ALLELOPATHIC EFFECTS OF NINE LEAF EXTRACTS INCLUDING RICE STRAW ON WEEDY RICE AND FOUR RICE VARIETIES

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ABSTRACT: Allelopathy can be defined as a process involving secondary metabolites produced by plants, micro-organisms, viruses, and fungi that influence the growth and development of agricultural and biological systems (excluding animals), including positive and negative effects. The present study was aimed at evaluating the allelopathic effects of straw of two rice varieties (B.G. 352 and B.G. 357) and seven plant leaf extracts namely *Calotropis procera, Cassia fistula, Cymborpogon nardus, Eucalyptus* sp., *Lantana camara, Leucas aspera and Pinus* sp. Four concentrations (05%, 10%, 15% and 20% w/v) were tested for allelopathy {Seed Germination Percentage (SGP) and Seedling Vigor Index (SVI)} on a weedy rice variety and four cultivated rice varieties namely AT 362 (Rosa Kekulu), BG 39/16, Samba 365/3 and Sudu 400/2. The data obtained were analysed employing general linear model ANOVA test using Minitab software 16.1.1 to detect the significance of differences at 5% probability level. All tested plant species showed allelopathic effect and it was species and concentration dependent as has been reported by others. Higher concentrations (15% ml and 20%) inhibited SGP and SVI or either of all receiver plants and *Calotropis procera* and *Eucalyptus* sp. were inhibitory on crop rice varieties too even at low concentrations (05% and 10%) and thus cannot be considered for control of weedy rice in a paddy crop. Most of the other species significantly inhibited the both SGP and SVI or only SVI and did not inhibit rice varieties indicating the possibility of exploiting them for management of weedy rice and other weeds of paddy crops. *Cassia fistula* was found to be the most promising candidate among tested plants.

Key Words: Allelopathy, Oriza Sativa, Weedy Rice, Weed Management

1 . INTRODUCTION

Among various weeds in rice ecosystem the weedy rice has become a major problem from recently. Weedy rice was first identified in Sri Lanka, in mid-1990's, as a threat from Vavunia, Ampara, and Batticaloa districts and later from Puttalam, Anuradhapura, Polonnaruwa, Kurunegala and Matara districts (Marambe and Amarasinghe, 2000). The yield losses from weedy rice have been estimated to vary from 10-100% due to their competitive ability (Marambe and Amarasinghe, 2000; Eleftherohorinos *et al.* 2002).

Morphologically, weedy rice appears to be an intermediate between wild and cultivated rice. Long term sympatric distribution has led to similarities between weedy rice and cultivated rice through natural hybridization and introgression, making the control of weedy rice very difficult when compared with other weeds (Marambe, 2009). At present, no single management technique can effectively control the problem of weedy rice. The multi-dimensional aspects of the diversity, phenology and ecology of weedy rice are complex and hence the control measures too are complex, (Delouche *et al*., 2007).

Mechanical methods of weed control such as hand weeding require more labour and time and hence costly. Chemical method provides an effective strategy, but over reliance on synthetic herbicides cause economic and ecological problems i.e. development of herbicide-resistant weed biotypes (Vyvyan, 2002; Kabir *et al.*, 2010), degradation of soil and water quality (Pell *et al.*, 1998; Aktar *et al.*, 2009) and the effects on non-target organisms (Batish *et al.*, 2002). These effects have shifted the attention of researchers to develop environment friendly, cost-effective and relatively safe weed management technology based on natural products (Copping and Duke, 2007; Duke *et al.*, 2010).

Plant allelopathy could be a potential tool for the control of weedy rice and studies on this aspect are rare. Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, from the release of biochemicals, known as allelochemicals, from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems (Ferguson *et al*., 2003). Phytotoxic impact of these compounds on other plants is usually dominant at early growth stages, causing inhibition of seed germination and seedling growth (Farooq *et al.,* 2008; Jabran *et al.,* 2010). The objective of this study was to evaluate the allelopathic effects of leaf extracts of seven plant species and straw of two rice varieties on seed germination and seedling vigour of a weedy rice variety and four cultivated rice varieties.

2. METHODOLGY

Young and mature leaves of 7 test plants (plants of which the extracts were tested for allelopathy effect *Calotropis procera* (Asclepiadaceae), *Cassia fistula* (Fabaceae), *Cymbopogen nardus* (Poaceae), *Eucalyptus* sp (Myrtaceae), *Lantana camara* (Verbenaceae), *Leucas aspera* (Lamiaceae), *Pinus* sp. (Pinaceae) and fresh straw of varieties BG 352 and BG 357 of *Oryza sativa* (Poaceae) and seeds of 6 subject plants (plants on which allelopathy was tested) *Raphanus sativus* (Brassicaceae) (reference plant), *Oryza sativa* f. *spontanea* (Weedy Rice) (Poaceae) and crop rice varieties AT 362, BG 39/16, Samba 365/3 and Sudu 400/2 of *Oryza sativa* (Poaceae) were used in this study.

