & Cheema (2004), Khanh *et al*., (2005) and Park *et al*., (2006) found synergistic effect on algal growth inhibition when added two or three phenolic compounds from the rice straw. The growth of *M. aeruginosa* was inhibited by rice straw extract concentrations. This activity was due to the synergistic effects of various phenolic compounds in the rice straw extracts. Shalini & Inderjit (2007) reported that rice extract may affect germination and growth of *P. minor* by changing soil chemical and biological properties.

Table 1a. Effect of rice straw extracts on extract x species means for germination percentage.

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	58.3 b	20.0 fgh	13.3 hi	30.6 c
Oryza sativa	65.0 a	21.7 fg	16.7 fghi	34.4 b
Zea mays	68.3 a	30.0 e	21.7 fg	40.0 a
Vigna radiata	68.3 a	31.7 e	21.7 fg	40.6 a
Gossypium hirsutum	46.7 d	16.7 fghi	5.0 k	22.8 ef
Ipomoea batatas	53.3 bc	16.7 fghi	6.7 jk	25.6 de
Sorghum halepense	53.3 bc	23.3 f	11.7 ij	29.4 c
Rumex dentatus	48.3 cd	16.7 fghi	5.0 k	23.3 ef
Convolvulus arvensis	43.3 d	15.0 ghi	5.0 k	21.1 f
Echinochola crusgalli	46.7 d	23.3 f	13.3 hi	27.8 cd
Extract means	55.2 a	21.5 b	12.0 c	

$LSD_{0.05}$ for Test species = 3.408, $LSD_{0.05}$ for Extracts = 1.866, $LSD_{0.05}$ for Interaction = 5.902

Table 1b. Effect of rice straw extract on runs x species x extracts means for germination percentage.

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	60.0 cde	20.0 mno	16.7 mno
	Oryza sativa	63.3 bcd	16.7 mno	16.7 mno
	Zea mays	70.0 ab	26.7 lm	23.3 mn
	Vigna radiata	63.3 bcd	26.7 lm	16.7 mno
	Gossypium hirsutum	46.7 ghi	13.3 no	0.0 p
	Ipomoea batatas	50.0 fgh	10.0 o	0.0 p
	Sorghum halepense	60.0 cde	23.3 mn	13.3 no
	Rumex dentatus	43.3 hij	13.3 no	0.0 p
	Convolvulus arvensis	46.7 ghi	10.0 o	0.0 p
	Echinochola crusgalli	53.3 efg	20.0 mno	13.3 no
Run 2nd	*Helianthus annuus*	56.7 def	20.0 mno	10.0 o
	Oryza sativa	66.7 abc	26.7 lm	16.7 mno
	Zea mays	66.7 abc	33.3 kl	20.0 mno
	Vigna radiata	73.3 a	36.7 jk	26.7 lm
	Gossypium hirsutum	46.7 ghi	20.0 mno	10.0 o
	Ipomoea batatas	56.7 def	23.3 mn	13.3 no
	Sorghum halepense	46.7 ghi	23.3 mn	10.0 o
	Rumex dentatus	53.3 efg	20.0 mno	10.0 o
	Convolvulus arvensis	40.0 ijk	20.0 mno	10.0 o
	Echinochola crusgalli	40.0 ijk	26.7 lm	13.3 no

$LSD_{0.05}$ value for Interaction = 8.347

Seedling mortality percentage: The analysis of variance revealed highly significant differences for rice straw extracts, test species, experimental runs and their two and three-way interactions (Table 2a). The mean values indicated that maximum (80.0%) mortality was recorded in 100% rice straw extract while minimum (44.0%) mortality was recorded in untreated check. Variability was exhibited among the test plants. The maximum mortality was noticed in *G. hirsutum* (77.2%) and *C. arvensis* (77.8%) which was statistically at par with the *R. dentatus* (76.1%) and *I. batatas* (74.4%). The minimum mortality was recorded in *V. radiata* (58.9%) and *Z. mays* (60.0%). Among Extract x Species interactions the maximum (95.0%) mortality was recorded in 100% rice straw extract x *G. hirsutum*, *R. dentatus* and *C. arvensis,* it was however statistically at par with the interaction of 100% extract involving *I. batatas* (93.3%) and *S. halepense* (88.3%). The minimum mortality was recorded in untreated check x *Z. mays* (31.7%) and *V. radiata* (30.0%), which was at par with *H. annuus* (40.0%) and *O. sativa* (35.0%) under untreated check (Table 2a). The data on effect of different concentrations of rice straw extract on seedling mortality of different test plants (Table 2b) exhibited that all the rice straw extract concentrations had significant three-way interactions with Runs and species. Among Runs x Species x Extracts interaction the maximum (100%) mortality was recorded in 100% rice straw extract x *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis* test plants while minimum mortality was recorded in untreated check x *V. radiata* (26.7%). The results indicate that rice straw extract acted as growth inhibitor to different test species. Lesser inhibition was recorded in *Z. mays* and *V. radiata* while severe inhibition was recorded in *G. hirsutum*, *I. batatas*, *R. dentatus* and *C. arvensis* test plants. Muhammad *et al.,* (2009) and Velu *et al.,* (1996) stated that rice straw extract restricted the germination and growth of certain plants and caused mortality as well.

