Testing drought-tolerant plant types of upland rice in Ghana using participatory methods

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BACKGROUND

Rice is becoming an increasingly important staple food consumed throughout Ghana and West Africa, and the per capita consumption of rice in Ghana has more than doubled in the last seven years. Much of this increase in demand is satisfied by imports and the release of improved cultivars to increase domestic production is a national priority. Rice is grown on about 130 000 ha in Ghana, of which more than half is in the upland/ hydromorphic ecosystem. Upland rice is grown in the forest zones in the south (Fig. 1) and the savanna zones in the north of the country (Fig. 2). The major constraints are weeds (Fig. 2) and drought. Average yields are low, less than 1 t ha^{-1}.

Figure 1. **Upland rice field near Todzi, Volta Region, Ghana.**

Figure2. **Upland rice cultivars being evaluated under intensive weed pressure at Nyankpala, Northern Region, Ghana.**

Since 1957, only 16 varieties, all for lowland cultivation, have been released in Ghana; none specifically adapted to uplands have been released to date. However, a

large number of upland varieties are available throughout the region. Furthermore, WARDA have recently developed interspecific crosses between *Oryza sativa* (Asian rice) and *O. glaberrima* (African rice) combining, in many different morphological and physiological types, the hardiness of African rice with the higher yield potential of Asian rice.

The PVS programme in Ghana was initiated in 1997 and has so far been implemented in six out of the 10 Regions of Ghana involving more than 2500 farmers. Researcher-managed, extension/NGO-facilitated and community-managed PVS's and Mother & Baby systems have been piloted with farmers.

RESULTS

Participatory research was conducted in three agro ecological zones in Ghana: in the forest zone at Hohoe, which has a weakly bimodal rainfall pattern and an annual rainfall of 1600 mm; in the transition zone at Aframso, which has a bimodal rainfall pattern with a high probability of drought during the growing season; and in the savanna zone at Nyankpala (Fig. 2), which has a monomodal rainfall pattern and an annual rainfall of 1140 mm.

Meetings were organised at the start of the project with local extension officers, village heads and farming communities in each zone to discuss the proposed programme (Fig. 3). At each location, 30 men and 30 women farmers were registered and semi-structured interviews, mapping, scoring and other exercises were carried out with groups and individuals to describe local rice farming practices, including cultivar selection criteria, and the socio-economic status of the participants.

Figure 3. **Meetings were organised with the village farming community at the start of the project to explain the PVS process.**

Farmers selection criteria and seed management

At all locations farmers grow mostly local *O. glaberrima* cultivars. Farmers have experimented with improved cultivars, usually brought by extension officers, but these are not widely grown. Farmers use a number of characters to assess new genotypes (Table 1), the most important of which are drought tolerance, disease resistance and yield. For example, at Aframso 'Mr More', which as its name implies is a high yielding, improved variety, is deemed better than the local variety with fertilizer and good rains (Table 1). However, for most other traits, and particularly drought tolerance, weed competition and taste, local cvs are preferred.

Table 1. **Comparison of traits of three upland rice varieties at Aframso, Ghana. Farmers scored each variety for traits using between 1 (poor) and 10 (good) pebbles.**

	Score		
Traits	**Mr More**	**Local Red**	**Local White**
Drought tolerance	2	6	7
Disease resistance	4	4	4
Yield with fertiliser	7	4	4
Yield without fertiliser	3	3	3
Yield with 'plenty of rain'	6	4	4
Taste	2	6	5
Market price	4	6	5
Resistance to bird damage	6	1	6
Resistance to stem borer	2	4	6
Competitive ability against weeds	3	6	6

Farmers generally rely on seed saved from the previous crop though occasionally seed may be purchased from a neighbour. At Aframso, great care is taken in selecting and storing seed; panicles are harvested, usually from ratooned plants which mature in the dry season, and selected (in order of priority) on freedom from disease, well-filled grains and long grains. These panicles are then threshed and stored on special platforms in their rooms. Seeds are checked regularly for mould and sorted prior to sowing. In contrast, at Hohoe farmers harvest all seeds at the same time and do not treat seeds for sowing differently from grain for consumption; grains/seeds are stored together in large earthenware pots and any seed left at sowing time is used as seed.

