Philippine Rice R&D Highlights 2013

AGRONOMY, SOILS AND PLANT PHYSIOLOGY DIVISION

TABLE OF CONTENTS

AGRONOMY, SOILS AND PLANT PHYSIOLOGY

Division Head: Evelyn F. Javier

Executive Summary

To contribute to the PhilRice's goal of attaining and sustaining rice self-sufficiency, the ASPP Division leads national efforts in the conduct of quality research focused toward identifying, evaluating, refining, and facilitating delivery of improved soil, plant, nutrient, and water management practices that are resource-use efficient and environment-friendly for rice and rice-based ecosystems. The midterm goal perhaps is to package a holistic rice agronomy that will increase yield by 15% in less productive environments and sustain yield in high-yielding environments. In line with achieving this goal, the Division is composed of creative, innovative and highly trained research scientists on agronomy, plant physiology, soil and water science, and integrated yet diversified rice-based farming system. Each one works as a team member to achieve what the division is tasked to do according to its 2010 interim functional objectives, which are: (1) identify and propagate approaches for integrating management of principal insect pests and disease with compatible nutrient and crop management; (2) develop technologies that will improve soil and water conservation practices; (3) develop practices to manage crop residues for healthy soils in rice ecosystems; (4) strengthen the scientific basis for rice-based cropping system technologies; (5) participate in the efficacy assessment of new agricultural inputs; and (6) assess the impact of developed technologies on environmental quality. Ultimately, the Division will deliver an identified technology component(s) that had improved and sustained crop productivity as well as increased resource-use efficiency in less productive environments, and high yielding or favorable environments.

In 2013, 4 R&D projects were conducted to partially approach the main objective of the Division: (1) Long-Term Soil Fertility Evaluation and Rice Plant Responses (ASD-002), (2) Improved rice productivity and resource-use efficiency using diagnostic support systems (ASD-003), (3) Assessment and Evaluation of Crop Intensification and Resource Use Efficiency in Rice (ASD-004), and (4) ASPPD Research and Analytical Laboratory Systems and Maintenance (ASD -005).

Under the Project ASD-002, several studies were conducted in 2013 DS cropping to assess the effectiveness of the different strategies in managing the nitrogen (N) requirement of lowland rice varieties under the Maligaya soil condition. In the application of inorganic fertilizers following the fixed time and rate at critical growth stages, highest grain yield of 8.4 t/

ha was obtained with the application of 90 and 180 kg ha-1. On the other hand, highest grain yield of 8.0 t/ha was achieved using inorganic fertilizers following the LCC-based N management. Varietal differences were observed on their response to the LCC-based N management. Total amounts of N applied varied among rice varieties and these ranged from 65-165 kg ha-1. Another study showed that the application of organic fertilizers following the LCC-based N management showed lower grain yield levels (about 6 t/ha). However, the total amounts of N applied was very, very low (0.04-1.28 kg ha-1). These results should be verified to assess the indigenous nutrient supplying (INS) capacity of the test site in order to determine the efficacy of the organic materials used for topdress N fertilization. In one site, the INS of the test site without fertilizer application was 54.7, 9.5 and 62.1 kg N, P and K ha-1, respectively.

Agronomic efficiency of the applied N (AEN) from different fertilizer sources (inorganic and organic) varied among rice varieties tested. Higher AEN was observed in the rice varieties fertilized with lower N rates. AEN ranged from 2.4-45.7 kg grain kg N-1 applied. The traditional rice variety Balattinaw gave the lowest AEN, while the traditional rice variety Dinorado showed the highest AEN. Increasing the amounts of N applied did not further increase AEN. Hence, during the 2013 DS cropping, 60 and 90 kg N ha-1 was the optimum N required to achieve the yield potentials of the rice varieties tested.

Partial factor productivities from the applied N (PFPN) of the rice varieties tested varied during the 2013 DS cropping. The purely organically-grown rice varieties showed higher PFPN (65.7-414.0 kg grain produced kg N-1 applied). On the other hand, the application of 60 kg N ha-1 using inorganic fertilizer source also showed higher PFPN (97.8 0 kg grain produced kg N-1 applied).

Overall, the use of the LCC in managing the N requirement of the rice varieties tested was able to achieve their yield potentials. Furthermore, more grains were produced per unit of N applied with the use of lower rates of N from organic and inorganic sources.

For the ASD-004 project, four studies were conducted in 2013 Dry Season (DS) and additional 3 studies from terminated program were included in Wet Season (WS). In the first study, seven genotypes were assessed for the effect of N application on the root responses to progressive water deficit. Among the genotypes, DRS14 increased yield significantly with N application under drought condition. Plastic root system developmental responses were enhanced through total root elongation with availability of N prior to drought.

Raised bed with 20 cm layer of top soil and 5 cm gravel layer was constructed to screen the rooting ability of drought resistant lines for upland rice breeding. CT9993, DHL50, DHL138, DHL40, DHL141 and PLB2242 were among the 20 genotypes that have potential deep rooting ability in response to drought stress condition. Dinorado and Kinandang-patong were also observed to be drought tolerant. Among the root parameters, total root length, total lateral root length and deepest nodal root below the gravel showed significant contribution to dry matter production.

Ratooning ability of PSB Rc82, NSIC Rc169, Rc222, Rc224, Rc216, Mestiso 19, 20 and 29 were evaluated. Mestiso 20 had the highest main crop yield with 8.6 t/ha while Rc160 had the lowest grain yield with 6.1 t/ha. On the other hand, Rc160 produced the highest ratoon yield of 2.9 t/ha which was 47.5% of the main crop yield. Mestiso 29 and PSB Rc82 showed the lowest ratoon yield while NSIC Rc222 and Mestiso 20 barely produced panicles from the ratoon. In WS, Mestiso 19 had the highest grain yield at 8.9 t/ha while Mestiso 29 had the lowest grain yield at 5.2 t/ha. Similarly, Mestiso 19 produced highest ratoon yield while PSB Rc82 had the lowest. Ratoon crop growth duration had more influence on grain yield. Varieties with longer growth duration produced higher ratoon grain yield.

A study on resource use efficient technologies include reduced tillage operation, crop establishment through drum seeding, controlled irrigation, LCC-based N application and harvesting through the use of combine harvester. Varieties evaluated were SL8H and NSIC Rc202H (Mestiso 19). In DS, the total time used in drum seeding by 2 persons 3.7 hrs ha-1 and an energy input of 7.7 MJ ha-1. Higher partial factor productivity (PFP) from the applied N was obtained in the LCC-based N application (fixed time adjustable rate or FTAR). Rice yield energy output regardless of fertilizer treatments ranged from 84,908 to 90,386 MJ ha-1. WS cropping was affected by typhoon Santi during the early flowering stage which resulted in low yield.

SRI retained crop management practices like planting density of 1 seedling per hill, alternate wetting and drying (AWD) and weed management using a rotary weeder were evaluated and compared with conventional methods using PSB Rc82 and NSIC Rc222. In DS, planting density of 1 seedling per hill had significantly lower yield than 3 seedlings per hill but comparable with 2 seedlings per hill. In WS, grain yields in all planting densities were comparable. AWD had significantly higher yield (6.1 t/ha) than continuous flooding (CF) (5.7 t/ha) in DS but in WS, grain yield was significantly higher in CF (5.1 t/ha) than in AWD (4.8 t/ha). On weed management, there was no significant yield difference between rotary and hand weeding in both DS and WS.

Water and nutrient use efficiencies and input energy of varieties with high yield potential were evaluated using controlled irrigation (CI) and LCC-based N application. CI significantly reduced water and fuel usage and irrigation energy input compared with continuous flooding in DS and WS. Among varieties, NSIC Rc204H (M20), NSIC Rc240 and Rc224 showed significantly lower water and fuel usage and irrigation energy input than the control variety PSB Rc82 while Rc216 and Rc226 were comparable to Rc82 during DS. In LCC-based N application, Rc226 gave the highest yield but it showed lower NUE than Rc240 during DS. N energy inputs in Rc226 and Rc224 were significantly lower than Rc82, Rc216, Rc240 and M20. Water and nutrient use efficiencies and input energy were also affected by cropping season.

Alternative and potential sources of non-fossil fuel based nitrogen fertilizer for rice were evaluated. Homogeneity trial was conducted at PhilRice-CES in DS using PSB Rc82 and Mestiso 20. Seeds of tayum, saluyot, taiwan and native mungo variety were collected and planted during rice fallow period. Azolla was also incorporated in the soil during WS. No conclusive remarks can be drawn yet since the study is still at the initial stage. Germination of the collected green manure was very low. Scarification methods for better seed germination and propagation will still be optimized.

Results on the assessment of root plasticity of different genotypes to progressive drought and seedbed calibration for screening of rooting ability of drought resistant upland genotypes will indirectly help in coming up with resource use efficient technology because it will hasten the selection process of breeding materials. Moreover, identifying varieties or genotypes with high ratooning ability and efficient crop management practices are vital in increasing rice productivity. The search for potential sources of non-fossil fuel based fertilizers should be continued. Finally, more resource use efficient technologies need further evaluation before recommendation to farmers.

As part of the analytical services of the Division, the project ASD-005 also provided technical and laboratory assistance to 3 thesis students from Juan Salcedo Jr. of Honorato C. Perez Science High School in Cabanatuan City in their thesis, as well as research study concerning the issue of mine tailings leaks from Pacdal Benguet to the San Roque Dam down to the Agno River where the main irrigation system come from to the different paddy fields in Pangasinan and Tarlac. This was in coordination with the Climate Change Program of the Department of Agriculture.

I. Long-Term Soil Fertility Evaluation and Rice Plant Responses

Project Leader: WB Collado

Prior to being able to deliver an optimized integrated rice crop production management technology, several scientific information and basic data are needed as the basis of packaging a technology for specific rice ecosystem. Generally, this project will provide information on the short- and long-term trend in soil fertility of lowland rice fields; and on the assessment of several management approaches for soil, plant, water and nutrition, optimizing each component for increased grain production.

Specifically, the project aimed to 1) achieve maximum and stable rice production on a sustainable basis; (2) assess the short- and long-term trends in the yield gap between the potential and actual yield, and the indigenous nutrient supplying-capacity of the soil; (3) develop and improve soil, plant, nutrient and water management approaches that are yield- and soil fertility-enhancing; and (4) assess the nutrient and water productivities and use efficiencies of developed/improved nutrient and water managements strategies.

Long-term Fertility Experiment

WB Collado(PhilRice), EV Laureles and RJ Buresh (IRRI)

The Long Term Fertility Experiment has been on-going at the Philippine Rice Research Institute, Maligaya, Science City of Muñoz, Nueva Ecija since 1968. The study serves the purpose of studying the sustainability of intensive double rice cropping and in providing an early warning indicator of nutrient imbalances and nutrient mining that can occur with intensification in farmer's fields. The study aimed to achieve high and stable rice production on a sustainable basis in the treatment with full application of nitrogen (N), phosphorus (P) and potassium (K). The treatments with combinations of N, P, and K fertilizer enable an assessment of the long-term nutrient supplying capacity of the soil. The control without N, P and K fertilizer application enables an assessment of the long-term indigenous nutrient-supplying capacity of the study site.

Highights:

Grain Yield

- Mean grain yield differences among the fertilizer treatments during the dry (DS) and wet seasons (WS) were obtained (Figure 1). Highest mean DS grain yield of 7.77 t/ha was obtained in the LCC-based application of N (SSNM-N) plus 50 kg elemental P ha-1 and 100 kg elemental K ha-1. However, this yield level was comparable to the fixed time and adjustable rate (FTAR-N) application of 210 kg N ha-1 plus 50 kg P ha-1 and 100 kg K ha-1 (7.64 t/ha). Total N applied was 188 and 210 kg N/ha for the LCC-based N and for the fixed time and adjustable rate treatments, respectively. A saving of 11% in N was obtained in the LCC-based N management compared to the fixed time and adjustable rate management. In the WS, grain yields of the varieties tested in the +NPK treatments were found to be lower than the previous WS croppings. This can be attributed to the effect of the typhoon during the maturity stage. Thus, grain yields obtained in all the treatments applied with N with or without P and K were comparable. Notably, lower yields were obtained in the 0 NPK and 0 N+PK treatments. The total N applied in the SSNM-N treatment was 10 kg ha-1 higher than the FTAR-N treatment (90 vs. 80 kg ha-1);

- In the omission plot treatments, grain yields obtained were comparable to each other (DS: 4.14-4.92 t/ha; WS: 3.38-4.44 t/ha);

- Lowest grain yields were obtained in the control treatment or no application of N, P and K;

- The total annual grain yields (average of 3 varieties) obtained during the 2013 was significantly higher in the +NPK treatments (SSNM-N: 12.52 t/ha; FTAR-N: 11.75 t/ha) than the other treatments.

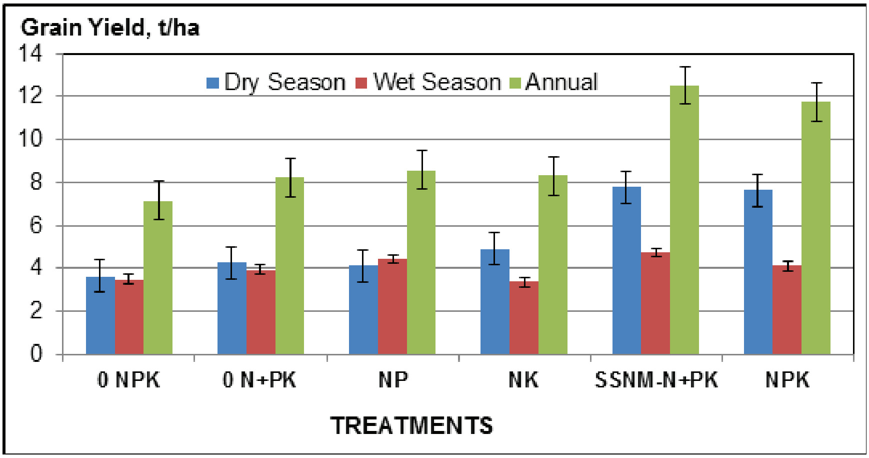


Figure 1. Mean dry season, wet season, and annual grain yields (average of 3 varieties) as affected by the different fertilizer treatments. 2013, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

Agronomic Efficiency and Partial Factor Productivity of Applied N

- In the DS, mean agronomic nitrogen-use efficiency (AEN) of the varieties tested in SSNM-N was 18.5 kg grain produced kg N-1 applied and was slightly higher than the FTAR-N management (16.0 kg grain kg N-1 applied). In the WS, AEN was only 8.9 and 2.0 kg grain produced kg N-1 applied in the SSNM-N and FTAR-N treatments, respectively. Again, this can be attributed to the effect of the typhoon during the maturity stage of the varieties tested.

