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# Evaluation of Breeding Lines of Sticky Rice under Irrigated Lowland Condition

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Evaluation of breeding lines helps breeders in the identification of useful traits that could be used as bases in selecting superior genotypes with the po tential to become a variety or as source of genetic variability that could be exploited for present and future breeding program. Nine $F_2$-derived lines (CLH234-1, CLH155, CLH163, CLH83-3, CLH144, CLH296, CLH82 (BC2), CLH298 and CLH234) together with a check (Bonquitan) were characterized/evaluated for morphological, agronomic and quality traits. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Evaluation was done at the Research Experimental Station of Central Luzon State University during wet season (WS) of 2014 and dry season (DS) of 2015. The lines were observed to be similar for leaf blade pubescence (glabrous), basal leaf sheath color (light green), ligule color (white), ligule shape (cleft), collar color (light green), auricle color (light green), stigma color (white), secondary branching of panicles (heavy), panicle type (intermediate), secondary branching of panicles (heavy), panicle axis (droopy), and sterile lemma color (straw). The lines had strong culms and easy threshability. Other characters differed among lines. Most of the lines produced 9-10 productive tillers per hill during DS and WS which were higher than the check (6) during WS. Six of the lines were short to intermediate (99.17-105.23 cm) during DS. Panicle length was generally shorter among lines during DS than in WS. Percent fertility was higher during DS (78.10-84.72%) than in WS (68.90-75.60%). All the lines except CLH 83-3 had earlier maturity during DS (93-108 days) and WS (93-108 days) than the check (112 days) during WS. All the lines except CLH 83-3, yielded 4.2-5.2 t/ha (DS) and 1.9-3.7t/ha (WS) which were higher than the check with yields of 2.5 t/ha (DS) and 1.6 t/ha (WS). Most of the lines had high milling recovery (66-68.0%). On the other hand, head rice recovery was also high in CLH 234-, 298, CLH 163 (57.1-64.1%). Brown rice length was long (>7.50 mm) to extra-long (6.60-7.50 mm) and brown rice shape, medium (2.1-3.0) to slender >3.0). Weight of 100-grains ranged from 2.4-2.9g (DS) and 2.2-2.5 g (WS); and seed coat color was opaque white. CLH 144 was the best line for stickiness.

**Keywords:** Breeding lines, irrigated lowland, sticky rice, agronomic performance

## Introduction

Rice (*Oryza sativa* L.) constitute the bulk of the food of almost of the world population as source of protein and dietary fiber while rice farming is an important source of employment and livelihood in rural areas in the

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Philippines. In 2013, total rough rice production in the country was 18.4 million tons from 4.7 million hectare of rice land (Laborte *et al*, 2013). Central Luzon which has been regarded in the history as the rice bowl of the Philippines constitute the highest percentage (18.7%) of volume of production of glutinous rice in the country.

Glutinous rice is predominantly grown in Southeast and East Asia (Laos, Thailand, Cambodia, Vietnam, India, Malaysia, Indonesia, Myanmar, Bangladesh, Northeast India, China, Japan, Korea, Taiwan and the Philippines.Worldwide, based on 2006, around 5% of the total rice production is glutinous rice. In the northern hilly part of Laos, 85% of their total rice production is glutinous rice where it is being consumed as staple food. China has been regarded to have the largest both in production and consumption. However data for worldwide production of glutinous rice is limited (Rice International Commodity Profile, FAO, 2006)

Glutinous rice which is known as sticky rice, sweet rice or waxy rice is also a major type of rice with long-standing cultural importance in Asia. Glutinous rice is characterized to have opaque grains, very low amylose content, 0-2% (Laborte, 2013) which makes it sticky when cooked. Because of its characteristic to be very sticky when cooked, most of the native delicacies are made from glutinous rice. Glutinous rice has some other special quality in terms of texture or fineness, aroma, taste and protein contents. Glutinous rice varieties varies in shades or color of pericarp such as white, light brown, speckled brown, brown, red, variable purple and purple.

