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Characterization of F_2-Derived Lines of White Aromatic Rice

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Morphological characterization and evaluation of agronomic traits of breeding lines are very important activities in any breeding program. These help identify useful traits that could be used as indices for selection. The study was carried out during the 2016 dry season (DS) and wet season (WS) which aimed to characterize/evaluate the morpho-agronomic characters of seven F2 derived lines of white aromatic rice (CLH 122, CLH 138, CLH 150, CLH 278, CLH 283-B1, CLH 283-B2-7 and CLH 295) with Burdagol and CL1 as check varieties. Evaluation was done under lowland irrigated condition at Central Luzon State University, Science City of Munoz, Nueva Ecija. The Randomized Complete Block Design (RCBD) with three replications was used. Leaf blade pubescence (intermediate), leaf blade color (dark green), ligules shape (cleft), ligule color (white), collar color (light green), auricle color (light green), stigma color (white), culm internode color (light gold), panicle type (intermediate), secondary branching of panicles (heavy), panicle axis (droopy) and sterile lemma color (straw) were observed to be similar among lines. Variations were manifested on the measurable traits. Most of the lines had intermediate flag leaf angle, straw apiculus, awnless and with lemma and palea of gold and gold furrows on straw background. Culm strength (strong); panicle exertion (enclosed to well-exserted); leaf senescence (late); and panicle threshability (easy) were observed. Most of the lines were rated 0 (none) to l (less than 10% of the kernel to have white belly, had extra-long grains (more than 7.5 mm) which were slender (3.42-4.42 mm). Most of the lines had medium maturity (111-120 days) across seasons and short to intermediate plant height during DS. Productive tillers ranged from 7 to 12 across season. CLH 278 had the longest panicles and highest percent filled grains (79.7%) during DS. CLH 295 had heavier weight of 1000 seeds than CL1. Likewise, CLH 295 which produced yield of 5.5 t/ha was higher than CL1 (0.9 t/ha) and Burdagol (2.9 t/ha) during WS. On the other hand, CLH 150, CLH 138 and CLH 295 out-yielded CL 1 4.8 t/ha) during DS. The lines recorded milling recovery of 57.1-63.9% which were higher than CL1 (40.5%). CLH 122, CLH 283-1 and CLH 138 had head rice recovery (57.8-63.8%) higher than CL 1 (46.5%) and Burdagol (49.3%). Among the lines evaluated, CLH 122, CLH 283-1 and CLH 295 were found aromatic, with good eating quality, had medium maturity and short to intermediate stature.

Keywords: Characterization, F_2 -derived lines, white aromatic rice, agronomic traits

Introduction

Rice constitute the major portion of the Filipino diet as source of dietary fiber and proteins while it is considered as the staple food of almost of the world's population. Rice contributes an average of 20% caloric intake

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of the world population while 30% of the population in Asia (Calpe and Prakash, 2007). An estimate of 90 percent are being produced and consumed in the Asian Region (China, India, Indonesia, Bangladesh, Vietnam and Japan) which is 80% of the world's production and consumption (Abdullah *et al.*, 2006). Self- sufficiency for this important commodity should therefore be given proper attention to address the needs of the ever increasing population.

Aromatic rice is gaining wide acceptance and now popular both in local and international market because of its unique flavor and scent and highly acceptable grain quality characteristics. It is considered best in quality so that its price is higher compared to the non-aromatic ones. Its wide acceptance in both domestic and international market, commands its production in large commercial scale.

A number of aromatic rice varieties exist in our country but are low yielders. Among which are traditional ones which originated from other countries. These include Basmati 370, Basmati 385, KDML and many other indigenous varieties of scented rice excelling equally as far as aroma and cooking quality are concerned. But unfortunately, these have somehow did not get the attention of rice scientists and traders, including exporters, to the extent that Basmati has. Lots had already been developed by the International Research Institute and Philrice but still there is a need to continue to develop rice varieties which are high yielding and good in quality.

Characterization and evaluation of breeding lines are very important acivities in crop improvement as these provide informations about their characteristics and these serve as a tool in making sound decisions which of the materials have the potential to be selected based on the project objectives. In any breeding program grain yield is the most important character for almost all crops. However, grain quality especially for aroma are important characters to be considered in rice varietal improvement since this dictates its market demand and price both in local and international markets. Aromatic rice is now an important commodity in international trade (Singh *et.al.*, 2000).