- Similarly, partial factor productivity of the applied N was slightly higher in the SSNM-N compared to the FTAR-N (41.3 kg grain kg N-1 applied 34.6 kg grain kg N-1); the additional N in the FTAR-N did not further increase the amount of grains per unit N applied;

Indigenous Nutrient Supplies

- Indigenous nutrient supplies for N, P and K during the year are shown in Table 1;

- In the control treatment (no NPK), indigenous nutrient supplies during the cropping season were 54.7, 9.5 and 62.1 kg N, P and K per ha, respectively;

- In the -N, +PK treatment (0-30-50 kg NPK/ha), INS was higher at 64.4 kg/ha compared to the control treatment;

- Indigenous P supply (IPS) in the –P, +NK treatment was higher at 12.8 kg P/ha compared to the control treatment;

- Indigenous K supply (IKS) in the –K, +NP treatment was similar to the control treatment;

Table 1. The indigenous nutrient supply of the experimental site during the 2013 Dry Season cropping. PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

TREATMENT	Indigenous Nutrient Supply		
	INS	IPS	IKS
0-0-0 kg NPK/ha	54.7	9.5	62.1
210-30-0 kg NPK/ha			62.1
210-0-50 kg NPK/ha		12.8	
0-30-50 kg NPK/ha	64.4		

Long-term use of organic fertilizers in paddy soils

EF Javier and AE Espiritu

With the intent of packaging an organic-based nutrient management, an experiment on the continuous use of organic fertilizers in paddy soils was started in 2003 wet season at the PhilRice Central Experiment Station with soil type characterized as Maligaya clay soil series, to (1) determine the long-term effects of different organic fertilizers or amendments on the physico-chemical characteristics and nutrient availability for rice in paddy soils; (2) assess sustainability of grain yield production and soil health by just the use of organic fertilizers in paddy soils as compared to the use of inorganic fertilizers; (3) determine the agronomic efficiency due to application of organic fertilizer and to build-up database and information on the continuous effect of organic fertilizers for the development of an organic-based irrigated rice production management protocol.

The field experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Treatments include (1) organic fertilizers alone (OF); (2) combination of organic and recommended full rate of inorganic fertilizers and; (3) combination of organic and half the recommended rate of inorganic fertilizers. Control plot (without any amendment) and plots applied with only inorganic fertilizer were also included as check. Organic fertilizers included fresh rice straw (RS) incorporated 30 days before transplanting , rice straw with Effective Microorganism Base Inoculants (RSEM) incorporated 14 days before transplanting, chicken manure (CM) applied 7 days before transplanting; wild sunflower (WSF) incorporated 3 days before transplanting; and commercial organic fertilizers (COF) applied 7 days before transplanting. Recommended full rate for inorganic fertilizer was 120-40-60 kg NPK/ha for DS and 90-40-40 kg NPK/ ha for WS.

Highlights:

- In 2013 DS, among the OF tested, highest yield was obtained from plots treated with CM (5.3 tons/ha), from RS (5 t/ha) and, from RSEM (5.10 t/ha). Lowest yield was obtained from WSF plot (3.94 t/ha) and from the COF plot (4.14 t/ha).

- In 2013 WS, similar trend of grain yield was observed. Highest yield among OF tested was obtained from plots treated with RSEM (6.64 t/ha), from RS (5.71 t/ha) and, from CM (6.11 t/ha). Lowest yield was obtained from WSF plot (4.5 t/ha) and from the COF (4.92 t/ha) plot.

- At the average, highest yield (ave 7.27 t/ha) in the 2013 DS was still obtained in plots applied with the full rate of inorganic

NPK in combination with organic materials basally applied, regardless of the materials used. Likewise, using only 50% of inorganic NPK fertilizer rate combined with basal OF gave an average yield of 6.58 t/ha. Lowest yields were obtained from the applied OF alone (ave 4.70 t/ha), and from those applied with only 50% the recommended (5.87 t/ha). In the wet season, all fertilized plots yielded comparably (ave 5.76 t/ha), but higher than the unfertilized plots (4.76 t/ha). This showed the trend of getting similar yield among the OF and/or with and without IF every after 3 years of continuous use of organic fertilizers in paddy soils, but only in the wet season, not however in the dry season (Annual Rice R&D highlights 2012).

- In terms of agronomic use efficiency, the use of organic materials in combination with inorganic fertilizer either in full or half recommendation showed higher agronomic use efficiency in DS than in WS (Figure 3).

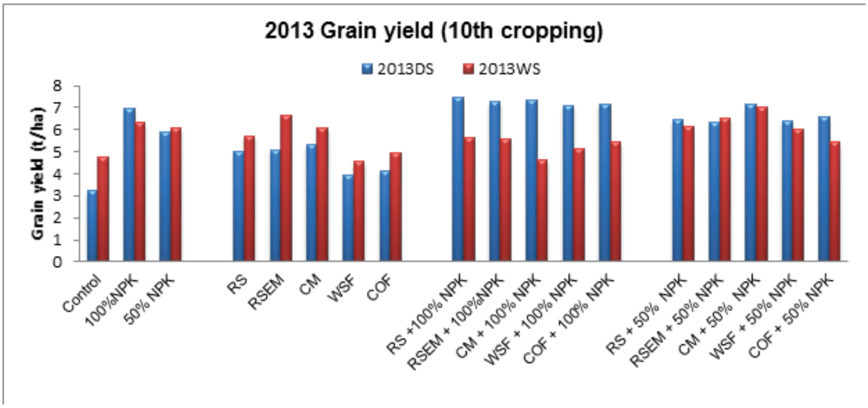


Figure 2. Grain yield (tons/ha) of PSB Rc82 applied with different types of organic and inorganic fertilizers in 2013 cropping season. 2013. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

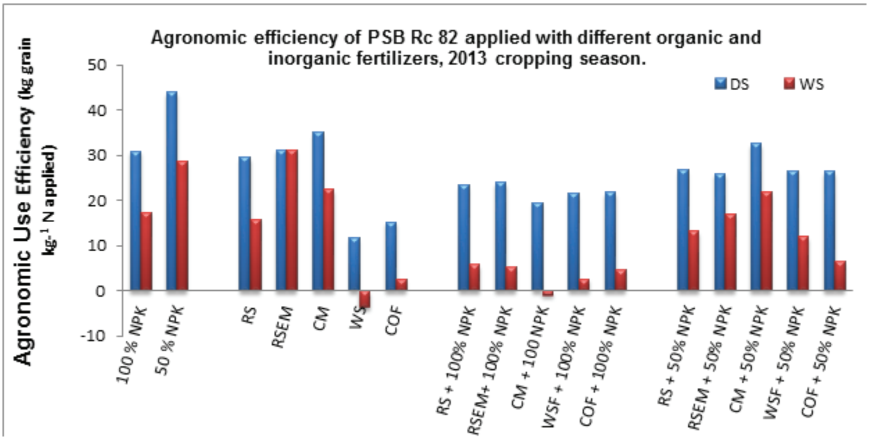


Figure 3. Agronomic use efficiency (kg grain kg-1 N applied) of PSB Rc82 applied with different types of organic and inorganic fertilizers in 2013 cropping season. 2013. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

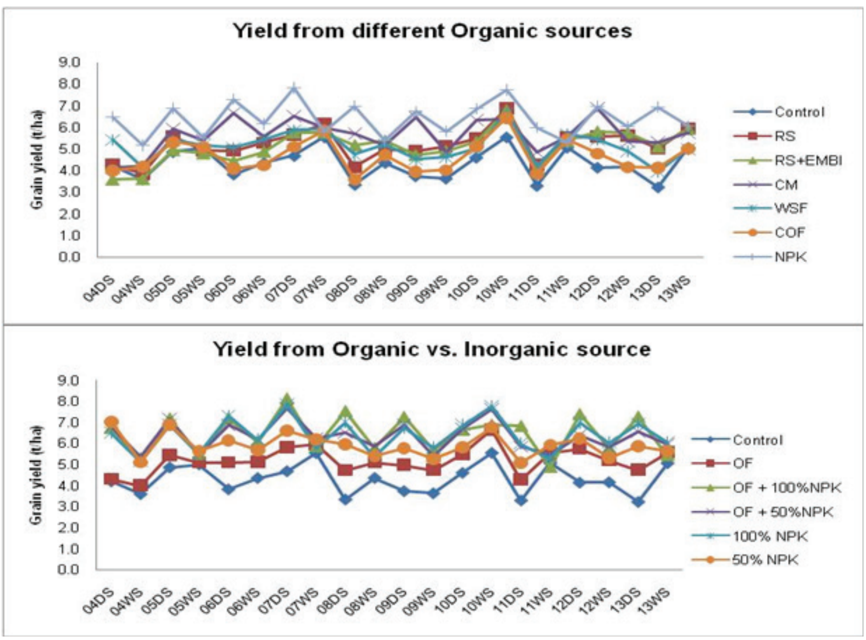


Figure 4. Yield of PSB Rc82 applied with different types of organic and inorganic fertilizers across seasons. Maligaya clay soil series. Science City of Muñoz, Nueva Ecija. (EFJavier, et al, 2013, PhilRice)

Evaluation of different organic source of nutrients to supply rice nutrient demands based on LCC level

XXG Sto. Domingo, AE Espiritu and EF Javier

Nitrogen (N) fertilizers, whether of organic or inorganic source, are essential for high rice yield. The Leaf Color Chart (LCC) is an easy-to-use and inexpensive tool to monitor crop N status in the field and determine the demand of N top-dress in any of the growth stages of the rice plant. Different rice varieties have different agronomical responses to N fertilizer hence may pose different LCC critical reading to suffice their N demand. Although several studies concerning the use of LCC had been conducted, its use in an organic-based nutrient management is rarely established yet. Hence, this study was conducted to assess and optimize LCC reading in different rice varieties at the application of Nitrogen from organic sources. Hybrid rice (Mestizo 19 in the dry season, Mestizo 20 in the wet season), and an inbred rice (PSB Rc 82) were planted into an organically applied plots (rice straw compost and chicken manure). Several top-dress fertilizers (inorganic foliar fertilizer (IFF), organic foliar fertilizer (OFF), urea, and wild sunflower (WSF)) were applied following 2 LCC critical readings (LCC3 and LCC4). All treatments were distributed in a split plot design (SPD) laid in randomized complete block design (RCBD).

Highlights:

- In DS, hybrid Mestizo 19 (7t/ha) showed higher yield than inbred PSB Rc82 (6.4t/ha) regardless of topdress fertilizer applied. In the WS the grain yield of the Mestizo 20 and PSB Rc82 were comparable (Table 3).

- In both seasons, regardless of rice variety tested, urea and wild sunflower (WSF) gave similar rice yield while organic (OFF) and inorganic (IFF) foliar fertilizers gave also the same grain yield. Likewise, solid or granular form of fertilizer (urea and WSF) gave higher yield than the foliar (OFF and IFF) form of fertilizer (Table 2).

- WSF can be used as alternative top-dress N fertilizer of urea due to better performance in both dry and wet seasons 2013 (Table 2) but it needs higher amount of volume to give the necessary N demand as per dictate by the leaf color chart and attain similar yield as that of urea fertilizers (Table 3).

- Generally, LCC 3 and LCC 4 have comparable grain yield (Table 2). For lesser volume of organic top-dress fertilizer, LCC 4 can be used.

- The interaction of the variety and treatments were observed to have an effect in wet season only (Table 3).

Table 2. Grain yield (t/ha) as affected by the applied different top-dress fertilizer treatments based on LCC readings in dry and wet season 2013. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

Treatments	Dry season	Wet Season
LCC 3	6.6	5.3
LCC 4	6.8	5.2
Urea	6.9 a	5.4 ab
Wild Sun Flower	7.3 a	5.6 a
Organic Foliar Fertilizer	5.7 b	4.9 bc
Inorganic Foliar Fertilizer	5.8 b	4.8 c

Table 3. Grain yield (t/ha) of different varieties as affected by different top-dress fertilizers (Volume of applied N sources and the estimated N applied), the application of which was determined by LCC readings in dry and wet season. 2013. PhilRice Central Experimental Station. Science City of Muñoz, Nueva Ecija.

Treatments (LCC readings x N sources)	Dry Season 2013					
	PSB Rc 82			Mestizo 19		
	volume applied	Estimated applied N (kg/ha)	Adjusted Grain yield to 14% grain moisture content (tons/ha)	volume applied	Estimated applied N (kg/ha)	Adjusted Grain yield to 14% grain moisture content (tons/ha)
LCC 3 Urea	3 bags/ha	69.00	7.30	3 bags/ha	69.00	7.33
LCC 4 Urea	11 bags/ha	241.50	7.15	8 bags/ha	172.50	6.86
LCC 3 WSF	18 tons/ha	570.60	5.70	9 tons/ha	285.30	6.34
LCC 4 WSF	21 tons/ha	665.70	5.69	18 tons/ha	570.60	6.57
LCC 3 OFF	7 li/ha	0.06	6.57	4 li/ha	0.04	7.99
LCC 4 OFF	8 li/ha	0.07	7.49	6 li/ha	0.06	7.98
LCC 3 IFF	6 kg/ha	1.09	5.86	3 kg/ha	0.55	6.24
LCC 4 IFF	7 kg/ha	1.28	5.72	6 kg/ha	1.09	6.50
Varietal Means			6.4 b			7.0 a

Treatments (LCC readings x N sources)	Wet Season 2013					
	PSB Rc 82			Mestizo 20		
	volume applied	Estimated applied N (kg/ha)	Adjusted Grain yield to 14% grain moisture content (tons/ha)	volume applied	Estimated applied N (kg/ha)	Adjusted Grain yield to 14% grain moisture content (tons/ha)
LCC 3 Urea	3 bags/ha	69	5.96 a	2 bags/ha	46	4.6 c
LCC 4 Urea	7 bags/ha	161	5.34 ab	7 bags/ha	161	5.83 a
LCC 3 WSF	12 tons/ha	380.4	5.09 bc	9 tons/ha	285.3	5.21 abc
LCC 4 WSF	21 tons/ha	665.7	4.85 bc	21 tons/ha	665.7	5.23 abc
LCC 3 OFF	5 li/ha	0.05	4.8 bc	5 li/ha	0.05	5.71 a
LCC 4 OFF	7 li/ha	0.07	5.86 a	7 li/ha	0.07	5.44 ab
LCC 3 IFF	6 kg/ha	1.09	4.42 c	5 kg/ha	0.91	5.25 abc
LCC 4 IFF	7 kg/ha	1.28	4.94 bc	7 kg/ha	1.28	4.89 bc
Varietal Means			5.2			5.3

Evaluation of nutrient diagnostic techniques based on yield and nutrient-use efficiency of rice

MVR Bascon and RT Cruz

There are a number of nutrient diagnostic techniques (NDTs) used as bases for fertilizer recommendation. The current NDTs are: (1) the PalayCheck System of integrated crop management that uses the Leaf Color Chart (PCheck-LCC) for in situ 'real-time' assessment of leaf N status, (2) Minus-One Element Technique (MOET) for determining N, P, K, Zn, and S deficiencies by visually assessing plant nutrient deficiency symptoms for the particular fertilizer element not applied, while applying the rest of the required elements in the pot of soil under irrigated lowland condition at the vegetative stage, (3) Soil Test Kit (STK) that uses a prepared solution for a fairly dry soil sample to determine soil pH and NPK levels by colorimetric method and uses a table for the fertilizer recommendation, and (4) Nutrient Manager (NM), a software program providing fertilizer recommendation based on standard soil and crop input data. However, the availability of many NDTs can be confusing to farmers and technicians. Thus, evaluation of the NDTs based on grain yield and nutrient-use efficiency can aid farmers and technicians in choosing which NDT to use.

