TESTING DROUGHT-TOLERANT PLANT TYPES OF UPLAND RICE IN GHANA USING PARTICIPATORY METHODS

DEPARTMENT OF INTERNATIONAL DEVELOPMENT (DFID)

PLANT SCIENCES RESEARCH PROGRAMME

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CONTENTS

4.7 Work in progress

5. Contribution of outputs

6. Future action and research

References

Abbreviations

°Cd - Degree Centigrade Days (thermal time or accumulated temperature)

AWS – Available Soil Water

BVP – Basic Vegetative Phase

CPI – Crop Performance Index

DAS – Days After Sowing

ITCZ – Inter-Tropical Convergence Zone

NARS – National Agricultural Research System

NGO – Non-Governmental Organisation

PET – Potential Evapo-Transpiration

PRA – Participatory Rural Appraisal

PRIGA – Participatory Rice Improvement and Gender Analysis

PSP – Photoperiod Sensitive Phase

PPB – Participatory Plant Breeding

PVS – Participatory Varietal Selection

WARDA – West African Rice Development Association

EXECUTIVE SUMMARY

Rice is economically very important in Ghana and West Africa. The lack of improved rice varieties, particularly upland varieties, is recognised as a constraint. The purpose of the project was: to analyse rainfall patterns and drought-spells in Ghana; to characterise the photothermal flowering responses of diverse varieties in order to understand adaptation; to understand farmers' indigenous technical knowledge of rice farming and varietal selection; to test and evaluate new drought- and weed-tolerant rice varieties with farmers using participatory techniques and formal replicated yield trials; and to disseminate participatory approaches to crop improvement in Ghana and West Africa.

Long-term (30 years) daily rainfall data were analysed for selected locations in each of the forest, transition and moist and dry savanna zones. Rainfall patterns (start, end and duration of the growing season) and drought-spells were calculated. A Crop Performance Index (CPI) was used to examine the effect of toposequence on drought patterns. Photothermal flowering responses of 83 varieties were quantified from sowing date experiments in the field and a controlled environment experiment in the UK. PRA techniques were used to describe indigenous technical knowledge at two locations, Hohoe in the forest zone and Aframso in the transition zone. A Participatory Varietal Selection (PVS) programme with 60-100 varieties was initiated at Hohoe, Aframso and at Nyankpala in the moist savanna. Replicated yield trials with High Input (fertiliser + weeding) and Low Input (low fertiliser + no weeding) treatments were planted at four locations in 1998 and 1999.

Rainfall patterns covering the major upland rice zones have been analysed. This analysis has shown that the savanna zone (i.e. Northern, Upper East and West Regions) and forest zone (Volta, Western Region) is favourable for rice production, with a minimum of a 100d growing season even in very shallow upland soils. In contrast, rice production is much riskier in the transition zone (Ashanti, Brong Ahafo Regions) because of the bi-modal rainfall pattern and the consequent break in the rains in August.

There was considerable variation in photothermal flowering responses and hence adaptation to different rice ecosystems among varieties. Photothermal characteristics were clearly defined in terms of a basic vegetative phase (BVP) and a photoperiod-sensitive phase (PSP).

The participatory process has shown that farmers have a considerable knowledge of varieties and their characteristics. Traits which contribute to weed competition and drought-tolerance are important, as are post-harvest traits. A PVS programme was successfully implemented with male and female farmers, traders and consumers. Male and female farmers made many similar varietal choices, the most notable difference being for grain characteristics; women selected grain types suitable for home consumption while men preferred grain types with a high market value. The market prefers long, white grains which are similar to those of imported grains. At Hohoe, almost all farmers selected the same variety, IDSA85, both in the PVS trials and from paired-comparisons on-farm. At Aframso a larger number of varieties was chosen, including interspecifics and improved upland japonicas. At Nyankpala, improved japonicas, interspecifics and local glaberrimas were selected.

A Regional Workshop has helped disseminate project findings and promote the participatory approach throughout the West African region

1. INTRODUCTION

1.1 Background

Eighty-four percent of rice ecosystems in West Africa are rainfed and the major constraints in the upland-hydromorphic valley continuum (uplands) are weed infestation and drought (Matlon *et al.*, 1998). About 80% of this area is cultivated by small-scale subsistence farmers with few resources and using shifting cultivation techniques with fallow periods which are no longer long enough to sustain production. Seed yields, which average 1.0-1.5 t ha^{-1} and are 40% of the world average, have risen at <2% per year since 1973 and in many areas yields are now declining as a consequence of more intensive land-use. This in turn has led to a deterioration in the resource-base, and the exacerbation of constraints due to weed infestation and drought.

Most crop improvement of upland rice in West Africa has focussed on the introduction of high yielding, input-responsive lowland varieties of Asian rice (*O. sativa*); improved varieties of upland rice have not been selected or introduced. However, these improved lowland varieties do not perform well under the low-input conditions typical of upland farms, having poor tolerance to weeds, drought and indigenous diseases and pests. African rices (*O. glaberrima*), which are well-adapted to the low-input, shifting cultivation system in which they evolved, are consequently still preferred by many farmers and are grown on between 25 and 40% of the upland area. New, putatively highly weed-competitive and drought-tolerant plant types based on interspecific crosses of Asian and African rice have been developed at WARDA.

The impact of new varieties from a breeding programme is dependent on their adoption by farmers. A range of participatory methods (PRA) are available that facilitate analysis of farming systems by farmers and researchers (e.g. Okali *et al.*, 1994; IIED Publications) and that help to identify constraints and potential solutions. In the context of successful varietal improvement and adoption researchers need first to: (a) identify the varietal traits/characteristics of local varieties, both those related to morphology/growth (e.g. plant height, tillering, crop duration) and post-harvest/quality (e.g. threshability, taste, market value) which are preferred by farmers and consumers; (b) determine from farmers the constraints they perceive as affecting rice production; (c) determine whether there are differences among farmers in varietal preference related to agroecological zone and environment (upland/hydromorphic), or to gender, ethnicity, farm size, family size, access to labour/inputs etc (i.e. social class); and (d) to ascertain from farmers themselves the best or most appropriate method to promote and make seed of new varieties available to the small-scale farmers, both men and women of different socioeconomic groups, who are the principal target of current research.

A second stage in this process is to involve farmers directly in the process of evaluating and selecting new varieties/plant types, so called Participatory Varietal Selection (PVS). This approach has proved a successful method to identify appropriate varieties and increase variety adoption rates and yields in rice in India, particularly in more marginal areas where varietal and technological input choices have been limited (see Witcombe *et al*., 1996-99, for examples and a discussion of participatory approaches in crop improvement). The PRA can be used to select characteristics or traits of varieties that farmers consider valuable; for example, traits that they think contribute to drought- or weed-tolerance. Variety trials either on-station or on-farm can then be used to expose farmers to a wide range of new plant types and selections made by farmers and researchers that match farmers' 'ideotypes'. These selected varieties are then given to farmers to grow on-farm alongside their traditional varieties for comparison, and farm walks and group discussions organised to discuss the trials and varietal traits. WARDA have available *c*. 30-50 new plant types from its upland rice breeding programme for evaluation and selection by farmers.

The impact of these new plant types will depend both on their drought- and weed-tolerance, and the acceptability and adoption of new plant types by farmers. The direct involvement of farmers in the testing and selection of new plant types should ensure that appropriate varieties are identified and hence are quickly adopted. Complementary agroclimatic analyses and simulation studies will characterise drought patterns and target new plant types to appropriate environments.

1.2. Demand

Demand for rice in West Africa has grown at an annual rate of 6% since 1973 as a result of population growth and substitution of coarse-grains (i.e. rice is preferred to other cereals). Although rice production rose 4% annually from 1973 to 1983, and 8% since 1983, regional production (4.8 mt in 1988-90) is insufficient to meet demand. The value of imports into the region in 1988-90 exceeded US$500m and in Ghana, which produces only 40% of its rice requirements, imports were valued at $26m.

The Ghana Medium Term Agricultural Development Programme (1990) and the National Agricultural Research Programme (1995) call for production to be intensified and average yield to be increased to 3 t ha^{-1}. More recently, a Ministerial Taskforce has highlighted the lack of improved varieties and improved seeds as a major problem (MOFA, 1999). The Programmes also call for potentially favourable areas for rice production to be identified and utilised.

Regionally, it is recognised that production must be intensified in more favourable areas (e.g. hydromorphic valley fringes and lowland environments) and yields stabilised in less favourable upland areas (WARDA, 1996).

2. PROJECT PURPOSE

Production of target crops on impoverished soils in semi-arid conditions increased by the selection and genetic enhancement of cultivars

This project will directly involve farmers in three agroecological zones in Ghana in testing and evaluating new drought- and weed-tolerant plant types using participatory techniques. The participatory approach should help ensure that farmers' motives for choosing particular plant types or varietal characteristics are understood and that drought- and weed-tolerant plant types adapted to actual (farmers’) and to recommended agronomic inputs are selected. Agro-climatic analysis and simulation modelling will be undertaken to characterise rice growing environments in Ghana, including drought patterns, and allow well adapted drought- and weed-tolerant varieties with acceptable characteristics to be targeted to the different agro-ecological zones. Project findings and the participatory approach will be promoted among breeders and agronomists within Ghana, and more widely among rice scientists in the region, using field days and an International Workshop.

3. RESEARCH ACTIVITIES

3.1 Agro-climatic analysis of rainfall patterns and drought spells in Ghana

3.1.1 Analysis of drought patterns using long-term daily weather data

Long-term (30 years, 1961-90) daily values for rainfall and minimum and maximum temperature were obtained from the Ghana Meteorological Services, Kumasi for a number of locations from about 7° to 11°N (Table 1). Daily values for sunshine hours, relative humidity and windspeed were not available, but monthly mean values were supplied.

The rainfall data for selected locations covering a transect from south to north were analysed, using the climate statistical package INSTAT (Stern and Knock, 1999) to determine the rainfall characteristics, the start and end of the rains, the probability of dry spells and the crop Performance Index (Frere and Popov, 1979). Full details of the analysis are given in Tanu (1999).

3.1.2 Weather at the experimental locations

Experiments were conducted at three main locations in Ghana: Hohoe, Aframso and Nyankpala.

Hohoe

Hohoe is situated in the semi-deciduous forest zone. This is a vast area stretching from the south-western portion of Ghana with the sandstone escarpment of the Volta Basin forming its northern boundry. This zone covers the greater part of the Eastern

Region, and parts of the Central, Ashanti, Brong-Ahafo, Volta and Western Regions. The topography is gently rolling slopes. The soils are forest ochrosols.

Rainfall distribution is weakly bi-modal (Fig. 1) with a break in August. Mean annual rainfall is about 1500 mm. The length of the growing periods are about 150-160d for the major season (March-July) and about 90d for the minor season (September-December).

Aframso

Aframso is in the forest-guinea savanna (transition) zone which occupies the southern part of the Volta Basin. This zone covers parts of Brong Ahafo, Ashanti, Eastern and Volta Regions. The topography of this zone is marked by gentle slopes and the vegetation is mainly guinea savanna woodland with remnants of forest trees in the southern portions of this zone. The soils are savanna ochrosols and groundwater laterites.

Rainfall distribution is bi-modal with a distinct break in the rains during August and the mean annual rainfall is 1300mm (Fig. 2). The length of the growing periods are 100-120 d for the major season (April-July) and 60d for the minor season (September-November).

Nyankpala

Nyankpala is in the moist savanna zone which occupies the northern part of Ghana. This zone covers the Northern, Upper East and Upper West Regions.

The rainfall distribution is monomodal with no break in the rains and a distinct peak rainfall in August/September (Fig. 3). Mean annual rainfall is 1063 mm. The length of the growing period is 160d.

