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Assessment of allellopathic potential of some traditional rice cultivars in Sri Lanka

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Abstract- Allelopathy refers to the chemical inhibition of growth of one species by another. With the objectives of understanding allelopathic effects of sixty seven traditional rice cultivars, a field experiment and laboratory experiments were carried out in 2011 *Yala* season at Faculty of Agriculture, University of Ruhuna, Mapalana, Sri Lanka. Rice cultivars were transplanted according to the completely randomized block design with four replicates. Each replicate consisted of three rows of rice plants and data were collected from the middle row. After three months of transplanting, plant height (cm) and number of tillers/plant, were evaluated in traditional rice cultivars and total dry matter weight of weeds in 0.093 m^2 (1ft2) area encircled by the rice plant were evaluated in three replicates. According to the statistical analysis there were significant differences in plant height and tiller number/plant in traditional rice cultivars. Further there was a significant difference in average dry matter weight of weeds in 0.093 m^2 area encircled by the plant of rice cultivar but there were no correlations in between plant height of traditional rice cultivar or tiller number/plant of them with average dry matter weight of weeds in 0.093 m2 area encircling rice plant emphasizing the non-significant effect of rice plant morphology in weed density. Separate experiments were carried out to see the allelopathic effects of these rice cultivars on germination of Barnyard grass (*Echinochloa crusgalli* L.) seeds. In one set of experiment three soil samples were collected from the soil area contacted with root system of the middle row rice plants in three row design. Twenty *Echinochloa crusgalli* L. seeds were sawn in soil samples and watered according to the necessity. After one month, germination percentage of *Echinochloa crusgalli* (L.) was evaluated. In the other set of experiment, each 5 g of leaf sample from individual traditional rice cultivar were crushed and mixed with non-rice grown soil samples in three replicates. Twenty seeds of *Echinochloa crusgalli* (L.) were sawn in each soil sample and germination percentage was counted one month after the seeding. According to the statistical analysis, there were significant differences in germination percentage of *Echinochloa crusgalli* L. in both soil types while germination percentage was significantly lower in soil samples collected from rice root zone. Furthermore, there was a strong correlation in between germination percentage of *Echinochloa crusgalli* (L.) in two types of soil samples. This study reveals the allelopathic effect of individual traditional rice cultivar on weeds in field condition and allelopathic effect of them on seed germination of *Echinochloa crusgalli* (L.) in root exudates and in leaf extracts as well. Root exudates of traditional rice cultivars *Murunga, Ran ruwan, Mudaliwi, Kirikara, Kahata Samba Molligoda Kalukanda* and *Sivuru wee* significantly suppressed the seed germination of *Echinochloa crusgalli* while leaf extracts of rice cultivars *Rathel, Sudu samba, Kalu heenati, Mahakuru wee, Kotanavalu, Galpa wee, Yakada wee, Gonabaru, Muthumala and Seedevi* significantly reduced the seed germination of *Echinochloa crusgalli* L. which emphasizes the potential usage of these rice cultivars for weed management after reconfirmation of the allelopathic effect.

Index Terms- Allelopathy, germination percentage, leaf extract, root exudates, traditional rice, weed density

I. INTRODUCTION

Allelopathy is the effect of one plant or microorganisms on growth of another plant or micro organism by releasing some chemical compounds into the environment (Rice et al. 1984) and it is a component of integrated weed management technology to reduce the herbicide use for sustainable agricultural development. This is an eco-friendly alternative approach to conventional weed control method, hence, exploitation of local resources to dissect the allelopathetic effect of known plants are timely needed. The rice allelopathy may be one of the potent methods for sustainable agricultural system. Rice has been studied for allelopathic effects in different bio assays (Chou et al. 1991; Hassan et al.1996; Maneechote et al. 1996; Ebana et al. 2001 and Kong et al. 2002). Results of Olofsdotter et al. (1889, 1999), Kraus et al. (2002), Kitazawa et al. (2005), and Kim and Shin (2008) have convinced the potential of rice allelopathy on controlling weeds in different ways. Though there is a real need for convenient, reliable, economical, efficient and repeatable universal methodology for screening rice for allelopathy, as cultivar shows different responses depending upon the screening method used, still such method has not been recommended. Crops or weeds such as *Echinochloa crusgalli* L. (Maneechote et al. 1996), Nutgrass flat sedge (Hussan et al. 1996) and lettuce (Fujii et al. 1992) have been used as biological determinants in such allelopathy studies.

