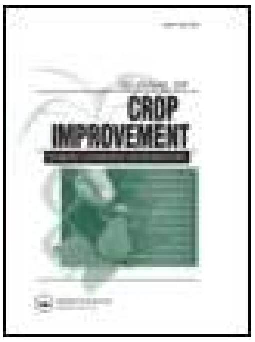

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Competitive ability of weedy rice: toward breeding weed-suppressive rice cultivars

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Competitive ability of weedy rice: toward breeding weed-suppressive rice cultivars

Swati Shrestha[a], Gourav Sharma[a], Nilda Roma Burgos [b], and Te-Ming Tseng [a]

[a]Plant and Soil Sciences Department, Mississippi State University, Mississippi State, MS, USA; [b]Crop Soil and Environmental Science Department, University of Arkansas, Fayetteville, AR, USA

ABSTRACT

Rice (*Oryza sativa* L.) is a vital crop for achieving global food security. Unfortunately, weeds are the major yield-constraining factor in rice production systems worldwide. Development of rice with higher competitive ability than weeds will help achieve sustainable weed management, as robust rice cultivars will have a competitive advantage over weeds. As wild relatives are often explored by plant breeders in crop improvement programs, greenhouse studies were conducted to evaluate weed-suppressive potential of 54 weedy rice accessions (weedy relatives of cultivated rice) against barnyardgrass (*Echinochloa crus-galli*) and Amazon sprangletop (*Leptochloa panicoides*). Three allelopathic rice cultivars (PI312777, PI338046, and Rondo), and two commercial rice cultivars (CL163 and REX) were included as a positive and negative control, respectively. Among all the test accessions of weedy rice, B2 suppressed the growth of *E. crus-galli* by 52%, whereas accession B81 suppressed *L. panicoides* growth by 61%. Accession B81 caused greater than 50% growth inhibition of both *E. crus-galli* and *L. panicoides*. Thus, B2 and B81 were identified as the most weed-suppressive weedy rice accessions. Weed-suppressive potential in weedy rice was associated morphologically with hull type and awn length. Weed-suppressive weedy rice accessions identified from this study can be used as a source of raw genetic material in rice improvement programs. Future research should focus on identifying the underlying mechanism for a high weed-suppressive potential of specific weedy rice accessions.

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Allelopathy; Amazon sprangletop (*Leptochloa panicoides*); barnyardgrass (*Echinochola crus-galli*); crop improvement; weed suppression

Introduction

Rice (*Oryza sativa* L.) is the staple food crop for more than half of the world's population and the potential crop to ensure global food security in the future (Fairhurst and Dobermann 2002). In the USA, rice is primarily cultivated in Arkansas, Mississippi, Texas, Louisiana, and California, covering approximately 1,274,760 ha of land with an average yield of 3471 kg ha^{-1} (USDA NASS 2017). The USA is a major exporter of high-quality rice, contributing more than 10% to the global rice trade annually (USDA-ERS 2017). In USA,

CONTACT Te-Ming Tseng t.tseng@msstate.edu Plant and Soil Sciences Department, Mississippi State University, MS 39762, USA
Supplemental data for this article can be accessed here

all rice fields are planted using a highly mechanized direct-seeded rice (DSR) system. In Asian countries, rice cultivation mostly involves the commonly used puddled transplanting system (PTR), thus providing competitive advantage to the crop, suppressing weeds. However, with the scarcity of labor and water, there has been a significant shift from PTR to DSR system in the past two decades (Pandey and Velasco 2002). DSR involves rice stand establishment directly by sowing seeds in the fields and uses less water, labor, and emits less methane than the PTR system (Chauhan 2012). Although DSR has numerous advantages over PTR, sustainability of DSR with reference to weed control is questionable. Weeds are a major yield-reducing factor in DSR and can cause yield reductions of up to 100% under severe weed infestation (Rao et al. 2007). Wide adoption of DSR has also raised concerns on weed adaptation and ecology, with higher weed diversity observed in DSR than PTR system (Tomita et al. 2003). There has been an increase in difficult to control weeds, such as grasses and sedges. For example, in Malaysia, broadleaf weeds were most prevalent in rice fields during the 1970s, when DSR had just been introduced, but by the 1990s grass weeds like barnyardgrass (*Echinochloa crus-galli*) and red sprangletop (*Leptochloa chinensis*) became increasingly dominant (Azmi et al. 2005).

