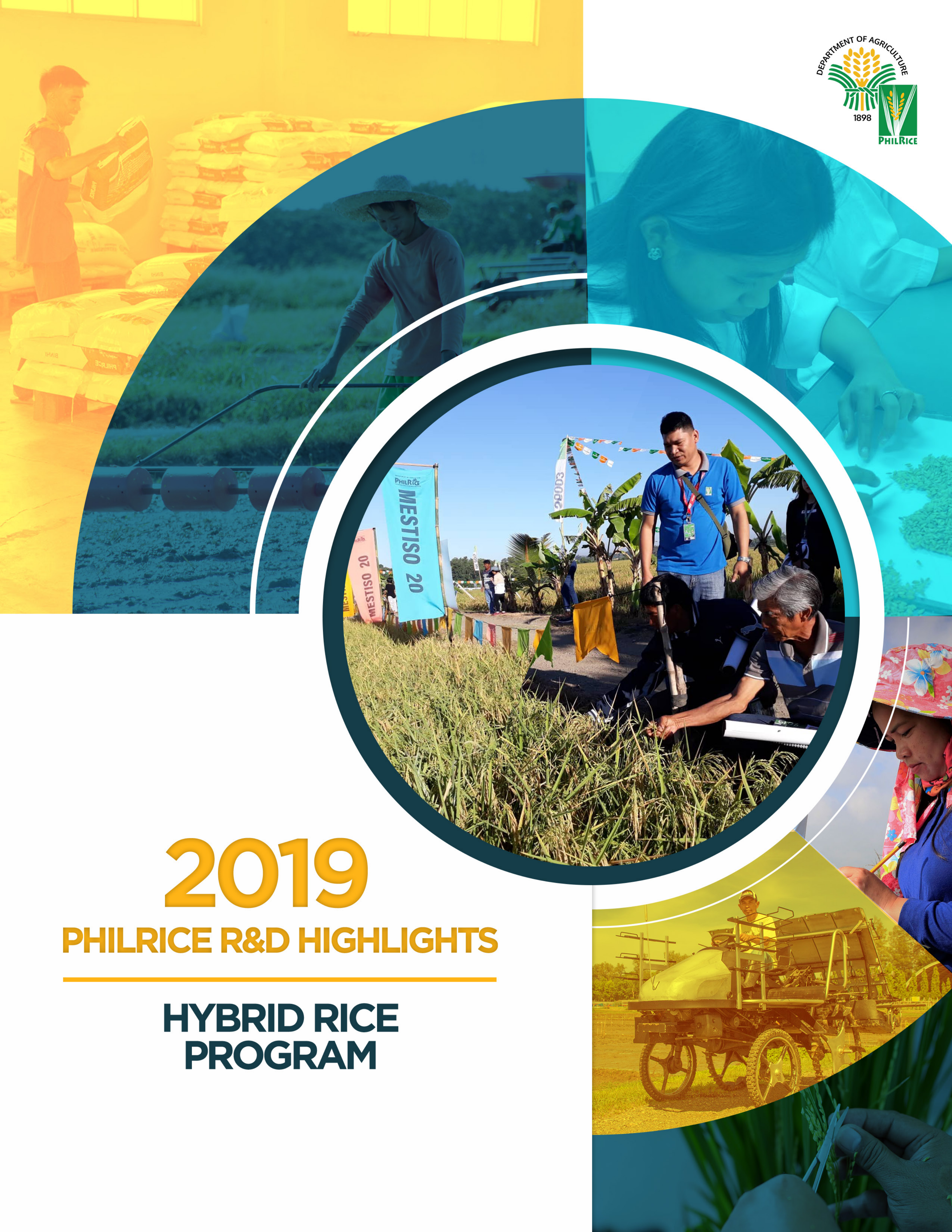


# 2019 PHILRICE R&D HIGHLIGHTS

## HYBRID RICE PROGRAM

# Contents

PROGRAM

# Hybrid Rice

*Program leader: Nenita V. Desamero*

## Executive Summary

The PhilRice Hybrid Rice Program (HRP), institutionalized in 2018, contributes in attaining rice sufficiency through development of wide adaptive, high-yielding, resistant to major insect pests and diseases, and of good grain and eating quality hybrid rice varieties; combined with appropriate crop management, for increased rice production and profitability; hence, enhancing farmers' competitiveness. To achieve this, the Program ensures sustained and adequate supply of genetically pure and quality nucleus and breeder seeds of parents and $F_1$ public hybrids in support to public hybrid rice commercialization. HRP addressed outcome 1 in the PhilRice Strategic Plan 2017-2022, which is on increased productivity, cost effectiveness, and profitability of rice farming in a sustainable manner. For 2019, the Program consisted of six projects addressing development of parent lines for cytoplasmic male sterility (CMS)-based three-line hybrids and thermo-sensitive genetic male sterility (TGMS)-based two-line hybrids. Incorporation of major insect pest and disease resistance, as well as grain and eating quality traits in the parents, was streamlined. Seed and seed production research were geared toward parent seed producibility and increasing quality $F_1$ seed yield, which were factors vital in hybrid rice commercialization.

The Program employed transdisciplinary and integrated approach in the implementation of the various projects. Two projects, HRP-002 based at PhilRice Los Baños, and HRP-003 based at PhilRice CES, generated the parents and corresponding hybrids. These projects closely worked together to facilitate sharing of germplasm for pollen parents, and other resources as needed. These projects' outputs were evaluated by project HRP-005 for pest resistance by the crop protection experts and for grain and eating quality traits by rice chemistry and food science experts conducted at PhilRice Los Baños and CES for TGMS-based and CMS-based breeding materials, respectively. Research on seed and seed production for selected elite parents and hybrids were also conducted in both stations under projects HRP-004 and HRP-007. The crop management component of HRP was externally-funded and it focused on nutrient management and field performance under various growing environments.

Strong coordination and feedbacking among projects were mandatory for proper and smooth flow of breeding materials, information exchange, knowledge generation, and technology development.

The Hybrid Rice Program bred good performing parents and highly marketable CMS- and TGMS-based public hybrids that would increase the yield and income of farmers. This warranted improvement in grain yield potential, grain and eating quality, disease and insect pest resistance of hybrids and parents, and increase in $F_1$ seed yield.

PROJECT 1

# Development of CMS-Based Three-Line Hybrid Rice

*Joanne D. Caguiat*

Breeding three-line hybrids requires development of cytoplasmic male sterile (CMS or A), maintainer (B), and restorer (R) lines. Maintenance of complete sterility in the CMS line is a requirement for a good maintainer line, while restorer line should have the ability to restore fertility of the CMS line.

Four interrelated studies were included in the project on the development of CMS-based hybrid: development of hybrid parent lines (maintainer, male-sterile, and restorers); generation of experimental hybrids; seed multiplication of experimental and elite hybrids and parents; and evaluation of field performance of advanced and elite hybrids. The best performing hybrids based on yield and with intermediate to resistant reactions to major pests and diseases were nominated to the multi-environment trials (MET) and National Cooperative Test (NCT).

In 2019, nine out of 55 entries in maintainer line development nursery were selected based on their intermediate to resistant reactions to blast, bacterial leaf blight (BLB), and sheath blight. Their maintaining ability will be evaluated next year. Advanced maintainer lines PR51055 and PR51053 with >60% exerted stigma will be used for testcrossing and selection of backcross population for CMS conversion. Additional 88 maintainer lines were evaluated for grain yield, agro-morphological traits, resistance to major pests, and grain quality.

For restorer line development, 52 out of 99 advanced breeding lines had grain yields ranging from 6.02 to 7.38t/ha with 6.45t/ha average DS yield. These lines were detected to have either Rf3 or Rf4 genes through marker genotyping. Of the 52 potential R lines, 29 (56%) had desirable traits such as 81 to 96% spikelet fertility, good grain quality, with at least one Rf gene (Rf3 or Rf4), and intermediate to resistant reactions to major insect pests and diseases. These identified potential restorer lines will be nominated to the hybrid source nursery for generation of experimental hybrids and prospecting of pollen parents.

Good performing experimental hybrids were evaluated at the observational nursery (ON), preliminary yield trial (PYT), advance yield trial (AYT), and multi-environment trials (MET). There were 1,635 testcrosses generated for prospecting of potential maintainer and restorer lines. Molecular-prospecting based on 416 pollen parents identified 77 lines with MNT gene for identification of potential maintainer lines. There were 135 with Rf3 gene, 133 lines with Rf4, and 59 lines with both Rf3 and Rf4 genes identified for selection of potential restorer lines.

Performance of experimental hybrids was evaluated in the ON and PYT to identify best performing hybrids to be forwarded to the AYT nursery. Of the 26 hybrids evaluated in the ON, five hybrids with yields ranging from 6.6 to 8.7t/ha out-yielded the check variety Mestizo 1 with 6.4t/ha yield. Experimental hybrid PR29A/PR39905-H003-142-4-1-2-2, which had *Xa4* and *xa5* genes for bacterial leaf blight resistance and *Rf3* gene for fertility restoration, had the highest yield of 8.7t/ha. For PYT, five (38%) experimental hybrids with yields ranging from 10.1 to 11.6t/ha (with 11-45% yield advantage over check varieties) were selected for further evaluation in the next season. The highest yielding hybrid PR51608H was detected to have *Xa4* gene for BLB resistance and *Rf4* fertility restoring gene. All entries from ON and PYT will be established in 2020 DS for further verification and characterization before forwarding to the AYT nursery.

Among the ten hybrids evaluated in multi-location yield trials, the elite hybrid PR47795H obtained highest average grain yield of 8.6t/ha was selected for NCT evaluation in 2020 WS. It had 7.4t/ha average yield for 2019 DS across seven locations and 7t/ha average yield across PhilRice stations (CES, Agusan, and Isabela) for 2018 WS to 2019 DS evaluation.

Seed production activities were performed to produce experimental hybrids and parents. Nine hundred twenty-nine effective crosses with an average of 49 AxB crosses per CMS were generated. There were 34 experimental hybrids generated for ON, 92 hybrids for PYT, and 12 hybrids for AYT. Seeds of three elite hybrids (PR47771H, PR40640H and PR47795H) were also produced for NCT use.

## Development of Superior Maintainer and Male-Sterile Lines

*IG Pacada, JC Bagarra, AG Pascua, MAM Miranda, LV Gramaje, FP Waing, JM Manangkil, JD Caguiat, and NV Desamero*

The development of diverse maintainer lines from different ecosystem and from another cultivar group will broaden the maintainer germplasm source. These maintainer lines when converted to selected CMS lines will not only widen the parental source but also increase the CMS germplasm pool that may facilitate the breeding of heterotic $F_1$ hybrids. Nine advance maintainer lines were profiled and found to be with intermediate to resistant reactions to blast, BLB, and sheath blight. PR48322HY-B-7-1-1-7 and PR48322HY-B-7-1-1-5 had intermediate reaction to white heads (CES) while PR48328HY-B-1-1-3-1 had intermediate reaction to BPH. The 88 developed and improved maintainer lines were characterized in terms of yield and selected agronomic characteristics to generate new breeding population having traits for enhancing yield, with resistance to major biotic stresses, and of good grain quality. *Azucena* (PRRI002235) and *Fancy* (PRRI003549) were confirmed and validated for wide compatibility variety (WCV) traits and they have the *S5n* gene. These germplasms were in the background of another cultivar group and will be used as new parental source for enhancing heterosis. Advance maintainer lines PR51055 and PR51053 were selected for having >60% exerted stigma (Figure 1). All improved and developed maintainer lines and the newly identified parental source were testcrossed to selected CMS lines to determine the presence of sterility inducing gene and eventually breed new CMS lines in the background of elite maintainer line.


*Figure 1. Flowering characteristics and exerted stigma of PR51055 (left) and PR51053 (right)*

## Development of Diverse Restorer Lines

*FP Waing, J II C Santiago, and LV Gramaje*

In hybrid rice seed production using three-line or CGMS (Cytoplasmic Genic Male sterility) system, the combination of a CMS line, maintainer line, and restorer line carrying the restorer gene (*Rf*) to restore the fertility is indispensable for the development of hybrids. However, one of the challenges for the three-line system to be successful is to develop a restorer line with good restoring ability coupled with other good agronomic characteristics. The study aimed to: (1) develop diverse restorer lines with 80 - 85% pollen and spikelet fertility, acceptable grain quality, and resistance to major biotic stresses, and (2) evaluate the performance of promising restorer lines for grain yield, and other important morpho-agronomic traits. In the pedigree nursery evaluation, 748 lines selected out of 1,466 $F_3$-$F_5$ lines were evaluated in DS and 634 lines were selected $F_3$-$F_5$ lines in WS. There were 441 plants from four $F_2$ populations with homozygous allele of *Xa21*, with at least one *Rf* gene, and with good phenotypic acceptability were selected. Field performance, grain quality, and reaction to major insect pests and diseases of the advanced breeding lines were evaluated. Of the 99 advance breeding lines, 55 had yields ranging from 6.02 to 7.38t/ha compared to the best performing check NSIC Rc 222 with 6.79t/ha yield in DS. All these lines contained at least one Rf genes (Rf3 or Rf4) detected through marker genotyping; 89 lines had at least one Rf gene and nine lines contained both Rf3 and Rf4 genes (Figure 2). The recorded data for pollen sterility ranged from 66 to 96% (Figure 3) while spikelet fertility was from 67 to 96% (Figure 4). Of the 52 lines, 29 have 81 - 96% spikelet fertility, passed the grain quality standards, and with intermediate to resistant reactions to major insect pests and diseases such as leaf blast, bacterial leaf blight, and sheath blight. These identified and selected potential restorer lines with desirable traits will be nominated to hybrid source nursery.