3.2 Indigenous technical knowledge of rice farming and socio-economic background

Questionnaires were administered to 30 male and female farmers at each of Aframso and Hohoe to determine their indigenous technical knowledge and socio-economic background. Questions covered: rice farming practices; varieties; constraints; storage, marketing and utilization; credit; access to labour; other sources of income; education; and crop budgets. Farmers knowledge of varietal traits, seed storage practices and constraints was also investigated by group discussions and matrix ranking using beans for scoring.

3.3 Participatory Varietal Selection (PVS) Programme

In 1997 PVS trials were established at two locations, Hohoe and Aframso. In 1998 the PVS was repeated at Hohoe and Aframso, and a new PVS conducted at Nyankpala. In 1999 seed was given directly to farmers at each location for farmer testing and evaluation.

3.3.1 1997

Varieties

During the 1997 Upland and Lowland Breeding TaskForce meetings at WARDA, NARS and WARDA breeders assembled a nursery of *c.* 80 varieties for the PVS program in Ghana. It was recommended at the meeting that the PVS should include lowland, hydromorphic (lowland/upland) and upland types, rather than purely upland types, since the area of pure upland in Ghana is limited and by having a wider range of ecotypes more farmers could be involved in the process. The selected varieties (Table 2) therefore included improved and traditional lowland indicas, improved and traditional upland japonicas, African rices (*Oryza glaberrima*) and interspecific progenies between *O. glaberrima* and *O. sativa*. The traditional lowland indicas are of very diverse adaptation, with Salumpikit resisting drought, Cisadane tolerating gall midge, Gambiaka tolerating floods and Suakoko8 tolerating iron toxicity, while the emphasis is on slightly taller types for better drought and flood resistance among the improved lowland indicas. The traditional and improved upland japonicas are classical upland rices that mostly do not like water-logging, except for Azucena from

Asia and IDSA6. The African rices are all upland types but which also tolerate flooding. The interspecific progenies were all selected for the upland and are sensitive to water-logging.

A limited amount of seed of these varieties was available from WARDA and NARS for the PVS (enough for two trials in Ghana) and characterisation trials at WARDA.

Trial locations

The PVS trial was planted at two locations in Ghana in 1997- Aframso and Hohoe.

Trial design and details

The PVS trials were conducted on farmers fields and were managed by researchers. The varieties in the PVS trials were grown in unreplicated plots of $10m^2$ arranged in blocks of eight with a replicated check variety, TGR75, in each block (n=16). There were also four replicates of each of three other varieties. There were two agronomic treatments: High Input, with weeding and fertilizer at recommended levels (weeding at 14 and 27 DAS and 40 kg N ha^{-1}); and Low Input, with one weeding at 14 DAS and 20 kg N ha^{-1}. Fertiliser was applied to the Low Input treatment because the fertility status of the fields was unknown.

The land was ploughed and double harrowed before planting. Plots were planted by hand at a spacing of 0.2 x 0.2m and seedlings thinned to 2-3 per hill 10 DAS. Hohoe was planted on 10 July and Aframso on xx. In the High Input treatment NPK was applied at a rate of 45:60:45 kg ha^{-1} 7 DAS followed by 45 kg N ha^{-1} at 36 DAS. Weeding (by hand) was carried out at 14 and 27 DAS.

Observations

Time to 50% flowering and maturity was recorded for each plot during the growing season. The incidence of blast (*Pyricularia oryzae*) was recorded at 37 DAS (in collaboration with R6783: CPP blast project). At maturity seed yield, plant height and the number of panicles was recorded.

Farmer evaluation

Prior to the start of the growing season the PVS Project had been discussed with the local community (farmers, extension workers, leaders of various organised groups, market traders) and interested farmers registered.

Forty male and 35 female rice farmers from five nearby communities were invited to evaluate the varieties at the flowering and maturity stages of development. There was no *a priori* selection of farmers in 1997. Farmers criteria for selection was ascertained from group discussions, separately for males and females, and varieties scored on a scale of 1 (bad) to 10 (good).

3.3.2 1998

The PVS trial was repeated at Hohoe and Aframso with 60 entries, 49 selected from the 1997 PVS (Table 3). Any disease susceptible genotypes and those that were poorly adapted were excluded. The design was similar to that of 1997.

A new PVS was initiated at Nyankpala in 1998. This PVS comprised 60 entries, all upland types but including common entries to those used at Hohoe and Aframso (see Table 12). The experiment also had two agronomic treatments similar to Hohoe and Aframso.

At all locations the genotypes were evaluated by approximately 60 farmers at three stages of crop development (tillering, flowering, maturity/harvest).

At Aframso and Hohoe a post-harvest evaluation was also held to examine cooking quality and taste traits. A post-harvest evaluation was also held with market traders (all female) at two markets, Kumasi and Tema (near Accra).

3.3.3 1999

In 1999 1-5kg seed lots were distributed to farmers at the three locations, one to two genotypes per farmer. Seed was distributed to both men and women farmers. At Hohoe and Aframso 96 and 47 farmers, respectively, were given seed. At Nyankpala seed was given to 21 farmers through Action Aid. Farmers were asked to grow the genotypes alongside their local genotypes and using their normal practice. Farmers were visited during the growing season and post-harvest to evaluate the genotypes.

3.4 Characterisation of photothermal flowering responses

3.4.1 Field experiment, Mbé, Cote d'Ivoire

WARDA planted 83 of the PVS varieties in each of lowland, hydromorphic and upland ecologies on five occasions between May and September at WARDA Headquarters at Mbé in 1997 to characterise photothermal responses and monitor biotic and abiotic stress as they occurred at specific planting dates and/or ecosystems. Full details of this experiment are given in Dingkuhn and Asch (1999).

3.4.2 Glasshouse experiment, Reading

An experiment with a subset of the genotypes studies by Dingkuhn and Asch (1999) was conducted using controlled environment glasshouses at Reading in 1999. Dingkuhn and Asch identified 10 major linkage groups among the 84 entries studied. Accordingly, two entries from each group were randomly selected along with two checks, IR36 and Azucena, whose photothermal responses have been quantified previously.

The 22 genotypes were grown in a factorial combination of two photoperiod regimes (11 and 13 h d^{-1}), two temperature regimes (31/25°C, mean 28°C and 25/19°C, mean 22°C) and two hydrology regimes (waterlogged to simulate lowland conditions and free-draining to simulate upland conditions). Plants were grown in 2.5L plastic pots, three per pot, filled with a mixture of sand:gravel: vermiculite: loamless compost in a ratio of 4:2:4:1 v/v. The hydrology treatments used specially modified pots (see Summerfield *et al*., 1992 for full details of husbandry). Full details of the experiment are given in Hauser (1999).

Days from sowing to seedling emergence, panicle emergence and flowering was recorded on each plant. Total mainshoot leaf number was also recorded.

3.5 Drought testing trials

Replicated yield trials were established in the main agroecologiocal zones in Ghana in 1998 and 1999 to test the adaptation of entries chosen from the PVS in 1997.

3.5.1 Entries, treatments and experimental design

Twenty-five genotypes were selected for the drought-testing trials (see Table 32). Entries included genotypes selected in the 1997 PVS at Hohoe, cvs with wide adaptation, interspecifics and breeder checks and a local check.

Each experiment comprised 25 entries arranged in a randomised block design with two agronomic treatments and four replicates. The agronomic treatments were: High Input - clean weeded and 90 kg ha^{-1}N; and Low Input - 20 kg ha^{-1} N and no weeding. Plot size was 10 or $15m^2$.

1998 Trials

Experiments were planted at Hohoe, Aframso, Kwadaso (Kumasi), Nyankpala and Manga.

1999 Trials

Experiments were planted at Kwadaso, Aframso, Nyankpala and Manga

3.5.2 Observations

Duration from sowing to first flowering, 50% flowering and 50% maturity were recorded during the season. At harvest, plant height, the number of panicles and seed yield was measured. At Nyankpala and Manga drought tolerance and recovery was also scored.

3.6 Dissemination

3.6.1 Farmer field days

Field days were held at each location between flowering and maturity as part of the participative process. Farmers were invited to visit the trials and make selections, and many more farmers than the 60 enrolled in the programme did so, particularly at Hohoe and Nyankpala. Many farmers also took small amounts of seed directly from the plots.

As part of Mr Apau's PhD studies, the participatory process was discussed with plant breeders and others involved in varietal release.

3.6.2 PRIGA Workshop

The project contributed funds to an International Workshop, 'Participatory Rice Improvement and Gender Analysis (PRIGA) held at Yammassoukro, Cote d'Ivoire in April 1999. This Workshop bought together scientists and NGOs from 13 West African countries for training and planning of participatory rice research.

4 OUTPUTS

4.1 Agroclimatic analysis of rainfall patterns and drought spells

4.1.1 Analysis of drought patterns using long-term daily weather data

The results of the rainfall analysis are presented using locations representing the four agro-ecological zones where experiments were carried out, i.e. the forest, transition, moist and dry savanna.

Rainfall probabilities were first examined to determine the probable start dates for the rainy season and these showed that potential start dates ranged from 15 March at Hohoe (forest zone) to 15 April at Nyankpala (moist savanna). The actual start of the rains was defined as the first occurrence of 20mm rain over a 2d period conditional upon there being no dry spell of more than 5 din the next 10d (Stern *et al*., 19xx). The end of the rains was defined using a simple water-balance, the end being defined as the first occasion after 01 August when the water-balance was zero for 5d. The length of the growing season was the difference between the start and the end of the rains. The start, end and season length for the four agro-ecological zones are given in Table 4. In the bi-modal southern sites the major and minor seasons are described.

The start of the rains ranged from an average of 24 March at Hohoe (forest) to 27 May at Navrongo (dry savanna), the south to north trend reflecting the movement of the ITCZ. The standard deviation for the start was 9-12 d at all locations and start dates varied by about 30d at each location. Therefore the variability in the start of the rains was similar from south to north. The start of the minor season also varied by about 30d, usually between the middle of August and the middle of September.

The end of the rains (major and minor season) also varied from south to north; the rains ended on average on 22 October at Navrongo (dry savanna) and 01 December at Hohoe (forest) . However, in the bi-modal rainfall sites in the transition zone the major season ended in late August/early September. In the moist and dry savanna the end of the rains varied by 30 to 40 d over the 30 years and was therefore slightly more variable than the start of the rains. In the transition and forest zones the end of the rains was vary variable (SD >44d). However, in some years there was no break in the rains during August and this resulted in a very much later end to the season. It would therefore be incorrect to say that the season length is more variable in the south.

Season length in the major and minor season varied, on average, from 126 to 278d and 77 to 100d, respectively (Table 4). The shortest season length occurred in the transition zone, where the season could be a short as 70 to 90d duration. In the savanna the season length was always >100d. The minor season was usually short, though in a few years could reach 100d.

The within-season variability was examined by calculating the occurrence and duration of dry spells after the start of the rains (Fig. 4). In the dry savanna there is a 50% chance of a dry spell of 8d or more during the first 30d; in contrast, at other sites the chance of an 8d dry spell is only 10 to 30%. In the transition and forest sites, however, the chance of a dry spell at the end of the season, i.e. between 90 and 120d, is high, between 50 and 70%. The longest dry spells are also greater in the transition zone – up to 26d.

Variation in season length was also examined in relation to the water-holding capacity of the soil. Water-holding capacities were varied from 50mm (unfavourable upland) to 150mm (favourable upland) and a water-balance used to estimate season length and the occurrence of drought. In the savanna, the season length was always >100d, even for the unfavourable upland, and in 80% of years >150d when the water-holding capacity was 100mm. In the forest zone, the season length was also always >100d at all water-holding capacities, and in 80% of years >220d when the water-holding capacity was 100mm. In the transition zone though the season length was only >100d in 20% of years in the unfavourable upland, but was >120d in 70% of years when the water-holding capacity was 100mm.

