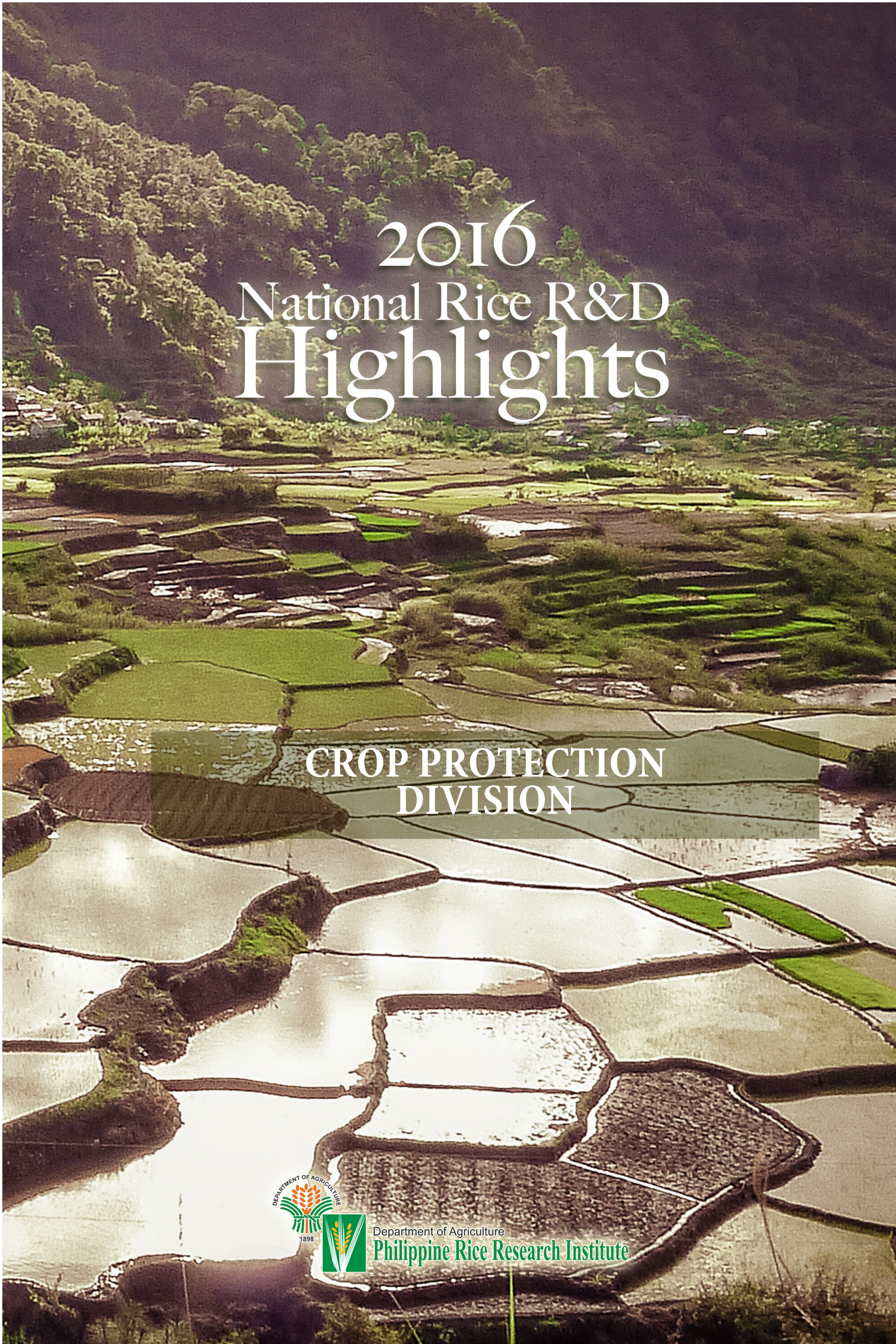

2016 National Rice R&D Highlights

CROP PROTECTION DIVISION

Department of Agriculture
Philippine Rice Research Institute

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Crop Protection Division

Division Head: Fe A. Dela Peña

Executive Summary

Research goal of the Crop Protection Division (CPD) focused on the development of technologies to help farmers improve their pest management decision-making towards rice self sufficiency. CPD generated information for the development of safe, economical, environment-friendly and sustainable pest management technologies.

The four division-based projects to address the above goal are the 1) Ecological Engineering Towards a Sustainable Integrated Pest Management (IPM) Program in Rice and Rice-based Farming System, 2) Screening of Rice Materials for Insect Pest and Disease Resistance, 3) Biology and Ecology of Pest, and 4) Evaluation and Optimization of Fossil Fuel-Free-Rice Pest Strategies and Techniques. These projects will contribute to the development of sound pest management strategies and eventually identify the risk factors in rice production.

Ecological engineering is a human activity that modifies the environment according to ecological principles. It is useful to consider the practice of habitat manipulation for arthropod pest management. Rice fields surrounded by flowering weeds had higher population of parasitoids and predators than in farmers' fields. The opposite was recorded on the population of herbivores (mostly plant hoppers and leafhoppers). Results indicated the high population of these beneficial organisms and arthropod species richness in the ecological engineering field as compared to farmers' fields.

Host plant resistance is the simplest and most practical pest management strategy. It is also compatible with other management strategies like biological control. There is a continued collaboration between our crop protection specialists and plant breeders in the screening of lines for resistance to major rice diseases and insect pests which will eventually be released as resistant varieties.

Pest management options of certain pests are usually based on its biology because control measures will be effective when applied at vulnerable stage of the pest. The study on rice grain bug revealed that it is attracted to light just like any other insect. There was a fluctuation in its population from January to June which peaked at the mature stage of the rice crop and even after harvest.

Blast caused by Magnaporthe grisea [Herbert] Barr., is one of the most important diseases of rice worldwide. Based on the preliminary analysis

on the morphological and cultural characteristics of M. grisea isolates in the laboratory this season, there were different growth patterns observed. Such instability revealed a significant assessment on variations among isolates as partitioned in space.

Yellow stemborer is a widely distributed, dominant and monophagous rice pest. Regular monitoring of pest incidence is useful to determine insect activity in relation to weather. It also helps in the study of population dynamics of other insects at a particular period. The peak of population was observed on April 12, 2016 with NSIC Rc292 having the most number of eggs at 5 egg masses/sqm. Other insect pests (brown planthopper, zigzag planthopper, green leafhopper and whitebacked planthopper) were also monitored.

Weedy rice is an upcoming threat to rice production in the Philippines. There were eight different biotypes observed and collected from North Cotabato and Sultan Kudarat. The most common weedy rice biotypes recorded were characterized either as long awned or awnless and no purple coloration or purple tipped. However, weedy rice is perceived to be a source of resistance to rice diseases. Twenty weedy rice biotypes were screened for resistance to rice tungro disease and bacterial blight for possible source of resistance to these particular diseases. Resistance screening to tungro was observed in four biotypes (WR-B3, WR-B13, WR-Ilo2 and WR-Ilo3) and recommended as parent materials for breeding. Screening for bacterial blight resistance showed that there were also four biotypes (WR-B3, WR-B4, WR-B5 and WR-B6) which can be utilized as parent materials.

Pesticide use is still the most common pest management option of many Filipino farmers though there are available strategies and techniques that are also effective against rice pests. A holistic approach is therefore necessary to achieve better pest management and avoid undesirable effects of pesticides to human, animals and the environment and lessen the utilization of fossil-fuel. The use of entomopathogenic fungus, Beauveria bassiana for the control of rice bug was evaluated as an alternative to pesticides. It reduced the rice bug population by 50% at one-week after application. Rice yield components were not affected by the application and rice plants sprayed with the fungal suspension had higher yield than those applied with insecticide.

Endophytes are bacterial or fungal microorganisms which colonize the inter- and/or intracellular spaces of a healthy host plant without causing apparent symptoms of disease. They are perceived to be useful in the biological control of rice diseases. A total of 132 endophytic fungal isolates were obtained from leaf tissues of 10 traditional rice varieties. There were more endophytes isolated from certain varieties like Hinumay 1, Asucena and Dinorado 1.

The phyllosphere which is the above ground surface of plants is a habitat rich in microorganisms called epiphytes. They play a wide range of roles as plant pathogens, natural antagonists of plant pathogens and plant growth promoters. Samples were collected from rice varieties for microbial isolation of epiphytic microorganisms with potential to antagonize the rice blast pathogen. A total of 50 isolates were purified and initially tested 10 isolates for antagonistic activity against the rice blast fungus.

Evaluation of *Trichoderma harzianum* isolates to manage blast, sheath rot and brown spot diseases of rice. In vitro test results showed that the two T. harzianum were very effective in suppressing the mycelial growth of the rice pathogens. Application of the isolates was more effective as compared to fungicide application.

I. Ecological Engineering Towards a Sustainable IPM Program in Rice and Rice-based Farming System

Project Leader: GS Arida

Ecological engineering approach for pest management: Effect of vegetation corridor on the population of the different arthropod functional groups and insect damage in farmers' fields

GS Arida, BS Punzal, LV Marquez and J Settele

Ecological engineering is a human activity that modifies the environment according to ecological principles. It is a useful conceptual framework for considering the practice of habitat manipulation for arthropod pest management. Its main philosophy is the use of cultural techniques to affect habitat manipulation like planting of flowering plants as source of nectar and pollen of parasitoids and in effect enhance biological control. It considers vegetation diversity which plays a central role in habitat manipulation. The role of ecological engineering approach in pest management is new in rice. The LEGATO Project (2011) defines it as the development of strategies to maximize ecosystem services through improving biodiversity to provide refugia, food and breeding places for predators, parasitoids and pollinators. Research on ecological engineering in rice and other crops in Asia is very limited.

Earlier studies documented the effects of plant diversity on the regulation of insect herbivore populations by favoring the abundance and efficacy of associated natural enemies. In other crops, the abundance and diversity of predators and parasites within a field is closely related to the nature of the vegetation in the field margins. There is wide acceptance of the importance of field margins as reservoirs of the natural enemies and more effective biological controls where crops are bordered by wild vegetation from which natural enemies colonize (Nicholls et. al 2001; Alfieri, 2004). Results of our earlier studies (Arida et. al, 2015, in press) at the Central Experimental Station (CES) of PhilRice showed that the population of predators and parasitoids were higher in fields close to area with flowering plants as compared to fields without those plants. This area provided a place for the conservation of beneficial organisms for a sustainable insect pest management in rice and rice-based ecosystem.

Acivities:

- Collection of arthropods by Blow-Vac Suction machine and sweep net.
- Sorting and identification of collected arthropods.
- Assessment of plant damage caused by defoliators and stem borer.
- Collection of parasitoids in Yellow Sticky Traps (YST).

Results:

- Arthropods Collected in Blow-Vac Suction Machine and Sweep Net: The population of herbivores collected using the two sampling techniques was generally higher in fields without flowering plants (without FP) compared to fields planted with flowering plants (with FP). On the other hand, the number of predators and parasitoids was higher in fields with FP. The flowering plants provided food like nectar and honey to beneficial arthropods. These were recorded in the two sites during the dry and wet seasons of 2016.

- Plant Damage Caused by Defoliators: Damage caused by defoliators at the late vegetative stage was lower in fields with FP compared to without flowering plants. This was recorded in Burgos and Matingkis sites. Percent damaged leaves in Burgos recorded were 3.3 and 6.1% in fields with and without FP, respectively. On the other hand, the recorded damaged leaves in Matingkis were 5.6 and 7.2% in fields with and without FP, respectively (Table 1). A similar trend was recorded during the wet season (Table 2.). Results indicated that the presence of high population of parasitoids in the field with FP contributed to this lower incidence of insect damage caused by defoliators.

- Rice Stem Borer Damage: The yellow stem borer, Scirpophaga

incertulas (Walker) is the species presently recorded in irrigated lowland rice in Central Luzon. The damage during the reproductive stage resulted in empty panicles called whitehead (WH)). Percent WH ranged from1.1 to 7.4% in two sites. The damage recorded in both sites were significantly lower in fields with FP compared to without FP. Incidence of whitehead in Burgos was 1.5% and 3% in fields with and without FP while whitehead recorded in Matingkis was 1.1% and 7.4%, respectively (Table 1). Similar observation was recorded during the wet season (Table 2).

- Parasitoids Recorded in Yellow Sticky Traps (YST): The number of parasitoids caught in YST was generally higher in fields with FP compared to without FP. This was recorded in both sites. This was attributed to the presence of FP which serves as source of food for adult parasitoids. The most common parasitoids collected were *Anagrus sp.*, *Gonatocerus sp. and Tetratichus sp*. Anagrus and Gonatocerus parasitize the eggs of rice plant and leafhoppers while Tetrastichus is a parasitoid of stem borer eggs. The population of Anagrus sp. was generally higher than *Gonatocerus sp*. In addition, high population of Braconid and Ichneumonid parasitoids was collected. These groups of parasitoids mostly attack larvae of rice leaf folder and stem borer. A higher number of parasitoids were recorded in Sto. Domingo as compared to Munoz during the wet season (Figures 1&2).

Table 1. Insect damage (mean ± se) in farmers' rice fields with and without flowering plants (FP). 2016 Dry season.

LOCATION	INSECT DAMAGE	WITH FP	WITHOUT FP
Sto. Domingo, Nueva Ecija	Damaged leaves (%)	3.30 ± 0.1	6.10 ±0.4
	Whitehead (%)	1.50 ± 0.6	3.00 ± 1.6
Munoz, Nueva Ecija	Damaged leaves (%)	5.60 ±0.9	7.20 ± 1.0
	Whitehead (%)	1.10 ± 0.3	7.40 ± 1.2

Table 2. Insect damage (mean ± se) in farmers' rice fields with and without flowering plants (FP). 2016 Wet season.

