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ORIGINAL ARTICLE

Diversity and Adaptive Traits of Weedy Rice (*Oryza sativa f. spontanea*) Biotypes Infesting Rice Fields in Batticaloa District, Sri Lanka.

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Abstract

Rice is the most important crop in Sri Lanka, occupying approximately 34% of the total cultivated area. Rice cultivation is constrained by several factors, among which weeds are a major problem, and weedy rice (*Oryza sativa f. spontanea*) is considered the most troublesome weed due to its close morphological similarity to cultivated rice, making its identification and management difficult. Although weedy rice infestation has been widely reported in Sri Lanka, season-wise characterization of weedy rice during both *Maha* and *Yala* seasons has not been previously studied in the Batticaloa District, making this study novel. The objectives of this study were to identify the morphological characters, assess the diversity, and determine the adaptive traits of weedy rice biotypes infesting rice-growing areas of the Batticaloa District during the *Maha* and *Yala* seasons. A survey was conducted in rice-growing areas of the Batticaloa District, where eighteen and seven weedy rice-infested locations were selected during the *Maha* and *Yala* seasons, respectively. Thirteen morphological traits were recorded to assess the overall variation of weedy rice populations. Data were analyzed using Minitab 17 software, and mean comparisons were performed using Tukey's test at the 5% significance level. Significant ($P < 0.05$) morphological variation among locations was observed during both seasons. During the *Maha* season, significant differences were recorded in number of filled grains per panicle, panicle length, panicle shattering percentage, plant height, and number of tillers, while panicle shattering percentage and plant height showed significant variation among locations during the *Yala* season. Qualitative traits such as green stem color, red awns, and straw-colored lemma and palea were more prevalent during the *Maha* season, whereas a higher proportion of red pericarp was observed during the *Yala* season. Overall, the results demonstrate the existence of considerable morphological variation among weedy rice populations in the Batticaloa District, highlighting the need for location- and season-specific management strategies.

Keywords: *Awn, Batticaloa, Maha, Morphology, Pericarp,Yala*

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1. Introduction

Rice (*Oryza sativa* L.) is one of the major staple food crops in the world, being especially important in Asia, where approximately 90% of the world's rice is produced and consumed (Khush 2004). Rice occupies about 34% of the total cultivated area in Sri Lanka, with an annual production of approximately 2.7 million metric tons of rough rice, meeting nearly 95% of domestic demand (Department of Census and Statistics 2020; FAO 2020). Rice demand is projected to increase by 1.1% per year, requiring production growth of about 2.9% annually to meet future needs (IRRI 2020). Increasing the cropping intensity and national average yield are the options available to achieve these production targets (Mathanraj and Kaleel 2016). Rice cultivation faces various constraints to its production and productivity. Among these there are several pests and diseases, most of which nowadays can be well managed, even by implementing Integrated Pest Management.

Weeds are also a severe problem (Varshney and Tiwari 2008). *Echinochloa colona, Echinichloa crus-galli, Digitaria setigera, Echinochioa glabrescens, Eleusine indica, Leptochloa chinensis, Oryza sativa f. spontanea, Cyperus iria, Cyperus diffomis,* and *Cyperus rotundus* are some of the rice field weeds (Caton et al. 2010). Among these weeds, weedy rice is currently considered as one of the most troublesome, difficult-to-manage, and economically damaging weed problems in Sri Lanka (Marambe 2009).

Weedy rice is taxonomically the same species as cultivated rice (*Oryza sativa* L.), but it is strongly characterized by its enhanced ability to disseminate seeds rapidly (Wijekoon and Weerasinghe 2015). It has been suggested that weedy rice could be a result of de-domestication of cultivated rice. Weedy rice has also been reported to be the progeny of crosses between wild rice and cultivated rice or the product of degradation of cultivated rice (Chin 1997). In Sri Lanka, weedy rice populations were first observed in *Ampara* district located in the southeastern part of the country in the mid-1990's (Marambe and Amarasinghe 2000). At present, it has become a common weed in almost all the rice-growing areas in the country (Abeysekara et al. 2010). Although its infestation and impact on yield are well documented, limited information exists on the season-wise (*Maha* and *Yala*) morphological diversity and adaptive traits of weedy rice in the Batticaloa District, a major rice-growing region (Marambe and Amarasinghe 2000; Abeysekara et al. 2010). Understanding these traits is essential for developing location- and season-specific management strategies, especially under direct-seeded rice systems where conventional control is difficult (Subasinghe et al. 2007). Weedy rice competes for resources, such as water, nutrients, and sunlight, with its cultivated counterparts in rice fields, causing considerable yield losses of cultivated rice (Cao et al. 2006; Cao et al. 2007; Delouche et al. 2007). Weedy rice occurs mostly

in direct-seeded rice lands, due to a shifting from transplanting to dry sowing and the non-use on certified seeds. As weedy rice is morphologically similar to cultivated rice, its control is more difficult (Subasinghe et al. 2007).

The management of weedy rice infestations is much more complicated than that of other rice weeds because of the high biological similarity with cultivated rice and the extended germination over a long period of rice growth (Fogliatto et al. 2010). The lack of a selective herbicide for the control of weedy rice, or other effective measures, has made its control a subject of national significance in the country (Ratnasekera and Rupasingha 2015). The lack of information concerning the morphological variation of weedy rice has led to confusion in identifying weedy rice from the endemic wild rice species in Sri Lanka (Ratnasekera et al. 2014). It is essential to study the morphological variation pattern of the weedy rice in the Batticaloa district.

