Morphological traits associated with competitiveness in rice

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Production of rice suffers a vital misfortune through weed pressure worldwide. The present work was carried out to evaluate ten rice plant characteristics related with the competitiveness against weeds. The experiment was conducted in a split-plot design with the weedy and weed-free treatments in the main plot and ten rice genotypes as the sub-plot treatment. Results depicted that rice genotypes reveal variable competitiveness against weeds. Among the genotypes, highest competitive rate was found in Govind and UPR 2962-6-2-1. The competitive ability of these genotypes could be attributed to high leaf number tiller number, plant height and shoot biomass at flowering stage. From the study we could understand that morphological parameter can be presuppose to be applied as suitable trait in rice weed interaction for sustainable agriculture.

Key Words: *Allelopathy; Rice genotypes; Competitive ability*

INTRODUCTION

Rice is one of the most important food crops of the world with approximately more than half of the world feeding on rice as a staple food crop. But rice production worldwide is severely affected by the weed infestation. In critical conditions weed infestation may lead to more than half of the crop production. To control weed outbreak, highest agricultural chemical input is seen in rice in the form of herbicides and weedicides, although these chemicals helps in controlling weeds but, are non-biodegradable and can cause adverse effects after entering into the food chain. More over these chemicals are a major cause of soil and water pollution, thus overall possess a major threat to environment so there is a requirement to control weeds without causing a threat to environment. In this respect allelopathy may be an attractive alternative.

Allelopathy is the competitive ability of plants by which they can inhibit the growth of other plant species. This ability is conferred to the plants by a group of various chemical compounds (allelochemicals) released by donor plant and effects the neighboring species These compounds have been shown to be secreted by the plant leaves, stem and roots and accumulate in soil and inhibit weed growth specifically. Many compounds including phenolics, flavonoids, organic acids have been have been shown to be putative allelochemicals in root exudates of many plant species. Thus use of allelopathic rice varieties play a very important role in suppression of paddy weeds and if allelopathic rice varieties can be combined with suitable cultural management options it would result in excellent control on paddy weeds, simultaneously minimizing pollution problem concerned with tremendous application of weedicides.

This Allelopathic trait when developed will help create crop varieties that will be resistant to weeds and also completely harmless to the environment.

Competitive ability is the joint the contribution of a range of traits that are not only genetically controlled but affected by the growth environment. Genetics and environment together determine the competitive outcome in a plant population. These traits can be morphological,or physiological, linked with plant canopy establishment such as early vigour, plant height, growth rate, biomass, leaf area, leaf angle and expansion, tillering capacity, etc. In sustainable agriculture, the possibility of incorporating allelopathic character into improved cultivars to enhance competitive ability of rice is worth exploring. Allelopathic varietiescan reduce the requirement of commercial herbicides, thus, reducing inputs into agrochemicals. Rice allelopathy has attracted great attention since it was demonstrated that some varieties have allelopathic potential against one or more paddy weeds. Selection of allelopathic rice germplasm has been conducted in many countries. However, development of allelopathic rice genotype has been limited due to the less knowledge on genetic control of crop allelopathy. However several main and epistatic quantitative loci have been identified for allelopathy in rice [1-8].

The current trend is to find a biological solution to minimize the perceived hazardous impacts from herbicides and insecticides in agriculture production. Allelopathy is defined as a beneficial or detrimental effect from a donor plant to the recipient by chemical pathway. The harmful impact of allelopathy can be exploited for pest and weed control. Weed control has been an important aspect of their management practices. Although the use of herbicides is a simple and effective method for weed control used worldwide, heavy use of herbicides may cause problems of environmental pollution and soil degradation hampering animal and human health. For this reason, various other methods of weed control have been studied. Various studies have employed the exploitation of allelopathic properties in plants which might give promising results analyzed 12,000 rice accessions or varieties from the USDA/ARS rice germplasm, many other scientists have documented the allelopathic potential of rice. Different work of allelopathy highly involved the screening of the allelopathic potential of different rice varieties, the exploration of allelochemicals from rice body parts, and the development of new allelopathic varieties. Keeping the above points in mind a field experiment was done to evaluate 10 rice genotypes for the allelopathic properties without any herbicide application. The objectives of the present study were to identify plant characteristics to serve as selection criteria for improved wed competitiveness in rice genotypes for high WSA under weedy condition [8-14].