The use of herbicides to control weeds in DSR is cost-effective and uses less labor; however, with the evolution of herbicide-resistant weeds, the effectiveness of herbicides alone for weed management has decreased. In rice, the first case of herbicide-resistant weed was reported in gooseweed (*Sphenoclea zeylanica*) in the Philippines in 1983 (Heap 2019); while in the USA, barnyardgrass was the first weed reported to be herbicide resistant in 1991. Currently, there are 50 different weed species documented to have developed resistance to numerous herbicides used in rice globally (Heap 2019). In such a situation, alternative weed control options need to be considered for sustainable DSR production. A promising weed control strategy could be to develop crops with a high weed-suppressive potential to increase their competitiveness against weeds.

Scrutinizing wild relatives of crops for genetic diversity is a common strategy in crop improvement programs (Bessey 1906). As weedy rice evolved through de-domestication of cultivated rice with relatively few genetic changes, selection, and introgression of beneficial traits from weedy rice to cultivated rice should be easy, because of low genetic barrier among them (Li et al. 2017). Weedy rice has wide genetic and morphological diversity but is conspecific to cultivated rice, hence, making them suitable for use in rice improvement programs (Shivrain et al. 2010a, 2010b; Tseng et al. 2013, 2018; Shrestha, Stallworth, and Tseng 2019). Therefore, exploring and identifying weedy rice for the traits of interest would provide valuable resources for future rice breeding programs. Studies have shown that weedy rice is more competitive than cultivated rice (Pantone and Baker 1991; Burgos et al.

2006). The word "competitive" in our context here and in future references in this paper means a higher potential to suppress the growth of surrounding weeds because of a plant's robust nature. For instance, weedy rice grows taller than cultivated rice, has high levels of seed shattering, and variable dormancy (Noldin, Chandler, and McCauley 1999). Pantone and Baker (1991), through the response surface model, suggested that weedy rice was more dominant than cultivated rice, and the competitive ability of one weedy rice was equivalent to that of three plants of commercial rice variety "Mars." Weedy rice also has higher nitrogen-use efficiency than cultivated rice (Burgos et al. 2006). Nitrogen applied at a rate of 20 g m^{-2} produced more culm biomass in weedy rice than in the rice cultivar "Mars." Since weedy rice is conspecific but more competitive and aggressive than cultivated rice, it is possible that weedy rice may have a higher weed-suppressive potential than cultivated rice. Germplasm of weedy rice having high competitiveness will be helpful in diversifying the cultivated rice gene pool for developing competitive/weed-suppressive rice varieties as both (rice and weedy rice) are closely related to each other. Thus, the objective of the study was: (i) To evaluate the weed-suppressive potential of diverse weedy rice germplasm, and (ii) to characterize weedy rice accessions morphologically based on their weed-suppressive potential.

Materials and methods

Greenhouse experiments were conducted in 2016–17 at the RR Foil Plant Science Research Center, Mississippi State University, Starkville, MS to evaluate the weed-suppressive potential of 54 weedy rice accessions against barnyardgrass and Amazon sprangletop. From our previous weedy rice morphological characterization study using 208 weedy rice accessions (Tseng 2013), a total of 54 most competitive accessions were selected based on ten traits, namely, ALS-inhibiting herbicide tolerance (<10% injury), cold tolerance (<10% injury), early flowering (<85 days after seeding), culm height (120–140 cm), high grain yield (140–160 g $plant^{-1}$), high leaf area (50–75 cm^2), high tillering capacity (culm number 110–130), lodging resistance (culm strength moderately strong to strong), high panicle shattering (>50%), and high spikelet fertility (>75% well-developed spikelets in proportion to total number of spikelets on five panicles). The information on the collection site and morphological characteristics of these accessions is provided in Supplemental Table 1. Two commercial rice cultivars (CL 163 and REX), and three allelopathic rice cultivars/lines (RONDO, PI 338,046, and PI 312,777) (Gealy and Yan 2012) were included in bioassay screenings together with 54 weedy rice accessions to serve as negative and positive controls, respectively. The purpose of using allelopathic and commercial rice cultivars as a positive and negative control was to check the weed-suppressive ability

Table 1. Effect of weedy rice hull color and awn length on height, biomass, and root length inhibition of barnyardgrass (*E. crus-galli*).