The Crop Performance Index (CPI), which is a measure of the proportion of the crop water requirement that is met during the season, was calculated for a hypothetical 100 and a 140d upland rice crop in the transition and savanna zone, following Doorenbos and Pruit (1992). The CPI was not calculated in the forest zone since the risk of drought is minimal. The CPI was calculated for the whole season and for the vegetative, flowering and maturity periods. For a 100d crop, the risk of drought during the vegetative stage is very small. At flowering the risk is also small; 30% of years in the savanna and 20% of years in the transition zone. At maturity, the CPI was reduced in 90% of years in the transition zone.   For longer duration (140d) genotypes the risk of drought during the vegetative and flowering periods was also low in both the savanna and transition zones; the risk of drought during the post-flowering period was slightly higher, occurring in about 20% of years.

An alternative, and perhaps more appropriate way to assess the risk of drought is to use a daily water-balance, since certain stages of crop development are particularly sensitive to short periods (i.e. 1 to 3d) of stress. A daily water-balance was calculated for favourable (available soil water [AWS] 100mm) and unfavourable (AWS 30mm) conditions at Nyankpala in the moist savanna. Periods where the ASW was reduced by >30% were considered as periods of drought. As the 15 years given in Figures 5 and 6 show, in favourable upland conditions in the savanna drought is not a frequent occurrence, even in 150d crops. However, in unfavourable upland conditions periods of water-deficit occurred in most years, often several times during the season. In general these drought periods occurred in August, during grain-filling in the short duration genotype and at flowering in the longer duration genotype.

These analyses all show that although rainfall totals are less in the savanna (though still comparatively favourable for dryland crops), these climates are favourable for crop production because of the strongly mono-modal rainfall pattern and the relatively low risk of drought occurring once the rains have established (i.e. after the first 30d). In the transition zone, the bi-modal rainfall pattern gives a greatly increased risk that drought will occur during the later stages of crop growth, and season length is about 30d shorter than in the savanna on average. In the forest zone, the rainfall pattern is weakly bi-modal and there is effectively one long cropping season.

These data require further analysis and additional inputs are needed to complete this objective. No daily values of sunshine or radiation, windspeed or RH were available and therefore daily values of PET could not be calculated. The analyses presented above used the monthly mean values for PET. Similarly, without daily values of sunshine or radiation and PET crop models could not be run. It would be most appropriate to simulate daily crop growth and water-use using ORYZA_W, and to define drought in terms of the daily values of AWS for particular soil types and rice ecologies. Daily values of radiation etc are now available for some locations and this activity will be carried over to Phase II.

4.2 Indigenous technical knowledge of rice farming and socio-economic background

Data are still being analysed at Reading by Mr A. Opoku-Apau as part of his PhD programme. Relations between varietal trait selection and socio-economic indicators are yet to be completed.

At all locations farmers grow mostly local *O. glaberrima* cvs. Farmers have experimented with improved cvs, usually brought by extension officers, but these are not widely grown. Farmers use a number of characters to assess new cvs (Table 5), 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 cv, is deemed better than the local cv with fertilizer and good rains. However, for most other traits, and particularly drought tolerance, weed competition and taste, local cvs are preferred.

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) based 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.

4.3 Participatory Varietal Selection Programme

4.3.1 1997 trials

Two PVS trials were planted in 1997, one at Hohoe in the forest zone and one at Aframso in the transition zone. The Aframso trial emerged well but subsequently most seedlings died. This was probably due to Zn or some other micro-nutrient deficiency, since the field had been previously cultivated to maize for a number of years. Fertiliser amendments did not cure the problem and the trial was abandoned. There was insufficient seed to replant in 1997. The trial at Hohoe established well and there were no serious biotic or abiotic problems. Mean, standard deviation, and range for seed yield, days to flower and maturity, plant height, number of panicles and blast score for the different ecotypes in the 1997 PVS trial at Hohoe are given in Table 6. This was an unreplicated trial on a farmers field and the variability among replicated varieties ranged from 10 to 50%.

There was a substantial effect on seed yield of the High and Low Input agronomic treatments, illustrated by TGR75 (check), where seed yield was 2.69 and 0.79 t ha^{-1} in the High and Low treatments, respectively (Table 6). The mean seed yield of the different ecotypes ranged from 1.40 t ha^{-1} in African rices to 2.96 t ha^{-1} in traditional upland japonicas in the High Input treatment and from 0.82 in the interspecific progenies to 1.58 t ha^{-1} in the traditional upland japonicas. The highest yield was 5.33 t ha^{-1} in the improved lowland indica check variety TGR75. The variability of the seed yield was lowest in the traditional upland types in the High treatment and in the interspecific progenies in the Low treatment. In general, yields of the African rices and interspecific progenies were lower than the indicas or japonicas

Days to flower were not affected by the management treatment and varied from 70 to 90 d between ecotypes, and from 65 to 111 d among varieties. The improved upland japonicas flowered, on average, at the same time as the African rices and the interspecific progenies, and were earlier flowering than the traditional upland japonicas. In contrast, the improved lowland indicas flowered later than the traditional lowland indicas.

There was also considerable variation in plant height between and among ecotypes, and management treatments, with the traditional upland japonicas generally being tallest. Overall, plant height varied from 69 to 161 cm. The incidence of blast in this trial was not high and was greatest in the lowland indicas and in the traditional upland japonicas. African rices and the interspecific progeny had very little blast. Interestingly, TGR75, which has been widely tested in Ghana, was affected by blast at Hohoe, indicating the race-specificity of this organism. [see: Identification and characterisation of key screening sites for blast and scald resistance in West Africa, R6738, NRI]

Farmer evaluation

Farmers evaluated the plots between flowering and maturity and some of the criteria they used are given in Table 7. Post harvest milling, storing and cooking quality tests, which are also likely to be very important criteria, could not be done this year as there was insufficient seed. These tests were carried out at the end of 1998 (see Tables 32-19).

Farmers used about 20 different criteria to evaluate the varieties at Hohoe of which the most important and frequently cited are:

Plant height: tall plants compete better than short plants against weeds. Tall plants are also easier to harvest;

Tillering ability: Farmers equate high yield with high tillering;

Leaf shape: Broad-leaved plants are more vigorous, suppress weeds more and are higher yielding;

Grain size/characteristics: Male farmers selected large (longer) grains, white in colour because they are preferred in the market. In contrast, female farmers prefer varieties with small grains because they produced for home consumption and small grains are better for local dishes. Varieties with red colour are also preferred because of their use in special dishes on festive occasions and according to women red grains are more nutritious than white grains.

Maturity: Some farmers selected early varieties to bridge the hunger gap while other preferred later maturing varieties saying that early maturing varieties are susceptible to bird damage and compete with other farm activities for labour.

Disease and lodging: Farmers select against susceptible types because they are lower yielding.

Plant shape/appearance: Farmers usually commented on the appeal or attractiveness of plants/plots, but exactly what they mean by this was not ascertained

The effect of gender was most apparent on grain size and colour, reflecting the fact that males primarily farm rice for the market while females farm primarily for home consumption.

The enthusiasm of both farmers and the breeder for the PVS activity has been high and farmers have participated actively and have taken/requested seed of preferred varieties. The breeder has also gained some insight into the traits that farmers consider important and which were largely ignored before, e.g. grain size and colour, leaf size.

4.3.2 1998 trials

The three PVS trials planned for 1998 were successfully completed with no serious problems. Mean yields in 1998 in the PVS trials were 1.85, 1.52 and 0.67 t/ha at Nyankpala, Hohoe and Aframso, respectively (Tables 8-13). Aframso had the lowest yields because of drought. The maximum yield recorded at Hohoe and Nyankpala was close to 4 t/ha.

Farmers used a wide range of criteria to evaluate new cvs, depending on the stage of crop growth and these are illustrated by results from Aframso (Tables 14-17). 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 post-flowering it was plant height and panicle traits that farmers equated to yield. Unsurprisingly, therefore, cv selection varied with the stage of crop growth (Fig. 7). For example, at the vegetative stage at Nyankpala cvs exhibiting good weed competitiveness were selected: e.g. local *O. glaberrima* cvs such as Kpukpula and high tillering *O. sativa* cvs such as WAB 36-54. Interestingly, at Nyankpala two cvs, WAB 36-54 and WAB 224-8-HB (both improved japonicas), were selected at all three stages of development. These cvs were selected because of their tall height, tillering ability, weed suppression ability, large panicles and large grains.

At Nyankpala farmers made selections independently in the low and high input blocks, and the frequency of selections at harvest are shown in Fig. 8. Of the 14 most frequently selected cvs 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 cvs are adapted to high and low input conditions. CT6398-521-18-2B did particularly well in both low and high input conditions, whereas WAB36-54 did particularly well under low input conditions and Kpukpula (a local cv) and CARD 170 under high input conditions.

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 (Figs. 9 & 10). The only notable difference between male and female selections was that females always included some local cvs with red grain colour among their selections, as these are used in the preparation of traditional dishes for festivals.

At Nyankpala (Fig. 8) and Aframso (Fig. 9) a wide range of cvs 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. 10) one cv, IDSA 85, was selected by the majority of farmers because of its highly desirable grain characteristics. One or two cvs 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.

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 cvs of rice are preferred (Table 5). Between 10 and 18 cvs were milled and evaluated by female traders at two major markets at Tema (Accra) and Kumasi. Market traders value long, bold, white grained cvs 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 (Table 17). Genotypes with coloured grains were also selected as these command a price premium for local dishes.

Male and female farmers and consumers also evaluated cvs for the sensory traits given in Table 7. The list of traits to be evaluated was reached in discussion with consumers, as was the quantity and method of cooking and evaluation. Traits were scored 1 to 4 (where 1 was bad/dislike and 4 was excellent/like). 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 cvs tested, consumers at Aframso were far more discriminating (Tables 18 & 19). IDSA 85, WAB 126-18-H-HB and Kleminson all scored highly for this trait, confirming the higher market value traders give to these cvs (see Table 17). However, local cvs, particularly among females, always scored higher than improved cvs for aroma and taste and the overall ranking of cvs such as IDSA 85 was poorer than the local cvs (e.g. Local Red at Aframso: Table 18). Nonetheless, most farmers express an interest in IDSA 85 because of its market value, particularly at Hohoe.

4.4 Characterisation studies

4.4.1 WARDA

Preliminary analysis of the characterisation data at WARDA have shown interesting, and somewhat unexpected, interactions between variety and ecology (Fig. 11) which clearly require further investigation. For example, in IG10, a traditional *O. glaberrima* variety, the relationship between the delay in panicle emergence (delta duration in the Figure) and photoperiod at the end of the BVP (basic vegetative phase) was the same in upland, hydromorphic and lowland ecologies. In contrast, in WAB638-1, a traditional rainfed upland variety, photoperiod had no effect on time to panicle emergence under upland conditions, but as hydrology changes from upland to hydromorphic to lowland, panicle emergence was increasingly delayed by photoperiod. IG10 was also much more sensitive to photoperiod than WAB638-1.

The preliminary analysis shows clearly that variation in photoperiod-sensitivity and hydrology are having a significant effect on phenology, and that hydrology will have to be included as a factor in phenology models. There was not much difference in responsiveness to temperature, but this is to be expected since variation in mean temperature between sowing dates is small. A preliminary principal component analysis has also shown that photothermal characteristics are closely related to both genetic origin and ecosystem adaptation (Table 20). These data are now being transformed to thermal time for compatibility with existing rice models in use at WARDA.