The test rice variety was the popular PSB Rc82 that received the following fertilizer treatments: (a) Control or No Fertilizer application; (b) Indigenous Nitrogen Supply or INS with application of 0-40-40 kg NPK/ha in dry season (DS) and 0-30-30 kg NPK/ha in wet season (WS) at 14 days after transplanting (DAT); INS plots were used to estimate the indigenous soil N supply and agronomic N-use efficiency of the NDTs; (c) PhilRice General Fertilizer Recommendation with application of 120-60-60 kg NPK/ha in DS and 90-40-40 kg NPK/ha in WS wherein 50% N and all phosphorus (P) and potassium (K) were applied at 14 DAT, 25% N at active tillering (AT) and 25% N at panicle initiation (PI); (d) MOET with LCC-based N application and P and K application based on deficiency symptoms; (e) PalayCheck System with LCC-based N application and application P and K for maintenance, i.e., 42-42 kg PK/ha in DS and 28-28 kg PK/ha in WS at 14 DAT; (f) STK with application of 120-20-60 kg NPK/ha in DS and 60-30-0 kg NPK/ha in WS wherein 50%N and all PK at 14 DAT and 50% N at PI; (g) Nutrient Manager with application of 150-35-65 kg NPK/ha in DS and 126-32-32 kg NPK/ha in WS wherein 20% N and all PK at 14 DAT, 40% N at AT and 40%N at PI and (h) Farmer's Fertilizer Practice with application of 106-14-14 kg NPK/ha in DS and 60-30-20 kg NPK/ha in WS wherein 56% N and all PK were applied at 14 DAT, 22% N at PI and 22% N at flowering.

Highlights:

- In the Control or No Fertilizer treatment, grain yield of PSB Rc82 was 4.5 t/ha which was comparable to grain yield of 4.8 t/ha in the INS treatment, i.e., no N but with P and K. This indicated that nitrogen (N) was more limiting than phosphorus (P) and potassium (K).

- Results from all NDTs showed that N was limiting in 2013 DS and WS. In DS, P and K applications were recommended by PCheck-LCC, STK and NM. In WS, P application was recommended by PCheck-LCC, STK and NM. K application was recommended by PCheck-LCC and NM. P and K application was not recommended by MOET in DS and WS. P and K applications were recommended by PCheck-LCC and NM to replenish P and K removed during harvest or as maintenance dose. STK recommended K application due to non-K application during 2012 cropping season.

- In DS (Figure 5A), LCC readings in the Control and N omission plot (i.e., -N, +P, +K) ranged from 2.5 to 3.1. LCC readings peaked at 28 DAT and continuously decreased up to 56 DAT. This indicates nitrogen deficiency throughout DS when N was not applied. When N was applied, average LCC readings of MOET ranged from 3.0 to 3.5 and PCheck-LCC ranged from 3.0 to 3.7. N applications were done at 14, 21 and 56 DAT in MOET and PCheck-LCC. N applications at 14 and 21 DAT resulted to sufficient N supply as indicated in Figure 1A. Relatively lower LCC readings were recorded for STK, Gen Fertilizer Recommendation, MOET and FFP but still above the Control and N omission plot. Based on N application in Table 1 and LCC readings in Figure 1A, total application of 60-80 kg N/ha up to 21 DAT, regardless of PK application, resulted to sufficient N supply up to 42-49 DAT. Total application of 90 kg N/ha up to 21 DAT resulted to sufficient N supply until the late reproductive stage.

- In WS (Figure 5B), LCC readings in the Control and N omission plot (i.e., -N, +P, +K) ranged from 3.0 to 3.7. LCC readings peaked at 21 DAT and continuously decreased until 56 DAT. LCC readings of MOET ranged from 3.2 to 4.0 and PCheck-LCC ranged from 3.1 to 3.9. N application (as top-dress) was done once in MOET at 49 DAT and in PCheck-LCC at 35 DAT. LCC readings in NM and STK did not decrease below 3.4. This indicated that 30-53 kg N/ha application during vegetative stage was sufficient in WS. When compared to DS, gaps in LCC readings among NDTs and between NDTs and N omission plot were narrower due to lower irradiance, hence, the lower demand for N in WS.

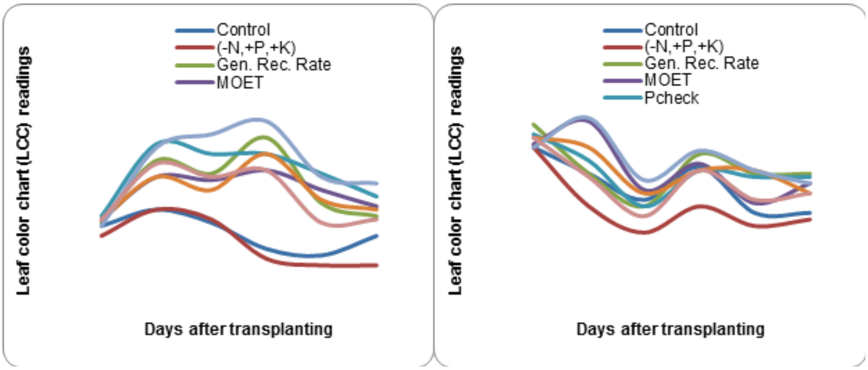


Figure 5. Leaf color chart (LCC) readings of the Control, Nitrogen Omission Plots and different NDTs in 2013 dry season (A) and wet season (B).

- Grain yields of the different NDTs ranged from 6.7 to 7.2 t/ha in DS and 4.8 to 6.0 t/ha in WS. No significant difference was observed among NDTs in both seasons (Table 4). Based on yield components, no significant difference was observed among NDTs. The number of tillers, associated with the number of panicles per unit area, did not vary among NDTs. In WS, grain yields were lower with MOET and NM than the other NDTs. This was probably due to higher N application during panicle initiation to flowering stages and ranged from 23 to 53 kg N/ha. N application at later stage resulted to lodging in MOET and NM, hence, the lowering of grain yield.

- Agronomic N-use efficiency (ANUE) ranged from 15.7 to 38.4 kg grain per kg N applied in DS and -6.5 to 15.7 kg grain per kg N applied in WS (Table 4). In DS, the Farmers Fertilizer Practice (FFP) had the highest ANUE of 38.4 kg grain per kg N applied and NM had the lowest ANUE of 15.7 kg grain per kg N applied. The high ANUE observed with FFP was due to lower N application at vegetative stage from 0-35 DAT and at heading stage. The high estimated INS required low N application of <50 kg N/ha within 21 DAT. High N application within this period could result to low N recovery. This was shown with NM with low ANUE due to high N application of 150 kg N/ha at 0-35 DAT. The next higher ANUE was observed with PCheck-LCC.

- In WS, PCheck-LCC, with its capacity for 'real-time' assessment of plant N status, had the highest ANUE of 15.7 kg grain per kg N applied. MOET had the lowest ANUE of -6.5 kg grain increase per kg N applied. Likewise, NM and FFP had negative ANUEs. The low to negative ANUE values suggest that with lower irradiance in WS, crop demand for N is lower, hence, lower amount of N fertilizer can be applied. Also, the fairly adequate indigenous N supply, as indicated by the N omission plot, can supply part of the crop demand for N in WS.

Table 4. Grain yield and Agronomic N-use efficiency (ANUE) of different NDTs in 2013 dry and wet seasons.

Treatment	Dry Season			Wet Season		
	Grain yield *(ton/ha)*	**Total NPK applied** *(kg NPK/ha)*	**ANUE** *(kg grain per kg N applied)*	**Grain yield** *(ton/ha)*	**Total NPK applied** *(kg NPK/ha)*	**ANUE** *(kg grain per kg N applied)*
Control	4.5 b		-	6.7 a		-
(-N,+P,+K)	4.8 b		-	5.2 a		-
Gen. Rec. Rate	7.1 a	120-60-60	19.4 a	5.1 a	90-40-40	-0.6 a
MOET	6.8 a	105- 0- 0	19.2 a	4.9 a	46- 0- 0	-6.5 a
PCheck-LCC	7.1 a	112-42-42	20.5 a	6.0 a	51-28-28	15.7 a
STK	6.8 a	120-20-60	16.9 a	5.3 a	60-30- 0	0.4 a
NM	7.2 a	150-35-65	15.7 a	4.8 a	126-32-32	-1.6 a
FFP	6.7 a	106-14-14	38.4 a	5.9 a	60-30-20	-1.2 a

Yield potential, nitrogen-use efficiency and grain quality of irrigated lowland rice varieties

HA F Makahiya, HM Corpuz, MV Romero, EC Arocena and RT Cruz

Yield potential is the maximum yield of a variety in an environment where nutrient and water are non-limiting and with minimum pests under favourable weather condition. Reports showed that yield potential and grain quality, such as protein content, are negatively correlated. This study aimed to assess the yield potential, nitrogen use efficiency and grain quality of different varieties in response to varying nitrogen (N) management. Field experiment was conducted at PhilRice Central Experiment Station in 2013 dry season (DS) and wet season (WS). Varieties tested were inbreds NSIC Rc148 (111 days), NSIC Rc160 (122 days), NSIC Rc222 (114 days), NSIC Rc240 (115 days), NSIC Rc13 (glutinous rice, 120 days), PSB Rc82 (110 days), hybrid Mestiso 20 (111 days), and traditional variety Balatinaw (pigmented rice, 115 days). Fertilizer treatments used were: (1) Control or no N fertilizer with adequate phosphorus (P) and potassium (K), (2) fixed-time N fertilizer application for a total of (a) 60 kg N/ha, (b) 90 kg N/ha and (c)

180 kg N/ha, wherein N fertilizer was applied in three splits, i.e., 14 days after transplanting (DAT), early panicle initiation (EPI) and heading, and (3) "real-time" LCC-based N fertilizer application wherein 35 kg N/ha in DS and 23 kg N/ha in WS were applied when LCC reading was below the critical value of 4. LCC readings were done weekly from 21 DAT until early flowering. Adequate P and K fertilizers were applied at 14 DAT. Grain yield (t/ha) was obtained from a 5 m2 sample area and adjusted to 14% grain moisture content. Agronomic nitrogen use efficiency [ANUE = (kg grain yield/ha in N fertilized plot – kg grain yield/ha in unfertilized plot) / total N fertilizer applied] was estimated from the difference between grain yields in N fertilized plot and plot that did not receive N fertilizer divided by total amount of N fertilizer applied.

Highlights:

- The fixed-time N fertilizer application with a total of 60, 90 and 180 kg N/ha, had an initial application of complete fertilizer of 14-14-14-12S at 14 DAT in DS and WS. In DS, in the control with no N fertilizer, grain yields ranged from 3.2 t/ha for the traditional variety Balatinaw to 5.8 t/ha for inbred NSIC Rc222 (Figure 6A). Grain yields ranged from 3.3 t/ha for Balatinaw to 7.3 t/ha for Mestiso 20 at 60 kg N/ha, from 4.4 t/ha for Balatinaw to 8.4 t/ha for NSIC Rc240 with 90 kg N/ha and from 3.7 t/ha for Balatinaw to 8.4 t/ha for Mestiso 20 at 180 kg N/ha. Balatinaw had the lowest yield among varieties tested across N fertilizer levels. Except for the hybrid Mestiso 20, most of the varieties achieved the optimum yield at 90 kg N/ha in DS. Hybrid Mestiso 20 had the highest yield of 8.4 t/ha at 180 kg N/ha. In WS, except for Mestiso 20 and NSIC Rc240, grain yields of most varieties tested were optimum at 60-90 kg N/ha (Figure 6B). Seasonal yield differences could be associated with lower irradiance in WS than in DS (37.2 MJ/m2/day in DS and 28.0 MJ/m2/day in WS). With lower irradiance in WS, the crop demand for N is lower.

- The "real-time" LCC-based N fertilizer application with a total of 65-135 kg N/ha in DS and 53-76 kg N/ha in WS had an initial application of complete fertilizer of 14-14-14-12S at 14 DAT. In DS for LCC-based N application, PSB Rc82 received the highest total N fertilizer application of 135 kg N/ha. The other varieties received a total of 65 kg N/ha (Figure 6C). With high amount of total N fertilizer applied, PSB Rc82 had a grain yield of 8.0 t/ha. However, the grain yield of PSB Rc82 was comparable to yields of 5.4-7.4 t/ha for other varieties that were achieved at a relatively lower total N fertilizer application of 65 kg N/ha. Hence, "real-time" LCC-based N fertilizer application can save in cost of N fertilizer. In WS, the total N fertilizer applied ranged from 53-76 kg N/ha (Figure 6D). Grain yields of varieties ranged from 2.3-5.4 t/ha.

- In DS, with fixed-time N fertilizer application for a total of 60 kg N/ha, the ANUEs of varieties ranged from 1.0-34.9 kg grain/kg N applied (Figure 7A). Balatinaw had the lowest ANUE of 1.0 kg grain/kg N applied. With 90 kg N/ha, the ANUEs of varieties ranged from 12.6-33.5 kg grain/kg N applied. With 180 kg N/ha, the ANUEs of varieties ranged from 2.5-18.0 kg grain/kg N applied. With "real-time" LCC-based N fertilizer application,, the ANUEs of varieties ranged from 6.4-34.1 kg grain/kg N applied and was significantly higher than ANUEs of varieties with fixed-time N fertilizer application for a total of 180 kg N/ha. Hence, with "real-time" LCC-based N fertilizer application, savings in N fertilizer can be as high as 33%. In WS, the ANUEs of varieties ranged from -1.7 to 19.4 kg grain/kg N applied with 60 kg N/ha, -8.1 to 12.3 kg grain/kg N applied with 90 kg N/ha, -1.2 to 4.9 kg grain/kg N applied with 180 kg N/ha and -8.7 to 11.5 kg grain/kg N applied with LCC-based N application (Figure 7B). Negative values could be due to higher yield in Control than yields in Fertilized Treatments usually observed in WS.

- Across seasons, trends in grain yield and ANUE varied among varieties and fertilizer treatments. With fixed-time N fertilizer application, the inbreds, hybrid and traditional varieties had optimum yields with total N fertilizer application of 90 kg N/ha in DS and 60-90 kg N/ha in WS. Compared to fixed-time N fertilizer application, the "real-time" LCC-based N fertilizer application can achieve grain yield potential and higher ANUE. Except for the traditional variety Balatinaw that had lower yield and ANUE, the inbred and hybrid rice varieties with comparable grain yields, had higher ANUEs with the "real-time" LCC-based N application method than with fixed-time N application. This translated to savings in N fertilizer of 25% and 58% in DS and WS, respectively. The harvest index of 0.4 for Balatinaw can be associated with its lower grain yield and ANUE. The average harvest index of 0.5 for inbreds and hybrid is associated with higher grain yields and ANUE.

- The grain samples in 2013 DS and WS are being analysed in the laboratory for milling potential, physical attributes like grain length, grain weight and chalky grains, and physico-chemical properties like amylose content, gelatinization temperature and crude protein content.