Numerous glutinous rice varieties had already been developed. In Laos which considered to be the center of biodiversity of glutinous rice has around thousands of varieties but mostly are traditional varieties. The first glutinous rice variety developed by rice varietal improvement program team of UPLB had been released by the National Seed Industry Council in 1985 is NSIC 13 (Malagkit 1). This had yield potential of 4.8 t/ha (DS performance) better than IR 65 and with maturity of 118-120 days and plant height of 86-96 cm However this was found to be susceptible to some insect pest and diseases (UPLB). It was suggested that to maximize its yield, synchronous planting and good cultural management should be employed. Likewise, Malagkit 2 (NSIC Rc15), Malagkit 3 (NSIC Rc17), and Malagkit 4 (NSIC Rc19) were likewise produced by Philrice (ricepedia.org/Philippines). In Bangladesh, some of the important glutinous rice varieties glutinous rice cultivars are Pakbiruine, Pushbiruine and Kathalibiruin. This was evaluated on the coastal area and the yield of these varieties were found to be very low (1.69-2. t/ha)

Compared with non- aromatic and aromatic rice varieties, glutinous rice seems given less of attention by policy makers and some research institutions all over the word when it comes to research and development despite that the price of glutinous rice in the market is very much higher than the non-glutinous or ordinary rice. With the existing varieties of glutinous which have low yield potential, although some are high yielding but were susceptible to pests and diseases, there is a need to continue develop glutinous rice varieties which are high yielding, quality, aromatic (boutique rice), with wide resistance to biotic and abiotic stresses, stable yield and wide adaptation for climate change. If given proper attention, this may contribute for the realization on sustainability and security for glutinous rice in the country and augmenting the income of small farmers in the future.

Objectives: To evaluate the agronomic performance of the selected sticky lines under lowland irrigated condition and to identify superior lines in terms of morpho-agronomic performance.

## Materials and methods

Ten advanced sticky rice lines ( CLH 83-3, CLH 144, CLH 155, CLH 163, CLH 234, CLH 234-2, CLH 296, CLH 298,r 298-2, CLH 82 x CL 35 together with Bungkitan as a check variety were evaluated for morpho-agronomic characteristics. These were evaluated under lowland irrigated condition during wet season (WS) of 2014 and dry season (DS) of 2015 at the research experimental station of Research Office, Central Luzon State University, Philippines.

### *Seedbed preparation and seedling production*

The area with appropriate soil moisture content was plowed, irrigated then harrowed and puddled using a hand tractor. This was submerged for two weeks to allow the decomposition of weeds and other crop residues present in the area. Two days before sowing, the area was re-plowed, re-harrowed, puddled and leveled thoroughly for equal distribution of water and efficient drainage. Eleven plots measured 4 sq m each with levees or dikes properly constructed in between plots with alleys of 50 cm wide in between blocks.

Seeds of each entry were placed in net bags, properly tagged and soaked in water for 24 hours. One day after soaking, the seeds were rinsed in running water then incubated for 24 hours to facilitate germination of the seeds. The third day from soaking, the pre-germinated seeds of each entry were sown in the designated plots. The plots were submerged at an appropriate water level then a day after excess water was drained to allow the germinated seeds to emerge from the ground surface. Irrigation of the plots was controlled up to seven days in order not to submerge the emerging pre-germinated seeds. Seven days after sowing, urea (10 g) was applied in each plot for the development of normal and healthy seedlings.

***Land preparation***

The area with ideal moisture content was first plowed then surface irrigated to allow the rice seeds present in the area to germinate. A week after, replowing was done followed by reharrowing then left submerged for two weeks to decompose the emerged rice seedlings, stubbles and weeds. One week before lay-outing, the area was replowed and reharrowed then thorougly puddled and leveled.

***Lay-outing, design of experiment and transplanting***

After the area was thoroughly prepared, lay outing was done and the plots measured 4 x 4 sq m, arranged in a square blocks with a distance of 1 meter between blocks in Randomized Complete Block Design (RCBD) with three replications. Twenty three day- old seedlings were transplanted following the planting distance of 20 x 20 cm with two seedlings per hill.

***Cultural management practices***

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

Just after transplanting, the area was sprayed with baylluscide to protect the newly transplanted seedlings from golden snail. Insecticides were sprayed during the vegetative stage and at flowering to control rice bugs and other pests such as leaf hoppers and stem borers. Fungicide was also sprayed to control blight and narrow leaf spot diseases which were observed at peak tillering stage of the rice plants.

Just after transplanting, a pre-emergent herbicide (machete) was sprayed 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. A week before harvesting, irrigation water was controlled for ease in harvesting.

***Data collection***

Morphological characterizations was done based on SES devedloped by IRRI. Other characters gathered were 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; number of filled and unfilled spikekelets which were counted from 16 panilces; weight of 1000 fully developed spikelets.grains which was randomly selected; and grain yield which was obtained from the inner rows (four outer rows excluded on four sides of the plots) then computed to per hectare basis and adjusted to 14% MC expressed in tons; milling recovery (MR), head rice recovery (HR) brown rice length, brown rice width, brown rice shape and seed coat color.