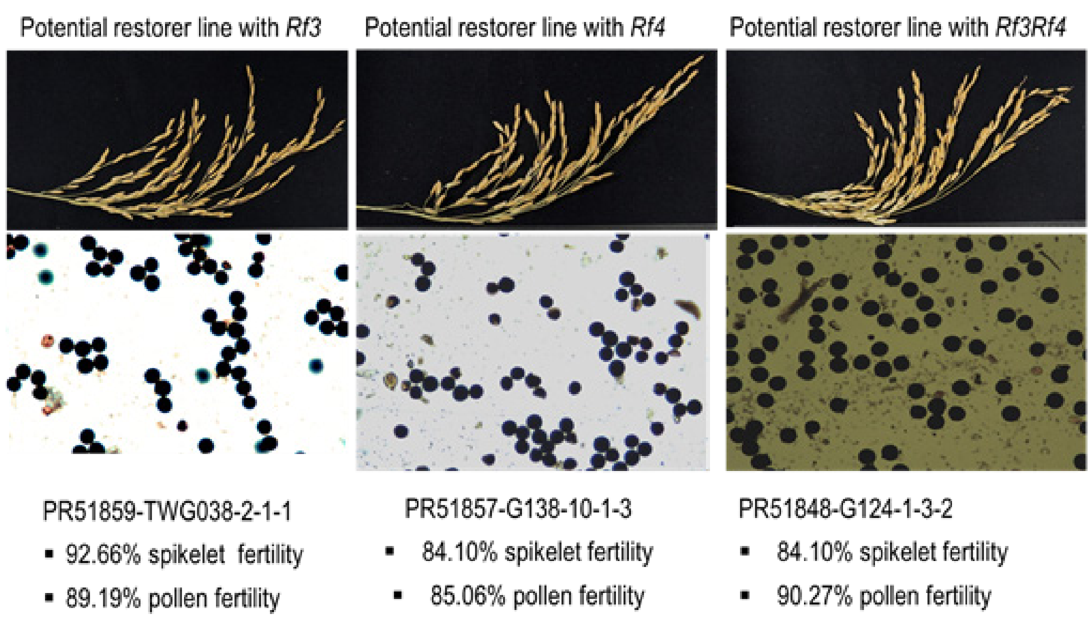


*Figure 2. Results of spikelet and pollen sterility from selected potential restorer lines containing Rf3 (left), Rf4 (middle), and with both Rf3 and Rf4 genes (right) in 2019 DS.*

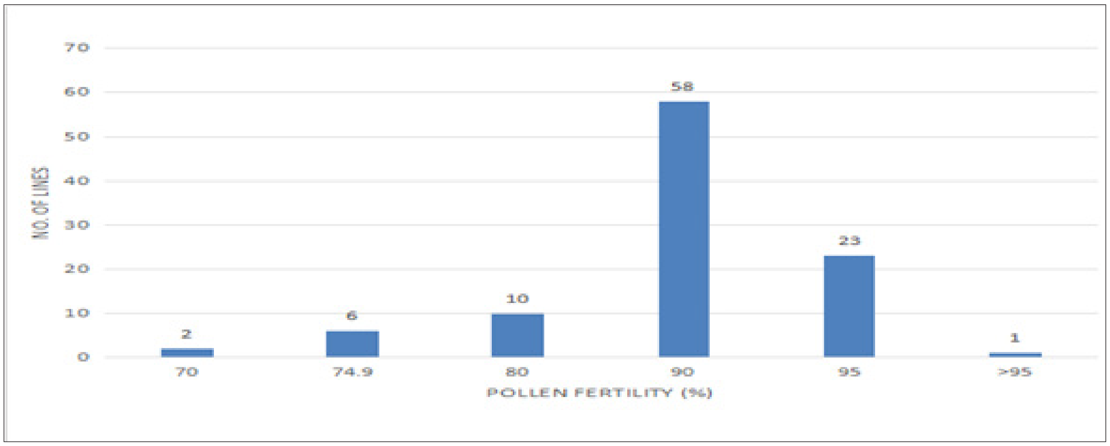


*Figure 3. Frequency distribution of percent pollen fertility among evaluated lines in AYT, 2019 DS*

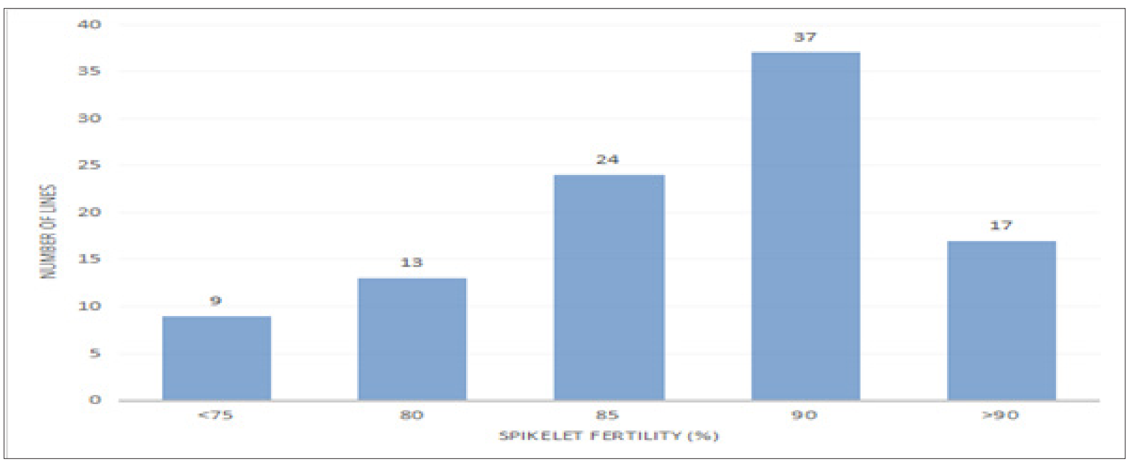


*Figure 4. Frequency distribution of percent spikelet fertility among evaluated entries in AYT, 2019 DS*

## Development and Field Performance Evaluation of Experimental Hybrids

*JD Caguiat, FP Waing, MAC Meman, JP Uera, MSF Ablaza, and NV Desamero*

This study generated experimental hybrids, prospected potential parent lines based on $F_1$ hybrid performance, and identified promising hybrids for nomination to multi-location yield trial. In 2019 DS and WS, 1,635 testcrosses were generated for prospecting of potential maintainer and restorer lines (Table 1). Molecular prospecting based on 416 pollen parents identified 77 lines with MNT gene for identification of potential maintainer lines. For the selection of potential restorer lines, 135 lines were identified with *Rf3* gene, 133 lines with *Rf4*, and 59 lines with both *Rf3* and *Rf4* genes. Performance of experimental hybrids was evaluated in the ON (Table 2) and PYT (Table 3) to identify potential hybrids to be forwarded to the AYT nursery and consequently select hybrids for nomination to multi-location. During 2019 DS, of the 26 hybrids evaluated, experimental hybrid PR29A/PR39905-H003-142-4-1-2-2 outyielded the rest at 8.7t/ha with the check variety, Mestizo 1 yielding only 6.4t/ha yield. This experimental hybrid also had *Xa4* and *Xa5* genes for bacterial leaf blight resistance and *Rf3* gene for fertility restoration. For PYT, five experimental hybrids with 10.1 - 11.6t/ha yield (11-45% yield advantage over check varieties) were selected for further evaluation in the next season. PR51608H obtained 11.6t/ha, the highest yield among all entries in the PYT including check varieties NSIC Rc 222 (9.1t/ha), Mestiso 20 (8.3t/ha), Mestizo 1 (8.2t/ha), and Mestiso 32 (8t/ha). This hybrid entry was also detected to have *Xa4* gene for bacterial leaf blight resistance and *Rf4* fertility restoring gene. Selected promising experimental hybrids will be further evaluated in succeeding nurseries and will be forwarded in multi-location yield trials. The elite hybrid PR47795H will be nominated for NCT evaluation in 2020 WS. This hybrid obtained 8.6t/ha average grain yield at PhilRice CES for 2018 WS-2019 DS; 7.4t/ha national average for 2019 DS, and 7t/ha average yield across PhilRice stations (CES, Agusan, and Isabela) for 2018 WS to 2019 DS evaluation.

*Table 1. Evaluation of pollen parents for fertility restoring and maintaining genes based on molecular marker prospecting in 2019 DS and WS*

| | DRY SEASON | WET SEASON | TOTAL |
|---|---|---|---|
| Total number of Pollen Parent | 219 | 197 | 416 |
| Total number of CMS lines | 5 | 7 | 12 |
| Pollen parent with MNT genes | 0 | 77 | 77 |
| Pollen parent with *Rf3* genes | 58 | 77 | 135 |
| Pollen parent with *Rf4* genes | 61 | 72 | 133 |
| Pollen Parent with both *Rf3* and *Rf4* genes | 13 | 46 | 59 |
| Total number of $F_1$ generated | 792 | 938 | 1,730 |

*Table 2. Performance of top yielding entries in observation nursery during 2019 DS*

| Cross combination | Mat | PHt | Pan | Yield (t/ ha) | YA (%) over M1 | BLB | ShB | FS | WH | BPH | LF | Defoliator |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PR29A/ PR39905 - H003 - 142 -4 - 1 - 2 - 2 | 116 | 108.4 | 15 | 8.7 | 35.9 | R | R | R | R | R | R | R |
| PR15A/ PR51841 - G106 - 2 - 1 - 2 | 110 | 101.5 | 14 | 8.1 | 26.6 | R | R | R | R | I | R | R |
| PR19A/ PR39908 - H006 - 2 - 1 - 1 - 3 - 1 - 1 | 110 | 108.5 | 16 | 7.2 | 12.5 | R | I | R | R | R | R | R |
| PR19A/ PR39914 - H012 - 198 - 21 - 1 - 2 | 109 | 128.2 | 17 | 6.8 | 6.2 | R | I | R | R | R | R | R |
| PR19A/ PR45952HY- B - 2858 - 207 - 168 - 220 - 276 | 109 | 131.2 | 14 | 6.6 | 3.1 | R | I | R | R | R | R | R |
| Mestizo 1 | 125 | 109.3 | 11 | 6.4 | | R | R | R | R | R | R | R |

*Mat= Maturity, PHt=Plant height, Pan= Panicle Number, YA= Yield advantage, Observations only under natural field condition: ShB= Sheath blight, FS= Falsemut, WH= Whiteheads, BPH= Brown plant hopper, LF= Leaf folder, R= Resistant I= Intermediate*

*Table 3. Performance of top yielding entries in preliminary yield trial during 2019 DS*

| Code | Genotype | Mat | Pn | Pht | Yield (t/ha) | Genes | Yield advantage (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | NSIC Rc 222 | M1 | M32 | M20 |
| PYT-2 | PR51608H | 110 | 15 | 105 | 11.6 | *Xa4, Rf4* | 27 | 41 | 45 | 40 |
| PYT-4 | PR51596H | 109 | 16 | 114 | 10.8 | *Xa4, Xa5, Rf4* | 19 | 32 | 35 | 30 |
| PYT-7 | PR51587H | 111 | 20 | 106 | 10.6 | *Xa4* | 16 | 29 | 33 | 28 |
| PYT-23 | PR51622H | 121 | 18 | 108 | 10.2 | *Xa5, Rf4* | 12 | 24 | 28 | 23 |
| PYT-5 | PR51620H | 109 | 13 | 110 | 10.1 | *Xa4* | 11 | 23 | 26 | 22 |
| PYT-17 | NSIC Rc 222 | 111 | 14 | 106 | 9.1 | *Xa4, Rf4* | | | | |
| PYT-27 | Mestizo 1 (M1) | 125 | 14 | 115 | 8.2 | | | | | |
| PYT-28 | Mestiso 32 (M32) | 116 | 13 | 112 | 8.0 | | | | | |
| PYT-29 | Mestiso 20 (M20) | 114 | 13 | 111 | 8.3 | | | | | |

# Seed Multiplication of Experimental Hybrids and Parent Lines

*LV Gramaje, FP Waing, MV Corpuz, MSF Ablaza, and NV Desamero*

Seed production of parents and experimental hybrids was done to ensure the availability of sufficient amount of seeds to be used in all stages from ON to NCT. It involved two steps: multiplication of CMS lines (A×B) and the production of $F_1$ seeds (A×R), both done alongside seed increase of maintainer and restorer lines. This study aimed to: (1) produce sufficient physically and genetically pure hybrid nucleus seeds of hybrid parent lines (A, B, and R), (2) produce sufficient and genetically pure seeds of experimental hybrids for PYT and NCT, and (3) identify hybrids with 1.5t/ha AxR seed yield for nomination to MYT and NCT. In CMS line multiplication, 929 effective crosses were generated, and 20 AxB CMS entries were multiplied for nucleus seeds (Table 4). For experimental hybrids, 136 entries were seed produced to be used in ON, PYT, and AYT nurseries (Figure 5). In addition, three experimental and five released hybrids were produced for NCT evaluation and as standard checks, respectively (Table 5). Seed increase of restorer lines was also done to cater to the needs of the different yield trials. Seed production capacity was also measured in AxR plots. Maximum seed yield attained was 1,910kg/ha for the Seed production for National Cooperative Testing (SPNCT). It was noted that most of the entries had high seed reproducibility during the dry season; therefore, prioritization of entries to be seed produced was done. Furthermore, maintaining the genetic purity of all seed production plots should be prioritized to get good result in experimental trials.