	Percent Inhibition†			
Character	Height	Biomass	Root length	Average
Hull color‡				
Blackhull	36b	39b	34b	36b
Strawhull	34 c	34 c	28 c	32 c
Positive control	51a	56a	56a	54a
Negative control	23b	22d	16d	20d
Awn‡				
Awned	36a	39a	34a	36a
Awnless	35a	36b	29b	33b
Positive control	51a	56a	56a	54a
Negative control	23b	22d	16d	20d

† Means in the column followed by the same letters are not significantly different from each other based on the means separated by Tukey's test at $\alpha = 0.05$.
‡ Hull color and awn length are the two major morphological characters used to classify weedy rice. Supplemental Table 1 has a list of 54 weedy rice accessions differentiated based on hull color and awn length.

of weedy rice with respect to these populations. The underlying assumption was that allelopathic rice has a higher potential to suppress surrounding weeds than commercial rice cultivars. Because of the robust nature of weedy rice, we hypothesized that weedy rice was more competitive than cultivated rice and would have higher weed-suppressive potential than both commercial and allelopathic rice cultivars. Although the objective of this paper was to evaluate competitive/weed-suppressive potential, we used allelopathic rice cultivars as positive controls since allelopathy ultimately results in the suppression of neighboring plants. Allelopathy, in general, is the suppressive effect of chemical(s) secreted by one plant on plants present in the surrounding environment (Rice 1984).

Seeds of weedy rice and rice cultivars were pre-germinated in 0.3% agar media to obtain uniform plant stands. Pots of 21.5 cm diameter were filled with Sunshine #1 (Sun Gro Horticulture Canada Ltd, Vancouver, Canada), an all-purpose growing mix with sphagnum peat moss, perlite, dolomitic limestone, long-lasting wetting agent and RESiLIENCE®. Weed-suppressive potential was evaluated using the method described by Li et al. (2015) with slight modification. Briefly, six rice plants were planted at equal spacing (~2.5 cm) from each other along the circumference of the pots. When rice plants reached the five-leaf stage, three pre-germinated barnyardgrass seedlings were planted at the center of the pot to evaluate the effects of weedy rice on the growth of barnyardgrass (Figure 1). Weed seeds for the study (barnyardgrass and Amazon sprangletop) were obtained from Azlin Seed Service, Leland, MS. The heights of barnyardgrass plants were recorded 7, 14, and 21 days after planting (DAP). In our preliminary experiment. it was observed that roots of weedy rice and the test species (barnyardgrass and Amazon

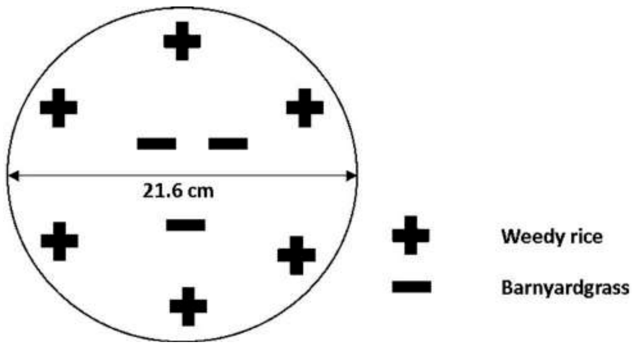

Figure 1. Diagrammatic representation of experimental setup for evaluating weed-suppressive potential of weedy rice against barnyardgrass (*E. crus-galli).*

sprangletop), in separate pots, did not overlap with each other until 3 weeks after planting when arranged in the same manner as indicated above, which is why the data were recorded only until 21 DAP. This would eliminate the possibility of inflated results attributable to over-crowding and nutrient insufficiency. Optimum light and water conditions were maintained, and similar micro-climatic environment was provided to each pot/experimental unit to minimize external variation as much as possible. Greenhouse day/night temperature and humidity were maintained at 30/25° C and 70%, respectively. The experiment was conducted using a completely randomized design with three replications and repeated (run 1 and 2). Barnyardgrass plants were uprooted carefully at 21 DAP, keeping the roots intact. Roots and shoots were separated using scissors, soil particles were removed from the roots gently using a brush, shoot dry mass, and root length were recorded after drying in an oven set at 60°C for 78 h. Nine barnyardgrass plants were grown in a similar set up without the weedy rice; and height, shoot biomass, and root length were recorded as a baseline value for calculating the weed growth inhibition (%) (see equation below). The same experimental setup was used for Amazon sprangletop. Weed growth inhibition was calculated as reduction in height, shoot biomass, and root length.

$$\text{Inhibition}(\%) = [(\text{Baseline value} - \text{Treated plant value})/\text{Control value}] \times 100$$

The average growth inhibition by each weedy rice accession was calculated, taking means of percent reduction in height, biomass, and root length of barnyardgrass and Amazon sprangletop when grown with weedy rice.