LOCATION	INSECT DAMAGE	WITH FP	WITHOUT FP
Sto. Domingo, Nueva Ecija	Damaged leaves (%)	2.5 ± 0.2	7.6 ± 0.5
	Whitehead (%)	1.0 ± 0.2	3.5 ± 0.5
Munoz, Nueva Ecija	Damaged leaves (%)	0.8 ± 0.2	2.8 ±0.3
	Whitehead (%)	3.1± 0.5	6.1 ±0.6

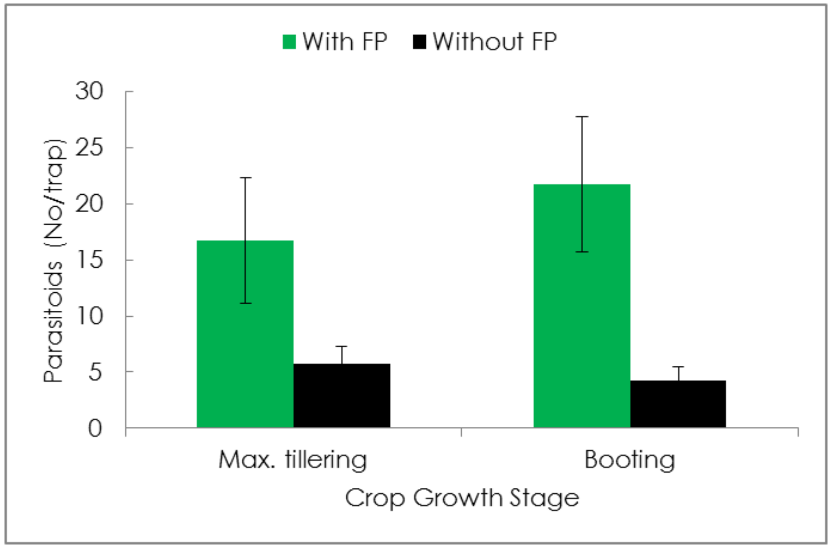

Figure 1. Number of parasitoids collected using yellow sticky traps in fields with and without flowering plants. Sto.Domingo, 2016 Wet season.

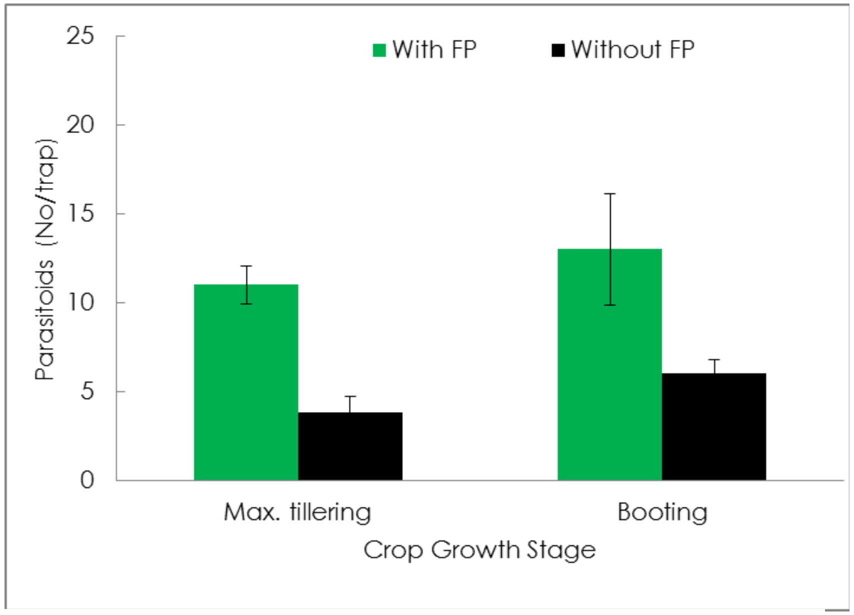

Figure 2. Number of parasitoids collected using yellow sticky traps in fields with and without flowering plants. Matingkis, Science City of Muñoz, 2016 Wet season.

II. Screening of Rice Materials for Insect Pest and Disease Resistance

Project Leader: JP Rillon

Developing rice varieties resistant to major insect pests and diseases is the most economically and environmentally sound management approach in breeding program to prolong performance of varieties in the field. One way to increase yield is to reduce losses due to insect pests and diseases. The role of screening is important in identifying rice lines that will show resistance to major rice pests. Resistance of rice lines to major pests can be used in the development of improved varieties. There will be a need for continuous screening for pest resistance. Promising lines were evaluated for resistance to blast, bacterial leaf blight, sheath blight and tungro. For insect pests, lines were evaluated for resistance to yellow stem borer, green leafhopper and brown planthopper. Susceptible varieties were used to check the validity of the data. Plants synthesize a greater array of secondary compounds than animals because they cannot rely on physical mobility to escape their predators. Plants therefore produce chemical defense against such predators. These compounds are secondary metabolites known to be part of the normal growth and development of a plant. However, some researches revealed that these compounds are also produced as part of their response to biotic attacks. The project will provide breeders timely information on pest and disease resistance of promising lines for breeding purposes.

Evaluation of rice lines for resistance to major diseases

JP Rillon and MSV Duca

Rice diseases are a major limiting factor in achieving the goal of increasing rice production. They are important barrier in reducing grain quality and yield. Among the diseases, tungro, blast and bacterial blight are considered to be the most devastating diseases. The changing environment like heavy rainfall can usually increase disease occurrence while hot and humid weather will lead to the occurrence and spread of disease. Rice plants need to be evaluated to determine the presence or outbreak of diseases in the field. Diseases cause significant yield and quality reductions resulting in farmers' income loss. The role of disease screening is important in identifying rice lines that will show resistance to the major rice diseases. Rice lines resistant to the major diseases can be used in breeding purposes. There will be a need for continuous screening for disease resistance from one year to the next due to disease resistance breakdown often with devastating results.

Activities:

- Rice lines were evaluated for resistance to blast under nursery condition. The plots were surrounded with IR42 and IR50 as susceptible check varieties. In bacterial leaf blight and sheath blight evaluation, plants were transplanted into the field and inoculated at 45 to 60 DAT and evaluated at 14 days after inoculation. For tungro evaluation, virus infected GLHs were allowed to feed on seedling test plants for 24 hours for virus inoculation. The entries were examined for the presence of symptoms 2 weeks after inoculation.

Results:

- One thousand five hundred sixty two rice entries representing 8 groups under preliminary yield trial (special purpose), preliminary yield trial (regular), preliminary yield trial (SM), rainfed, direct seeded, blast lines, hybrid blast lines, International rice blast nursery, and KOPIA rice lines were screened for their resistance to blast, bacterial leaf blight, sheath blight and tungro during the season (Table 3).

- Under blast evaluation, 1,562 rice entries were directly seeded in blast screening nursery surrounded with IR42 and IR50 as susceptible check varieties. Four hundred eighteen entries were found resistant to blast, while 344 showed intermediate reaction to the disease (Table 3 and 4).

- For tungro evaluation, virus infected GLH were allowed to feed on seedling test plants for 24 hours for virus inoculation. The entries were examined for the presence of symptoms after 2 weeks of inoculation. RF18 had resistant reaction while RF 7, KOPIA 89, KOPIA 210 and KOPIA 140 showed intermediate reaction to the disease (Tables 3 and 4).

- In bacterial leaf blight and sheath blight evaluation, plants were transplanted into the field and inoculated at 45 to 60 DAT. Evaluations were performed for development of bacterial leaf blight and sheath blight. Six hundred eighteen lines have been identified with intermediate reactions to bacterial leaf blight while 7 entries had intermediate reaction to sheath blight.

Table 3. Summary table of reactions of promising lines and varieties to major rice diseases. PhilRice CES.

SELECTION	NO. OF ENTRIES	BLAST			BACTERIAL LEAF BLIGHT			SHEATH BLIGHT			TUNGRO		
		R	I	S	R	I	S	R	I	S	R	I	S
PYT-R	209	16	40	116	0	466	143	0	1	208	0	1	208
PYT-SP	170	7	65	91	0	52	116	0	0	168	0	0	168
DSR	74	3	10	60	0	9	65	0	0	74	0	0	74
RF	145	31	35	79	0	23	122	0	0	145	1	1	142
KOPIA	230	48	51	106	0	68	162	0	6	152	0	1	229
IRBN	60	22	7	18	*	*	*	*	*	*	*	*	*
Blast lines	560	238	125	197	*	*	*	*	*	*	*	*	*
Hybrid lines	114	53	11	48	*	*	*	*	*	*	*	*	*
TOTAL	**1562**	**418**	**344**	**715**	**0**	**618**	**608**	**0**	**7**	**747**	**1**	**3**	**821**

* not included in other disease evaluation

Table 4. Summary table of reactions of promising lines and varieties to major rice diseases. PhilRice CES.

REACTION	NUMBER OF RICE LINES			
	BLAST	BACTERIAL LEAF BLIGHT	SHEATH BLIGHT	RICE TUNGRO
Resistant	418	0	0	0
Intermediate	344	618	7	3
Susceptible	715	608	747	821

Centralized screening for resistance to insect pests of rice
GC Santiago

Breeding is a long term project and priorities may change over time. A new selection may well need to be tested in a range of environments, affected by different factors and grown under several cultural techniques. In most breeding programs there are successive stages of testing: seedlings are initially screened and only the most promising lines go on for further testing.

Most of the important sources of resistance to major insect pests have been incorporated into lines that have improved plant types. Some lines were considered promising enough to be named varieties while others have proved to be good parents in the new crosses. Focusing on a system to facilitate screening for resistance will hasten the development of a new variety and will save on resources.

Activities:

- During 2016 dry season, a total of 541 lines were evaluated against stem borer under field condition and these entries were planted late to meet the required insect pressure. The same numbers of entries were also evaluated under the screenhouse condition against brown plant hopper (BPH) and green leafhopper (GLH). Similarly, during 2016 wet season, a total of 770 lines were planted late on August 24, 2016 and were evaluated against stem borer under natural field and screenhouse condition.

Results:

- During 2016 dry season, a total of 541 lines were evaluated against stem borer under field condition and these entries were planted late to meet the required insect pressure. The same numbers of entries were also evaluated under the screen house condition against brown plant hopper (BPH) and green leafhopper (GLH). Similarly, during 2016 wet season, a total of 770 lines were planted late on August 24, 2016 and were evaluated against stem borer under natural field and screen house condition.

- The result of the evaluation under the screen house condition (Table 5) during 2016 DS showed that out of 541 entries, majority were resistant to brown plant hopper (BPH) and green leafhopper (GLH). Deadheart (DH) evaluation under the natural field condition showed a valid data based on susceptible check, TN1 with 25.84% damage. Majority of the entries were resistant to DH. Data on reproductive stage (whiteheads) was not valid due to a heavy infestation of brown plant hopper that resulted in hopper burn on susceptible check, TN1.

- Result during 2016 WS showed that during the evaluation at 49 DAT on October 12, 2016 on deadhearts showed a very low insect pressure with 6.58% damage on susceptible check TN1. Evaluation at reproductive stage is scheduled on the 2nd week of December 2016 and evaluation under screen house condition is still on-going.

Table 5. Reactions of different entries to stemborer (DH), BPH and GLH. PhilRice CES. 2016 DS.

ENTRIES	DEADHEARTS (DH)			BPH			GLH		
	R	I	S	R	I	S	R	I	S
PYT-R (95)	92	0	0	7	61	27	16	45	34
PYT-SP (85)	82	3	0	11	52	22	0	43	42
RF (100)	88	5	0	21	45	34	5	54	41
KOPIA (62)	56	6	0	16	32	14	10	31	21
DSR (54)	49	3	0	17	23	14	6	28	20

Profile and role of secondary metabolites in rice plant immunity to rice leaf blast and bacterial leaf blight

NC Ramos and JP Rillon

Plants synthesize a greater array of secondary compounds than animals because they cannot rely on physical mobility to escape their predators. Plants therefore produce chemical defense against such predators. These compounds are secondary metabolites known to be part of the normal growth and development of a plant. However, some researches revealed that these compounds are also produced as part of their response to biotic attacks.

Rice blast is caused by the fungus *Pyricularia oryzae*, where several organ of the plant can be infected. Rice blast infects the rice plant at any growth stage. This study would like to identify the secondary metabolite present and quantity the amount produced in rice leaf, during and after the rice leaf blast infection. Samples resistant and susceptible to rice blast were the test samples in this study. Leaf samples at different plant stages were collected and analyzed.

Activities:

- Rice varieties susceptible to BLB such as IR 24 and TN 1 were selected. Meanwhile, rice varieties resistant to BLB such as PL 27 and IRBB 21 were also chosen.

- A duplicate for each variety was collected every week starting 0 days of transplanting (DAT) on January 26, 2016 at the CPD Experimental Field.

- On March 11, 2016, 45DAT, the rice plants were infected under induced condition.

- A total of 13 batches of collection were conducted. In total, there were 104 samples for analyses.

Results:

- Rice varieties susceptible to BLB such as IR 24 and TN 1 were selected. Meanwhile, rice varieties resistant to BLB such as PL 27 and IRBB 21 were also chosen.

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- A total of 13 batches of collection were conducted with 104 samples for analyses.

- All rice leaf samples were freeze-dried for 4 days at the Rice Chemistry and Food Science Division. When all samples were brittle, the samples were ground using mortar and pestle.

- A 5-gram of each samples were measured and extracted using acetone (Rakwal et al., 1996). The extracts were filtered, and defatted using chloroform. The pooled extracts were concentrated using Eppendorf equipment at the Plant Breeding and Biotechnology Division. The resulting extracts were reconstituted using acetone to 100μl (Figure 3).

Figure 3. Rice leaf extracts and standard reference samples for method validation.

- Gas Chromatography with FID as the detector was used to measure the secondary metabolites. The analyses were conducted at the National Institute of Geological Sciences at the University of the Philippines Diliman, and National Power Corporation in Quezon City (Figure 4).

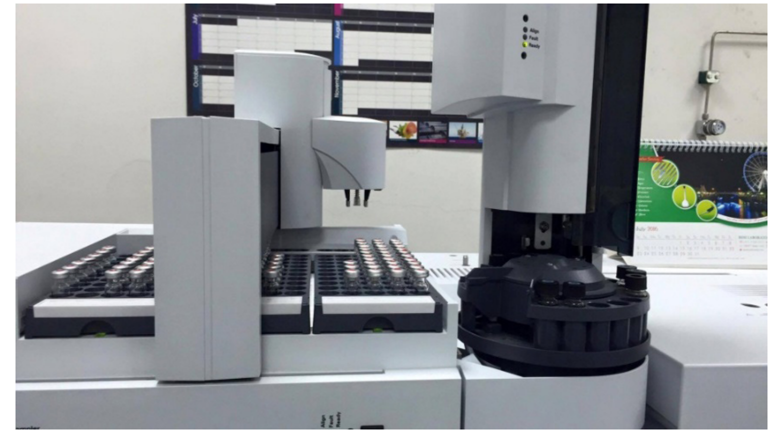


Figure 4. Secondary metabolites analysis in rice leaf extracts using Gas Chromatography.