*Table 4. Evaluated paired crosses (EPC) for CMS multiplication, 2019 DS/WS*

| Entry | Cross Combination | Seed Yield (g) | |
|---|---|---|---|
| | | CMS | B-line |
| IR79156A | IR79156A x IR79156B | 7720.2 | 16482.6 |
| 21A | PR21A x PR21B | 4395.1 | 11974.9 |
| IR80559A | IR80559A x IR80559B | 2670.8 | 14510.6 |
| PR28A | PR28A x PR28B | 1855.2 | 12682.2 |
| IR79128A | IR79128A x IR79128B | 1805.8 | 9553.1 |
| PR19A | PR19A x PR19B | 1141.7 | 7205.2 |
| IR68897A | IR68897A x IR68897B | 759.4 | 300.0 |
| PRH1A | PRH1A x PRH1B | 647.4 | 3251.5 |
| PR15A | PR15A x PR15B | 433.0 | 14564.8 |
| PR 29A | PR 29A x PR29B | 413.6 | 8911.0 |
| PR27A | PR27A x PR27B | 233.9 | 11990.4 |
| PR24A | PR24A x PR24B | 184.9 | 8228.2 |
| PR20A | PR20A x PR20B | 167.7 | 11424.0 |

| | | | |
|---|---|---|---|
| PR46622A | PR46622A x PR46622B | 981.2 | 2578.6 |
| IR73328A | IR73328A x IR73328B | 922.2 | 3491.1 |
| IR79128A | IR79128A x IR79128B | 884.7 | 5954.8 |
| PR27A | PR27A x PR27B | 628.6 | 3496.0 |
| IR80559A | IR80559A x IR80559B | 521.9 | 6641.1 |
| IR80156A | IR80156A x IR80156B | 315.9 | 4115.6 |
| IR80151A | IR80151A x IR80151B | 200.0 | 1518.5 |

*Table 5. Seed production of experimental and released hybrids for NCT evaluation, 2019 DS/WS*

| Entry | Cross Combination | Yield (kg) | Seed yield (t/ha) |
|---|---|---|---|
| M32 | IR68897A x IR73013-95-1-3-2R | 28.7 | 804.1 |
| M55 | IR79128A x PR31559-AR32-4-3-2R | 41.5 | 1639.5 |
| M73 | TG101 x SN758 | 12.4 | 917.7 |
| M3 | IR68897A x IR60819-34-2R | 10.7 | 720.0 |
| PR47771H | PR29A x PR34302R | 27.0 | 838.4 |
| PR40640H | PR29A x 19R56R | 13.5 | 982.8 |
| M55 | IR79128A x PR31559-AR32-4-3-2R | 6.1 | 1910 |
| PR47795H | IR80559A x PR31559-AR32-4-3-2R | 6.2 | 1068 |

*Figure 5. Seed production for PYT (left) and AYT (right)*

# Development of Thermo-Sensitive Genetic Male Sterile (TGMS)-Based Two-line Hybrids

*Mel Anthony T. Talavera*

This Project was composed of six interrelated studies; three were devoted for line development of both female and male parents; two for generating new and promising experimental hybrids, and one for field performance evaluation of new and promising experimental hybrids. The product of TGMS and pollen parent line development was used to generate new promising experimental hybrids. Untested $F_1$s were evaluated in the Hybrid Observational Nursery (HON). Promising hybrids identified in HON underwent reconstruction of $F_1$ seeds to ensure sufficient seeds for Hybrid PYT and AYT. Only the best performing hybrids were nominated to the NCT for countrywide performance evaluation.

This year, the TGMS two-line hybrid breeding focused on characterization of new TGMS (female parent line) and pollen parent lines, seed production of experimental hybrids, performance evaluation of new and promising experimental hybrids, generation of $F_1$ seed production protocol, characterization of a promising experimental hybrid (AYT 191) and its parents, and the release of new TGMS hybrid PRUP 12 in the NCT.

For line development, the Project handled five composite populations (2 for TGMS, 3 for pollen parents), 70 large $F_2$ populations, 2,592 segregating breeding lines from $F_3$ to $F_6$ (1,784 for TGMS breeding and 1,094 for pollen parent breeding), and 28 ON lines (4 for TGMS breeding, 24 for pollen parent breeding). At male fertile environment (MFE), 3,816 plants (1,249 plants for hybridization method; 2,567 for recurrent selection method) coming from $F_2$ to $F_6$ generations were evaluated for fertility restoration and seed increase. The MFE site was exclusive for TGMS breeding only. Advancing of breeding lines in segregating generations resulted in the selection of 4,770 and 722 plants from $F_2$ to $F_6$ for TGMS and pollen parent breeding during the dry season (DS), respectively. Four fixed lines for female line development were characterized for agronomic data, disease and insect resistance, and sterility behavior at the male sterile environment (MSE). TGON 34, 39, 46, and 47 stood not more than 90 cm, were resistant to major insect pests and diseases, and had stable sterility at MSE. These new medium-maturing TGMS lines will be further evaluated for fertility restoration during 2020 DS at MFE. For male development, three pollen parents had completed evaluation for agronomic data, grain quality, and combining ability estimate. The medium-maturing new pollen parents RPP6 9, 251, and

262 had plant heights of at least 100cm, acceptable grain quality, and possible good combining abilities. These materials will be transferred to active collection of pollen parents for developing new experimental hybrids.

New lines developed in TGMS and pollen parent breeding were included in the pool of parents for generation of new and promising experimental hybrids. This year, 892 new experimental hybrids were generated with sufficient seeds using manual crossing and pollination, and modified isolation free method. Of these new experimental hybrids, 640 (72%) were evaluated in HON, identifying 30 cross combinations that showed superiority over the highest yielding hybrid check M20 for grain yield during DS trial.

Promising experimental hybrids identified in HON were further tested in HPYT and AYT. Seed requirement for HPYT and AYT were generated using isolation free method. This year, 122 promising experimental hybrids identified for HPYT and AYT during the previous seasons were reconstructed. From this, 48 and 20 experimental hybrids were used in HPYT and AYT evaluation, respectively. Ten (6 in DS; 4 in WS) promising experimental hybrids were identified to be better than the highest yielding hybrid check M20 in HPYT. The highest-yielding promising hybrid HPYT 700 had 7,941kg/ha with a yield advantage of 9% against M20 during DS while HPYT 729 (6,751kg/ha) exceeded the yield of M73 (6,225kg/ha), gaining a yield advantage of 8%.

Promising hybrids identified in HPYT comprised the AYT. During DS, four experimental hybrids were identified to be better than the check M20. AYT 187 was the highest yielding among early-maturing hybrids evaluated with a grain yield of 7,090kg/ha. AYT 189, 190, and 191, all medium-maturing, had grain yields ranging from 7,276 to 8,090kg/ha with yield advantage ranging 2.7–3.6% against M20. During WS, among the identified experimental hybrids in AYT, only AYT 191 was evaluated due to seed insufficiency. It yielded 5,746kg/ha with 9% yield advantage over M20. AYT 191 will be seed increased using SxP to produce enough $F_1$ seeds for multi-location yield trial.

Also this year, PRUP 12, an essentially derived variety of M19, completed the required seasons of field evaluation and validation using molecular data. NCT data showed that agronomic data, yield, and grain quality parameters were comparable to M19. Genotyping of the parents of this hybrid were completed and was submitted to the NCT. This variety was approved for release by the National Seed Industry Council (NSIC) for national cultivation.

# Development of New and Diverse TGMS Lines through Hybridization and Selection

*EE Sajise, KC Gonzales, and MAT Talavera*

In this study, transfer of TGMS trait into individuals of improved genetic background was done through hybridization and selection. Segregating generations were handled using pedigree system while evaluation of breeding materials and fixed lines was done using pedigree selection for both MSE and MFE through shuttle breeding. In this scheme, sterility of TGMS breeding materials were evaluated at MSE while fertility and seed generation were assessed at MFE. Of the 114 $F_1$s generated for TGMS line development, 70 were advanced to $F_2$. Thirty populations were planted in the DS and 40 in WS. In the pedigree nursery established at MSE, 792 sterile plants in the $F_2$ populations were selected, ratooned, and allowed to set seeds at MFE. Likewise, 537 fertile plant selections in the $F_2$ were advanced to $F_3$ for further segregation to select for sterile lines. In the early to advanced generations, 839 $F_3$-$F_6$ lines were selected and allowed to produce seeds at MFE. Once pedigree selection reached advanced generations ($F_6$ and up), selected lines underwent a more rigorous evaluation in the TGMS observation nursery (TGMS ON). Nine promising TGMS lines, which were completely sterile and medium-maturing with plant heights of 64-85cm (Table 6), will undergo further evaluation (for stability of sterility/fertility expression, pest and disease resistance, and grain quality) and agro-morphological characterization in 2020 WS. These lines will also be used in generating two-line experimental hybrids to check combining ability with available pollen parents in the collection.

*Table 6. Summary of important agro-morphological traits and pest and disease reactions under natural field condition of nine promising TGMS lines at MSE*

| Entry code | DTH | Ht. (cm) | Tiller No. | Sterility | Natural Field Evaluation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Insect | | Disease | | | | |
| | | | | | DH | WH | SHB | BLB | RTV | Bspot | ShR |
| **2019 Dry Season** | | | | | | | | | | | |
| TGON 34 | 91 | 84 | 19 | 1F | 0.27 | 1.81 | I | I | S | R | I |
| TGON 39 | 95 | 82 | 16 | CS | 0.45 | 0 | S | I | S | I | I |
| TGON 46 | 98 | 68 | 22 | CS | 0.99 | 0.28 | I | R | I | R | I |
| TGON 47 | 102 | 90 | 19 | CS | 0 | 5.61 | I | R | I | R | I |
| **2019 Wet Season** | | | | | | | | | | | |
| TGON 61 | 96 | 85 | 15 | CS | - | - | - | - | - | - | - |
| TGON 62 | 96 | 81 | 17 | CS | - | - | - | - | - | - | - |
| TGON 65 | 100 | 84 | 10 | CS | - | - | - | - | - | - | - |
| TGON 67 | 96 | 81 | 15 | CS | - | - | - | - | - | - | - |
| TGON 71 | 96 | 82 | 17 | CS | - | - | - | - | - | - | - |

** Data collection and processing for wet season is ongoing*

## Extraction of Stable and Improved TGMS Lines through Recurrent Selection

*EE Sajise, KC Gonzales, and BR Punzalan*

Continuous development of more diverse and improved TGMS lines is essential to generate better performing two-line hybrids. Recurrent selection as a breeding method concentrates on fewer individuals in the population desirable traits through recurrent cycles of intercrossing and selection. It allows intercrossing among individuals in the population to keep population in heterozygous conditions allowing more chances of genetic recombination. This method involves the development of composite intercrossing population from which potential TGMS lines with stable sterility/fertility at MSE and MFE, earliness and shorter stature, resistance to pests and diseases, and good grain quality are selected. In 2019, 12 previously identified promising TGMS lines were further evaluated in the TGMS ON at MSE for sterility stability. The potential new TGMS lines have plant heights from 73 to 93 cm, with tiller number ranging from 15 to 25, while the number of days to heading was from 91 to 105 days after seeding (DAS) (Table 7). Pest and disease reactions based on natural field conditions indicated resistance to stemborer, and intermediate to resistant reactions to sheath blight and bacterial leaf blight. Seeds harvested from ratoons of promising TGMS lines will be planted in the 2020 DS for seed increase and evaluation at MFE to determine seed reproducibility and ability of the male sterile lines to revert to fertile condition. Likewise, the 12 TGMS lines will be submitted for grain quality evaluation and screening for pest and disease reactions using the induced method once seeds are sufficient for testing.