Although weedy rice infestation has been widely reported in Sri Lanka, season-wise characterization of weedy rice during both *Maha* and *Yala* seasons has not previously been studied in the Batticaloa District, making this study novel. The objectives of this study were to identify the morphological characters, assess the diversity, and determine the adaptive traits of weedy rice biotypes infesting rice-growing areas of the Batticaloa District during the *Maha* and *Yala* seasons.

2. Materials and Methods

2.1 A sampling of the weedy rice

An extensive survey was carried out in the rice-growing areas of the Batticaloa district, and eighteen weedy rice-infested locations were selected as sampling sites during the *Maha* season in 2020/2021, and seven locations were selected during the *Yala* season in 2020. The study area, Batticaloa, belongs to the low country dry zone having a mean rainfall of less than 1,750 mm. Samples were collected from *Paalaiyadivaddai*, *Paavakkodichchenai*, *38th colony*, *39th colony*, *Kilakkodichchenai*, *Kokkaddicholai*, *Marappaalakandam*, *Mandoor*, *Karavetti*, *Tharappillavelikandam*, and *Nellikuda* during the*Maha* season, and from *Paavakkodichchenai*, *Nediyamadu*, *Kilakkodichchenai*, *Mandoor*, *Nellikuda*, *Thaanthamalai*, and *Kadukkamunai* during the *Yala* season. Samples of weedy rice at the maturity stages were collected from a 1 m^2 area at the field in each location. Weedy rice samples were carefully uprooted and covered with a polyethene bag, they were transferred to the Crop Science Laboratory, Eastern University, Sri Lanka during the *Maha* and *Yala* seasons.

2.2 Morphological characterization

Thirteen morphological traits were recorded; plant height (cm), number of tillers, panicle length (cm), 100-seed weight (g), number of filled grains per panicle, lemma and palea colour at maturity, pericarp colour, presence of awn, awn colour at maturity, panicle shattering percentage (%), stem colour, grain length, and grain width (Table 1). The plants were selected randomly from the field, and the data were recorded at their maturity stage. Measurements were taken as described by the International Rice Research Institute.

Table 1: Morphological characters of weedy rice and methods of measurement

Character	Method of measurement
1. **Plant height (cm)**	Height was measured from ground level to the tip of the leaf of the tallest tiller. (If the panicle is longer than the leaves, plant height should be measured up to the tip of the panicle**,** not the leaf. If the spikelets have awns, the measurement should be taken excluding the awns, up to the tip of the panicle only.)
2. Number of tillers	Total tiller number per plant was counted.
3. **Panicle length (cm)**	Panicle length was measured from the base to the tip of the panicle.
4. **100 seed weight (g)**	A random sample of 100 well-developed grains was used to determine the 100-seed weight at standard grain moisture content (approximetly 14%)
5. **Number of filled grains/panicles**	The number of spikelets (including empty ones) per panicle was counted at maturity.
6. Lemma and palea colour at maturity	When the terminal spikelets are ripened, the colour of the lemma and palea is classified into 11 classes. straw, (1) gold and/or gold furrows on straw background, (2) brown spots on straw, (3) brown furrows on straw, (4) brown (tawny), (5) reddish to light purple, (6) purple spots on straw, (7) purple furrows on straw, (8) purple, (10) black, and (11) white.
7. **Pericarp colour**	Seed coat colour of dehulled grains was classified as: white, (2) brown to yellow, (3) brown furrows to grey, (4) brown, (5) red, (6) variable purple, (7) and purple
8. **Awn colour at maturity**	The colour of awns was recorded at maturity as: straw, (2) gold, (3) brown(tawny), (4) red, (5) purple and (6) black.

9. **Panicle shattering percentage (%)**	The number of seeds that shattered when a gentle press was given by hand, was counted for panicle shattering percentage. (Panicle shattering percentage was calculated per plant because a plant has many panicles, and measuring at the plant level gives a more accurate overall shattering ability. The number of shattered seeds was summed from all panicles of one plant and divided by the total number of seeds on that plant to calculate panicle shattering percentage.) $\boldsymbol{Panicle\ shattering}\ \% = \frac{\boldsymbol{Number\ of\ seeds\ shattered\ by\ hand\ press\ per\ plant}}{\boldsymbol{total\ number\ of\ seeds\ per\ plant}} \times 100\%$
10. **Stem colour**	Stem colour was observed physically at maturity stage.
11. **Grain length**	Grain length was measured in millimetres using a millimetre-graduated ruler as the distance from the base of the lowermost sterile lemma or palea, whichever is longer. In the case of awned varieties, the grain was measured to a point comparable to the tip of the apiculus.
12. **Grain width:**	Width of the grain was measured as the distance across the fertile lemma and palea at the widest point. A modified photo enlarger was used for measuring grain dimensions.

2.3 Data analysis

The parameters were measured to estimate the general variation of weedy rice in the Batticaloa district. Data measured were statistically analyzed using Minitab 17, and the mean comparison within treatments was performed by Tukey's test at the 5% significant level.