Allelopathic effect and competitive traits of rice cause weed suppression under field conditions. The critical period for yield reduction of rice due to weeds is the first month of the crop growth and during this period expression of allelopathy in rice is prominent (Olofsdotter, 2001).

Root exudation, leaching by dews and rains, and volatilization or decaying plant tissue from allelopathic plants results in release of compounds into the environment (Rice, 1984). These compounds have been identified as alkaloids, flavonoids or phenolic compounds (Chau et al., 1999).

Allelopathic substances can be present in different parts of the plant; in leaves, flowers, roots, fruits, or stems. Further they can also be found in the surrounding soil as exudates from the root system. Other species are affected by these toxins in many different ways. The allelopathic effects of various parts of the same weed also differ for their effects on germination and on initial growth of plants (Economou et al. 2002; Aziz et al. 2008). The effects of allelopathic toxins on plants can be examined in a laboratory or in a greenhouse. Seeds are the easiest and least expensive to use as allelopathy determinant. In the presence of allelotoxins, seeds do not germinate as they do in the absence of the allelopathetic substances (Mubeen et al. 2011). Plants can also be used for the same and chlorosis and eventually die in the presence of allelotoxins are the signs of toxicity to the chemicals. The greatest inhibition of germination percentage was recorded by rice seeds soaking in leaf extracts of *T. portulacastrum* (Mubeen et al. 2011).

The overuse or misuse of inorganic agrochemicals often causes adverse effect on environment such as imbalance of soil microorganisms, nutrient deficiency, and change of soil physicochemical properties, resulting in a decrease of crop productivity. The incorporation of allelopathic substances into agricultural management may reduce the use of agrochemicals and lessen environmental pollution.

Chuo (1999) has concluded 6 aspects on which future allelopathy researches must be focused on. Those are continuous survey of potential allelochemicals from natural sources, finding out practical ways of using allelochemicals in the field, understanding mode of action of different allelopathic chemicals, understanding the role of allelopathic chemicals in biodiversity and ecosystem function, exploration of advanced biotechnological tools to dissect allelopathic chemical genes in plants or microorganisms for biological control, and challenging the extraction of allelopathic compounds from the relevant source. The present study targeted: to find out allelopathic effects of traditional rice cultivars on weed density at field conditions, to understand the effect of plant height and tiller number/plant of rice cultivars on weed density in the field conditions, to assess allelopathic effect of root exudates on seed germination of *Echinochloa crusgalli* (L.) and to compare the allelopathic effects of root exudates with that of leaf extracts on seed germination of *Echinochloa crusgalli* (L.)

II. MATERIALS AND METHODS

The experiment was conducted both in the field and in the laboratory. In the field experiment land preparation was done after the field was treated with Glyphosate (N-phosphonomethyl glycine). Experiment was carried out in 2011 Yala season. Seeds of 67 traditional rice cultivars were collected from PGRC, Gannoruwa. Rice seedlings were raised in a Dapog nursery. Well grown rice seedlings of each cultivar were planted in the field (10 cm X 15 cm spacing) in three rows according to randomized complete block design so that 20 seedlings were in each row. The spacing between adjacent lines of two different rice cultivars was 20 cm.

After three months, weeds were collected in to polythene bags, from the three replicates of each 0.093m2 areas around the base of rice plant in the middle row of each rice cultivar. Weed samples were washed with water to remove contact soils in the root system. All the weeds were dried on papers under the fans for three days to remove excess water. After three days, weeds were oven dried at 70 oC for 10 days until the dry matter weight become constant. Finally, dry matter weights of the weed samples were recorded. Plant height and number of tillers/plant of traditional rice cultivars were also evaluated at the same time.