PVS trials

Participatory varietal selection (PVS) trials were established at Hohoe, Aframso and Nyankpala with between 60 and 100 entries. At Hohoe and Aframso these entries included lowland, hydromorphic and upland varieties and breeding lines, while at Nyankpala entries were mostly hydromorphic and upland varieties and breeding lines. The PVS trials were arranged in two blocks, low and high input, differing in weed pressure and fertility, with repeated checks. Men and women farmers were invited to evaluate and select varieties four times: during the vegetative and flowering stages, and at harvest and post-harvest.

Mean yields in 1998 in the PVS trials were 1.85 t ha^{-1} at Nyankpala, 1.52 t ha^{-1} at Hohoe and 0.67 t ha^{-1} Aframso. Aframso had the lowest yields because of drought. The maximum yield recorded at Hohoe and Nyankpala was nearly 4 t ha^{-1}.

Farmers used a wide range of criteria to evaluate new varieties, depending on the stage of crop growth (Table 2). During vegetative growth, farmers selected for traits that contributed to greater weed competitiveness, e.g., broad leaves, plenty of tillers and vigorous early growth, while at the post-flowering stage it was plant height and panicle traits that farmers equated with yield. Unsurprisingly, therefore, choices varied with the stage of crop growth (Fig. 4). For example, at the vegetative stage at Nyankpala varieties with good weed competitiveness were selected: e.g., local *O. glaberrima* cvs such as Kpukpula and high tillering *O. sativa* indicas. Interestingly, at Nyankpala, WAB 36-54 and WAB 224-8-HB (both improved japonicas), were selected at all three stages of development. These were selected because of their tall height, tillering ability, weed suppression ability, large panicles and large grains.

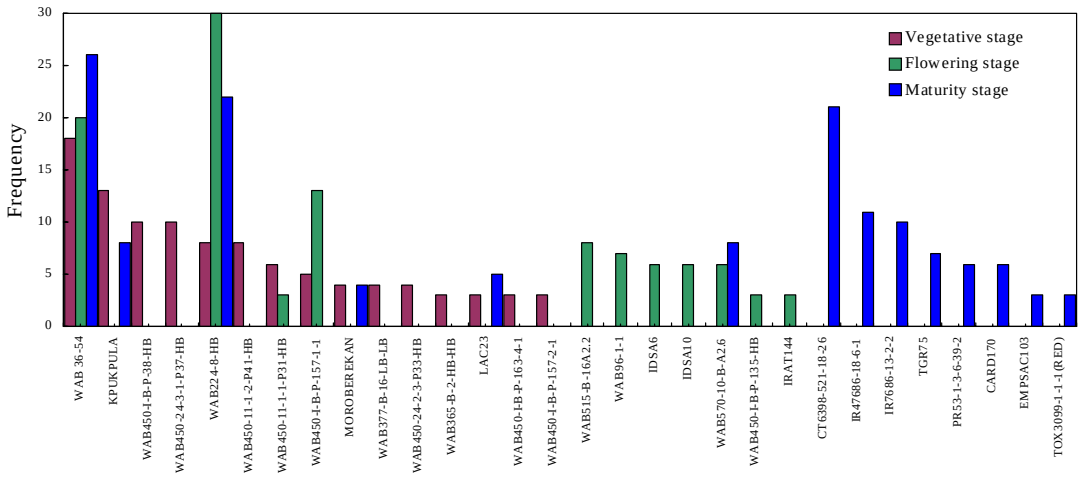

Figure 4. **Frequency of selection of varieties by 60 farmers at three stages of crop growth at Nyankpala, Ghana in 1998.**

At Nyankpala, farmers made selections independently in the low and high input blocks, and the frequency of selections at harvest are shown in Fig. 5. Of the 14 most frequently selected varieties in low or high input blocks, 11 were selected in both blocks, many with similar frequencies. This is encouraging, since it suggests that the traits of interest to farmers are expressed in different agronomic conditions and that a number of varieties are adapted to both high and low input conditions. CT6398-521-18-2B did particularly well in both low and high input conditions, WAB36-54 under low input conditions, and Kpukpula (a local cultivar) and CARD 170 under high input conditions.