For data analysis, the experimental model used was:

$$Y_{ijk} = \mu + \beta_i + \alpha_j + (\beta\alpha)_{ij} + e_{ijk}$$

where Y_{ijk} is the response variable, β_i is the effect of experimental run, α_j is the effect of accessions on the response variable, $(\beta\alpha)_{ij}$ is the interaction between runs and accessions and e_{ijk} is the error term. Data were analyzed in R v.3.5.2

(R Core Team 2018) and visualized in R Studio (RStudio Team 2016). Mean values were separated using Tukey's test at α = 0.05 from agricolae package (De Mendiburu 2019). The boxplots for inhibition (%) for both the species (barnyardgrass and Amazon sprangletop) were created using *ggplot2* package (Wickham 2016). Principal component analysis (PCA) was performed on a correlation matrix produced by base package princomp. PCA biplots were visualized using *ggfortify* package (Horikoshi and Tang 2016).

Results

Weed-suppressive potential of weedy rice against barnyardgrass

Weedy rice accessions varied significantly ($p < 0.0001$) in their weed-suppressive potential against barnyardgrass. Accession B2 inhibited growth (height, biomass, and root length) of barnyardgrass by 61% and had the highest inhibition potential among all accessions used in the study. B2 showed 7% and 65% higher weed-suppressive potential than allelopathic (PI312777, PI338046, and RONDO) and commercial rice (CL163 and REX), which were used as positive and negative controls, respectively (Supplemental Table 2 and Figure 2). Accession B81 also showed a high weed-suppressive potential of 54%.

The average height of barnyardgrass plants grown in monoculture, was 26 cm, whereas those planted with test accessions ranged from 10.3 to 20.7 cm. Reduction in the height of barnyardgrass plants by known allelopathic rice cultivars ranged from 50% to 52%. Weedy rice accessions B2 and B81 inhibited height of barnyardgrass by 61% and 52%, respectively, whereas rice cultivar CL163 and REX weakly inhibited barnyardgrass, with a height reduction of only 21% and 25%, respectively. Among weedy rice, S33, a strawhull accession, showed the least height reduction (22%) in barnyardgrass plants.

The average above-ground biomass of barnyardgrass plants in monoculture was 0.29 g, whereas those plants grown with weedy rice had biomass ranging from 0.10 to 0.24 g. Weedy rice accession B2 reduced barnyardgrass biomass by 65%, which was the highest among all accessions used in this study. PI312777, PI338046, RONDO, and weedy rice accession B81 reduced barnyardgrass biomass by 57%, 56%, 54%, and 59%, respectively. Weedy rice accession S33 caused least biomass reduction (17%), whereas commercial rice cultivars, CL163 and REX, reduced biomass by 21% and 23%, respectively.

The average root length of barnyardgrass planted in monoculture was 22 cm, whereas those planted with test accessions ranged from 8 to 19 cm. Percent root length reduction of barnyardgrass plants by allelopathic rice cultivars PI338046, PI312777, RONDO was 63%, 53%, and 52%, respectively. Weedy rice accessions B2 and B81 reduced the root length by 59% and 52%, respectively. Rice cultivars CL163 and REX caused a root length reduction of 14% and 17%, respectively, which was lower than that of most of the weedy rice accessions used in this study. Among the weedy rice accessions, S113 reduced barnyardgrass root length the least (by 12%).

Allelopathic rice cultivars used in this study as a positive control had higher weed-suppressive potential than most of the weedy rice accessions and the commercial rice cultivars CL163 and REX, as expected. However, two weedy rice accessions (B2 and B81) showed higher weed suppression than positive control and inhibited the growth of barnyardgrass by more than 50%, implying their competitiveness and potential to suppress neighboring species (Figure 2).

PCA examining the relationships among different weedy rice accessions based on their ability to reduce height, biomass, and root length of barnyardgrass showed that principal component 1 (PC1) contributed 72% variation and PC 2 accounted for 16% variation (Figure 3). The first PC axis (PC1) clearly separated height, biomass, and root length reductions in positive direction. All the three vectors (height, biomass, and root length) were close, forming acute angles with each other indicating they were positively correlated. In general, the PCA showed that most of the allelopathic rice and some of the blackhull weedy rice accessions clustered together (Figure 3 black circle), indicating a high weed-suppressive ability of these blackhull weedy rice. However, none of the straw-hulled weedy rice accessions clustered with allelopathic rice, indicating that black-hulled accessions were more similar to allelopathic rice than straw-hulled weedy rice.

