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Performance of eleven introduced improved lowland rice varieties in the northern Savanna zones of Ghana

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From 2007 to 2010, we evaluated eleven introduced improved rice materials, mainly lowland NERICAs and Thailand varieties for yield and other farmers' preferred agronomic traits compared to Gbewaa (aromatic local check) and Digang (non aromatic local check). The trials, each year, were laid out in a Randomized Complete Block Designed (RCBD) with four replicates at two locations (Nyankpala and Salaga) in Northern Region, Ghana. Six cultivars namely, WAS 163-B-5-3, WAS 122-13-WAS-10-WAR, L2-4, PERFUME IRRIGATED, LONG GRAIN ORDINARY 2 and EXBAICA yielded significantly higher (p<0.5) with mean yield advantage range of 21 to 73% over Gbewaa, 16 to 66% over Digang, adapted to the target environment and tolerant to the major biotic stresses. These materials include two aromatic varieties which could serve as substitutes for Gbewaa (the market aromatic quality) and give farmers a choice to meet the existing market demand for aromatic rice.

Key words: Rice evaluation, Savanna agro ecologies of Ghana, NERICAs, improved varieties.

INTRODUCTION

Rice has successfully become a staple food in Ghana. This is a result of the rapid change in lifestyle and food habit; particularly in urban centers (Nyanteng, 1987; Balasubramanian et al., 2007). The per capita rice consumption has risen from average of 17.5 kg in 2001 to 22.6 kg in 2004 and is estimated to reach 63 kg in 2015 (JICA, 2007).

Ghana continues to import about 60% of its rice needs and consequently spends about US$ 450 million annually on imports (MOFA, 2010; Mohapatra, 2012). Efforts to increase domestic rice production will contribute directly to foreign currency saving and balance of payment, in addition to improving farmers' incomes. Increased productivity from increased yield per unit area through the use of high yielding locally adapted varieties and good agronomic practices is the most viable strategy to reduce dependency on importation (MOFA, 2009).

Ghana mostly depends on the Consultative Group on International Agricultural Research (CGIAR) centers, that is, Africa Rice Centre (AfricaRice) and International Rice Research Institute (IRRI) for its improved breeding materials (MOFA, 2009).

The Participatory Varietal Selection approach (PVS), which aids easy access of promising materials to farmers (AfricaRice, 2010), is mostly employed in evaluating the materials. Promising ones tested at multi-locations and

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Table 1. Varieties and sources used for the Multi-location trials.

Variety	Source	Year introduced/released
WAS 122-IDSA-13-WAS-10-WAB-B-TGR5	AfricaRice	2004
WAS 163-B-5-3	AfricaRice	2004
L-2-4	AfricaRice	2004
WAS 122-IDSA-11-WAS-11-4-FKR1	AfricaRice	2004
WAS 161-B-6-4-FKR1	AfricaRice	2004
Thai 3(Long grain ordinary rice 2 irrigated)	Thailand	2008
Thai 4 (heavy jasmine lowland)	Thailand	2008
Thai2 (Long grain ordinary rice 1 irrigated)	Thailand	2008
Thai 1 (Perfume irrigated)	Thailand	2008
Thai 5 (Light Jasmine Lowland (95 days)	Thailand	2008
EXBAIKA	University Farm, Kpong	2004
DIGANG*	SARI	2002
GBEWAA RICE/ JASMINE 85*	USA	2002/2009**

*Released varieties used as local check; ** Introduced in 2002 and released as a variety in 2009.

on-farm are recommend for release as varieties.

The savanna zones of Ghana which constitute the three Northern regions (that is, Northern, Upper East, and Upper West) produce over 60% of the local rice (JICA, 2007). The Savanna Agricultural Research Institute (SARI), one of the 13 institutes of the Council for Scientific and Industrial Research (CSIR) is mandated to conduct research and introduce improved technologies to enhance agricultural productivity in this zone.

As part of its mandate, new higher yielding rice varieties are to be introduced to farmers to enable them improve their productivity. This paper presents the performance of introduced lowland NERICAs and some Thailand materials in the Savanna agro ecological zones of Ghana.

