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Morphological Traits Associated with Competitiveness in *Oryza sativa*. L: A Case Study

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ABSTRACT

Production of rice suffers a vital force suffering from weed pressure worldwide. Among the weeds, barnyard grass is reported as the most destructive weed species. Synthetic herbicides are preferred method to control weeds. However, continuous application of synthetic herbicides can have a negative impact on the environment, health and result in emergence of herbicide-tolerant weeds. Therefore, another strategy to overcome weed problem is the major concern of scientists. Rice plants with suitable allelopathic trait must be identified which are responsible for secreting secondary metabolites called allelochemicals, and are hopefully very important in controlling weed outbreak.Present work was carried out to evaluate ten rice genotypes based on characteristics related with the competitiveness against weeds. The main plot experiment was conducted in split-plot design with two treatments, weedy and weed free check which was replicated thrice. Morphological parameters such as plant height, tiller number, leaf number and biomass content were measured at flowering stage. Results suggested that rice genotypes reveal variable competitiveness against weeds.

Among the genotypes, highest competitive rate was recorded in Govind and UPR 2962-6-2-1,this could be attributed due to the minimum reduction in plant height (4.0%, 0.6%) .tiller number (4.8%, 9.8%) leaf number(6.4% ,6.6%), and plant biomass content (10%, 5.1%) obtained in rice genotypes respectively at flowering stage. From the study we could assume 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 based on different morphological parameters can be applied which can reduce the heavy stress of herbicides in the rice field and can lead to an increase in the rice productivity in an environment friendly way. It is a biggest challenge for weed scientists to identify suitable trait and incorporate in suitable rice allelopathic cultivar and develop integrated weed management systems that are innovative, effective, economical, and environmentally safe for current and future cropping systems.

KEY WORDS: ALLELOPATHY RICE GENOTYPES, COMPETITIVE ABILITY .

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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. The major loss in yield due to weeds infestation is greater than the combined yield losses caused by insect pests and diseases (Asaduzzaman et al. 2010).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. Moreover, these chemicals are a major cause of soil and water pollution, thus overall possess a major threat to environment, (Bhadoria 2011; Mohammadi 2013).

So there is a requirement to control weeds without causing a threat to environment. In this respect allelopathy may be an attractive alternative. Growing allelopathic rice to control paddy field weeds is often required to reduce herbicidey dependency and contribute to better approach both for environment and sustainable development of agriculture (Kim, 2011, Kong et al., 2008, Duke, 2010). Many crops including rice have been reported possess allelopathy properties (Dilday et al. 1989; Bhadoria 2011; Bravo et al. 2013; Amb and Ahluwalia 2016, Chung et al 2020).

Rice allelopathy is release of allelochemicals from rice plant itself to suppress weeds growth which is environmentally friendly approach, therefore allelopathy is suggested as a promising approach for biological control of weeds in sustainable agriculture practice (Fang et al. 2013; Khanh et al. 2007).Allelopathic crop varieties can release their own “phytotoxins” as allelochemicals to reduce the growth of weeds, thus permitting ecological weed management in cropping systems (Kong, et al 2011). Rice plants have to face different abiotic and biotic stresses which is responsible for releasing multiple secondary metabolites required to activate defense pathway and protect themselves, (Maruyama et al 2014., Kusano et al 2015).

More than 16,000 rice varieties collected from 99 countries have been screened for their allelopathic capacity, and reported that 4.0% of rice cultivars show weed-suppression of paddy weeds (Khanh, et al 2007).Most allelochemicals are reported as secondary metabolites, which are not essential in primary metabolic processes but play a very important role in defense mechanism ,such as phenolic acids, fatty acids, phenyl alkanoic acids, hydroxamic acids, terpenes, indoles, and the labdane-related diterpenoid momilactones, have been identified as potential rice allelochemicals (Rimando & Duke 2003; Khanh et al. 2007; Kato-Noguchi & Peters 2013). Allelopathic effects can be increased with the increase in temperature and photoperiod conditions, depicting the role of different environmental factors governing the allelopathic traits (Fang et al 2018).

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 out comein 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. (Olofsdotter et al. 2002). Higher magnitude of leaf area index; higher root growth in-terms dry root weight, length and volume are positively correlated with crop’s competitiveness against weeds, (Dass et al 2017).

Rauber (2000) reported that plant height, tiller number and LAI measured at 43 DAS under weedy conditions were positively correlated with weedy yield. In sustainable agriculture, the possibility of incorporating allelopathic character into improved cultivars to enhance competitive ability of rice is worth exploring, (He et al. 2004). Allelopathic varieties can reduce the requirement of commercial herbicides, thus, reducing inputs into agrochemicals (Pervez et al. 2003). Rice allelopathy has attracted great attention since it was demonstrated that some varieties have allelopathic potential against one or more paddy weeds, (Dilday et al. 1989). 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 (Rice, 1984). The harmful impact of allelopathy can be exploited for pest and weed control (Narwal, 1994; Kohli et al., 1998).