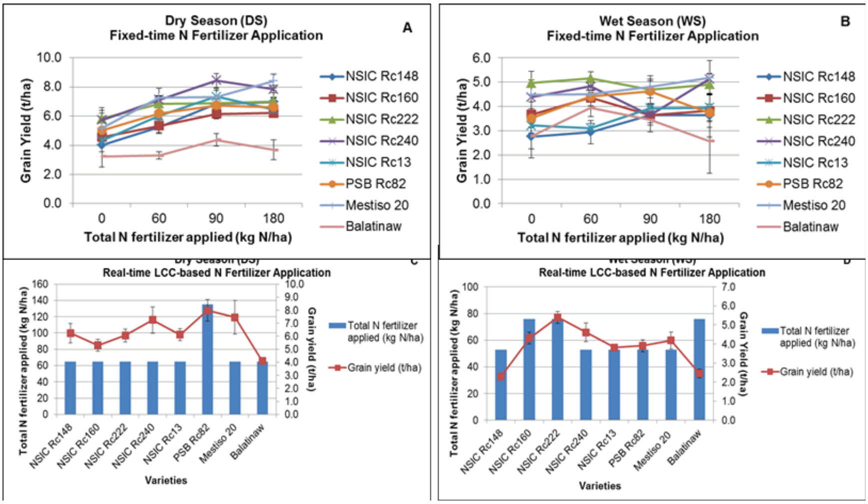
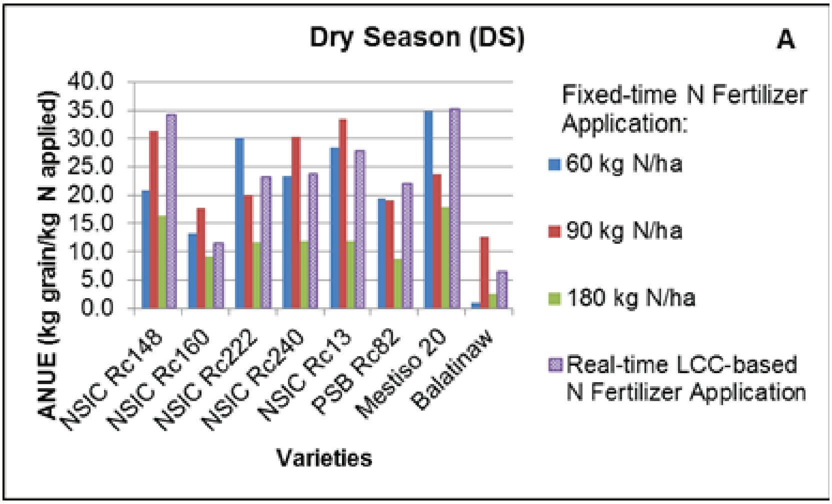


Figure 6. Grain yield (t/ha) of irrigated lowland rice varieties in response to fixed-time N fertilizer application for a total of 0, 60, 90 and 180 kg N/ha in dry season, where N was applied in three equal splits at 14 days (after transplanting (DAT), early panicle initiation and heading in (A) DS and (B) WS and total N fertilizer applied (kg N/ha) and grain yield (t/ha)of irrigated lowland rice varieties in response to real-time LCC-based N fertilizer application. LCC-based total N fertilizer applied ranged from 65 to 135 kg N/ha in (C) DS and ranged from 53 to 76 kg N/ha in (D) WS. Both the fixed-time N fertilizer application and real-time LCC-based N fertilizer application had an initial application of complete fertilizer, i.e. 14-14-14-12S in DS and WS. Vertical bars indicate standard error of the mean.



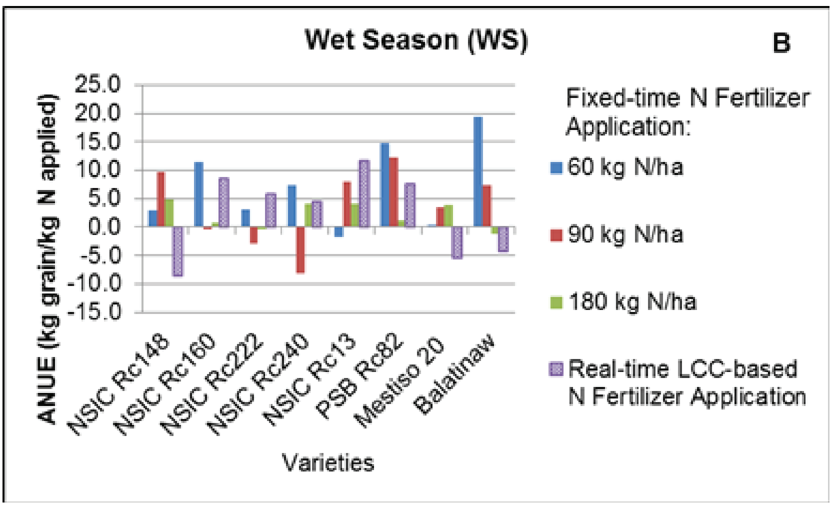


Figure 7. Agronomic nitrogen use efficiency or ANUE (kg grain/kg N applied) of irrigated lowland rice varieties in response to fixed-time N fertilizer application for a total of 0, 60, 90 and 180 kg N/ha in dry season, where N was applied in three equal splits at 14 days (after transplanting (DAT), early panicle initiation and heading, and in real-time LCC-based N fertilizer application in (A) DS and (B) WS. LCC-based total N fertilizer applied ranged from 65 to 135 kg N/ha in DS and ranged from 53 to 76 kg N/ha in WS. Both the fixed-time N fertilizer application and real-time LCC-based N fertilizer application had an initial application of complete fertilizer, i.e. 14-14-14-12S in DS and WS.

II. Improved rice productivity and resource-use efficiency using diagnostic support systems

Project Leader: CA Asis, Jr./EF Javier

To reduce inputs, and minimize losses of water and nutrient, development of diagnostic support systems, and improvement of current techniques are considered in this project. It aimed to have precise amount, on-time application, and right amount of nutrient and water supplement to rice paddies, both in rainfed and irrigated, thus increasing nutrient use and water use efficiency of evaluated high-yielding varieties. Crop modelling, evaluation of the existing nutrient diagnostic techniques, and development and optimizing new decision support tools to predict real-time need of fertilizer and irrigation water under optimum nutrient, and real-time monitoring of irrigation water need are some of the activities to be done.

The use of Decision Support System for Agrotechnology Transfer (DSSAT) rice crop model to evaluate the potential yield of irrigated lowland rice under different nutrient management levels and climate types in the Philippines. I. Nueva Ecija (Type II climate)

HAF Makahiya, FH Bordey and RT Cruz

The Decision Support System for Agrotechnology Transfer (DSSAT) is an application software developed to integrate the effects of crop genotype, soil, weather, and management options. In the calibration of the model, a set of genetic coefficients of the rice varieties will be obtained. Genetic coefficients are values that describe the phenology and growth stages of the varieties. Once the model is calibrated, DSSAT can be used to simulate potential yield of varieties under optimum crop management in different locations with varying weather conditions. The observed yield potential from the well-managed experimental field and simulated potential yield will be compared to validate the rice crop model. Hence, the DSSAT CERES-rice crop model was utilized in this study to establish a new protocol to determine the yield potential of different inbred and hybrid rice varieties, determine the nitrogen management practice that will optimize the yield potential and nitrogen use efficiency of the test varieties, and determine the optimum nitrogen management practice for similar varieties under different climate types in irrigated lowland rice areas in the Philippines.

Field experiment was conducted in 2012 dry (DS) and wet (WS) seasons to assess the yield potential and agronomic nitrogen use efficiency (ANUE) of three varieties namely, PSB Rc82 (110 days), NSIC Rc160 (122 days) and Mestiso 20 (111 days) under varying NPK ratios. Fertilizer treatments were: (1) Control or no fertilizer, (2) -N, +P, +K where 30 kg/ha in DS and 40 kg each in DS of P and K fertilizers were applied, (3) LCC-based N fertilizer application with 4:2:1 NPK ratio where 35 kg N/ha in DS and 23 kg N/ha in WS were applied when LCC reading was below 4, (4) LCC-based N fertilizer application with 4:1:2 NPK ratio where 35 kg N/ha in DS and 23 kg N/ha in WS were applied when LCC reading was below 4, and (5) growth stage-based N fertilizer management where N was applied in three splits: 35 kg N/ha (DS) and 23 kg N/ha (WS) each at mid-tillering, panicle initiation (EPI), and flowering stages. All P and K fertilizers were applied at 14 days after transplanting (DAT). LCC reading was done every week that began at 21 DAT until early flowering. Grain yield (t/ha) was obtained from 5 m2 sample area and adjusted to 14% grain moisture content. In 2012 DS and WS, the soil, weather, crop management data and experimental data on growth and phenology were collected and inputted into the CERES-Rice model in the DSSAT program. Different sets of genetic coefficients for each variety were generated using the GenCalc tool in DSSAT. The genetic coefficients generated were used to initially validate the model using a different set of data. Using an experiment with varying N levels conducted in PhilRice Nueva Ecija in 2013 DS, the soil, weather and management data were inputted into the model. The genetic coefficients of PSB Rc82, NSIC Rc160 and Mestiso 20 were used to simulate the panicle initiation, anthesis, maturity and potential grain yield under 0, 60, 90 and 180 kg N/ha. The simulated and observed values were compared to validate the model performance using the root mean square error {RMSE = $\sqrt{}$ [$\sum$ (simulated value - observed value)^2/number of samples)]}. The normalized RMSE [nRMSE = (RMSE/mean of measured values)] was determined to express the mean difference as a percentage of the average of the observed values.

Highlights:

- The genetic coefficients of PSB Rc82, NSIC Rc160 and Mestizo 20 were shown in Table 5. Each variety had one set of genetic coefficients. The genetic coefficients generated will be used to simulate the potential yield of PSB Rc82, NSIC Rc160 and Mestizo 20 under different nutrient management levels in different climate types in the Philippines.

Table 5. Initial genetic coefficients of PSB Rc82, NSIC Rc160 and Mestizo 20 generated using the GenCalc tool in the DSSAT model using data from Nueva Ecija with Type II climate.

Codes	Genetic Coefficients		
	PSB Rc82	NSIC Rc160	Mestizo 20
P1	566.1	691.2	469.5
P2R	171.2	91.71	170.7
P5	338.8	335.0	458.8
P2O	11.71	11.62	10.48
G1	59.09	55.64	58.20
G2	0.026	0.025	0.027
G3	0.954	0.552	0.879
G4	1.19	1.187	0.97

Note: P1- basic vegetative phase of the plant (GDD); P2R- extent to which phasic development leading to panicle initiation is delayed (GDD); P5- beginning of grain filling to physiological maturity (GDD); P2O- critical photoperiod or longest daylength at which the development occurs at a maximum rate (hr); G1- potential spikelet number coefficient; G2- single grain weight (g); G3- tillering coefficient (scaler value); G4- temperature tolerance coefficient.

- In DS, the simulated values in PSB Rc82 with 50 days for panicle initiation, 84 days for anthesis and 111 days for maturity were similar in 0, 60, 90 and 180 kg N/ha fertilizer treatments but the simulated grain yields differed across N levels. The calculated nRMSEs were 7% for panicle initiation, 1% for anthesis, 2% for maturity and 10% for grain yield. The simulated values for NSIC Rc160 were 56 days for panicle initiation, 91 days for anthesis and 117 days for maturity. These simulated values were similar across fertilizer treatments except for simulated grain yields. The calculated nRMSE were 2% each for panicle initiation and anthesis, 0% for maturity and 7% for grain yield. The simulated values for Mestiso 20 were 55 days for panicle initiation, 91 days for anthesis and 119 days for maturity. These simulated values were similar across fertilizer treatments except for simulated grain yields. The calculated nRMSE were 1% each for panicle initiation, 3% each for anthesis and maturity, and 9% for grain yield. The low nRMSE i.e. $< 10\%$ based on literatures may indicate good predictive capability of the model using the generated genetic coefficients for all varieties. However, these initial results were obtained from a different experiment, i.e. different treatments, conducted in similar sites. Hence, simulation of growth, development and potential yield will have to be done using experimental data from different sites with different weather and soil conditions.

- In general, the DSSAT CERES-Rice crop model was able to generate the genetic coefficients for PSB Rc82, NSIC Rc160 and Mestiso 20. Using these genetic coefficients, simulated values for panicle initiation, anthesis, maturity and potential grain yield were obtained from the different N level treatments. The calculated nRMSEs were low but this could be due to similarities in soil and weather conditions in the given site.

Table 6. Comparison of simulated and observed panicle initiation, anthesis, maturity and grain yields of PSB Rc82, NSIC Rc160 and Mestiso 20. RMSE = Root Mean Square Error. nRMSE = Normalized Root Mean Square Error using observed values. DAP = days after planting.

Data/Variety	0 kg N/ha		60 kg N/ha		90 kg N/ha		180 kg N/ha		RMSE	nRMSE
	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed		
PSB Rc82										
Panicle initiation (DAP)	50	54	50	54	50	54	50	54	4.0	0.07
Anthesis (DAP)	84	85	84	85	84	85	84	85	1.0	0.01
Physiological maturity (DAP)	111	109	111	109	111	109	111	109	2.0	0.02
Grain yield (kg/ha)	3966	5026	6058	6195	6900	6740	7126	6616	597.5	0.10
NSIC Rc160										
Panicle initiation (DAP)	56	55	56	55	56	55	56	55	1.0	0.02
Anthesis (DAP)	91	93	91	93	91	93	91	93	2.0	0.02
Physiological maturity (DAP)	117	117	117	117	117	117	117	117	0.0	0.00
Grain yield (kg/ha)	4473	4550	5914	5340	6542	6147	6655	6204	416.8	0.07
Mestiso 20										
Panicle initiation (DAP)	56	55	56	55	56	55	56	55	0.5	0.01
Anthesis (DAP)	89	91	89	91	89	91	89	91	2.8	0.03
Physiological maturity (DAP)	116	119	116	119	116	119	116	119	3.8	0.03
Grain yield (kg/ha)	4932	5159	7446	7251	8436	7291	8962	8397	655.7	0.09

III. Assessment and Evaluation of Crop Intensification and Resource-Use Efficiency in Rice Production

Project Leader: MD Malabayabas

With the country's current goal to achieve rice self sufficiency, rice productivity must be continuously improved. Crop intensification and resource use efficient technologies can be adopted to meet the demand for rice of the growing population. Ratooning of rice is another practical way of increasing production per unit area and per unit time (Krishnamurthy 1988). However, crop management practices must be further improved to make ratooning more feasible. The System of Rice Intensification (SRI) has also gained interest for it offers many advantages to farmers. Crop management practices in SRI have evolved and the merits of these retained practices through time need further evaluation. Many farmers and stakeholders will be encouraged to produce more rice even in marginal areas when rice farming technologies are cost-effective. The use of responsive varieties especially in drought prone areas and the appropriate crop management are likewise important.