MATERIALS AND METHODS

Ten rice lines namely Pant Dhan-16, UPR2916-211, Pant Sankar Dhan-3, UPR-2919-14-1-1, UPR 2962-6-2-1, UPR-2992-17-3-1, UPRI 2005-15, UPR 2805-14-12, V3R11, Govind were chosen and cultivated under split-plot design at Norman borlogue crop research center, G.B. Pant University of Agriculture and Technology. All the cultivars were maintained under two main plots viz. weedy and weed free. Various morphological and physiological data were recorded. The statistical analysis for all the parameters was done using analysis of variance for split-plot design with means being tested at P=0.05 using an STPR software designed at the Department of Mathematics, Statistics and Computer Science, CBSH, G. P. Pant University of Agriculture and Technology.

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Details of the treatments

Varieties: V1=Pant Dhan 16, V2=UPR 2916-211, V3=Pant Sankar Dhan-3, V4=UPR 291914-1-1, V5=UPR 2962-6-2-1, V6=UPR 2992-17-3-1, V7=UPRI 2005-15, V8=UPR 2805-4-12, V9=V3R11 and V10=Govind

Replications: 3

Treatments: 2 (Weedy, Hand weeding)

Spacing: Row to row: 20 cm

Plant to plant: 10 cm

Plot size: 3.0 m × 1.8 m

Observations: Morphological parameters such as plant height, tiller number, biomass production at flowering was recorded.

RESULTS AND DISCUSSION

Various morphological parameters like Plant height, number of leaves, number of tillers, leaf area and dry matter were recorded at the time of flowering and are presented in Table 1. From the data presented it can be clearly seen that all the parameters recorded showed a decrease in the weedy plots where weeds were allowed to grow with the rice population when compared to the weed free plots. But in some varieties the data for weedy plot is at par or equal to the weed free plots. For plant height, variety V5 has recorded only a mere 0.56% decrease for the weedy plot when compared to the weed free plot, this can be considered at par with the weed free condition. This observation suggests that the plants under weedy condition are growing as luxuriantly as they are growing under weed free condition probably suggesting the allelopathic potential of the rice genotype. Similarly, other parameters like tiller number, leaf number, leaf area and dry matter were also at par for weedy and weed free treatments for the rice variety V5. Also varieties other than V5 like V9, V10 showed a similar trend like the variety V5 hence these varieties can said to be allelopathic in nature. In weed free situation the genotype Govind recorded maximum number of tillers at flowering; However highest percent reduction was recorded in PD-16.

Besides these varieties V6 which showed a marked decrease in all the parameters in weedy condition can be concluded to be the non allelopathic cultivar. These findings were supported by the findings of Dilday and Olofsdotter. For example, Dilday et al., screened approximately 5,000 rice varieties for allelopathy against ducksalad (*Heteranthera limosa* (Sw.) Willd.), of which about 4% demonstrated some allelopathic activity [6,11].

Parameters of vegetative growth of rice have earlier been correlated with its weed competitiveness. Plant height has often been described as one of the most important factors for total competitive ability of a crop. Plant height of field grown rice can be correlated to the competition of rice plant with the weeds to attain more light. It has been shown that an early increase in the plant height results in lower weed population as it creates pressure on the emerging weed species for light by shading the later. In the present study, it was found that plant height was higher for the genotypes Govind, UPR 2962-6-2-1 and UPR 2916-211, increase in plant height at flowering suggesting that Govind, UPR 2962-6-2-1 and UPR 2916-211 posed a greater competition on emerging weeds in comparison to other genotypes in early growth stages. Moreover, it was found that Govind and UPR 2962-6-2-1 have a higher yield potential in comparison to other eight genotypes which is consistent with the competitive nature of these genotypes (Data not shown). Lowest reduction in leaf number, under weedy situation was found in the genotypes UPR 2962-6-2-1 and Govind, hence these genotypes were more competitive while, highest reduction in leaf number was found in UPR 2992-17-3-1 making it least competitive.

Tillering ability directly controls the plant’s potential to produce more number of leaves and a higher leaf area. Production of more number of tillers at an early growth phase results in competition imposed on weed seed germination in terms of space and nutrients. Production of high number of tillers under weedy conditions is an important competitive character. Fofana and Rauber reported that tiller number measured at 43 DAS under weedy conditions were positively correlated with weedy yield, suggesting that early growth at the vegetative growth stage is essential for high yield under severe weed competition. Also a high leaf number means, more light absorption, high photosynthesis and consequently a higher yield. In the present investigation, lowest per cent reduction in tiller number and leaf number was found in the genotypes UPR 2962-6-2-1 and Govind. Whereas, PD 16 and UPR 2992-17-3-1 showed highest per cent reduction in leaf number under weedy situation showing their non-competitive character. In a similar study reported tillering ability is a key characteristic for WSA under specific growing environments. Its contribution to WSA could be affected by crop establishment method, agro-ecosystems (upland or lowland) or weed species. Total plant biomass is another important characteristic defining the yield potential and weeds suppressive ability of the rice plants. Saito et al. suggested that accumulation of high biomass at early growth stages is a good indicator of competitive rice genotypes. Also reported the role of plant dry matter maintenance under weedy conditions to be an important character for the selection of weed competitive rice cultivars [7].