3. Results and Discussion

Table 2. Average number of filled grains per panicle, plant height and panicle length of weedy rice sample collected in Maha season (2020/2021) and Yala season (2020).

	Maha season (2020/2021)			***Yala season (2020)***		
Location	***Number of filled grains per panicle***	***Plant height(cm)***	***Panicle length (cm)***	***Number of filled grains per panicle***	***Plant height (cm)***	***Panicle length (cm)***
Paalaiyadivaddai	76.56 ± 4.69^{c}	124.67 ± 2.13^{abc}	16.29 ± 1.06^{e}	-	-	-
Paavakkodichchenai	74.78 ± 3.44^{c}	130.07 ± 4.57^{abc}	23.21 ± 1.86^{bcde}	93.80 ± 41.40^{a}	125.37 ± 2.65^{b}	27.75 ± 1.91^{a}
38th colony	83.33 ± 9.67^{bc}	137.83 ± 3.24^{abc}	30.57 ± 1.28^{a}	-	-	-
39th colony	36.67 ± 2.59^{c}	134.00 ± 4.03^{abc}	22.22 ± 1.71^{cde}	-	-	-

Kilakkodichchenai	58.67 ± 9.02^{c}	138.37 ± 6.72^{abc}	24.63 ± 0.99^{abc}	96.70 ± 22.00^{a}	160.30 ± 7.88^{a}	25.17 ± 1.24^{a}
Kokkaddicholai	36.11 ± 9.83^{c}	144.37 ± 7.96^{ab}	29.24 ± 2.32^{ab}	-	-	-
Marappaalakandam	63.11 ± 7.73^{c}	144.20 ± 11.50^{ab}	23.23 ± 0.43^{bcde}	-	-	-
Mandoor	45.11 ± 2.96^{c}	140.63 ± 8.45^{abc}	22.7 ± 0.68^{bcde}	118.20 ± 15.80^{a}	150.43 ± 8.10^{ab}	22.20 ± 1.23^{a}
Karavetti	45.00 ± 3.53^{c}	141.50 ± 14.10^{abc}	23.28 ± 2.32^{bcd}	-	-	-
Tharappillavelikandam	155.90 ± 28.00^{a}	147.07 ± 5.23^{a}	24.79 ± 0.56^{abc}	-	-	-
Kadukkamunai	69.56 ± 4.45^{c}	144.30 ± 3.52^{ab}	26.87 ± 1.43^{abc}	81.72 ± 5.37^{a}	148.37 ± 4.59^{b}	29.06 ± 0.58^{a}
Nathanaimelthoddam	55.56 ± 4.87^{c}	137.00 ± 11.50^{abc}	23.97 ± 0.79^{abcd}	-	-	-
Batticaloa	68.00 ± 14.80^{c}	133.27 ± 8.79^{abc}	25.31 ± 1.46^{abc}	-	-	-
Kurumanveli	53.70 ± 12.90^{c}	124.13 ± 5.42^{abc}	23.06 ± 1.24^{bcde}	-	-	-
Nediyamadu	89.60± 13.30^{bc}	143.17 ± 7.65^{abc}	25.89 ± 0.22^{abc}	128.70 ± 23.30^{a}	160.17 ± 4.34^{a}	30.24± 3.49^{a}
Vellaveli	146.67 ± 0.33^{ab}	104.67 ± 2.33^{bc}	26.72 ± 0.24^{abc}	-	-	-
Kullavadi	72.60 ± 29.30^{c}	133.70 ± 14.10^{abc}	25.94 ± 1.57^{abc}	-	-	-
Nellikuda	45.33 ± 3.06^{c}	102.27 ± 1.46^{c}	17.67 ± 0.53^{de}	95.10 ± 38.90^{a}	130.73 ± 6.90^{ab}	26.86 ± 2.94^{a}
Thaanthamali	-	-	-	84.17 ± 5.99^{a}	148.57 ± 5.02^{ab}	28.96 ± 0.77^{a}
P-Value	<0.05	<0.05	<0.05	>0.05	<0.05	<0.05

The value represents the mean ± standard error (n=3). Means followed by the same are not significantly different at 0.05 probability level.

3.1 Maha season (2020/2021)

Number of grains per panicle

Table 2 shows the variation in the mean number of grains per panicle of weedy rice in different locations in the Batticaloa district. A significant difference (P<0.05) was recorded between the locations. The mean value ranged from 36.11 to 155.90. The highest mean value was recorded at Tharappillavelikandam (155.90), and the lowest mean value recorded at Kokkaddicholai (36.11). This result indicates that the number of grains per panicle of weedy rice varied among locations. This may be due to the presence of genetically diverse weedy rice populations in the Batticaloa district. The number of spikelets per panicle is primarily controlled by genetic factors, and differences among locations likely reflect different weedy rice genotypes rather than seed movement alone. Environmental conditions and crop management may have had a minor

influence, but the observed variation is mainly attributed to genetic variation (Marambe 2016). A previous study reported that the number of seeds per panicle varied among sites and ranged from 39 to 67 in Peradeniya, Kegalle, Ratnapura, and Mahailuppallama locations (Marambe 2016).