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 (Chung et al., 1997; Stephenson, 2000). 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 (Chung et al., 2003). Dilday et al. (1989, 1991) 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 (Ahn et al. 2005). 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 which could serve as important selection tool selection criteria for improved wed competitiveness in rice genotypes for high WSA under weedy condition.

MATERIAL AND METHODS

Ten rice genotypes, (*Oryza sativa* L) 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.

Details of the treatments
Varieties : V1=Pant Dhan 16, V2= UPR 2916-211, V3 = Pant
Sankar Dhan- 3, V4= UPR 2919-14-1-1, V5 = UPR 2962-6-2-1, V6 = UPR 2992-17-3-1, V7 = UPRI
2005-15, V8 = UPR 2805-14-12, 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 X 1.8 m

Morphological parameters such as plant height, leaf number, tiller number and biomass production at flowering were 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 say 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 are well supported by the findings of Dilday et al., (1994) Olofsdotter et al., (1995). For example, Dilday et al. (1989) screened approximately 5,000 rice varieties for allelopathy against ducksalad (*Heteranthera limosa* (Sw.) Willd.), of which about 4% demonstrated some allelopathic activity.

The use of allelopathy for weed control has great potential as a biological control method. Despite this, few genetic studies have examined allelopathy (Chang et al 2015) due to the complex challenge of allelopathic interactions in field situations in the presence of natural variability and changing environmental conditions. 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 (Gaudet and Keddy, 1988). 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, (Khush, 1996; Fisher et al., 1997, 2001).

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. Tilling ability directly controls the plant's potential to produce a greater number of leaves and a higher leaf area. Production of a greater 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 (Harding and Jalloh, 2011).

Fofana and Rauber, (2000) 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 by (Saito et al., 2010) reported tillering ability is a key characteristic for WSA under specific growing environments. Total plant biomass is another important characteristic defining the yield potential and weed suppressive ability of the rice plants. Saito et al. (2010) suggested that accumulation of high biomass at early growth stages is a good indicator of competitive rice genotypes. Also (Zhao et al. 2006) reported the role of plant dry matter maintenance under weedy conditions to be an important character for the selection of weed competitive rice cultivars. The shoot extracts of two similar competitive rice genotypes, UPR-2962-6-2-1 and Govind, decreased *E. colona* seed germination, via the release of different phenolic acid compound reported from the plant, (Patni et al. 2019).

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 (9.4)	12.6	9.7 (23)	32.3	29.9 (7.6)	1572.3	1442.3 (8.3)	14.63	13.63 (6.8)
UPR2916-211	**V2**	93.3	84.8 (9.1)	8.3	8.0 (4.0)	29.1	29.2 (9.3)	1696.7	1505.4 (11.3)	17.10	15.53 (9.2)
PSD-3	**V3**	103.8	93.2 (10.3)	12.3	9.8 (20)	34.6	34.7 (13)	1784.3	1574.3 (11.8)	15.90	13.67 (14.0)
UPR-2919-14-1-1	**V4**	92.8	84.0 (9.5)	10.8	10.3 (4.6)	39	39.0 (13)	1900.7	1669.7 (12.2)	19.37	17.43 (10.0)
UPR-2962-5-2-1	**V5**	88.8	88.3 (0.6)	8.5	7.7 (9.8)	32.3	39.0 (8.6)	1642.6	1587.3 (3.4)	18.13	17.20 (5.1)
UPR-2992-17-3-1	**V6**	94	91.3 (9.1)	10.5	10.5 (16)	35.1	35.2 (29)	1380	823.7 (40.3)	18.50	16.30 (11.9)
UPRI 2005-15	**V7**	101.5	84.7 (16.6)	9.6	8.2 (15)	36	33.3 (9.9)	2002.3	1834.47 (8.4)	13.77	10.63 (22.4)
UPR 2805-14-12	**V8**	77.5	80.3 (6.2)	9.2	7.8 (14)	35.6	31.0 (13)	1497.7	956 (36.2)	7.77	6.93 (10.8)
V3R11	**V9**	89.8	82.2 (8.5)	12.3	10.5 (14)	46.8	46.8 (4.7)	1131	1056.24 (6.6)	16.97	15.33 (9.7)
Govind	**V10**	82.5	79.2 (4.0)	14	13.3 (4.8)	36.3	36.3 (6.4)	949.3	902.23 (5.0)	17.40	15.57 (10.6)
SEm1		0.633		0.184		4.555		13.910		0.529	
SEm2		1.577		0.436		1.669		15.388		0.855	
CV-a		3.873		9.934		15.719		5.350		19.301	
CV-b		4.316		10.526		10.770		4.367		13.942	

(Values in parenthesis depict per cent reduction under weedy situation in comparison to weed free situation)

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. (2010) who reported that suitable characteristics like shoot dry matter may have great potential for developing high-yielding genotypes under a wide range of weed infestation levels. Different advances in molecular technologies, such as the development of high-density DNA markers, DNA chips, and next-generation sequencing (NGS), have facilitated the identification and characterization of many genes associated with quantitative traits (Chung et al 2020).

CONCLUSION

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 which 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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