Effect of nitrogen application before the onset of drought on the plastic root system development responses to progressive water deficit in rice

NB Lucob, JM Niones and RR Suralta

Crop productivity under drought is determined by maintained water uptake during progressive soil drying. However, the ability to maximize soil water capture depends on the degree of plastic root system development in response to progressive drought. This study examined that the availability of Nitrogen (N) can enhance plastic root system development during onset of drought in rice.

Seven genotypes (DrS14, DrS111, DrS66, IR64, NSIC Rc9, NSIC Rc11 and DHL98) were grown under continuously waterlogged (CWL) and drought (DR, simulated rainfed) conditions with two N fertilizer treatments without N (-N) as control and with 30 kg ha-1 N (+N) applied at 60 DAT before the onset of drought during the panicle initiation under field conditions during Dry Season (DS).

In Wet Season (WS), IR64 as control genotype and DrS14 and NSIC Rc11 with high Nitrogen response were used in the green house set-up. The genotypes were grown under continuously waterlogged (CWL) and drought (DR) conditions with different N fertilizer rates: 0 kg ha-1 N (control), 60 kg ha-1 N, 90 kg ha-1 N and 120 kg ha-1 N. Nitrogen fertilizer was applied before the onset of drought during the panicle initiation under field conditions.

Highlights:

- Genotypic variations in grain yield were correlated with harvest index and total biomass with limited available N under DR (Table 7). However, with more N available in the soil, genotypic variations in grain yield were strongly and positively correlated with 1000 grain weight, total biomass, harvest index and percent filled grains per panicle.

- Among genotypes, root system development response based on total root length (TRL) in DrS14, IR64 and NSIC Rc11 only tended to increase with the availability of N fertilizer before the onset of drought (Figure.8). DrS 14, IR64 and NSIC Rc11 had an increase of 25%, 35%, 52.21% and 95.0 % in total root length, respectively. Under CWL, only IR64 and NSIC Rc11 had an increase in total root length with N fertilizer application during the panicle initiation stage.

- In DS, plastic root system developmental responses were apparently enhanced through total root elongation with the availability of N prior to drought. Consequently, this contributed to the increase in yield and biomass production. This was particularly observed only with DrS14 and IR64.

- In WS greenhouse set-up, there was an interaction between the genotype and different fertilizer N rates applied before the onset of drought on the grain yield. Among genotypes, grain yield of DrS14 was significantly increased with 90 kg ha-1 N application (Figure.9).

Table 7. Grain yield and total biomass of seven genotypes with different N fertilizer treatment grown under CWL and DR conditions.

	Grain yield (tons/ha)		Biomass (tons/ha)	
	-N	+N	-N	+N
CWL				
NSIC Rc9	10.25 abc	10.40 abc	15.06 a	15.97 a
DRS111	9.52 abc	8.60 abc	12.87 a	15.18 a
DRS14	9.39 ab	11.61 a	13.71 a	15.65 a
DRS66	7.02 abc	9.73 abc	15.06 a	16.06 a
DHL98	8.03 bc	6.96 abc	11.27 a	12.68 a
IR64	6.77 abc	9.18 abc	11.99 a	14.86 a
NSIC Rc11	9.11 abc	9.49 abc	13.79 a	13.95 a
DR				
NSIC Rc9	4.31 ab	4.32 ab	10.25 ab	10.40 ab
DRS111	3.83 ab	3.30 ab	9.52 ab	8.60 abc
DRS14	4.20 ab	5.58 a	9.39 ab	11.61 a
DRS66	3.99 ab	4.13 ab	7.02 ab	9.73 abc
DHL98	2.92 b	2.51 ab	8.03 b	6.96 abc
IR64	2.31 b	4.10 ab	6.77 b	9.18 abc
NSIC Rc11	4.08 ab	4.39 ab	9.11 ab	9.49 abc

Means followed by a common letter across N treatments and water treatments are not significantly different at 5% level of HSD.

Table 8. Correlation of grain yield with 1000 grain weight, total biomass, harvest index and percent filled grains with different N fertilizer treatment under DR.

	Grain yield	
	-N	+N
1000 grain weight	0.26 ns	0.53 ***
Total biomass	0.54 ***	0.91 ***
Harvest index	0.77***	0.73 ***
% filled grains	0.26 ns	0.65 ***

ns-not significant; ***, significant at P=0.001 level

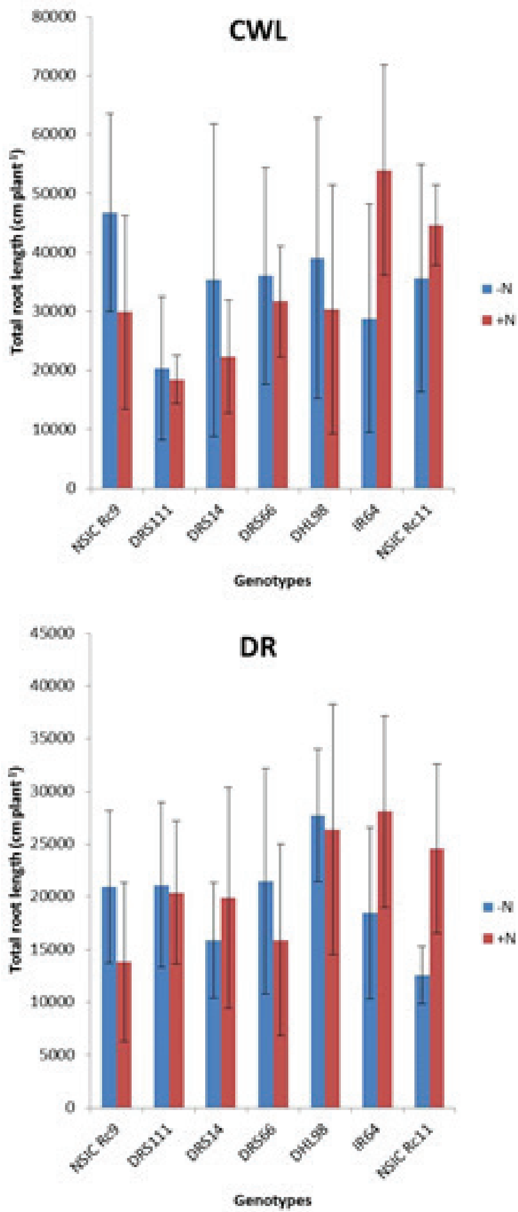


Figure. 8. Total root length of seven genotypes with different N fertilizer treatments grown under CWL and DR conditions. Dry Season 2013.

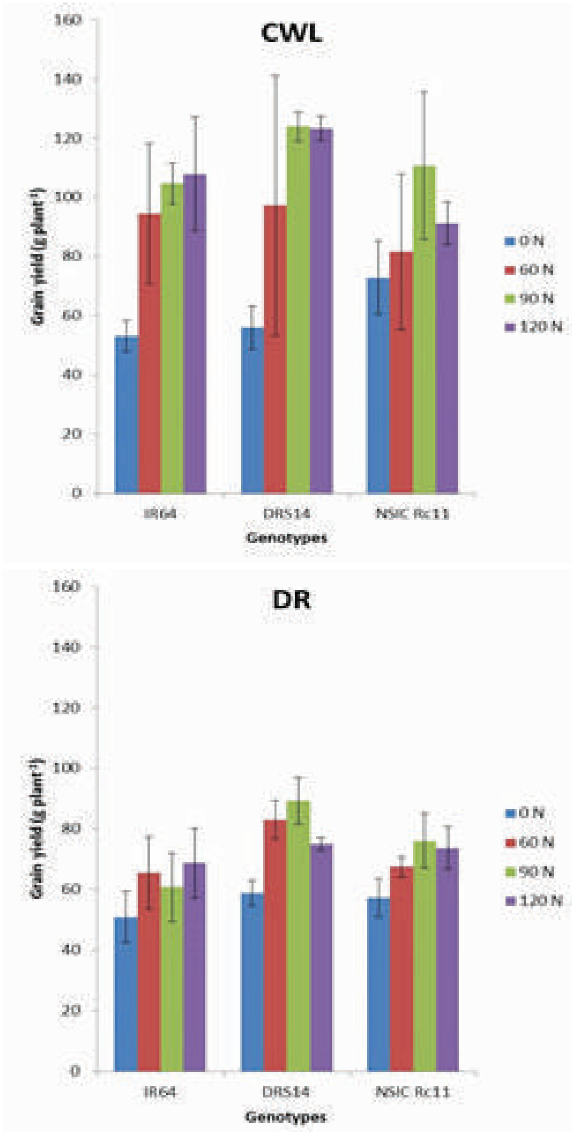


Figure. 9. Grain yield of IR64 as check genotypes and two genotypes with high Nitrogen response under continuous waterlogged (CWL) and progressive drought (DR). Wet Season 2013.

Calibration of raised bed as a facility for screening drought resistant lines for upland rice breeding

NB Lucob, JM Niones and RR Suralta

Crops with deep root system allow extraction of more water available at deeper soil layer during drought. Rice cultivars adapted exclusively to upland conditions are typically characterized by deep and coarse root system. The study aims to calibrate raised bed system as a screening facility for identifying genotypes with deep rooting traits and utilize this in breeding to improve drought resistance in rainfed and upland systems.

A raised bed was constructed 25cm above the ground level. In the bed, 20-cm-thick layer of topsoil was added above 5-cm-thick gravel layer. On the other hand, normal bed (without gravel layer), which received well-watering, served as control (Figure 10). Twenty genotypes composed of advance breeding lines with potential stay-green characteristics and double haploid lines (CT9993/ IR62266 crosses and parents) were grown in each bed until maturity. In WS, raised bed was constructed 20 cm above the ground level. The 5-cm-thick gravel was placed at 15 cm below soil surface. Twenty traditional varieties were grown and evaluated using the bed. Raised bed system was simulated in plastic tubes with 5-cm-thick gravel layer placed at 30 cm depth below soil surface using the same set of selected CT9993/ IR62266 DHLs and parents to validate the relationship of TLRL below gravel layer and dry matter production during drought stress. Shoot and root traits under drought stress only was accounted by calculating the difference between values of traits under DR (plants received 20 days well-watering thereafter water was withheld until 45 DAS) and well watered (plants received 20 days well-watering then harvested).

Highlights:

- Soil moisture dynamics in the raised bed showed that the soil above the gravel layer was constantly higher than the soil below the gravel layer (Figure 11). This result indicates that the gravel layer embedded at 20 cm below the soil surface effectively blocked the capillary rise of water thereby creating two distinct soil moisture conditions.

- Thermal image analysis during one of the drought periods showed that genotypes in raised bed had higher leaf temperature than in the well-watered bed (Figure 12).

- CT9993, DHL50, DHL138, DHL40, DHL141 and PLB2242 were among the genotypes observed during the root extraction using monolith to have penetrated the gravel layer. This indicates that these genotypes have potential deep rooting ability in response to drought stress condition. (Scanning of root samples and analysis of roots using WinRhizo software are still on-going.)

- In WS, Dinorado and Kinandang-patong were observed to be drought-tolerant while the rest of the genotypes wilted. (Processing of shoot and roots are still on going.)

- The result of the raised bed calibration since 2011 WS showed that the optimum depth of gravel layer embedded below the soil surface for accurate selection of rice is at 25 cm and 30 cm depth. A raised bed with gravel layer embedded at 30 cm below soil surface is being used for mass screening of deep-rooting genotypes (40 genotypes).

- In the plastic tube experiment, soil moisture at 0-30 cm depth (above gravel) was lower than 30-90 cm depth (below gravel), indicating that gravel layer prevented the capillary rise of water underneath gravel (Figure 13).

- There was no significant difference among genotypes on shoot dry weight (SDW) under drought condition (Figure 14). However, DHL 103, DHL 142 and DHL 50 genotypes showed the highest dry matter production while DHL39 and DHL44 had the lowest dry matter production. Between parents, CT9993 had higher SDW than IR62266 parent.

- The root parameters such as total root length, total lateral root length and deepest nodal root below the gravel showed a significant contribution to dry matter production while total nodal root length and mean nodal root length showed low contribution (Table 11).

Figure 10. The well-watered bed and raisedbed at 74 days after sowing. Images were taken during one of the drought periods in raised bed.

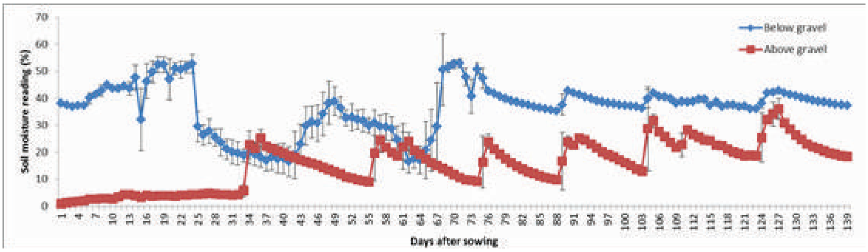


Figure 11. Soil moisture dynamics above and below the gravel layer in raised bed system.

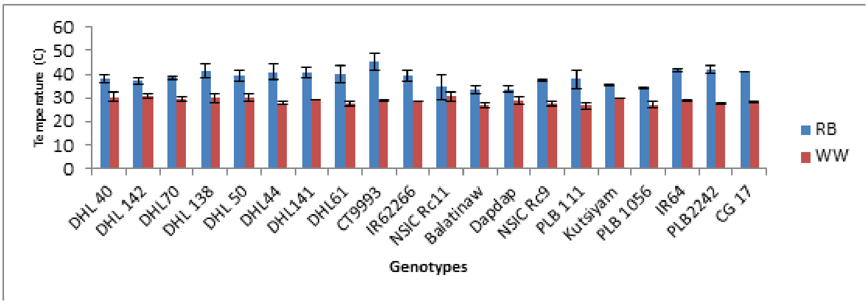


Figure 12. Thermal image analysis of raisedbed and well-watered bed

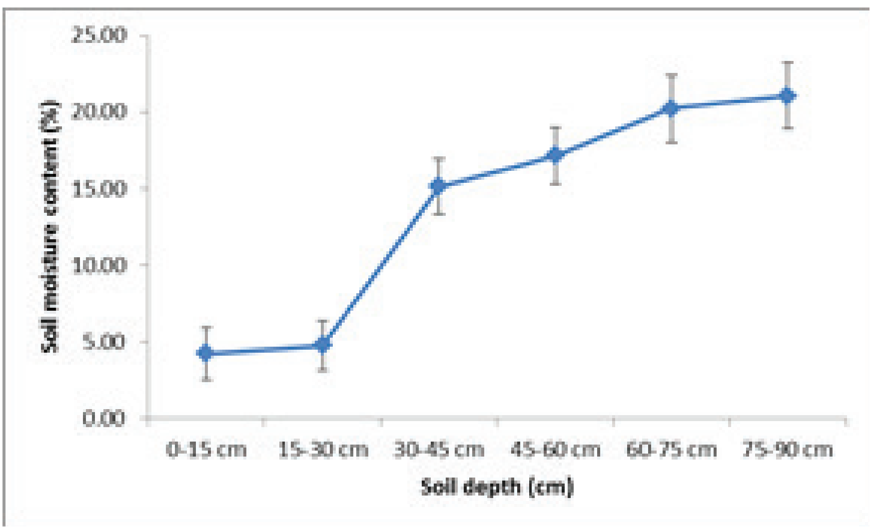


Figure 13. Soil moisture dynamics at different depths in plastic tube with 5cm gravel layer embedded at 30 cm below soil surface

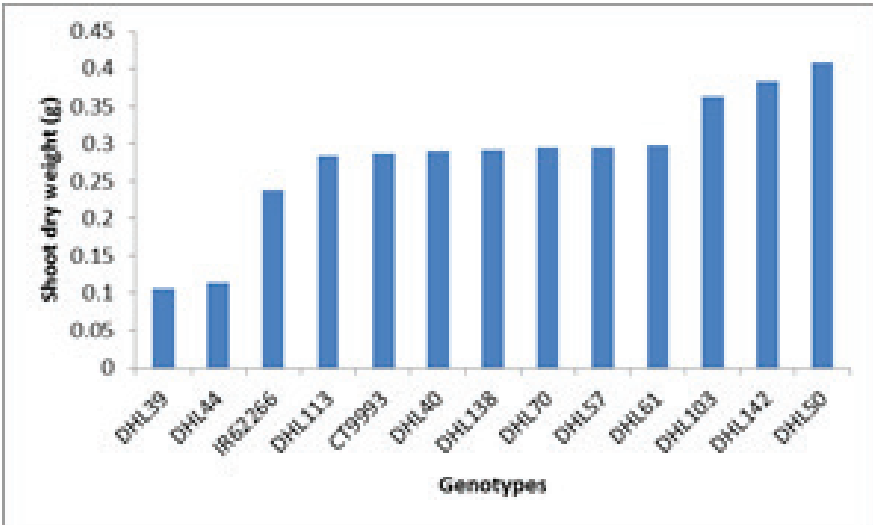


Figure 14. Shoot dry weight of the different DHLs, CT9993 and IR62266 under drought stress only.