4.4.2 Reading

The experiment at Reading provided excellent complementary data to the field studies at Mbé, and there was good agreement (R^2>0.70) between estimates of the BVP and PSP in the two studies. The warm, short-day treatment (28°C/11h) allowed the BVP to be more accurately estimated, and the response to photoperiod in cool and warm temperatures was quantified (Table 21). These data should increase the range of environments in which duration to flowering can be accurately predicted.

Another important finding from this experiment was that hydrology *per se* had no effect on duration to flowering, other than that associated with differences in water or soil temperature. Therefore, it is likely that the interactions observed between flowering and hydrology observed at Mbé are due to other edaphic factors associated with hydrology.

The experiment also confirmed that the photothermal responses of the different species/ecotypes were different, and that the responses reflected known differences in adaptation and breeding targets (Table 22). Glaberrimas had the shortest minimum duration to flower, the shortest BVP but were highly photoperiod-sensitive. The degree of photoperiod-sensitivity varied with latitude of origin, photoperiod-sensitivity increasing from low to high latitude, as expected. The combination of short BVP and variable PSP gives adaptation to short-season environments (i.e. drought escape) combined with flexibility of sowing dates. Traditional japonicas are, in contrast to glaberrimas, much later flowering with a longer BVP and strong photoperiod-sensitivity. These genotypes are much later maturing and perhaps explains why many farmers continue to plant the earlier glaberrimas. Improved indicas and japonicas, and the interspecifics, all had intermediate values for minimum duration to flower, BVP and PSP. In general, therefore, these genotypes are earlier flowering than the traditional japonicas, reflecting plant breeding targets of short-duration, relatively photoperiod insensitive genotypes. The indicas were also noticeably shorter than other genotypes, reflecting the aims of Asian breeding programmes; however, for weed competition and hand-harvesting these genotypes are too short for West Africa.

The data from WARDA and Reading has not been combined yet and simulations of crop phenology using the daily weather data in Ghana have not been carried out yet. This activity will be completed in Phase II now that the daily weather data for simulation modelling is available for some locations.

4.5 Drought-testing experiments

Replicated yield trials for drought- and weed-tolerance testing were conducted in 1998 and 1999. The trials at Hohoe, Kwadaso and Aframso in 1998 were not completed. The trial at Hohoe was planted in the minor season and terminal drought killed all the plants before maturity. Similarly the trial at Kwadaso was late planted to ensure drought and most entries also failed to produce seed. Drought also affected the trials at Aframso, though some useful, albeit incomplete data, was obtained. The trials at Manga and Nyankpala were completed (Tables 23-26). The trials in 1999 at Aframso, Kwadaso, Nyankpala and Manga were all successfully completed (Tables 27-34). Yield was also measured in the unreplicated PVS trials (see Tables 8-13).

Seed yields across the locations ranged from zero to 4 t ha^{-1}, the highest yield being obtained at Hohoe and Nyankpala. Both of these sites are favourable in terms of their climate for rice production, whereas the trials in the transition zone (Aframso and Kwadaso) were badly affected by drought. High yield was not correlated with early flowering in most trials, although flowering dates varied by 50d (Fig. 12). In general flowering dates of about 100d were optimal. There were also no strong relationships between yield in the high and low input trials, and yield across locations.

In general, in both the yield trials and the PVS trials, the highest yields were obtained by lowland adapted lines (e.g. TOX 3108- 56-4-2-2-2) and improved upland japonicas (e.g. WAB 56-50). This was true in both the high input and the low input trials. However, given that some lowland adapted lines did so well, it may be that the trial sites were too favourable, at least in terms of their hydrology. The interspecifics (WAB450 lines) were rarely as good as sativas, even under high weed and drought pressure. These data confirm results from other countries, which also show that in many circumstances, and particularly in better environments, that sativas out yield interspecifics. These data also complement the farmer varietal selections, which were also mostly sativas rather than interspecifics.

A great deal more analysis is needed of these data, and data sets from 1999 are not yet complete. Relationships within and between locations and years, and effects of management and weather, need to be analysed.

4.6 Dissemination

4.6.1. Farmer field days

Field days were held at all locations for farmers and extension agents to view the new varieties. There was considerable demand for seed from farmers, and at Nyankpala seed was distributed to Action Aid farmers. Many farmers also took panicles directly from the field. This dissemination is being followed up.

4.6.2 PRIGA Workshop

A Workshop co-sponsored by WARDA, the CGIAR System Wide Program for Participatory Research and Gender Analysis, the Japanese Government and DFID was held in April 1999 on participatory research in rice. Scientists from 13 NARS attended. The workshop was publicised in the form of a WARDA booklet, entitled 'Participatory Varietal Selection: The Spark that Lit the Flame'.

The PRIGA Workshop series will be continued in April 2000.

4.7 Work in progress

Final yield data from the drought testing trials is still being collated and has yet to be analysed.

Cultivar selection and trait data are currently being analysed by correspondence analysis and cross-tabulation to identify cvs exhibiting desirable suites of traits. Hypotheses relating cv selection and trait preference to socio-economic factors such as gender, ethnicity, age and education are being tested.

Currently, about 30 different cvs are being evaluated, mostly by paired comparisons, by farmers on their own farms in each agroecological zone.

5. Contribution of outputs

- Rice is economically very important in West Africa and Ghana, and the value of imports in the region is valued at nearly US$1 billion. Despite this, expenditure on rice is low, only about 0.1-0.2% of the value of regional production. This lack of investment in rice is reflected in the lack of varieties released and/or grown by farmers. Participatory Varietal Selection (PVS) programmes, and the more advanced Participatory Plant Breeding (PPB) programmes, can be an effective (and probably cost-effective) mechanism to get new and improved varieties rapidly disseminated to farmers (Witcombe *et al*., 1996-99). If NARS in Ghana adopts a more participatory approach with respect to varietal improvement and testing this will be the major contribution of this project

- Rainfall patterns covering the major upland rice growing zones in Ghana have been analysed. This analysis has shown very clearly that the savanna zone (i.e. Northern, Upper East and West Regions) is favourable for rice production, with a minimum of a 100d growing season even in very shallow upland soils. In contrast, rice production is much riskier in the transition zone (Ashanti, Brong Ahafo Regions) because of the bi-modal rainfall pattern and the consequent break in the rains in August. Timeliness of operations is also much more important here. In the forest zone (Volta, Western Region) the season is long with little risk of drought, and considerable flexibility in sowing dates
- The photothermal flowering responses (Vergara and Chang, 1985) of 83 varieties grown throughout West Africa , comprising lowland indicas, improved and traditional upland japonica, glaberrimas and interspecific progenies, were quantified using sowing date experiments in Cote d'Ivoire. For 22 of these genotypes further data was collected from a controlled environment experiment at Reading. Given adequate daily weather data (which is not readily available in Ghana and in the Region), the phenology and yield can be simulated in Ghana and elsewhere
- Among the varieties examined there was considerable variation in the photothermal flowering responses and adaptation to different rice ecosystems. The photothermal characteristics of the different rice species and ecotypes were clearly defined in terms of a basic vegetative phase (BVP) and a photoperiod-sensitive phase (PSP). *O. glaberrima* varieties all had a short BVP but were highly photoperiod-sensitive and are therefore well adapted at particular locations to variable sowing dates (i.e. exhibit homeostasis of flowering date). However, these local varieties will not be widely adapted. Traditional and improved upland *O. sativa* japonicas both exhibit moderate photoperiod-sensitivity combined with either a long or moderate BVP, respectively. Thus traditional japonicas are long-duration types while improved japonicas are medium duration. Interspecifics are intermediate between *O. glaberrima* and improved japonicas, with a short BVP and moderate photoperiod-sensitivity. This makes these varieties earlier maturing

but with some flexibility for variation in sowing date. Farmers value these types because of their earlier maturity

- The participatory process has shown that farmers have a considerable knowledge of varieties and their characteristics, and are able to identify a wide range of characteristics they recognise as being important. Traits which contribute to weed competition and drought-tolerance are important, as are post-harvest traits. The knowledge gained from farmers about traits is already proving valuable for plant breeders to develop 'ideotypes' for upland rice farmers in West Africa. Indeed, over the longer term 'feedback' from the participatory process should greatly enhance the efficiency and contribution of plant breeding, and contribute to the maintenance of diversity, by catering for 'demand'. The logical extension of this process is PPB
- In Ghana, there has been no formal release of any upland rice variety and most farmers continue to grow traditional local *O. glaberrima* varieties. Farmers report having grown improved varieties from time to time, usually obtained from the local extension agent, but most of these have lapsed as they were not better than the local variety. Nonetheless, farmers are very keen to grow and test new varieties
- A PVS programme was successfully implemented with male and female farmers, and traders and consumers, at three locations in Ghana: Hohoe in the forest zone, Aframso in the transition zone and Nyankpala in the savanna zone. Farmers have enthusiastically taken part in the process and selected varieties, and the trials have created a local demand for seed
- Male and female farmers made many similar varietal choices, the most notable difference being for grain characteristics; women selected grain types suitable for home consumption while men preferred grain types with a high market value. The market prefers long, white grains which are similar to those of imported grains
- At Hohoe, almost all farmers selected the same variety, IDSA85, both in the PVS trials and from paired-comparisons on-farm. At Aframso a larger number of varieties was chosen, including interspecifics and improved upland japonicas. At Nyankpala, improved japonicas, interspecifics and local glaberrimas were selected

- Market traders also evaluated varieties and IDSA 85 also proved popular with market traders because of it's long, white grains. Locally produced rice can command a high market price if it is of the same quality as imported rice
- Farmers who participated in the process and who grew varieties on their own farms made valuable suggestions as to how the process could be improved and, in particular, the information they needed at the start of the process to help make informed decisions about when and where to grow the new varieties
- The PVS process has been demonstrated to NARS in Ghana and there is strong support for the concept. However, there is a formal release system in Ghana and the participatory approach, and/or the formal system, needs to be adapted for variety release. Thus, there must be adequate coverage within and between agro-ecological zones in terms of sites and years for release, and some formal yield and other data will also still be required. Nonetheless, NARS are keen to expand this system, recognizing the advantages.
- Given the lack of released varieties in upland rice it is impossible to say whether the formal system can deliver new varieties. Similarly, the role of the informal system is not understood in rice at present. Contacts with NGOs (Action Aid in the north, World Vision in the south) have been made and these contacts will be strengthened in order to use NGOs as a means of dissemination
- A Regional Workshop has helped disseminate project findings and promote the participatory approach throughout West Africa

6. Future action and research

- Participatory varietal selection and testing program to identify, evaluate and release drought-tolerant, weed-competitive *and disease resistant* cvs piloted in key systems in two agroecological zones. The PVS system needs to be expanded to provide the necessary coverage for varietal release. The proposed system will be based on varietal needs assessments, PVS trials, farmer comparisons and formal yield and disease assessment trials.
- Farmer and informal sector seed production practices described, and improved seed quality and health management practices promoted. The informal sector is likely to be the most important sector for disseminating new varieties, and there is

little understanding of this sector. Seed health and quality is likely to be an important issue here, since most seed used by farmers is produced on-farm. Seed production practices need to be described and quality determined, and strategies developed to improve these aspects, if new varieties are to have an impact over the medium to long term

- The spread and adoption of new cvs measured and seed uptake pathways identified. Following from above, the spread of varieties tested by farmers' needs to be followed in order to identify potential uptake pathways. Uptake pathways, e.g. NGOs, need to be promoted as well
- Potential impact of new drought and weed-competitive cvs assessed. Yield-gaps and the potential yield, and hence the potential 'gain' from new varieties, still needs to be determined once the necessary daily weather data is available.