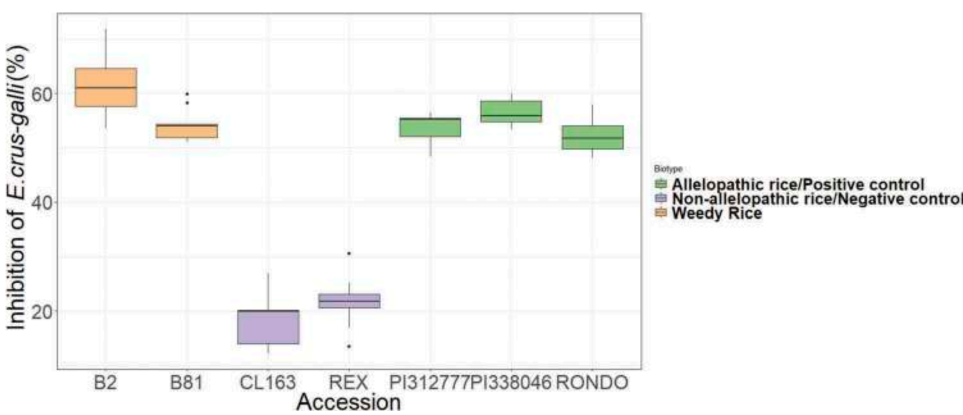

Figure 2. Comparison of weed-suppressive potential of two weedy rice accessions, B2 and B81 (out of 54) with the highest inhibition of barnyardgrass (*E. crus-galli*), to weed-suppressive potential of CL163, REX (commercial rice), PI338046, PI312777 and RONDO (allelopathic rice). Weed-suppressive potential of all the 54 weedy rice accessions against barnyardgrass is provided in Supplemental.Table 2.

Table 2. Inhibition of Amazon sprangletop (*L. panicoides*) by weedy rice accessions based on morphological characters of weedy rice hull color and awn length (Supplemental Table 1 has a list of weedy rice differentiated based on hull color and awn length).

	Percent Inhibition†			
Character	Height	Biomass	Root length	Average
Hull color				
Blackhull	38b	24b	37b	33b
Strawhull	20 c	16 c	28 c	22 c
Positive control	43a	33a	48a	45a
Negative control	16 c	13 c	26 c	18d
Awn				
Awned	35b	23b	36b	31b
Awnless	27 c	19 c	32 c	26 c
Positive control	43a	33a	48a	45a
Negative control	16d	13d	26d	19d

† Means in the column followed by the same letters are not significantly different from each other based the student's t test at α = 0.05.

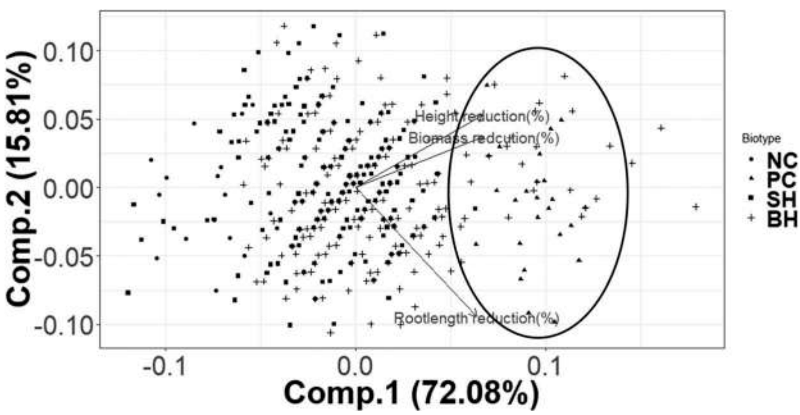

Figure 3. Principal component analysis representing the relationship among test accessions† in terms of their mean inhibition in height, biomass, and root length of barnyardgrass (*E. crus-galli*), 3 weeks after transplanting. Some blackhull weedy rice clustered together with allelopathic rice showing their high allelopathic nature (large black circle). † PC-Positive control/Allelopathic rice; NC-Negative control/Commercial rice; BH-Black hulled weedy rice; SH-straw hulled weedy rice.