The increasing demand and economic importance for both aromatic and non-aromatic rice, it is now the central focus of our government for agricultural policies in cooperation with the Department of Agriculture (DA) through the International Rice Research Instititute (IRRI), Philippine Rice Research and other government agencies to enhance research on rice breeding to continue develop rice varieties for both aromatic and non-aromatic which are high yielding, with good eating quality and possess resistance to a wide range of biotic and abiotic stresses. The research office had started developing aromatic rice varieties not only to help sustain the production of aromatic rice varieties but also to improve lives of rice farmers/producers in the community.

Objectives: To characterize/evaluate the morpho-agronomic performance of seleted of F_2-derived lines of aromatic rice.

Materials and methods

Seven lines (CLH 122, CLH 108, CLH 150, CLH 278, CLH 283-1, CLH 283-2-7 and CLH 295) which were derived from F2-segregating population were evaluated along with Burdagol and CL 1 as check varieties. These were evaluated during 2016 dry season (DS) and wet season (WS) at the research experimental area of the Research Office, Central Luzon State University, Science City of Munoz, Nueva Ecija, Philippines.

Seedbed preparation and seedling production

The area was thoroughly prepared using a hand tractor. This was done by plowing then irrigated overnight to soften the clods. This was followed by harrowing and puddling to break the clods and incorporate weeds and crop residues present in the area. The area was submerged for two weeks to allow the decomposition of the weeds and crop residues. Two days before sowing, the area was finally prepared by replowing, reharrowing then puddled thoroughly to create hard pan. The area was levelled thoroughly using a leveller for equal distribution of water and efficient drainage. Eleven plots were established measuring 4 sq m each with levees or dikes properly constructed in between plots with alleys of 50 cm wide in between blocks.

The seeds of each line were placed in net bags then soaked overnight. After soaking, the seeds were washed in running tap water then incubated for 24 hours to facilitate germination of the seeds. After incubation, the pregerminated seeds were sown carefully in each assigned plots. The plots remained with an appropriate water level for one day then drained to allow the germinated seeds to emerge from the ground surface. Irrigation water was controlled up to seven days to protect the growing seedlings from submergence. Urea (10 g) was applied in each plot seven days after sowing (DAS) for normal and healthy seedlings.

Land preparation

The area which was previously planted with rice was used for the experiment. This was plowed using a hand tractor then surface irrigated to allow the shattered rice seeds in the area to germinate. As soon as the rice seeds were all germinated, replowing and reharrowing and partial puddling were done and then the area was left submerged for two weeks to allow the decomposition of the rice seedlings, stubbles and weeds. The area was finally prepared by replowing and reharrowing and thoroughly puddled and levelled.

Layouting, design of experiment and transplanting

The plots measured 4 x 4 sq m arranged in a square blocks with a distance of one meter between blocks and one meter beween plots were constructed. The Randomized Complete Block Design (RCBD) with three replications was followed. Twenty one day- old seedlings were transplanted following the planting distance of 20 x 20 cm with two seedlings per hill.

Cultural management practices

The recommended rate of fertilizer of 120-30-30- kg NPK/ha (WS) and 90-30-30 (DS) were applied using complete fertilizer (14-14-14) and urea (46-0-0). The required amount of phosphorous and potassium plus 1/3 of the N requirement were applied one week after transplanting. The remaining N was applied in split, at 30 and 45 days after transplanting (DAT).

The area was sprayed with baylluscide just after transplanting to protect the newly transplanted seedlings from the damage of the golden apple snails. The rice plants were protected at seedlings, vegetative and early reproductive from insects pests and diseases by spraying the appropriate pesticides and insecticides. Fungicides were also sprayed to control blight and narrow leaf spot diseases which were observed at peak tillering stage of the rice plants.

A pre-emergent herbicide (machete) was sprayed just after transplanting to prevent the growth of weeds. Spot weeding by hand pulling was also done.

Water level of 2-3 cm was maintained during the early growth of the plants and 5 cm during the later stages. Before harvesting, irrigation water was drained to facilitate harvesting.