*Table 7. Important agronomic characteristics and degree of sterility of promising new TGMS lines in the Observation Nursery, 2019 DS*

| Entry code | DTH | Ht. (cm) | Tiller No. | Sterility | Natural Field Evaluation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Insect | | Disease | | | | |
| | | | | | DH | WH | SHB | BLB | RTV | Bspot | ShR |
| **TGON 2** | **91** | **83** | **19** | **CS** | **3.56** | **2.58** | **I** | I | I | R | I |
| TGON 6 | 91 | 87 | 20 | CS | 0 | 2.15 | I | I | S | I | S |
| TGON 7 | 102 | 92.7 | 25 | CS | 0 | 4.23 | I | R | S | R | S |
| TGON 8 | 105 | 82.3 | 18 | CS | 0.16 | 3.3 | I | I | S | R | S |
| TGON 9 | 105 | 92.3 | 22 | CS | 0 | 0.53 | I | R | S | R | S |
| **TGON 11** | **102** | **98** | **23** | **CS** | **0.48** | **1.18** | **I** | R | S | R | S |
| TGON 13 | 95 | 75 | 27 | CS | 0.64 | 0 | R | I | S | R | S |
| TGON 17 | 95 | 76 | 24 | CS | 1.39 | 1.23 | I | R | S | R | I |
| TGON 21 | 91 | 76.7 | 23 | CS | 0.44 | 0 | R | I | S | I | I |
| TGON 23 | 98 | 78 | 19 | CS | 0 | 0 | R | I | S | R | I |
| TGON 26 | 95 | 72.7 | 22 | CS | 0 | 0 | I | R | S | S | I |
| TGON 28 | 102 | 77.3 | 15 | CS | 0 | 0 | I | R | I | S | I |

## Identification and Development of Pollen Parents for Two-Line Hybrids

*MAT Talavera, EE Sajise, and KC Gonzales*

Three composite populations, 758 $F_2$ lines and 836 segregating lines from $F_3$ to $F_6$, and 33 fixed lines were established in the pollen parent pedigree nursery. Selection criteria used were good phenotypic acceptability (PA), plant height of at least 100cm, and acceptable grain quality. In 2019 DS, 205 $F_2$ populations were identified with potential segregants resulting in selection of 612 plants, while for $F_3$-$F_6$ generation, 121 lines were selected. The 17 fixed lines were further trimmed down to eight after the final season of evaluation. These new pollen parents will be purified before being used as male parents in generating experimental hybrids. For the 2019 WS, three composite populations were selected with at least 200 fertile plants and 300 sterile plants. For the $F_5$ generation, initial selection identified five pollen parents with at least 100cm plant height, medium maturing, and amylose content/ gelatinization temperature (AC/GT) combinations of low (L/L) and intermediate (I/I). For the 16 lines evaluated in the ON, 10 families were initially selected. These lines matured in 121 to 128 days, with plant height from 129 to 155cm, and with good to excellent PA rating. These 10 lines, harvested in bulk, will be used in generating new and promising experimental hybrids in 2020 DS.

Sixteen pollen parents were evaluated for agronomic data, grain quality, and pests and diseases for DS and WS in pollen parent performance nursery. All pollen parents evaluated passed the selection criteria mentioned previously. For grain quality, 12 pollen parents passed the standards set. Only RPP6 231 had an I/I AC/GT combination, while the remaining 12 had AC/GT combination of L/I and I/L. Combining ability was also estimated during the year. Using data from 2019 DS evaluation of all experimental hybrids (HON, HPYT, and AYT), RPP6 262, RPP6 9, and RPP6 251 were identified as potential pollen parents with good combining ability (Table 8).

Table 8. Agronomic and grain quality performance of new pollen parents, 2019 DS / WS

| Index No. | GQ | PLANT HEIGHT | | Tiller count | | Maturity | | Combining ability |
|---|---|---|---|---|---|---|---|---|
| | | DS | WS | DS | WS | DS | WS | 19DS |
| RPP6 262 | L/I | 96 | 107 | 13 | 14 | | 123 | TGMS 131 X RPP6 262 (6.23% YA over M19 AYT) |
| RPP6 258 | L/I | 92 | 110 | 13 | 15 | | 126 | |
| RPP7 41 | I/L | 117 | 139 | 14 | 15 | | 129 | |
| RPP7 31 | I/L | 108 | 124 | 14 | 15 | | 126 | |
| RPP6 229 | I/L | 108 | 119 | 16 | 14 | | 126 | |
| SN 758 | I/L | 107 | 112 | 15 | 17 | | 126 | |
| RPP6 238 | L/I | 112 | 131 | 16 | 20 | | 126 | |
| RPP6 241 | L/I | 103 | 128 | 15 | 13 | | 126 | |
| RPP6 85 | I/L | 107 | 120 | 15 | 12 | | 123 | |
| RPP7 25 | I/L | 108 | 132 | 14 | 14 | | ND | |
| RPP6 9 | I/L | 106 | 121 | 15 | 17 | | ND | 8005 kg/ha average; 3/5 crosses significant over M19 HON |
| RPP6 231 | I/I | 94 | 115 | 13 | 13 | | 135 | |
| RPP6 101 | H/I | 99 | 128 | 14 | 16 | | 126 | |
| RPP5 579 | H/I | 98 | 131 | 15 | 18 | | 133 | |
| RPP6 251 | H/I | 101 | 121 | 15 | 13 | | 120 | TGMSON 704 X RPP6 251(0.51% YA over M19 HPYT); TGMS 78 X RPP6 251 (14.12% YA over M19 AYT) |
| SN 821 | H/I | 106 | 135 | 14 | 22 | | 127 | Male parent PRUP 13 |
| PSB Rc82 | YIELD CH | 99 | 116 | 13 | 18 | | 123 | |
| NSIC Rc222 | YIELD CH | 101 | 115 | 13 | 20 | | 127 | |

## Development of Two-Line Experimental Hybrids

*EE Sajise, KC Gonzales, and MAT Talavera*

Maintaining a sizable number of experimental hybrids generated and tested in any hybrid rice breeding program ensures chances of identifying good heterotic hybrids. This is especially true when hybrid prediction through identified heterotic groups or some other means are not yet in place. To generate two-line experimental hybrids, promising TGMS lines and pollen parents were assembled in a test cross nursery. New experimental hybrids were generated through hand crossing or using isolation-free method. There were 892 new experimental hybrids generated; 537 in DS and 355 in WS. Hybrids developed composed HON for preliminary performance testing and evaluation.

## Evaluation and Field Performance of Promising Two-Line Hybrids

*BR Punzalan, MAT Talavera, KC Gonzales, and EE Sajise*

Two-line hybrids involving TGMS lines were evaluated for yield performance under field conditions at Los Baños, Laguna. The study evaluated 400 new experimental hybrids per season in the HON. Hybrids with favorable PA identified in HON advanced to the next phase of evaluation in the HPYT, then promising hybrids progressed to AYT. In AYT, additional traits including biomass production, translocation, and yield components were also evaluated. In HPYT, six hybrids were identified superior to highest-yielding hybrid check for each set (Mestiso 20: Set 1, 6,848kg/ha; Set 2, 6,996kg/ha; Set 3, 7,286kg/ha). The best-performing promising hybrid, HPYT 700, yielding 7.49t/ha showed 9.0% yield advantage over M20. In WS, four hybrids were identified to advance from HPYT to AYT with a yield advantage over M20 (5,739kg/ha) and NSIC Rc 222 (5,349kg/ha) of at least 5% and 15%, respectively. Two potentially outstanding hybrids were identified: HPYT 700 (7,941kg/ha; 8.4% yield advantage over M73) in DS and HPYT 729 (6,751kg/ha; 8.45% yield advantage to M73) in WS. In AYT, two early maturing hybrids (Group 1) superior to Mestiso 19 (6,013kg/ha); and two medium-to-late maturing hybrids (Group 2) superior to M20 (6,622kg/ha) were identified in DS. In WS, AYT 191 (5,746kg/ha) remained as the top performer among tested hybrids (Figure 6). However, none showed yield advantage over the highest-yielding hybrid check M19 (5,762kg/ha). AYT 191 was identified to be a potential candidate for NCT for hybrids. Good performing hybrids which did not meet the requirements for advancement will be re-evaluated. Further studies on yield stability across seasons and environment is also recommended.

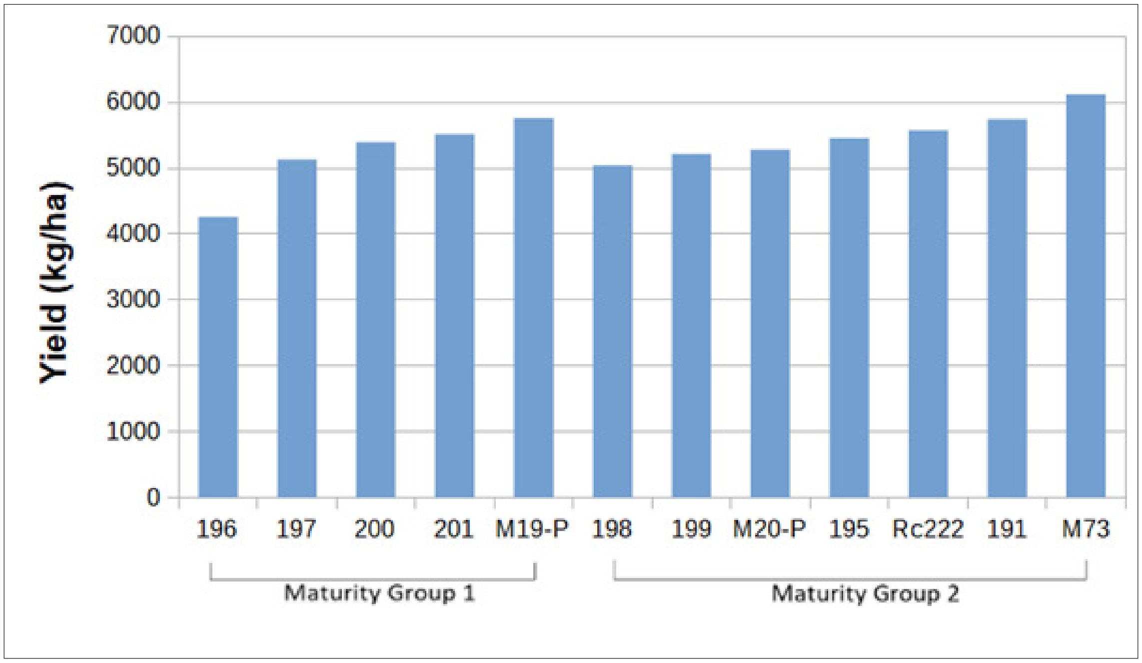


*Figure 6. Actual yield of hybrid entries in AYT, 2019 WS*

## $F_1$ Seed Production of Two-line Hybrids for Testing and Evaluation

*MAT Talavera, BR Punzalan, KC Gonzales, and EE Sajise*

The study aimed to establish initial flowering synchronization protocol for hybrid in the pipeline and to produce sufficient quantity of $F_1$ seeds for yield trials and submission to th NCT. Isolation free method was used to generate promising experimental hybrids, while SXP method was employed for generating $F_1$ seeds. Fifty-four pollen parents and 36 TGMS lines were used to generate promising experimental hybrids. For 2019, 122 cross combinations were generated producing enough experimental hybrids for testing in the HPYT and AYT in 2019 WS and 2020 DS, respectively. Initial characterization of parents of promising hybrids identified in AYT, AYT 189 and AYT 191, was conducted (Table 9). Results showed that the female parent of these two experimental hybrids bloomed four days later than the male parent. For plant height, the male parent of AYT 189 and AYT 191 had 26 and 45cm height advantage than the female parent, respectively. Seed production of parents of AYT 189 and 191 will be conducted the following season.

Initial seed production protocol for the newly released public hybrid Mestiso 99 (NSIC Rc 544H) was generated in 2019 DS (Table 10). Results showed that the flowering of female parent (PRUP TG 102) was earlier by five days compared with the male parent (SN 779-P). Using three sets of male parents planted at three days interval, sufficient pollen was supplied to the female parent. $F_1$ seeds, parent seeds, and information generated by the study will be shared to the basic seed production team for flowering synchronization refinement and conduct of $F_1$ seed production capacity.

*Table 9. Initial characterization of AYT 189 and 191, 2019 WS*

| Parents | Plant height (cm) | 50% Flowering (days) | Seed status |
|---|---|---|---|
| AYT 189 | | | |
| Female parent | 78 | 96 | Seed increase on-going |
| Male Parent | 104 | 91 | Seed increase on-going |
| AYT 191 | | | |
| Female parent | 90 | 91 | Seed increase on-going |
| Male Parent | 121 | 91 | Seed increase on-going |

*Table 10. Initial seed production protocol for Mestiso 99 (NSIC Rc 544H), 2019 DS*

| Parents | Seeding schedule | FL start | FL end | Fl duration | Culm length | Plant height |
|---|---|---|---|---|---|---|
| **PRUP TG 102** | 6-Feb | 91 | 107 | 16 | 73 | 90 |
| **SN 779-P (s1)** | 29-Jan | 96 | 112 | 16 | 90 | 123 |
| **SN 779-P (s2)** | 1-Feb | | | | | |
| **SN 779-P (s3)** | 4-Feb | | | | | |

# Hybrid Seed and Seed Production Research

*Susan R. Brena*

The Project consisted of four studies grouped into two: first (HRP 004-001 and HRP 004-003) dealt with seed production of parental lines in the male fertile environment and hybrid seed production of newly released CMS hybrid, Mestiso 55, and TGMS hybrid, Mestiso 73; and the second (HRP 004-004 and HRP 004-005) involved research on genetic purity of hybrid parental lines and hybrids used in the current public hybrid commercialization program.

In 2019, SxP experimental setup using newly released TGMS hybrid, Mestiso 73 (NSIC Rc 244H) was established in CES in both seasons to evaluate pollen load and dispersal using six row ratios (2:8, 2:10, 2:12, 3:8, 3:10, and 3:12). Pollen grains were collected during anther dehiscence from 9:00 to 11:00AM. Among all the row ratios used, the highest number of pollens collected was observed in 3:8 row ratio regardless of pollen collection time. Pollen collected was highest between 10:00 and 11:00AM. The S-lines (seed parent or female rows) near the pollen source (male rows) had the highest number of trapped pollen viewed under the microscope.

Seed yield of female line (PRUP TG102) as affected by varying dates of planting at bi-weekly interval was determined in a replicated trial in Negros MFE site. The mid-November planting, with four splits of nitrogen fertilizer, had the highest yield at 398kg/ha but less than the target yield of 1.5t/ha. The high seed yield in mid-November coincided with low temperature at the critical stages of panicle development. The MOET analysis after the trial showed multiple nutrient deficiencies, requiring adjustments in the fertilizer application for the succeeding trial.