Weed-suppressive potential of barnyardgrass based on hull type and awn length

Weedy rice found in the USA is morphologically categorized into two hull types (blackhull and strawhull). Most of the blackhull accessions are awned, and strawhull accessions are awnless (Shivrain et al. 2010a). Since the PCA result for barnyardgrass suppression grouped the blackhull and strawhull accessions into separate clusters, it was further determined if the weed-suppressive potential of accessions was associated with hulltype and/or awn length. The average inhibition of barnyardgrass by blackhull and strawhull accessions was 36% and 32%, respectively (Table 1). Allelopathic accessions used as positive and negative control inhibited barnyardgrass by 54% and 20%, respectively. Higher allelopathy of allelopathic rice cultivars than blackhull and strawhull weedy rice accessions indicated that allelopathic rice cultivars were consistent in their allelopathic potential, unlike weedy rice accessions. Percentage inhibition in height 21 DAP by blackhull and strawhull accessions was 36% and 34%, respectively. Reduction in biomass of barnyardgrass was 39% and 34%, whereas root length was inhibited by 34% and 28% by blackhull and strawhull accessions, respectively. In general, awned weedy rice accessions showed higher weed-suppressive potential (36%) than awnless accessions (33%). Awned and awnless accessions did not differ in height inhibition (36% and 35%, respectively). However, the percentage reduction in biomass and root length was different between awned and awnless accessions (39% and 36% biomass reduction, and 34% and 29% root length reduction, respectively).

Weed-suppressive potential of accessions against amazon sprangletop

Among weedy rice accessions, B81 was found to have the highest inhibition potential (52%) against Amazon sprangletop. Inhibition by B81 was 14% and 66% greater than positive and negative control, respectively (Figure 4). Height reduction by B81 was 59%, and it was 57%, 56%, and 47% for PI312777, PI338046, and RONDO, respectively. Unlike the allelopathic cultivars, commercial rice cultivars, CL163 and REX, caused less height reduction (16% and 13%, respectively). Among weedy rice accessions, S18 caused the least height reduction in Amazon sprangletop, i.e. 13% (Supplemental Table 3 and Figure 4).

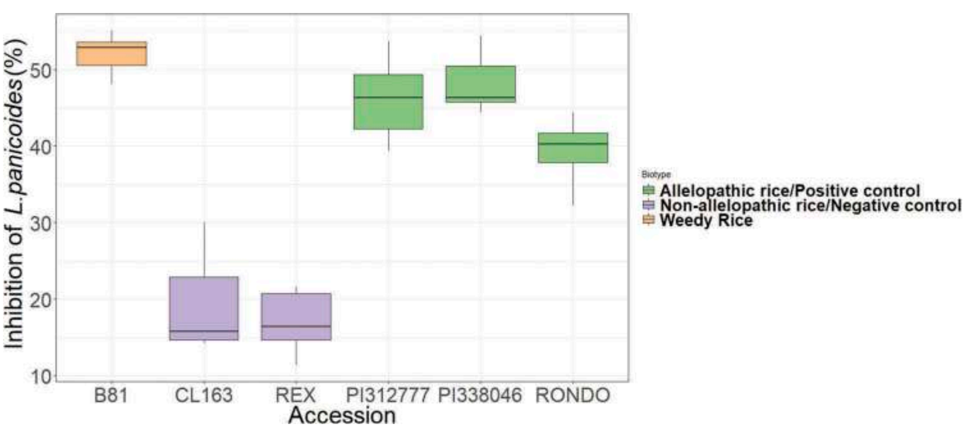

Figure 4. Comparison of weed-suppressive potential of weedy rice accession with the highest inhibition of B81 Amazon sprangletop (*L. panicoides*), with weed-suppressive potential of CL163, REX, PI338046, PI312777, and RONDO. Weed-suppressive potential of all the 54 weedy rice accessions used in the study against Amazon sprangeltop is provided in Supplemental Table 3.

The average biomass of Amazon sprangletop grown with test accessions ranged from 0.22 to 0.33 g. Weedy rice accession B81 reduced biomass of Amazon sprangletop the most (42%) and was comparable to the biomass reduction by the allelopathic rice cultivar PI338046 (38%). PI31277 and RONDO reduced biomass by 33% and 28%, respectively, whereas rice cultivars, CL163 and REX, caused a biomass reduction of 13% and 14%, respectively. S124 resulted in the least biomass reduction (12%).