- Method validation was conducted following the method of A Focus for Analytical Chemistry in Europe (Eurachem) as shown in Figure 5. Precision is defined as the closeness of agreement between a series of measurements obtained from multiple sampling of the same homogeneous sample under prescribed condition. Using the method of Rakwal et al. (1996), deliberate variations to the method under routine conditions were introduced. A 0.50mg/L standard solution of sakuranetin and momilactone A was repeatedly injected to the GC-FID. Results showed that 5 to 6% of RSD was observed. Thus, the method is precise since it is lower than the Horwitz and AOAC PVM acceptable values of 22.6% and 15%, respectively.

- Accuracy is defined as closeness of a single result to a reference value. In this study, standard addition was conducted. Results showed that sakuranetin had 5% bias while momilactone A had 7%. In general, the method can be concluded as accurate.

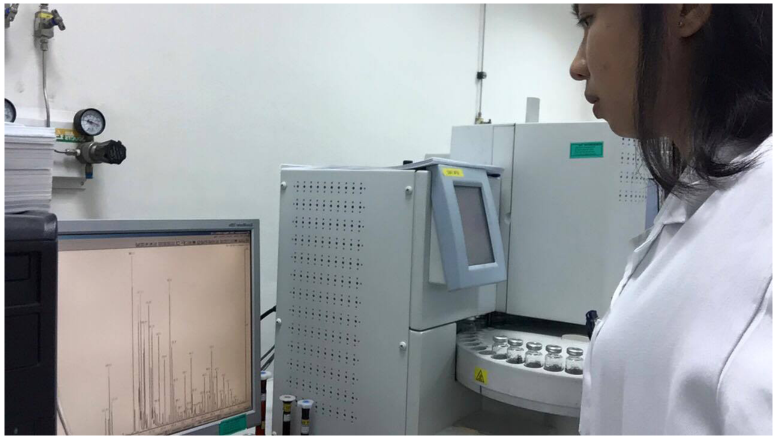


Figure 5. Method validation using Gas Chromatography.

- *Sakuranetin* and *Momilactone A* were discovered in the control samples. Table 6 shows the varying amount of Sakuranetin during BLB infection for the susceptible, IR24 and TN1; and resistant, PL27 and IRBB21. Sakuranetin ranges from 12.3 to 43.7 ppm for IR24, 13.1 to 35.5 ppm for TN 1, 56.5 to 132 ppm for PL 27, and 44 to 98 ppm for IRBB 21.

Table 6. Concentrations (ppb) of Sakuranetin in rice leaf samples (N = 3).

WEEK	IR 24	TN 1	PL 27	IRBB 21
1	22.2	15.3	56.5	44
2	24.3	22.2	56.9	44
3	22.4	23.4	58	47.8
4	31.2	22.4	63	56.7
5	32.5	34	66.4	75.2
6	32.7	33.4	69	77
7	33.4	33.3	84	79
8	32.8	33.7	88	83
9	39.3	35.5	89.4	88.3
10	41.5	35.4	97	98
11	43.7	34.7	132	92
12	20.3	13.1	96	77
13	12.3	12	88.1	54

- Results showed that Sakuranetin had higher concentration for the resistant varieties during the pathogen infection that eventually decreased into significant amount after the BLB infection. In fact, higher concentrations were detected for all varieties during weeks 6 to 10, but decreased after week 11. It is possible that significant relative roles of Sakuranetin play in the resistance of rice to BLB. This will further depend on a combination of amount produced with Momilactone A and to the speed of production.

- The varying amounts of *Momilactone A* during the BLB infection in rice leaf samples were shown in Table 7 for both susceptible and resistant varieties. *Momilactone A* ranges from 12.0 to 34.2 ppm for IR 24, 12.4 to 15.7 for TN 1, 20.0 to 66.3 ppm for PL 27, and 33.0 to 98.7 ppm for IRBB 21.

Table 7. Concentrations (ppb) of Momilactone A in rice leaf samples (N = 3).

WEEK	IR 24	TN 1	PL 27	IRBB 21
1	-	-	20	34.2
2	-	-	20.2	33
3	12	-	24.4	42.4
4	22.3	12.4	44.3	53.3
5	22.4	13.2	46.6	56.6
6	24.6	13.5	52.2	63.4
7	33.1	14.2	55.5	67.7
8	35.7	14.6	55.5	67.8
9	37.2	15.2	55.6	73.8
10	32.1	15.7	62.8	75.5
11	34.2	15.4	66.3	89.7
12	33.1	-	43.5	98.7
13	22.8	-	34.2	45.2

- Results showed that similar to *Sakunetin, Momilactone A* was produced significantly during weeks 6 to 10. These periods were the favorable time for the plant to produce secondary metabolites to be used not only for defense but also for growth and development.

- The susceptible varieties, IR 24 and TN 1, were not detected during the early period of plant development. TN 1 was also not detected during later weeks. Changes in secondary metabolite formation may also be an important feature to understand its response and susceptibility to plant diseases (Dillon et al. 1996). Whether this observation applies before BLB infection remains to be validated.

Resistance stability of high yielding varieties to major insect pests and diseases of rice
GC Santiago, MSV Duca, and EM Valdez

Resistant rice varieties reduce losses caused by insect pests and diseases in irrigated rice. The stability of resistance depends on the genetic interaction between the rice host, insect herbivore and pathogen. The expression and long-term stability of resistance to the herbivore insect and to the pathogen in a plant species depend on the genotype of the host, the genotype of the insect and the pathogen and their interaction to environmental condition. Durable resistance is expected to relieve rice farmers of the need to repeatedly change varieties. Durability combined with multiple pests and disease resistance will further reduce the need to apply pesticides.

A field study was established to determine the resistance stability of high yielding/popular varieties to the major insect pests and diseases of rice.

Activities:

- Forty two (42) high yielding varieties and eight (8) checks were planted late during 2016 DS. The composition of these high yielding varieties were inbred irrigated lowland (15), special purpose irrigated lowland (4) rainfed irrigated lowland (7), upland (4), saline (12) and check varieties (8). Evaluation for resistance to stem borer at vegetative and reproductive stage were done. Similarly, evaluations for major diseases such as bacterial leaf blight (BLB), blast (leaf blast/panicle blast), Sheath blight (ShB) and tungro (RTD) were also done but some confirmatory activities in the greenhouse for disease evaluation were suspended due to lack of manpower.

- During 2016 WS, same high yielding varieties were planted late on Sept. 7, 2016. These varieties will be evaluated against the major insect pest and diseases of rice.

Results:

- Different high yielding varieties were evaluated against stem borer (SB) under natural field condition. It was observed that at 48 days after transplanting (DAT), 11 varieties including the susceptible check (TN1) were heavily infested by the brown planthopper (>50%) that caused hopperburn and were not further evaluated for SB damage. Evaluations for deadheart (DH) in the remaining varieties showed that majority of the entries were intermediate. Similarly, whitehead evaluation showed that majority of the variety had susceptible reactions (Table 8).

- For disease evaluation, it was observed during the 1st evaluation (48 DAT) that majority of the entries were resistant to BLB, blast and sheath blight. Tungro was not observed during the 1st and 2nd evaluation (Tables 9 & 10). During the 2nd evaluation (85 DAT), result showed that out of 50 varieties, 19 had resistant and 19 had susceptible reactions to BLB, 41 had resistant reactions to blast and 40 had resistant reactions to sheath blight (Table 10). Other diseases observed during the season were sheath rot, brown spot and narrow brown spot (Table 11).

- Several factors affected the initial result of the study during the seasons hence; a thorough validation of data for the next season is needed.

- During 2016 WS, same high yielding varieties were planted late on Sept. 7, 2016. Deadheart evaluation at 45 DAT showed a very low insect pressure with damage ranging from 0 to 9.28% equivalent to resistant reaction. Similarly, majority of the varieties were resistant to major diseases. Incidence of tungro was observed at vegetative stage. Evaluation of entries at reproductive stage is scheduled on the 2nd week of December. Encoding of some data for this season is still on-going.

Table 8. Reactions of high yielding varieties to stem borer at vegetative and reproductive stages at PhilRice CES. DS 2016.

VARIETY	NO. OF ENTRIES	DEADHEART (DH)			WHITEHEAD (WH)		
		R	I	S	R	I	S
Irrigated lowland (inbred)	15	8	7	0	4	10	1
Irrigated lowland (SP)	4	3	1	0	0	1	3
Rainfed lowland	7	0	7	0	2	4	1
Upland	4	0	4	0	0	1	3
Saline	12	4	8	0	0	2	10
Check	8	2	5	1	0	3	5

Table 9. Reactions of high yielding varieties to major diseases at 48 DAT at PhilRice CES. DS 2016.

Ecosystem	No. of varieties	BLB			Blast			Sheath blight		
		R	I	S	R	I	S	R	I	S
Irrigated lowland (inbred)	15	8	5	2	14	1	0	13	1	1
Irrigated lowland (SP)	4	4	0	0	4	0	0	4	0	0
Rainfed lowland	7	6	0	1	5	2	0	6	1	0
Upland	4	4	0	0	3	0	1	3	1	0
Saline	12	7	2	3	12	0	0	12	0	0
Check	5	3	1	1	4	0	1	5	0	0

*no tungro disease pressure

Table 10. Reactions of high yielding varieties to major diseases at 85 DAT at PhilRice CES. DS 2016.

Ecosystem	No. of varieties	BLB			Blast			Sheath blight		
		R	I	S	R	I	S	R	I	S
Irrigated lowland (inbred)	15	8	2	5	15	0	0	15	0	0
Irrigated lowland (SP)	4	2	1	1	3	1	0	3	1	0
Rainfed lowland	7	7	0	0	7	0	0	7	0	0
Upland	4	2	0	2	4	0	0	4	0	0
Saline	12	0	1	11	12	0	0	12	0	0
Check	2	1	0	1	1	0	1	0	1	1

*no tungro disease pressure

Table 11. Reactions of high yielding varieties to other diseases observed at 85 DAT at PhilRice CES. DS 2016.

Ecosystem	No. of varieties	Sheath rot			Brown spot		
		R	I	S	R	I	S
Irrigated lowland (inbred)	15	6	9	0	15	0	0
Irrigated lowland (SP)	4	1	3	0	4	0	0
Rainfed lowland	7	1	6	0	7	0	0
Upland	4	0	4	0	4	0	0
Saline	12	0	12	0	12	0	0
Check	2	1	0	1	2	0	0

III. Biology and Ecology of Pests
Project Leader: GFEstoy, Jr.

Agriculture, especially monoculture has affected the natural biodiversity through the simplification of habitats and ecosystems. As a result, the loss of floristic and structured diversity leads to the reduction of faunal heterogeneity and pest incidence. Philippines has a vast area for upland, rainfed, saline- and submergence-prone environments for rice production. However, some of these areas are often affected by biotic and abiotic stresses which resulted in low rice production.

Control measures of a certain pest are usually based on its biology because control measures will work effectively when applied at the vulnerable stage of the pest. Thus, there is a need to know its basic biology and some aspects of its ecology so that it can be properly managed. The affected rice farmers should be given management options and awareness campaign should be done on unaffected rice areas.

Biology, ecology and management of the rice grain bug (Hemiptera: Lygaeidae) - a new emerging insect pest of rice
GF Estoy. Jr., BM Tabudlong, and AM Rojo

Control measures of a certain pest are usually based on its biology because control measures will work effectively when applied at the vulnerable stage of the pest. The rice grain bug (RGB), Paraeucosmetus pallicornis Dallas, a formerly pest of legume (as reported by BPI based on Barrion, AT, 2009 fax communication) and presently infesting the rice crop near the flood-prone areas of Mainit lake in Caraga, Mindanao has no basic biological studies. Thus, there is need to know its basic biology and some aspects of its ecology so that it can be properly managed. The affected rice farmers should be given management options and awareness campaign should be done on unaffected rice areas.

Activity:

- Installation of 3 light trap catches in Kitcharao, Agusan del Norte and Alegria, Surigao del Norte to monitor RGB population.
- Net sweeping in Kitcharao, Agusan del Norte and Alegria, Surigao del Norte to monitor RGB population.

Results:

- There were 3 light trap catches installed in selected barangays in Kitcharao, Agusan del Norte and Alegria, Surigao del Norte to determine if the rice grain bug (RGB) is attracted to light and to know the peak population of RGB during the cropping season. Results showed a population fluctuation trend of the RGB from Jan-November 2016 (Figure 6). Initial population started on the 1st week of January and decreased on the following month. Light trap catches of RGB started to increase on the month of March and peak population was observed on June 2016 (57 to 67 adults/light trap) at 2 sites in Alegria, Surigao del Norte when the rice crop was at the ripening stage.

- Assessment of the population dynamics of the insect (nymphs and adults) started to occurr during milking to soft dough until hard dough stages and even after harvest regardless of the variety planted. Damage due to RGB was more or less similar to the damage caused by the rice bug showing unfilled grains during early infestation and spotted dark brown during milking to soft dough stage.

- Figure 7 shows the population of the rice grain bug on different stages of the rice plant in Anibongan, Kitcharao, Agusan Del Norte from January to June 2016 cropping season. Moreover, Figure 8 shows the population of the rice grain bug on different stages of the rice plant in Anahaw, Alegria, Surigao del Norte from January to June 2016 cropping season and Figure 9 shows the population of the rice grain bug on different stages of the rice plant in San Pedro, Alegria, Surigao del Norte from January to June 2016 cropping season.

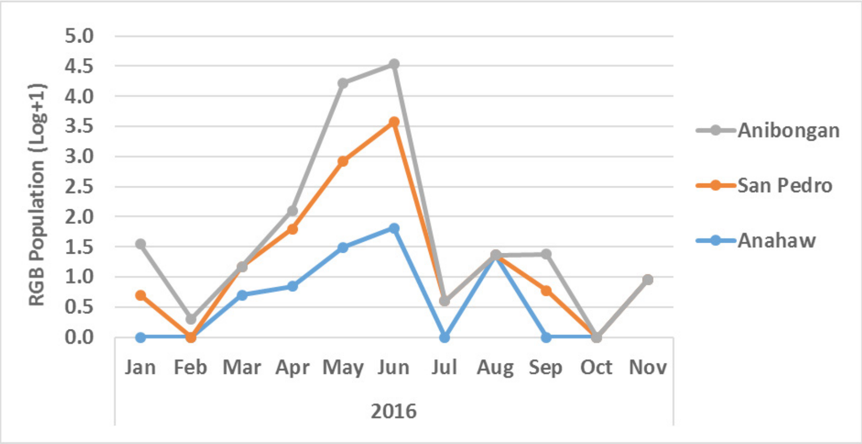


Figure 6. Monthly population fluctuation of the rice grain bug caught in the light trap on selected barangays in Kitcharao, Agusan Del Norte and Alegria, Surigao Del Norte from January to November 2016.