MATERIALS AND METHODS

From 2007 to 2010, we evaluated at Nyankpala and Salaga five lowland NERICA Varieties, 5 introductions from Thailand, one introduction from University of Ghana Research station (Kpong) and two local control varieties. The five Lowland NERICAs were the most preferred farmer selections out of 30 entries during a previous Participatory Variety Selection (PVS-R) in 2004 (SARI, 2010). The introductions from Thailand and Kpong were included in 2008. The list of varieties used for the multi-location tests are presented in Table 1.

Experimental sites

The materials were tested at CSIR-SARI main station at Nyankpala and sub-station at Salaga. The Nyankpala site which falls within the Guinea savanna agro ecological zone is located 16 km West of Tamale the capital city of northern region of Ghana. The area lies in latitude 9° 25' 41" N and longitude 0° 56' 42" W, altitude 183 m above mean sea level. Annual average rainfall is about 1000 mm and mean temperature of 39°C (Kasei, 1988). The Salaga site falls within the west savanna transitional agro-ecological zone and is located 5 km south of Salaga the capital city of East Gonja district. The area lies in latitude 8° 33' 25" N and longitude 0° 31' 04'' W, 156 m above mean sea level. Annual average rainfall is 1100 mm and mean temperature 27.9°C (Kasei, 1988). Weather conditions during the experimental years at Nyankpala is presented in Table 2.

Characteristics of the experimental soil

The characteristics of the experimental soils at the two sites are presented on Table 3. Total N was determined by the Kjeldahl procedure (Tel and Hegatey, 1984), available P by the Bray 1 extraction solution procedure (Bray and Kurtz, 1945) and exchangeable K by 1.0 M neutral NH_4OAc solution (Black, 1965). According to the physical and chemical characteristics, the soils can be described as deep sandy loam to clay loam (Buri et al., 2012). The pH was 4.8 at the 0 to 15 cm level and 4.9 at 15 to 30 cm. Compared to Buri et al. (2012), the levels of N, P and K in the soils were considered to be low.

Field preparation and experimental design

The experimental sites each year were ploughed around the first week of June and harrowed a week or two after (at the middle of June). A Randomized Complete Block Design (RCBD) with four replicates and a unit plot size of 3 m x 5 m was used.

Planting and cultural practices

Planting was done by dibbling seeds in a space of 20 cm × 20 cm between rows and hills. One seedling was allowed per hill three weeks after sowing. The recommended rate of compound fertilizer N-P-K of 60-60-30 kg/ha was applied in two split applications (Ragasa et al., 2013). Three weeks after each planting date, the basal fertilizer of 30-60-30 kg/ha NPK (grade 15-15-15) (300 g) and triple superphosphate fertilizer (98.7 g) were applied per experimental plot of 15 m^2. The remaining nitrogen was applied as top dressing at seven weeks after planting using sulphate of ammonia (214 g/plot). Weeds were initially controlled with pre-emergence herbicide (Pendimethaline 400 g/l; Alligator) at 3.2 L/ha a day after planting and then by hand weeding. Rice was harvested and threshed manually at maturity using sickles and beating on tarpaulin respectively. After measurement of grain moisture, weight

Table 2. Summary of weather data for May to October at Nyankpala for the experimental years.

Expt year	Data	Rain fall (mm)	Rain days (mm)	Evaporation (kph)	Wind speed (km/hr)	Sun shine (°C)	Min temp (°C)	Max Temp (°C)	Mean Temp (%)	Min Rel-Hum (%)	Max Rel-Hum (%)	Mean Rel-Hum (%)
	Total	734.4	52	-	19.7	31.1	138.9	186.8	163	414	542	478
2006	Mean	122	8.7	-	3	7.3	22.7	33.8	28.2	55	79	67
	Total	873.5	54	624.14	20.6	39.4	141	188.5	164	419	543	481
2007	Mean	146	9.0	104	3	7	24	31	27	70	79	66
	Total	1184.9	72	738.25	20.13	58.79	269.8	404.1	336.8	680	949	819
2008	Mean	197	12	123	3	4.89	22.5	33.7	28.1	57	79	68
	Total	1209.1	53	717.34	16.25	14.6	140.8	202	172.3	437	554	497
2009	Mean	202	8.8	120	2.87	7.84	23.2	35.6	29.5	59	82	70

Table 3. Physical and chemical characteristics of soils used.

