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Occurrence and distribution of *Sacciolepis interrupta*, a potential problematic weed in the rice tracts of Kerala

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ABSTRACT

A survey was conducted in major rice tracts of Kerala *i.e.* Kole, Kuttanad and Palakkad during 2018 and 2019 to assess the distribution and occurrence of *Sacciolepis interrupta*. In Palakkad and Kole tract the highest density, frequency, abundance, relative density, relative frequency, and summed dominance ratio of *Sacciolepis* was recorded whereas, in Kuttanad tract it was *Echinochloa crusgalli* followed by *Sacciolepis*. Weed vegetation analysis indices were lowest in Palakkad compared to Kole and Kuttanad tract showing a high degree of domination of one species in Palakkad and larger diversity of weed species in other two tracts. The cluster analysis classified *Sacciolepis* types into 6 groups at 66.67% similarity level, and using principal component analysis these morphotypes were clustered into 3 groups A, B and C based on morphological characters. Association between *Sacciolepis* types and soil nutrient parameters indicated that Group A was abundant in less fertile saturated soils whereas group B and C were dominant in nutrient rich submerged soils of Kole and Kuttanad. The study concludes that *Sacciolepis interrupta* is a serious weed problem in direct seeded rice of Palakkad tract and is fast attaining the status of a dominant weed in other rice tracts also, thereby becoming a major menace in rice fields of Kerala.

INTRODUCTION

Direct-seeded rice is a method of rice cultivation in which cost of production is significantly reduced. However, yield reduction due to weeds is greater in direct-seeded rice (DSR) than in transplanted rice, and sometimes goes up to 50-90% (Rao *et al.* 2007). This is because the weed diversity is greater with a higher diversity index (Kim *et al.* 1992) and rice is subjected to a higher weed pressure. (Balasubramanian and Hill 2002, Tomita *et al.* 2003). The dominant category of weeds in DSR is contributed by grasses (Jayasuria *et al.* 2011). However, a common observation is the occurrence and dominance of new weeds in DSR, with variation in the number, relative densities and proportions, and a greatly altered scenario of competition between and within weed species. It was also observed that specific weeds were more competitive in DSR than in transplanted rice (Matloob *et al.* 2015), making them more difficult to control. In this context, the occurrence and spread of *Sacciolepis interrupta*, a tropical grass weed which mimics rice is of grave concern in the rice tracts of Kerala.

Sacciolepis interrupta was initially seen as a minor weed in the semi dry rice growing areas of Palakkad. However, extremely fast growth habit and multiple methods of propagation have led its gain the status of a major troublesome weed. It is also now reported in both wet-seeded and transplanted rice. A study by Renu (1999) concluded that competition from *Sacciolepis interrupta* alone could reduce the rice grain yield by 50%. The intensity of occurrence of *Sacciolepis interrupta* in Palakkad and other important rice growing tracts of the state, *viz.* Kole lands in Thrissur district and Kuttanad in Alleppey and Ernakulam districts, has not been assessed. Hence a study was conducted to assess the distribution and occurrence of *Sacciolepis interrupta* in the major rice growing tracts of Kerala.

MATERIALS AND METHODS

To study the distribution of *Sacciolepis*, a survey was conducted in three major rice growing tracts of Kerala *i.e.*, Kuttanad, Kole and Palakkad. In Kuttanad and Kole, the survey was conducted in December to March, and in Palakkad tract from April to May in the year 2017-18 and 2018-19, being the periods of most appropriate representation of majority of weed species in the respective tracts. For each rice tract, based on the dominance of the weeds, various indices on density of individual weeds and different characters of morphotypes were worked out. Sampling was done using quadrate of 0.5 x 0.5 m in the surveyed area with the quadrate being randomly placed in each location and total of 15 quadrates were sampled. Data of each year were pooled for each locality and average counts of different weeds were worked out. Weed phytosociological observations on density (d), relative density (RD), abundance (a), frequency (f), relative frequency (RF) and summed dominance ratio (SDR) or importance value index (IVI) of individual weeds were calculated as per methods suggested by Misra (1968) and Raju (1977).