### *Data Analysis*

The data on yield and agro-morphological 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

### *Morphological characterization*

Most of the lines showed similar characteristics in terms of leaf blade pubescence (glabrous), basal leaf sheath color (light green), ligule color (white), ligule shape (cleft), collar color (light green), auricle color (light green), stigma color (white), secondary branching of panicles (heavy), panicle type (intermediate), secondary branching of panicles (heavy), panicle axis (droopy) and sterile lemma color (straw). Quantitative traits measured have shown to be variable among the lines: leaf width (1.1-1.28 cm); leaf length (10.00-19.20 cm); ligule length (10.00-19.20 mm); culm length (63.30-91.20 mm); culm diameter/diameter of basal internode (5.40-7.70 mm); and sterile lemma length (2.00-2.90 mm). On the other hand, most of the lines dominated for leaf angle attitude (horizontal), culm internode color (light gold) and culm angle (erect). Considering some of the agronomic traits, most of the lines had strong culms, late senescence and easy panicle threshability. The lines showed variation on panicle exsertion: H 234-1 and H 234-2 were partly exserted; H 155, H 83-3, H 144 and H 82 x CL 35, enclosed; H 163 and H 298, moderately well exserted; H 55 and H 296, just exserted.

Brown rice length ranged from 6.9-8.9 mm, most of which were considered long while brown rice shape (length/width ratio = 3.00-4.57), medium.and slender. Seed coat (bran) was white (opaque) or waxy.

### *Agronomic and yield components*

The yield and other agronomic performance of the different lines arei presented in Tables 1, 2 3. Results showed significant differences among genotypes across season.

All the lines surpassed the yield of the check in both wet and dry seasons. Most of the lines produced yield of more than 4.00 t/ha (DS) and 3.00 t/ha (WS) which were higher than the check, 2.00 t/ha (DS) and 1.60 t/ha (WS). It can be noted that the lines obtained a yield advantage of 68.40-110% during DS and 61.29-145.81% over the check during WS.

During dry season, early maturity was observed on CLH 155 (94 days), CLH 234-2 (96 days), CLH 144 (98 days), CLH 298 (99 days) and CLH 163 (99 DAS) which were different with the check. The rest of the lines recorded maturity of 103-113 days which did not differ with the check. During WS, all the lines had maturity which were significantly earlier (97-107 DAS) than the check (109 DAS).

**Table 1.** Computed yield per hectare (t), days to maturity and plant height (cm) of the 10 lines evaluated.

| **Lines/ Selections** | **Computed yield per hectare (t)** | | **Days to maturity** | | **Plant height (cm)** | |
|---|---|---|---|---|---|---|
| | Dry Season 2014 | Wet Season 2015 | Dry Season 2014 | Wet Season 2015 | Dry Season 2014 | Wet Season 2015 |
| CLH 83-3 | $4.9^{ab}$ | $1.9^{cd}$ | $106^{abc}$ | $113^{bc}$ | $113.3^{bc}$ | $118.2^{cde}$ |
| CLH 144 | $4.3^{b}$ | $2.6^{b}$ | $98^{cde}$ | $104^{de}$ | $104.5^{de}$ | $112.4^{e}$ |
| CLH 155 | $4.5^{ab}$ | $3.4^{a}$ | $94^{e}$ | $105^{de}$ | $105.2^{de}$ | $113.9^{e}$ |
| CLH 163 | $4.9^{ab}$ | $3.5^{a}$ | $99^{cde}$ | $99^{e}$ | $99.2^{e}$ | $118.4^{cde}$ |
| CLH 234-1 | $4.6^{ab}$ | $3.6^{a}$ | $103^{bcd}$ | $118^{b}$ | $117.8^{b}$ | $116.1^{de}$ |
| CLH 234-2 | $4.4^{b}$ | $2.6^{b}$ | $96^{de}$ | $102^{de}$ | $102.2^{de}$ | $121.6^{cd}$ |
| CLH 296 | $5.2^{a}$ | $3.8^{a}$ | $101^{b-e}$ | $103^{de}$ | $102.8^{de}$ | $123.2^{bc}$ |
| CLH 298 | $4.9^{ab}$ | $3.7^{a}$ | $99^{cde}$ | $104^{de}$ | $104.3^{de}$ | $118.4^{cde}$ |
| CLH 82 x CL 35 | $4.2^{b}$ | $3.3^{a}$ | $114^{a}$ | $121^{ab}$ | $120.5^{ab}$ | $129.8^{b}$ |
| Bonquitan (check) | 2.5c | $1.6^{d}$ | $109^{ab}$ | $128^{a}$ | $127.6^{a}$ | $144.9^{a}$ |
| CV (%) | 10.14 | 10.31 | 4.97 | 3.96 | 3.96 | 3.25 |

Column means followed by the same letter (s) are not significantly different at 5% level by LSD.