Plant height (cm)

Table 2 describes the variation in average plant height. A significant difference (p<0.05) was recorded between the locations. The average value ranged from 102.27–147.07 cm and the highest average value was recorded at Tharappillavelikandam (147.07 cm), and the lowest recorded at Nellikuda (102.27 cm). These results indicate that the plant height of weedy rice varied among locations. This may be due to the expression of a quantitative trait controlled by multiple genes. Plant height in rice and weedy rice is strongly influenced by environmental factors such as soil fertility, water availability, nutrient status, and plant density, in addition to genetic background (Yoshida 1981; Khush 1997). Therefore, the observed location-wise variation in plant height is mainly attributed to environmental conditions affecting trait expression, rather than seed movement alone.

A similar result was reported by Perera et al. (2012), where plant height varied with location. In Ampara, significantly shortest plants were recorded at Thottama (144.30 cm) among weedy rice populations compared to other sites. The plants recorded at Akkaraipattu (149.27cm) and Lahugala (147.13 cm) were much taller, and no significant difference was shown among them. A previous study reported that 90% of weedy rice population were found to be taller plants ranging from 90 to 165 cm in Sri Lanka (Abeysekara et al. 2010).

Panicle length (cm)

Table 2 describes the variation in average panicle length. A significant difference (p<0.05) was recorded between the locations. The average value ranged from 16.29–30.57 cm. The highest average value was recorded at 38th colony (30.57 cm), and the lowest average value was recorded at Paalaiyadivaddai (16.29 cm). These results indicate that the panicle length of weedy rice varied among locations. The significant variation in panicle length among locations indicates differences in the expression of a quantitative trait controlled by genetic factors and their interaction with the environment. Panicle length in rice and weedy rice is largely governed by genotype, while environmental conditions such as nutrient availability, water status, and crop management influence its expression (Yoshida 1981; Khush 1997). Therefore, the observed differences among locations are mainly attributed to genetic variation among weedy rice populations and genotype × environment interactions, rather than seed movement alone.

Shivrain et al. (2010) recorded different weedy rice types with panicle length ranging from 18 cm– 39 cm in the United States of America.

3.2 Yala season (2020)

Number of filled grains per panicle

Table 2 shows the variation of the mean number of filled grains per panicle. No significant difference (p>0.05) was recorded among the locations. The mean value ranged from 81.72 to 128.70. The highest mean value was recorded at Nediyamadu (128.70), and the lowest mean value was recorded at Kadukamunai (81.72). A previous study reported that the number of seeds per panicle varied among sites and ranged from 39 to 67 in Peradeniya, Kegalle, Ratnapura, and Mahailuppallama locations (Marambe 2016).

Plant height (cm)

Table 2 describes the variation of average plant height (cm). A significant difference (P<0.05) was recorded between the locations. The average value varied within the range of 125.37–160.30 cm and the highest average value was recorded at Nediyamadu (160.30 cm), and the lowest average value recorded at Paavakodichenai (125.37 cm). This result indicates that the plant height of weedy rice varied with locations. This significant difference may be due to the quantitative trait controlled by genetic factors, environmental conditions, and their interactions (G × E). Plant height in weedy rice is influenced by genotype, as well as location-specific environmental factors such as soil fertility, water availability, nutrient management, and plant density, which together explain the observed variation rather than the movement of weedy rice seeds alone (Yoshida, 1981; Khush, 1997).

A similar result was reported by Perera et al. (2012): the plant height varied with location. In Ampara, significantly the shortest plants were recorded at Thottama (144.30) weedy rice populations compared to other sites. The plants recorded at Akkaraipattu (149.27) and Lahugala (147.132) were much taller, and there was no significant difference among them. A previous study reported that, 90 % of weedy rice population were found to be taller plant ranging from 90 to 165 cm in Sri Lanka (Abeysekara et al. 2010).

Panicle length (cm)

Table 2 describes the variation of average panicle length (cm). No significant difference (p>0.05) was recorded among the locations. The average value ranged from 22.20 cm–30.24 cm. The highest average value was recorded at Nediyamadu (30.24 cm), and the lowest average value was

recorded at Mandoor (22.20 cm). Shivrain et al. (2010) recorded different weedy rice types with panicle length ranging from 18 cm- 39 cm in the United States of America.

3.3 Maha season (2020/2021)

Panicle shattering percentage (%)

Table 3 demonstrates the variation of average panicle shattering percentage (%). A significant difference (p<0.05) was recorded between the locations. The mean value ranged from 0.48 to 47.92. Location Kurumanveli exhibited the highest mean value (47.92), and Paavakkodichchenai showed the lowest mean value (0.48). This result indicates that the panicle shattering % of weedy rice varied among locations. The significant variation in panicle shattering percentage among locations reflects differences in the genetic makeup of weedy rice populations, as shattering is a highly heritable trait in weedy rice. The very low shattering percentages observed at some locations may be due to environmental conditions during grain maturity (such as high humidity and rainfall in the Maha season) and possible introgression from cultivated rice with reduced shattering, which can suppress shattering expression (Yoshida 1981; Thurber et al. 2010).
Abeysekera et al. (2013) reported that most of the weedy rice identified near to the coastal areas in the country-viz Ampara, Mannar Puttalam, and Matara are similar to wild rice in that they have a high degree of seed shattering >90% and samples collected from inside the country-viz. Kurunegala, Polonnaruwa, and Anuradhapura, have a lower degree of seed shattering 40–70%.

