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Improvement of upland rice in West Africa

by

Abifarin, A.O.* & A.J. Carpenter +

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INTRODUCTION

In West Africa upland rice cultivation comprises about 75% of the total area devoted to rice. This situation will continue until some of the bottlenecks for irrigated rice production are removed. These include topography, economics and farmers' habit. In many parts of West Africa the steep hills with narrow valley bottom are not condusive to paddy development. Development of paddies requires a lot of capital and in West Africa the availability of such capital is limited. Many farmers are upland farmers and the idea of getting their feet wet is not popular. Along with this is the fear of infestation by many water related worms.

Rice consumption is on the increase especially in urban areas. Rice is no longer a ceremonial food and has, in fact, become the staple food for Sierra Leone and Liberia. Therefore to meet the increased demand for rice many researchers in West Africa have programs to improve upland rice.

Upland rice research stations in West Africa.

The major West African rice research centers are Rokupr in Sierra Leone, Sefa in Senegal, Nyankpala in Ghana, Suakoko in Liberia, Bouake in Ivory Coast, IRAT

Rice Breeder at the International Institute of Tropical Agriculture (IITA) Ibadan.

UNDP Rice Specialist, Suakoko, Liberia.

Federal Agricultural Research Station, Ibadan, and the International Institute of Tropical Agriculture, (IITA), Ibadan.

OBJECTIVES OF UPLAND RICE PROGRAM

The general main objectives in rice breeding programs in the above stations are:

I Grain yield improvement

II Plant type improvement

III Maintenance of high grain quality

IV Resistance to African pests and diseases

RESEARCH METHODOLOGY ADOPTED

Methodology varies from one place to another depending on the facility and available staff. In general, however, methods followed are:

a. Introduction of rice varieties and advanced lines from all over the world, with IRRI being the most important source.

b. Screening of the materials for disease and pest resistance.

c. Yield trials of various levels from non replicated to eight replications.

d. Crossing promising varieties and lines to create variability for selection.

At Bouake induced mutation is also done by the IRAT scientists. They had also made a diallel cross between four sativa and four glaberrima varieties.

Usually the segregating populations following a cross are handled by the pedigree method. At IITA recently a type of recurrent selection was carried out.

Entomology.

Several lines and varieties have been screened for insect resistance.

At IITA, Taitung 16, W 1263 and Sikasso were found to be resistant to the African pink borers (Sesamia calamistis).

Physiology

Both IRAT, Bouake and IITA, Ibadan, are studying various traits that may be linked with drought resistance to help in selection for these traits. Areas of research at IITA are: screening for drought resistance, studying the effect of drought stress at different stages of growth on yield and yield components, investigation of sensitivity of rice at different growth stages to different levels of water deficit, and the effect of mulching on growth and development of rice. The IRAT scientists approach is to study the mechanism of drought resistance, to find some varieties that are drought resistant and find out why they are resistant. Meanwhile two experiments have been initiated for the above. One is the global resistance and effect of drought on rice characters. The other is the differences between varieties in their transpiration rates.

In general other ideas for future investigations are: root studies (started in Senegal and IITA) correlations of transpiration results with number and size of stomata, and opening of stomata linked to soil moisture pressure, cuticular transpiration, resistance to dehydration and stability of enzymes during drought, recovery after drought and the link between drought and photosynthesis.

Pathology

In addition to the programs of the rice pathologists, breeders in their screening reject materials that have high infestation of blast. An active research program in Bouake, Ivory Coast includes the following investigations:

1. Determining level of resistance of the breeder's lines to leaf blast and neck blast.

2. Determination of the best design for blast experiments after the nursery stage, investigation of the different type of blast races in Ivory Coast using 14 lines from Japan and limited work on fungicide. From diallel crosses of eight varieties (Columbial, Moroberekan, 63-83, OS6, Bokolon, Miro-miro, OS42, IR5, IR8 and Oma-Rosso) the mechanism of horizontal resistance to blast is being studied in Bouake.