All the lines were significantly shorter than the check in both seasons except for CLH 82 x CL 35 which were comparable with the check during DS. Most of the lines were observed to be taller during WS than during DS. Line CLH 82 x CL 35 was observed to be the latest and the tallest among lines across seasons. The same was observed with the check variety. Other lines were shorter across seasons but matured later during WS as observed on CLH 163 and CLH 234-2 check variety. During WS, all the lines had maturity which were significantly.

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Line CLH 82 x CL 35 was observed to be the latest and the tallest among lines across seasons. The same was observed with the check variety. Other lines were shorter across seasons but matured later during WS as observed on CLH 163 and CLH 234-2.

The number of productive tillers that were produced by the different lines during DS ranged from 9-10 per hill. Lines CLH 144, CLH 234-2 and CLH 298 were found to have significantly lower productive tillers than the check variety. The rest of the lines did not vary with the check variety. On the other hand during WS, all the lines produced more productive tillers (8-10) than the check variety.

**Table 2.** Number of productive tillers, panicle length (cm) and number of filled of the 10 lines evaluated.

| Lines/ Selections | Number of productive tillers/hill | | Panicle length (cm) | | Number of filled spikelets/panicle | |
|---|---|---|---|---|---|---|
| | Dry Season 2014 | Wet Season 2015 | Dry Season 2014 | Wet Season 2015 | Dry Season 2014 | Wet Season 2015 |
| CLH 83-3 | $10^{abc}$ | $10^{ab}$ | $26.2^{b}$ | $26.2^{bc}$ | $111^{cd}$ | $103^{de}$ |
| CLH 144 | $9^{c}$ | $9a^{bc}$ | $25.4^{bc}$ | $26.5^{bc}$ | $136^{ab}$ | $126^{bc}$ |
| CLH 155 | $10^{abc}$ | $8^{c}$ | $24.6^{bc}$ | $25.3^{c}$ | $122^{bc}$ | $112^{cd}$ |
| CLH 163 | $10^{abc}$ | $9^{bc}$ | $24.2^{bc}$ | $26.6^{bc}$ | $132^{ab}$ | $120^{bcd}$ |
| CLH 234-1 | $10^{abc}$ | $9^{abc}$ | $26.0^{b}$ | $22.9^{d}$ | $126^{bc}$ | $148^{a}$ |
| CLH 234-2 | $90^{abc}$ | $10^{a}$ | $24.8^{bc}$ | $26.7^{b}$ | $139^{ab}$ | $111^{cd}$ |
| CLH 296 | $10^{bc}$ | $9^{bc}$ | $24.0^{bc}$ | $26.2^{bc}$ | $123^{bc}$ | $112^{cd}$ |
| CLH 298 | $10^{abc}$ | $8^{c}$ | $24.4^{bc}$ | $26.9^{b}$ | $124^{bc}$ | $120^{bcd}$ |
| CLH 82 x CL 35 | $9^{bc}$ | $9^{bc}$ | $25.3^{bc}$ | $26.8^{b}$ | $96^{d}$ | $84^{f}$ |
| Bonquitan (check) | 11a | $6^{d}$ | $28.8^{a}$ | $28.4^{a}$ | $149^{a}$ | $132^{ab}$ |
| CV (%) | 11.19 | 8.84 | 5.73 | 2.86 | 9.95 | 9.35 |

Column means followed by the same letter (s) are not significantly different at 5% level by LSD.

Panicle length ranged from 24.0-26.2 cm (DS) and 22.9-26.9 cm (WS). The lines had panicle length significantly shorter than the check in both seasons.

During DS more filled grains per panicle were noted on CLH 163 (132), CLH 144 (136) and CLH 234-2 (139) but did not differ with the check (149). The rest had lesser filled grains which were significantly different over the check. During WS, CLH 163, CLH 144, CLH 234-2 and CLH 234-1 were comparable with the check variety. The number of unfilled grains did not vary between lines and the check variety during DS. However, during WS more unfilled were noted among lines than the check (23).