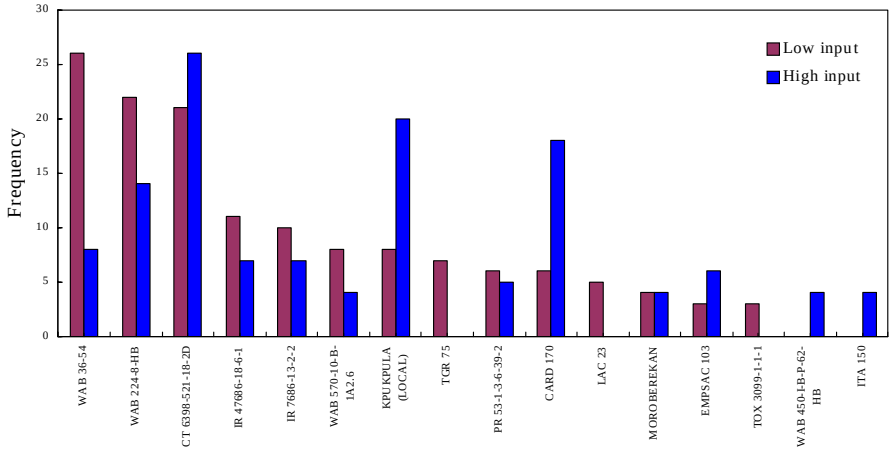

Figure 5. **Frequency of selection of cvs in low-and high-input conditions at maturity by 60 farmers at Nyankpala, Ghana in 1998.**

At Aframso and Hohoe, male and female farmers made independent selections at all four stages of development. At both locations, and at each stage of development, male and female farmers generally made similar choices (Fig. 6). The only notable difference between male and female selections was that females always included some local varieties with red grain colour among their selections, as these are used in the preparation of traditional dishes for festivals.

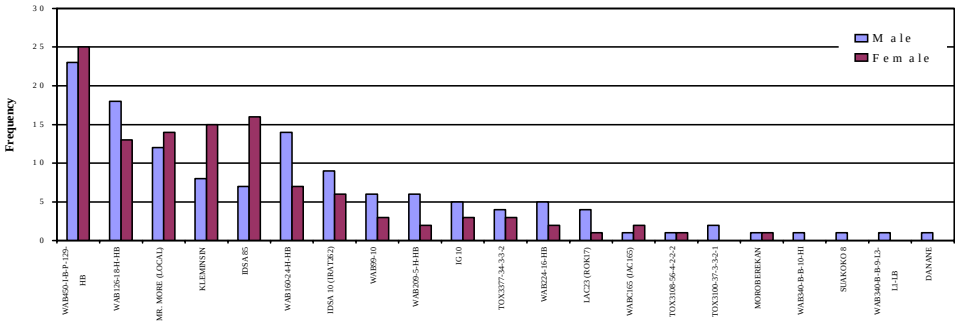

Figure 6. **Frequency of selection of varieties by 30 male and 30 female farmers at maturity at Aframso, Ghana in 1998.**

At Aframso (Fig. 6) and Nyankpala (Fig. 5) a wide range of varieties were selected at harvest, and these included local *glaberrimas*, improved upland *japonicas* (e.g., WAB 126-18-H-HB, WAB 36-56) and interspecific progenies (e.g., WAB 450-I-B-P-129-HB). However, at Hohoe (Fig. 8), IDSA 85, was selected by the majority of farmers because of its highly desirable grain characteristics. One or two varieties were

selected at more than one location (e.g., IDSA 85, WAB 126-18-H-HB, Moroberekan and LAC 23), but as expected choices were different in the different agroecological zones.

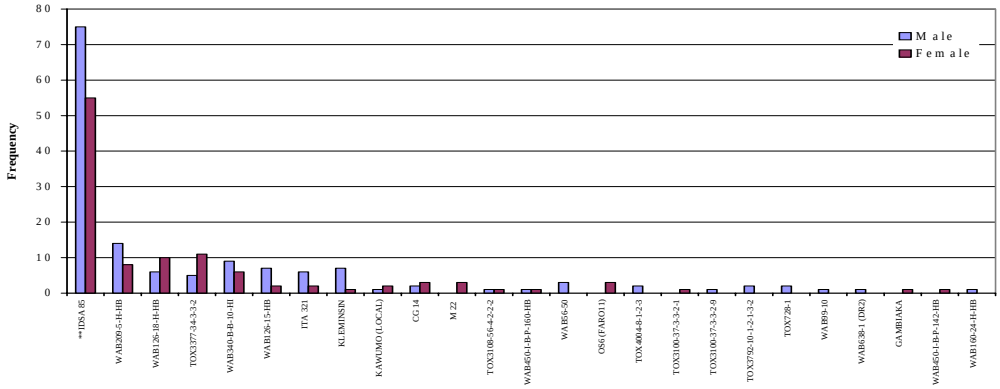

Figure 7. **Frequency of selection of varieties by 30 male and 30 female farmers at maturity at Hohoe, Ghana in 1998.**

Post-harvest evaluations

Taste and other organo-leptic traits are extremely important selection criteria and better taste and higher market price are key reasons why local varieties of rice are preferred (Table 1). Between 10 and 18 varieties were milled and evaluated by male and female traders at two major markets at Tema (Accra) and Kumasi. Market traders value long, bold, white grains as these are closest to those of imported rice. IDSA 85, Kleminson and WAB 126-15-HB all scored highly for these traits with traders. Genotypes with coloured grains were also selected as these command a price premium for local dishes.