All seed lots of parental lines harvested for use in both AxR or SxP seed production and public hybrids were planted in conventional grow out test for genetic purity assessment based on morphological characters. Hybrids evaluated were provided by the BPI-NSQCS from the samples submitted for seed certification. Of the 17 seed lots of foundation seeds (FS) of PRUP TG102 (S-line of M20), only one seed lot had less than 90% purity. Likewise, one of the four seed lots of IR58025A from BDD Los Baños had low genetic purity. Genetic purity of other parental lines ranged from 98 to 100%. All 75 seed lots of public hybrids evaluated had very high genetic purity.

Genetic purity of TGMS parental lines were also assessed using molecular markers. SSR (simple sequence repeats) molecular markers, RM 1 and RM511, detected impurities in the TGMS parental lines. Between these markers, RM1 detected more off-types in S-lines and RM511 for the pollen parent.

# Flowering Behavior and Pollen Dispersal, Row Ratio and Leaf Count Method for Synchronization of Flowering in Hybrid Seed Production of Promising and Newly Released Hybrids

*SR Brena*

Two separate experimental hybrid seed production plots, AxR for Mestiso 55 and SxP seed production of Mestiso 73, were established at CES. Good synchronization was achieved in M55 based on 1.0 leaf-difference in leaf count. This leaf count difference was equivalent to six days seeding interval for M55 to obtain synchronized flowering under Nueva Ecija condition. Two sets of M55 AxR plots were established: set A had the row-ratio of 2:6, 2:9, 2:12, and 2:15, and set B had 2:6 and 2:12. The flowering synchronization was achieved in set A and in the row ratio used in set B. Plot seed yield was highest in 2:12 with actual yield (10,133.8g), plot yield (1,137.7g), and seed yield (158g/$m^2$) but in terms of percent seed set 2:6 row ratio had the highest (32.55%).

In SxP plots, flowering behavior of parental lines (Figure 7) and the pollen dispersal from the male parent, SN758, during pollination were assessed using six row ratios (2:8; 2:10; 2:12; 3:8; 3:10; and 3:12). In each row ratio, wooden laths were installed in three different heights (95cm, 85cm, and 75cm). During pollination, microscope slides coated with petroleum jelly were placed on top of the wooden laths per row of S-lines. All slides were collected after each pollination period from 9AM and were replaced with new slides every hour until 11AM which was the peak of anthesis. Collected slides were evaluated for pollen count under the microscope. In DS, regardless of slide position in the wooden lath and time of collection, pollen load was highest in 3:8 row ratio. S-lines very near the pollen source had the highest pollen load which decreased as the S-lines moved farther from the pollen source. S-lines in the middle rows had the least pollen trapped. Although slides evaluation in WS were those collected at 9AM only during pollination day 1, the same trend was noted where pollen load was highest in 3:8 row ratio.


*Figure 7. Flowering opening of M73 parental lines documented in WS SxP trial*

## Staggered Planting of TGMS Lines in MFE Sites for Increased Seed Yield and Seed Quality

*MO Palanog and SR Brena*

Maximizing seed yield of parental seed production can help in attaining hybrid seed requirement of the country. However, it is empirical that yield-limiting factors should be addressed in order to optimize the parental seed production. Timing of planting that coincides with favorable climatic conditions particularly temperature and appropriate nutrient management are crucial factors to consider in optimizing seed production yield MFE. A field experiment was conducted to determine the appropriate planting schedule(s) and nitrogen levels and timing of application to ensure optimum grain yield of S-line parentals. In the initial staggered planting of TGMS lines in MFE, results showed that grain yield was very low, ranging from 4.27 to 381.61kg/ha, across eighteen planting dates (Figure 8). The low yield performance could possibly be attributed to low relative humidity, limited irrigation water, and high temperature during the critical stages of the rice plant resulting in low spikelet fertility. The highest spikelet fertility was achieved in early (P18) and mid-November (P19) planting. Highest grain yield was observed in mid-November planting since it coincided with 25˚C average temperature and 81% relative humidity. Among the planting dates, mid-November planting (P19) consistently obtained the highest grain yield. Analysis of variance showed highly significant interaction of planting dates and N-levels.

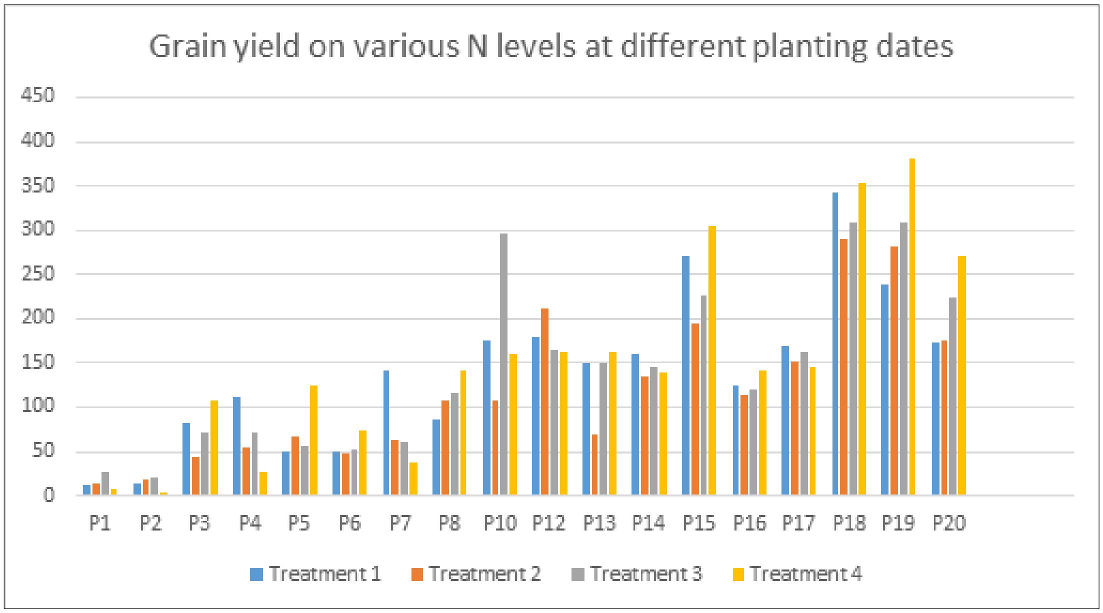


*Figure 8. Grain yield performance across planting dates applied with varying N-levels*

## Assessing Seed Quality, Purity, and Genetic Identity of Hybrid Parental Lines of Public Released Hybrid Produced at PhilRice

*Kathleen Kaye S. Delos Angeles and Susan R. Brena*

The full potential of hybrid seeds can be exploited only if the seeds are genetically pure. Genetic purity of hybrid parental lines produced by PhilRice was assessed through the conventional grow out test (GOT) before distribution for commercial seed production by the hybrid seed growers. Plants were grown up to maturity to identify off-types by assessing several morphological characteristics such as base color, leaf color, heading date, and grain size and shape. This study evaluated the genetic purity of various parental lines produced in both DS and WS 2019. In 2019, 14 and 13 seed lots of parental lines were planted in GOT in DS and WS, respectively. In DS, 13 Mestizo 1 and 62 Mestiso 20 seed lots were evaluated and resulted to >97% genetic purity. Except for one seed lot of IR58025A and one seed lot of PRUPTG102 in WS2019, all other seed lots of parental lines had >97% genetic purity. All seed lots came from the same samples submitted for seed certification in BPI-NSQCS.

## Utilization of SSR Markers for Seed Purity Testing in TGMS Hybrids of Mestiso 19 and Mestiso 20

*KKS Delos Angeles and SR Brena*

Impurity in seeds can lead to yield reduction. Thus, it is necessary to plant genetically pure seeds to achieve uniform crop stand in the field. In 2019, parental lines produced from Los Baños, Midsayap, Negros, and CES were assessed using microsatellite markers. Leaf samples used in DNA extraction were sampled in the grow out test (GOT) matrix. Off-types were identified based on markers RM 1 and RM 511. Fourteen seed lots of parental lines (PRUP TG102 and TG 102M) tested were produced in WS 2018 and six were produced in DS 2019. Twelve seed lots of PRUP TG102 produced from Negros had an average purity of 99.1% while two seed lots of TG 102M had average purity of 99.80% (Table 11).

*Table 11. Comparison of purity in grow out test and using SSR markers in 2019 DS and WS*

| Season | Parentals | Seed Class | No. of Seed Lots | Method of Amount | |
|---|---|---|---|---|---|
| | | | | GOT | SSR Marker |
| DS | PRUP TG102 | FS | 12 | 99.5 | 99.0 |
| | TG 102M | FS | 2 | 99.3 | 98.9 |
| WS | PRUP TG102 | FS | 5 | 96.5 | 96.2 |
| | SN 758 | FS | 1 | 99.9 | 100 |

PROJECT 4

# Screening of CMS and TGMS Parentals, Breeding Lines, and Promising Hybrids for Grain Quality and Resistance to Major Insect Pests and Diseases

*GS Rillon (CES) and EE Sajise (Los Baños)*

One of the objectives of the HRP is to breed good performing parents and highly marketable CMS and TGMS public hybrids that will increase both the yield and income of farmers. To achieve this, improvement should focus on grain yield, $F_1$ seed yield, grain quality, and disease and insect resistance. Breeding is considered efficient when early screening is conducted particularly for pest resistance and grain quality as materials of poor grain quality and susceptible to major pests are discarded at earlier stages of breeding. Hence, evaluation at later generations are for materials with higher chances of passing the NCT, and released as good public hybrid variety. While grain yield is directly affected by the susceptibility of a variety to major pests, its marketability is influenced by grain quality because varieties with poor grain and cooked rice quality are less likely preferred by consumers. Hence, the project aimed to evaluate CMS and TGMS parentals and promising hybrids for grain quality and resistance to major pests. Only the identified CMS and TGMS parentals and promising hybrids with acceptable grain quality, and resistance to major pests were used in the breeding program. To facilitate efficient evaluation of entries, the Project was grouped into two: CMS-based entries were evaluated in PhilRice CES while TGMS entries were handled by PhilRice Los Baños and UPLB. Both groups conducted grain quality evaluation, and insect pest and disease resistance evaluation.

For the evaluation of CMS parentals, breeding lines and promising hybrids, 160 usable CMS-based parentals (B and R lines) and 146 promising hybrids were screened in 2019 for milling potentials, physical attributes, physicochemical properties, and sensory quality. Nineteen entries in the CMS breeding nurseries were identified to have good to excellent grain quality. On the other hand, 372 lines in the CMS-based breeding nurseries and promising hybrids were evaluated for resistance to major insect pest and diseases in four PhilRice stations using the induced and modified field methods. For two-season evaluation, 25 CMS parental lines expressed resistances to pests and diseases in different experimental sites. These parental hybrid lines showed most number of resistances to pests and diseases across sites. Combining the results of grain quality evaluation, and reactions to major insect pests and diseases, only two restorer lines (AYT-5 and PYT-94) were noted to have intermediate to resistant reactions to blast, BLB and stemborers, and at same time had good to excellent grain and eating quality.

For the screening of TGMS parentals (S and P lines), breeding lines and promising hybrids, 707 entries were evaluated for physicochemical properties (amylose content or AC, gelatinization temperature or GT) while 12 promising hybrids were tested for milling potential, physical attributes, and physicochemical properties. Majority (84%) of the 707 samples tested were classified under Clusters 1 and 2 for AC-GT scores indicating good eating quality. On the other hand, five (42%) of the 12 promising entries passed the NCT standards for physicochemical properties and milling potential. Reactions of 218 TGMS parentals (S and P lines) to major insect pest and diseases were likewise evaluated using the induced method. Results showed that all tested entries were susceptible to the rice tungro virus (RTV). Nevertheless, two entries showed moderately resistant to resistant reactions to all major insect pests and diseases rated for the year. Excluding reactions to rice tungro virus, combined evaluation results for TGMS breeding materials identified two elite pollen parents (PS17 and 19) to have good eating quality and have moderate resistance to resistance to major insect pest and diseases.

## Screening of CMS Parentals, Breeding Lines, and Promising Hybrids for Grain Quality

*EH Bandonill, JCA Cacerez, LC Castillo, OC Soco, FP Waing, and JD Caguiat*

To identify CMS parentals, breeding lines, and promising hybrids with acceptable grain quality, 86 usable CMS-based parentals (CBP) and 40 promising hybrids were screened in 2018 WS and 80 CBP (34 restorer and 46 maintainer lines) and 109 promising hybrids in 2019 DS. Entries were evaluated for milling potentials, physical attributes, physicochemical properties, and sensory quality. In 2018 WS, 95% (82 entries) had Fair brown rice (BR) and Grade 1 to Premium milled rice (MR), while 50% (43 entries) had Grade 1 to Premium head rice (HR). Of the entries, 34% (29 entries) had Grade 1 to Premium chalky grains (CG) and 87% (75 entries) were long and slender. Nineteen percent (16 entries) had low AC/low to intermediate/high intermediate GT combination and 31% (27 entries) with intermediate AC/intermediate/high intermediate GT. Only 5% (4 entries) had high AC/low GT which indicates hard texture when cooked. The 40 promising hybrid entries had slightly glossy to glossy, slightly cohesive to cohesive, and slightly tender to tender texture of cooked rice. Additionally, four entries were described to be slightly aromatic (PR49B, IR79128B) to aromatic (PR36246HY-1-19-2-2R, PR24B), and slightly tasty. In 2019 DS, 58% (33 restorer; 14 maintainer) had Fair to Good BR while 82% (34 restorer; 31 maintainer) had Grade 1 to Premium milled rice while only 9% (7 entries) had Grade 1 head rice recovery (Table 12). For chalky grains, 10% (8 restorer) were classified as Grade 1 to Premium while majority (56%) had intermediate AC/intermediate to high intermediate GT (23 restorer; 22 maintainer) combination. Six and 13 entries had good to excellent grain quality in 2018 WS and 2019 DS, respectively (Table 13).