Site	% Sand	% Silt	% Clay	pH (H_2O)	% OC	% N	P (mg/kg)	K (mg/kg)
Nyankpala	57.8	40.2	2.0	4.8	0.57	0.046	10.75	49.02
Salaga	53.96	21.72	24.32	4.5	1.07	0.088	8.65	48.63

per plot yield of winnowed paddy was assessed at 14% moisture content.

Traits evaluation

Traits evaluated for the study include grain yield, plant height, number of tillers, number of panicles, days to 50% flowering, maturity days, 1000 grain weight, disease scores for blast, brown spot and leaf scald based on IRRI's Standard Evaluation System for rice (IRRI, 1996).

Statistical analysis

Analysis of variance was first performed (SAS Statistical Package) followed by LSD for mean comparison and separation when necessary.

RESULTS

Results of selected parameters measured in 2007 are summarized in Table 4. The recorded yields for the two locations; Nyankpala and Salaga in 2007 are also presented in Table 5.

The yield performance for the years 2008, 2009 and 2010 are presented in Table 7.

DISCUSSION

Generally, the recorded yields were low compared to previous report (JICA, 2007). The yield ranged between 0.7 and 5.5 t/ha for Nyanpkala and 0.8 to 4.5 t/ha at Salaga over the years. Gbewaa, the aromatic check recorded average yield of 2.28 t/ha (Table 7) over the years which is just about 40% of its potential yield of 6 to 7 t/ha (SARI, 2008). Intermittent moisture stress could account for the recorded low yields since experimental fields were rain fed and the plants occasionally suffered from severe moisture stress during the various seasons especially at Salaga in 2010 where the recorded yields were particularly low (Table 7). Terminal season drought is the major abiotic constraint of rice production in the savanna regions (MOFA, 2009). Digang, the non aromatic check averagely performed better (2.4 t/ha) than Gbewaa (2.28 t/ha) (Table 7).

Digang is known to tolerate drought better than Gbewaa. Gbewaa is reported to have problem

Table 4. Plant parameters measured in 2007.

Genotype	Average plant height (cm)	Maturity (days)	Average number of tillers/hill	Disease scores		
				L. Blast	B. Spots	L. Scald
WAS 122-13-WAS-10-WAB-B-TGR5	126	126	14	1	2	3
WAB 163-B-5-3	115	126	12	1	2	3
L2-4	106	111	13	1	3	1
WAS 122-IDSA-10-WAS 11-4-FKR1	93	115	16	0	1	0
WAS 161-B-6-4-FKRI	99	112	16	1	0	0
DIGANG	118	113	9	1	1	0
JASMINE 85	101	116	16	0	1	3

Table 5. Yield (t/ha) of promising varieties at the two sites in 2007.

Variety	Nyankpala	Salaga	Mean
WAS 122-13-WAS-10-WAB-B-TGR5	5.3	4.3	4.8
WAB 163-B-5-3	5.5	4.5	5.0
L2-4	5.0	4.4	4.7
WAS 122-IDSA-10-WAS 11-4-FKR1	5.0	4.4	4.7
WAS 161-B-6-4-FKRI	4.4	4.1	4.3
DIGANG	4.5	4.0	4.3
JASMINE 85	4.3	4.0	4.2
LSD (0.05)	0.6	0.2	-

with drought and diseases (Acheampong, 2010). Planting early and medium duration varieties has been the reliable strategy to escape the effect of terminal season droughts. The selected materials are of medium duration (ranging from 108 to 130 days) (Table 6) which makes them suitable for cultivation in the region. However, to ensure stable yields and sustainable cultivation of these materials in the drought-prone savanna zones, effort should be made to improve the level of drought tolerance of these materials. Analysis of variance across the two locations showed no significant genotype by location interaction indicating that the selected materials can be grown across the target environment.

The selected materials have plant height range of 96 to 126 cm, (Table 6), mostly semi dwarfs to avoid lodging. The materials also have adequate tolerance to brown spot, leaf blast and leaf scald (Table 6); the most prevalent diseases in the tested environment. Screening against these diseases was incorporated in the evaluation process right from the observational nursery scoring each year based on the Standard Evaluation System (SES) of rice by IRRI (1996). The materials also have appreciable levels of tolerance to African gall midge; the most prevalent insect pest (Table 6).

