

MORPHOLOGICAL CHARACTERIZATION OF *ATTAKKARI* RICE THROUGH NATURAL FIELD TRIALS

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Introduction

Rice is the staple food for most Sri Lankans, forming the basis of at least two of the three main meals [1]. Among the many rice varieties cultivated in Sri Lanka, *Attakkari* rice holds a special place due to its cultural significance and historical background. *Attakkari* rice, also known locally as "Jaffna Red Rice," is a traditional rice cultivar believed to have been introduced to the Kilinochchi region around 2009, likely from India. This cultivar was brought to the Northern region, specifically to the "Vanni" area, during the Sri Lankan Civil War by the then-existing "Porunmiyam" Association according to the farming community [2]. Initially, it was well adapted to the local environment, thriving in the Northern region. However, over time, it became highly susceptible to blast disease caused by *Magnaporthe oryzae*, a major fungal disease that severely affects rice yields [1]. Despite this vulnerability, many farmers in the Northern region of Sri Lanka continue to cultivate *Attakkari*, primarily for personal consumption. The cultural significance of *Attakkari* rice is deeply rooted in the traditional agricultural practices of the region. One of its most notable traits is its resilience against flooding, as the grains do not shatter even under prolonged submersion, making it ideal for regions prone to waterlogging. However, due to its susceptibility to blast disease, the Department of Agriculture, Sri Lanka does not recommend this cultivation [3].

Attakkari rice cultivation in the Northern region of Sri Lanka farmers are typically practiced under low-input management systems. Farmers generally apply minimal fertilizers and adopt simplified management practices compared to those used for other rice varieties. Such low-input approaches reduce production costs while promoting environmental sustainability by minimizing chemical use [2]. In addition, the cultivation of *Attakkari* rice preserves its inherent nutritional qualities, making it both ecologically sustainable and nutritionally valuable for the region. The cultivation cycle of *Attakkari* rice, similar to other traditional Sri Lankan rice varieties, is closely aligned with the island's two major monsoon seasons: *Maha* (October to March) and *Yala* (May to September), which provide the essential water required for paddy growth [4]. From a nutritional perspective, *Attakkari* rice is reported to be richer in essential nutrients [2] compared to many newly improved varieties (Farmers information), which has increased its popularity among health-conscious consumers. Despite these advantages, research on *Attakkari* remains limited. Moreover, since this variety has been cultivated for over 15 years across different

regions of the Northern Province, considerable genetic variability is likely to exist among its populations.

Given these factors, exploring *Attakkari* rice potential for breeding programs is of critical importance, particularly for improving resistance to blast disease, a major constraint in its cultivation. With rising consumer preference and market demand for *Attakkari* rice this research was undertaken to evaluate the morphological variability of *Attakkari* rice, confirm morphological variants through field trials, and thereby provide a foundation for breeding efforts aimed at enhancing disease resistance and ensuring the long-term sustainability of this cultivar.

Materials and Methods

Study Site

The study was conducted using the laboratory facilities of the Department of Agricultural Biology, Faculty of Agriculture, and the Department of Zoology, Faculty of Science, University of Jaffna. Field studies were carried out at the Rice Research Station (RRS) in Paranthan, Sri Lanka.

Selection of Samples

A total of 117 samples were collected following the selection process. The collected samples were subsequently evaluated using seed morphological traits. From each sample, 100 seeds were randomly selected and weighed to assess seed parameters. An additional portion of seeds were then separated to distinguish between healthy and non-healthy seeds. Seed parameter assessments included measurements of seed length, width, and color, using a color chart to categorize normal and abnormal seeds. For each sample, the average length and width of 10 seeds were recorded. The total weight of 100 seeds was measured for each sample. Maximum and minimum lengths and widths were also documented. Image sensing analysis using average intensity of the RGB values and the average intensity of the grayscale was performed. A cluster analysis (k-means clustering) was conducted to identify distinct morphotypes using the measured morphometric parameters within the collected *Attakkari* samples in Minitab v18. There were 10 unique clusters identified. These were named A, B, C, D, E, F, G, H, I, J. Among these clusters, one type was selected for field trial and molecular analysis. The selected types were Att 34, Att 94, Att 29, Att 44, Att 14, Att 116, Att 06, Att 16,

