PHILIPPINE RICE R&D HIGHLIGHTS 2012

The Deployment and Validation of High Beta-Carotene Rice Varieties in the Philippines and Bangladesh to Combat Vitamin A Deficiency

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The Deployment and Validation of High Beta-Carotene Rice Varieties in the Philippines and Bangladesh to Combat Vitamin A Deficiency

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Vitamin A Deficiency (VAD) is a public health problem that affects an estimated 190 million children and 19 million pregnant women globally . It impairs the immune system, which increases the risk of death from certain common infections among young children and also the leading cause of blindness among children. Globally, approximately 670,000 children die every year because they are vitamin A-deficient , and another 350,000 go blind . Vitamin A deficiency is often severe in areas where people consume nutrient-poor staple foods (i.e. rice) and other nutritious food is scarce, unavailable, or too expensive. In the Philippines, VAD is still a public health problem among pre-school children (15.2% prevalence) and among pregnant (9.5% prevalence) and lactating women (6.4% prevalence) .

Golden Rice (GR), a genetically-modified rice with beta carotene, could be particularly effective in reducing VAD in countries such as the Philippines, where rice consumption is high, assuming it will be efficacious and acceptable to those most in need. In 2005, new Golden Rice materials (GR2) produced by Syngenta were donated by the company for use by the Golden Rice Network. These materials were then transferred to IRRI for introgression to important rice varieties. The introgressed lines were tested under contained (screenhouse) and confined field tests in IRRI and PhilRice under conditions approved by the National Committee on Biosafety of the Philippines (NCBP). In 2012, two seasons of Multi-Location Field Trials (MLT) using nine advanced lines of IR64-GR2R were completed under the purview of the Department of Agriculture – Bureau of Plant Industry (DA-BPI). The objectives of the trials were to evaluate the agronomic and product performance in different growing environments, assess environmental biosafety, and produce grains of Golden Rice for various tests required to complete the data requirements set by the national government.

Results of the two-season MLT indicated that there were slight differences in yield of Golden Rice lines and the wild type counterpart. However, the combined yield data for the two seasons reveal that GR lines are comparable to the wild type. In terms of other agronomic characteristics, there are also slight differences among the IR64-GR2R introgressed lines and IR64. Total carotenoid readings were significantly higher in Golden Rice lines compared to the wild type. Data from nematode evaluation and dormancy studies however showed no significant difference between GR and non-GR lines. If biosafety data prove the Golden Rice is safe to humans and the environment after the completion of the MLT (3 seasons), nutritional studies

will proceed and if proven effective, it will be deployed as a commercial variety later on.

Multi-Location Field Trials of Beta Carotene-Enriched 'Golden Rice' Event GR2-R in the Philippines (First Season)

From March to August 2012, the first season of MLT was conducted in four sites, namely: (1) Bicol Experiment Station (BEST) of the Department of Agriculture- Regional Field Unit 5 (DA-RFU 5) in Pili Camarines Sur; (2) Orfanel Farm in Brgy. Caraycayon, Tigaon, Camarines Sur; (3) PhilRice-Central Experiment Station (PhilRice-CES) in Brgy. Maligaya, Science City of Muñoz, Nueva Ecija; and (4) PhilRice-Batac Station in Barangay Tabug, Batac City, Ilocos Norte.

Highlights:

- Entries 7, 8, and 9 were the most different, morpho-agronomically, from IR64. They were taller, their paddy grains tended to be longer and heavier than IR64, and their number of filled spikelets tended to be lower. In two locations, they registered a flowering period that was 5 days earlier and a maturity period that was 6 days earlier than IR64 (Pili), and flowering and maturity periods that were two days earlier than IR64 (Tigaon). They had the lowest grain yield levels.

- Entries 1, 4, 5, and 6 were different from IR64 in terms of days to flowering, days to maturity and number of spikelets. The yield was slightly lower.

- Entry 3 had a tendency to flower and mature earlier than IR64 (as reflected in Pili and Tigaon). Other than that, it was the most similar GR line, morpho-agronomically, to IR64.