Weed biodiversity in these rice tracts was studied using indices like species richness R (*i.e.*, the total number of species, which occurred in field), species diversity (H) measured by the Shannon-Wiener diversity index *i.e.* $H= Pi \log Pi$, in which Pi is the proportion of individual numbers of the i species to the total individual number of each species in the quadrates. Thus, $Pi = Ni/N$, of which N is the total individual number of each weed species and Ni is the individual number of the I species. Degree of community dominance, measured by the Simpson diversity index, D where $D = 1\text{-}Pi^2$ and community evenness was measured by the evenness index (Pielou index), J where $J = H/logR$.

Using Euclidean distance as similarity index, cluster analysis was done to differentiate between the eleven morphological characters of different morphotypes collected from the surveyed locations. For this analysis statistical package 'Minitab Version 19' was used and associated dendrogram was obtained. To find out the components which were important for clustering the *Sacciolepis* types, principal component analysis (PCA) was done with the same package. Soil analysis was also carried for each surveyed rice tract, to find out the association of dominance and occurrence of *Sacciolepis* morphotypes.

RESULTS AND DISCUSSION

In surveyed areas of Palakkad, a total of 15 species dominated and out of them, *Sacciolepis* recorded highest density, frequency, abundance, relative density, relative frequency and summed dominance ratio followed by *Leptochloa* sp. (**Table 1**).

In Kole tract, a total of 11 species were recorded in surveyed areas, and out of these *Sacciolepis* and weedy rice recorded highest density, frequency, abundance, relative density, relative frequency and summed dominance ratio (**Table 2**). This was in line with the report by Latha and Jaikumaran (2015), where a quantitative weed survey in the rice fields of Kole lands revealed a relative density of 2.46% of *Sacciolepis.*

Echinochloa crus-galli found to be the dominant weed in the surveyed areas of Kuttanad, with highest density, frequency, abundance, relative density, relative frequency and summed dominance ratio out of 12 species, followed by *Sacciolepis* and *Salvinia molesta* (**Table 3**).

Comparison of weed vegetation analysis indices in different rice tracts of Kerala showed the highest weed species richness (R) of 15 in Palakkad tract compared to other two tracts, showing the dominance of weeds, primarily *Sacciolepis,* under

Table 1. Distribution and dominance of weed species in surveyed areas of Palakkad tract

Species	Density (no./m^2)	Frequency (%)	Abundance (no./m^2)	RD (%)	RF (%)	SDR (%)
Echinochloa colona	1.9	70.0	2.7	5.9	9.0	7.4
Leptochloa chinensis	2.7	80.0	3.4	8.4	10.3	9.3
Fimbristylis miliacea	1.0	40.0	2.5	3.1	5.1	4.1
Eclipta alba	1.0	50.0	2.0	3.1	6.4	4.8
Ludwigia parviflora	1.8	70.0	2.6	5.6	9.0	7.3
Lindernia crustacea	0.4	20.0	2.0	1.2	2.6	1.9
Commelina diffusa	1.0	30.0	3.3	3.1	3.8	3.5
Cynotis axillaris	1.4	60.0	2.3	4.3	7.7	6.0
Leucas aspera	0.8	30.0	2.7	2.5	3.8	3.2
Scoparia dulcis	1.0	40.0	2.5	3.1	5.1	4.1
Isachne miliacea	1.8	60.0	3.0	5.6	7.7	6.6
Spilanthus calva	1.0	50.0	2.0	3.1	6.4	4.8
Sacciolepis interrupta	13.6	100.0	13.6	42.2	12.8	27.5
Schoenoplectus juncoides	1.5	40.0	3.8	4.7	5.1	4.9
Cyperus iria	1.3	40.0	3.3	4.0	5.1	4.6

