# Evaluation of Yield and Yield-related Characteristics of Selected Advance Rice Breeding Lines under Low Country Wet Zone Conditions in Sri Lanka

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**Abstract –** *Rice (Oryza sativa L.) is the most important staple food, it is important to enhance rice production to meet the demand of the world's population. To face this challenge, it needs to identify proper genetic materials with reliable characteristics to enhance the rice yield per unit area. Therefore this experiment was conducted at the Regional Rice Research and Development Centre, Bombuwala in the 2022 Yala season to evaluate the five selected elite advanced breeding lines, which were selected from different cross combinations was evaluated with their respective standard varieties under low country wet zone conditions in Sri Lanka. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five treatments randomized in three replicates. The five selected advanced rice breeding lines of Bw20-1281, Bw20-1285, Bw 20-612, Bw19-1398, Bw19-1430 and two respective standard varieties of Bw 451 and Bg 403 were used as treatments. All the cultural and agronomic practices were done according to the Department of Agriculture recommendations. Data were collected on growth, yield, and yield-related parameters on the selected rice breeding lines. The data obtained were tabulated and analyzed by using the Statistical Analysis System (SAS). Duncan's Mulpiple Range Test (DMRT) was performed to compare the differences among treatment means at p=0.05. All the tested characters showed significantly different (p>0.05) among the tested entries and standard varieties. Considering yield components such as the number of panicles per unit area and thousand grain weight, Bw 20-612 performed better than the other tested entries and it has nonlodging type steady plant architecture also. Therefore, Bw 20-612 can be selected as the potential rice germplasm to be used in further varietal improvement and evaluation purposes in major yield trials of the Research Centre.*

*Key Words: Advanced breeding lines, Rice, Yield, Agronomic characters*

## Nomenclature

*Bw - Bombuwala* *Bg - Bathalagoda*
*RCBD - Randomized Complete Block Design*
*DMRT - Duncan's Mulpiple Range Test*

## 1 INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food of more than half of the world's population. It is dominantly produced and consumed in Asia. In Sri Lanka, Rice is the staple food and is the livelihood of more than 1.8 million farmers (Sandika and Dushani 2011). An increase in rice production must be achieved largely by increasing yield per unit

area. Improving rice yield has accordingly become one of the major objectives of breeders and growers in many countries over the past several decades. Rice is uniquely suited to wet environments in which other crops would not survive, hence its widespread popularity across Asia. In Sri Lanka, rice is grown under a wide range of ecological environments such as different elevations, different soil conditions, and different agroecological regimes. The Department of Agriculture in Sri Lanka released 92 of rice varieties under different age groups for the farmer population in Sri Lanka (Hamangoda and pushpakumari 2018). With the higher population growth rate available land for paddy cultivation is decreasing leaving a limited land area for paddy cultivation in Sri Lanka. Therefore, the solution for that situation could be development of rice varieties with high-yielding ability with tolerance to biotic and abiotic stress. The growth and yield characteristics of genotypes depend on genetic and environmental factors (Akrum et al. 2007). In this situation rice breeding and selection programs conducted in research stations focus on developing selected advanced breeding lines for their yield and yield-related characters. The mandate of the Regional Agricultural Research and Development Center (RRRDC), Bombuwela is to develop high-yielding both red and white rice varieties particularly tolerant to iron toxicity and associated technologies for Low Country Wet Zone (LCWZ) problem soils and ecosystems. The rice breeding and selection programmes of the country target to evaluate selected advanced breeding lines for their yield performance and agronomic characters before being nominated to the national coordinated rice varietal testing programme of the country.

## 2 METHODOLOGY

The experiment was conducted at the Regional Rice Research and Development Centre (RRRDC), Bombuwela, Kalutara, Sri Lanka 2022 during *the Yala* season. The research station was located in $6^0$.57"N latitude and $80^0$.01"E longitudes and belonging to the agro ecological zone $WL_{1a}$. The soil type of this area is low humic glay soil Soil pH was 6.4. The five selected advanced breeding lines (ABL) and two respective standard varieties were used as the treatments in this research (Table 1). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 7 plots of 12 $m^2$ in size in each of the three replications resulting in 21 plots in total. The distance maintained between two blocks and two plots was 30 cm, respectively.