In a separate study soil samples were collected from the rhizospher of the root system after three months of transplanting. Three replicates of soil samples from each rice cultivar were collected in to 100 ml plastic containers from the middle line of the rice cultivar. Mature seeds of Echinochloa crusgalli (L.) were collected from the field. Seeds of Echinochloa crusgalli (L.) were thoroughly washed away with clean water. Twenty seeds of Echinochloa crusgalli (L.) were sown in each soil sample and watered according to the necessity. After one month, number of germinated seeds was counted in three replicates.

In another set of experiment, 5 g of leaf samples from each traditional rice cultivar was crushed separately and mixed in plastic containers with autoclaved non-rice grown soil samples collected from the field. Cleaned seeds of *Echinochloa crusgalli* (L.) were sawn in the prepared soil. A constant water level in the plastic containers was maintained throughout the experiment. Number of germinated seeds was calculated four weeks after the seeding of *Echinochloa crusgalli* (L.).
Control experiments for each experiment were done accordingly. Data were analyzed using SAS (System of statistical analysis) Inc. 9.2. (2010).

III. RESULTS AND DISCUSSION

According to the statistical analysis, plant height and number of tillers/plant in traditional rice cultivars were significantly different. Though the critical period for yield reduction in rice due to weeds is in the first month of crop growth (Olofsdotter et al. 1999) total dry matter weight of weed samples were collected three months after planting. The reason for collecting weeds after three months was that the variation of mutual shading due to plant height and number of tillers/plant was maxima at the 3 months after planting. Those factors remained almost the same during the early age of the crop growth. However there were no correlations between plant height of rice cultivar and tiller number of the rice cultivar with the dry matter weight of the weeds in the unit are of plant base. Though the screening methodology designed to test large amount of rice accessions in the field at once was inconvenience, the methodology is reproducible and the results give clear values related to effect of individual rice cultivar on seed germination suppression of *Echinochloa crusgalli* (L.).

Weed dry matter weight in 0.093 m^2 around the rice plant base in individual rice cultivar was varied from 0.86 g/0.093 m^2 (rice cultivar *Kalu wee*) to 37.967 g/0.093 m^2 (rice cultivar *Murunga*) (Table 1). Olofsdotter et al. (1999) emphasized allelopathy as a difficult factor to distinguish from competition and therefore such screening must be compared with data where resource competition can be eliminated as a factor in the experiment. According to the statistical analysis there were no correlations in between rice plant height *Vs* weed dry matter weight or rice number of tiller/plant *Vs* weed dry matter weight. This proves that effect of mutual shading due to plant height and number of tillers/plant of rice cultivar has not significantly affected on weed spreading in this cultivation. On the other hand there was a significant effect of rice cultivar on weed dry matter weight, emphasizing a minimum effect of weed competition on allelopathic effect of rice cultivars on weeds.

Table 1 Dry matter weight of weeds in 0.093 m^2 area of rice cultivar root base, germination percentage of *Echinochloa crusgalli* in soil samples collected from root base of traditional rice cultivars and germination percentage of *Echinochloa crusgalli* in leaf extracts of traditional rice cultivars