dryland and direct seeded conditions. Higher values of diversity and evenness indices (>1), indicate that the weed species within the habitat were diverse and more equally distributed, but increase in dominance of one weed species would decrease the diversity of the habitat and also lower the values (Wilson *et al*., 2003). Simpson diversity (D), Shannon-Wiener diversity (H) and Evenness (J) indices were highest in Kuttanad and Kole, *i.e.*, 0.9, 2.3 and 0.95, and 0.8, 2.2 and 0.94, respectively, whereas in Palakkad tract it was 0.7, 1.5 and 0.57 respectively, showing a high degree of domination of one species in Palakkad tract and a larger diversity of weed species in other two tracts (**Figure 1**).

Morphotypes are a group of different types of individuals of the same species (Klingman and Oliver 1994). Growth stage, age, biotype or environment play a vital role in affecting the morphological appearance or a particular morphological traits of the same weed species (Booth *et al*. 2010). Based on morphological characters, fifteen types of *Sacciolepis interrupta* morphotypes were categorized from three surveyed rice tracts (**Table 4**).

Sacciolepis was classified into six groups by cluster analysis at 66.67% similarity level. Group 1 included 4 types *i.e*., type 1, 8, 12 and 9. Group 2 included 4 types *i.e*., 4, 10, 5 and 6. Type 11 and 2 occupied separate groups (Group 3 and Group 4 respectively). Group 5 included five types 3, 15, 7 and 13. Group 6 included type 14 (**Figure 2**).

Scree plot of principal component analysis (PCA) indicated that first two PCA corresponded to whole percentage variance in the data, as they possessed Eigen value of >1 (**Figure 3**). PC1 and PC2 together accounted for 81.7% of total variations of which PC1 accounted for 61.9% and PC2 accounted for 19.8%.

PC1 was related to all morphological characters except width of spikelets and PC2 was related to characters like plant height, panicle length, leaf

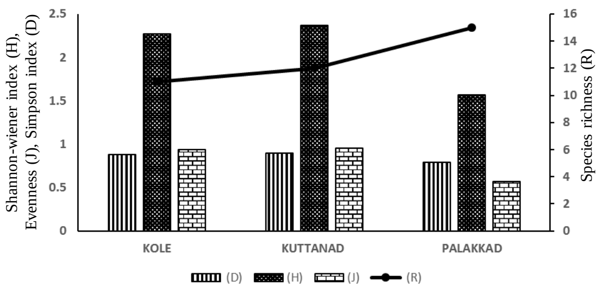

Figure 1. Weed vegetation analysis indices in different rice tracts of Kerala

Table 2. Distribution and dominance of weed species in surveyed areas of *Kole* tract

Species	Density (no./m^2)	Frequency (%)	Abundance (no./m^2)	RD (%)	RF (%)	SDR (%)
Echinochloa colona	2.7	70.0	3.9	10.6	9.2	9.9
Salvinia molesta	1.5	50.0	3.0	5.9	6.6	6.2
Monochoria vaginalis	1.5	70.0	2.1	5.9	9.2	7.6
Cyperus haspan	2.5	60.0	4.2	9.8	7.9	8.9
Sacciolepis interrupta	4.9	100.0	4.9	19.3	13.2	16.2
Leptochloa chinensis	3.3	70.0	4.7	13.0	9.2	11.1
Oryza rufipogon	3.6	90.0	4.0	14.2	11.8	13.0
Ludwigia parviflora	0.9	60.0	1.5	3.5	7.9	5.7
Limnocharis flava	0.9	50.0	1.8	3.5	6.6	5.1
Isachne miliacea	2.2	80.0	2.8	8.7	10.5	9.6
Kyllinga monocephala	1.4	60.0	2.3	5.5	7.9	6.7

Table 3. Distribution and dominance of weed species in surveyed areas of Kuttanad tract