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Table 1. Details of the sites used for rainfall analysis

Site	Longitude and latitude	Altitude (m)	Mean annual rainfall (mm)	Mean no. raindays	Agro-ecological zone
Navrongo	10°54'N; 01°06'W	201	982	69	Savanna (dry)
Wa	10°03'N; 02°30'W	323	939	87	Savanna (dry)
Nyankpala	09°42'N; 00°85'W	183	1092	91	Savanna (moist)
Yendi	09°27'N; 00°01'E	195	1241	99	Savanna (moist)
Ejura	07°29'N; 01°02'W	315	1166	100	Transition
Sunyani	07°20'N; 02°20'W	309	1177	103	Transition
Kumasi	06°72'N; 01°59'W	286	1405	128	Transition
Hohoe	07°09'N; 00°29'E	158	1578	119	Forest

Table 2. List of rice genotypes (cultivars, breeding lines, landraces) grown in the PVS trials in Ghana in 1997

Improved lowland indicas	
ITA 123 (FKR28)	FKR14 (4418)
TCA 80-4	TOX 4004-43-1-2-1
TOX 3118-47-1-1	TOX 3154-17-1-3-2-2
IR54	TOX 3440-171-1-1-1-1 (WITA7)
ITA 331	BOUAKE 189
TOX 3093-35-2-3-3 (WITA2)	FARO 8
TOX 3416-170-2-1-1 (WITA11)	TOX 3255-82-1-3-2 (WITA5)
TOX 4251-WAT-99-1	TOX 3880-38-1-1-2
CK 73	TOX 728-1
ITA 150 (FARO46)	CK4
TOX 85C-C5-85-1	TOX 3792-10-1-2-1-1-3-2
TOX 3870-28-2-1-1	TOX 3882-18-3-1-2-3-5 (WATO1318)
TOX 3440-132-3-3-1	TOX 3792-11-2-1-1-3-3-3
TOX 3100-32-2-1-3-5 (WITA3)	TOX 3233-31-6-2-1-2 (WITA10)
TOX 3058-28-1-1 (WITA9)	4418 x IR6115-1-1-1 (FKR48)
TOX 4204-WAT-147-2-E1	TOX 3440-176-1-2-1 (WITA8)
ITA 301 (FARO48)	ITA 321
TOX 4004-8-1-2-3	
Traditional lowland indicas	
CISADANE	GAMBIAKA (CI)
SUAKOKO 8 (ROK24)	SALUMPIKIT
Improved upland japonicas	
WAB224-16-HB	ITA 257
WABC165 (IAC 165)	IDSA 85
WAB56-50 (FKR 37)	WAB126-18-HB
WAB 99-1-1	WAB56-125 (FKR41)
WAB56-104	WAB126-15-HB
WAB340-B-B-9-L3-L1-LB	WABIR 12979
WAB340-B-B-10-H1	WAB181-18
WAB377-B-16-L3-LB	WAB 96-1-1
WAB160-24-H-HB	WAB189-B-B-B-8-HB
WAB209-5-H-HB	WAB32-80
IDSA6 (IRAT216) (2)	
Traditional upland japonicas	
WAB638-1 (DR2)	MOROBEREKAN
IDSA 10 (IRAT 262)	KLEMINSIN
AZUCENA	0S 6 (FARO11)
M22	LAC 23 (ROK17)
IGUAPE CATETO	DANANE
Interspecific progenies (*O. glaberrima* × *O. sativa*)	
WAB450-24-2-3-P33-HB	WAB450-24-3-2-P18-HB
WAB450-I-B-P-133-HB	WAB450-I-B-P-26-1-1
WAB450-I-B-P-38-HB	WAB450-I-B-P-129-HB
WAB450-I-B-P-160-HB	WAB450-24-2-5-P4-HB
Traditional African rice (*O. glaberrima*)	
IG10	TOG 6545
CG17	CG14
CG20	

Table 3. Seed yield in high and low management treatments and the farmers evaluation score for varieties selected by the rice breeder and by rice farmers from the PVS at Hohoe in 1997

Variety	Mean seed yield (t ha^{-1})	Mean score	Breeder	Farmer
Improved lowland indica				
TOX3792-10-1-2-1-1-3-2	1.80	6.0	✓	
TOX3058-25-1-1 (WITA9)	1.81	5.0	✓	
FKR14 (4418)	2.50	6.0	✓	
TOX4004-43-1-2-3	2.40	7.0	✓	
TOX4004-8-1-2-3	2.82	7.0	✓	
TOX3440-178-1-2-1	4.01	4.5	✓	
TOX3108-56-4-2-2-2		6.5	✓	
FKR 48 (4418 X IR6115-1-1-1)	2.31	7.0	✓	✓
TOX728-1	2.50	8.0	✓	✓
TOX3100-37-3-3-2-1	3.03	7.5	✓	✓
TOX3377-34-3-3-2	1.70	7.0	✓	✓
TGR75	2.08	6.0	✓	✓
TOX3118-47-1-1	2.49	7.0		✓
FARO8	1.38	6.5		✓
TOX3340-177-1-1-1 (WITA7)	2.15	7.0		✓
Traditional lowland indica				
SALUMPIKIT	1.21	6.5	✓	
CISADANE		3.5	✓	
GAMBIAKA	1.66	7.0	✓	✓
SUSOKO8	1.21	7.0	✓	✓
Improved upland japonica				
WAB126-15-HB	2.00	4.0	✓	
WAB340-B-B-9-L3-L1-LB	2.19	7.5	✓	✓
WAB224-16-HB	2.87	8.5	✓	✓
IDSA10 (IRAT262)	2.13	7.0	✓	✓
WAB126-18-H-HB	1.71	7.5	✓	✓
WAB340-B-B-10-H1	1.22	8.5	✓	✓
IDSA85	2.01	7.0	✓	✓
WAB56-50 (FKR37)	1.50	7.5	✓	✓
WAB99-10	1.23	3.5	✓	✓
WAB209-5-H-HB	2.00	7.5		✓
WAB638-1	1.98	7.5		✓
WAB160-24-H-HB	1.50	7.5		✓
Traditional upland japonica				
IGUAPE CATETO	2.52		✓	✓
M22	2.86	7.0	✓	✓
MOROBEREKAN	1.27	6.5	✓	✓
LAC23 (ROK17)	2.67	7.0		✓
OS6 (FARO11)	2.51	7.5		✓
KLEMINSIN	2.85	7.0		✓
AZUCENA	1.67	7.0		✓
DANANE	2.12	7.5		✓
Traditional African rice (*O. glaberrima*)				
CG14	1.13	5.5	✓	
TOG6545	1.84	6.5	✓	
CG20	0.69	4.0	✓	
IG10	1.35	6.5	✓	
Interspecific progenies (*O. glaberrima x O. sativa*)				
WAB450-IBP-133-HB	2.25	5.5	✓	
WAB450-IBP-26-HB	1.81	6.5	✓	
WAB450-24-2-5-P4-HB	2.01	7.5	✓	✓
WAB450-24-3-2-P18-HB	2.13	7.5	✓	✓
WAB450-IBP-160-HB		7.0		✓
WAB450-IBP-129-HB	1.21	7.0		✓

Table 4. The mean dates, range and standard deviation (SD) for the onset, end and duration of the major and minor seasons in three agro-ecological zones in Ghana. Data are based on 30 years of daily weather data from selected locations in each zone.

	Onset			End			Season length		
Zone	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Major season									
Dry savanna	15/05-17/06	27/05	12	04/10-06/11	22/10	10	113-173	148	17
Moist savanna	15/05-19/06	23/05	9	14/10-25/11	05/11	11	132-189	166	13
Transition	15/04-16/05	24/04	9	11/06-13/12	31/08	51	71-242	126	52
Forest	15/03-17/04	24/03	9	22/07-23/12	11/04	44	102-278	231	45
Minor season									
Transition	15/08-28/09	28/08	12	16/10-13/12	16/11	17	30-115	80	21
Forest	15/08-10/09	23/08	7	21/10-12/12	01/12	16	63-127	100	15

Table 5. Comparison of traits of three upland rice cvs at (a) Aframso and (b) Hohoe, Ghana. Farmers scored each cv for traits using between 1 (poor) and 10 (good) pebbles

(a) Aframso

Trait	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

(b) Hohoe

Trait	Viono	Kawumo	Tema
Drought tolerance	2	6	3
Yield	7	6	6
Taste	4	5	3
Resistance to bird damage	6	3	2
Lodging resistance	4	2	4
Competitive ability against weeds	3	5	3

Table 6. Mean, standard deviation (STD) and range of seed yield, days to flower, plant height, no. panicles and blast score for different ecotypes of rice grown at High and Low management levels

		Seed yield (t ha^{-1})		Days to flower		Plant height (cm)		No. panicles m^{-2}		Blast score	
Ecotype		High	Low	High	Low	High	Low	High	Low	High	Low
TGR75 (check)	Mean	2.69	0.79	81		106	83	238	288	1.4	0.0
	STD	1.148	0.436	6.1	7.4	10.0	9.4	76.1	61.8	1.71	0.00
	Range	1.25-5.33	0.19-1.63	82-100	79-101	89-127	76-108	112-336	75-288	0-5	0-0
Improved lowland indicas	Mean	2.84	1.12	90	91	106	86	225	152	1.6	0.2
	STD	1.144	0.656	7.8	9.3	11.9	12.0	84.6	60.6	1.98	0.82
	Range	0.58-5.33	0.13-3.01	72-108	67-108	89-135	32-110	107-517	57-288	0-7	0-5
Traditional lowland indicas	Mean	2.05	0.83	70	68	113	92	125	97	0.7	0.2
	STD	1.006	0.429	24.9	24.9	35.3	30.1	54.8	48.5	1.32	0.61
	Range	0.51-4.09	0.20-1.89	7-111	6-103	13-152	11-142	35-225	16-211	0-5	0-3
Improved upland japonicas	Mean	2.22	0.96	73	74	116	101	148	87	0.1	0.0
	STD	0.815	0.598	12.0	8.0	13.9	16.5	40.2	30.1	0.53	0.00
	Range	0.26-4.09	0.00-1.89	60-111	63-86	91-149	69-142	70-224	45-163	0-3	0-0
Traditional upland japonicas	Mean	2.96	1.58	89	91	138	127	116	94	0.6	0.3
	STD	0.584	0.643	6.3	8.1	23.1	6.4	49.7	20.6	1.67	1.0
	Range	2.18-3.84	0.36-2.41	82-98	79-102	81-161	119-139	73-231	60-122	0-5	0-3
Traditional African rices	Mean	1.40	0.87	75	77	119	99	144	118	0.0	0.0
(*O. glaberrima*)	STD	0.746	0.440	10.0	7.0	13.3	14.0	53.6	83.5	0.00	0.00
	Range	0.51-2.16	0.51-1.51	67-86	70-84	104-128	84-112	109-206	50-211	0-0	0-0
Interspecific progenies	Mean	2.52	0.82	72	70	122	96	107	87	0.1	0.0
(*O. glaberrima* x *O. sativa*)	STD	0.869	0.264	6.9	6.4	16.4	11.1	35.3	15.6	0.35	0.00
	Range	1.10-3.34	0.41-1.22	67-83	65-77	98-152	84-115	47-156	72-103	0-1	0-0

Table 7. Selection criteria used by male and female farmers to evaluate cvs of rice in Ghana

	During crop growth		
Yield	Panicle size	Plant architecture	Leaf serration
Plant height	Maturity period	Plant appeal	Panicle excision
Tillering ability	Lodging	Canopy density	Leafiness
Leaf shape/width	Plant vigour	Tiller length	Uniformity of maturity
	Harvest		
Grain length	Grain size	Grain colour	Grain hardness
Grain taste (milk)	Boldness	Milling recovery	Market value
	Sensory traits		
Aroma	Taste	Stickiness	Hardness
Expansion ability			