- Entry 2 was like Entry 3, very similar to IR64 and had a tendency to flower and mature earlier. Its yield, though, was slightly lower.

- Total carotenoid (TC) content (μg/g) of the nine IR64-GR2R lines ranged from 4.51 to 5.55. These values were all significantly different from the TC content levels of IR64 (i.e., 0.35 for IR64 Entry 10, and 0.29 for IR64 Entry 11). In each test site, grain samples from three replications were pooled. In the statistical analysis, the pooled samples from the four test sites were considered as the biological replication. Thus, each IR64-GR2R entry had four replications.

- The analysis of variance of germination rates indicates that the treatment means were equal (i.e., there was no significant variation in the treatment means) at 95% confidence level. Post-hoc analysis (i.e., mean comparison) returned mostly no significant difference between

means as expected. Two IR64-GR2R lines (Entry #3 and Entry #6) showed significantly different germination rates than IR64 Entry 11 when seeds were not heat-treated; but otherwise, the germination rate of the test entries was generally the same as that of IR64 under untreated and heat-treated conditions.

Multi-Location Field Trials of Beta Carotene-Enriched 'Golden Rice' Event GR2-R in the Philippines (Second Season)

The second season MLT was conducted from August 2012 to March 2012 in the same sites, with PhilRice-Isabela in Brgy. Malasin, San Mateo, Isabela as an additional site. As with the first season, all biosafety guidelines were followed including monitoring by DA-BPI and Regional Quarantine Officers (RQO) during major field activities. Excess grains were heat-killed and buried in a pit inside the fenced area and volunteer plants were also monitored for one month.

Highlights:

- Grain yield of test entries across the five locations ranged from 3330 kg/ha for Entry 4 to 4128 kg/ha for Entry 3. Of the nine GR2R entries, only the grain yield of Entry 4 was significantly lower than that of IR64 (4097 kg/ha). Location means were relatively lower for Pili (2474 kg/ha) and Tigaon (2756 kg/ha) than those for Batac (4434 kg/ha), Muñoz (4571 kg/ha) and Isabela (4425 kg/ha).

- For both corrected plot yield and kg per ha yield, genotype by environment interaction was significant, and CV, R2, and error were all within acceptable limits. The increased precision when analysis was performed across multiple environments resulted in the F test and Dunnett's t-test being more sensitive to detect significant differences.

- For morpho-agronomic characteristics, GR lines are generally taller, some with shorter grain length, longer days to flowering, and lesser days to maturity compared to the wild type.

- Based on the two-season data, Entries 2 and 3 are the closest to IR64 and thus, selected for further generation advance.

Table 1. List of IR64-GR2R entries used in the two seasons of MLT.

Entry Number	Line Designation
1	GR2-RXIR64-B3F5-148-10-10-10-19
2	GR2-RXIR64-B3F5-148-10-10-10-12
3	GR2-RXIR64-B3F5-148-10-10-10-59
4	IR64XGR2-R-B3F5-239-10-16-11-36
5	IR64XGR2-R-B3F5-239-19-4-20-11
6	IR64XGR2-R-B3F5-239-19-9-13-32
7	IR64XGR2-R-B3F5-239-28-6-3-3
8	IR64XGR2-R-B3F5-239-28-6-3-7
9	IR64XGR2-R-B3F5-239-28-6-3-55