Species	Density (no./m^2)	Frequency (%)	Abundance (no./m^2)	RD (%)	RF (%)	SDR (%)
Echinochloa crus-galli	3.0	73.3	4.1	15.8	15.5	15.6
Oryza rufipogon	1.4	46.7	3.0	7.4	7.2	7.3
Cyperus iria	1.5	80.0	1.8	7.7	7.6	7.6
Cyperus haspan	0.5	40.0	1.3	2.8	2.8	2.8
Salvinia molesta	2.7	73.3	3.7	14.4	14.1	14.2
Monochoria vaginalis	1.5	53.3	2.8	7.7	7.6	7.6
Fimbristylis miliacea	1.5	46.7	3.1	7.7	7.6	7.6
Leptochloa chinensis	1.5	66.7	2.3	8.1	7.9	8.0
Schneopletis juncoides	0.9	46.7	1.9	4.6	4.5	4.5
Alternathera sessilis	0.7	46.7	1.6	3.9	3.8	3.8
Digitaria ciliaris	1.1	40.0	2.7	5.6	5.5	5.6
Sacciolepis interrupta	2.7	66.7	4.1	14.4	14.1	14.2

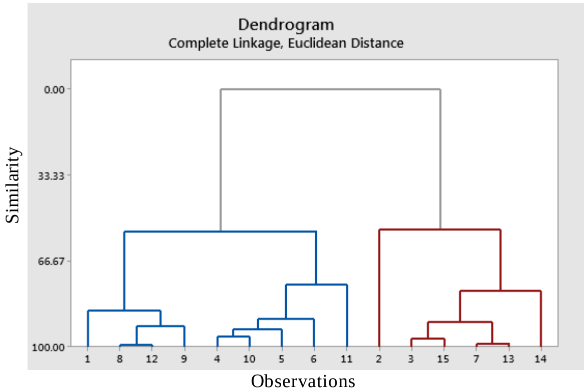

Figure 2. Dendrogram from hierarchical cluster analysis for dissimilarity among the 15 morphotypes of *Sacciolepis interrupta*

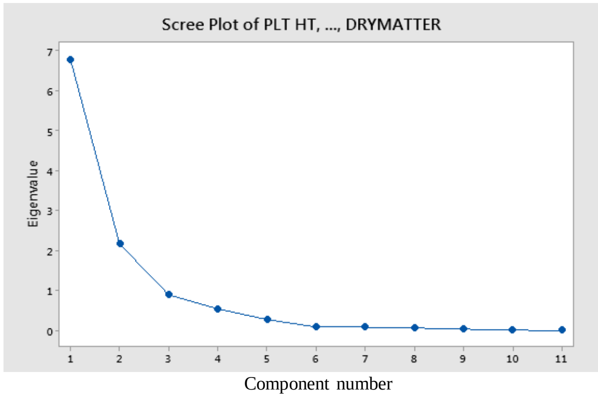

Figure 3. Scree plot showing the Eigen values in response to the morphological characters of *Sacciolepis interrupta*

Table 4. Distribution of *Sacciolepis interrupta* morphotypes in rice fields of surveyed areas

Location		Latitude (^{0}N)	Longitude (^{0}E)	*Sacciolepis* morphotypes	Code no.
Palakkad	Chithali 1	10°41'40.8"	76°35'23.4"	Green variegated	1
	Chithali 2	10°41'41.0"	76°35'00.1"	Green variegated	2 and 3
	Chithali 3	10°41'40.9"	76°35'01.7"	Green variegated	4
	Chithali 4	10°41'40.4"	76°35'02.0"	Green variegated	5
	Kavasseri	10°38'01.6"	76°31'07.2"	Green variegated	6
Kole lands	Pullazhi	10°31'32.1"	76°10'16.0"	Purple variegated	7
	Manakkody	10°29'08.5"	76°10'10.9"	Purple variegated	8 and 9
	Alappad	10°31'00.8"	76°13'25.1"	Purple variegated	10 and 11
Kuttanad		9°21'04.1"	76°28'10.0"	Green-purple variegated	12
	Veeyapuram	9°21'04.2"	76°28'10.2"	Green-purple variegated	13
		9°25'02.6"	76°29'32.2"	Green-purple variegated	13
	Kidangara	9°24'55.7"	76°29'37.6"	Green-purple variegated	14