One sample formed a separate cluster (No. 32) was not used in the further analysis because it contained only one sample, and its seeds failed to germinate. The image sensing processes revealed two main color variants (1 and 2), which were further subdivided into four distinct sub-variants (A, B, C, D). These variations were analyzed and confirmed using Principal Component Analysis (PCA) in Minitab 17. Based on this PCA, nine representative variants showing clear morphological differentiation were selected for field-level confirmation [2]. In addition to these farmer-sourced variants, two reference cultivars and several improved breeding lines were obtained

from the Regional Research Station (RRS) in Paranthan. This reference set included *Attakkari* collections from both the Maha (2022/2023) and Yala (2023) seasons, as well as breeding lines developed from conventional crosses between *Attakkari* and other known lines (e.g., AR-9-3 / Att). Details of all selected samples are provided in Table 1.

Table 1. Details of Selected *Attakkari* variants, Reference cultivars, and Breeding lines used for field evaluation

Sample Code	Collected place	Remarks
Att 34	Vaddakkachi, Kilinochchi	<i>Attakkari</i> variant
Att 94	Mannar	<i>Attakkari</i> variant
Att 29	Varany, Jaffna	<i>Attakkari</i> variant
Att 44	Vaddukkoddai, Jaffna	<i>Attakkari</i> variant
Att 14	Alaveddy, Jaffna	<i>Attakkari</i> variant
Att 116	Udayarkaddu, Mullaitheevu	<i>Attakkari</i> variant
Att 06	Paranthan, Kilinochchi	<i>Attakkari</i> variant
Att 16	Uruththirapuram, Kilinochchi	<i>Attakkari</i> variant
Att 32	Mannar	<i>Attakkari</i> variant
Improved Line (ILa)	RRS, Paranthan	Improved Line using AR-9-3 and <i>Attakkari</i>
Reference <i>Maha</i> (RM)	RRS, Paranthan	<i>Maha</i> 2022/2023 Season collection
Reference <i>Yala</i> (RY)	RRS, Paranthan	<i>Yala</i> 2023 season collection

Assessment of Growth and Yield parameters

Prior to nursery establishment, a seed viability test was conducted to ensure optimal germination. Approximately 90% of the selected *Attakkari* seed samples were found to be viable. To promote uniform germination, seeds were pre-treated using a standard three-step protocol as described below. First, the seeds were soaked in water for 24 hours to activate metabolic processes. Subsequently, the soaked seeds were wrapped in a moist cloth and incubated under warm conditions for 48 hours to maintain humidity and encourage sprouting. The germinated seeds were then transferred to nursery trays (parachute trays) filled with a prepared substrate composed of soil, a 50 g of Urea, Ammonia and Ammonium phosphate of mixture of inorganic fertilizer, 500 g of cow dung, and 2 kg of vermicompost. The trays were watered regularly and maintained for 14 days, until 21 days of seedlings stage reached for transplanting. I have used 500m² of the field with each line planted with 100 plants. Growth parameters were measured at two-week intervals following planting among *Attakkari* variants and reference varieties. The following parameters

were recorded: the stage of vegetative, milking stage and harvesting stage, beginning two weeks after transplanting [5].

The matured plants were harvested, placed in labeled bags, and dried for two days [6]. Five representative plants from each line were then selected for analysis. Grain processing involved a traditional winnowing process to separate husks from the grains. Measurements were taken using a precision balance, focusing on the number of grains per spike, panicle count, number of spikelets per spike, 100-grain weight, and paddy grain yield per 100 plants [6]. To assess variability, key growth parameters, including plant height, leaf number, flag leaf length, and leaf color, were measured 3.5 months post-planting. Following grain formation, yield performance and key postharvest traits were evaluated. Prior to harvesting, individual plants were labeled to ensure accurate tracking. All measured data were analyzed using ANOVA in Minitab v18.