Table 9. Correlation matrices among root parameters below the gravel layer and shoot dry weight of selected doubled-haploid lines under drought stress only.

Root traits below gravel layer	Shoot dry weight
Deepest nodal root	0.43 **
Nodal root length	0.28 ns
Total root length	0.32 *
Total lateral root length	0.32 *
Mean nodal root length	0.22 ns

Ratooning ability of irrigated lowland rice: Response of diverse rice genotypes under optimum water and nitrogen management under transplanted system

RT Cruz, MVR Bascon and MJC Regalado

Rice ratooning is one practical way of intensifying crop production per unit area and per unit time. Ratooning is the ability of the plant to regenerate new tillers from the main crop stubbles. To make ratooning more productive and economic, cultivars with good ratooning ability must be evaluated. Thus, the study aims to assess the ratooning ability of different rice genotypes, which are widely used by farmers.

The rice varieties used were: (1). PSB Rc82, (2). NSIC Rc160, (3). NSIC Rc222, (4). NSIC Rc222, (5). NSIC Rc216, (6). Mestiso 19, (7). Mestiso 20 and (8). Mestiso 29. The main rice crops were managed using the PalayCheck System for Irrigated Lowland Rice. Nitrogen application was based on the weekly LCC readings up to panicle initiation. Phosphorus and potassium applications were done at 0-14 days after transplanting (DAT) at 42 kg PK/ha in dry season (DS) and 28 kg PK/ha in wet season (WS). Main crop stubbles were cut at 20 cm, flooding with 3 cm water depth and application of 90 kg N/ha were done right after main crop harvest.

Highlights:

- In DS, main crop grain yields ranged from 6.1 to 7.7 t/ha in inbred and 8.2 to 8.6 t/ha in hybrid. Mestizo 20 had the highest grain yield at 8.6 t/ha while NSIC Rc160 had the lowest grain yield at 6.1 t/ha. In WS, main crop grain yields ranged from 6.5 to 8.1 t/ha in inbred and 5.2 to 8.6 t/ha in hybrid. Mestizo 19 had the highest grain yield at 8.6 t/ha while Mestizo 29 had the lowest grain yield at 5.2 t/ha (Table10).

- In DS, straw yields from the main crop ranged from 3.2 to 7.2 t/ha in inbred and 2.3 to 6.7 t/ha in hybrid. NSIC Rc160 had the highest straw yield at 7.2 t/ha while Mestizo 19 had lowest straw yield at 2.3 t/ha. In WS, straw yields were 8.4 to 8.9 t/ha in inbred and 7.0 to 8.5 t/ha in hybrid. NSIC Rc222 had the highest straw yield at 8.9 t/ha while Mestizo 19 had the lowest straw yield at 7.0 t/ha.

- Harvest index (HI) ranged from 0.5 to 0.8 in DS and 0.4 to 0.5 in WS. In DS, Mestizo 19 had the highest HI of 0.8 and NSIC Rc160 had the lowest HI of 0.5. In WS, no significant difference in HI was observed between varieties.

- Partial factor productivity of N (PFPN) in DS ranged from 54.0 to 69.2 kg grain/kg N applied in inbred and 72.6 to 76.6 kg grain/kg N applied in hybrid. Mestizo 20 had the highest PFPN at 76.6 kg grain/kg N applied and NSIC Rc160 had the lowest PFPN at 54.0 kg grain/kg N applied. In WS, PFPN ranged from 72.0 to 93.4 kg grain/kg N applied. No significant difference in PFPN was observed among varieties.

- Main crop in DS and WS were ratooned after harvest. In ratoon DS, varieties NSIC Rc222 and NSIC Rc224 had ratooned tillers but no panicle intitation even at 70 days after cutting the main crop stubbles. No emergence of ratooned tillers in Mestiso 20 occurred. PSB Rc82, NSIC Rc160, NSIC Rc216, Mestiso 19 and Mestiso 29 showed good ratoon stand

and had ratoon grain yield. In ratoon WS, all eight varieties were successfully ratooned.

- In DS, ratooning vigor (i.e., extra vigorous: tillers arising from basal and upper nodes; normal or intermediate vigor: tillers arising from basal nodes only; and weak vigor: very weak and few tillers) of the varieties were: (1) Extra vigorous or for PSB Rc82, NSIC Rc160, NSIC Rc216, Mestiso 19 and Mestiso 29; (2) Normal and intermediate for NSIC Rc222 and NSIC Rc224 and (3) Weak for Mestiso 20. In WS, all varieties had normal or intermediate ratooning vigor.

- Ratoon grain yields ranged from 1.5 to 2.9 t/ha in DS and 1.8 to 3.0 t/ha in WS. In DS, no significant difference was observed among the five varieties. In WS, Mestizo 19 had the highest grain yield at 3.0 t/ha and Mestizo 29 had the lowest grain yield at 1.8 t/ha (Table 10).

- In DS, percent yield of the main crop ranged from 20.5 to 47.5%. NSIC Rc160 had the highest percent yield of the main crop while Mestizo 29 had the lowest percent yield of the main crop. In WS, percent yield of the main crop ranged from 27.5 to 34.9%. Mestizo 19 had the highest percent yield of the main crop while PSB Rc82 had the lowest percent yield of the main crop (Table 10).

- Based on Table 10, the lowest main crop grain yield of NSIC Rc160 with 6.1 t/ha had the highest ratoon crop grain yield with 2.9 t/ha during DS. Likewise, high main crop grain yield of Mestizo 20 with 8.6 t/ha had no successful ratoon stand. However in WS, varieties with high main crop grain yield had also higher ratoon crop grain yield (i.e. Mestizo 19 had main crop yield of 8.6 t/ha and ratoon crop yield of 3.0 t/ha).

- Ratoon crop growth duration had more influence on grain yield. Varieties with longer maturity days had higher grain yield. In DS, NSIC Rc160 had a grain yield of 2.9 t/ha with 60 maturity days while PSB Rc82 had a grain yield of 1.5 t/ha with 45 maturity days. In WS, Mestizo 19 had a grain yield of 3.0 with 61 maturity days while Mestizo 20 had a grain yield of 2.0 t/ha with 50 maturity days (Table 10).

- In DS, main crops were not infested with white stemborer. Ratooned crops were infested with white stemborer except with NSIC Rc160. At maturity stage, Mestizo 29 had the highest infestation with 53%, Mestizo 19 with 36%, NSIC

Rc216 with 32% and PSB Rc82 with 19%. In WS, Mestizo 29 was infested with birds. Ratooned crops were infested with stemborer. PSB Rc82 and Mestizo 20 had the lowest damage with 6% and 9%, respectively. NSIC Rc160, NSIC Rc224 and Mestizo 19 had 12% damage. NSIC Rc222 NSIC Rc216 and Mestizo 29 had 25% to 27% stemborer damage.

- Panicle per sq. meter of ratooned crops ranged from 246 to 346 panicles per sq. meter in DS and 234 to 324 panicles per sq. meter in WS. Panicles per sq. meter of ratooned crops were 57 to 85% of the main crop in DS and 63 to 103% of the main crop in WS. Percent filled spikelets of ratooned crops ranged from 60% to 71% in DS and 52% to 75% in WS. Percent filled spikelets of ratooned crop were 67% to 88% of the main crop in DS and 68% to 90% of the main crop in WS. Number of spikelet per panicle of ratooned crops ranged from 36 to 62 spikelets per panicle in DS and 48 to 82 spikelets per panicle in WS. Number of spikelet per panicle of ratooned crops were 36% to 71% of the main crop in DS and 40% to 67% of the main crop in WS.

- In DS, ratoon crop of PSB Rc82 had the lowest PFPN at 25.6 kg grain/kg N applied and NSIC Rc160 had the highest PFPN at 48.1 kg grain/kg N applied. In WS, ratoon crop of Mestiso 20 had the lowest PFPN at 20.1 kg grain/kg N applied and Mestiso 19 had the highest PFPN at 32.6 kg grain/kg N applied. In DS, main crop with high PFPN resulted to ratoon crop with low PFPN. In WS, main crop with high PFPN also resulted to ratoon crop with high PFPN.

- In DS, the lower ratoon grain yields observed from PSB Rc82, NSIC Rc216, Mestiso 19 and Mestiso 29 were mainly due to reduced productive tillers and shorter growth duration. NSIC Rc160 had higher grain yield due to higher plant height, productive tiller, percent filled spikelets and absence of white stemborer infestation. Higher plant height promoted higher accumulation of assimilates in the culm that can be translocated to the grain.

- In WS, lower ratoon grain yield observed from Mestizo 29 because the main crop was damaged by birds and the ratoon crop was infested with stemborer. Mestizo 19 and NSIC Rc222 had higher ratoon grain yield due to more productive tillers and high percent filled spikelets.

- Based on the results, ratoon grain yields differ between varieties and between seasons within a variety. In general, ratoon crops with longer growth duration appeared to have higher grain yield. Longer growth duration promotes more tillers during the vegetative stage of ratoon before the panicle initiation. This was indicated by the higher panicle per sq. meter observed from ratoon crops of PSB Rc82, NSIC Rc160 in DS and NSIC Rc222 and NSIC Rc224 in WS (Table 11). On the other hand, varietal performance differs between seasons. Varieties were more responsive to ratooning in WS than in DS. Based on the results, number of spikelet per panicle was higher in WS than in DS by 25%, resulting to higher grain yield. This was probably due to lower temperature in WS (October to November) compared to DS (April to May). During the reproductive stage of ratoon which was in November, the spikelet number per plant increases as the temperature drops.

Table 10. Main crop and ratoon grain yield, PFPN and maturity days in 2013 dry and wet seasons.

Varieties	Grain yield (t/ha)[1]				PFPN (kg grain/kg N applied)				Maturity days (d)			
	Main crop		Ratoon crop		Main crop		Ratoon crop		Main crop		Ratoon crop	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
PSB Rc82	7.2	6.9	1.5 (20.8)	1.9 (27.5)	64	77.1	25.6	21.1	110	123	45	60
NSIC Rc160	6.1	8.1	2.9 (47.5)	1.9 (23.5)	54	90.1	48.1	20.7	122	126	60	55
NSIC Rc222	7.1	6.8	-	2.3 (33.8)	63.6	75.6	-	25.3	114	125	-	61
NSIC Rc216	7.6	6.5	-	2.0 (30.8)	67.6	72.2	-	22	111	126	46	61
NSIC Rc224	7.7	6.6	1.7 (22.4)	2.0 (30.3)	69.2	73.7	27.7	22.8	112	123	-	59
Mestiso 19	8.2	8.6	1.8 (22.0)	3.0 (34.9)	72.6	95.9	29.7	32.6	110	126	46	61
Mestiso 20	8.6	6.5	-	2.0 (30.8)	76.6	72	-	20.1	100	123	-	50
Mestiso 29	8.3	5.2	1.7 (20.5)	1.8 (34.6)	73.7	57.3	28.3	22.3	111	129	46	57
Mean	*7.6*	*6.9*	*1.9*	*2.1*	*67.7*	*76.7*	*22.9*	*23.4*	*111*	*125*	*49*	*58*
S.E.	*0.3*	*0.4*	*0.2*	*0.1*	*2.5*	*4.2*	*3.2*	*1.4*	-	-	-	-

[1] Figures in parentheses are percentages of main crop yield.

Table 11. Yield components of main and ratoon crop in 2013 dry and wet seasons.

Varieties	Panicle per sq. meter				Percent filled spikelets				No. of spikelet per panicle			
	Main crop		Ratoon crop		Main crop		Ratoon crop		Main crop		Ratoon crop	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
PSB Rc82	442	409	324	324	90	82	60	56	73	85	42	50
NSIC Rc160	415	392	346	245	81	82	71	57	72	101	51	60
NSIC Rc222	433	352	-	272	69	73	-	64	101	114	-	65
NSIC Rc216	410	309	-	260	88	78	-	59	75	95	-	55
NSIC Rc224	385	293	329	280	78	72	63	59	100	120	36	54
Mestiso 19	356	354	275	254	79	77	61	63	109	122	55	82
Mestiso 20	379	243	-	249	79	89	-	75	115	121	-	72
Mestiso 29	435	293	246	234	75	58	61	52	105	120	62	48
Mean	407	331	304	265	80	76	63	60	94	110	49	61
S.E.	11	20	15	10	2	3	2	2	6	5	4	4

Resource use efficient technologies for maximizing rice productivity

WB Collado, MD Malabayabas, AJ Espriritu and MJC Regalado

With the enduring effort to attain rice self-sufficiency and increased productivity, PhilRice continuously develops rice production technologies that can readily be used by farmers and other rice stakeholders. Recently, technological progress has enabled multi-cropping per unit area. The adoption of high-yielding rice varieties, appropriate machinery and fertilizers has generally enhanced soil productivity. However, these schemes have increased the energy input per unit area. The utilization of technologies should be appropriately evaluated to ensure high energy efficient production. Thus, the study was conducted to evaluate the performance of selected newly-released high-yielding rice varieties using resource-efficient rice technologies like the drum-seeding method of crop establishment in the dry season (DS) and mechanical transplanter in the wet season (WS), the researchers' fixed time and rate (FTR) and the LCC-based (FTAR) nitrogen fertilizer application methods, and the controlled irrigation scheme.

Highlights:

Dry Season

- The yields of the two varieties tested were similar (Figure15).