100 seed weight (g)

Table 3 shows the variation of the average 100 seed weight of weedy rice collected in different locations of Batticaloa district. There is no significant difference (p>0.05) in 100 seed weight of weedy rice recorded between the locations. All measurements were recorded at a standardized grain moisture content of approximately 14%. The 100 seed weight of the weedy rice ranged between 0.68 g–6.18 g. The highest average value was recorded in 39th colony (6.18 g), and the lowest mean value was recorded at Nathanaimelthoddam (0.68 g). From this result, the 100 seed weight of weedy rice samples collected from Batticaloa was less than 7 g. A study reported that the 1000 grain weight of weedy rice samples collected from coastal areas of Ampara, Batticaloa, Hambantota, Matara, and Galle was less than 20 g (Abeysekera et al. 2013).

Table 3: Panicle shattering percentage, 100 seed weight and Tillers number of weedy rice sample collected in Maha season (2020/2021) and Yala season (2020)

The value represents the mean ± standard error (n=3). Means followed by the same are not significantly different at 0.05 probability level.

	Maha season (2020/2021)			**Yala season (2020)**		
Location	**Panicle shattering percentage (%)**	**100 seed weight (g)**	**Tillers number**	**Panicle shattering percentage (%)**	**100 seed weight (g)**	**Tillers number**
Paalaiyadivaddai	6.85 ± 2.37^{cd}	2.52 ± 0.17^{a}	7.67 ± 1.33^{b}	-	-	-
Paavakkodichchenai	0.48 ± 0.29^{d}	1.18 ± 0.23^{a}	9.33 ± 1.45^{ab}	9.45 ± 3.28^{a}	1.84 ± 0.58^{a}	1.33 ± 0.333^{a}
38th colony	10.40 ± 10.20^{bcd}	1.46 ± 0.23^{a}	12.33 ± 0.88^{ab}	-	-	-
39th colony	20.88 ± 6.57^{abcd}	6.18 ± 4.77^{a}	6.00 ± 0.58^{b}	-	-	-
Kilakkodichchenai	16.59 ± 8.01^{abcd}	1.59 ± 0.08^{a}	10.33 ± 1.45^{ab}	7.79 ± 2.59^{a}	1.21 ± 0.51^{a}	6.33 ± 2.96^{a}
Kokkaddicholai	29.12 ± 6.99^{abcd}	1.50 ± 0.53^{a}	6.00± 0.58^{b}	-	-	-
Marappaalakandam	41.74 ± 0.71^{abc}	2.16 ± 0.45^{a}	9.33 ± 1.86^{ab}	-	-	-
Mandoor	18.07 ± 7.26^{abcd}	1.44 ± 0.34^{a}	23.33 ± 9.94^{a}	15.51 ± 2.68^{a}	1.88 ± 0.03^{a}	1.67 ± 0.333^{a}
Karavetti	28.50± 4.02^{abcd}	0.75 ± 0.22^{a}	10.67 ± 1.76^{ab}	-	-	-
Tharappillavelikandam	15.77 ± 8.56^{abcd}	2.28 ± 0.28^{a}	11.33 ± 2.33^{ab}	-	-	-
Kadukkamunai	23.73 ± 3.34^{abcd}	1.36 ± 0.41^{a}	7.00 ± 0.00^{b}	24.43 ± 3.56^{a}	1.54 ± 0.39^{a}	3.67 ± 1.20^{a}
Nathanaimelthoddam	12.06 ± 6.41^{abcd}	0.68 ± 0.07^{a}	5.67 ± 0.88^{b}	-	-	-
Batticaloa	23.80 ± 14.10^{abcd}	1.56 ± 0.14^{a}	14.00 ± 4.73^{ab}	-	-	-
Kurumanveli	47.92 ± 9.19^{a}	1.58 ± 0.51^{a}	9.00 ± 0.58^{ab}	-	-	-
Nediyamadu	46.34 ± 9.38^{ab}	1.46 ± 0.11^{a}	15.00 ± 2.31^{ab}	14.99 ± 3.13^{a}	0.69 ± 0.39^{a}	4.00 ± 1.15^{a}
Vellaveli	1.03 ± 0.52^{d}	1.16 ± 0.03^{a}	5.67 ± 0.88^{b}	-	-	-
Kullavadi	35.23 ± 6.96^{abcd}	0.86 ± 0.20^{a}	7.00 ± 2.08^{b}	-	-	-
Nellikuda	9.83 ± 4.38^{bcd}	1.64 ± 0.12^{a}	18.67 ± 1.20^{ab}	18.21 ± 4.08^{a}	1.66 ± 0.35^{a}	3.00 ± 1.00^{a}
Thaanthamalai	-	-	-	26.72 ± 6.70^{a}	1.37 ± 0.31^{a}	3.67 ± 0.33^{a}
P-Value	<0.05	>0.05	<0.05	>0.05	>0.05	>0.05

Tillers number

Table 3 describes the variation of average tiller number. A significant difference (p<0.05) was recorded between the locations. The average value ranged between 5.67 and 23.33. Mandoor (23.33) exhibited the highest mean value, and Vellaveli and Nathanaimelthoddam (5.67) exhibited the lowest mean value. Tiller number in weedy rice is strongly influenced by environmental factors such as soil fertility, nutrient availability, water management, and plant density, as well as genotype × environment interactions, which likely account for the observed location-wise variation rather than seed movement alone (Yoshida 1981; Khush 1997).