PARENTAL MATERIALS USED

In the first series of hybridization performed by breeders in West Africa, the parents used are those currently recommended, crossed with each other or with exotic varieties or lines. The IRAT scientists have the following parents in their corsses. Miro miro from Senegal, Bokolon from Guinea, Moroberekan, Iquape Citeto from Brazil, 63-83, Lurado Precoce, Taichung Native 1, IR8, 63-104, OS42. In Rokupr parents that have been used are Azecene, Faya, Anethoda, IR26, Tikiri Samba. At IITA crosses have been made between most of the promising West African upland varieties and IRRI lines and varieties. Some of these parents are OS6, IR20, IR22, Moroberekan, IR154-61-1, IR878B_2, SML Alupi, IR269-26-3-3-3, IR305-3-17-1-3, LAC23 and Taichung 16.

RESUME OF PROGRESS MADE

In Bouake a line called 2243 (semi dwarf) resulting from a cross in Bouake and No.1716/2/3 a selection from a cross between IR1931-69 and Taichung Native 1 have shown promise. On small plot yields of the latter were estimated to 6000 kg/ha (IRAT, "Rapport de synthese" unpublished).

In Liberia under upland conditions LAC23 has been found to be a promising variety.

In IITA promising selections have been made from a cross between IR154-61-1 and OS6. These are the TOX 7 lines shown in Table 1.

In the screening efforts for identifying varieties and lines that will be good for upland, several yield trials have been performed. One such trial is the short to intermediate duration variety.

Some of the promising TOX lines were put to early yield trials though some were not uniform yet. The relatively lower yields of these lines in this trial may also be due to the poor stand obtained due to their longer than-expected seed dormancy. Table 2 illustrates, however, the existing potentials in these lines. OS6 is the upland recommended variety in Nigeria.

Comparative trials

The main objective of these two trials was to determine the general performances of entries under two different cultures. The entries were sown in a seed bed for transplanting under irrigation the same day the upland entries were planted. Table 3 shows the data collected under the two conditions. The entries were lines or varieties that might be used for both irrigated and upland conditions. Entries 1, 3, 5, and 6 apparently are not suitable for upland culture judging from their yields and other traits under the two conditions. It is striking to note the little difference of OS6, an upland variety, under irrigated and upland condition. This investigation reveals that under satisfactory rainfall some varieties will do well when planted either in upland or under irrigated culture. IR269 is a good example of this type of adaptability.

Table 1. Agronomic, diseases, and quality data on selected lines in the 1973 IITA upland nursery.

Variety/Lines	Leaf blast	Days to Mat.	Ht at Harv.	% Lodging	Yield Kg/Ha at 14% M.C.	1000 grain Wt in gm	Grain (Hulled) Length	Width	L & W ratio	Protein	Amylose
TOX 7-2-4-3-B_1	3	110	111	0	6240	27.2	6.5	1.6	4.06	12.1	12.8
" 7-3-2-3-B_2	2	114	84	0	4770	31.5	6.9	1.9	3.63	13.4	17.4
" 7-3-2-9-B_2	2	113	123	0	5210	33	7.1	1.9	3.68	11.9	15.8
" 7-3-4-4-B	2	108	100	0	4463	24	6.6	2.0	3.30	8.7	18.9
" 7-3-4-10-B_1	3	98	141	0	4986	30.5	7.0	1.8	3.68	11.7	18.6
" 7-3-5-B1-B_1	3	115	123	0	5486	26	7.3	1.6	4.56	10.5	16.1
" 7-3-5-14-B_1	0	123	118	0	3943	27	7.5	1.8	4.17	11.2	18.9
" 7-3-8-2-1--	3	109	97	0	5545	28	6.8	1.6	4.25		
" 7-3-10-10-3	2	95	130	0	3122	26	6.5	1.8	3.6	9.8	17.8
" 7-3-11-6-B_2	2	113	75	0	5617	25	6.1	2.0	3.50		
" 7-3-11-8-B	2	115	94	0	4220	28	6.8	1.8	3.6		
" 7-3-15-7-2	1	104	136	0	6502	29	6.9	1.7	4.06	9.3	17.3
" 7-3-16-6-B_2	3	113	121	0	5566	28	7.0	2.0	3.50	11.7	20.3
" 7-4-1-10-B	2	105	128	0	3992	33.0	7.7	2.0	3.85	10.7	19.7
" 7-4-2-B_2-B	2	115	143	0	4009	33	7.4	1.9	3.89		
" 7-4-2-3-B_2	3	116	130	0	4314	30	6.8	2.0	3.40	10.0	16.8
" 7-4-2-5-1	0	98	62	0	3143	33	7.5	1.8	4.2		
" 7-4-2-5-2	3	95	115	0	3905	33	7.0	1.7	4.12		
" 7-4-2-5-4	0	101	137	0	1418	26	7.0	2.0	3.50		
" 9-3-17-3 B_2	2	108	91	0	4553	26	7.1	2.0	3.55	11.2	21.1
OS6/486	2	119	177	100	2967	35	7.1	2.3	3.09	8.5	17.4