*Table 12. Summary of milling potentials of usable CMS-based parental lines and hybrids in 2019 DS*

| Classification | Milling Potentials | | | | | |
|---|---|---|---|---|---|---|
| | % Brown Rice | | % Milled Rice | | % Head Rice | |
| | Restorer | Maintainer | Restorer | Maintainer | Restorer | Maintainer |
| Good | | 1 | | | | |
| Fair | 33 | 13 | | | | |
| Poor | 1 | 32 | | | | |
| Premium | | | 12 | 0 | | |
| Grade 1 | | | 22 | 31 | 7 | 0 |
| Grade 2 | | | 0 | 14 | 14 | 2 |
| Grade 3 | | | 0 | 1 | 13 | 13 |
| Below Grade 3 (aa) | | | | | 0 | 31 |
| **Total** | **34** | **46** | **34** | **46** | **34** | **46** |

*Table 13. Grain quality characteristics of promising usable CMS-based parental lines and hybrids in 2018 WS and 2019 DS*

| Line Designation | % Total Milled Rice | | % Head Rice | | % Chalky Grain | | Amylose Content | | Gelatinization Temperature | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2018 WS | | | | | | | | | | |
| PR34302R | 70.7 | Pr | 63.3 | Pr | 2.7 | G1 | 20.2 | I | 6.8 | L |
| PR47795H | 71.4 | Pr | 62.8 | Pr | 3.9 | G1 | 18.2 | I | 5.8 | L/I |
| PR31559 - AR32 - 4 - 3 - 2R | 68 | G1 | 50.2 | G1 | 1.9 | Pr | 18.9 | I | 7 | L |
| IR73013R | 70.6 | Pr | 64.2 | Pr | 3 | G1 | 18.1 | I | 4.1 | I/HI |
| PR48800H | 74.1 | Pr | 59.7 | Pr | 4.5 | G1 | 21 | I | 4.7 | I |
| PR47207HY - seed mut - 32 | 70.9 | Pr | 59 | Pr | 3 | G1 | 21.9 | I | 6.9 | L |
| 2019 DS | | | | | | | | | | |
| PR51848-G124-2-6-2 | 70.6 | Pr | 54.1 | G1 | 5.2 | G2 | 20.5 | I | 3 | HI |
| PR51848-G124-2-5-3 | 69.6 | G1 | 48.8 | G1 | 8 | G2 | 20.7 | I | 3.3 | HI |
| PR51842-G107-2-1-3 | 70 | G1 | 47 | G2 | 4.2 | G1 | 19.8 | I | 3.3 | HI/I |
| PR51844-G115-1-1-3 | 71.6 | Pr | 49.5 | G1 | 7.1 | G2 | 18 | I | 6 | L |
| PR51848-G124-2-1-3 | 70.4 | Pr | 43.5 | G2 | 5 | G1 | 20.9 | I | 3.6 | HI/I |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PR 47721HY-B-1205-469-363-1 | 68.2 | G1 | 44.7 | G2 | 8.4 | G2 | 20.3 | I | 3.4 | HI/I |
| PR51858-G139-1-1-2 | 69.3 | G1 | 43.3 | G2 | 5.9 | G2 | 19.6 | I | 4.7 | I |
| PR51857-G138-3-1-1 | 70.1 | Pr | 45.7 | G2 | 2.2 | G1 | 21.3 | I | 3.8 | HI/I |
| PR51842-G107-2-1-1 | 70.3 | Pr | 50.5 | G1 | 8 | G2 | 19.9 | I | 3.8 | HI/I |
| PR51848-G124-2-5-1 | 69.1 | G1 | 44.5 | G2 | 7.7 | G2 | 20.7 | I | 4.4 | I/HI |
| PR51832-G087-1-1-3 | 67.5 | G1 | 51.2 | G1 | 0.6 | Pr | 14.9 | L | 5 | I |
| PR51839-G102-3-1-2 | 68.5 | G1 | 40.1 | G2 | 8.4 | G2 | 22.5 | H | 5 | I |
| PR51848-G124-2-4-3 | 71 | Pr | 44.8 | G2 | 4.4 | G1 | 20.9 | I | 5 | I |

## Grain Quality Evaluation of TGMS Parentals, Breeding Lines, and Promising Hybrids

*AQ Jumawan (January 2018 – July 31, 2019), AKM Bagunu (starting August 1, 2019), AdR Felix, EE Sajise, and MAT Talavera*

This study aimed to evaluate the grain quality of TGMS parentals, breeding lines, and promising hybrids following the NCT method of grain quality evaluation. In 2019, 707 entries from nine different nurseries were evaluated for AC and GT. Majority (84%) of the parentals and breeding lines evaluated were clustered to soft/tender to moderately tender cooked rice which will most likely be used to develop hybrid rice varieties (Table 14). Of the samples, 502 (71%) had intermediate AC while 134 (19%) had high AC. Three out of four entries exhibited intermediate GT. Twelve promising hybrids from HPYT and AYT were also evaluated for milling potential, with all samples passing the NCT standards for acceptable milling recovery of brown rice, total milled rice, and head rice. Of the 12 promising hybrids, elite hybrids AYT 189 and 191 were further evaluated for physical and physicochemical attributes. Both had long and slender grains and soft/tender texture cooked rice. AYT 189 had low AC-intermediate GT while AYT 191 had intermediate AC and GT. Hence, these elite hybrids have the potential to advance in the development of hybrid rice varieties.

*Table 14. Combination of AC and GT types of 707 submitted parentals and breeding lines evaluated during 2019 DS and WS*

| AC Type | GT Type | | | | |
|---|---|---|---|---|---|
| | **Low** | **Intermediate** | **High-Intermediate** | **High** | **Total (AC)** |
| Waxy | | | | | |
| Very Low | 2 | 1 | | | 3 |
| Low | 12 (1)* | 47 | 8 | 1 | 68 |
| Intermediate | 16 (2)* | 388 (1)* | 81 (1)* | 17 | 502 |
| High | 39 (3&4)* | 95 (2)* | | | 134 |
| **Total (GT)** | **69** | **531** | **89** | **18** | **707** |

**Cluster number for nonwaxy rice in parentheses*
*1-soft cluster, 2-intermediate/medium texture, 3&4-hard texture*
*AC-amylose content, GT-Gelatinization temperature*

## Evaluation of CMS Parentals, Breeding Lines, and Promising Hybrids for Resistance to Major Insect Pests and Diseases

*SE Santiago, GS Rillon, JP Rillon, FP Waing (PhilRice CES), GB Amar (PhilRice Isabela), IV Boholano (PhilRice Midsayap), CU Seville (PhilRice Negros), KMB Guarin, ZFT Lunag, RM Marcos, CJE Parina, CCB Encarnacion, and JIIC Santiago (PhilRice CES)*

The study evaluated 372 CMS parentals, breeding lines, and promising hybrids for resistance to blast, bacterial leaf blight (BLB), sheath blight (ShB), tungro, stemborer, brown planthopper (BPH), and green leafhopper (GLH) in PhilRice stations: CES, Midsayap, Isabela, and Negros. In the DS, of the 178 hybrid rice lines evaluated, 79 and 72 entries showed resistance to blast in CES and Midsayap, respectively (Figure 9). For BLB evaluation, 57 resistant hybrid lines were recorded in Isabela, and 42 entries had intermediate reaction and 135 entries susceptible to the disease at CES. Thirty hybrid entries exhibited resistance to sheath blight disease in Isabela while none was noted resistant in CES. All entries were susceptible to tungro under induced method of evaluation in CES. However, no tungro disease pressure was observed under modified field method in all sites. During the wet season (WS), blast resistance was observed in 108 hybrid entries in CES and 109 entries in Isabela (Figure 10). BLB evaluation showed 30 and 53 resistant entries in CES and Isabela, respectively while 40 entries showed resistance to sheath blight at CES. All hybrid test entries exhibited susceptibility to the tungro disease under induced method.

But for tungro evaluation under modified field method, 11 hybrid entries had intermediate reaction and 175 entries were susceptible to the disease in PhilRice Negros. Evaluation of resistance against stemborer damage was also conducted (Figure 11) with 170 lines found resistant to deadheart at 55 DAT in DS at CES. For whitehead evaluation, 13 entries in CES and three hybrid entries in Isabela had resistant reaction with low stemborer damage observed in PhilRice CES and Isabela during WS. In DS, none of the test entries showed resistance to BPH and GLH at CES. For BPH during WS, 67 hybrid entries had intermediate reaction while 125 rice entries were susceptible. For GLH resistance screening, all hybrid entries evaluated were susceptible.

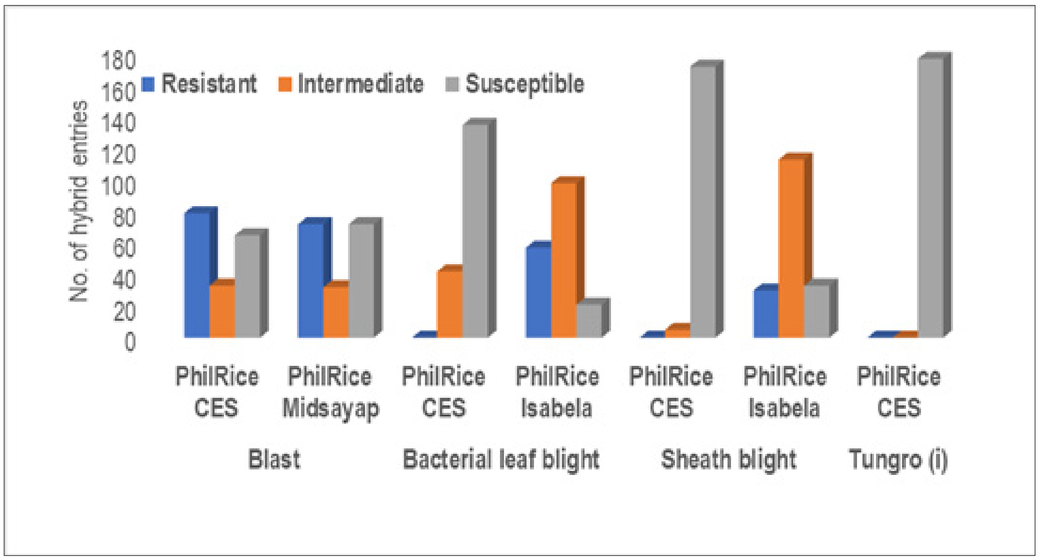


*Figure 9. Reactions of hybrid lines to major rice diseases at PhilRice CES, Midsayap, and Isabela during the 2019 DS*

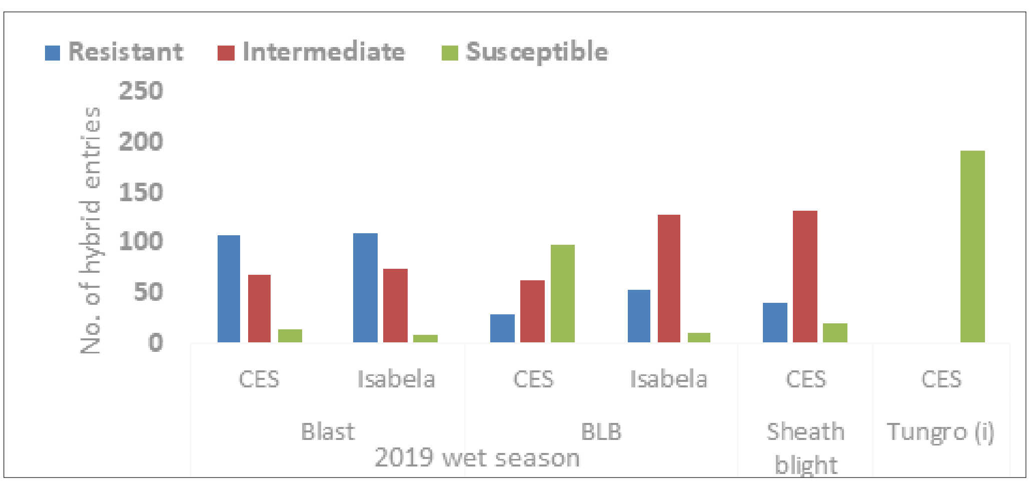


*Figure 10. Reactions of hybrid lines to major rice diseases at PhilRice CES and Isabela during the 2019 WS*