Data gathered

Each line was characterized morphologically following the Standard Evaluation System (SES) developed by the International Rice Research Institute (IRRI). The agronomic characters gathered were- the number of days to maturity which were recorded from sowing to 85% of the grains turned straw or yellow color; plant height which was measured from the base up to the tip of the highest panicle in cm measured from 16 sample plants; number of productive tillers which was the number of grain bearing tiller/panicle per hill counted from the 16 sample plants at harvest, percent filled spikekelets which were computed by deviding the total filled grains with the total grains (filled + unfilled spikelets) multiplied by 100 which were gathered from 16 panicles; weight of 1000 fully developed grains which was randomly selected; grain yield which was obtained from the inner rows (four outer rows excluded on four sides of the plots) which was computed at per hectare basis and adjusted to 14% moisture content (MC) which was expressed in tons (t), milling recovery (MR), head rice recovery (HR); brown rice length and width; brown rice shape; seed coat color; and aroma.

Data Analysis

The agronomic characters were analyzed using the SAS statistical software (v. 9.1). Means were compared using the Least Significant Difference (LSD) at 5% probability (p=0.05).

Results

The lines were characterized to have: leaf blade pubescence (intermediate), leaf blade color (dark green), ligules shape (cleft), ligule color (white), collar color (light green), auricle color (light green), stigma color (white), culm internode color (light gold), panicle type (intermediate), secondary branching of panicles (heavy), panicle axis (droopy) and sterile lemma color (straw).

The characters measured were: leaf length (27.46-41.00 mm), leaf width (0.80-1.16 mm), ligule length (16.60-25.20 mm), culm length (63.80-78.10 mm), diameter of basal internode (5.30-9.10 mm), culm angle (erect), sterile lemma length (2.40-2.90), grain length (9.90 - 11.80 mm) and grain width (2.20-2.80 mm).

Majority of the lines had erect leaf angle, intermediate flag leaf angle, straw apiculus and with lemma and palea of gold and gold furrows on straw background and were awnless.

The lines had strong culms and varied on panicle exsertion (enclosed, partly enclosed, just exserted, moderately well exserted). Likewise, leaf senescence was observed to be late and with easy panicle threshability.

With respect to the agronomic performance (Tables 1-4), significant differences were observed among genotypes except for the number of productive tillers and panicle length during DS.

Lines CLH 295 and CLH 283-1 had the same maturity (113 days) relative to Burdagol (114 days) while the other lines matured later (120-128 days) than the two checks, CL 1 (198 days) and Burdagol (114 days) during WS. Similar with most of the entries during DS which had maturity of 111-120 days were the same with Burdagol (115 days) and CL 1 (117 days). When the lines are classified into early, medium and late, most of the lines had medium maturity (111-120 days) across seasons which were the same with Burdagol.

During WS, all lines were significantly taller (89.9-121.9 cm) than CL1 (79.1 cm) while CLH 138 and CLH 150 with plant height of 89.9 cm and 92.2 cm were comparable with Burdagol (94.2 cm). During DS, CLH 150 and CLH 283-2-7 with plant height of 84.1 cm and 83.2 cm were taller than Burdagol (80.3 cm) but were shorter than CL 1 (89.8 cm). The rest of the lines were taller (97.6-106.5 cm) than CL 1. Acording to SES, CLH 138 was recognized to be short across season . The same with CLH 150, CLH 283-2-7 which were also classified as short during DS but were short to intermediate during WS. However, most of the lines were tend to be taller during WS.

Table 1. Maturity, plant height (cm) and productive tillers of the seven lines of white aromatic rice.

Lines/ Selections	Maturity[1/]		Plant height (cm)[1/]		Productive tillers[1/]	
	Wet Season (2016-2017)	Dry Season (2016-2017)	Wet Season (2016-2017)	Dry Season (2016-2017)	Wet Season (2016-2017)	Dry Season (2016-2017)
CLH 122	121^{b}	120.0^{ab}	107.3^{b}	103.2^{ab}	6.9^{de}	9.9
CLH 138	123^{b}	118.3^{bc}	89.9^{c}	87.7^{cd}	8.4^{bcd}	10.6
CLH 150	120^{b}	111.0^{c}	92.2^{c}	83.2^{de}	10.0^{a}	11.7
CLH 278	128^{a}	126.0^{a}	106.9^{b}	101.8^{ab}	7.2^{cde}	10.2
CLH 283-1	113^{c}	118.7^{ab}	116.2^{a}	97.6^{b}	9.3^{ab}	10.4
CLH 283-2-7	128^{a}	112.7^{bc}	101.9^{b}	84.1^{cde}	6.5^{e}	11.4
CLH 295	113^{c}	126.0^{a}	121.9^{a}	106.5^{a}	7.8^{cde}	9.6
Burdagol (Check)	114^{c}	114.7^{bc}	94.2^{c}	80.3^{e}	7.3^{cde}	10.2
CL1 (Check)	98^{d}	116.7^{bc}	79.1^{d}	89.8^{c}	8.6^{abc}	11.3
CV (%)	1.69	3.72	3.72	4.09	10.36	11.79