A similar result was reported by Perera et al. (2012): the tiller number varied with locations. At Lahugala, significant differences were recorded for tiller number (3.22), and the highest number of tillers (4.5) recorded at Akkaraipattu in Ampara district. A previous study which compared Bg-300, a traditional variety (Kaluheneti), and wild rice (*Oryza nivara*) with weedy rice reported that the average number of tillers per plant was significantly higher (p<0.05) in *Oryza nivara*. The lowest number of tillers was recorded in Bg-300. Weedy Rice accessions showed intermediate characters between Bg-300 and *Oryza nivara* in the Puttlam district and the Galle district (Subasinghe et al. 2007).

3.4 Yala season (2020)

Panicle shattering percentage (%)

Table 3 demonstrates the variation of average panicle shattering percentage. A significant difference (p<0.05) was recorded between the locations. The mean value ranged from 7.79 to 26.72. Location Thaanthamalai exhibited the highest mean value (26.72), and Killakodichenai showed the lowest mean value (7.79). This result indicates that the panicle shattering percentage of weedy rice varied with locations. The variation in panicle shattering percentage among locations during the Yala season reflecting differences in the expression of a trait mainly controlled by genetic factors, with additional influence from environmental conditions and genotype × environment (G × E) interactions. The relatively low panicle shattering percentages observed may be due to dry climatic conditions, higher temperatures, and reduced humidity during the Yala season, which can limit the expression of shattering, as well as possible introgression from cultivated rice with reduced shattering, rather than movement of weedy rice seeds among locations (Yoshida 1981; Thurber et al. 2010).

Abeysekera et al. (2013) reported that most of the weedy rice identified near to the coastal areas in the country-viz Ampara, Mannar Puttalam, and Matara are similar to wild rice in that they have a high degree of seed shattering of >90% and samples collected from inside the country-viz. Kurunegala, Polonnaruwa, Anuradhapura, have a lower degree of seed shattering 40–70%.

The100 seed weight (g)

Table 3 shows the variation in the average 100-seed weight of weedy rice collected from different locations in the Batticaloa district, with no significant difference (p>0.05) among locations. The 100-seed weight ranged from 0.69 to 1.88 g, and all measurements were taken at a standardized grain moisture content of approximately 14%, as recommended for rice seed weight determination to minimize the effect of moisture variation. Although 1000-seed weight is more commonly reported, 100-seed weight was used in this study due to limited seed availability, following standard rice measurement procedures (IRRI, 2013). A study by Abeysekera et al. (2013) reported that the 1000 grain weight of weedy rice samples collected from coastal areas of Ampara, Batticaloa, Hambantota, Matara, and Gallewas less than 20 g.

Tillers number

Table 3 describes the variation of average tillers number. No significant difference (p>0.05) was recorded among the locations. The average value ranged between 1.33–6.33. Killakodichenai (6.33) exhibited the highest mean value and Paavakodichenai (1.33) showed the lowest mean value. A previous result was reported by Perera et al. (2012): the tiller number varied with locations. At Lahugala, significant differences were recorded for tiller number (3.22), and the highest number of tillers (4.5) was recorded at Akkaraipattu in Ampara district. A previous study which compared Bg-300, a traditional variety (Kaluheneti), and wild rice (*Oryza nivara*) with weedy rice reported that the average number of tillers per plant was significantly higher (p<0.05) in *Oryza nivara.* The lowest number of tillers was recorded in Bg3-00. Weedy rice accessions showed intermediate characters between Bg-300 and *Oryza nivara* in the Puttlam district, and in the Galle district (Subasinghe et al., 2007).

Grain length (mm)

Table 3 shows the variation of the average grain length (mm). No significant difference (p>0.05) was recorded among the locations. The mean value ranged between 7.07 and 8.37 mm. The highest average value was recorded at Batticaloa and Nellikuda (8.37 mm) divisions, while the lowest average value was recorded at Vellaveli (7.07 mm). A previous study reported that different weedy rice types with an average seed length of 8.62 mm were recorded in the United States of America (Shivrain et al. 2010).

Table 4: Grain length and Grain width of weedy rice sample collected in Maha season (2020/2021) and Yala season (2020)