**Table 1 Characters of the selected advanced breeding lines and respective standard varieties used for the study**

| Treatments (Lines/ Varieties) | Parentage | Colour of pericarp | Type of grain |
|---|---|---|---|
| **Bw 20-1281** | Bg 360/Bw 367 | White | Short round |
| **Bw 20-1285** | At 362/Bw 272-6b | White | Short round |
| **Bw 20-612** | Bw 367/At 373 | White | Long medium |
| **Bw 19-1398** | At 362/Bw 272-6b | White | Short round |
| **Bw 19-1430** | Bw 05-1805/Bw 363/Bw 05-1805 | Red | Long medium |
| **Bw 451*** | Bg 400-1/Bg 11-11 | White | Short round |
| **Bg 403*** | Bg 83-1026/Bg 379-2 | White | Intermediate Bold |

* Standard recommended varieties

The pre-germinated seed materials of each tested varieties and respective standard varieties were broadcast in the experimental plots and all cultural and management

practices were done according to the recommendations given by the Department of Agriculture (DOA). Agronomic characters such as plant height, culm length and reproductive characters such as panicle length, days to 50% flowering, days taken to 85% maturity and yield related characters, i.e. number of panicles per square meter, number of productive tillers per plant, thousand grain weight and number of filled grains per panicle were determined at various growth stages of the each tested varieties using the Standard Evaluation System (SES 2014) for rice developed by the International Rice Research Institute (IRRI). Data were analyzed using Statistical analysis software (SAS) package and mean separation was done according to the Duncan's multiple range test (DMRT).

## 3 RESULTS AND DISCUSSION

### 3.1 Agronomic Characters

#### *3.1.1 Plant Height*

Plant height is an important character for standing the plant in the field. When the plant height more, the rice plant cannot stand properly and it will be subjected to lodged. Also, shorter height is not accepted due harvesting difficulties. According to the results of tested advanced breeding lines and standard varieties there was significant difference among the plant height ($p<0.05$). The highest plant height (106.37 cm) was recorded by Bw 451.The lowest plant height (81.9 cm) was recorded by Bw 20-612. Because of lower plant height Bw 20-612 was performed well in field condition (Table 2). It was recorded non lodging type breeding line.

#### *3.1.2 Panicle Length*

Panicle length is an important trait for improving panicle architecture and grain yield in rice (*Oryza sativa L.*). According to the results of panicle length of tested entries and standard varieties were recorded significant different ($p<0.05$). The highest panicle length was recorded by Bg 403 (24.9 cm). The lowest panicle length was recorded by Bw 20-612 (20.36 cm) (Table 2). Among the tested entries panicle lengths were varied in between 20.36cm to 24.95cm. Rice plants with long panicles potentially have a high number of grain total and high yield because there is a positive correlation between panicle length and the number of grains per panicle, (Haryanto et al. 2008).

#### *3.1.3 Number of Productive Tillers per Plant*

Number of reproductive tillers and number of spikelets per panicle provide useful information for the rice breeders and those characters have direct effect on yield per plant (Sadeghi 2011). Considering about number of productive tillers per plant of tested entries and standard varieties there were no significant difference can be observed between them ($p<0.05$). Bw 20-1281, Bw 20-1285, Bw 20-612, Bw 19-1430, Bw 19-1398, Bw 451,Bg 403 mean value for number of productive tillers per plant was 1.76 (Table 2).

#### *3.1.4 Time Taken to 85% Maturity of Rice Plants*

Yield is depending on the flowering. When the optimal time yield are maximized. Flowering duration as an important factor to get uniform seed setting rate. By consider these days to 85% maturity we can be predicted how many days taken to harvest that entries and standard varieties. Bw 19-1430 was the earliest line (mean value 94.66), that was taken very low days to 85 % maturity. So can be harvest earlier than others. Lower age varieties are important for wet zone rice cultivation because of unpredicted environmental changes (Table 2). In timely harvesting of rice ensures good quality with higher yield (Ali et al. 1990). Grain yield and its quality depend on the right judgment at harvesting. Rice

production is highly seasonal, and timely operation has a relatively significant impact on its yields, especially the appropriate timing of the harvest (J. Wang et.al.2004, A. Kessler et.al.2020).

### *3.1.5 Time Taken to 50% Flowering*

There are no significant difference between tested entries of Bw 20-1281, Bw 20-1285, Bw 20-612, Bw 19-1398, Bg 403 (mean value 76.0) ($p< 0.05$). In addition to that, Bw 19-1430 Breeding line flowered earlier than others (mean value 37.0). Bw 451 mean value was 86.33. So that variety was already released by DOA under 4-4 ½ months age group (Table 2). Among many agronomic characteristics, days to flowering, plant height and yield potential determine the economical production of any crop including rice (Xue et al. 2008). Days to flowering recorded positive and significant correlation with plant height and negative and significant association with grain yield per plant (Babu VR et al.2012).