Table 8. Seed yield in the High Input PVS trial at Hohoe, Ghana, 1998. Yields are from unreplicated plots of 10m^2

Entry no.	Genotype	Yield (t ha^{-1})	Entry no.	Genotype	Yield (t ha^{-1})
76	TOX3108-56-4-2-2-2	4.15	109	WAB126-15-HB	1.36
75	FKR14 (4418)	3.40	112	WAB450-I-B-P-26-HB	1.35
111	TOX4004-43-1-2-1	2.80	80	WAB224-16-HB	1.35
122	TOX3100-37-3-3-2-1	2.65	121	LAC23 (ROK17)	1.35
138	TOX3118-47-1-1	2.60	105	ITA321	1.35
127	TOX3440-171-1-1-1 (WITA7)	2.58	102	WAB209-5-H-HB	1.25
135	ITA320	2.55	125	TOX3440-178-1-2-1	1.20
84	TOX3058-28-1-1 (WITA9)	2.45	88	GAMBIAKA	1.20
133	IR33356-22-3-1-2	2.40	126	IDSA85	1.10
89	WAB450-I-B-P-160-HB	2.32	130	FARO8	1.10
77	WAB340-B-B-10-HI	2.32	128	KAWUMO	1.05
82	SUAKOKO8	2.30	136	IDSA85	1.05
73	TGR75	2.05	90	WAB56-50	1.00
86	AZUCENA	2.05	79	WAB450-I-B-P-133-HB	1.00
137	TOX3100-37-3-3-2-4	2.00	97	MOROBEREKAN	1.00
78	IDSA85	1.95	115	KAWUMO	1.00
92	M22	1.90	107	IGUAPE CATETO	1.00
124	KLEMINSIN	1.90	118	SALUMPIKIT	0.90
99	FKR48 (4418 X IR6115-1-1-1)	1.90	83	CG20	0.90
106	TOX3792-10-1-2-1-3-2	1.86	101	CG14	0.74
132	TOX3100-37-3-3-2-9	1.85	129	WAB160-24-H-HB	0.70
81	TOG6545	1.78	103	IDSA85	0.70
131	WAB450-I-B-P-26-4-1**	1.76	74	DANANE	0.70
91	IDSA85	1.70	85	WAB99-10	0.45
117	TOX3100-37-3-3-2-1	1.55	108	WAB450-24-2-5-P4-HB	0.40
87	WAB638-1 (DR2)	1.50	98	WAB126-18-H-HB	0.40
95	TOX728-1	1.50	119	TOX4004-8-1-2-3	0.32
114	OS6 (FARO11)	1.50	110	WAB450-24-3-2-P18-HB	0.30
96	TOX3377-34-3-3-2	1.45	100	WAB340-B-B-9-L3-L1-LB	0.25
113	IDSA85	1.42	123	IDSA10 (IRAT262)	0.15

Table 9. Seed yield in the Low Input PVS trial at Hohoe, Ghana, 1998. Yields are from unreplicated plots of 10m^2

Entry no.	Genotype	Yield (t ha^{-1})	Entry no.	Genotype	Yield (t ha^{-1})
37	TOX3792-10-1-2-1-3-2	4.30	28	MOROBEREKAN	1.30
42	TOX4004-43-1-2-1	4.20	52	LAC23 (ROK17)	1.30
58	TOX3440-171-1-1-1 (WITA7)	4.00	44	IDSA85	1.30
69	TOX3118-47-1-1	3.10	49	SALUMPIKIT	1.25
50	TOX4004-8-1-2-3	2.85	39	WAB450-24-2-5-P4-HB	1.20
30	FKR48 (4418 X IR6115-1-1-1)	2.80	11	WAB224-16-HB	1.20
40	WAB126-15-HB	2.75	61	FARO8	1.18
36	ITA321	2.50	60	WAB160-24-H-HB	1.10
56	TOX3440-178-1-2-1	2.40	66	ITA320	1.10
34	IDSA85	2.40	38	IGUAPE CATETO	1.10
33	WAB209-5-H-HB	2.30	32	CG14	1.10
55	KLEMINSIN	2.30	17	AZUCENA	1.05
15	TOX3058-28-1-1 (WITA9)	2.25	4	TGR75	1.00
43	WAB450-I-B-P-26-HB	2.20	9	IDSA85	0.95
41	WAB450-24-3-2-P18-HB	2.10	14	CG20	0.85
29	WAB126-18-H-HB	2.05	3	KAWUMO ex. Akpafu Odoni	0.75
7	TOX3108-56-4-2-2-2	2.00	8	WAB340-B-B-10-HI	0.70
64	IR33356-22-3-1-2	1.95	18	WAB638-1 (DR2)	0.65
6	FKR14 (4418)	1.86	72	KAWUMO ex. Akpafu Odoni	0.60
24	TOX3100-37-3-3-2-1	1.85	23	M22	0.55
27	TOX3377-34-3-3-2	1.75	13	SUAKOKO8	0.50
57	IDSA85	1.72	22	IDSA85	0.50
20	WAB450-I-B-P-160-HB	1.65	71	TOX3100-37-3-3-2-1	0.49
26	TOX728-1	1.60	21	WAB56-50	0.35
48	TOX3100-37-3-3-2-1	1.60	54	IDSA10 (IRAT262)	0.32
25	TOX3100-37-3-3-2-1	1.60	12	TOG6545	0.30
67	IDSA85	1.55	19	GAMBIAKA	0.20
62	WAB450-I-B-P-26-4-1**	1.50	10	WAB450-I-B-P-133-HB	0.15
31	WAB340-B-B-9-L3-L1-LB	1.50	5	DANANE	0.15
45	OS6 (FARO11)	1.36	16	WAB99-10	0.10

Table 10. Seed yield in the High Input PVS trial at Aframso, Ghana, 1998. Yields are from unreplicated plots of 10m^2

Entry no.	Genotype	Yield (t ha^{-1})	Entry no.	Genotype	Yield (t ha^{-1})
64	TOX3108-56-4-2-2-2	2.05	119	TOX3100-37-3-3-2-4	0.55
63	FKR14 (4418)	1.95	100	OS6 (FARO11)	0.55
62	DANANE	1.90	97	TOX4004-43-1-2-1	0.50
75	WAB638-1 (DR2)	1.45	101	SALUMPIKIT	0.40
104	LAC23 (ROK17)	1.45	99	IDSA85	0.40
82	TOX3377-34-3-3-2	1.40	106	IDSA10 (IRAT262)	0.40
83	MOROBEREKAN	1.40	91	ITA321	0.36
74	AZUCENA	1.40	95	WAB126-15-HB	0.35
85	FKR48 (4418 X IR6115-1-1-1)	1.35	92	TOX3792-10-1-2-1-3-2	0.35
84	WAB126-18-H-HB	1.25	70	SUAKOKO8	0.35
61	TGR75	1.25	110	TOX3440-171-1-1-1 (WITA7)	0.30
68	WAB224-16-HB	1.15	105	TOX3100-37-3-3-2-1	0.26
102	TOX4004-8-1-2-3	1.10	103	IG10	0.26
66	IDSA85	1.05	78	WAB56-50	0.25
65	WAB340-B-B-10-HI	1.00	117	ITA320	0.25
116	WABC165 (IAC165)	0.95	115	IR33356-22-3-1-2	0.25
73	WAB99-10	0.95	118	IDSA85	0.25
120	TOX3118-47-1-1	0.95	98	WAB450-I-B-P-26-HB	0.20
81	TOX728-1	0.85	111	WAB160-24-H-HB	0.20
107	KLEMINSIN	0.85	108	TOX3440-178-1-2-1	0.20
93	IGUAPE CATETO	0.83	94	WAB450-24-2-5-P4-HB	0.15
67	WAB450-I-B-P-133-HB	0.80	79	IDSA85	0.15
113	WAB450-I-B-P-129-HB**	0.80	76	GAMBIAKA	0.15
88	WAB209-5-H-HB	0.80	114	TOX3100-37-3-3-2-9	0.10
72	TOX3058-28-1-1 (WITA9)	0.75	112	FARO8	0.10
86	WAB340-B-B-9-L3-L1-LB	0.66	90	CISADANE	0.05
69	TOG6545	0.65	96	WAB450-24-3-2-P18-HB	0.00
89	IDSA85	0.65	80	M22	0.00
87	CG14	0.62	109	IDSA85	0.00
77	WAB450-I-B-P-160-HB	0.55	71	CG20	0.00

Table 11. Seed yield in the Low Input PVS trial at Aframso, Ghana, 1998. Yields are from unreplicated plots of $10m^2$

Entry no.	Genotype	Yield ($t\ ha^{-1}$)	Entry no.	Genotype	Yield ($t\ ha^{-1}$)
4	TOX3108-56-4-2-2-2	2.25	6	IDSA85	0.60
42	TOX4004-8-1-2-3	2.20	16	GAMBIAKA	0.55
50	TOX3440-171-1-1-1 (WITA7)	1.80	2	DANANE	0.50
46	IDSA10 (IRAT262)	1.70	33	IGUAPE CATETO	0.40
45	TOX3100-37-3-3-2-1	1.65	15	WAB638-1 (DR2)	0.35
47	KLEMINSIN	1.60	1	TGR75	0.35
51	WAB160-24-H-HB	1.50	14	AZUCENA	0.35
28	WAB209-5-H-HB	1.40	30	CISADANE	0.30
48	TOX3440-178-1-2-1	1.35	58	IDSA85	0.20
8	WAB224-16-HB	1.30	17	WAB450-I-B-P-160-HB	0.15
24	WAB126-18-H-HB	1.30	35	WAB126-15-HB	0.15
3	FKR14 (4418)	1.30	37	TOX4004-43-1-2-1	0.05
56	WABC165 (IAC165)	1.25	18	WAB56-50	0.00
44	LAC23 (ROK17)	1.25	38	WAB450-I-B-P-26-HB	0.00
29	IDSA85	1.20	36	WAB450-24-3-2-P18-HB	0.00
31	ITA321	1.15	34	WAB450-24-2-5-P4-HB	0.00
25	FKR48 (4418 X IR6115-1-1-1)	1.15	5	WAB340-B-B-10-HI	0.00
27	CG14	1.15	22	TOX3377-34-3-3-2	0.00
23	MOROBEREKAN	1.10	60	TOX3118-47-1-1	0.00
10	SUAKOKO8	1.05	54	TOX3100-37-3-3-2-9	0.00
32	TOX3792-10-1-2-1-3-2	1.00	59	TOX3100-37-3-3-2-4	0.00
41	SALUMPIKIT	1.00	12	TOX3058-28-1-1 (WITA9)	0.00
49	IDSA85	0.95	40	OS6 (FARO11)	0.00
26	WAB340-B-B-9-L3-L1-LB	0.75	20	M22	0.00
21	TOX728-1	0.75	57	ITA320	0.00
53	WAB450-I-B-P-129-HB**	0.70	55	IR33356-22-3-1-2	0.00
9	TOG6545	0.70	39	IDSA85	0.00
43	IG10	0.70	19	IDSA85	0.00
7	WAB450-I-B-P-133-HB	0.65	52	FARO8	0.00
13	WAB99-10	0.60	11	CG20	0.00

Table 12. Seed yield in the High Input PVS trial at Nyankpala, Ghana, 1998. Yields are from unreplicated plots of $10m^2$