The five introductions from Thailand were included in 2008 because of the market demand for aromatic rice. The Ghanaian market has high preference for intermediate amylose, long slender aromatic rice grains, with these characters accounting for over 40% increase in price quotations (Asante, 2005; Minkah, 2007; Anang et al., 2011). Gbewaa rice is cultivated by majority of Ghanaian farmers because of its aromatic quality. However, it is susceptible to blast and Rice Yellow Mottled Virus (RYMV) (Asante, 2012). Digang (the non aromatic check) is resistant to these two diseases but not preferred because of its poor grain quality (Asante, 2012).

Table 6. Agronomic characteristic of Lowland NERICAs and introduced varieties from Thailand in 2008.

Variety	No. of tillers/hill	Days at 50% flowering	Days to maturity	Plant height (cm)	No. of panicles per hill	Brown spot	Leaf blast	Leaf scald	Gall midge
L2 - 4	13.9	89	118	95	9.3	2.25	0.5	3	0
WAS 161-B-6-4-FKR1	14.3	93	117	92.9	9.7	1	0	3.5	3
WAS 163-B-5-3	12.7	89	117	105.8	9	3	0.25	3.5	0
Thai 3 (long grain ordinary rice2 irrigated	10.3	98	130	124.4	7.7	1.25	0.25	3	3
WAS 122-13-WAS-10-WAB-B-TGR5	12	93	126	101.4	9.1	4	0.5	3	0
Jasmine 85	13.6	89	116	93.9	7.8	3	0	3	3.5
Thai 4	13.8	114	133	143.5	4.8	1.5	0	4.5	4.5
Digang	12.2	87	113	108.8	6.8	1.75	0.5	2.5	0
WAS 122-IDSA-11-WAS 11-4-FKR1	14.1	90	117	86.5	9.6	1.25	0	6	6
Exbaika	12.7	98	122	90	9.2	3.25	0.25	4	5.5
Thai 2	11.7	77	108	92.3	9.4	2	0.25	3	0
Thai 1 (Perfume irrigated (110 days)	14.2	110	131	104	7.1	1	0	6.5	6.5
Thai 5	11.2	106	129	137.7	7.2	1.5	0	4	7
Lsd(0.05)	2.1	7.8	5.5	8.4	1.81	1.33	NS	1.19	1.1

Diseased scores based on IRRI's SES (1996).

Table 7. Yield (t/ha) of varieties at the two sites in 2008, 2009, and 2010.

Variety	Yield (t/ha)					Mean & SD
	2008	2009		2010		
	Nyank	Nyank	Sala	Nyank	Sala	
L2 - 4	3.9	4.5	3.3	4.3	3.9	3.98 ± 0.632
WAS 161-B-6-4-FKR1	3.7	3.0	1.5	2.4	1.0	2.32 ± 1.094
WAS 163-B-5-3	3.6	4.2	2.8	4.1	3.7	3.68 ± 0.554
Thai3 (Long grain ordinary rice 2 irrigated)	3.2	4.0	3.4	3.4	3.0	3.4 ± 0.374
WAS 122-13-WAS-10-WAB-B-TGR5	3.2	3.8	3.0	4.1	3.9	3.6 ± 0.474
GBEWAA (L/C)	2.9	3.0	2.0	2.4	1.1	2.28 ± 0.773
Thai 4 (heavy jasmine lowland)	2.8	2.5	2.0	0.7	0.9	1.78 ± 0.942
DIGANG(L/C)	2.7	2.9	2.5	2.5	1.4	2.4 ± 0.583
WAS 122-IDSA-11-WAS 11-4-FKR1	2.6	3.6	1.8	3.0	1.6	2.52 ± 0.832
EXBAIKA	2.6	3.8	3.0	4.1	3.9	3.48 ± 0.646
Thai 2 (Long grain ordinary rice 1 irrigated)	2.5	2.1	1.1	2.1	0.8	1.72 ± 0.729
Thai 1 (Perfume irrigated)	2.2	3.0	2.6	1.8	1.4	2.2 ± 0.632
Thai 5 (Light Jasmine Lowland (95 days)	2.0	2.8	2.3	2.5	1.0	2.12 ± 0.691
Lsd (0.05)	0.8	0.4	0.3	0.8	0.2	-

Nyank=Nyankpala, Sala=Salaga, SD=Standard deviation.