- Only in the two fertilization techniques that a difference had shown on the total amounts of N required to achieve their yield: 180 kg N/ha in the fixed rate and time (FTR) attained 7.14 tons/ha while 165 kg N/ha in the LCC-based, fixed time-adjustable rate (FTAR) had obtained 7.40 tons/ha;

- Conversely, higher partial factor productivities from the applied N (PFPN) were obtained by the rice varieties tested in the LCC-based N application or FTAR treatment (Fig. 16), hence, the lower cost of N yet a higher return on investment can be attained.

- As to energy use efficiency:
  1. The total time used in the drum-seeding activity by 2 persons was 1.25 hours for an area of 3,341.8 m2 or a total of 3.7 hours/ha and an energy input of 2.6 MJ/0.33418 ha or 7.7 MJ ha-1;

  2. The total time spent in the irrigation of the experimental area (0.33418 ha) from start to the last irrigation (6 times) during the growing period was 28.1 hours or 84.1 hr/ha;

3. The rice yield energy output (RYEO) was similar to all tested varieties ranging from 84,908-90,386 MJ ha-1 (Figure. 17).

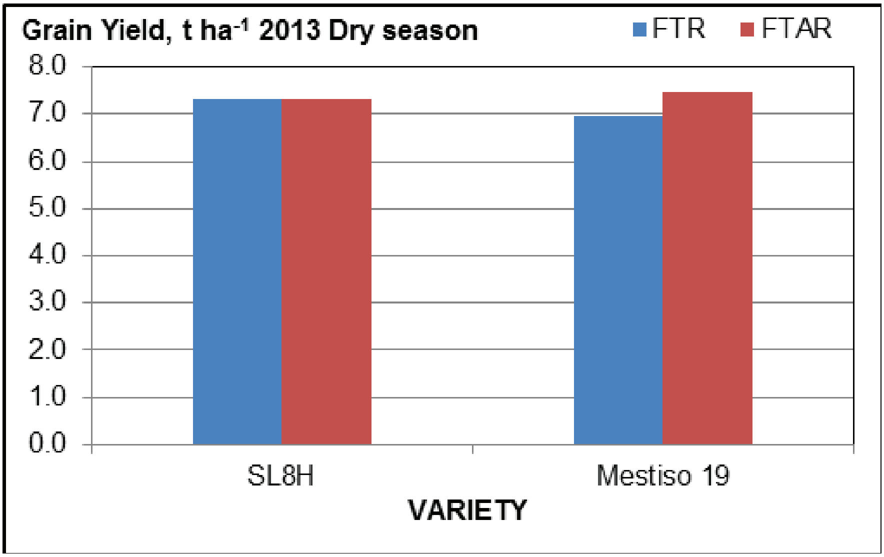


Figure 15. Grain yields of the test rice varieties as affected by the fertilizer treatments. 2013 Dry Season, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

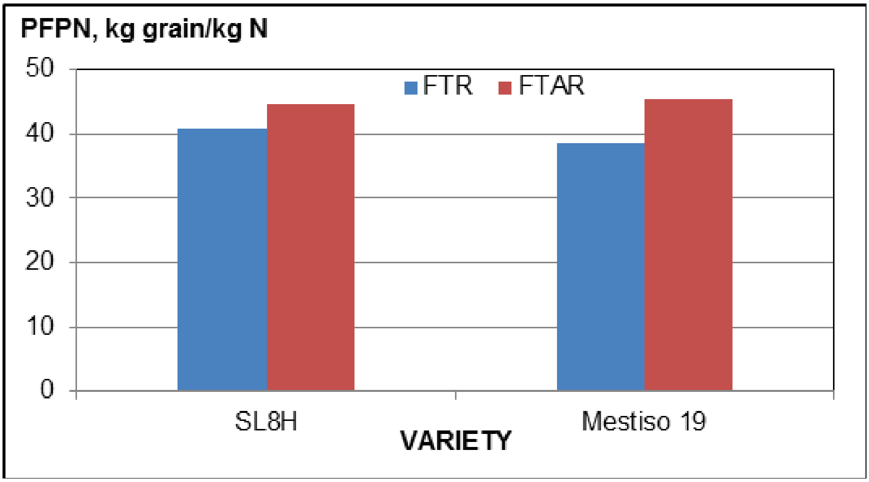


Figure 16. The partial factor productivity (PFP) from the applied N of the test rice varieties. 2013 Dry Season, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

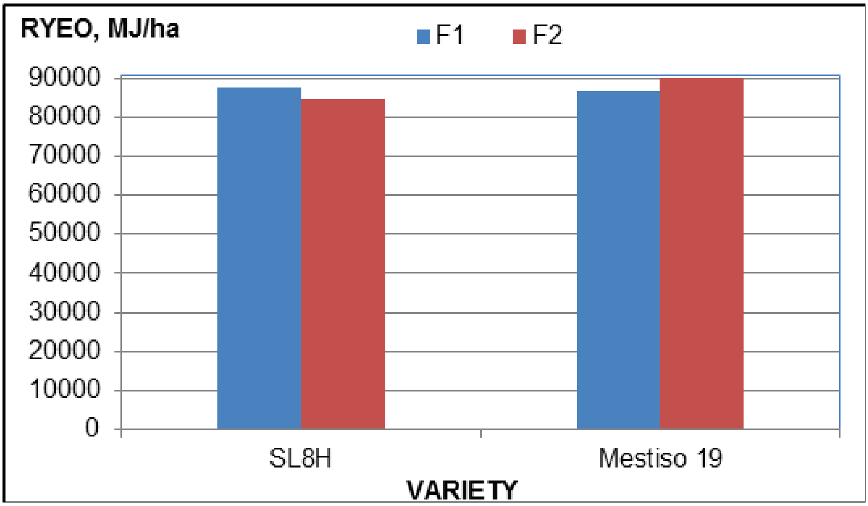


Figure 17. The rice yield energy output (RYEO) of the varieties tested during the 2013 Dry Season, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

Wet Season

- The low yield (Fig. 18) of hybrid rice varieties tested was attributed to the very low percentage of filled spikelets and number of panicles per unit area measured at harvest (Table 12); This may be due to strong winds and heavy rains brought by typhoon Santi during the early flowering stage and not much of the treatment employed.

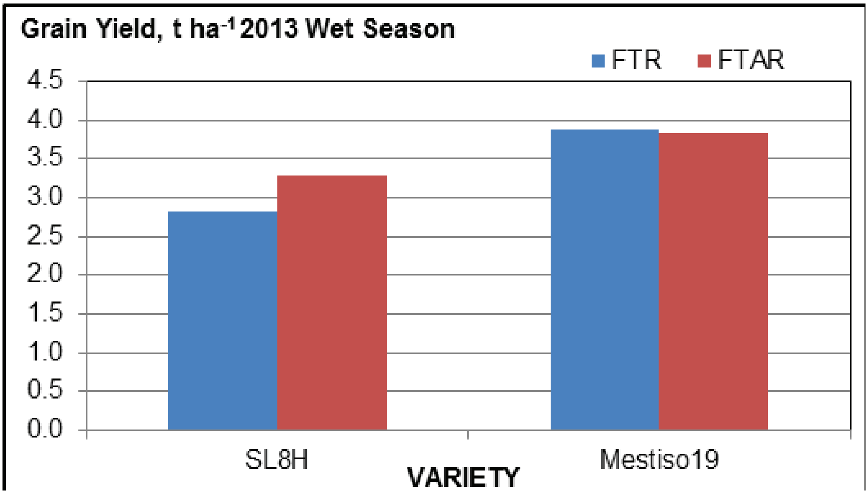


Figure 18. Grain yields of the test rice varieties as affected by the fertilizer treatments. 2013 WS cropping, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

Table 12. The components of yield of the rice varieties tested. 2013 WS cropping, PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines.

FERTILIZER TREATMENT	Panicle/m^2		Spikelets/panicle		Filled Spikelets (%)		1,000-Grain Weight (g)	
	SL8H	M19	SL8H	M19	SL8H	M19	SL8H	M19
FTR (F1)	268	274	87	79	60.9	63.2	23.8	22.6
FTAR (F2)	267	259	78	86	58.2	63.0	23.7	23.7

Evaluation of the common System of Rice Intensification (SRI) practices in irrigated lowland

RT Cruz, MV Bascon and ET Rasco

The System of Rice Intensification (SRI) is a set of principles developed to increase productivity of the land, labor and water. It is characterized with widely spaced transplanting of young seedlings and use of alternate wetting and drying. It has been critically evaluated with regard to its potential to raise rice yield. However, results from various researches showed that the influence of SRI on rice yield was variable. This is possibly due to the changes of SRI over time in crop management practices. However, there are three SRI practices that remained across the years. These are: (a) crop establishment that utilized a planting density of 1 seedling per hill, (b) water management that utilized alternate wetting and drying or intermittent irrigation or controlled irrigation, and (c) weed management that utilized a rotary weeder. Therefore, the study aims to evaluate the effect of the retained SRI practices on rice crop growth, yield and return on investment. The following treatments were used: (1) planting density – 1, 2, and 3 seedlings/hill; (2) genotype – NSIC Rc222 and PSB Rc82; (3) water management - alternate wetting & drying (AWD) and continous flooding (CF), and (4) weed management - hand weeding up to 40 days after transplanting (DAT) and mechanical weeding using rotary weeder with 7-day interval from 10-40 days after transplanting (DAT). Nutrient application with commercial organic fertilizer was 45 kg N/ha, 60 kg P/ha and 45 kg K/ha in DS and WS. The adjacent experimental setup for PalayCheck System of crop management served as the Control. Nutrient application in PalayCheck System was 112 kg N/ha, 42 kg P/ha and 42 kg K/ha in dry season (DS) and 74 kg N/ha, 28 kg P/ha and 28 kg K/ha in wet season (WS).

Highlights:

- In DS, plant height during mid-tillering (MT) and panicle initiation (PI) did not differ between planting densities and water and weed managements. PSB Rc82 had higher plant height with 61.1 cm in MT and 73.6 cm in PI than NSIC

Rc222 with 54.9 cm in MT and 67.5 cm in PI. In WS, plant height during MT and PI did not differ between planting densities, varieties, and weed management. Plant height during MT and PI was higher in continuous flooding with 82.2 cm than in alternate wetting and drying with 78.2 cm. At PI, water management did not differ in plant height. This indicates that water in AWD was supplied in sufficient time to allow recovery of plants.

- Weeding was done five times with hand weeding while four times with rotary weeding in DS. In WS, weeding was done four times in both weeding management. Weeding frequency and required time did not differ between varieties, planting densities, and water management. In WS, weeding frequency and time did not differ between planting densities, varieties and water management.

- In DS, grain yield from different planting densities were 5.5 t/ha in 1 seedling/hill, 5.8 t/ha in 2 seedlings and 6.3 t/ha in 3 seedlings/hill. PSB Rc82 had a grain yield of 5.7 t/ha while NSIC Rc222 had 6.0 t/ha. AWD had a grain yield of 6.1 t/ha and CF had 5.7 t/ha. Rotary weeding and hand weeding had comparable grain yields with 5.9 t/ha and 5.8 t/ha, respectively. In WS, no significant effect on grain yield was observed between planting densities and weed management. PSB Rc82 (5.1 t/ha) had higher grain yield than NSIC Rc222 (4.8 t/ha). CF plots (5.1 t/ha) had higher grain yield than AWD plots (4.8 t/ha).

- Straw yield ranged from 6.0 to 6.7 t/ha in DS and 4.0 to 4.3 t/ha in WS. In terms of harvest index (HI), SRI treatments in WS resulted to higher HI than in DS. HI in DS ranged from 0.45 to 47 while HI ranged from 0.53 to 0.55 in WS.

- Partial factor productivity of N (PFPN) was higher in DS than in WS. In DS, PFPN ranged from 123.1 to 139.6 kg grain per kg N applied while PFPN in WS ranged from 96.8 to 99.9 kg grain per kg N applied. In DS, PFPN of AWD with 135.5 kg grain/kg N applied was higher than in CF with 125.4 kg grain/kg N applied. It was above the normal PFPN values of 40 -70 kg grain/kg N applied since it is the initial cropping season. PalayCheck System had a lower PFPN of 64 kg grain/kg N applied, compared with the SRI treatments. In WS, no significant difference in PFPN was observed between treatments.

- Panicle per sq. meter ranged from 262 to 286 panicles per sq. meter in DS and 182 to 203 panicles per sq. meter in WS. Percent filled spikelet ranged from 79% to 83% in DS and 81% to 86% in WS. No. of spikelet per panicle ranged from 88 to 102 spikelets per panicle in DS and 104 to 121 spikelets per panicle in WS.

- In DS, PSB Rc82 and NSIC Rc222 did not differ in grain yield. The two varieties had comparable panicle per sq. meter. NSIC Rc222 had higher number of spikelet per panicle but had lower percent filled spikelet. AWD had higher grain yield than CF. AWD had higher percentage of filled spikelet than CF. Planting density at 3 seedlings /hill appeared to have higher yield than with 1 and 2 seedlings/hill. The presence of many replanted hills in 1 and 2 seedlings/ hill may have contributed to this lower grain yield. Nevertheless, the increase of planting density from 1 to 3 seedlings/hill showed the following: (1) the increase in planting density resulted in increase in panicle per sq. meter, 286 panicle per sq. meter in 3 seedlings/ hill and 262 panicle per sq. meter in 1 seedling/hill and (2) the increase in planting density resulted in lower number of spikelet per panicle, 95 spikelets per panicle in 3 seedlings/ hill and In WS, PSB Rc82 (5.1 t/ha) had higher grain yield than PSB Rc82 (4.8 t/ha). CF plots had higher grain yield than AWD plots due to more panicles per sq. meter. No significant difference in yield components was observed in planting densities and weed management. Planting densities of 1 to 3 seedlings /hill were expected not to differ in grain yield since the increase in panicle per sq. meter at higher planting density will be compensated by the higher number of spikelet per panicle at lower planting density.

Table 13. Grain and straw yield, harvest index and partial factor productivity for N of SRI treatments in 2013 dry and wet seasons.

SRI Treatment	Grain Yield (t/ha)		Straw yield (t/ha)		Harvest Index		Partial factor productivity for N	
	DS	WS	DS	WS	DS	WS	DS	WS
				Variety				
PSB Rc82	5.7 a	5.1 a	6.1 a	4.3 a	0.46 a	0.54 a	127.2 a	96.8 a
NSIC Rc222	6.0 a	4.8 b	6.5 a	4.0 b	0.46 a	0.54 a	133.7 a	99.9 a
				Water Management				
Continuous flooding	5.7 b	5.1 a	6.4 a	4.3 a	0.46 a	0.54 a	125.4 b	97.3 a
Alternate wetting and drying	6.1 a	4.8 b	6.2 a	4.0 b	0.47 a	0.54 a	135.5 a	99.5 a
				Planting density				
1 seedling/hill	5.5 b	4.9 a	6.0 a	4.2 a	0.45 a	0.54 a	123.1 b	96.6 a
2 seedlings/hill	5.8 b	4.8 a	6.3 a	4.1 a	0.47 a	0.54 a	128.7 b	99.0 a
3 seedlings/hill	6.3 a	5.1 a	6.7 a	4.2 a	0.47 a	0.55 a	139.6 a	99.6 a
				Weed Management				
Rotary weeding	5.9 a	5.0 a	6.2 a	4.2 a	0.45 a	0.55 a	131.0 a	96.2 a
Hand weeding	5.8 a	4.9 a	6.4 a	4.1 a	0.47 a	0.53 a	129.9 a	100.6 a

Table 14. Yield components of SRI treatments in 2013 dry and wet seasons.