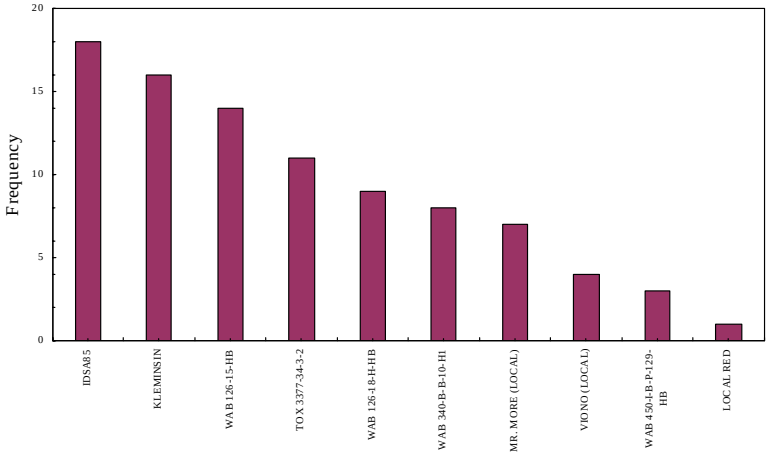

Figure 8. **Frequency of selection of varieties by male and female market traders at Tema**

and Kumasi, Ghana 1998.

Male and female farmers and consumers also evaluated cultivars for the sensory traits (Table 2). Expansion ability is particularly important in the drier and northern areas where rice is par-boiled. Thus, while consumers at Hohoe were satisfied with the expansion ability of all the varieties tested, consumers at Aframso were far more discriminating. IDSA 85, WAB 126-18-H-HB and Kleminson all scored highly for this trait, confirming the higher market value traders gave them (Fig. 8). However, local varieties always had higher scores, particularly when scored by females, than improved ones for aroma and taste, and the overall ranking of improved varieties such as IDSA 85 was poorer than the local varieties (e.g., Local Red at Aframso: Fig. 9). Nonetheless, most farmers express an interest in IDSA 85 because of its higher market value, particularly at Hohoe.

Table 2. **Selection criteria used by male and female farmers to evaluate rice varieties in Ghana**

Stage	Criteria		
During crop growth	Yield	Lodging	Leaf Serration
	Plant Height	Plant vigour	Panicle excision
	Tillering ability	Plant Architecture	Leafiness
	Leaf shape/width	Plant appeal	Uniformity of maturity
	Panicle Size	Canopy density	
	Maturity Period	Tiller length	
At harvest	Grain length	Boldness	Grain hardness
	Grain taste (milk)	Grain colour	Market value
	Grain size	Milling recovery	
Sensory Traints	Aroma	Taste	Hardness
	Expansion ability	Stickiness	

Informal Seed Dissemination and Uptake Pathways

In 2000, seed of eight upland rice varieties was distributed to farmers (1-2 kg per farmer) using different pathways in five communities around Hohoe. The most successful dissemination method was a community seed bank, whereby for each kg a farmer received, 2 kg had to be returned to the bank after harvest. Two communities independently organised such a seed bank. Irrespective of how seed was initially distributed, seed moved first through kin relations, often by exchange, and was only sold when larger quantities were available. Seed sold at a premium and demand far outstripped supply in the first two years. However, by the third year a few seed producers were harvesting large quantities of seed and there was a noticeable increase in uptake. By 2000, seed given to six villages had spread to 40 km by 2001 (Fig. 10). By 2003 seed had moved >100 km through informal channels.