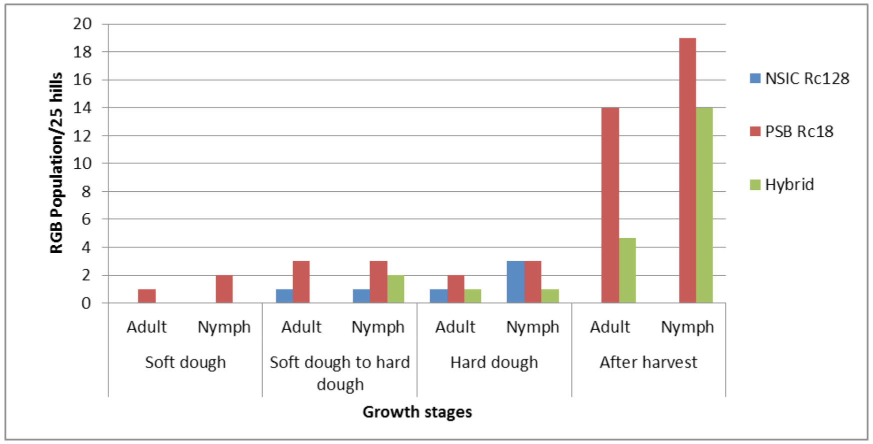


Figure 7. Population of the rice grain bug at different stages of the rice plant in Anibongan, Kitcharao, Agusan Del Norte from January to June 2016 cropping season.

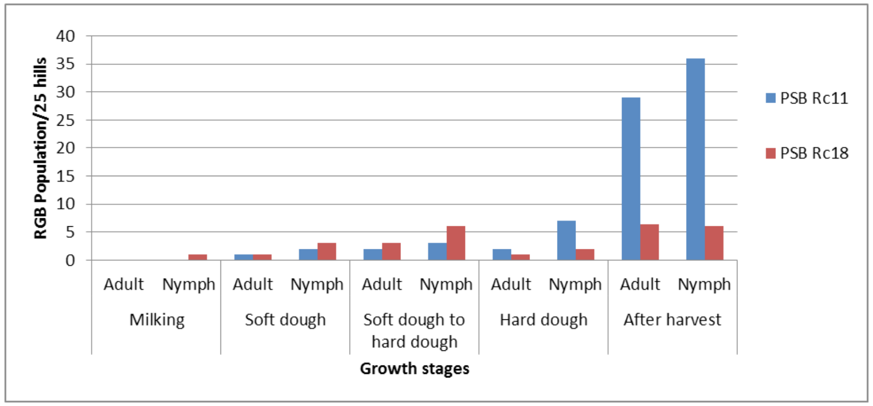


Figure 8. Population of the rice grain bug at different stages of the rice plant in Anahaw, Alegria, Surigao del Norte from January to June 2016 cropping season.

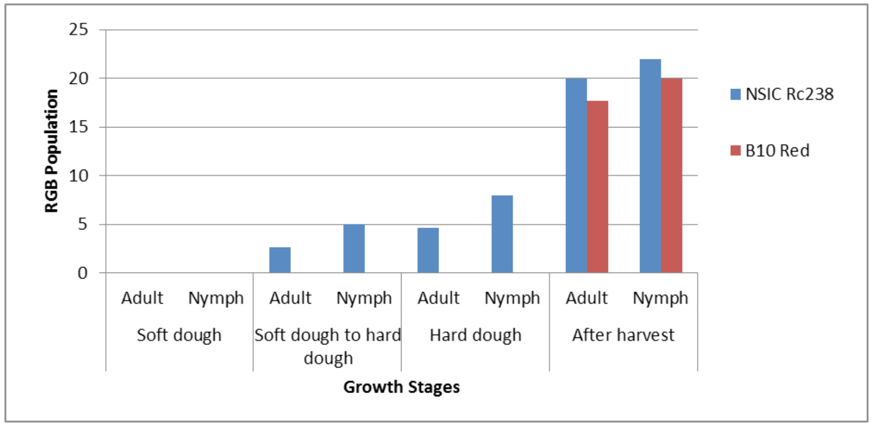


Figure 9. Population of the rice grain bug on different stages of the rice plant in San Pedro, Alegria, Surigao del Norte from January to June 2016 cropping season.

Genetic diversity and cultural characterisctis of Magnaporthe grisea in the Philippines

FA Dela Pena, AA Dela Cruz, MJC Duque, and RG Capacao

Blast caused by Magnaporthe grisea [Herbert] Barr (T.T. Herbert) Yaegashi & Udagawa, is one of the most destructive diseases of rice worldwide because of its wide distribution and high incidence under favorable conditions (Ou, 1985; Singh et al., 2000). It has become a major problem in rice growing areas particularly where there is water stress (upland and rainfed) and in cool-elevated areas. It is also becoming a problem in some irrigated areas, particularly in the lowlands.

To control the disease, many rice cultivars with blast resistance have been developed. However, resistance can be broken down within several years after release due to increase in new blast races virulent to the resistance. It was also emphasized that the genetic lineages of the rice blast fungus are related to pathotypes with different cultivar specificity. Typically, a variety released as blast-resistant shows signs of susceptibility after only very few seasons of cultivation in blast-prone environments (Zeigler and Correa, 2000). To address the problem, a more in-depth study of the structure and dynamics of the pathogen population is highly valuable for more effective management strategies of the disease.

The objective of the study is to a) assess the genetic diversity of isolates of the rice blast pathogen from different rice growing areas in the Philippines (rainfed, upland, cool-elevated, saline-prone and the irrigated lowland); b) determine the variation among isolates as partitioned in space; c) determine the relationships among individuals within and between populations; and e) determine the cultural characteristics of the different rice blast isolates

Activities:

- Pure cultures of blast isolates collected from different geographical locations in the Philippines were revived and maintained for further tests. Blast isolates were characterized in four solid media (Host Extract Agar + 2% Sucrose, Oatmeal Agar, Potato Dextrose Agar + Biotin + Thiamine, and Richard's Agar) based on type of margin, colony color, form and elevation. Data were gathered and consolidated. Sporulation capacity of blast isolates in four media were also rated.

- DNA of blast isolates was extracted using CTAB method. Each of the blast DNA were subjected to PCR amplification and quality and quantity standardization by running in 1.25% agarose gel along with several dilutions of DNA of known concentration.

- Ten primers were optimized by changing the amount of the different ingredients of the cocktail. PCR amplification for genetic analysis using different primers (Table 1) is still on-going at the Molecular Genetics Laboratory. Optimization of PCR detection (Figure 5) is still evaluated of each of the different primers. Primers H6 1-15 and E-10 were already used for PCR amplification.

Results:

- A total of 89 blast isolates were already characterized in four solid media, the remaining 11 isolates to complete the target 100 isolates is still on-going. Figures 10, 11, 12 and 13 show the considerable variation of the growth of Magnaporthe grisea in each of the solid media used. There were four growth patterns in PDA + Biotin and Thiamine, four in Richard's Agar, four in Host Extract Agar and six in Oatmeal Agar. Growth patterns determined in Potato Dextrose Agar were: A. moist white colony, circular, flat and entire translucent margin; B. white to brownish colony, circular umbonate and entire translucent margin; C. white to gray color, raised, circular/filamentous, entire translucent margin; and D. white edge with dark concentric ring, circular, flat and entire margin. Moreover, in Host Extract Agar+ 2% Sucrose were: A. white to gray colony, circular, raised, entire translucent margin; B. grayish to dark colony, circular, flat, entire margin; C. white colony, circular, flat, entire translucent margin; and D. white to dark colony, umbonate, entire margin. Furthermore, in Richard's Agar were: A. grayish to green colony, circular, flat, translucent entire margin with concentric ring; B. white colony, circular umbonate and entire translucent margin; C. white to green colony, circular, flat entire translucent margin with concentric ring; and D. green colony circular, flat translucent entire margin. Lastly, in Oatmeal Agar were: A. grayish colony, circular, flat, entire translucent margin; B. white to dark colony, circular, flat, entire margin; C. grayish to dark colony, circular, flat, entire translucent margin with concentric ring; D. grayish colony, circular, flat entire translucent margin; E. white to grayish colony, circular, flat, entire translucent margin; and F. white colony, circular, raised, entire translucent margin. Sporulation capacity of blast isolates was also rated in which M. grisea isolates showed better sporulation in Oatmeal Agar > Host Extract + 2% Sucrose Agar > Potato Dextrose Agar + Biotin and Thiamine with poor sporulation in Richard's Agar, respectively.

- Figure 14 shows the optimization of primers (Table 12) for PCR detection. Moreover, Figure 15 shows the finger print profiles of 28 blast isolates DNA using H6 1-15 and E-10 primers. A total of 78 DNAs were extracted from blast isolates and were subjected to PCR amplification for genetic analysis. However, DNA quality deteriorited after months of being used. Thus, DNA extraction of blast isolates was again conducted. Eighteen blast DNA were already extracted using different methods following cited literatures and are ready for quality check. A total of 65 mycelial mat were also prepared and now ready for DNA extraction.

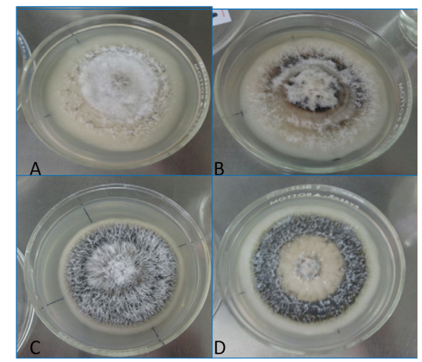


Figure 10. Growth response of *M. grisea* in Potato Dextrose Agar + Biotin + Thiamin.

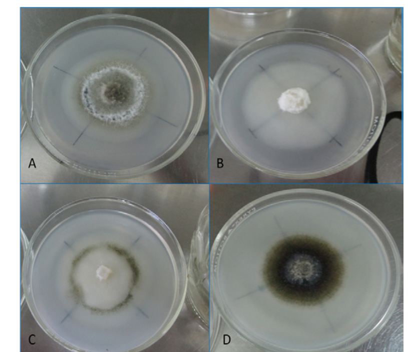


Figure 11. Growth response of *M. grisea* in Richard's Agar.

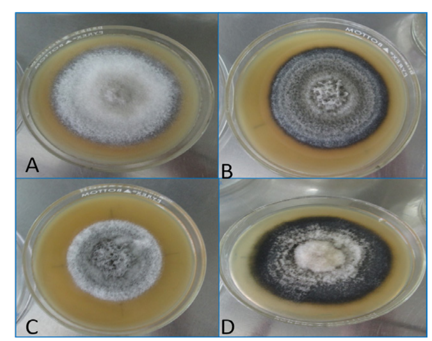


Figure 12. Growth response of *M. grisea* in Host Extract +2% Sucrose Agar.

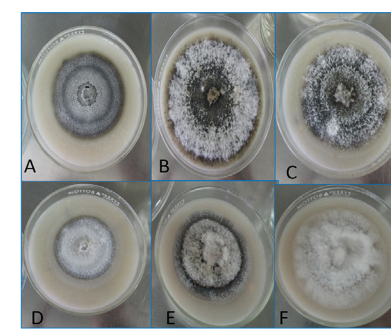


Figure 13. Growth response of *M. grisea* in Oatmeal Agar.

Table 12. List of primers and primer sequences for DNA fingerprinting for the molecular characterization of *Magnaporthe grisea*.

Number	Primer		Sequences
1	C7 1.4	F	TGC CGC CTG CTC TAA GTA AA
		R	TAT CCT TCA CCA ACG ACA CC
2	CUT 1	F	TAT AGC GTT GAC CTT GTG GA
		R	TAA GCA TCT CAG ACC GAA CC
3	E10	F	ACC AGG TGA CGT CGA TAA CC
		R	CTG ACG CCA AAA GCA AGT TA
4	ERG2	F	GCA GGG CTC ATT CTT TTC TA
		R	CCG ACT GGA AGG TTT CTT TA
5	HO 0.85	F	CAT CTA CAA CCC GAG CAA GG
		R	TGT AAA ACA GCC CAT CAA AG
6	H6 1.15	F	TGT ATG ATG CGA GCG GAC TT
		R	TGG ACT GGG TAT TGT TGA GC
7	J16 0.7	F	GTT AGG GCT ACA GGC GGA AG
		R	CTG TGG CGA CGA TCT GTG GT
8	P9 1.0	F	ACC CCA CTC GCT GAC CTT TA
		R	CGG ACG CTT GAT TGC TGT TA
9	PWL2	F	TCC GCC ACT TTT CTC ATT CC
		R	GCC CTC TTC TCG CTG TTC AC
10	Pot2	F	CGG AAG CCC TAA AGC TGT TT
		R	CCC TCA TTC GTC ACA CGT TC

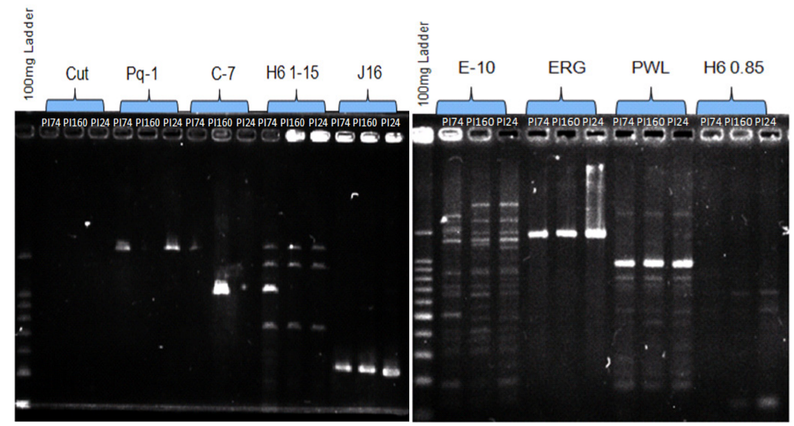


Figure 14. Primer optimization for PCR detection using three blast isolates (PI 74, PI 24, PI 160).