The average root length of Amazon sprangletop (as control) was 30 cm, whereas the root length of those grown with test accessions ranged from 8 to 19 cm. The largest root length reduction was caused by B81 (56%) and was in the range of the root length reduction by PI338046, PI312777, and RONDO. Rice cultivars, CL163, and REX reduced root length by 26% and 24%, respectively. It is worth noting that B81 inhibited Amazon sprangletop the most across all the three measured factors, thus indicating its consistent weed-suppressive potential and superior nature over other accessions used in this experiment. B81 was the only accession showing an average inhibition of more than 50% against Amazon sprangletop. About 57% of the accessions inhibited Amazon sprangletop growth by less than 30%, whereas the rest of the accessions (41%) showed inhibition ranging from 30% to 40%.

PCA revealed that the total variation accounted by the first two axes was 94.16%, out of which PC1 contributed 85.45% of the variation, whereas PC2 contributed 8.71% (Figure 5). All three variables, i.e. height, biomass, and root length reduction separated on the PC axis (PC1) in its positive direction. Overall, the PCA biplots indicated a high allelopathic potential of blackhull

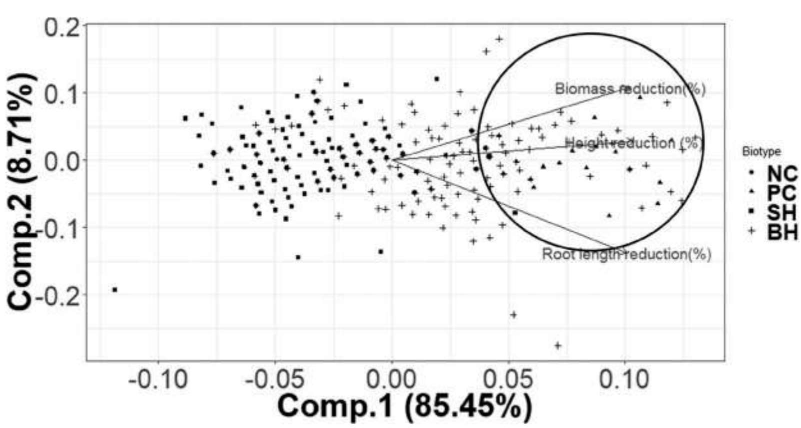

Figure 5. Principal component analysis representing the relationship among test accessions† in terms of their ability to inhibit height, biomass, and root length of Amazon sprangletop three weeks after transplanting. Blackhull accessions and allelopathic rice clustered together (large black circle), indicating the high allelopathic potential of blackhull as compared to strawhull accessions. † PC-Positive control/Allelopathic rice; NC-Negative control/Commercial rice; BH-Black hulled weedy rice; SH-straw hulled weedy rice.

weedy rice accessions against Amazon sprangletop, as all allelopathic rice and most blackhull accessions clustered together (Figure 5 black circle).

Weed-suppressive potential of amazon sprangletop based on hull type and awn length

Average inhibition of Amazon sprangletop by blackhull and strawhull accessions was 33% and 22%, respectively. Positive and negative control inhibited growth by 45% and 18%, respectively. Suppression in height, biomass, and root length by blackhull accessions was 38%, 24%, and 37%, respectively. Strawhull accessions suppressed height, biomass and root length by 20%, 16%, and 28%, respectively (Table 2). Overall, awned weedy rice accessions had significantly higher weed-suppressive potential (31%) than awnless accessions (26%). Percentage inhibition in height, biomass, and root length by awned accessions was 35%, 23%, and 36%, respectively, whereas that of awnless accessions, it was 27%, 19%, and 32%, respectively.

Discussion

At present, PI312777, PI338046, and RONDO are the proven weed-suppressive rice cultivars, but they are not very popular among farmers because of their inconsistent performance (Gealy et al. 2003; Gealy and Yan 2012). Potential of weedy rice to suppress weed growth remains unknown. Our data confirmed high suppression of barnyardgrass and Amazon sprangletop by two weedy rice accessions; however, the cause of their suppression is still unknown. The greater weed-suppressive potential in these two weedy rice accessions may be attributable to their inherent robustness or allelopathy; however, we do not have enough evidence to deem the phenomenon observed in this study as “allelopathy.” Either way, it can be confidently stated that weedy rice can be used as raw genetic material for the production of rice cultivars with enhanced ability to suppress surrounding weeds because of their robust nature and genetic similarity to cultivated rice.