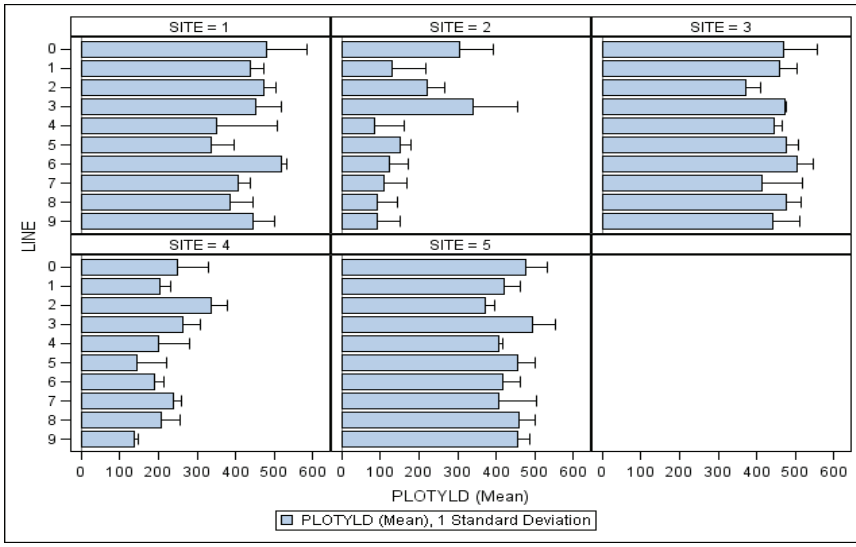

Figure 1. Second season mean plot yield in grams of GR lines (1-9) and IR64 (0) at five sites- Batac (1); Tigaon (2); Muñoz (3); Pili (4); and San Mateo (5).

Table 2. Total Carotenoid (TC) content of IR64-GR2R and IR64 Wild-Type (WT) entries across four sites (First Season).

Entry No.	Line Designation	TC means* (ug/g)
6	IR64XGR2-R-B3F6-239-19-9-13-32	5.55017[a]
5	IR64XGR2-R-B3F6-239-19-4-20-11	5.31261[b]
3	GR2-RXIR64-B3F6-148-10-10-10-59	5.18174[bc]
4	IR64XGR2-R-B3F6-239-10-16-11-36	5.05008[c]
1	GR2-RXIR64-B3F6-148-10-10-10-19	4.83922[d]
8	IR64XGR2-R-B3F6-239-28-6-3-7	4.68986[de]
7	IR64XGR2-R-B3F6-239-28-6-3-3	4.57753[ef]
9	IR64XGR2-R-B3F6-239-28-6-3-55	4.52982[f]
2	GR2-RXIR64-B3F6-148-10-10-10-12	4.51224[f]
10	IR64 WT	0.34978[g]
11	IR64 WT	0.29318[g]

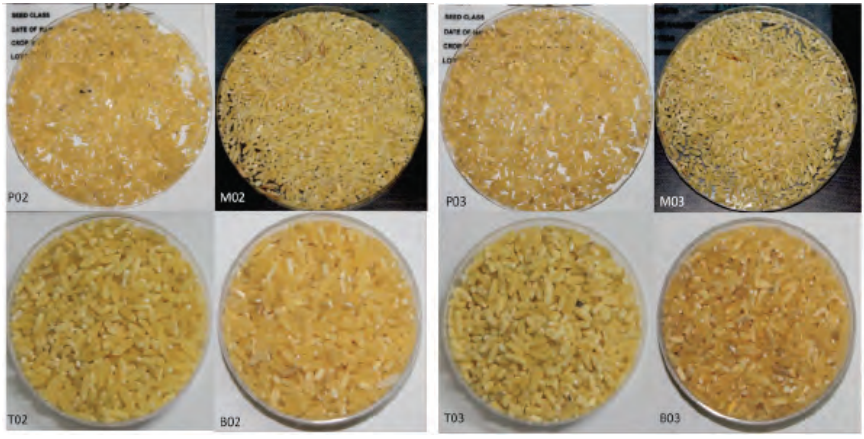

Figure 2. Selected lines (Entries 2 and 3) based on yield, phenotype, and total carotenoid content. P- Pili, M- Muñoz, T- Tigaon, B- Batac.

Abbreviations and acronymns

ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit

LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

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PHILIPPINE RICE RESEARCH INSTITUTE

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 technologies 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 58 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-sufficiency; 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 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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CERTIFICATION INTERNATIONAL
ISO 9001:2008 CIP/4360Q/09/1068
ISO 14001:2004 CIP/4360E/09/1068
OHSAS 18001:2007 CIP/4360H/09/1068