Table 2a. Effect of rice straw extracts on extract x species for mortality %age.

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	40.0 jk	80.0 def	86.7 bcd	68.9 de
Oryza sativa	35.0 kl	78.3 ef	83.3 cdef	65.6 e
Zea mays	31.7 l	70.0 gh	78.3 ef	60.0 f
Vigna radiata	30.0 l	68.3 h	78.3 ef	58.9 f
Gossypium hirsutum	53.3 I	83.3 cdef	95.0 a	77.2 a
Ipomoea batatas	46.7 ij	83.3 cdef	93.3 ab	74.4 abc
Sorghum halepense	46.7 ij	76.7 fg	88.3 abc	70.6 cd
Rumex dentatus	50.0 I	83.3 cdef	95.0 a	76.1 ab
Convolvulus arvensis	53.3 I	85.0 cde	95.0 a	77.8 a
Echinochola crusgalli	53.3i	76.7 fg	86.7 bcd	72.2 bcd
Extracts mean	44.0 c	78.5 b	88.0 a	

$LSD_{0.05}$ for Test species = 3.745, $LSD_{0.05}$ for Extracts = 2.051, $LSD_{0.05}$ for Interaction = 6.487

Table 2b. Effect of rice straw extracts on runs x species x extracts means for mortality percentage.

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	36.7 klmn	80.0 bcd	83.3 bcd
	Oryza sativa	36.7 klmn	83.3 bcd	83.3 bcd
	Zea mays	30.0 mn	73.3 def	76.7 cde
	Vigna radiata	33.3 lmn	73.3 def	83.3 bcd
	Gossypium hirsutum	53.3 hi	86.7 bc	100.0 a
	Ipomoea batatas	50.0 hij	90.0 ab	100.0 a
	Sorghum halepense	40.0 jklm	76.7 cde	86.7 bc
	Rumex dentatus	53.3 hi	86.7 bc	100.0 a
	Convolvulus arvensis	46.7 ijk	90.0 ab	100.0 a
	Echinochola crusgalli	46.7 ijk	80.0 bcd	86.7 bc
Run 2nd	*Helianthus annuus*	43.3 ijk	80.0 bcd	90.0 ab
	Oryza sativa	33.3 lmn	73.3 def	83.3 bcd
	Zea mays	33.3 lmn	66.7 efg	80.0 bcde
	Vigna radiata	26.7 n	63.3 fg	73.3 def
	Gossypium hirsutum	53.3 hi	80.0 bcd	90.0 ab
	Ipomoea batatas	43.3 ijkl	76.7 cde	86.7 bc
	Sorghum halepense	53.3 hi	76.7 cde	90.0 ab
	Rumex dentatus	46.7 ijk	80.0 bcd	90.0 ab
	Convolvulus arvensis	60.0 gh	80.0 bcd	90.0 ab
	Echinochola crusgalli	60.0 gh	73.3 def	86.7 bc