[1]/Means in column followed by the same letter (s) are not significantly different at 5% level using LSD

Lines CLH150 and CLH283-1 produced significantly more productive tillers (10 and 9) than Burdagol (7) but were comparable with CL1 (9). The rest of the lines did not vary with Burdagol and CL 1 except CLH 122 and CLH 283-2-7 which produced fewer tillers than CL 1.

Line CLH 278 produced panicles which were significantly longer (28.9 cm) than Burdagol (23.5 cm) and CL 1 (26.2 cm). All other lines had panicles which were also longer ((25.2-28.9 cm) than Burdagol but were comparable with CL 1 except CLH 283-2-7.

During WS, all the lines had percent filled spikelets (66.2-79.7%) which were higher than CL 1 (50.1%). On the other hand, CLH 278 and

CLH 295 recorded 79.7% and 78.2% filled spikelets differed to that of Burdagol (71.6%). The rest of the lines were the same with Burdagol. Higher percent filled spikelets were recorded during DS (72.48-84.79%) among genotypes. However, five of the lines were found comparable with Burdagol and CL1 while the other lines had lower percentage of filled spikelets than the two checks.

Table 3. Panicle length (cm), percent filled grains and weight of 1000 seeds (g) of the seven lines of white aromatic rice.

Lines/ Selections	**Panicle length[1/]**		**Percent filled grains[1/]**		**Weight of 1000 grains (g)[1/]**	
	Wet Season (2016-2017)	Dry Season (2016-2017)	Wet Season (2016-2017)	Dry Season (2016-2017)	Wet Season (2016-2017)	Dry Season (2016-2017)
CLH 122	25.2[c]	26.0	75.4[abc]	83.9[ab]	26.4 [bc]	30.6[b]
CLH 138	25.4[c]	23.7	72.4[bc]	79.5[bc]	21.9[de]	29.1[b]
CLH 150	26.9[b]	23.6	66.2[d]	72.5[d]	19.6[ef]	24.3[c]
CLH 278	28.9[a]	26.3	79.7[a]	84.1[ab]	23.2[d]	28.8[b]
CLH 283-1	27.3[b]	25.1	77.3[abc]	83.7[ab]	26.7[b]	28.8[b]
CLH 283-2-7	22.5[d]	24.4	76.3[abc]	76.1[cd]	24.1[cd]	30.8[b]
CLH 295	26.2[bc]	23.6	78.2[ab]	84.8[a]	30.07[a]	34.3[a]
Burdagol (Check)	23.5[d]	25.4	71.6[cd]	82.6[ab]	30.8[a]	35.4[a]
CL1 (Check)	26.2[bc]	26.4	50.1[e]	82.4[ab]	17.67[f]	28.7[b]
CV (%)	2.73	11.49	4.72	3.7	5.98	4.79

[1/]Means in column followed by the same letter (s) are not significantly different at 5% level using LSD

All the lines except CLH 295 had lighter weight of 1000 grains, 19.6-26.4 g (WS) and 24.3-30.6 g (DS) than Burdagol (30.8 (DS)-35.4 (WS). In addition, the lines except CL 150 had 1000 seed weight which were heavier than CL 1 (17.67 g) during WS. However, during DS most of the were the same with CL1.

The lines had the potential to produce yield of 1.5-3.4 t/ha during WS while 4.2-5.6 t/ha during DS. Line CLH 295 produced yield of 3.4 t/ha which was significantly higher than CL 1 across season and also yielded higher than Burdagol during WS. Similar with the other lines which

Table 4. Computed yield per hectare (t), milling potential and grain dimension of the seven lines of white aromatic rice.