PGRC Acc. No.	*Rice cultivar name*	DMW of weeds (g/0.093m^2)	GM of *E.c* in soil samples	GM of *E.c.* in leaf extracts
2196	*Rathel*	1.07	3.33^{g}	0.00^{d}
2202	*Sudu samba*	2.29	3.33^{g}	0.00^{d}
2203	*Dik wee*	6.72	3.33^{g}	3.33^{c}
2340	*Weda Heenati*	5.53	3.33^{g}	3.33^{c}
2349	*Mas samba*	4.75	3.33^{g}	3.33^{c}
2866	*Randunipagal*	5.96	3.33^{g}	6.667^{b}
3071	*Polayal*	1.83	6.66^{f}	5.834^{b}
3072	*Thanthiri balan*	6.22	6.66^{f}	3.33^{c}
3131	*Dahanala 2014*	7.40	3.33^{g}	5.834^{b}
3132	*Heenati 309*	4.41	14.44^{e}	3.33^{c}
3136	*Pachchai perumal*	6.04	3.33^{g}	6.667^{b}
3142	*Molaga samba*	6.80	14.44^{e}	3.33^{c}
3142	*Heendik wee*	10.20	3.33^{g}	3.33^{c}
3158	*Kalubala wee*	4.96	3.33^{g}	3.33^{c}
3160	*Valihandiram*	6.74	14.44^{e}	3.33^{c}
3161	*Heen wee*	10.46	6.66^{f}	3.33^{c}
3164	*Heras*	13.85	3.33^{g}	3.33^{c}
3170	*Kalu heenati*	13.63	3.33^{g}	0.00^{d}
3171	*Sudu hetada*	15.19	14.44^{e}	3.33^{c}
3172	*Kalubala wee*	9.42	14.44^{e}	3.33^{c}
3174	*Podihatatha*	17.09	3.33^{g}	3.33^{c}
3183	*Hathiel*	5.13	3.33^{g}	3.33^{c}
3190	*Mahakuru wee*	35.517	3.33^{g}	0.00^{d}
3191	*Heendik wee*	15.19	3.33^{g}	3.33^{c}
3195	*Gallkatta*	9.14	3.33^{g}	3.33^{c}
3200	*Kalu heenati*	24.667	14.44^{e}	3.33^{c}
3203	*Kotanavalu*	7.74	3.33^{g}	0.00^{d}
3214	*Matholuwa*	9.07	3.33^{g}	5.834^{b}
3341	*Galpa wee*	11.62	6.66^{f}	0.00^{d}
3387	*Kahata wee*	5.36	3.33^{g}	3.33^{c}
3388	*Moddai karuppan*	9.87	3.33^{g}	3.33^{c}
3390	*Rathu heenati*	2.28	40.00^{b}	13.333^{a}
3444	*Dik wee*	7.57	6.66^{f}	6.67^{b}
3445	*Yakada wee*	3.09	6.66^{f}	0.00^{d}
3472	*Masuran*	3.63	6.66^{f}	5.834^{b}
3473	*Ratu wee*	22.53	3.33^{g}	3.33^{c}
3515	*3515*	2.00	3.33^{g}	5.834^{b}
3543	*Gonabaru*	8.55	3.33^{g}	0.00^{d}
3548	*Kuruluthudu 2*	9.52	6.66^{f}	3.33^{c}
3550	*Bathkiri el*	8.75	3.33^{g}	3.33^{c}
3592	*Ranhiriyal*	22.927	3.33^{g}	3.33^{c}
3596	*Muthumala*	10.79	3.33^{g}	0.00^{d}
3605	*Seedevi*	6.45	3.33^{g}	0.00^{d}
3634	*Thawalu*	12.94	20.00^{d}	3.33^{c}
3644	*Herath*	5.01	6.66^{f}	3.33^{c}
3662	*Mahasudu wee*	3.37	3.33^{g}	3.33^{c}
3663	*Murunga*	37.97	0.00^{h}	3.33^{c}
3664	*Tissa wee*	9.77	6.66^{f}	3.33^{c}
3668	*Ran ruwan*	5.40	0.00^{h}	3.33^{c}
3672	*Mudaliwi*	7.89	0.00^{h}	3.33^{c}
3674	*Kirikara*	4.37	0.00^{h}	3.33^{c}
3676	*Dena wee*	7.18	6.66^{f}	3.33^{c}
3684	*Rathkara*	11.81	14.44^{e}	6.67^{b}
3695	*Kahata Samba*	16.71	0.00^{h}	3.33^{c}
3697	*Molligoda*	0.97	0.00^{h}	5.834^{b}
3698	*Surumaniyan*	4.03	54.44^{a}	5.834^{b}
3707	*Heenati*	26.933	3.33^{g}	3.33^{c}
3710	*Sudhu balawee*	5.75	3.33^{g}	5.834^{b}
3712	*Kahata wee*	10.70	3.33^{g}	5.834^{b}
3713	*Kalukanda*	23.253	0.00^{h}	3.33^{c}
3721	*Manamalaya*	9.75	3.33^{g}	3.33^{c}
3725	*Sivuru wee*	26.933	0.00^{h}	3.33^{c}
3728	*Kalu wee*	0.86	6.66^{f}	5.834^{b}
3735	*Welihandiran*	3.48	6.66^{f}	5.834^{b}
3871	*Rathran wee*	10.04	3.33^{g}	5.834^{b}
3905	*Rathu wee*	2.83	6.66^{f}	3.33^{c}
3908	*Rathkara wee*	6.93	3.33^{g}	3.33^{c}

Superscript letters indicate DMRT groups. The same letters in the same raw are not significantly differed.