2.1. Preparation of Aqueous Extracts of Test Plants

The leaves or straw were washed three times with clean tap water and air dried for four weeks. The dried parts were ground to a fine powder using an electric mortar. Twenty percent weight by volume (w/v) extracts of the test plants were prepared by mixing 20.00 grams of fine powder in 100.00 ml of distilled water and shaking constantly for 24 h. The extracts were filtered through double layers of filter papers (Whatmann no.1). The 5%, 10% and 15% (w/v) concentrations were prepared by diluting the 20% extract with distilled water in the ratios of 2:6, 4:4 and 6:2 respectively. The extracts were stored at 4^{o}C when not in use.

2.2 Seed Germination Bioassay

The seeds of the subject plants were immersed in distilled water and the submerged seeds were soaked 24 h after removal of floating seeds. Ten healthy and uniform sized seeds were placed on one side of double layered tissue papers (14.5 cm x 33.5 cm) separately. The seeds free side of the tissue paper was brought over the seeds in order to cover the seeds and made into a pack and 37 such packs were prepared for each subject plant. Eight milliliters test extract of a particular concentration of a particular plant was sprayed onto the pack. Thus each subject plant was subjected to spray of 4 concentrations x 9 test plants and one pack sprayed with distilled water as the control. The tissue papers having the seeds were rolled carefully, placed inside polythene bags separately. Each treatment had three replications. They were kept inside an incubator at 32^{o}C for 72 h and germinated seeds (considered when radicle emergence ≥ 2mm) were counted each day over five days. Finally, seed germination percentage (SGP) { SGP = (*a/b*) 100 where, *a* is the number of germinated seeds and *b* the total number of seeds (Hassan *et al*., 2012)} and seedling vigor index (SVI) { SVI = *l* * G% where, *l* is the seedling length in cm and G% is the seed germination percentage (Orchard, 1977)} were calculated.

The data were analyzed using general linear model ANOVA test using Minitab 2011. Minitab ver. 16.1.1, Satistical Software. Minitab, State College, PA.

3. RESULTS AND DISCUSSION

All test plant species showed allelopathic effect on reference plant *R. sativus* and all other subject plant species tested. The inhibitory effect of the extracts of the different test plants on different subject plants was different at different concentrations (Table 1 to 4). Thus the allelopathic effect among plants apparently is species and concentration dependent as has been reported. Plants containing allelochemicals can affect growth

Table 1: Effect of 20% (w/v) Extract Concentration on SGP and SVI of Subject Plants

	Test plants							
Subject Plants	*Calotropis procera*	*Cassia fistula*	*Cymbopogon nardus*	*Eucalyptus sp.*	*Lantana camara*	*Leucas aspera*	*Pinus sp.*	Control
AT 362								
SGP	0.0d	46.7b	43.3b	16.7c	63.3b	56.7b	53.3b	90.0a
SVI	0.0c	0.6c	1.8b	0.1c	2.8b	2.0b	1.4b	7.0a
BG 39/16								
SGP	0.0d	40.0b	40.0b	23.3c	56.7b	50.0b	33.3c	96.7a
SVI	0.0c	1.5b	1.8b	0.1c	1.0b	1.5b	0.6c	4.9a
Raphanus sativus								
SGP	0.0d	6.7c	10.0c	0.0d	3.3c	36.7b	3.3c	56.7a
SVI	0.0d	0.4c	0.2c	0.0d	0.1c	1.0b	0.1c	2.0a
SAMBA 365/3								
SGP	0.0c	16.7b	10.0b	0.0c	13.3b	0.0c	23.3b	46.7a
SVI	0.0c	0.6a	0.2b	0.0c	0.3a	0.0c	0.4a	0.8a
SUDU 400/2								
SGP	0.0c	60.0b	70.0a	0.0c	53.3b	43.3b	20.0b	86.7a
SVI	0.0c	2.1b	2.6b	0.0c	1.5b	1.0b	0.2c	5.8a

WEEDY RICE								
SGP	0.0d	26.7c	66.7b	0.0d	33.3c	33.3c	50b	93.3a
SVI	0.0c	0.5b	1.1b	0.0c	0.4b	0.4b	0.8b	6.8a

*Means that do not share same letter in same row are significantly different at 0.05 probability level.

and germination of other plants on concentration dependent manner; and the effects of these chemicals are selective and can vary with different plant species (Rice, 1984; Morita *et a*l., 2005; Hossain and Alam, 2010).