Lines/ Selections	Computed yield/ha[1/] (t)		Milling Potential[1/]		Grain Dimension[1/]	
	Wet Season (2016-2017)	Dry Season (2016-2017)	MR (%)	HR (%)	Length (mm)	Length/ width ratio
CLH 122	1.9[ef]	5.0[abc]	66	63.8	8.4	3.8
CLH 138	2.6[bc]	5.5[a]	67	57.8	8.1	3.4
CLH 150	2.50[cd]	5.6[a]	61	46.9	7.2	3.3
CLH 278	2.1[de]	5.2[ab]	64	47.0	8.4	4.4
CLH 283-1	2.8[bc]	4.4[cd]	65	60.4	8.2	4.3
CLH 283-2-7	1.49[f]	4.2[d]	62	50.7	8.1	4.0
CLH 295	3.4[a]	5.5[a]	67	54.1	8.2	3.
Burdagol (Check)	2.9[b]	5.0[abc]	71	49.3	6.9	2.56
CL1 (Check)	0.9[g]	4.8[bcd]	65	46.5	8.2	4.2
CV (%)	10.55	7.58	-	-	-	-

[1/]Means in column followed by the same letter (s) are not significantly different at 5% level using LSD

yielded higher than CL1 during WS. Likewise, during DS, CLH 138 and CLH 150 exceeded CL 1 by 14.3% and 16.2% while most of the lines were comparable with Burdagol.

For some of the grain quality traits, most of the lines were rated 0 (None) to 1 (Small- less than 10% of the kernel to have white belly). Most of the lines had extra long grains (more than 7.5 mm) and were slender (3.42-4.4 mm). Lines CLH 122, CLH 278 and CLH 283-1 were found smooth, soft and aromatic.

Milling recovery ranged from 61.0-71.0% with CLH 150 recorded the lowest while CLH 295, the highest. When the lines were classified according to grade, CLH 295 was premium while CLH 122, CLH 138 and CLH 331-4-2 were Grade 1. Burdagol was classified as Grade 1 while CL 1, Grade 2. For HR, CLH138, CLH 283-1 and CLH 122 were higher than CL1(46.5%) and Burdagol (49.3%). Likewise, CLH 295 had HR higher than CL 1. Lines CLH 122, CLH 138 and CLH 283-1 were premium. Likewise, CLH 283-2-7 and CLH 295 were Grade 1.

Discussion

Results of the experiment have shown that all the lines evaluated performed better than the check (CL 1) during WS while CLH 295 performed consistently across seasons and outyielded the two checks during

WS. The line had yield potential of 3.4 t/ha during WS while 5.5 t/ha during DS. This maybe attributed to the heavy weight of 1000 seeds and higher percent filled grains which is in accordance with the findings of Islam *et. al.* (2013) and Singh and Gangwer (1989).

The yield of the different lines was comparable with the yield of other aromatic rice varieties such as the California Basmati Plly RP (5.5t/ha), Hu (1991) but were higher than Basmati 198 and Basmati 370 which yielded 2.0 and 1.8 t/ha (Choudhury and Rahman, 1989). It is expected that the yield during WS is lower than during the DS which is the same results obtained by Islam *et. al.* (2013)

Grain yield was not only influenced by environmental factors but mainly depends on the number of effective tillers per unit area, panicle length and 1000 (Islam *et. al*., 2013). According to Luzzi-Kahippi (1998), the number of field grains per panicle, number of panicles per plant and 1000 seed weight are the important characters that influenced grain yield. He concluded that the number of filled grains per panicle and grain weight could be used as index for selection. Doroni Jr. (2012) was found that yield was positively and significantly correlated with filled grains per panicle which is also supported by the work of Ratna *et.al*. (2015) by path analysis.

The presence of aroma has been detected through sensory evaluation of cooked rice. It showed that CLH 278, CLH 283-1 and CLH 295 were found aromatic. However, CLH 122 was found to be the most aromatic which was comparable with the checks, CL1 and Burdagol. These lines had long grains and slender in shape and these are the traits that are most preferred by consumers and traders. Amylose content was not determined but these were tasted to be soft and had a good eating quality. For speciality rice, grain quality amylose, shape and size, endosperm color and aroma are the important criteria to class rice grain quality (Chaudhary, 2003). These lines met the standard of a rice grain quality.

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