Table 2. Data on agronomic traits, grain yields on 14 short medium duration entries under upland in IITA 1973 wet season.

	Varieties/Lines	Yield (Kg/Ha) at 14% MC	Days to 50% Fl.	Days to Mat.	Height (cm)	Lodging %	Tillers per plant	Panicle per plant	Blast Score	N/rot %	Rhyc.- cos.
1	IR750-35-5-3	3855a	96	122	71.6	0	5.06	4.6	3	7.6	10.0
2	IR527-1-10-3	3083b	90	119	65.4	0	6.06	5.03	2	3	31.0
3	TOX7-4 1 10-B	2895bc	91	121	131.6	46.0	4.25	3.70	2	..4	3.0
4	TOX7-3 13-1-3	2811bc	87	115	128.4	42.0	3.52	2.32	1	2.0	18.0
5	IR579-52 2	2758bc	98	139	78.4	0	5.28	[illegible]	3	17.4	[illegible]
6	TOX7-3-10-10 B	2616bc	92	119	132.0	46.0	4.39	3.70	2	0.0	20.0
7	TOX6-19-9-1 B	2457bc	118	140	97.8	0	5.00	4.32	2	21.6	14.0
8	TOX7 3 14-5 B1	2429bc	97	122	129.2	58.0	3.80	3.44	1	0.3	22.0
9	IR5[illegible] 1-32	2353bcd	85	119	70.6	0	6.33	5.56	3	2.6	49.0
10	TOX7-3-5-B1-B	2188cd	94	122	126	38.0	4.04	3.38	2	5.0	45.0
11	OOS	1665de	107	134	152.6	54.0	2.77	2.55	4	2.4	12.0
12	TOX7-3-6-5-B	1486ef	90	118	127.8	38.0	3.00	1.97	3	0.0	16.0
13	TOX7-3-8-3-B1	1465ef	88	116	116.6	17.0	3.85	3.00	3	0.0	23.0
14	TAKALON	956f	121	146	150.0	16.0	3.43	1.55	4	6.0	19.0
	C.V.	21.9%	4.6	3.4	10.9	131.3			55.3	98.4	91.8

Table 3. Grain yield, diseases, and other data on varieties or lines planted concurrently under upland and irrigated condition in IITA in 1973.