Improving the competitive ability of rice might reduce yield loss caused by weeds as well as decrease herbicide use. Numerous attempts have been made to increase the competitive ability of rice; however, no rice cultivars with superior competitive ability and consistent yield have been developed (Olofsdotter 2001; Gealy and Yan 2012). In such a scenario, exploring the weedy rice accessions with high competitive ability identified in the study (B2 and B81), and using them for the development of elite weed-suppressive/competitive rice cultivars, would help in reducing yield loss caused by weeds in the future. Variability was observed among selected weedy rice accessions in suppressing the growth of barnyardgrass and Amazon sprangletop, thus indicating that the weed-suppressive potential of weedy rice is accession-dependent. Since weedy rice accessions present in the USA has high genetic variability among themselves (Shivrain et al. 2010b), it is possible that some of the weedy rice accessions with high weed-suppressive potential, such as B2 and B81, have genes coding for the production of chemicals to suppress surrounding weed species. However, further analysis is necessary to confirm this preliminary indication. Studies have shown that a few rice cultivars can suppress the growth of multiple weed species. For example, Dilday, Lin, and Yan (1994) reported that rice accessions B850/Cros 1-7-18-3-2, Johna 349, and Mahlar 346, suppressed the growth of both *Heteranthera limosa* (ducksalad) and *Ammannia coccinea* (redstem) by 70-85%. Similarly, in our study, weedy rice accession B81 suppressed the height, biomass, and root length of barnyardgrass and Amazon sprangletop more than the other weedy rice accessions and allelopathic rice. Moreover, to the best of our knowledge, no rice cultivar has been previously shown to suppress the growth of both barnyradgrass and Amazon sprangletop simultaneously; the two most problematic weeds in rice production system in Arkansas and Mississippi (Norsworthy, Bond, and Scott 2013). Thus, B81, with its high ability to suppress both of these weeds, could serve as an important resource in rice improvement programs. It is a common practice in crop breeding programs to select for biotic and abiotic stress tolerance from wild relatives. For instance, resistance to bacterial blight (*Xanthomonas oryzae* pv. *oryzae*), and blast (*Pyricularia grisea*) has been transferred from wild rice (*O. minuta*) to cultivated rice (*O. sativa* L.) (Amante-Bordeos et al. 1992). Additionally, resistance to brown planthopper (*Nilaparvata lugens*) has been transferred from a wild rice species, *O. australiansis*, to cultivated rice (Multani et al. 1994). Thus, this unique ability of B81 to suppress barnyardgrass and Amazon sprangletop could be a useful raw material for the development of rice cultivars that could naturally suppress two major weeds of rice.

Not all the weedy rice accessions had high weed inhibition potential in this study. For instance, only two of the 54 accessions tested, inhibited barnyardgrass growth by more than 50%, and only one inhibited growth of Amazon sprangletop by more than 50%. These accessions may have developed high weed-suppressive potential through selection pressure to outcompete surrounding plants in the evolution process. The mechanism conferring improved competitiveness on these unique accessions needs to be explored and identified to gain insight into their competitive nature. The rice cultivars CL163 and REX were observed to have lower weed-suppressive potential than most of the weedy rice accessions, thus affirming the competitive nature of weedy rice and their potential usefulness in future breeding programs. In the present study, weedy rice accessions differed significantly in weed-suppressive potential with respect to hull type and awn length. Blackhull and awned types generally had slightly higher weed-suppressive potential than strawhull and awnless types (Tables 1 and 2). Weed-suppressive potential of rice cultivars is influenced by genetic and phenotypic characters (flowering, maturity, plant parts – leaves, straw, hull) (Chung et al. 2003; Ahn et al. 2005), thus indicating similar mechanism(s) might be responsible for weed inhibition in rice cultivars and weedy rice.

In this study, we were able to identify two weedy rice accessions (B2 and B81) with the natural potential to suppress weeds of rice. These accessions may serve as a useful resource for future rice breeding program. The development of rice cultivars with high competitiveness will help in the natural control of weeds, thus reducing the need for herbicides, enhancing sustainability, and providing effective control of herbicide-resistant weeds. There will, however, be concerns about the possibility of the transfer of weed-suppressive trait from rice to a non weed-suppressive weedy rice, thus increasing the competitive advantage of these weedy rice's. Because of this, strict measures need to be taken to prevent gene flow. Additionally, the release of weed-suppressive rice will depend on risk assessments to avoid areas of heavy weedy rice infestation to mitigate intercrossing. The risks and benefits will, therefore, need to be assessed before the commercialization of weed-suppressive rice varieties.

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ORCID

Nilda Roma Burgos http://orcid.org/0000-0002-6977-6873
Te-Ming Tseng http://orcid.org/0000-0002-8102-8149

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