Entry no.	Genotype	Yield ($t\ ha^{-1}$)	Entry no.	Genotype	Yield ($t\ ha^{-1}$)
48	CT6398-521-18-2D	3.95	7	WAB450-I-B-P-135-HB	1.86
43	WAB36-54	3.26	42	WAB365-B-1-H1-HB	1.81
56	EMPSAC103	3.23	47	TGR75	1.76
57	CARD170	3.22	12	WAB450-11-1-1-P31-HB	1.75
58	P5464-19A-18-H-1	3.12	45	WAB99-11-14-HB	1.74
31	WB96-1-1	2.94	17	WAB450-24-3-4-P18-3-1	1.72
46	IR47686-18-6-1	2.76	22	WAB450-24-3-1-P37-HB	1.72
4	IR7686-13-2-2	2.76	60	TOX3099-1-1-1 (RED)	1.68
50	PR53-1-3-6-39-2	2.72	54	IRAT216	1.66
13	WAB515-B-16-A22	2.51	49	WAB99-7	1.66
14	WAB450-I-B-P-157-2-1	2.50	19	WAB450-I-B-P-163-4-1	1.66
40	WAB224-8-HB	2.47	36	ITA150	1.65
26	WAB450-I-B-P-105-HB	2.42	15	WAB450-I-B-P-51-1-1	1.60
24	WAB450-24-3-2-P18-HB	2.41	59	TOX3377-34-3-3-2	1.59
3	KPUKPULA	2.32	51	WAB272-B-B-7	1.58
32	IDSA6	2.31	23	WAB450-I-B-P-62-HB	1.58
25	WAB450-I-B-P-160-HB	2.29	37	LAC23	1.58
34	MOROBEREKAN	2.22	28	WAB56-50	1.58
35	IRAT144	2.10	16	WAB450-I-B-P-32-HB	1.54
18	WAB450-I-B-P-38-HB	2.09	52	WAB32-55	1.48
55	CNA4126	2.08	2	WAB450-I-B-31-HB	1.46
6	WAB450-11-1-2-P41-HB	2.03	27	WAB450-4-1-A16	1.45
44	TOX3444-9-3-2	2.00	8	WAB450-I-B-P-153-HB	1.42
5	WAB570-10-B-1-A26	1.97	29	WB56-125	1.42
9	WAB450-I-B-P-33-HB	1.95	1	WAB95-B-B-B-B-16-112	1.38
10	WAB450-11-1-1-P50-HB	1.94	11	WB450-I-B-P-24-HB	1.38
30	WB181-18	1.90	38	WAB56-104	1.32
41	WAB365-B-2-H3-HB	1.89	39	WAB377-B-16-L3-LB	1.07
33	IDSA10	1.87	20	WAB450-24-2-3-P33-HB	0.90
21	WAB450-I-B-P-157-1-1	1.87	53	WAB99-10	0.85

Table 13. Seed yield in the Low Input PVS trial at Nyankpala, Ghana, 1998. Yields are from unreplicated plots of 10m^2

Entry no.	Genotype	Yield (t ha^{-1})	Entry no.	Genotype	Yield (t ha^{-1})
43	WAB36-54	3.82	13	WAB515-B-16-A22	1.55
48	CT6398-521-18-2D	2.83	2	WAB450-I-B-31-HB	1.51
4	IR7686-13-2-2	2.73	53	WAB99-10	1.49
46	IR47686-18-6-1	2.71	25	WAB450-I-B-P-160-HB	1.49
56	EMPSAC103	2.66	52	WAB32-55	1.47
57	CARD170	2.63	14	WAB450-I-B-P-157-2-1	1.46
47	TGR75	2.54	45	WAB99-11-14-HB	1.43
40	WAB224-8-HB	2.5	29	WB56-125	1.37
31	WB96-1-1	2.42	22	WAB450-24-3-1-P37-HB	1.32
50	PR53-1-3-6-39-2	2.26	23	WAB450-I-B-P-62-HB	1.26
54	IRAT216	2.23	1	WAB95-B-B-B-B-16-112	1.25
21	WAB450-I-B-P-157-1-1	2.23	20	WAB450-24-2-3-P33-HB	1.23
58	P5464-19A-18-H-1	2.15	32	IDSA6	1.22
37	LAC23	2.11	39	WAB377-B-16-L3-LB	1.21
60	TOX3099-1-1-1 (RED)	2.09	27	WAB450-4-1-A16	1.21
59	TOX3377-34-3-3-2	2.06	16	WAB450-I-B-P-32-HB	1.2
17	WAB450-24-3-4-P18-3-1	2.01	55	CNA4126	1.16
5	WAB570-10-B-1-A26	1.95	30	WB181-18	1.14
51	WAB272-B-B-7	1.89	12	WAB450-11-1-1-P31-HB	1.09
6	WAB450-11-1-2-P41-HB	1.85	28	WAB56-50	1.07
44	TOX3444-9-3-2	1.81	36	ITA150	1.05
41	WAB365-B-2-H3-HB	1.81	38	WAB56-104	1.04
34	MOROBEREKAN	1.8	19	WAB450-I-B-P-163-4-1	1.02
49	WAB99-7	1.79	15	WAB450-I-B-P-51-1-1	0.97
33	IDSA10	1.76	3	KPUKPULA	0.93
42	WAB365-B-1-H1-HB	1.75	10	WAB450-11-1-1-P50-HB	0.9
18	WAB450-I-B-P-38-HB	1.68	7	WAB450-I-B-P-135-HB	0.89
35	IRAT144	1.58	9	WAB450-I-B-P-33-HB	0.79
24	WAB450-24-3-2-P18-HB	1.56	11	WB450-I-B-P-24-HB	0.66
26	WAB450-I-B-P-105-HB	1.55	8	WAB450-I-B-P-153-HB	0.58

Table 14. Farmer varietal selection criteria at the vegetative stage at Aframso in 1998

		CHARACTERISTICS/TRAITS								
Variety	Frequency	Seedling emergence	Tillering ability	Long leaves	Broad leaves	Green Leaves	Closed canopy	Fertiliser response	Drought tolerance	Weed suppressant
TOX3377-34-3-3-3-2	37	25	22	33	37	36	13	19	16	3
WAB450-I-B-P-133-HB	30	26	15	23	30	30	1	28	3	0
WAB126-15-HB	27	13	21	14	27	27	9	20	5	1
WAB99-10	27	1	4	24	9	27	1	26	17	0
TOX3058-28-1-1 (WITA9)	20	0	20	3	15	19	6	14	5	2
IDSA 85	18	17	14	18	18	18	1	15	4	0
WAB340-B-B-10-HI	13	10	12	13	10	13	5	11	9	0
WAB450-24-3-2-P18-HB	13	5	12	2	13	13	0	12	4	0
TGR 75	11	11	11	5	0	6	4	5	0	6
TOX3100-37-3-3-2-9	9	2	9	2	0	8	1	3	5	1
WAB126-18-H-HB	9	6	8	8	9	9	0	7	2	1
DANANE	7	7	7	7	7	7	0	5	0	0
MR. MORE (LOCAL)	7	5	7	7	3	7	1	7	6	0
CG 20	7	5	6	5	1	6	6	3	3	4
WAB638-1 (DR2)	6	6	6	6	6	5	2	4	0	0
WAB56-50	5	5	3	5	5	5	0	4	0	0
LAC23 (ROK17)	5	5	0	5	5	5	0	5	1	0
TOX728-1	3	3	3	3	1	3	2	2	1	1
WAB340-B-B-9-L3-L1-LB	3	2	3	2	2	3	1	2	1	0
WABC165 (IAC165)	2	2	2	2	2	2	0	2	0	0
WAB450-I-B-P-160-HB	2	2	0	1	2	2	0	1	2	0
WAB450-I-B-P-26-HB	2	2	1	2	2	1	0	0	0	0
WAB160-24-H-HB	2	1	2	2	2	2	1	2	1	0
WAB450-I-B-P-129-HB	2	2	0	2	2	2	1	2	1	0
TOX4004-43-1-2-1	1	1	1	1	1	1	1	0	0	0
TOX3440-171-1-1-1 (WITA7)	1	1	1	0	1	0	0	0	1	0
TOTALS		165	190	195	210	257	56	199	87	19

Table 15. Farmer varietal selection criteria at the flowering to maturity stage at Aframso in 1998

		CHARACTERISTICS/TRAITS												
Variety	Frequency	Tall plant height	Medium plant height	Short plant height	Long panicles	Large panicle head	Small panicle head	Early maturing	Medium maturing	Late maturing	Large grain size	Small grain size	No lodging	No diseases & pests
WAB160-24-H-HB	61	12	37	12	0	49	0	61	0	0	61	0	17	12
WAB209-5-H-HB	76	44	32	0	0	71	0	72	0	0	61	1	33	12
WAB224-16-HB	36	34	4	0	0	26	4	33	0	0	36	1	15	9
TOX3377-34-3-3-2	24	24	0	0	0	22	0	24	0	0	24	0	7	3
WAB56-50	15	6	9	0	0	14	0	14	0	0	14	0	10	8
MOROBEREKAN	19	19	0	1	0	17	1	18	0	0	18	0	5	3
WAB126-18-H-HB	21	8	12	0	0	20	0	21	0	0	15	5	11	7
TOX4004-8-1-2-3	11	0	11	0	0	0	0	11	0	0	11	0	11	0
LAC23 (ROK17)	8	8	0	0	0	5	0	0	0	8	8	0	4	1
WAB340-B-B-10-HI	7	7	0	0	0	7	0	7	0	0	7	0	1	0
FKR 14 (4418)	7	0	1	6	0	6	0	6	0	1	6	0	3	0
ITA 321	7	7	0	0	0	7	0	6	0	0	6	0	3	1
IDSA 85	6	0	5	1	0	4	2	5	0	0	6	0	4	2
WAB450-I-B-P-160-HB	3	3	0	0	0	3	0	3	0	0	3	0	2	1
TOX3058-28-1-1 (WITA9)	2	0	0	2	0	0	0	0	0	2	0	0	2	0
OS 6 (FARO 11)	2	2	0	0	0	0	1	2	0	0	2	0	2	1
IR3356-22-3-1-2	1	0	0	1	0	1	0	0	0	1	0	0	1	1
IG 10	1	0	1	0	0	0	0	0	0	1	0	0	1	1
GAMBIAKA	1	0	1	0	0	0	0	0	0	1	0	0	1	1
TOTALS		174	113	23	0	252	8	283	0	14	278	7	133	63

Table 16. Farmer varietal selection criteria at harvest stage at Aframso in 1998

		CHARACTERISTICS/TRAITS									
Variety	Frequency	High (good) yielding	Bold (fat) grain	Well-filled grain	Long grain	Slender Grain	Sweet milk (grain)	Nice/fine grain	Red grain	White grain	Disease/pest free grain
WAB450-I-B-P-129-HB	48	10	29	17	24	0	0	22	0	2	2
WAB126-18-H-HB	31	4	20	7	15	0	2	14	0	0	1
MR. MORE (LOCAL)	26	13	7	2	15	0	1	17	0	0	2
KLEMINSIN	23	5	3	2	12	2	3	11	0	0	2
IDSA 85	23	1	6	4	20	0	0	3	0	0	1
WAB160-24-H-HB	21	7	15	10	6	0	0	5	0	0	1
IDSA 10 (IRAT262)	15	1	10	10	0	0	0	10	0	0	0
WAB99-10	9	1	5	4	5	0	0	4	0	0	0
WAB209-5-H-HB	8	0	4	6	1	0	0	7	0	0	0
IG 10	8	1	0	0	0	0	4	0	8	0	0
TOX3377-34-3-3-2	7	2	4	2	5	0	0	3	0	0	1
WAB224-16-HB	7	1	3	6	6	0	1	0	0	0	0
LAC23 (ROK17)	5	1	5	1	0	0	0	3	0	0	0
WABC165 (IAC165)	3	1	0	0	0	1	1	2	0	0	0
TOX3108-56-4-2-2-2	2	2	0	0	0	0	0	0	0	0	0
TOX3100-37-3-3-2-1	2	0	0	0	1	0	0	2	0	0	0
MOROBEREKAN	2	0	2	0	0	0	0	1	0	0	0
WAB340-B-B-10-HI	1	1	1	0	0	0	0	1	0	0	1
SUAKOKO 8	1	0	0	0	0	1	1	0	0	0	0
WAB340-B-B-9-L3-L1-LB	1	1	1	0	0	0	0	1	0	0	0
DANANE	1	0	0	0	0	0	1	0	0	0	0
TOTAL		52	115	71	120	4	14	107	8	2	11

Table 17. Frequency of selection of milled rice genotypes and their traits by rice traders at Ashaiman and Kumasi markets. Data were collected from 10 traders at each market

		Grain traits						
Genotype	Frequency	Long grain	Bold grain	White grain	Red grain	Brownish grain	High milling recovery rate	High market value
IDSA 85	18	15	2	17	0	0	9	17
Kleminsin	16	16	0	16	0	0	3	11
WAB 126-15-HB	14	0	14	14	0	0	1	8
TOX 3377-34-3-2	11	3	8	11	0	0	4	7
WAB126-18-H-HB	9	2	7	9	0	0	1	6
WAB340-B-B-10-HI	8	3	5	8	0	0	1	5
Mr More (Local)	7	7	0	0	0	7	4	2
Viono (Local)	4	0	4	0	4	0	1	2
WAB450-I-B-P-129-HB	3	3	0	3	0	0	0	0
Local Red	1	0	1	0	1	0	0	0
Total	91	49	41	78	5	7	24	58

Table 18. Scores (1 = very poor; 4 = very good) for cooking quality traits by male and female consumers at Aframso. Data are mean scores for 10 male or female consumers.