	Varieties or Lines	Yield in Kg/Ha. at 14% M.C.		Days to Maturity		Height (cm)		Neck rot %	
		Irrig.	Upland	Irrig.	Upland	Irrig.	Upland	Irrig.	Upland
	TOs								
1	858/PANKAJ	5474a*	868e*	163	160	143	109.3	0	29.7
2	78/IR269-26-3-3-3	5061ab	4360a	144	151	117	103	3.6	14.7
3	887/AXBG15.3	4936ab	1470de	135	146	138	160.3	0	15.8
4	46/IR305-3-17.1-34	4784 b	3076b	136	132	101	32.7	45	43.7
5	356/JAYA	4557 abc	2191c	131	133	104	37.3	3	58.3
6	121/IR773A-1-36-2-1	4426bc	1800c	112	110	98	78.3	5.2	11.8
7	1108/IR442	4344bcd	2274c	153	139	127	95.3	6	17
8	921/IR937-76-2-2-	4238bcd	3258b	136	149	111	81.3	3.2	58.3
9	912/IR1163-134-1-2	4149bcd	2084ed	143	155	113	96.3	35	14.5
10	542/IR790-28-2-1	3663cd	2235c	146	145	112	85.8	4.8	22
11	920/IR1112-28	3385de	2032cd	134	150	104	89.3	2.8	28.5
12	486/OS6	2737e	2040cd	120	130	151	177.2	0	6.7
	C.V.	14.1	24.3	3.3	6.7	6.9	9.8	67.2	112.6

* Figures within same column having the same letter are not significantly different at 5% level.

In Liberia and Sierra Leone rainfall is high and practically uninterrupted by a bi-modal distribution. They are among the most important producers of upland rice probably somewhat exceeding in production area the total of Nigeria and Ivory Coast. Here there is less need for drought tolerant and short duration varieties as rainfall is usually in excess, sometimes vastly so with over 4 metres common along the coast. Most "varieties" grown are of from 120 - 140 days duration, tall and rather low tillering with large panicles. They have broad, soft pale green leaves and are of low photoperiod sensitivity, typically initiating flowers in late July or early August. A great deal of variation is seen particularly in spikelet characters. Most farms contain a small percentage of Oryza glaberrima plants and a few grow pure stands of O. glaberrima. All farms are intercropped with varying collections of other crops; over 30 species are involved with corn, sorghum and bulrush millet prominent. These supplementary crops make an important contribution to family nutrition and cash income and cannot be ignored in planning for upland rice improvement. Yields are very variable and largely dependent on available soil fertility which is itself related to the period of bush fallow. Vertebrate pests are also very destructive and seem responsible for a 20 - 30% average loss in Liberia. They also involve families in much unproductive work in fencing farms and bird scaring. Losses from insect pests and diseases seem very low. Rynchosporium leaf scald lesions are often seen but are doubtfully responsible for much yield loss. Pyricularia leaf spots are common but the neck rot stage is scarcely ever seen on farmer's farms.

In both Liberia and Sierra Leone a relatively small effort has demonstrated

that very substantial yield improvements are possible by varietal selection. Table 4 sets out the results of nearly 300 farmer's farms trials in Liberia in 1971 and 1972. The mean 30% increase due to LAC 23 unfertilised would wipe out Liberia's imports of rice (about 70,000 tons paddy equivalent/year) if only half the farmers grew the variety and sold the extra production. Table 5 sets out similar results obtained with Anethoda and Tikiri Samba in Sierra Leone. LAC 23 was selected from a collection of local varieties by Dr. T. Hart. Anethoda and Tikiri Samba originated in India and Sri Lanka respectively.

In Liberia more recent trials at the Suakoko station are summarised in Tables 6 - . The varieties included came from several sources. Liberian local selections were compared with leading varieties from the Ivory Coast and Sierra Leone and with a number of IRRI lines with semi-dwarf plant type. A few other introductions such as H 4 (Sri Lanka) and Socotera 55 (Tanzania) were also studied. In 1973 two trials were carried out for WARDA (table 7) and a WARDA advanced collection of breeder s lines from five countries was also grown in observation plots. The most attractive of these are listed in Table 8. In Sierra Leone interest has been concentrated on a series of hybrid lines derived from some good upland varieties crossed onto several promising irrigated varieties in 1962. Table 9 summarises recent results with these varieties some of which have also performed well in Liberia.

Reviewing the Liberian results we see that three varieties, LAC 23, IR 442-2-58 and H 4 have been outstanding. This result is most interesting as the varieties represent three very distinct plant types. LAC 23 is a typical local upland low tillering variety with a very long panicle often exceeding 30 cm.