At highest concentrations tested (20%) all test species inhibited both SGP and SVI of all subject plant varieties (Table 4.1). Even at 15% concentration the effect was same with regard to most of the test species on both SGP and SVI or either SGP or SVI of all subject plants (Table 4). Thus concentrations above 15% of any test plant cannot be considered for control of weedy rice in a paddy crop as they inhibited the SGP or SVI of the crop rice varieties to less than 85% Rizwan *et al*., (2013) reported similar effects with regard to concentration. The leaf extracts of *C. procera* imposed allelopathic effects on germination of lentil seeds and this inhibition of germination increased with an increase in the concentration of the leaf extract. *C. procera* and *Eucalyptus sp*. were highly inhibitory on both weedy rice and crop rice varieties even at low concentrations (05% and 10%) (Table 5 and Table 6) and hence are not suitable candidates for control of weedy rice in a paddy crops.

Table 2: Effect of 15% (w/v) Extract Concentration on SGP and SVI of Subject Plants

	Test plants							
Subject Plants	*Calotropis procera*	*Cassia fistula*	*Cymbopogon nardus*	*Eucalyptus sp.*	*Lantana camara*	*Leucas aspera*	*Pinus sp.*	Control
AT 362								
SGP	0.0c	63.3b	66.7a	43.3b	80.0a	66.7a	66.7a	90.0a
SVI	0.0d	1.6c	4.1b	1.2c	4.5b	3.2b	3.0b	7.0a
BG 39/16								
SGP	0.0c	73.3a	63.3b	40.0b	76.7a	60.0b	60.0b	96.7a
SVI	0.0d	4.4a	4.1b	0.3d	2.5c	2.5c	1.3c	4.9a
Raphanus sativus								
SGP	0.0d	13.3b	33.3b	0.0d	16.7b	43.3a	10.0c	56.7a
0.0SVI	0.0c	0.5b	0.7b	0.0c	0.4b	1.4a	0.1b	2.0a
SAMBA 365/3								
SGP	0.0c	20.0b	20.0b	0.0c	33.3a	16.7b	46.7a	46.7a
SVI	0.0b	0.5a	0.6a	0.0b	1.0a	0.4a	1.0a	0.8a

SUDU 400/2								
SGP	0.0c	16.7b	40.0b	0.0c	60.0a	23.3b	63.3a	86.7a
SVI	0.0d	0.4c	1.5b	0.0d	2.0b	0.5c	2.1b	5.8a
WEEDY RICE								
SGP	0.0c	63.3b	80.0a	23.3b	76.7a	56.7b	63.3b	93.3a
SVI	0.0c	1.7b	2.4b	0.1c	1.8b	1.4b	1.4b	6.8a

*Means that do not share same letter in same row are significantly different at 0.05 probability level.

The effect of higher concentrations of rice straw could not be tested as extracts were not yielded in sufficient volumes. Use of rice straw as mulch have been reported to improve agronomic traits of different crops (Khanh *et al*., 2007). However, the rice straw extracts did not show any positive effect on SGP or SVI of rice crops in our study, though 10% and 05% extracts improved the SVI of the reference plant. Rice straw of BG 352 and BG 357 variety did not have any inhibitory effect on subject crop rice varieties except the SVI of Sudu 400/2, though they inhibited the SVI of weedy rice (Table 5 and Table 6) indicating mulching with straw has the additional benefit of controlling weedy rice and possibly other rice weeds too and thus as has been reported by Narwal, (2000) incorporation of wheat and rice residues could be exploited as a possible weed management strategy. This would be of great importance since rice straw is the readily available and least costly material among the test plants investigated and this would help to curb the problems farmers facing in disposing straw.

All of the other test plant species, except *C. procera* and *Eucalyptus* sp., significantly inhibited the SVI of weedy rice at 05% and 10% concentrations but not the SGP or SVI of crop rice plants (Table 5 and Table 6). These indicate the possibility of exploiting them for management of weedy rice and other weeds of paddy crop. *C. fistula* although significantly inhibited both SGP and SVI of weedy rice at 05% and 10% concentrations it did not inhibit any of the crop rice variety except SVI of Sudu 400/2 rice variety. It also, has promoted the SVI of BG 39/16 rice variety indicating the most promising test plant for further investigation for management of weedy rice in paddy crops.