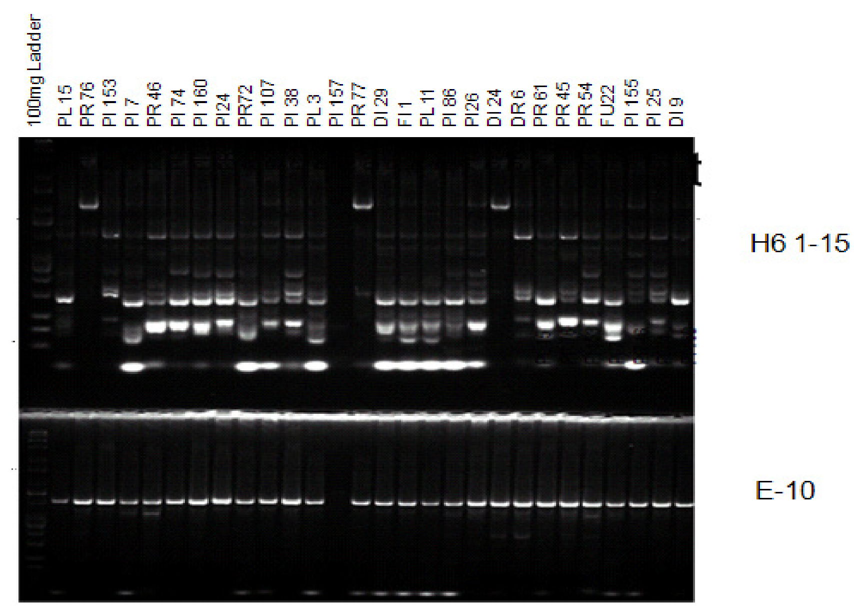


Figure 15. Analysis with H6 1-15 and E-10 showing DNA fingerprint profiles of M. grisea isolates collected from different geographical locations in the Philippines.

Seasonal fluctuation of stem borer at PhilRice CES
GC Santiago and EM Valdez

Yellow stem borer is one of the widely distributed, dominant and monophagous pests of rice. With this view, regular observations on incidence of pests in field are not only found useful to determine the activity of insect pests in relation to several weather factors but also help to study the population dynamics of other insects during the particular period.

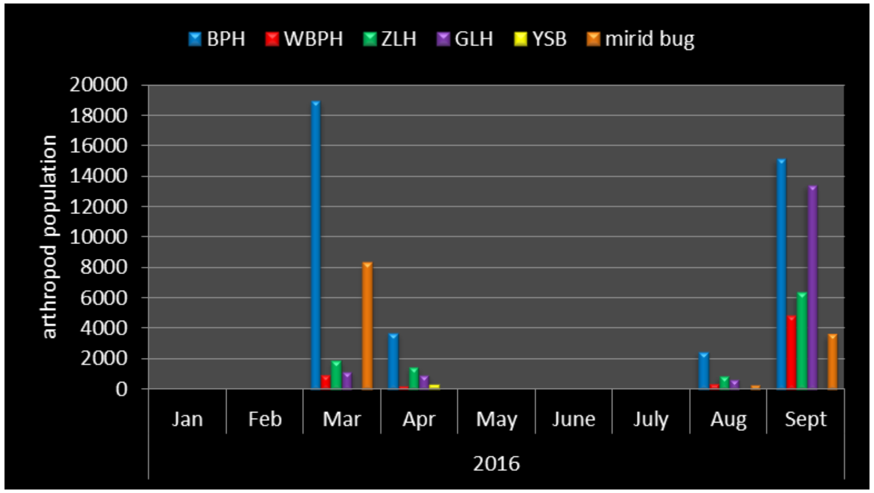
Collections of a light trap provide a significant clue to the diversity of insects active at night (Southwood and Henderson, 2000) and to understand and predict how populations function. Such information, if properly documented, could be put to multidimensional use by field-researchers, such as selection of light-traps for attracting specific order of insects. Inspite of the market being flooded with different models of light traps with light sources varying in their intensity and wave lengths, no scientific data on the trap collection, diversity, number and its efficacy is available for ready use. Such a data could shed light on the insects attracted to specific range of light. Further, correlating this data with weather parameters could help to predict the period of maximum insect diversity and activity. In order to make such information available, a complete segregation of the individual trap collection over a period of time on the basis of order and total catch, and simultaneously correlating it with a prevalent weather conditions becomes necessary. Hence, a comparative analysis of the light-trap collections using two different light sources and different agroecosystem is to be carried out correlating with weather conditions.

Activity:

- Weekly light trap collections were brought in the Entomology Laboratory for sorting, identification and counting.

Results:

- The stem borer and other arthropods catches that started during 2016 dry season (DS) is presented in Figure 16. Majority of the arthropod populations peaked in March. A total of 18 species of insect pests were recorded from the light trap catches which was dominated by hoppers. Light trap collections from January – June, 2016 showed that the peak population of adult yellow stem borer (YSB) was observed on April 12, 2016. The brown planthopper (BPH) population started to peak on March 8, 2016 and the most number of catches (17,643) was on March 24, 2016. The same trend was observed for other hoppers: zigzag leafhopper (ZLH), green leafhopper (GLH) and whitebacked planthopper (WBPH). Other insect pests of major importance were the rice bug (RB) and rice black bug (RBB) but the populations were very low.
- For the natural enemies, there were six (6) parasitoids and 18 predators recorded which was dominated by the mirid bug, Cyrtorhinus lividipennis. It was observed that high population of the mirid bug was only high during the peak of hopper populations. Fourteen (14) families of detritivores/tourists were also recorded.
- For 2016 wet season (WS), collection from July to September showed that hopper population started to peak on Aug. 23, 2016. Adult YSB catches was very low. Predators, parasitoids and detritivores/tourists were also recorded.
- Sorting, identification and counting of light trap collected samples were continuously done in the Entomology laboratory for the remaining months of the year to determine the peak of the population for wet season.



Brown planthopper (BPH), White-backed planthopper (WBPH), Zigzag leafhopper (ZLH), Green leafhopper (GLH) and Yellow stemborer (YSB).

Figure 16. Monthly light trap catches of different arthropods* at PhilRice CES. 2016.

Survey and characterization of weedy rice biotypes in Northern and Southern Mindanao

EC Martin, DKM Donayre, CBCodod, and FR Sandoval

Several surveys have been conducted to determine the occurrence and extent of distribution of weedy rice in some parts of the Philippines. While these surveys are limited and do not give a complete picture of the extent of distribution of weedy rice in the Philippines, they do indicate the increasing number of fields where weedy rice is found. To our knowledge and based on published literatures, no study has yet been conducted to assess the impact of weedy rice infestation in the Philippines, particularly in northern and southern Mindanao. In several instances, farmers/collaborators in these areas have reported some mixtures in their rice fields especially in direct seeded rice. Therefore, survey and characterization of different biotypes present in these areas can provide the information needed for weedy rice management.

Activities:

- Surveyed different rice field areas of Northern and Southern Mindanao during reproductive stage for possible occurrence of weedy rice. Height of five weedy rice and cultivated rice plant samples was measured in each field. Type of rice establishment, number of panicles/plant and number of hills/m2 were recorded. A global positioning system (GPS) was used to map the distribution and to track the position of the areas where weedy rice was spotted.

- Collected weedy rice seeds from the area surveyed was brought in the laboratory for morphological characterization.

Results:

- A total of eight different weedy rice biotypes were observed and collected from North Cotabato and Sultan Kudarat (2016 DS). In local terms, the farmers call the weedy rices as "sabag" or "weather-weather". The most common weedy rice biotypes recorded in the sampling sites were characterized as long awn, no purple coloration weedy rice (WR-SuK2) and awnless, purple tip weedy rice (WR-Cot2). The weedy rice biotypes had light brown to brown (red) pericarp coloration. The grains had straw, whitish, or light gold color. Three biotypes had purple coloration on the tip of the grains, while the other 5 biotypes had no purple tip coloration. Four biotypes have straw to yellow colored awns, while the other 4 are awnless. In terms of size, WR-Cot2 and WR-SuK5 had longer grains with an average length of 9.80 and 9.83 mm, respectively. On the other hand, WR-SuK4 had wider grains (3.24 width) than the other biotypes. Weedy rice biotype 2 from Sultan Kudarat (WR-SuK2) had the longest awn of 55.67mm followed by WR-SuK1 with 32.50mm length (Table 13 and Fig. 17).

- In 2016 WS, survey was done in North Cotabato, South Cotabato and Maguindanao. A total of 24 weedy rice biotypes were collected with 5 biotypes previously identified (WR-Cot2, WR-Cot3, WR-Suk3, WR-Suk4 and WR-Suk5) and 19 newly identified biotypes. The most common biotype recorded was WR-Suk3 charcterized with no purple coloration and awnless. The weedy rice biotypes had brown (red) to light brown, white to whitish and black pericarp. The grains had straw, yellow and blackish brown color. The awns had straw and light brown color. Thirteen biotypes had purple coloration on the tip of the grains, 10 biotypes had no purple coloration and 1 biotype with blackish brown grain color. Thirteen biotypes had straw colored awns, 1 biotype had light brown awn and 10 biotypes were awnless. The weedy rice biotype with longest grain length was WR-Min13 (8.64mm) while WR-Min12 and WR-Min19 (2.00mm) had the widest grain length. The longest awn length was recorded on WR-Min13 with an average of 56.76mm (Table 14 and Fig. 18).

Table 13. Morphological characteristics of weedy rice biotypes collected in Northern and Southern Mindanao.

BIOTYPES	SEED MORHPHOLOGY					
	Grain color	Pericarp color	Awn color	Grain length	Grain width	Awn length
WR-Cot1	whitish	brown	yellow	7.67	3.00	18.83
WR-Cot2	straw, purple tip	brown	NONE	9.80	3.00	NONE
WR-Cot3	straw	light brown	straw	8.67	3.00	4.83
WR-Suk1	straw, purple tip	light brown	yellow	8.13	3.00	32.50
WR-Suk2	light gold	brown	yellow	8.00	3.00	55.67
WR-Suk3	straw	brown	NONE	8.70	2.80	NONE
WR-Suk4	straw	light brown	NONE	7.86	3.14	NONE
WR-Suk5	straw, purple tip	light brown	straw	9.83	2.92	16.00

Note: All measurements are in millimeter (mm); Colors are based on RHS color chart in Descriptors for wild and cultivated rice by IRRI

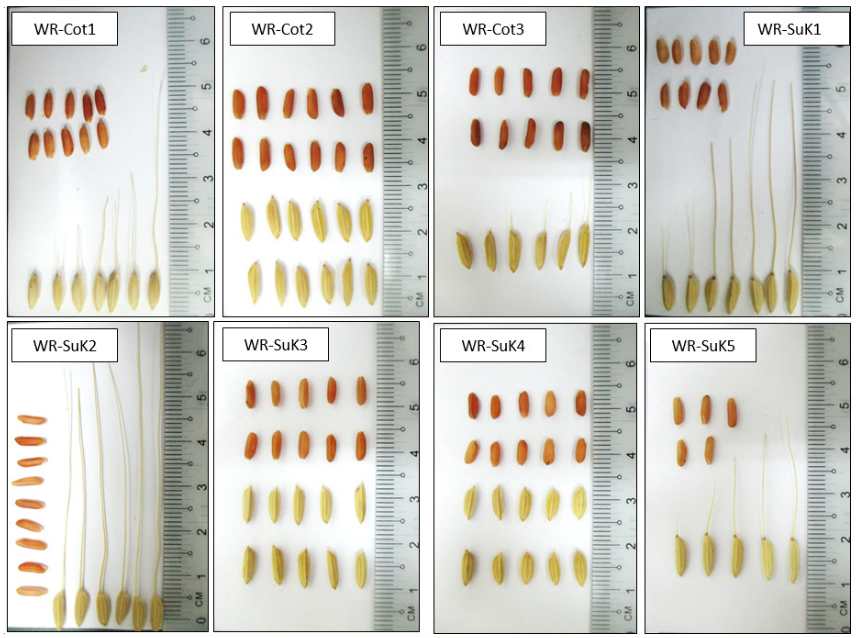


Figure 17. Seeds of eight weedy rice biotypes from Northern and Southern Mindanao (2016 DS).

Table 14. Morphological characteristics of weedy rice biotypes collected from Northern and Southern Mindanao (2016 WS).