IR 442 is a semi-dwarf which becomes very short indeed (80 cm) under upland conditions. H 4 is an improved variety but not a semi-dwarf. It is high tillering and was originally selected for irrigated conditions. What are the characters which permit these widely contrasting varieties to perform well under upland conditions in Liberia while others, superficially rather similar, fail miserably? Drought resistance does not seem to be an important factor. We have never seen leaf rolling or die-back in the field even at the end of 10 - 12 day dry periods in August. These dry periods even seem to induce a surge of growth due to extra sunlight. Apparently the heavy early rains charge the soil with adequate moisture even at Suakoko where rain shadow reduces precipitation to about 2 metres; rather low for the region. One important factor is resistance to neck rot blast. While all local varieties seem to have stable resistance, at least half the bred semi-dwarf lines tested are severely damaged. Ivory Coast and Sierra Leone entries have been generally resistant but varieties from Gambia, IITA and, for example, OS 6 and E 425 have succumbed to neck rot. In 1973 IR 442 followed suit with over 30% of dead panicles in the WARDA trials, after showing no damage in 1972 (note IR 442 still came top in the trial in spite of this damage!) Clearly very thorough screening at many sites must be a high priority and breeding must incorporate plenty of stable blast resistance from many sources. Upland rice is at great risk from neck rot blast, a situation that has been somewhat masked by the low incidence in farmer's farms. Widespread release of a variety which subsequently collapsed with neck rot would be an unprecedented disaster for farmers who can usually bank on reliable, if low, yields. The existance of the WARDA network of trials

stations should make this screening feasible.

Apart from blast, many lines fail to grow freely, and exhibit symptoms of physiological stress. Typically they remain stunted and yellowish frequently with Helminthosporium spotting, while varieties like LAC 23 and Moroberekan are green and vigorous. We have little information as to the factors involved, but foliar analysis may indicate if deficiencies or perhaps manganese toxicity are involved. We have noticed that LAC 23 germinates slowly and produces a large vigorous root system before emerging from the soil. Other workers have noticed similar vigorous root systems in OS 6 and Iguape Cateto. As De Datta has pointed out IR 442 has one parent (Leb Mue Nahng) which is a floating variety. Such varieties have usually to be sown early under rather dry upland conditions in order to make enough growth to manifest the floating habit when flood waters arrive. Floaters may prove to be a rich if somewhat unexpected source of physiological fitness for upland conditions. Selection of segregating populations for root vigour is difficult but deserves close study particularly if it can be identified in the seedling stage as with LAC 23.

Finally, we should consider where these varieties will be grown, and who will grow them. It seems likely that the most eager customer will be the bush fallow farmer who with a simple variety - fertilizer combination can almost double his yields. We have received strong objections from many of the farmers who have accommodated our trials to the semi-dwarf type (notably IR 442) on the grounds that extra fatigue and delay in harvesting are unacceptable. Rat damage to the low panicles is high and bird damage during the extended harvesting period is worsened. One must question therefore whether short varieties

are needed particularly where soil and climatic factors lead to very poor recovery of applied nitrogen. We can also envisage intercropping of tree crop projects with mechanical assistance and here semi-dwarf varieties might be useful. These seems little scope for bush clearance and extended annual cropping rotations in this high rainfall belt dominated by gravelly ferrugineous oxysols very low in phosphorus and with poor exchange capacities. Development of hydromorphic soils will be very important however, and here upland varieties could be essential for cropping areas where full irrigation facilities would be uneconomic.

SUMMARY

Upland rice cultivation continues to be important in West Africa. The general main objectives are those for grain yeild, pests, diseases, and drought resistance. Researchers have made many introductions, screening and hybridizations to find better varieties for African conditions. Both old and new varieties are involved in the research programs. Development of such lines as 2243, 1716/2/3, LAC 23 and TOX 7 lines are the early results of researchers. Some introduced lines such as IR 269-26 3-3-3, IR 750-35-5-3 and IR 442-2-58 have been found to perform well under upland conditions in a good rainy season. However farmers are not too keen on accepting them.