Table 3: Effect of 10 % (w/v) Extract Concentration on SGP and SVI of Subject Plants

	Test plants									
Subject Plants	*Calotropis procera*	*Cassia fistula*	*Cymbopogen nardus*	*Eucalyptus sp.*	*Lantana camara*	*Leucas aspera*	*Pinus sp.*	*Oryza sativa* BG variety 352	*Oryza sativa* BG variety 357	Control
AT 362										
SGP	0.0c	80.0a	93.3a	70.0b	86.7a	83.3a	80.0a	76.7a	86.7a	90.0a
SVI	0.0c	4.0b	7.3a	2.5c	5.7a	5.3b	4.3b	6.4a	6.6a	7.0a
BG 39/16										

SGP	0.0b	93.3a	86.7a	93.3a	93.3a	90.0a	86.7a	93.3a	93.3a	96.7a
SVI	0.0c	7.1a	6.8a	1.3b	4.1a	4.4a	3.4b	4.9a	5.2a	4.9a
Raphanus sativus										
SGP	0.0c	33.3b	30.0b	0.0c	46.7a	60.0a	33.3b	66.7a	73.3a	56.7a
SVI	0.0c	1.3b	1.0b	0.0c	1.7b	2.4b	1.3b	4.3a	5.3a	2.0b
SAMBA 365/3										
SGP	0.0c	46.7a	23.3b	10.0c	46.7a	0.0c	46.7a	63.3a	16.7b	46.7a
SVI	0.0b	0.5a	0.4a	0.1b	0.8a	0.0b	0.8a	0.8a	0.2a	0.8a
SUDU 400/2										
SGP	0.0c	56.7b	56.7b	36.7b	56.7b	63.3a	73.3a	76.6a	63.3a	86.7a
SVI	0.0c	1.5b	2.2b	0.3c	2.3b	1.9b	2.3b	4.4a	2.1b	5.8a
WEEDY RICE										
SGP	3.3c	53.3b	90.0a	50.0b	70.0a	76.7a	76.6a	76.6a	66.7a	93.3a
SVI	0.0d	1.9c	3.9b	0.5d	2.2b	3.2b	2.5b	4.1b	3.6c	6.8a

*Means that do not share same letter in same row are significantly different at 0.05 probability level.

Table 4: Effect of 05% (w/v) Extract Concentration on SGP and SVI of Subject Plants

	Test plants									
Subject Plants	*Calotropis procera*	*Cassia fistula*	*Cymbopogen nardus*	*Eucalyptus sp.*	*Lantana camara*	*Leucas aspera*	*Pinus sp.*	*Oryza sativa* variety BG 352	*Oryza sativa* variety BG 357	Control
AT 362										
SGP	66.7b	86.7a	86.7a	83.3a	83.3a	93.3a	96.7a	80.0a	90.0a	90.0a
SVI	2.0b	6.6a	6.2a	5.1b	5.8a	7.1a	6.6a	6.8a	7.4a	7.0a
BG 39/16										
SGP	63.3b	96.7a	90.0a	96.7a	93.3a	93.3a	93.3a	96.7a	93.3a	96.7a
SVI	1.9c	7.2a	6.5a	2.9c	5.1b	4.9b	4.1b	5.6b	5.3b	4.9a
Raphanus sativus										
SGP	0.0b	43.3a	66.7a	0.0b	63.3a	83.3a	76.7a	76.7a	66.7a	56.7a
SVI	0.0c	1.9b	3.2b	0.0c	3.0b	3.2b	4.1b	5.5a	5.4a	2.0b
SAMBA 365/3										
SGP	0.0c	46.7a	26.7a	13.3b	30.0a	43.3a	33.3a	56.7a	63.3a	46.7a
SVI	0.0a	0.8a	0.3a	0.1a	0.6a	1.2a	1.1a	1.3a	1.1a	0.8a
SUDU 400/2										
SGP	0.0c	73.3a	76.7a	56.7a	73.3a	53.3b	73.3a	86.7a	73.3a	86.7a

SVI	0.0c	3.3b	2.3b	1.2b	4.5a	2.1b	2.5b	3.7b	4.1a	5.8a
WEEDY RICE										
SGP	26.7c	63.3b	96.7a	66.7b	83.3a	86.7a	90.0a	76.7a	83.3a	93.3a
SVI	0.3c	2.7b	5.3a	1.6b	2.8b	4.4b	3.1b	3.9b	4.4b	6.8a

*Means that do not share same letter in same row are significantly different at 0.05 probability level.

3 CONCLUSION

All test plant species showed allelopathy against the subject plants *R. sativus*, weedy rice and tested crop rice varieties. The effect was both concentration and species dependent. Concentrations of leaf extracts above 15% and lower concentrations were highly inhibitory on both weedy rice and crop rice varieties. All other test plants were inhibitory on weedy rice but not on some crop rice varieties indicating the possibility of exploiting them as natural herbicides or as sources of potential allelochemicals for management of weedy rice and other weeds. *Cassia fistula* was effective at the lowest concentration tested (05%) and thus is the most promising from among the tested plants. Further studies are needed in this regard.

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