**Table 2 Agronomic characters of selected entries and standard varieties of Rice**

| Treatments (Lines/Varieties) | Plant height (cm) | Panicle length (cm) | Number of productive tillers per plant | Time taken (days) to 85% maturity | Time taken (days) to 50% flowering |
|---|---|---|---|---|---|
| **Bw 20-1281** | 98.88$^{b}$ | 23.93 $^{ab}$ | 1.0$^{a}$ | 97.33$^{b}$ | 76.0 $^{b}$ |
| **Bw 20-1285** | 102.2$^{ab}$ | 23.7$^{ab}$ | 2.0$^{a}$ | 98.0$^{b}$ | 78.0$^{b}$ |
| **Bw 20-612** | 81.9$^{c}$ | 20.37 $^{c}$ | 1.33$^{a}$ | 96.0$^{bc}$ | 75.66$^{b}$ |
| **Bw 19-1398** | 98.87$^{b}$ | 23.1 $^{b}$ | 1.67$^{a}$ | 97.33$^{b}$ | 76.33$^{b}$ |
| **Bw 19-1430** | 99.43$^{ab}$ | 22.97 $^{b}$ | 2.0$^{a}$ | 94.66$^{c}$ | 37.0$^{c}$ |
| **Bw 451** | 106.37$^{a}$ | 21.03 $^{c}$ | 2.33$^{a}$ | 109.0$^{a}$ | 86.33$^{a}$ |
| **Bg 403** | 86.03$^{c}$ | 24.95 $^{a}$ | 2.0a | 96.66$^{bc}$ | 74.0$^{b}$ |
| **CV** | 4.09 | 4.54 | 29.93 | 1.14 | 3.35 |

*Mean values of each column with the same letter are not significantly different at $p<0.05$*
CV –Coefficient of Variance

## 3.2 Yield related characters

### *3.2.1 Number of Filled Grains per Panicle*

There were significant different can be observed among tested entries and standard varieties ($p<0.05$). The Bw 20-1281 were recorded the highest number of filled grains per panicle (165.0).The Bw 19-1430 were recorded the lowest number of filled grains per panicle (61.6) (Table 3). Filled grains per panicle is a most important factor which mainly determine the yield of a variety (Hussain et al.,2014). The fertile grain number per panicle is one of the important yield attributing traits. Grevois and Helms (1992) also observed positive direct effects for filled fertile grains per panicle on rice yield.

### 3.2.2 Number of panicles per unit area

Grain yield in rice is mainly determined by the number of panicles, number of grains per panicle and grain weight, all of which are typical quantitative traits (Xing and Zhang 2010). There were no significant variation can be observed among tested entries and standard varieties ($p<0.05$). But compared to each tested entries comparatively Bw 20-612 was achieved highest value of number of panicles per unit area (57.33). Comparatively the Bw 19-1430 was recorded the lowest value of number of panicles per unit area (31.3). The

number of panicles per unit area (usually consider about panicles/ft²) is determined by the number of established seedlings and tillers produced per seedling. In general, 60 to 70 panicles/ft² are needed to achieve good yields (Table 3).

### *3.2.3 Thousand Grain Weight (g)*

Thousand-grain weight (TGW) is one of the most important determinants of rice grain yield and is determined by grain length (GL), grain width (GW) and grain thickness. According to the table 3, thousand grain weight was significantly varied among the tested entries. The maximum thousand grain weight was reported Bw 19-1430 (35.67 g) and the minimum weight of thousand grain was reported by Bw 20-1281 (24.33 g).
Yoshida (1981) stated that grain filling during the ripening is characterized by the increase in size and weight of kernels as starch and sugars are translocate from culms and leaves. Sarwar *et al*., (2012) found that there are significant differences regarding the values of morphological characters of rice grains. Grain size is the most important factor which influences the yield of rice quality.