length, leaf width and dry matter production/plant. PC1 was more positively contributed by six morphological characters in the order plant height, panicle length, length of spikelet, leaf length, leaf width, dry matter production/plant, number of tillers/ plant and number of panicles/plant. PC2 was more positively contributed by dry matter production/plant, panicle length, plant height, leaf length and leaf width (**Table 5**). The scree plot between PC1 and PC2, which together contributed more than 81% of total variation, showed that *Sacciolepis* included in different groups showed distinguishable variations in morphological characters.

The first component data is efficient in grouping and separating one group from others. Group A referred to the morphotypes from Palakkad having green coloured panicles, oblong spikelets, medium stature and narrow light green leaves (green variegated), Group B from Kole tract having purple coloured panicles, enlongated spikelets, tall stature and narrow dark green leaves (purple variegated) and Kuttanad tract ones were categorized into Group C having bicoloured green and purple panicles, oblong

Table 5. PCA values of morphological characters of *Sacciolepis interrupta*

Morphological observations	PC1	PC2
Plant height	0.367	0.115
No of tillers	0.274	-0.190
No. of panicles	0.162	-0.490
Panicle Length	0.362	0.124
No. of spikelets	0.166	-0.324
Seeds per plant	0.203	-0.549
Length of spikelets	0.362	-0.105
Width of spikelets	-0.244	-0.429
Leaf length	0.375	0.073
Leaf width	0.349	0.054
Drymatter production per plant	0.334	0.291

to bulged spikelets, short stature, profuse tillering and with broad dark green leaves (green-purple variegated).

Majority of group B morphotypes were differentiated from group A by the first component, PC1, which is depicted on right hand side of scree plot, and group A on left hand side, and Group C is placed intermediary on the scree plot (**Figure 4**).

Table 6. Soil chemical properties and moisture level in rice tracts of Kerala

Rice tract	pH	Organic C (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Soil moisture level
Kole	5.5	1.9	229.6	11.7	168.6	Submerged
Palakkad	6.1	1.1	131.6	16.6	186.2	Saturated
Kuttanad	4.4	3.7	265.0	20.5	188.4	Submerged

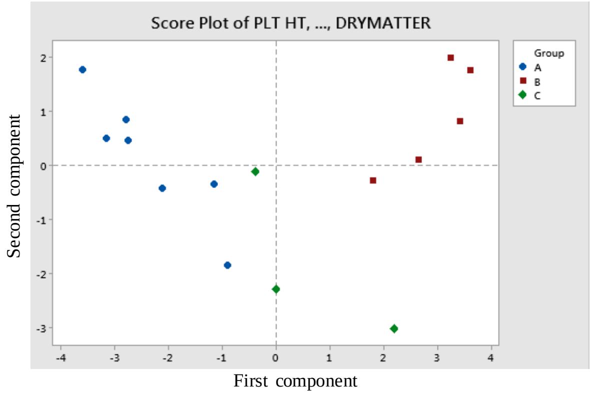

Figure 4. Scree plot of first two PC indicating the variability in morphological characters of *Sacciolepis interrupta*

Severe infestation of *Sacciolepis* group A was observed in saturated soils of Palakkad with near neutral pH, low organic carbon and low nutrient status. Group B dominated in acidic pH, medium organic carbon and submerged soils of Kole lands, and group C morphotypes were prominent in highly acidic and nutrient rich submerged soils of Kuttanad (**Table 6**).

The density and dominance indices clearly indicate the severity of *Sacciolepis interrupta* in the surveyed areas. Based on their morphology, *Sacciolepis interrupta* could be grouped into three groups A, B and C which might have evolved as an adaptation to the existing habitat, changing cultural practices and climatic conditions.

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