$LSD_{0.05}$ value for Interaction = 9.173

Days to germination: The analysis of variance revealed highly significant differences for rice straw extracts, test species, and their two and three-way interactions (Table 3a). The mean values indicated that maximum (5.6 days) days to germinations were recorded in 100% rice straw extract while minimum (3.3 days) days were recorded in untreated check. Among the test plants, maximum days to germination were recorded in *G. hirsutum* (5.4 days) and *R. dentatus* (5.2 days) while minimum days to germination were recorded in *Z. mays* (3.5 days) and *V. radiata* (3.9days). Among Extract x Species interactions the maximum days to germination were recorded in 100% rice straw extract x *G. hirsutum* (6.8 days) and *R. dentatus* (6.3days) while minimum days to germination were recorded in untreated check x *Z. mays* (2.3 days). The mean values (Table 3b) for Runs x Species x Extract interactions reveal the maximum days to germination as recorded in 100 % rice straw extract x *G. hirsutum* (7.0 days) while minimum days to germination were recorded in untreated check x *Z. mays* (2.0 days). The data pertaining to the variable under reference show that germination was affected by different concentrations of rice straw extract. It could be concluded from the results that delay in germination of the test plants was due to the fact that injury was caused by allelochemicals of the rice straw extract during the experiment; therefore, test plants took some time to overcome the effect. Similar results have been reported by Sharma & Mishra (1997) who stated that some plant allelochemicals caused injury in different plants species. Meena & Varshney (1998) and Leela (1995) stated that aqueous extracts of *C. rotundus* inhibited germination and growth of test plants. Castro *et al*., (1983) also indicated that *C. rotundus* tuber caused injury in plants during germination time and also reduced the growth of crops. Similar results have been reported by Ibrahim *et al*., (1999) who stated that leaf and litter extracts of *E. camaldulensis* and *E. microthecia* delayed and inhibited germination of the *G. hirsutum* and other crops.

Table 3a. Effect of rice straw extract on extract x species means for days to germination.

Tested plants	0	50%	100%	Test plant means
Helianthus annuus	3.2 jkl	4.3 ghi	5.0 defg	4.2 de
Oryza sativa	2.7 lm	4.3 ghi	5.3 cdef	4.1 de
Zea mays	2.3 m	3.7 ijk	4.5 fghi	3.5 f
Vigna radiata	2.5 lm	4.2 ghi	5.2 cdef	3.9 ef
Gossypium hirsutum	4.0 hij	5.3 cdef	6.8 a	5.4 a
Ipomoea batatas	3.3 jkl	4.3 ghi	5.3 cdef	4.3 de
Sorghum halepense	3.8 ijk	5.0 defg	6.0 bc	4.9 b
Rumex dentatus	4.0 hij	5.3 cdef	6.3 ab	5.2 ab
Convolvulus arvensis	3.0 klm	4.7 efgh	5.5 bcde	4.4 cd
Echinochola crusgalli	3.7 ijk	5.0 defg	5.7 bcd	4.8 bc
Extract means	3.3 c	4.6 b	5.6 a	

$LSD_{0.05}$ for Test species = 0.4277, $LSD_{0.05}$ for Extracts = 0.2343, $LSD_{0.05}$ value for Interaction = 0.7408

Table 3b. Effect of rice straw extracts on runs x species x extracts means for days to germination.

Period	Tested plants	0	50%	100%
Run 1st	*Helianthus annuus*	3.3 hijk	4.7 efg	5.3 cdef
	Oryza sativa	2.7 jkl	5.3 cdef	6.0 abcd
	Zea mays	2.7 jkl	4.3 fgh	4.7 efg
	Vigna radiata	2.3 kl	4.7 efg	4.7 efg
	Gossypium hirsutum	4.3 fgh	5.7 bcde	6.7 ab
	Ipomoea batatas	3.3 hijk	4.7 efg	5.7 bcde
	Sorghum halepense	3.7 ghij	5.3 fgh	6.3 abc
	Rumex dentatus	4.7 efg	5.7 bcde	6.3 abc
	Convolvulus arvensis	3.7 ghij	5.7 bcde	6.0 abcd
	Echinochola crusgalli	4.3 fgh	5.7 bcde	5.7 bcde
Run 2nd	*Helianthus annuus*	3.0 ijkl	4.0 fghi	4.7 efg
	Oryza sativa	2.7 jkl	3.3 hijk	4.7 efg
	Zea mays	2.0 l	3.0 ijkl	4.3 fgh
	Vigna radiata	2.7 jkl	3.7 ghij	5.7 bcde
	Gossypium hirsutum	3.7 ghij	5.0 defg	7.0 a
	Ipomoea batatas	3.3 hijk	4.0 fghi	5.0 defg
	Sorghum halepense	4.0 fghi	4.7 efg	5.7 bcde
	Rumex dentatus	3.3 hijk	5.0 defg	6.3 abc
	Convolvulus arvensis	2.3 kl	3.7 ghij	5.0 defg
	Echinochola crusgalli	3.0 ijkl	4.3 fgh	5.7 bcde

$LSD_{0.05}$ value for Interaction = 1.048

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