### *3.2.4 Grain Yield (t/ha)*

According to the literature in rice, yield is indirectly determined by traits like plant height, growth period, tillering ability, panicle length, seed length, seed setting rate and grains per panicle and it was directly determined by traits like panicle number per unit area / per plant, filled grains per panicle and 1000 grain weight (Sakamoto and Matsuoka,2008). However, in the present study, there is no significant difference observed among all the entries including slandered varieties. However, standard variety Bg 403 recorded comparatively higher yield of 3.06t/ha while Bw 20-612 rice line was recorded 2.67t/ha (Table 3).

### *3.2.5 Grain Shattering Percentage*

A moderate degree of seed shattering in cultivated species is usually preferred, the degree of seed shattering in rice cultivars depends on the harvesting methods followed in different geographic regions. Moderate shattering rice varieties are preferred for both hand and combine harvesting, but harvesting by small head feeding combines requires hard to thresh or non -shattering varieties. In this study, Bw 20-1285 was showed high shattering percentage (37.2). It is not a acceptable character for good paddy variety. Bg 403 standard variety showed the lowest shattering percentage (1.6). Compared the tested entries, Bw 20-612 showed the moderately shattering percentage of 13.33. Among the tested entries lowest shattering percentage recorded by Bw 19-1430 (4.33) (Table 3).

## 3.3 Grain Quality Characters (Milling Quality)

Consider about milling quality parameters of tested entries and standard varieties there were significant variation can be observed from percentage of brown rice, no significant difference can be observed from percentage of milled rice and percentage of head grain among tested entries and standard varieties ($p<0.05$). Among different treatment combinations tested, compared comparatively the highest brown rice recovery was recored by Bw 20-1285 (82.96), highest total mill rice recovery was recorded by Bw 20-1285 (80.13). On the other hand, the lowest brown rice recovery (77.5) was recorded from Bw 19-1430 total milled rice recovery (74.3) was recorded from Bw 19-1430 and lowest Head grain recovery (42.35) recorded from Bw 19-1430. Bw 20-612 was recorded the percentage of brown rice (77.73), percentage of milled rice (74.66), percentage of head grain (69.82) (Table 4).

**Table 3 Yield parameters of selected entries and standard varieties of Rice**

| Treatments (Lines/Varieties) | Number of filled grains per panicle | Number of panicles per unit area (30 cm*30 cm) | Thousand grain weight (g) | Grain Yield (t/ha) | Grain Shattering% |
|---|---|---|---|---|---|
| **Bw 20-1281** | 165.0 $^{a}$ | 39.67$^{a}$ | 24.33 $^{d}$ | 1.58$^{a}$ | 18.67$^{a}$ |
| **Bw 20-1285** | 117.33 $^{b}$ | 38.0$^{a}$ | 25.0 $^{cd}$ | 2.37$^{a}$ | 37.2$^{a}$ |
| **Bw 20-612** | 132.33 $^{ab}$ | 57.33$^{a}$ | 26.67$^{bc}$ | 2.67$^{a}$ | 13.33$^{a}$ |
| **Bw 19-1398** | 162.33 $^{a}$ | 37.0$^{a}$ | 25.33 $^{bcd}$ | 1.99$^{a}$ | 24.93$^{a}$ |
| **Bw 19-1430** | 61.67 $^{c}$ | 31.33$^{a}$ | 35.67 $^{a}$ | 2.19$^{a}$ | 4.33$^{a}$ |
| **Bw 451** | 133.0 $^{ab}$ | 37.33$^{a}$ | 27.33 $^{b}$ | 2.07$^{a}$ | 11.73$^{a}$ |
| **Bg 403** | 73.67 $^{c}$ | 34.0$^{a}$ | 25.33$^{bcd}$ | 3.06$^{a}$ | 1.6$^{a}$ |
| **CV** | 19.05 | 21.97 | 4.82 | 28.63 | 99.08 |

*Mean values of each column with the same letter are not significantly different at p<0.05*

CV –Coefficient of Variance

**Table 4 Grain quality characteristics of selected entries and standard varieties**

| Treatments (Lines/Varieties) | Percentage of brown rice | Percentage of milled rice | Percentage of head grain |
|---|---|---|---|
| **Bw 20-612** | 77.73$^{c}$ | 74.66$^{a}$ | 69.82$^{a}$ |
| **Bw 20-1285** | 82.96$^{a}$ | 80.13$^{a}$ | 74.02$^{a}$ |
| **Bw 20-1281** | 81.33$^{ab}$ | 77.53$^{a}$ | 76.12$^{a}$ |
| **Bw 19-1398** | 81.33$^{ab}$ | 76.8$^{a}$ | 71.80$^{a}$ |
| **Bw 19-1430** | 77.5$^{c}$ | 74.3$^{a}$ | 42.35$^{b}$ |
| **Bw 451** | 78.03$^{bc}$ | 75.3$^{a}$ | 74.77$^{a}$ |
| **Bg 403** | 80.66$^{abc}$ | 78.46$^{a}$ | 52.76$^{b}$ |
| **CV** | 1.726 | 2.445 | 6.067 |