In the present investigation, the genotypes UPR 2962-6-2-1 and Govind maintained highest plant biomass under weedy condition. Overall, least per cent reduction in plant biomass was recorded for the genotypes Govind and UPR 2962-6-2-1. Similar results were obtained by Saito et al. who reported that an indirect selection based on the characteristics like shoot dry matter may have great potential for developing high-yielding genotypes under a wide range of weed infestation levels. In another study it was found that TDM was higher when mechanical weeding was done, due to broad spectrum control of weeds and reduced weed dry weight which lead to more nutrient uptake by the crop, exposure of crop to sunlight and weed free condition at the early stages of crop growth itself, results in better competitive ability of rice plant with weeds.

TABLE 1) Morphological parameters recorded at the time of flowering.

		Plant Height		Tiller No.		Leaf No.		Leaf Area		Dry matter	
		Weed free	Weedy	Weed free	Weedy	Weed free	Weedy	Weed free	Weedy	Weed free	Weedy
PD-16	V1	100.8	91.3	12.6	9.7	32.3	29.9	1572.3	1442.3	14.63	13.63
			(9.4)		(23)		(7.6)		(8.3)		(6.8)
UPR2916-211	V2	93.3	84.8	8.3	8	29.1	29.2	1696.7	1505.4	17.1	15.53
			(9.1)		(4)		(9.3)		(11.3)		(9.2)
PSD-3	V3	103.8	93.2	12.3	9.8	34.6	34.7	1784.3	1574.3	15.9	13.67
			(10.3)		(20)		(13		(11.8)		(14)
UPR-2919-14-1-1	V4	92.8	84	10.8	10.3	39	39	1900.7	1669.7	19.37	17.43

			(9.5)		(4.6		(13)		(12.2)		(10)
UPR-2962-5-2-1	V5	88.8	88.3	8.5	7.7	32.3	39	1642.6	1587.3	18.13	17.2
			(0.6)		(9.8)		(8.6)		(3.4)		(5.1)
UPR-2992-17-3-1	V6	94	91.3	10.5	10.5	35.1	35.2	1380	823.7	18.5	16.3
			(9.1)		(16)		(29)		(40.3)		(11.9)
UPRI 2005-15	V7	101.5	84.7	9.6	8.2	36	33.3	2002.3	1834.47	13.77	10.63
			(16.6)		(15)		(9.9)		(8.4)		(22.4)
UPR 2805-14-12	V8	77.5	80.3	9.2	7.8	35.6	31	1497.7	956	7.77	6.93
			(6.2)		(14)		(13)		(36.2)		(10.8)
V3R11	V9	89.8	82.2	12.3	10.5	46.8	46.8	1131	1056.24	16.97	15.33
			(8.5)		(14)		(4.7)		(6.6)		(9.7)
Govind	V10	82.5	79.2	14	13.3	36.3	36.3	949.3	902.23	17.4	15.57
			(4)		(4.8)		(6.4)		(5)		(10.6)
SEm1		0.633		0.184		4.555		13.91		0.529	
SEm2		1.577		0.436		1.669		15.388		0.855	
CV-a		3.873		9.934		15.719		5.35		19.301	
CV-b		4.316		10.526		10.77		4.367		13.942	

CONCLUSION

Several reports indicate different plant characteristics that contribute towards competitiveness and suppressive ability of rice against weeds. Genotypes with strong weed suppressive ability have been reported to accumulate more biomass, produced more tillers, and displayed higher leaf area index during the vegetative growth stage than those with weak weed suppressive ability.

In the present investigation, an attempt was made to evaluate the competitive ability of ten rice genotypes in terms of their growth physiology at the time of flowering against weeds. Based on the analysis of the data it can be concluded that from all the ten rice varieties under study UPR-2962-5-2-1 and Govind are the allelopathic rice varieties and the rice variety UPR-2992-17-3-1 is regarded as non-allelopathic rice variety. From the study we could understand that morphological parameter can be presuppose to be applied as suitable trait in rice weed interaction for sustainable agriculture. Hence it can be suggested that cultivation of rice varieties having suitable allelopathic potential after assessing the morphological features can substantially be implied and can reduce the heavy burden of herbicides in the rice field and can lead to an increase in the rice productivity in an environment friendly way.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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