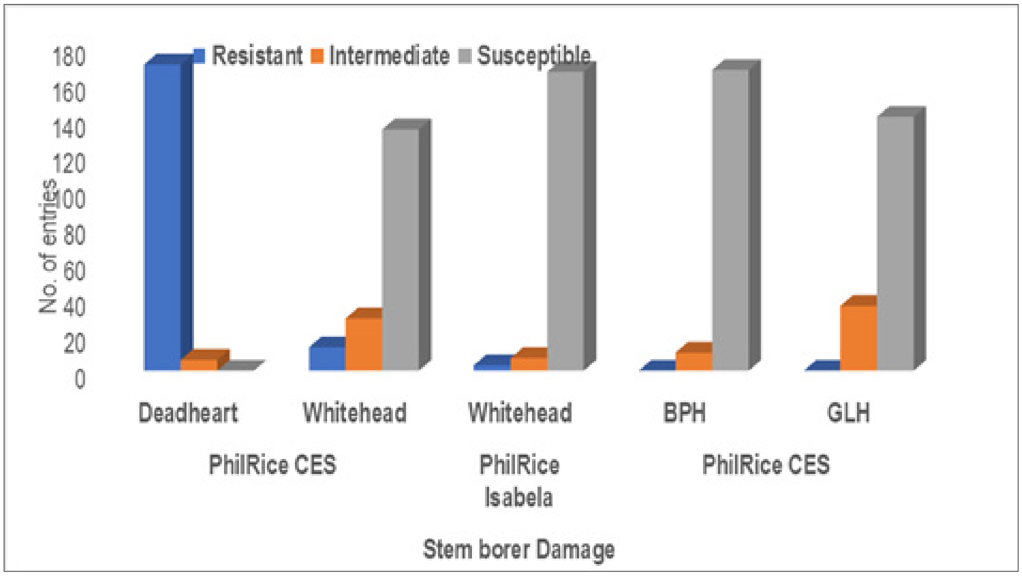


*Figure 11. Reactions of hybrid lines to major rice insect pests atPhilRice CES and Isabela during the 2019 DS*

## Evaluation of TGMS Parentals, Breeding Lines, and Promising Hybrids for Resistance to Major Insect Pests

*EA Magsino (UPLB), KAS Domingo, IJG Zara, FJ Carandang, and R Lopez*

This study aimed to characterize TGMS lines, pollen parents (PS), and TGMS-based experimental hybrids on their resistance to major insect pests. More than 200 PS and TGMS materials were evaluated for their resistance to field populations of stemborers and greenhouse cultures of GLH and BPH in DS and WS 2019 insect screening trial. There were 3,806 entries in the hybridization/yield trials screened for stemborer resistance under field condition. Methodologies followed the Insect Screening Protocol of the NCT for Rice. From 217 entries evaluated under the insect screening trial, the following number of entries were found resistant and moderately resistant: 158 (73%) for GLH, 47 (22%) for BPH, and 78 (36%) for stemborer (Table 15). Partial results in the hybridization/yield trial showed that 1,103 (29%) entries were observed for their resistance to stemborer under field condition (Table 16).

*Table 15. Number of entries evaluated against field population of stemborer and greenhouse cultures of green leafhopper and brown planthopper in the different nurseries under the insect screening trial, 2019, UPLB*

| | **Number of entries evaluated** | **Number of entries under the different resistance categories** | | | | |
|---|---|---|---|---|---|---|
| | | **R** | **MR** | **I** | **MS** | **S** |
| **Dry Season 2019** | | | | | | |
| PS | 79 | | | | | |
| Stemborers (Whiteheads)* | | 61 | 17 | 1 | 0 | 0 |
| GLH | | 4 | 39 | 25 | 7 | 4 |
| BPH | | 6 | 38 | 24 | 7 | 4 |
| | | | | | | |
| **Wet Season 2019** | | | | | | |
| PS | 121 | | | | | |
| Stemborers (Whiteheads)*/** | | | | | | |
| GLH | | 43 | 63 | 14 | 1 | 0 |
| BPH*** | | | | | | |
| | | | | | | |
| TGMS | 17 | | | | | |
| Stemborers (Whiteheads)*/** | | | | | | |
| GLH | | 0 | 9 | 8 | 0 | 0 |
| BPH | | 0 | 3 | 6 | 8 | 0 |
| **TOTAL** | **217** | **114** | **169** | **78** | **23** | **8** |

*Table 16. Number of entries evaluated against field population of stemborer in the different nurseries under the hybridization and yield trials, 2019, UPLB*

| Nurseries | Number of entries evaluated | Number of entries under the different resistance categories | | | | |
|---|---|---|---|---|---|---|
| | | R | MR | I | MS | S |
| Dry Season 2019 | | | | | | |
| TG3* | 273 | 195 | 46 | 19 | 10 | 3 |
| TG4* | 157 | 114 | 27 | 9 | 7 | 0 |
| TG5** | 51 | | | | | |
| TG6** | 10 | | | | | |
| TGON** | 47 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| RTG2* | 377 | 313 | 54 | 8 | 1 | 1 |
| RTG3* | 179 | 122 | 43 | 12 | 2 | 0 |
| RTG5** | 51 | | | | | |
| RPP6** | 39 | | | | | |
| PUR** | 26 | | | | | |
| GMS** | 60 | | | | | |
| **SUBTOTAL** | **1,270** | **744** | **170** | **48** | **20** | **4** |
| | | | | | | |
| **Wet Season 2019** | | | | | | |
| TG ON* | 26 | 23 | 3 | 0 | 0 | 0 |
| TG6* | 133 | 112 | 14 | 5 | 2 | 0 |
| REC* | 38 | 34 | 3 | 1 | 0 | 0 |
| KOR 55** | 96 | | | | | |
| NC** | 65 | | | | | |
| HON** | 400 | | | | | |
| AYT** | 56 | | | | | |
| GL3** | 95 | | | | | |
| HTG*** | 46 | | | | | |
| IR*** | 270 | | | | | |
| EES*** | 300 | | | | | |
| RPP5*** | 181 | | | | | |
| RPP6*** | 12 | | | | | |
| RPP7*** | 5 | | | | | |
| TGMS*** | 22 | | | | | |
| TG5*** | 36 | | | | | |
| TG4*** | 211 | | | | | |
| GMS*** | 90 | | | | | |
| PUR*** | 160 | | | | | |
| RSON*** | 56 | | | | | |
| HPYT** | 144 | | | | | |
| PPYT*** | 72 | | | | | |
| TGMS & TGMSON*** | 22 | | | | | |
| SUBTOTAL | 2,536 | 169 | 20 | 6 | 2 | 0 |
| TOTAL | 3,806 | 913 | 190 | 54 | 22 | 4 |
| REC* | 38 | 34 | 3 | 1 | 0 | 0 |
| KOR 55** | 96 | | | | | |
| NC** | 65 | | | | | |
| HON** | 400 | | | | | |
| AYT** | 56 | | | | | |
| GL3** | 95 | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| HTG*** | 46 | | | | | |
| IR*** | 270 | | | | | |
| EES*** | 300 | | | | | |
| RPP5*** | 181 | | | | | |
| RPP6*** | 12 | | | | | |
| RPP7*** | 5 | | | | | |
| TGMS*** | 22 | | | | | |
| TG5*** | 36 | | | | | |
| TG4*** | 211 | | | | | |
| GMS*** | 90 | | | | | |
| PUR*** | 160 | | | | | |
| RSON*** | 56 | | | | | |
| HPYT** | 144 | | | | | |
| PPYT*** | 72 | | | | | |
| TGMS & TGMSON*** | 22 | | | | | |
| **SUBTOTAL** | **2,536** | **169** | **20** | **6** | **2** | **0** |
| **TOTAL** | **3,806** | **913** | **190** | **54** | **22** | **4** |

## Evaluation of TGMS Parentals, Breeding Lines, and Promising Hybrids for Resistance to Major Diseases

*BO Budot, RD Saavedra, and GM Diamante*

This study aimed to evaluate TGMS parental lines and promising hybrids with resistance to major rice diseases. Two hundred eighteen pollen parents, comprised of 80 entries during 2019 DS and 138 entries during 2019 WS, were evaluated for their reaction to blast, ShB, BLB, and tungro under the induced method (Table 17). Additional 2,908 entries, comprised of 1,835 entries during 2019 DS and 1,073 during 2019 WS, were also evaluated under natural infection in the field (Figures 12-13). Evaluation results showed that under the induced method, 12 entries were resistant to blast, 71 and 78 entries were intermediate to ShB and BLB, respectively. All entries were susceptible to RTD. Under natural infection in the DS, majority of experimental hybrids evaluated showed intermediate reaction to ShB, BLB, and RTD. For breeding lines and TGMS parentals, majority were susceptible to ShB and RTD while intermediate for BLB. On the other hand, during the 2019 WS, majority of experimental hybrids were resistant to ShB, RTD, and other diseases such as Brown Spot (BS), Sheath Rot (ShR), and Bacterial Leaf Streak (BLS). For breeding lines and TGMS parentals, majority showed resistant reaction to ShB and BLB while intermediate for RTD and ShR.

*Table 17. Number of entries evaluated with resistant, intermediate, and susceptible reactions of major rice diseases under the induced method of evaluation during the 2019 DS*

| Entries | | 2019 DS | | | | | | | | | | | | 2019 WS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Disease Reaction | B | | | ShB | | | BLB | | | RTV | | | B | | | ShB | | | BLB | | | RTV | | |
| | | R | I | S | R | I | S | R | I | S | R | I | S | R | I | S | R | I | S | R | I | S | R | I | S |
| | | 5 | 9 | 66 | 5 | 4 | 31 | 1 | 58 | 21 | 0 | 0 | 80 | 11 | 18 | 92 | 0 | 71 | 50 | 0 | 78 | 43 | 0 | 0 | 121 |
| PS | | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 |
| TGMS | | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 2 | 12 | 0 | 7 | 7 | 0 | 7 | 7 | 0 | 0 | 14 |
| TGMS ON | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | 5 | 9 | 66 | 5 | 4 | 31 | 1 | 58 | 21 | 0 | 0 | 80 | 11 | 20 | 107 | 0 | 78 | 60 | 0 | 85 | 53 | 0 | 0 | 138 |
| Total | | | | | | | | | | | | | | | | | | | | | | | | | |

*B- Blast, ShB-Sheath Blight, BLB-Bacterial Leaf Blight, RTV-Rice Tungro Virus*
*R- Resistant, I-Intermediate, S-Susceptible*
*- -sample not tested*

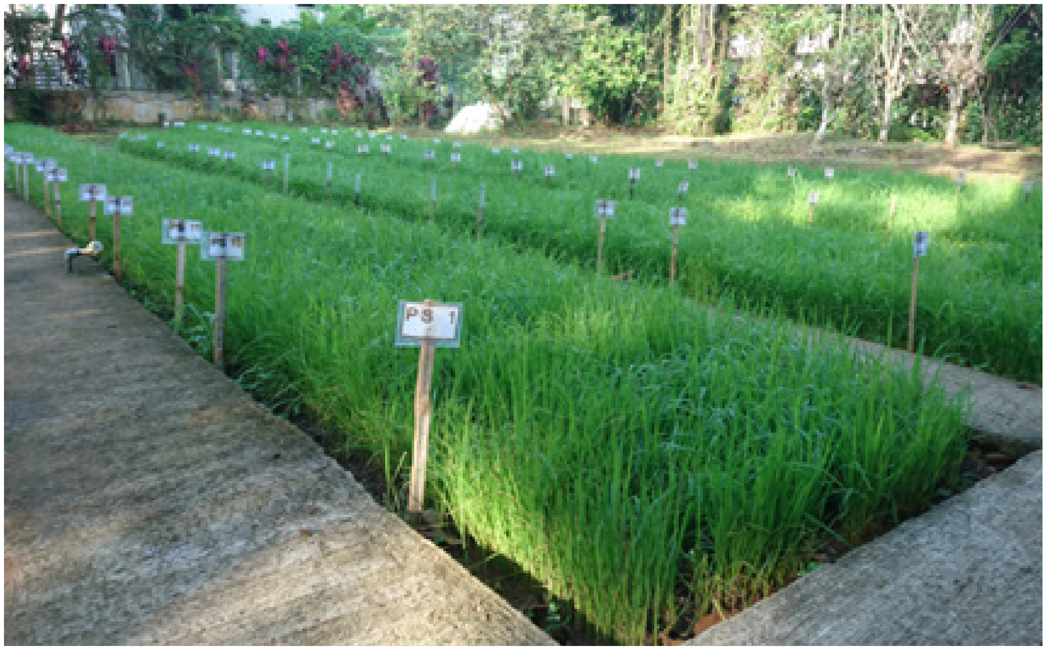


*Figure 12. Rice blast set-up during 2019 WS inside UPLB's blast nursery*

*Figure 13. Field data collection of bacterial leaf blight 14 days after inoculation (DAI).*

# Hybrid Nucleus and Breeder Seed Production Research and Maintenance

*Lowel V. Guittap*

The Project produced, supplied, and maintained basic seeds of released public hybrids in support of the Public Hybrid Rice Commercialization Project (PHRCP), breeding activities, and hybrid seed-related research. For several years, this project supplied the required breeder seeds to meet the national public hybrid cultivation target. Initial characterization and evaluation of seed reproducibility of promising hybrid parental lines and $F_1$ seeds were also performed. Basic seeds of released public hybrids were maintained for research-related purposes.

In 2019, Mestizo 1 (PSB Rc72H) and Mestiso 20 (NSIC Rc204H) parental lines were produced to supply the foundation seed (FS) requirements of the PHRCP. Breeder seeds of A/S-line and R/P-line produced were 988 kg and 250 kg, respectively, enough to cover 60 ha of FS production. The project distributed 180 kg IR58025A (with corresponding B-line) and 210 kg PRUP TG102 BS to PhilRice Isabela, Negros, and Midsayap. Male parents were also provided for FS production.