Results and Discussion

Comparative evaluation of growth parameters among *Attakkari* variants and the reference cultivars (RY and RM) revealed a statistical notable difference. Att 116 exhibited the greatest plant height 89.6 cm and a superior maximum tiller number (11.24 tillers per plant) compared with the reference cultivars RY (86.28 cm; 7.24 tillers per plant) and RM (85.92 cm; 7.12 tillers per plant). The growth parameters, Att 44 showed the highest leaf count (41.84 leaves/plant), markedly surpassing the reference cultivars RY (27.76 leaves/plant) and RM (30 leaves/plant). Regarding flag leaf length, Att 94 had the longest flag leaves (25.8 cm), slightly exceeding the reference cultivars RY (23.8 cm) and RM (23.2 cm). Comparative analysis of yield parameters among *Attakkari* variants and the reference cultivars (RY and RM) also revealed distinct variations. Att 34 exhibited the highest productive tiller number (7.8 tillers/plant) and substantial seed numbers per panicle (148 seeds), outperforming the reference cultivars RY (5.2 tillers/plant; 82 seeds/panicle) and RM (6.2 tillers/plant; 82 seeds/panicle). Att 94 achieved the highest seeds per panicle (179.6 seeds) and the greatest 100-grain weight (3.436 g), significantly surpassing the reference cultivars. However, Att 34 and Att 94 showed comparatively lower 100-plant yield (0.779 kg and 1.761 kg, respectively) than expected given their high seed numbers. Among the reference cultivars, RY produced a moderate yield (1.473 kg per 100 plants), while RM yielded relatively lower (1.2 kg per 100 plants). The variant Att 29 demonstrated notably high seeds per spikelet (19.4) but a moderate yield (0.859 kg per 100 plants).

Overall, the best-performing *Attakkari* variants were Att 116 for vegetative vigor, Att 44 for leaf production, and Att 94 for reproductive potential, while Att 34 contributed to productive tillering and panicle fertility. Despite their high seed and grain performance, yield stability still favored the reference cultivar RY. Thus, the evaluation indicates that *Attakkari* variants, particularly Att 94 and Att 116, exhibit

promising traits that can be effectively utilized in breeding programs to enhance both growth and yield efficiency.

Conclusions and Recommendations

The analysis of growth parameters among *Attakkari* variants and the reference cultivars revealed substantial phenotypic diversity. Att 116 exhibited superior vegetative vigor through greater plant height and higher tillering ability, while Att 44 demonstrated enhanced photosynthetic potential through increased number of leaf production. Similarly, Att 94 expressed favorable flag leaf traits, which are critical for efficient grain filling and ultimately contribute to higher yield potential. The yield assessment further highlighted Att 94 as a superior morphotype, owing to its high seed productivity per panicle and elevated 100-grain weight, both of which are decisive determinants of grain yield. In contrast, Att 34 and Att 29 displayed limitations in grain filling efficiency despite their relatively higher seeds per spikelet, resulting in only moderate yield performance. When growth and yield parameters are considered together, a clear pattern emerges: Att 116 contributes strong vegetative performance and tillering performance, Att 44 enhances assimilate production through leaf traits, and Att 94 combines favorable flag leaf morphology with superior seed set and grain weight, making it the most promising high-yielding genotype.

Collectively, these findings indicate that Att 116, Att 44, and especially Att 94 represent valuable genetic resources for rice improvement. Their complementary strengths in vegetative vigor, photosynthetic efficiency, and yield performance provide strong potential for utilization in breeding programs targeting the development of high-yielding and resilient rice cultivars.

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