Two of the Thailand introductions (PERFUME IRRIGATED and LONG GRAIN ORDINARY 2) proved suitable for cultivation in the savanna ecology. Other interesting characteristics of the selected materials include high tillering ability, large panicle size and long grains preferred by the Ghanaian market.

Conclusion

Six of the test materials (WAS 163-B-5-3, WAS 122-13-WAS-10-WAR, L2-4, PERFUME IRRIGATED, LONG GRAIN ORDINARY 2 and EXBAICA) outperformed the local popular checks (Digang and Gbewaa) and are currently undergoing on-farm testing pending possible recommendation for release as varieties. Two aromatic varieties (PERFUME IRRIGATED and LONG GRAIN ORDINARY 2) could serve as substitute for Gbewaa and give farmers a choice to meet existing demand for aromatic rice.

Conflict of interest

The authors have not declared any conflict of interest

REFERENCES

Acheampong PP. (2010). Baseline report on AGRA PASS 036 project. CSIR-Crops Research Institute Kumasi, Ghana.13p.

Africa Rice (Africa Rice Centre) (2010). Participatory Varietal Selection of Rice-The Technician's Manual. Africa Rice Cotonou, Benin. 120p.

Anang BT, Adjetey SNA, Abiriwe SA (2011). The consumer preferences for rice quality characteristics and the effect on price in the Tamale Metropolis, Northern Region, Ghana. Int. J. Agric. Sci. 1(2):67-74.

Asante MD (2005). Genetic Analysis of Some Quality Traits in Three Rice Cultivars. MSc Thesis submitted to Kwame Nkrumah University of Sci. Tech., Kumasi, Ghana. 84p.

Asante MD (2012). Genetic analysis of grain quality traits in rice. PhD Thesis, University of Ghana, Legon.

Balasubramanian V, Sei M, Hijmans RJ, Otsuka K (2007). Increasing rice production in Sub-Saharan Africa: Challenges and opportunities. Adv. Agron. 94:55-133.

Black CA (1965). Methods of soil analysis. Part I. Physical and mineralogical properties including statistics and measurements and sampling. Part II. Chemical and mineralogical properties. Agronomy series. ASA. Madison, Wisconsin USA.

Bray RH, Kurtz LT (1945). Determination of total organic available forms of phosphorous in soils. Soil Sci. 59:39-45.

IRRI (1996). Standard Evaluation System for Rice. International Rice Research Institute, Manila, Philippines. pp. 13-46.

JICA (Japan International Cooperation Agency) (2007). The study on the production of domestic rice in the republic of Ghana. Draft final report. Nippon Koei Co Ltd.

Kasei CN (1988). Weather patterns in 1988. In. Nyankpala Agricultural Experiment Station 1988 annual report. Verlag Josef Margraf, Germany. P 18.

Buri MM, Issaka RN, Senayah JK, Fujii H, Wakatsuki, T (2012). Lowland Soils for Rice Cultivation in Ghana, Crop Production Technologies. Available at: http://www.intechopen.com/books/crop-production-technologies/lowland-soils-for-ricecultivation- in-ghana.

Minkah E (2007). Drying and milling characteristics of some selected upland and lowland rice varieties (*Oryza sativa*) grown in Ghana. MSc Thesis submitted to Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. 90p.

MOFA (Ministry of Food and Agriculture) (2010) Agriculture in Ghana: Facts and figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

MOFA (Ministry of Food and Agriculture) (2009) National Rice Development Strategy (NRDS) Draft. Kumasi Ghana.

Mohapatra S, (2012). Ghana celebrates rice. In: IRRI's Rice Today. IRRI, Manila, Philippines. 12(2).

Nyanteng VK (1987). Rice in West Africa. Consumption, imports and production with projections to the year 2000. WARDA, Monrovia, Liberia.

Ragasa C, Dankyi A, Acheampong P, Wiredu AN, Chapotoa A, Asamoah M, Tripp R (2013). Patterns of Adoption of improved rice technologies in Ghana. IFPRI, Washington DC, USA. 36p.

SARI (Savanna Agricultural Research Institute) (2010). 2008 Annual Report, CSIR-SARI, Tamale, Ghana. 79p

Tel DA, Hagatey M, (1984). Methodology in Soils Chemical Analyses. In: Soil and Plant analyses. Study guide for Agricultural laboratory directors and entomologist working in tropical regions. IITA, Nigeria. pp. 119-138.