For seed production research activities, four promising hybrids (two each CMS and TGMS) were characterized and evaluated for basic and $F_1$ seed production capacity. The parental lines of PR40640H, PR46838H, AYT 170, and PRUP 13 were characterized during the dry season (DS). Based on characterization data in 2018 WS and 2019 DS, PR46838H was replaced with PR47995H. Similarly, the TGMS breeding group also replaced PRUP 13 and AYT 170 with promising TGMS hybrids AYT 189 and AYT 191.

Availability of parental lines of released public hybrids was sustained. The project maintained 5kg seeds each of 30 genotypes, which were parental lines of 20 public hybrids, and were made available to breeders and researchers upon request.

## Hybrid Nucleus and Breeder Seed Production

*LV Guittap, WB Abonitalla, SR Brena, and EE Sajise*

The study supplied the required amount of breeder seeds (BS) of public hybrid parental lines of Mestizo 1 and Mestiso 20 to meet the national hybrid target. The activities of the study included purification, nucleus and BS production, and distribution of BS to supply the foundation seed (FS) requirements of the PHRCP. The purification of Mestizo 1 started with the generation of paired crosses. Of the 3,220 IR58025A plants evaluated during the year, 776 paired crosses were generated (Table 18). From this, 582 effective crosses or entries with at least 50 seeds were selected. Evaluation nurseries were established, and crosses generated from 2018 WS and 2019 DS were evaluated in 2019 DS and WS, respectively. The selected A-lines based on trueness, pollen sterility, and agro-morphological characteristics were the seed source for nucleus seed production. During the year, 49kg IR58025A nucleus seeds were produced and 60kg of PRUP TG102 nucleus seeds were produced at the MFE. The nucleus seeds produced were enough to plant 3ha of AxB and S-line BS production. BS of female parents of Mestizo 1 and Mestiso 20 produced was 988kg (Table 19). The restorer line and pollen parent were also established during DS with 150kg IR34686R and 100kg TG102M harvested. From January to October 2019, 390kg A/S-line and 60kg R/P-line were distributed to PhilRice Isabela, Negros, and Midsayap enough to plant 12ha of AxB and 10 ha S-line FS production (Table 20).

*Table 18. Number of IR58025A x B paired-cross generated in 2019*

| Season | No. of A-line plants evaluated | No. of CS A-line plants | No. of effective crosses |
|---|---|---|---|
| 2019 dry season | 1,460 | 246 | 229 |
| 2019 wet season | 1,760 | 530 | 353 |
| **Total** | **3,220** | **776** | **582** |

*Table 19. Amount of breeder seeds produced in 2019 DS*

| Line/variety | Amount produced (kg) | | Total |
|---|---|---|---|
| | Dry season | Wet season | |
| Mestizo 1 | | | |
| IR58025A | 432 | 181 | **613** |
| IR58025B | 414 | 57 | **473** |
| IR34686R | 150 | - | **150** |
| Mestiso 20 | | | |
| PRUP TG102 | 195 | 180 | **375** |
| TG102M | 100 | - | **100** |

*Table 20. Amount of Mestizo 1 and Mestiso 20 parental lines distributed to PhilRice stations for foundation seed production from January to October 2019*

| Line/variety | Amount (kg) | | | Total |
|---|---|---|---|---|
| | Isabela | Midsayap | Negros | |
| Mestizo 1 | | | | |
| IR58025A | 150 | 30 | - | **180** |
| IR58025B | 60 | 12 | - | **72** |
| IR34686R | 10 | 20 | - | **30** |
| Mestiso 20 | | | | |
| PRUP TG102 | 150 | 45 | 15 | **210** |
| TG102M | 10 | 20 | - | **30** |

## Characterization of Promising Hybrid Parental Lines

*LV Guittap, WB Abonitalla, MAT Talavera, and LV Gramaje*

The study characterized promising hybrid parental lines to determine the important characteristics of parental lines and seed reproducibility of basic and $F_1$ hybrid seed production. Four promising hybrids: PR40640H, PR46838H, PRUP 13, and AYT 170 were included in the study. The parental lines of PR40640H evaluated in the DS were PR29A, PR29B, and 19R56. The days to 50% flowering (DTH) of the A- and B-lines were 85 and 83 days, respectively while the DTH of the restorer line was 86 days. For the AxB seed production, the A-line should be established two days earlier. For PR46838H, a difference of four days in the DTH of IR80559A and B was observed. The recorded DTH of the restorer line PR34302R was 86 days, similar to the A-line. For TGMS-based hybrids, parental lines of PRUP 13 (PRUP TG102 and SN 821) and AYT 170 (RPP6 82 and TG103M) were characterized in the DS. Recorded DTH for RPP6 82 was 92 days while TG103M was observed to be 90 days. On the other hand, DTH of PRUP TG102 was 102 days while the pollen parent SN 821 was 103 days. In terms of plant height, pollen parent TG103M was taller than the S-line RPP6 82. A taller P-line plant was also observed from the parental lines of PRUP 13. The height advantage of male parents relative to S-line was at least 10cm, which was very ideal in $F_1$ seed production. PR29AxB obtained a yield of 600kg/ha. The AxB seed production for IR80559AxB was discarded owing to high percentage of off-types in the seeds provided. The S-line seed yield at the MFE for PRUP TG102 was 2,000kg/ha. Based on gathered information from the characterization study, the CMS breeding group recommended to replace PR46838H with PR47995H. Similarly, the TGMS breeding group suggested replacing PRUP 13 and AYT 170 with promising TGMS hybrids AYT 189 and AYT 191.

## Fertility/Sterility Stability Evaluation of TGMS and CMS Parents of Promising Hybrids

*WB Abonitalla, LV Guittap, MAT Talavera, and LV Gramaje*

Female parents of promising hybrids, namely: PR29A (PR40640H), IR80559A (PR40640H), and PRUP TG102 (PRUP 13) were evaluated for fertility/sterility stability during the year. Evaluation for the stability of promising CMS-lines PR29A and IR80559A started in 2018 WS. For PR29A, seed set from the selected 81 completely sterile (CS), 29 sterile (S), and 45 partially sterile (PS) plants were planted in the DS. During the evaluation, seed sets were observed in 44 of 81 completely sterile plants, 12 of 29 sterile plants, and 21 of 45 partially sterile plants. However, owing to the reported issue on purity of the seed samples, the activity for this CMS-line was discontinued. Same case was reported for IR80559A. For the monthly planting of PRUP TG102 (Figure 14) from June 2018 to August 2019 in Los Baños, initial results showed that the highest percentage of seed set and pollen fertility were observed in S-line plants planted in December. Seed set was also observed in S-line plants established in October and January. Monthly planting of the S-line of AYT 170 is on-going. Blooming habits such as time and duration of anthesis and 50% days to heading were also recorded. Moreover, agro-morphological characteristics such as plant height, tiller number, and panicle length were also recorded.

*Figure 14. Monthly planting of S-line*

## Basic Seed Maintenance of Public Hybrid Parentals

*WB Abonitalla, LV Guittap, and AV Tandang*

The study maintained basic seeds of public hybrid parental lines for research purposes. There were 30 parental lines of 20 released public hybrids maintained during the year. At least 5kg each of the parental lines were stored in the cold storage facility of Los Baños (Figure 15) and maintained for the research activities of the program. From January to October 2019, 33.5kg of different parental lines were distributed to researchers in support to research activities (Table 21). As part of the objective to gather data useful in seed production, the dormancy period of eight parental lines of identified pre-commercial and commercial hybrid rice varieties were determined. This information will be very helpful especially in the seed certification and distribution activities. Dormancy period of IR58025A, IR68897A, and corresponding maintainer lines was seven days and 17 days for PRUP TG 102. Dormancy of restorer lines IR73013R and IR34686R was 20 and 30 days, respectively and 21 days for the pollen parent TG 102M.

*Table 21. Parental lines distributed for research purposes from January to October 2019*

| Line/Variety | Amount (kg) |
|---|---|
| IR58025B | 3.5 |
| IR34686R | 6.0 |
| TG102M | 6.0 |
| IR68897B | 6.0 |
| IR73013R | 6.0 |
| SN 758 | 6.0 |

*Figure 15. Parental lines of released public hybrids in cold storage (20-22°C)*

# Abbreviations and acronyms

AYT - Advanced Yield Trial
ABE - Agricultural and Biosystems Engineering
AEW - Agricultural Extension Worker
ATI – Agriculture Training Institute
AESA - Agro-ecosystem Analysis
AC - Amylose content
BLB - Bacterial leaf blight
BLS -Bacterial Leaf Streak
BCA - Biological Control Agent
BS - Breeder seeds
BPH -Brown Planthopper
BPI - Bureau of Plant Industry
CGMS - Cytoplasmic Genic Male sterility
COF - commercial organic fertilizer
CDA - Cooperative Development Authority
DAS - Days after sowing
DAT - Days after transplanting
DF - Days to flowering
DM- Days to maturity
DAR - Department of Agrarian Reform
DA-RFOs - Department of Agriculture-Regional Field Offices
DoF - Department of Finance
DOLE - Department of Labor and Employment
DTI - Department of Trade and Industry
DSR - Direct-seeded Rice
DS - Dry season
FBS – Farmers' Business School
FC - Farmers' cooperative
FSM - Farming Systems Models
FAA - Fish Amino Acid
FGD - Focused group discussion
FSP - Foundation seed production
FRK - Farm Record Keeping
GABA - Gamma-aminobutyric acid
GT - Gelatinization temperature
GAD - Gender and development
GYT  - General yield trial
GCA - Genetic combining ability
GIS - Geographic information system
GEMS - Germplasm Management System
GAS - Golden apple snail
GL - Grain length
GQ - Grain quality
GW - Grain weight
GY - Grain yield
GLH - Green leafhopper
GOT - Grow out test
HR - Head rice
HRA - Heat recovery attachment
HIPS – Highly-intensified production system
HQS - High-quality rice seeds
HON - Hybrid Observational Nursery
HPYT - Hybrid Preliminary Yield Trial
ICT - Information and communication technology
IEC - Information education communication
IBNM - Inorganic-based nutrient management
ICM - Integrated Crop Management
IPM - Integrated Pest Management
JICA - Japan International Cooperation Agency
IRRI - International Rice Research Institute
IA - Irrigators' Association
KP - Knowledge product
KSL - Knowledge sharing and learning
LCC - Leaf color chart
LFT - Local farmer technicians
LGU - Local Government Units
LPS - Low pressure steam-operated
SB - Stemborer
LE-CYPRO - Lowland ecotype Cyperus rotundus
MFE - Male Fertile Environment
MSE - Male Sterile Environment
MAS - Marker-assisted selection
MRL - Maximum root length
MR - Milled rice
MER - Minimum enclosing rectangle
MOET - Minus-One Element Technique
MC - Moisture content

MAT - Multi-Adaptation Trials
MCRTP - Multi-crop reduced till planter
MET - Multi-environment trial
MYT - Multi-location yield trial
NAAP - National Azolla Action Program
NCT - National Cooperative Test
NFA - National Food Authority
NRAM - National Rice Awareness Month
NSIC - National Seed Industry Council
NSQCS - National Seed Quality Control Services
N - Nitrogen
NBSP - Nucleus and Breeder Seed Production Project
NFGP - Number of filled grains panicle
ON - Observation Nursery
OSIS - One Stop Information Shop
OBNM - Organic-based nutrient management
PL - Panicle length
PW - Panicle weight
PVS - Participatory varietal selection
PWD - Person with disabilities
PhilMech - Philippine Center for Postharvest Development and Mechanization
PRISM - Philippine Rice Information System
PhilRice - Philippine Rice Research Institute
PSA - Philippine Statistics Authority
PTC - PhilRice Text Center
P - Phosphorus
PVS - Plant variety selection
K - Potassium
QTL - Quantitative trait loci
RCBD - Randomized Complete Block Design
RSP - Registered seed production
RBB - Rice black bug
RCEF - Rice Competitiveness Enhancement Fund
RCEP - Rice Competitiveness Enhancement Program
RCM - Rice Crop Manager
RHGEPS - Rice hull gasifier engine pump system
RPH - Rice planthoppers
RSTC - Rice Specialists' Training Course
RTV - Rice Tungro Virus
RBFHS - Rice-Based Farming Household Survey
KQ - Rigid kernel quality
SV - seedling vigor
ShB - Sheath Blight
ShR - Sheath Rot
SMS - Short messaging service
SNP - Single nucleotide polymorphism
SWRIP- Small Water Reservoir Irrigation Project
SRB - Stabilized rice bran
SUCs - State Universities and Colleges
SB - Stem borer
TESDA - Technical Education and Skills Development Authority
TDF - Technology demonstration farm
TRV - Traditional Rice Varieties
TOT - Training of trainers
TPR - Transplanted rice
URBFS - Upland rice-based farming
WS - Wet season
WCV - Wide compatibility variety
YSB - Yellow stemborer

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We are a government corporate entity (Classification E) under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding and cost-reducing technologies so farmers can produce enough rice for all Filipinos.

With a "Rice-Secure Philippines" vision, we want the Filipino rice farmers and the Philippine rice industry to be competitive through research for development in our central and seven branch stations, coordinating with a network that comprises 59 agencies strategically located nationwide.

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