SRI Treatment	Panicle/ m²		Percent filled spikelet		No. of spikelet per panicle	
	DS	WS	DS	WS	DS	WS
			Variety			
PSB Rc82	286 a	203 a	0.83 a	0.86 a	88 b	104 b
NSIC Rc222	282 a	182 b	0.79 b	0.81 b	112 a	121 a
			Water Management			
Continuous flooding	279 a	199 a	0.80 b	0.83 a	99 a	111 a
Alternate wetting and drying	269 a	186 b	0.82 a	0.83 a	101 a	114 a
			Planting density			
1 seedling/hill	262 b	195 a	0.79 b	0.84 a	104 a	110 a
2 seedlings/hill	274 b	190 a	0.81 ab	0.83 a	101 ab	112 a
3 seedlings/hill	286 a	192 a	0.83 a	0.84 a	95 b	116 a
			Weed Management			
Rotary weeding	272 a	196 a	0.81 a	0.83 a	103 a	112 a
Hand weeding	276 a	189 a	0.81 a	0.83 a	98 b	113 a

Evaluation of water and nutrient use efficiencies of varieties with high yield potential

MD Malabayabas, AJ Espiritu and CR Esaga

Nutrients and water are vital factors in the attainment of higher rice productivity. However, the cost of fertilizer is continuously increasing while water is becoming scarce. Water and nutrients must be efficiently utilized by rice to compensate for the high production cost. The adoption of energy resource use efficient varieties with high yield potential should be considered to reduce production cost while maintaining productivity.

Water, nitrogen and energy input efficiencies of new high yielding varieties, namely: NSIC Rc216, Rc224, Rc226, Rc240 and Rc204H including control variety PSB Rc82 were evaluated under continuous flooding (CF) and controlled irrigation (CI) in 2013 Dry Season (DS) and Wet Season (WS). Using the same varieties, nitrogen use efficiency (NUE) and N input energy (NIE) were determined with Leaf Color Chart (LCC)-based N application and fixed rate N application of 120 kg ha-1 during DS and 90 kg ha-1 during WS. Seeding rate of 20 kg seed ha-1 was used.

Highlights:

- Grain yield ranged from 5.53 to 7.44 t/ha in DS and 5.44 to 6.49 t/ha in WS. There were no significant yield differences between CF and CI and among varieties during DS and WS. This further confirmed previous studies that CI does not cause yield reduction.

- CI significantly reduced water use, irrigation energy input (IEI), and fuel input energy (FIE) during DS and WS (Table 15 and 16). Among varieties, NSIC Rc204H, Rc240 and Rc224 had significantly lowered water use, IEI, and FIE than the control variety PSB Rc82 while Rc216 and Rc226 were comparable to Rc82 during DS (Table 15).

- During DS, NSIC Rc226 had significantly the highest yield (6.64 t/ha) among varieties (Table 17). Rc216 had significantly higher NUE than Rc82, Rc224 and Rc204H but comparable with Rc226 and Rc240. With LCC-based N application, Rc82, Rc216, Rc230 and Rc204H had the lowest NIE because they had lower N usage than Rc224 and Rc226.

- During WS, there were no significant differences in yield and NUE among varieties (Table 18). Rc226 showed significantly the lowest NIE followed by Rc240 while the rest had comparable NIE (Table 19).

- Results showed that most new high yielding varieties like NSIC Rc240, Rc024H and Rc224 were water and energy efficient. PSB Rc82, NSIC Rc216, Rc240 and Rc204H were efficient users of nitrogen fertilizer in DS. Water and nutrient use efficiencies and input energy were also affected by cropping season.

Table 15. Water used, irrigation energy input (IEI)) and fuel input energy (FIE) of high yielding varieties under continuous flooding (CF) and controlled irrigation (CI), 2013 DS.

Variety	Water used (mm)		IEI (MJ ha^{-1})		FIE (MJ ha^{-1})	
	CF	CI	CF	CI	CF	CI
PSB Rc82	1938.1 a	839.7 a	11919.6 a	5164.5 a	15118.8 a	6693.8 a
NSIC Rc216	1934.4 a	791.9 ab	11896.4 a	4870.6 ab	15061.1 a	6289.9 ab
NSIC Rc224	1938.2 a	720.2 b	11919.6 a	4429.5 b	15118.8 a	5712.8 b
NSIC Rc226	1939.9 a	734.6 ab	11930.1 a	4517.7 ab	15118.8 a	5828.2 ab
NSIC Rc240	1934.4 a	677.2 b	11896.4 a	4164.9 b	15061.1 a	5366.6 b
NSIC Rc204H	1934.4 a	677.2 b	11896.4 a	4164.9 b	15061.1 a	5366.6 b

In a column, means with the same letter are not significantly different at 5% level by HSD.

Table 16. Water used, irrigation energy input (IEI)) and fuel input energy (FIE) and under continuous flooding (CF) and controlled irrigation (CI), 2013 WS.

Water mgt	Water used (m^3 ha^{-1})	IEI (MJ ha^{-1})	FIE (MJ ha^{-1})
Continuous flooding (CF)	4814 a	2960 a	4847.25 a
Controlled irrigation (CI)	2859 b	1758 b	2423.62 b

In a column, means with the same letter are not significantly different at 5% level by HSD.

Table 17. Grain yield, NUE and N input energy of high yield varieties, 2013

Variety	Grain yield (t/ha)	NUE (kg kg^{-1})	NIE (MJ ha^{-1})	
			Fixed rate of 120 kg N ha^{-1}	LCC-based N application (kg N ha^{-1})
PSB Rc82	5.10 cd	22.62 b	9600 a	8400 b (105)
NSIC Rc216	5.84 b	33.66 a	9600 a	8400 b (105)
NSIC Rc224	5.12 cd	19.95 b	9600 a	10240 a (128)
NSIC Rc226	6.64 a	25.62 ab	9600 a	10240 a (128)
NSIC Rc240	5.65 bc	27.68 ab	9600 a	8400 b (105)
NSIC Rc204H	4.96 d	23.69 b	9600 a	8400 b (105)

In a column, means with the same letter are not significantly different at 5% level by HSD.
In the fourth column, figures in parentheses are the total rate of N fertilizer applied based on LCC.

Table 18. Grain yield and NUE under different N management, 2013 WS.

N treatment	Grain yield (t/ha)	NUE (kg kg^{-1})
No N application	4.24 b	-
Fixed rate N application	5.41 a	12.96 a
LCC-based N application	5.62 a	16.07 a

In a column, means with the same letter are not significantly different at 5% level by HSD.

Table 19. NIE of high yield varieties with fixed rate and LCC-based N application, 2013 WS.

Variety	Fixed N rate (90 kg ha^{-1})	LCC-based N (kg N ha^{-1})
PSB Rc82	7200 a	7360 a (92)
NSIC Rc216	7200 a	7360 a (92)
NSIC Rc224	7200 a	7360 a (92)
NSIC Rc226	7200 a	5520 c (69)
NSIC Rc240	7200 a	6160 b (77)
NSIC Rc204H	7200 a	7360 a (92)

In a column, means with the same letter are not significantly different at 5% level by HSD.
In the third column, figures in parentheses are the total rate of N fertilizer applied based on LCC.

Evaluation of alternative and potential non-fossil fuel based nitrogen fertilizer for rice

EF Javier, XXG Sto. Domingo, AJ Espiritu

Nitrogen is highly correlated to increase grain yield. Production of nitrogen fertilizers requires higher amount of fossil fuel energy, thus, the cost of fertilizer increases. Due to lack of financial means to buy these fertilizers, the farmers usually do not apply the right amount of nitrogen needed by the plants that leads to a decline of grain yield especially in high yielding variety. Hence, an alternative non-fossil fuel-based N fertilizers like green manures or those organic farm wastes with low C:N ratio were revisited and considered for evaluation. This study aimed to assess and determine optimum use of these green manures as nutrient supplements from high to low energy while sustaining productivity, profitability, and ecologically-friendly rice cultural production.

After the conduct of homogeneity trial in dry season 2013 at Philippine Rice Research Institute- Central Experiment Station, seeds of Indigo (tayum), Chorchoros (saluyot), and 2 varieties of Vigna (mungbean), were collected, and planted during the fallow period between two rice cropping season. Another green manure, Azolla was also used as treatment but it was only applied and incorporated in the soil: a) during last harrowing, b) 20 DAT and c) 40 DAT. The Palaycheck keycheck #5 was also included in the treatments as checks. The treatments were laid out in Split plot design in 4 replications with the two rice varieties, inbred (PSB Rc 82) and hybrid (Mestizo 20) set as the main plots.

Highlights:

- In this prelimary trial, grain yield was significantly higher still when the PC Keycheck #5 was followed, putting all the required N by the plants using urea fertilizers, followed by the application of native mungbean. The rest of the green manures gave lowest grain yield comparative to the unfertilized plots (Figure 19).

- Propagation of the green manures was observed to be one of the problems as to optimizing their use as alternate N fertilizer sources. Preliminary observations that need to be addressed in the succeeding experimentation:
    1. Low germination and reproduction of the green manures used in the experiments. This is maybe due to either wrong scarification procedure of the seeds, or due to the heavy clayey soils on which they were grown in this trial.

2. Azolla propagation was also very low, hence, alternate Azolla varieties that could adapt to high temperature and high humidity have to be studied. Likewise, heavy rain tended to cause run-off of Azolla to the mini-canals constructed around the experimental units or plots.

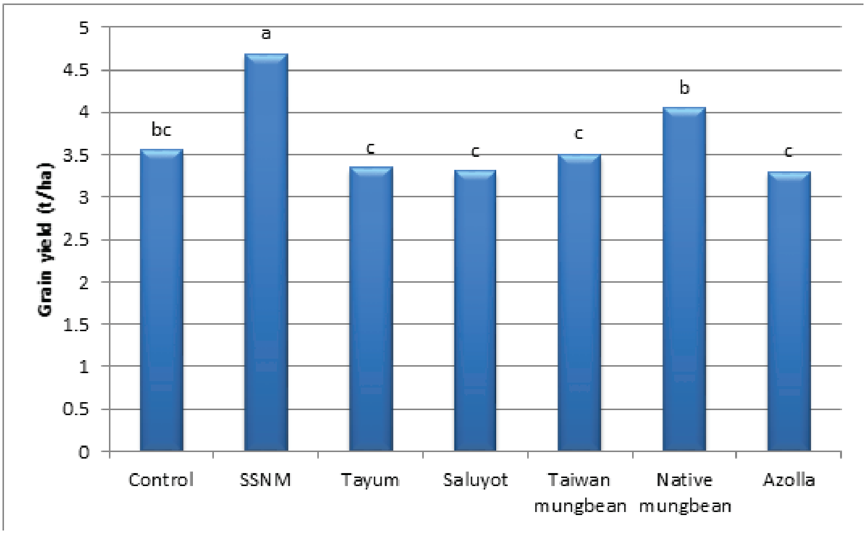


Figure19. Average grain yield as affected by the application of green manures regardless of variety used. Wet season 2013.

IV. ASPPD Research and Analytical Laboratory Systems and Maintenance

Project Leader: EF Javier

The project was established to (1) provide assistance in the improvement/upgrade of the laboratory facilities for better quality research output; (2) constantly optimize laboratory/ chemical procedures for soils and plant samples; and (3) build-up database and inventory of information on the chemical and laboratory supplies and usages. Activities in this project include (1) chemical and laboratory supplies inventory and purchase; (2) annual equipment preventive maintenance service and calibration; (3) data-based management system; and (4) consultation, technical networking and inter-laboratory collaboration.

In 2013, two theses on elucidation and bioassay of new agricultural soils and plant nutrition products were provided with preliminary bioefficacy information. The theses are the following:

- The Assay of Botong (Barringtonia asiatica) as Molluscicide against Pomacea canaliculata and fertilizer on Oryza sativa. (on going patent application). Honorato C. Perez Sr. Memorial Science High School. Cabanatuan City.

- Effects of the application of chemical photosynthetic booster on the growth of hybrid rice. Honorato C. Perez Sr. Memorial Science High School. Mabini Extension, Cabanatuan City.

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

List of Tables

List of Tables

List of Figures

List of Figures

List of Figures

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

We accomplish this mission through research and development work in our central and seven branch stations, coordinating with a network that comprises 57 agencies and 70 seed centers strategically located nationwide.

To help farmers achieve holistic development, we will pursue the following goals in 2010-2020: attaining and sustaining rice self-suffiency; reducing poverty and malnutrition; and achieving competitiveness through agricultural science and technology.

We have the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environment Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

PhilRice Central Experiment Station
Science City of Muñoz, 3119 Nueva Ecija
TRUNKLINES: 63 (44) 456-0277, -0258, 0285
Direct Line/Telefax: (044) 456-0112
prri.mail@philrice.gov.ph

PhilRice Agusan
Basilisa, RTR Romualdez, 8611 Agusan del Norte
Tel: (085) 343-0778
Telefax: (085) 343-0768
agusan.station@philrice.gov.ph

PhilRice Batac
MMSU Campus, Batac City, 2906 Ilocos Norte
Tel: (077) 670-1867
Telefax: (077) 792-4702, -2544
batac.station@philrice.gov.ph

PhilRice Bicol
Batang Ligao City, 4504 Albay
Mobile: 0906-935-8560; 0918 946-7439
bicol.station@philrice.gov.ph

PhilRice Isabela
San Mateo, 3318 Isabela
Tel: (078) 664-2954
Telefax: (078) 664-2953
isabela.station@philrice.gov.ph

PhilRice Los Baños
UPLB Campus, College, 4031 Laguna
Tel: (049) 501-1917
Telefax: (049) 536-8620
losbanos.station@philrice.gov.ph

PhilRice Midsayap
Bual Norte, Midsayap, 9410 North Cotabato
Tel: (064) 229-8178
Telefax: (064) 229-7242
midsayap.station@philrice.gov.ph

PhilRice Negros
Cansilayan, Murcia, 6129 Negros Occidental
Mobile: 0928-506-0515
negros.station@philrice.gov.ph

PhilRice Field Office
CMU Campus, Maramag, 8714 Bukidnon
Tel: (088) 222-5744

PhilRice Liason Office
3rd Flr. ATI Bldg, Elliptical Road
Diliman, Quezon City
Tel/Fax: (02) 920-5129
Mobile: 0920-906-9052

PhilRice Text Center
0920-911-1398

PhilRice Website
www.philrice.gov.ph

PhilRice Website
www.pinoyrkb.com

CERTIFICATION INTERNATIONAL
ISO 9001:2008 CIP/4360IQ/09/10/668
ISO 14001:2004 CIP/4360IE/09/10/668
OHSAS 18001:2007 CIP 4360ISH/09/10/668