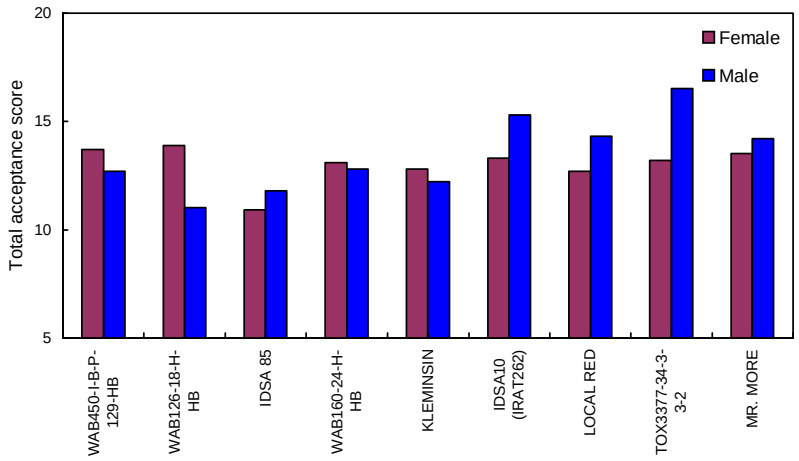

Figure 9. **Overall acceptance scores (maximum 20) for varieties evaluated for their cooking quality by male and female farmers and consumers at Aframso in Ghana in 1998.**

Farmer adoption of new PVS varieties

A survey of approximately 2500 upland farmers around Hohoe was undertaken five years after the project began and showed that that 36% of households were growing a PVS cv, and 83% were aware of PVS cvs. The most popular cv was IDSA85, a cv with a highly desirable grain type, and which farmers named '*Idana*', meaning you'll not be tired to reflect it's ease of threshing. Three other cvs from the original PVS (WAB209, WAB126 and WAB340) were also being grown widely.

In northern Ghana, SARI formally released a cv, IR12979-24-1 using a combination of formal and PVS/ Mother & Baby data. This cv was first tested in 1985 but was promoted only after it's inclusion in a PVS in 2000 and subsequent selection by many farmers. This cv performed outstandingly well on-farm. An integrated system of PVS/Mother & Baby trials and formal multi-locational testing is proposed to release cvs in Ghana.

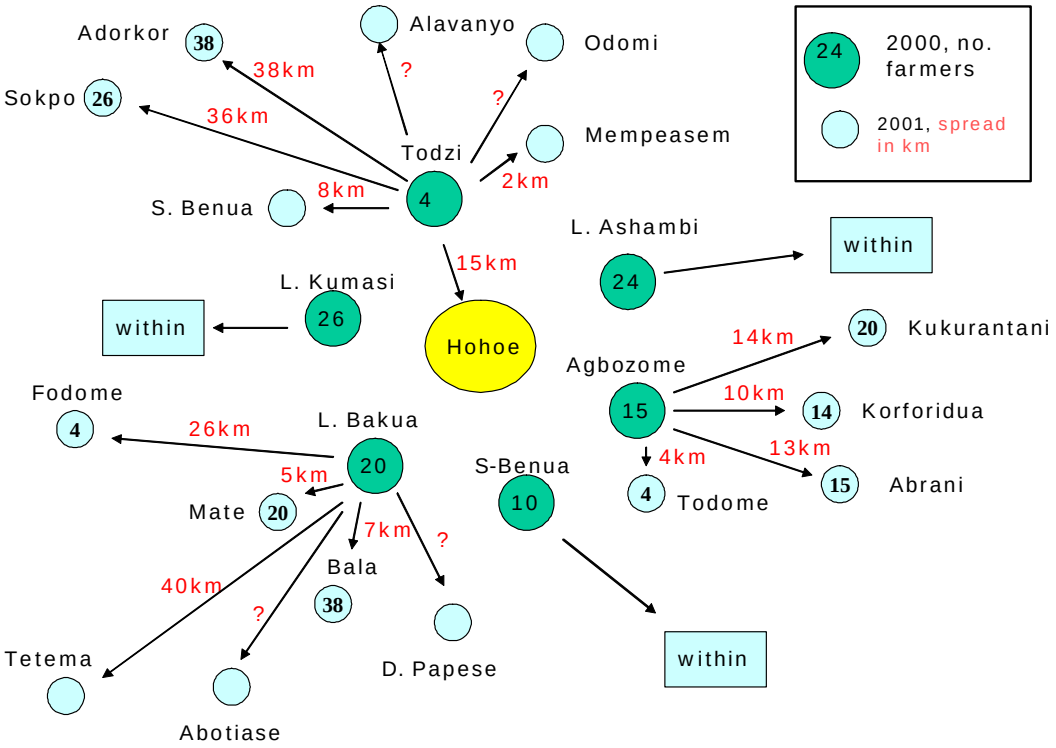

***Figure 10*. Seed dissemination in Volta Region in 2000 and spread in 2001.**