**Table 3.** Number unfilled spikelets per panicle and weight of 1000 grains (g) of the 10 sticky rice lines.

| Lines/ Selections | Number of unfilled spikelets per panicle | | Weight of 1000 grains (g) | |
|---|---|---|---|---|
| | Dry Season 2014 | Wet Season 2015 | Dry Season 2014 | Wet Season 2015 |
| CLH 83-3 | 24 $^{c}$ | 42$^{bc}$ | 28.$^{ab}$ | 24.6$^{cd}$ |
| CLH 144 | 37 $^{a}$ | 45$^{bc}$ | 23.9 $^{d}$ | 21.8$^{f}$ |
| CLH 155 | 25 $^{c}$ | 39$^{bc}$ | 29.1 $^{a}$ | 24.3$^{d}$ |
| CLH 163 | 32$^{abc}$ | 49$^{abc}$ | 25.4 $^{cd}$ | 23.4$^{e}$ |
| CLH 234-1 | 25$^{bc}$ | 48$^{abc}$ | 27.7$^{abc}$ | 25.3$^{c}$ |
| CLH 234-2 | 35$^{ab}$ | 37$^{c}$ | 25.9$^{bcd}$ | 24.6$^{d}$ |
| CLH 296 | 22 $^{cd}$ | 52$^{ab}$ | 26.6 $^{a-d}$ | 24.6$^{cd}$ |
| CLH 298 | 29$^{abc}$ | 47$^{abc}$ | 26.1$^{bcd}$ | 24.3$^{d}$ |
| CLH 82 x CL 35 | 27$^{bc}$ | 43$^{bc}$ | 27.8$^{abc}$ | 26.1$^{b}$ |
| Bonquitan (check) | 31$^{abc}$ | 23$^{d}$ | 26.3 $^{a-d}$ | 26.9$^{a}$ |
| CV (%) | 20.84 | 16.52 | 6.44 | 1.78 |

Column means followed by the same letter (s) are not significantly different at 5% level by LSD.

The lines registered weight of 1000 grains which ranged from 23.9-29.1 g (DS) and 21.80-26.13 grams (WS). No significant difference between lines and the check (26.33 g) during DS. However during WS, all the lines had 1000 seed weight lighter than the check (26.90 g).

## Discussion

This study is of immense value to identify useful traits that could be used as index/ices for selection of superior genotypes which have the potential to become a variety or as source of genetic variability that could be exploited for present and future breeding program.

In any breeding program, the most important trait is high and stable yield which is coupled with other important trats such as short stature plant height (short-medium), earliness in maturity (early-intermediate) (Laborte *et.al*. 2013) with wide resistance to biotic and abiotic stresses, wide adaptation to different agro-ecological zones, high grain quality and highly acceptable cooking/eating qualities.

Most of the lines performed consistently in terms of yield performance across seasons. As expected the yield of rice regardless of varieties is higher during DS than in WS. The low yield obtained during WS could be attributed to the heavy rains and strong winds which greatly affected the growth of the rice plants which ultimately caused yield reduction and grain quality among genotypes. In countries having temperate climate where there is long day and short night regimes and is coupled with high level of solar radiation during reproductive and ripening phases of rice are generally favorable for high yield (Nguyen, n.d.).

Most of the lines evaluated had early to medium maturity and were short to intermediate which are one among of the desirable traits of a rice variety (Laborte *et. al.* 2013).

A better plant type might be of moderate height with short leaves (Jennings *et.al*., 1999). The lines had shown to have leaf lengtht which ranged from 33.9-44.8 cm. Likewise, It had been shown that heavy tillering is desirable for maximum productivity. However, most of the lines evaluated produced productive tillers/hill (10) which were considered to have medium tillering ability (based on SES, IRRI).

Grain length and shape describe the appearance of the grain. These are important traits considered by farmers, millers, traders and consumers in addition to MR and HR (Mackmill *et.al.*1996). Most of the lines evaluated had extra long grains and slender shape and with MR and HR which were graded as premium. These are the most important grain quality traits in addition to chalkiness and amylose content (Laborte, 2013).

The result of the srudy showed that the lines were comparable or better than the existing glutinous rice varieties in the Philippines since they have the potential to produce yield of 5 t/ha during DS while 2-4 t/ha during WS. With sound and proper management practices, the yield could be further increase to more than 5 t/ha. Further assessment of the different lines are being done at present to evaluate for grain and quality traits as well as screening for blast resistance.

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