	Maha season (2020/2021)		Yala season (2020)	
Location	**Grain length (mm)**	**Grain width (mm)**	**Grain length (mm)**	**Grain width (mm)**
Paalaiyadivaddai	7.88 ± 0.06[a]	3.10 ± 0.12[a]	-	-
Paavakkodichchenai	7.87 ± 0.41[a]	2.70 ± 0.27[a]	8.32 ± 0.43[a]	2.76 ± 0.07[a]
38th colony	8.20 ± 0.40[a]	2.80 ± 0.11[a]	-	-
39th colony	7.68 ± 0.21[a]	2.56 ± 0.06[a]	-	-
Kilakkodichchenai	8.32 ± 0.05[a]	2.57 ± 0.05[a]	7.86 ± 0.87[a]	2.55 ± 0.25[a]
Kokkaddicholai	7.83 ± 0.22[a]	2.80 ± 0.10[a]	-	-
Marappaalakandam	8.08 ± 0.32[a]	3.14 ± 0.18[a]	-	-
Mandoor	8.11 ± 0.20[a]	2.46 ± 0.03[a]	7.58 ± 0.66[a]	2.96 ± 0.23[a]
Karavetti	8.30 ± 0.03[a]	2.69 ± 0.13[a]	-	-
Tharappillavelikandam	7.59 ± 0.37[a]	2.80 ± 0.17[a]	-	-
Kadukkamunai	7.94 ± 0.41[a]	2.43 ± 0.23[a]	8.15 ± 0.48[a]	2.64 ± 0.15[a]
Nathanaimelthoddam	7.93 ± 0.55[a]	2.54 ± 0.11[a]	-	-
Batticaloa	8.37 ± 0.31[a]	2.89 ± 0.17[a]	-	-
Kurumanveli	8.36 ± 0.27[a]	2.50 ± 0.07[a]	-	-
Nediyamadu	8.09 ± 0.38[a]	2.81 ± 0.11[a]	6.27 ± 0.46[a]	2.21 ± 0.22[a]
Vellaveli	7.07 ± 0.05[a]	2.74 ± 0.12[a]	-	-
Kullavadi	8.34 ± 0.47[a]	2.65 ± 0.07[a]	-	-
Nellikuda	8.37 ± 0.37[a]	3.16 ± 0.40[a]	7.76 ± 0.18[a]	2.97 ± 0.10[a]
Thaanthamalai	-	-	7.49 ± 0.86[a]	2.51 ± 0.27[a]
P-Value	>0.05	>0.05	>0.05	>0.05

Grain width (mm)

Table 4 shows the variation of the average grain width (mm). No significant difference (p>0.05) was recorded among the locations. The mean value ranged from 2.43–3.16 mm and Nellikuda exhibited the highest mean value (3.16 mm) and Kadukkamunai exhibited the lowest mean value (2.43 mm). Shivrain et al. (2010) reported that different weedy rice types with an average seed width of 2.55 mm were recorded in the United States of America.

3.5 Yala season (2020)

Grain length (mm)

Table 4 shows the variation of the average grain length (mm) of weedy rice in the different locations of the Batticaloa district. No significant difference (p>0.05) was recorded among the locations. The mean value ranged between 6.27– 8.32 mm. The highest average value was recorded at Paavakodichenai (8.32 mm), and the lowest average value was recorded at Nediyamadu (6.27 mm). A previous study reported that different weedy rice types with an average seed length of 8.62 mm were recorded in the United States of America (Shivrain et al. 2010).

Grain width (mm)

Table 4 shows the variation of the average grain width (mm). No significant difference (p>0.05) was recorded among the locations. The mean value ranged from 2.21 to 2.97 mm. Location Nellikuda exhibited the highest mean value (2.97 mm), and Nediyamadu showed the lowest mean value (2.21 mm). Shivrain et al. (2010) reported that different weedy rice types with an average seed width of 2.55 mm were recorded in the United States of America.

3.6 Pericarp colour

Table 5: Pericarp colour of weedy rice samples collected in the Maha season (2020/2021) and Yala season (2020)

Pericarp colour	Maha season (2020/2021)	Yala season (2020)
Red	75.86%	83.33%
White	24.14%	16.67%

Table 5 illustrates the variation in pericarp colour of weedy rice collected from the Batticaloa district during the Maha season (2020/2021) and the Yala season (2020). In the Maha season, 75.86% of the weedy rice seeds exhibited red pericarp, while 24.14% had white pericarp. In contrast, during the Yala season, a higher proportion of seeds showed red pericarp (83.33%), whereas only 16.67% exhibited white pericarp.

These findings indicate that red pericarp is the predominant trait in weedy rice across both seasons in the study area. Similar trends have been reported in previous studies, where 84.4% of Asian weedy rice accessions were found to possess red or brown pericarp, and only 15.6% had white pericarp (Zhang et al., 2015). Likewise, Ratnasekera and Rupasingha (2015) reported that red pericarp was more prominent (>80%) than white pericarp (<7%) in weedy rice populations in Sri Lanka. While the Yala season results of the present study align closely with these findings, the Maha season showed a comparatively higher proportion of white pericarp seeds, indicating seasonal or regional variation.

3.7 Awn colour at maturity

Table 6: Awn colour at maturity of weedy rice samples, collected in the Maha season (2020/2021) and Yala season (2020)

Awn colour at maturity (%)	Maha season (2020/2021)	Yala season (2020)
Red	53.33%	58.82%
Straw	46.67%	41.18%

Table 6 presents the variation in awn colour at maturity of weedy rice collected from the Batticaloa district during the Maha and Yala seasons. In the Maha season, 53.33% of the weedy rice exhibited red-coloured awns, while 46.67% had straw-coloured awns. Similarly, during the Yala season, a

slightly higher proportion of weedy rice showed red awns (58.82%), whereas 41.18% exhibited straw-coloured awns.