BIOTYPES	SEED MORHPHOLOGY (2016 WS)					
	GRAIN COLOR	PERICARP	AWN	GRAIN	GRAIN	AWN
WR-Cot2	straw, purple tip	brown	NONE	7.17	1.61	
WR-Cot3	straw	light brown	straw	8.45	1.66	10.47
WR-Suk3	straw	brown	NONE	8	1.61	
WR-Suk4	straw	light brown	NONE	7.96	1.63	
WR-Suk5	straw, purple tip	light brown	straw	7.19	1.71	10.76
WR-Min1	straw	white	NONE	7.93	1.52	
WR-Min2	straw, purple tip	brown	straw	6.9	1.9	3.42
WR-Min3	straw, purple tip	brown	NONE	6.78	1.78	
WR-Min4	straw	brown	straw	7.59	1.46	5.73
WR-Min5	straw, purple tip	brown	straw	6.39	1.67	22.36
WR-Min6	straw	brown	straw	7.87	1.64	40.89
WR-Min7	straw, purple tip	brown	straw	6.91	1.7	50.92
WR-Min8	straw, purple tip	brown	NONE	6.9	1.52	
WR-Min9	straw, purple tip	light brown	NONE	7.99	1.71	
WR-Min10	straw, purple tip	white	NONE	7.94	1.42	
WR-Min11	straw	black	NONE	7.2	1.54	
WR-Min12	blackish brown	black	NONE	8.33	1.98	
WR-Min13	straw	light brown	straw	8.64	1.68	56.76
WR-Min14	straw, purple tip	brown	straw	6.18	1.54	5.96
WR-Min15	straw, purple tip	light brown	straw	7.16	1.53	29.68
WR-Min16	straw, purple tip	whitish	straw	6.9	1.86	21.8
WR-Min17	straw, purple tip	light brown	light brown	8.32	1.78	32.06
WR-Min18	yellow	brown	straw	6.5	1.56	3.34
WR-Min19	straw	whitish	straw	7.66	2.02	23.06

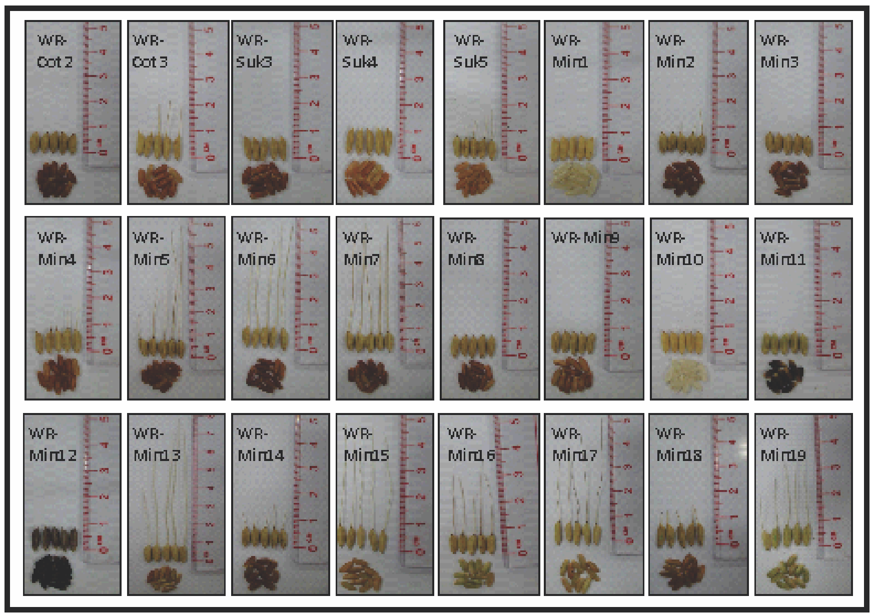


Figure 18. Seeds of twenty four weedy rice biotypes from Northern and Southern Mindanao (2016 WS).

IV. Evaluation and Optimization of Fossil Fuel-Free–Rice Pest Management Strategies and Techniques

Project Leader: DKM Donayre

Pesticides still remain the top option for many farmers in the Philippines to combat different kinds of rice pests. Because of this, outbreaks and resurgence of some major pests came out as a result of continuous use of the same quality and quantity of pesticides in the field. Since pesticides are the main shields of farmers for their crops, continuous production of these chemicals must have been round the clock using the system that requires the use of fossil fuel energy. There are other available pest management strategies and techniques that are also effective against different pest species of rice and at the same time do not or minimally require the use of fossil fuel such as use of resistant varieties, cultural and biological control methods. Since none of these will work alone, therefore, a holistic approach is needed to achieve better pest management, and avoid undesirable effects to humans, animals and the environment while at the same time lessen the utilization of fossil fuel.

Field evaluation of Beauveria bassiana (balsamo) Vuillemin for the control of the rice bug, Leptocorisa oratorius Fabricus

GF Estoy Jr and BM Tabudlong

Rice bug is one of the major insect pests of rice during reproductive stage. The control is primarily dependent on the use of pesticides. However, chemical insecticides pose several hazards to human beings, animals, beneficial insects and environment. There is a need to look for other alternative methods of control like the use of entomopathogenic fungi. The fungus, Beauveria bassiana (Balsamo) Vuillemin, is a common group of fungi that is used in the control of insects under different orders. This study aims to evaluate the efficacy of B. bassiana for the control of the rice bug under field conditions, determine the effective rate of application of B. bassiana against the rice bug and compare the use of B. bassiana and insecticide application against rice bug population.

Activities:

- Production of the fungus in plastic polypropylene bags at 200 grams per bag was done in the laboratory. Pure culture of B. bassiana grown in corn grits substrates were mass-produced in dry formulation in polypropylene bags.

- Established one field experiment from January to December 2016 at Agusan Experiment Station, Basilisa, RTRomualdez, Agusan Del Norte. Fungal suspension was standardized (1x109 conidia/ml) following serial dilution and sprayed on rice plants (NSIC Rc212) infested by rice bugs during the heading stage.

Results:

- *B. bassiana* reduced the population of rice bug by 50% at one week after fungal application in the field (Figure 19).
- *B. bassiana*-infected rice bugs increased within three weeks after fungal application (Figure 20).
- Low yield was recorded during the 1st season (1.30 to 2.13t/ha) and did not significantly differed regardless of the treatments applied (Table 15). However, higher yield was observed in 2nd season (4.79 to 6.00t/ha). The application of the higher concentration of fungal suspension was significantly higher than those in the control treatment.
- Rice yield components were not affected by the application of B. bassiana fungal suspension (Table 16).
- Some of the rice bug nymphs were not affected by the fungus. The result might be due to non-contact of the nymphs with the fungus.
- In addition, different species of spiders were the most common beneficial arthropods based on population density followed by lady beetle and wasps (Figure 21).

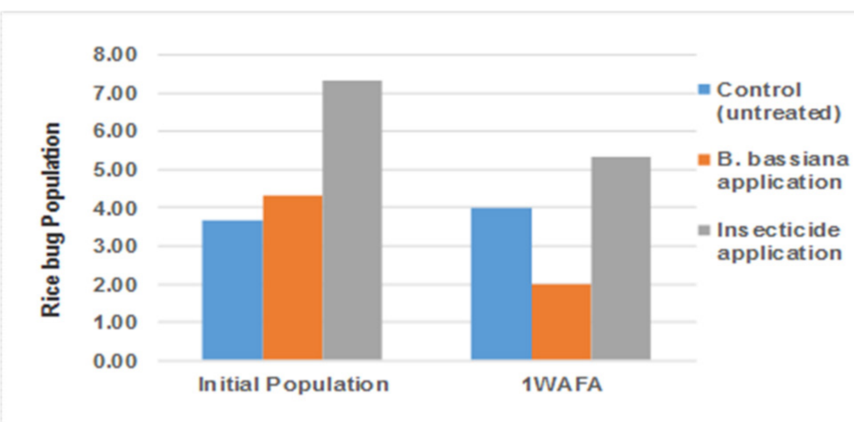


Figure 19. Population of adult rice bugs as affected by application of Beauveria bassiana (Jan to June 2016).

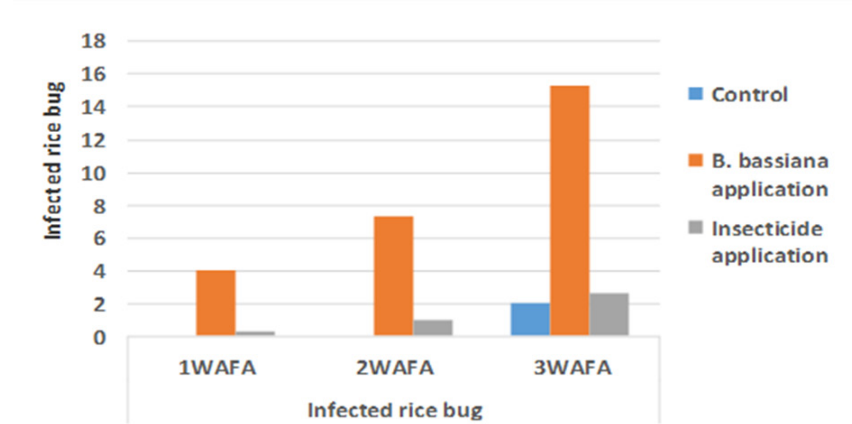


Figure 20. Total number of Beauveria bassiana-infected rice bug after application of the fungus in the field.

Table 15. Yield (tons/ha) of NSIC Rc212 as affected by the application of Beauveria bassiana suspension in the field*.

TREATMENTS	YIELD (tons/ha)	
	JAN-JUNE 2016	JULY-DEC 2016
Control (untreated)	1.30 ns	4.79 b
B. bassiana application	2.13	6.00 a
Insecticide application	1.79	5.14 ab

*Data based on 2m x 5m crop cut samples.

Table 16. Yield components of rice as affected by application of Beauveria bassiana suspension*.

TREATMENTS	NO. OF FILLED GRAINS/PANICLE	% FILLED SPIKELET/HILL	GRAIN WEIGHT/HILL	% DAMAGE GRAINS	WEIGHT OF 1000 GRAINS (grams)
Control (untreated)	52.47	60.32	32.17	7.64	25.87
B. bassiana application	59.72	66.27	37.73	5.11	27.27
Insecticide application	53.57	62.76	34.4	4.76	25.87

*Data based on 5 sample hills per replication.

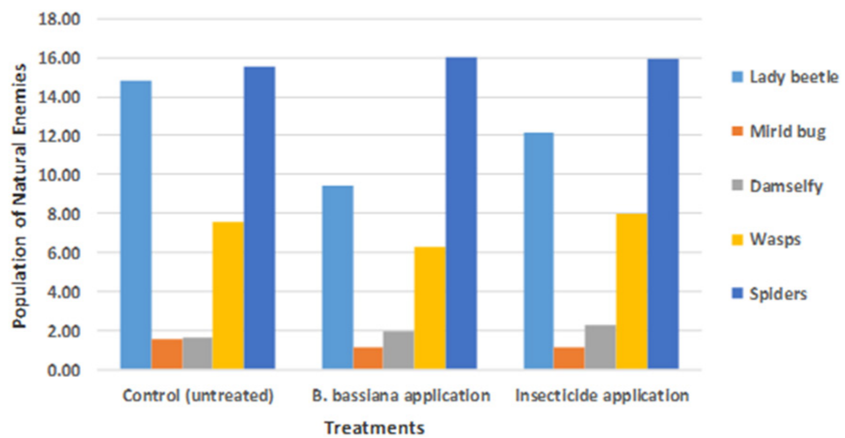


Figure 21. Population of beneficial insects in rice as affected by application of *Beauveria bassiana*.

Weedy rice: a potential source of resistance to bacterial blight and tungro diseases

ECMartin, FRSandoval, CBCodod, MSVduca, JSBruno, XG ICaguiat, FP Waing and ERTiongco

Weedy rice was recognized as an upcoming threat to rice production, research studies regarding these harmful weeds were generally focused on survey to determine the occurrence and extent of their distribution (Azmi et al., 2000; Baltazar and Janiya, 2000; Moody, 1994; Pyon et al., 2000). However, no research undertaking is being done on the beneficial role weedy rice may provide to rice production. One of these may be as possible source of resistance to rice major diseases. In 2014 to 2015, 20 weedy rice biotypes were screened for resistance to rice tungro disease (RTD) and bacterial leaf blight (BLB) to assess whether weedy rices can be used as a source of resistance genes to RTD and BLB. In 2016 DS, a confirmation trial was conducted on selected weedy rice biotypes to choose parent materials to be recommended for breeding activities. Hybridization between identified weedy rice biotypes was done in 2016 WS.

Activities:

- Six pre-selected weedy rice biotypes from Aurora, Pampanga, Pangasinan and Iloilo were re-evaluated for tungro resistance under induced method in greenhouse condition (2016 dry season). TN1 was used as the check variety. Weedy rice biotypes at 30 and 45 DAS were inoculated with tungro. Evaluations were done 3 to 4 weeks after the inoculation and the percentage infection was determined.

- Thirteen pre-selected weedy rice biotypes from Negros, Pangasinan, Tarlac, Bulacan, and Pampanga were re-evaluated for bacterial leaf blight (BLB) resistance under greenhouse condition (2016 dry season). TN1 was used as the check variety. Weedy rice biotypes were inoculated with BLB inoculum, cut 6cm from the tip of the plant using the inoculating clipper at 30 and 45 DAS. Evaluation was done at 14 days after inoculation.

- In 2016 wet season, hybridization between identified weedy rice with resistance to tungro and bacterial leaf blight (BLB) was done. Generation of various crosses was done in order to evaluate the crossability of identified weedy rice resistant to RTD and BLB into adapted rice varieties. The selected weedy rice resistant to tungro and BLB (WR-B3, WR-B4, WR-ILO2 and ILO-3) were used as donor parent, whereas TN1 as known for its susceptibility to both diseases, and NSIC released varieties Rc160, Rc222 and Rc402, were selected as the recurrent parent or recipient of the resistance from weedy rice.

Results:

- The pre-selected weedy rice biotypes showed resistance to RTD with a rating of 0 to 40% infection when inoculated at 30 and 45 days after sowing (DAS). The RTD infected plants showed slight shortening of internodes or 1-10% reduction in plant height with no distinct yellow to yellow orange leaf discoloration. Weedy rice biotypes from Maria Aurora, Aurora Province (WR-B3) and Ilo-ilo (WR-Ilo2 and WR-Ilo3) had the least infection of 0-10%. Weedy rice biotypes which had resistant reaction (0-20% infection) either in the plants inoculated at 30 or 45DAS were selected for breeding purposes. Thus, WR-B3, WR-B13, WR-Ilo2, and WR-Ilo3 were recommended as parent materials for breeding (Figure 22).

- Four out of 13 weedy rice biotypes had resistant to intermediate reaction to BLB; three of which had intermediate reaction while only one (WR-B4) showed resistant reaction with an average infection of 8.2% when inoculated at 30 DAS. These four biotypes namely WR-B3, WR-B4, WR-B5, and WR-B6 will be utilized as parent material for breeding to produce BLB resistant varieties. All weedy rice biotypes were susceptible to BLB when inoculated at 45 DAS (Figure 23).

- A total of 11 cross combinations were generated in 2016 WS (Table 17). These F1 seeds will be established inside the screenhouse in 2017 DS. The F1 plants will be characterized for the pollen behavior to evaluate whether their spikelets were fertile or sterile in order to determine crossability and compatibility of this weedy rice into adapted varieties.