PGRC:Plant genetic resource center, Gannoruwa, Sri Lanka

DMW:Dry matter weight

GM: Germination percentage

E.c:: Echinochloa crusgalli

According to the applied bio assay conditions, twenty three rice Both laboratory experiments and field experiments are needed to quantify the important interactions between different competitive variables (Niemeyer 1988), such as physical and chemical interference, including allelopathy. Field and laboratory or greenhouse studies must work together to get the exact variation explain by the allelopathy of rice. In the present study field experiment was carried out to understand the allelopathic effects of individual traditional rice cultivar and to understand whether morphological characters of rice cultivar such as plant height and tiller number/plant effect on the weed density or dry matter weight of weeds in unique area that encircle the root base of the rice plant. The laboratory experiments were carried out to understand the direct effect of allelopathy on *Echinochloa crusgalli* (L.) seed germination in soils contaminated with root exudates and in soils saturated with leaf extracts of traditional rice cultivars.

It was noticed that *Echinocloa crusgulli* (L.) germination was varied from 0% (*Murunga, Ran ruwan, Mudaliwi, Kirikara, Kahata Samba, Molligoda, Kalukanda, Sivuru wee* cultivars) to

54.48% (*Surumaniyan*) in soil samples collected from root zone of rice cultivars while the seed germination of *Echinocloa crusgulli* (L.) was significantly different in soil samples collected from root zones of different rice cultivars (Table 1).

Echinocloa crusgulli (L.) seeds were not germinated in soil samples mixed with leaf extracts of traditional rice cultivars *Rathel, Sudu samba, Kalu heenati, Mahakuru wee, Kotanavalu, Galpa wee, Yakada wee, Gonabaru, Muthumala* and *Seedevi.* There was a significant difference in between germination percentages of *Echinochloa crusgalli* (L.) seeds in soil samples collected from root zone of individual traditional rice cultivars and in the soil samples prepared with the leaf extracts of individual traditional rice cultivars. This condition has been revealed by Mubeen et al. (2011) where they used *T. portulacastrum* as a determinant for allelopathic effects.

However, there was a correlation in between seed germination of *Echinochloa crusgalli* (L.) in soil samples collected from root zone and seed germination of *Echinochloa crusgalli* (L.) in leaf extracts in soil mixture. This indicates that the pattern of allelopathic effect on seed germination of *Echinochloa crusgalli* (L.) in different rice cultivars are the same in root exudates and in leaf extracts though the amount of seed germination suppression is differed.

The results of the present study explain the effect of individual rice cultivar on weed density of the root zone and the effect of the same cultivars on seed germination of *Echinochloa crusgalli* (L.) in two different allelopathetic exudates; from roots and leaf extract. Allelopathic potential of root exudates on seed germination of *Echinochloa crusgalli* was maxima in traditional rice cultivars *Murunga, Ran ruwan, Mudaliwi, Kirikara, Kahata Samba Molligoda Kalukanda* and *Sivuru wee* while allelopathic potential of leaf extract was maxima in rice cultivars *Rathel, Sudu samba, Kalu heenati, Mahakuru wee, Kotanavalu, Galpa wee, Yakada wee, Gonabaru, Muthumala and Seedevi.* These rice cultivars can be in cooperated in rice farming systems to reduce the usage of synthetic chemicals for weed management.

Still many factors must be taken in to account to eliminate environmental effect of the experiment such as type of weeds localized within a rice cultivar, irrigation methodology, season of cultivation and physiology of *Echinochloa crusgalli* (L.) seeds in the time of seeding those can affect on *Echinochloa crusgalli* (L.) seed germination other than that of allelopathy. More complex experimental procedures must be implemented for dissection of the total variation of allelopathy on weeds after exclusion of these factors.

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