*Mean values of each column with the same letter are not significantly different at p<0.05*
CV –Co efficient of Variance

Grain yield per plant exhibited highly significant and positively correlation with Number of productive tillers (0.173), Number of panicles per unit area (0.270), Panicle length (0.103). The plant height (-0.50), Culm length (-0.553), Days to 50% flowering (-0.027), Days to 85% maturity (-0.111), Number of filled grains per panicle (- 0.396), Panicle weight (-0.006), Thousand grain weight (-0.067) showed the highly significant and negative correlation with grain yield (Table 5).

**Table 5 Estimation of Reproductive characters correlation between yield characters and Grain yield of tested entries**

| Characters | Panicle length(cm) | Panicle weight(g) | Number of productive tillers per plant | Thousand grain weight(g) | Number of panicles per unit area | Number of filled grains per panicle | Grain yield(t/ha) |
|---|---|---|---|---|---|---|---|
| **Panicle length** | 1 | 0.524* | 0.440* | 0.503* | -0.496* | 0.359 | -0.500* |
| **Panicle weight** | 0.524* | 1 | 0.105 | 0.930** | -0.411 | 0.255 | -0.006 |
| **Number of productive tillers** | 0.084 | 0.105 | 1 | 0.026 | -0.031 | -0.301 | 0.173 |
| **Thousand grain weight** | 0.104 | 0.930** | 0.026 | 1 | -0.446* | 0.192 | -0.067 |
| **Number of panicles per unit area** | -0.604** | -0.411 | -0.031 | -0.446* | 1 | -0.019 | 0.270 |
| **Number of filled grains per panicle** | -0.011 | 0.255 | -0.301 | 0.192 | -0.019 | 1 | -0.396 |
| **Grain yield** | 0.103 | -0.006 | 0.173 | -0.067 | 0.270 | -0.396 | 1 |

**Correlation is significant at the 0.05 level (2- tailed)*
*** Correlation is significant at the 0.01 level (2-tailed)*

## 4 CONCLUSIONS

Among the tested five advance breeding lines compared with their recommended standard varieties advance breeding line Bw 20-612 performed better than the other advance breeding lines. Consider about agronomic characters of plant height (81.9 cm), culm length (60.87 cm), days to 50% flowering (75.6), days to 85% maturity (96.0) Bw 20-612 breeding line was achieved preferable values. In field conditions Bw 20-612 advance breeding line was showed non lodging type steady plant architecture. Considering yield related characters, one of the major yield component of the number of panicles per unit area, highest value was recorded by Bw 20-612 (57.33). So maximum grain yield was recorded by Bw 20-612 (2.67t/ha). Considering reproductive characters, grain shattering percentage of Bw 20-612 was recorded moderate shattering percentage (13.33). It was farmer preferable character when harvesting and threshing of paddy. Among the tested entries considering about pest and disease reactions Bw 20-612 was recorded resistant to the blast and bacterial leaf blight disease, moderately resistant to the brown plant hopper those characters are very important during the further advancement of the rice lines. According to the grain quality characters of tested entries Bw 20-612 was achieved moderate percentage of brown rice (77.73), milled rice (74.66) and head grain (69.82) recovery values. When considering the correlation analysis, grain yield per plant exhibited highly significant and positive correlation with number of productive tillers and number of panicles per unit area, panicle length. The number of days taken to 50% flowering was highly significant and positive correlation with days to 85% maturity. The numbers of

productive tillers, number of filled grains per panicle, panicle weight and, thousand grain weight showed highly significant and positively correlated with days to 85% maturity. According to the results of the correlation analysis, it can be concluded that the grain yield exhibited significant and positive correlation with number of panicles per unit area and number of productive tillers. In comparison of advanced breeding lines with recommended existing local rice varieties Bw 20-612 performed better during the study period. Therefore, Bw 20-612 has been selected as an advance parental breeding line for further evaluation purposes. However further study can be extended to be *maha* season as well to confirm the results.

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