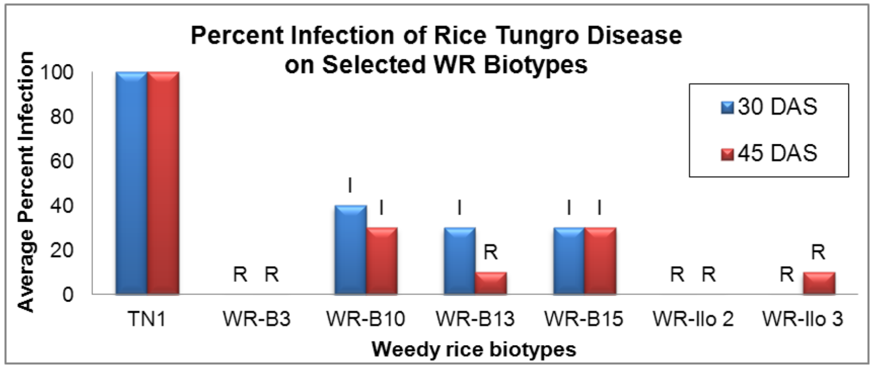


Figure 22. Percent infection of rice tungro disease on weedy rice biotypes at 15 DAI.

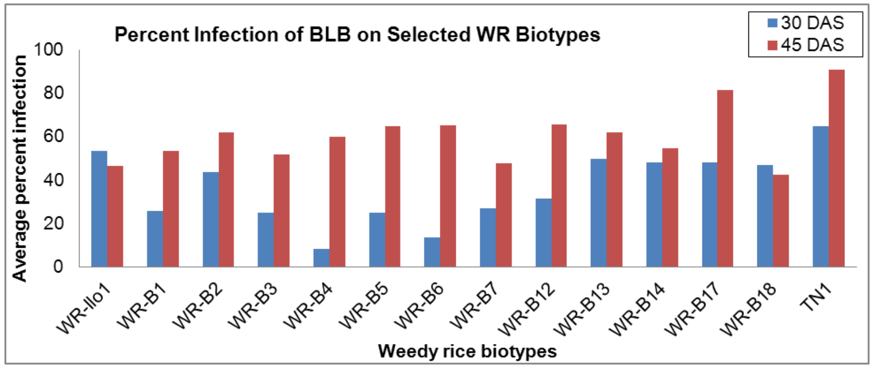


Figure 23. Percent infection of bacterial leaf blight on weedy rice biotypes at 14 DAI.

Table 17. List of various crosses generated in 2016 wet season.

CROSS COMBINATION		NO. OF F1 SEEDS GENERATED
FEMALE	POLLINATOR	
TN1	WR-B4	13
NSIC Rc222	WR-B4	25
NSIC Rc402	WR-B4	16
TN1	WR-B3	9
NSIC Rc160	WR-B3	91
NSIC Rc222	WR-B3	33
NSIC Rc402	WR-B3	24
NSIC Rc222	WR-ILO3	43
NSIC Rc402	WR-ILO3	11
NSIC Rc160	WR-ILO2	151
NSIC Rc222	WR-ILO2	7

Exploring endophytic fungi from rice: Their role in plant protection and practical use in biological control
JT Niones, JA Poblete, and DKM Donayre

Endophytes are bacterial (including actinomycete) or fungal microorganisms, which spend the whole or part of its life cycle colonizing the inter- and/or intracellular spaces of a healthy host plant without causing apparent symptoms of disease (Wilson, 1995). The association between the endophyte and its host plant ranged from latent phytopathogenesis to mutualistic symbiosis (Carroll, 1988). Although identification of endophytes dated as early as 1904, only recently that they receive an increasing attention owing to their pharmaceutical, ecological significance as well their potential application in biological control (Gunatilaka, 2006).

Traditionally cultivated rice with its long history of cultivation in different unfavorable environment likely to harbor unique populations of endophytes that differ from those in extensively bred modern varieties of rice subjected to the application of various fertilizers and agrochemicals. Disease resistant traditional rice cultivars may live in symbiosis with a unique and rich mycoflora providing its host resistance from pathogen infection either through direct antibiosis or induction of plant's systemic resistance.

This study aims to a) isolate, screen, identify, and characterize rice endophytic fungi with bioprotective ability against rice blast (*Pyricularia oryzae*) and sheath blight (*Rhizoctonia solani*) pathogens, b) elucidate mechanisms of plant immune responses, including that of defense related-gene expression changes and cellular defense responses triggered by selected endophytic fungi, and c) develop an assay system to analyze the functional role and persistence of endophytic fungi in rice tissues.

Activities:

- Isolation of endophytic fungi from select Philippine traditional varieties. Endophytes were isolated from young and from older leaves of a rice plant.
- Dual culture assay of endophytic fungi isolates against *Rhizoctonia solani*, the causal pathogen of rice sheath blight and *Pyricularia oryzae* , the causal pathogen of rice leaf blast.

Results:

- A total of 215 endophytic fungal isolates were obtained from leaf tissues of 26 Philippine traditional rice varieties. Among those varieties, Hinumay 1 has the most number of isolated fungal endophytes, followed by Asucena and then Dinorado 1 (Figure 24).

- More fungal endophytes were isolated from older leaves (68%) than those from younger leaves (32%) (Figure 25).
- Out of 215 isolates, 56 were subjected to preliminary in vitro bio-efficacy screening against *Rhizoctonia solani* and 31 isolates against *Pyricularia oryzae*.
- Eight isolates showed inhibitory effect against *R. solani* and 10 isolates against *P. oryzae*. Two isolates of endophyte can inhibit the mycelial growth of both *R. solani* and *P. oryzae*. (Table 18).

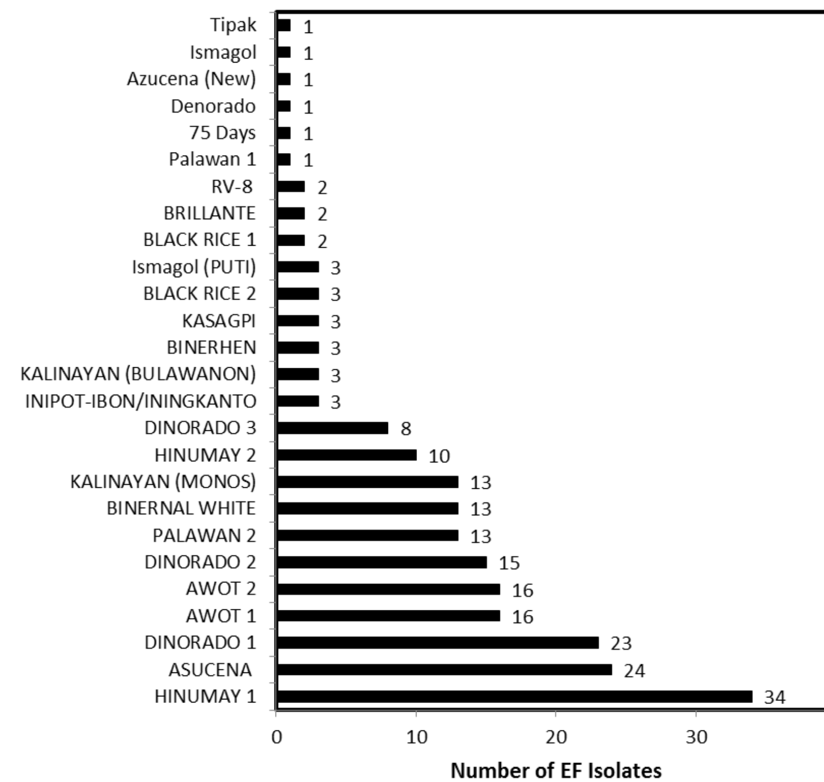


Figure 24. Number of endophytic fungi isolated from different Philippine traditional rice varieties.

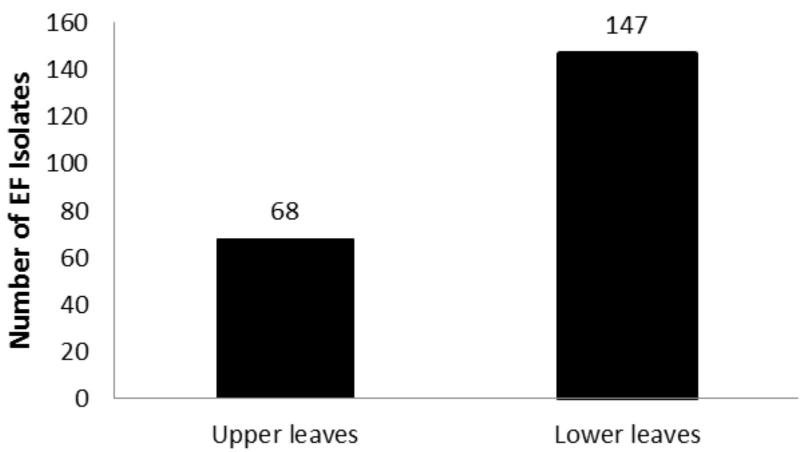


Figure 25. Number of endophytic fungal isolates obtained from different leaf samples of traditional rice varieties.

Table 18. List of fungal endophytes with inhibitory activity against Rhizoctonia solani and Pyricularia oryzae.

ISOLATE CODE	PATHOGEN	
	R. solani	*P. oryzae*
3BLt	+	-
6BLm	+++	-
10ALt 3	-	+
10ALb 2	-	+
10ALb 5	-	+
10ALb 6	-	+
18BLm 2	-	+
19ALb 2	-	+
19ALb 3	+	
19BUt	**+**	**+**
19AUt 1	+	-
19AUt 2	+	-
19AUm	+	-
21CUt	**+++**	**++**
21BLt 2	-	+++
36ALb	-	+++

Legend: Degree of inhibition was scored as region of no fungal growth between the endophyte and pathogen colonies: - , no inhibition; +, no observed zone of inhibition yet the pathogen colony exhibited reduced mycelial growth when compared to the negative control plate (pathogen only) ; ++, <2 mm; +++, 2-4 mm.

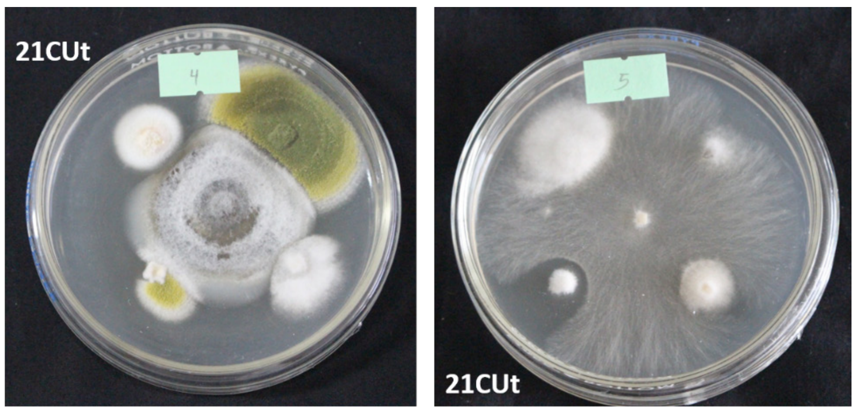


Figure 26. Inhibitory effect of 21CUt isolate on mycelial growth of *Pyricularia oryzae* (left), and *Rhizoctonia solani* (right) on Potato Dextrose agar plate culture. Four isolates of fungal endophytes were grown to a diameter of 10 to 12mm before a mycelial plug of *R. solani* was inoculated. For a slow growing *P. oryzae*, the pathogen was allowed to grow for 5 days before the endophyte isolates were introduced to the culture plate. The culture was incubated at 23°C for 7 to 14 days until either a clear inhibition was observed or the colonies of the two fungi had made in contact.

Epiphytic microbial antagonists and their effects on the rice blast pathogen
FA dela Peña and R Capacao

The discovery of synthetic chemicals has contributed greatly to the increase in food production by controlling insect pests and diseases. However, the use of these synthetic chemicals during the last three decades has raised a number of ecological concerns and may put non-pathogenic organisms, including human at risks. Therefore, the potential of various biological control methods has been investigated, with varying degrees of success. Meanwhile, various components of the rice agroecosystem, including water in the paddies, soil, rice, seeds and its plant parts, have been found to be rich sources of antagonists against pathogens of rice such as *Magnaporthe grisea, Rhizoctonia solani, and Fusarium moniliforme*. The phyllosphere, which is the above ground surface of the plant is a habitat rich in bacteria, fungi, yeasts and algae, all epiphytic microorganisms. They play a wide range of roles as plant pathogens, natural antagonists of plant pathogens and plant growth promoters. Considering this nature of infection, the present study focused on screening potential antagonists to the rice blast pathogen from the phyllosphere of different rice varieties grown in rainfed rice areas in different geographical locations in the Philippines and determining their efficiency in controlling rice blast development under greenhouse condition.

The objective of this study is to a) isolate and evaluate potential epiphytic antagonists against the rice blast pathogen; b) determine the effects of the potential antagonists against the rice blast pathogen under greenhouse condition, c) evaluate and identify secondary metabolites production of the potential antagonists; and d) characterize and identify the potential antagonists.

Activities:

- Rice plant samples were collected from different rainfed areas for microbial isolation of epiphytic microorganisms that has potential to antagonize rice blast pathogen.

- Using the said samples collected, different epiphytic micro-organisms (bacteria and fungi) were isolated and purified and stored at -20°C for further testing as potential antagonist to the rice blast pathogen.

- Antagonistic test of purified epiphytic microorganisms were conducted to test their efficacy against rice blast pathogen. Epiphytes that did not show antagonistic effect on rice blast pathogen were eliminated while those with antagonistic effect will be subjected for further testing in In Vitro (dual assay) and under greenhouse condition.

- Epiphytes that show antagonistic activity against the rice blast pathogen were tested for their toxicity against rice (pathogenicity test) to ensure that it cannot harm the crop when used as antagonist. Twenty-one-day-old seedlings were used for pathogenicity test using the IR50 variety.

Results:

- A total of 216 isolates were purified from the collected leaf samples of rice plants.

- Of the 216 isolates, 55 were subjected to antagonistic test where 25 of which were found to have antagonistic activity against the rice blast pathogen; those with no antagonistic effect were eliminated, otherwise, stored at -20^{o}C and will be subjected for further test.

- Figures 27 and 28 show some of the antagonistic efficacy of the selected purified epiphytes in preliminary assay. In the figure, inhibition of the rice blast pathogen was very evident. We can see the mycelia discoloration of the blast pathogen. This confirmed that epiphytes present in the leaves of rice have potential as bio-control agents against the rice blast disease-causing pathogen. Further test of its antagonistic potential against the rice blast pathogen will be conducted to verify its efficacy in both in vitro and in vivo experiments.

- A total of three potential epiphytes were subjected to pathogenicity test/toxicity test on IR50 variety to determine if it is harmful or not to the crop. As we can observed in Figure 29, the tested potential epiphytes showed no toxicity effect on IR50 plants. Thus, it is a good bio-control agent which cannot harm the crop.