Awn colour is a genetically controlled qualitative trait; however, its expression may vary with grain developmental stage, as awns often appear reddish at the dough stage and turn straw-coloured upon full maturity. Comparable variation in awn presence and colour has been reported in Sri Lankan weedy rice populations, where awn colours ranged from straw to dark brown (Abeysekera et al. 2013). In the same study, approximately 54% of 1,300 observed weedy rice variants possessed long awns, further supporting the wide phenotypic diversity observed in the present study.

Figure 1: Red colour awn

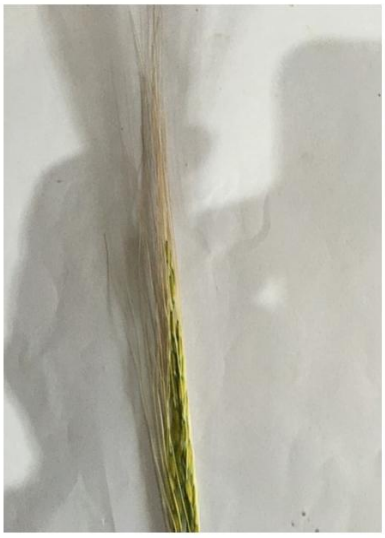

Figure 2: Straw colour awn

3.8 Presence of Awn

Table 7: Presence of weedy rice samples collected in the Maha season (2020/2021) and Yala season (2020)

Presence of Awn	Maha season (2020/2021)	Yala season (2020)
Awnless	15.09%	19.05%
Awn	84.91%	80.95%

Table 7 describes the variation in awn characters of weedy rice collected from the Batticaloa district during the Maha and Yala seasons. In the Maha season, 84.91% of the weedy rice accessions possessed awns, while only 15.09% were awnless. Similarly, in the Yala season, a majority of the weedy rice exhibited awns, with 80.95% being awned and 19.05% awnless.

These results indicate that the presence of awns is a dominant characteristic of weedy rice populations in the Batticaloa district across both seasons. Comparable findings were reported that, on average, 60% of total panicles in the Ampara district were awned (Perera et al. 2012). In the same study, awn presence varied across locations, with 64% and 62% of accessions having awns in Thottama and Akkaraipattu, respectively, while 51% were awnless in Lahugala, highlighting regional variation in awn characteristics.

3.9 Lemma and palea colour at maturity

Table 8: Lemma and palea colour at maturity of weedy rice samples collected in the Maha season (2020/2021) and Yala season (2020)

Lemma and palea colour at maturity (%)	Maha season (2020/2021)	Yala season (2020)
Straw	66.67%	71.43%
Brown	20.37%	14.29%
Black	12.96%	14.29%

Table 8 presents the variation in lemma and palea colour at maturity of weedy rice collected from the Batticaloa district during the Maha and Yala seasons. In the Maha season, the majority of weedy rice accessions exhibited straw-coloured lemma and palea (66.67%), followed by brown (20.37%) and black (12.96%) colours. Similarly, in the Yala season, straw colour was the most prevalent (71.43%), while equal proportions of brown and black coloured lemma and palea were observed (14.29% each).

These results indicate that straw-coloured lemma and palea predominate in weedy rice populations of the Batticaloa district across both seasons. Comparable findings were reported showing that straw-coloured hulls occurred at a higher frequency (>50%) than black (<25%) and grey (<30%) hull-coloured seeds in Sri Lankan weedy rice populations (Ratnasekera & Rupasingha 2015).

3.10 Stem colour

Table 9: Stem colour of weedy rice at the reproductive stage sample collected in the Maha season (2020/2021) and Yala season (2020)

Stem colour (%)	Maha season (2020/2021)	Yala season (2020)
Straw	66.67%	-
Pale yellow	11.11%	-
Yellow	5.56%	-
Yellowish green	16.67%	4.76%
Pale green	14.81%	42.86%
Green	51.85%	52.38%

Table 9 describes the variation in stem colour of weedy rice collected from the Batticaloa district during the Maha. 66.67% of samples exhibited straw-coloured stems. Additionally, green stem colour was observed in51.85% of samples, yellowish-green in 16.67%, pale green in 14.81%, pale yellow in 11.11% , and yellow in5.56%. In contrast, during the Yala season, the majority of weedy rice exhibited green stems (52.38%), while 42.86% showed pale green stems and a smaller proportion (4.76%) displayed yellowish-green stem colour. Overall, green and pale green stem colours predominated across both seasons, although a wider range of stem colour variation was observed during the Maha season compared to the Yala season.

4. Conclusions

According to our study, significant morphological variation of weedy rice was observed among locations. In the *Yala* season during 2020, panicle shattering percentage and plant height showed considerable differences, and in the Maha season the number of grains per panicle, panicle length, panicle shattering percentage, plant height, and tiller number showed significant differences among locations in 2020/2021. In both the *Maha* and *Yala* season green-coloured stems, red-colour awns, and straw-coloured lemma and palea were observed in a higher percentage. A higher percentage of red-coloured pericarp was observed in the Yala season. Therefore, considering the results from the *Maha* and *Yala* seasons among the locations, there is morphological variations of weedy rice in the *Batticaloa* district. These study results will help to develop management strategies for weedy rice. Knowledge of such a morphological variation pattern provides opportunities to design strategic management methods for weedy rice control in Sri Lanka.

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