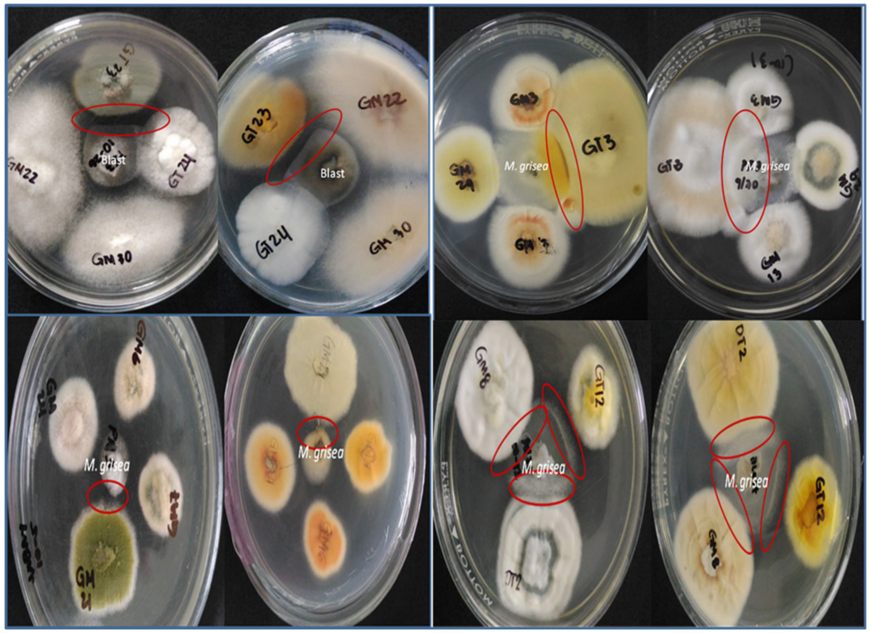


Figure 27. Preliminary assay of antagonistic activity of the epiphytes against the rice blast pathogen.

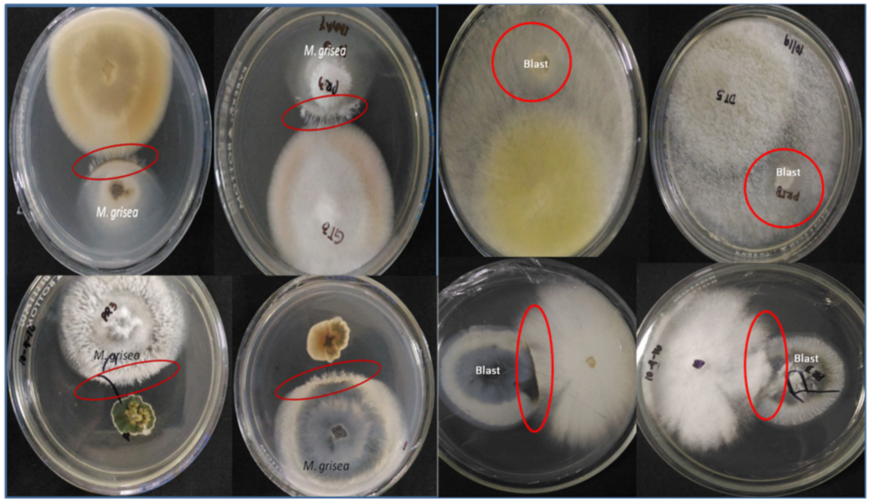


Figure 28. Dual assay tests between the potential epiphytes and the rice blat pathogen.

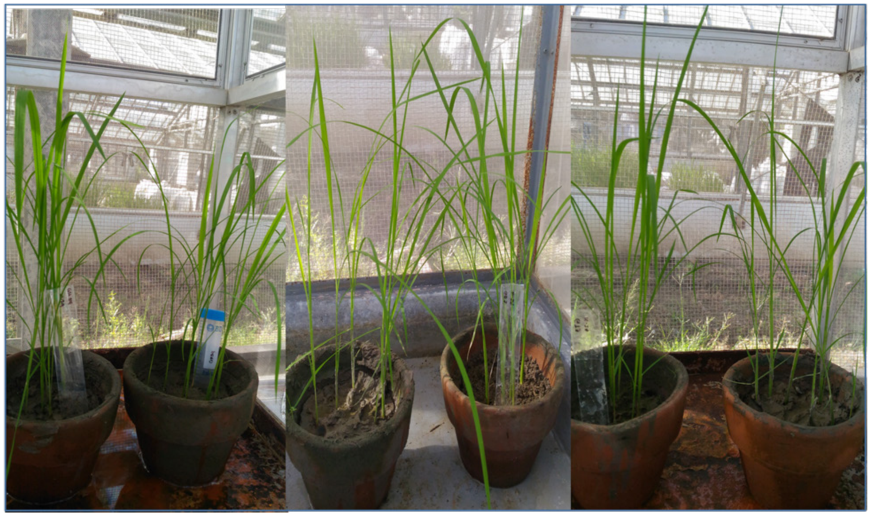


Figure 29. Pathogenicity tests of potential epiphytes on IR50 variety.

Evaluation of Trichoderma harzianum isolates for the management of blast, sheath rot and brown spot diseases of rice
MV Duca, DKM Donayre, and FR Sandoval

Trichoderma species are ubiquitous fungi in the soil that have antagonistic activity against soil borne plant pathogens. They can significantly inhibit mycelium growth of pathogen in vitro by producing volatile and nonvolatile metabolites. The mechanisms of Trichoderma as biocontrol are rhizosphere, competence and induced system resistance, by way of long plant defenses against plant pathogens. The objectives of this study are to a) determine the effecacies of Trichoderma harzianum isolates (T5Oi and TMDRi) as biological control agents against *Magnaporthe oryzae*, Sarocladium oryzae and Bipolaris oryzae causing blast, sheath rot and brown spot diseases to rice, respectively and b) evaluate the efficacies of *T. harzianum* isolates using different delivery methods and timing of applications.

Activities:

- *T. harzianum* isolates (T5Oi and TMDRi) were evaluated in vitro to determine their efficacy as biocontrol agents against P. oryzae, *S. oryzae* and *B. oryzae* (blast, sheath rot and brown spot diseases) using the dual culture test.
- Seven-day old mycelial disk of *P. oryzae, S. oryzae, B. oryzae,* T5Oi and TMDRi were cut from edges of actively growing colonies and placed opposite each other, 1.5 cm from the edge of 9 cm petri dishes containing Potato Dextrose Agar (PDA).
- Each of the T. harzianum isolates were paired with the *P. oryzae, S. oryzae and B. oryzae* in petri dishes and incubated at 28°C for 7 days. Copper hydroxide at 50 grams/16 liter was used as fungicide control.
- Each pair was replicated 5 times and the experiment was repeated three times for verification of the result. The degree of antagonism was measured using the rating scale described by Bell et al (1982).
- Slide culture method was used to investigate the hyperparasitic nature of T. harzianum isolates against S. oryzae.
- Potato dextrose agar (PDA) disks (5mm) were placed on top of a sterilized glass slide 1cm apart from each other. Each of PDA disk was inoculated with T. harzianum and S. oryzae. All paired cultures were incubated at 28°C and regions where the hyphae of *T. harzianum* isolate met the hyphae of *S. oryzae* were observed under microscope.

Results:

- Rice blast, sheath rot and brown spot disease samples were collected.
- Causal pathogens were isolated and purified inside the laboratory
- Three trials on bioassays (dual culture test) of 2 T. harzianum isolates against blast, sheath rot and brown spot pathogen were conducted.
- Results showed that the two T. harzianum isolates effectively suppressed the mycelial growth of the three pathogens (Figure 30).
- Mycelial growth of B. oryzae, *S. oryzae* and *P. oryzae* were inhibited by 55.78, 47.32 and 74.52% when applied with TMDRi; and 53.91, 46.47 and 71.77% when applied with T5Oi. On the other hand, when applied with fungicide, growth inhibition was recorded at 12.58, 0.32 and 29.69%. These showed that the 3 pathogens were not controlled by the use of fungicide as compared to T5Oi and TMDRi which was more effective than fungicide application in inhibiting the mycelial growth of the three test pathogens (Figure 31).

- Microscopic observations showed mycoparasitic behavior of TMDRi like coiling around the hyphae of *S. oryzae*. The hyphae of T5Oi penetrated the hyphae of *S. oryzae* thus leading to breakage and shrinkage of the hyphae (Figure 32).

- Greenhouse assay of two *T. harzianum* isolates against *B. oryzae* and *S. oryzae* has on going set up in greenhouse (Figure 33).

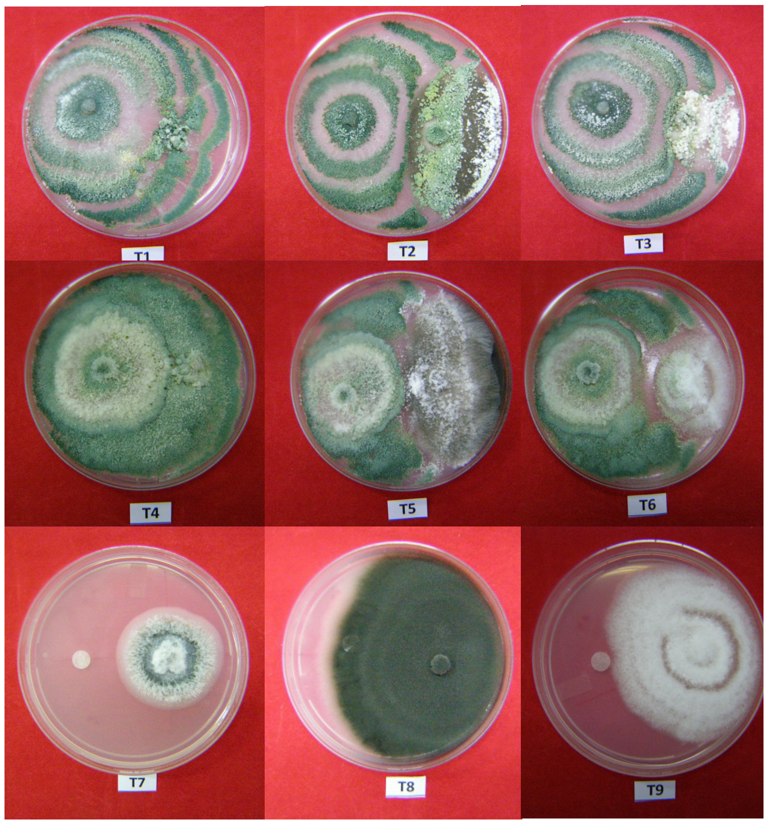


Figure 30. Trichoderma harzianum isolates (T5Oi & TMDRi) showing their antagonism against rice blast, brown spot, and sheath rot pathogens. Treatments were T5Oi against blast (T1), brown spot (T2) and sheath rot (T3); TMDRi against blast (T4), brown spot (T5) and sheath rot (T6); fungicide against blast (T7), brown spot (T8) and sheath rot (T9).

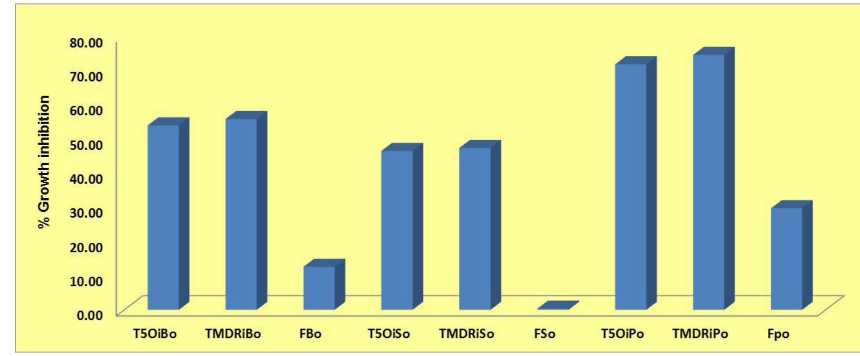


Figure 31. Mycelial growth inhibition of *Bipolaris oryzae, Sarocladium oryzae and Pyricularia oryzae* as affected by T5Oi, TMDRi and fungicide.

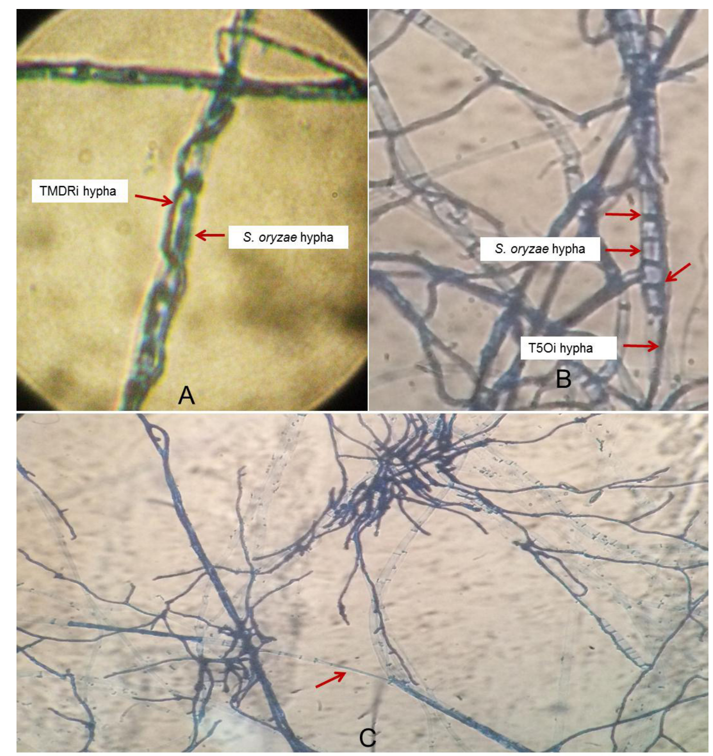


Figure 32. Microscopic observations showing the hyphae parasitized by TMDRi and T5Oi hyphae resulting in coiling (A), penetration (B) and shrinkage hyphae (C) of *Sarocladium oryzae*.

Figure 33. Greenhouse assay of 2 Trichoderma harzianum isolates applied as seed treatment in controlling *Bipolaris oryzae* (Bo) and *Sarocladium oryzae* (So).

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit
LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
mtha^{-1} - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

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