Genotype	Aroma	Taste	Stickiness	Hardness	Expansion ability	Total score
			Male consumers			
WAB450-I-B-P-129-HB	2.3	2.7	2.9	2.6	2.2	12.7
WAB126-18-H-HB	1.2	1.7	2.7	2.0	3.4	11.0
IDSA 85	1.1	1.4	2.8	2.4	4.0	11.8
WAB 160-24-H-HB	2.0	2.9	2.9	2.3	2.7	12.8
Kleminsin	1.8	2.5	2.2	2.1	3.6	12.2
IDSA 10	2.5	3.6	2.7	2.9	3.6	15.3
Local Red	1.9	2.8	2.6	3.6	3.4	14.3
TOX 3377-34-3-3-2	3.3	3.6	3.0	3.0	3.6	16.5
Mr More (Local)	2.2	3.0	2.0	3.6	3.4	14.2
			Female consumers			
WAB450-I-B-P-129-HB	3.3	3.2	2.8	1.7	2.7	13.7
WAB126-18-H-HB	2.5	2.5	2.7	2.2	3.9	13.9
IDSA 85	1.3	1.3	2.3	2.1	3.9	10.9
WAB 160-24-H-HB	2.4	2.9	2.7	2.5	2.7	13.1
Kleminsin	2.2	2.4	2.6	2.2	3.4	12.8
IDSA 10	2.8	2.6	2.3	2.2	3.4	13.3
Local Red	2.6	2.7	2.0	2.2	3.2	12.7
TOX 3377-34-3-3-2	2.9	3.3	2.6	2.0	2.4	13.2
Mr More (Local)	2.4	2.7	2.1	2.8	3.5	13.5

Table 19. Scores (1 = very poor; 4 = very good) for cooking quality traits by male and female consumers at Hohoe. Data are mean scores for 10 male or female consumers.

Genotype	Aroma	Taste	Stickiness	Hardness	Expansion ability	Total score
			Male consumers			
WAB209-5-H-HB	1.6	2.3	3.2	3.0	3.8	13.9
WAB340-B-B-10-HI	2.1	3.0	2.9	2.9	4.0	14.9
IDSA 85	1.7	1.6	2.0	2.8	3.7	11.8
WAB126-18-H-HB	3.0	3.8	3.5	3.1	3.9	17.3
Kleminsin	3.4	3.8	3.1	2.1	3.6	15.2
Kawumo (Local)	3.4	2.9	3.0	2.1	3.8	15.2
WAB126-15-HB	2.6	2.4	3.0	2.2	4.0	14.2
TOX 3377-34-3-3-2	3.6	3.1	3.8	2.6	3.9	17.0
Viono (Local)	3.8	3.6	3.2	2.6	4.0	17.2
			Female consumers			
WAB209-5-H-HB	1.4	1.5	1.7	2.0	3.5	10.1
WAB340-B-B-10-HI	2.7	2.6	2.9	3.1	2.7	14.0
IDSA 85	2.6	2.9	2.7	3.1	3.4	14.7
WAB126-18-H-HB	3.6	3.0	3.3	3.1	3.6	16.6
Kleminsin	3.5	3.8	3.5	3.8	3.9	18.5
Kawumo (Local)	3.6	3.6	3.2	3.2	3.6	17.2
WAB126-15-HB	2.8	3.0	3.0	2.7	3.5	15.0
TOX 3377-34-3-3-2	3.6	3.6	3.6	3.2	3.7	17.7
Viono (Local)	4.0	3.5	3.2	3.1	3.0	16.8

Table 20. Characteristics of linkage groups identified on the basis of phenological parameters. Groups derived from PCA of 83 genotypes grown of five occasions under upland, hydromorphic and lowland conditions at Mbé, Bouaké, Cote d'Ivoire in 1997. From Dingkuhn and Asch (1999).

Linkage group	No. genotypes	Species/eco-types				Upland		Lowland		Maturity ± SE (d)	Predominant ecotypes
		Glab.	Inter.	Sat. jap.	Sat. Ind.	Trad.	Impr.	Trad.	Impr.		
1	1	1				1				138±0.0	Highly photoperiod-sensitive, traditional upland (*O. glaberrima)*
2	2		2				2			108±5.9	Short duration, moderate photoperiod-sensitive, improved upland (interspecifics)
3	2	2				2				109.5±3.4	Short duration, moderate photoperiod-sensitive, improved upland (*O. glaberrima*)
4	6	1	1	4		1	5			99.8±0.4	Ultra-short duration, photoperiod-sensitive in lowland, improved upland (japonica)
4a	15	1	5	8	1	1	13	1		100.7±1.8	Ultra-short duration, improved upland (japonica & interspecifics)
5	2			2		2				134.5±2.5	Long duration, photoperiod-sensitive, traditional upland (japonica)
6	10			1	9			3	7	130.4±1.4	Medium to long duration, photoperiod insensitive, improved & traditional lowland (indica)
6a	11			1	10	1			19	129.5±2.2	Medium to long duration, photoperiod-sensitive in upland, improved lowland (indica)
7	15			4	11	3	1		11	127.9±1.4	Medium duration, photoperiod-sensitive in upland, improved lowland (indica)
7a	19		1	13	5		14		5	114.2±1.5	Short to medium duration, photoperiod insensitive, improved upland (japonica)
Total	83	5	9	33	36	11	35	5	32	117.9	

Table 21. Minimum and maximum duration from emergence to flowering (d), minimum main shoot leaf number, BVP (°Cd) and PSP (°Cd h^{-1}) and mean plant height for twenty two genotypes of rice

Genotype	Type	Duration from emergence to flowering (d)		Minimum mainshoot leaf number	BVP (°Cd)	PSP (°Cd h^{-1})	Plant height (cm)
		Minimum (28°C/11h)	Maximum (28°C/13h or 22°C/13h)				
IG10	*O. glaberrima*	41.5	>102¶	7.3	230	-	73
WAB 450-24-2-3-P33-HB	Interspecific	55.5	79.5	8.3	430	208	89
WAB 450-I -B-P-160-HB	Interspecific	59.3	85.8	8.6	500	255	88
CG 17	*O. glaberrima*	40.5	68.5	7.9	221	283	89
TOG 6545	*O. glaberrima*	55.8	82.5	9.7	391	413	102
IDSA 10	*O. sativa* japonica	58.8	80.0	8.9	591	131	74
WAB 56-104	*O. sativa* japonica	57.0	78.8	8.5	470	156	85
CG14	*O. glaberrima*	49.0	76.8	8.4	333	384	98
WAB 450-24-2-3-3-P18-HB	Interspecific	52.3	79.5	8.1	470	459	88
IAC 165	*O. sativa* japonica	57.0	81.3	8.8	506	164	110
Danane	*O. sativa* japonica	87.3	>102¶	12.2	1019	-	91
LAC 23	*O. sativa* japonica	83.5	>102¶	11.8	951	-	93
WITA 5	*O. sativa* indica	71.3	>102¶	11.6	733	321	65
TOX 4004-43-1-2-1	*O. sativa* indica	67.5	>102¶	11.5	699	331	97
Cisadance	*O. sativa* indica	72.8	>102¶	11.3	699	374	60
TOX 3440-132-3-3-1	*O. sativa* indica	64.0	>102¶	10.5	686	326	80
Bouaké 189	*O. sativa* indica	66.8	>102¶	10.8	676	353	83
FKR 14	*O. sativa* indica	50.5	86.3	8.6	458	271	52
Azucena	*O. sativa* japonica	77.8	>102¶	11.6	848	-	121
WAB 126-18-HB	*O. sativa* japonica	84.5	>102¶	12.0	656	324	90
IDSA 85	*O. sativa* japonica	71.3	91.3	10.0	683	206	89
IR36	*O. sativa* indica	61.8	92.0	10.3	658	115	37

¶ Had not flowered by the end of the experiment

Table 22. BVP, PSP, minimum duration to flowering, minimum mainshoot leaf number and plant height of rice species/eco-types

Species/eco-type	BVP (°Cd)	PSP (°Cd h^{-1})	Minimum duration to flower (d)	Minimum mainshoot leaf number	Plant height (cm)
O. glaberrima (n=4)	294 ± 82.4	360 ± 68.2	46.7 ± 7.1	8 ± 0.9	91 ± 11.1
O. glaberrima × *O. sativa* (n=3)	467 ± 35.1	207 ± 48.0	55.7 ± 3.5	8 ± 0.2	88 ± 0.5
O. sativa indica (n=7)	658 ± 91.4	299 ± 87.0	65.0 ± 7.4	11 ± 1.0	68 ± 18.9
O. sativa japonica					
Traditional (n=3)	939 ± 86.1	>400	82.9 ± 4.8	11 ± 1.0	102 ± 13.7
Improved (n=5)	581 ± 92.3	581 ± 76.4	65.7 ± 12.1	10 ± 1.3	90 ± 11.7

Table 23. Seed yield, components and scores for replicated yield trial at Manga, High Input, 1998

Genotype	Yield (t ha^{-1})	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Drought tolerance Score	Drought recovery score
WAB638-1 (DR2)	2.20	67	113	125	61	135	2	3	4	1
MOROBEREKAN	2.05	60	104	125	42	139	0	3	2	1
WAB340-B-B-9-L3-L1-LB	2.09	57	87	122	54	110	0	4	2	1
WAB224-16-HB	1.51	62	90	116	64	95	0	1	1	2
WAB126-15-H-HB	2.23	67	87	116	62	99	4	1	1	1
IDSA 10 (IRAT 262)	0.59	62	85	112	66	80	0	2	2	2
WAB126-18-HB	1.99	73	93	125	83	111	0	1	1	1
WAB340-B-B-10-HI	1.61	55	95	120	61	108	0	4	2	1
WAB450-24-2-5-P4-HB	0.89	52	74	108	61	79	0	5	1	1
WAB450-24-3-2-P18-HB	1.95	73	86	115	65	84	0	3	2	1
WAB450-I-B-P-133-HB	1.17	55	73	123	63	85	0	2	2	1
WAB450-I-B-P-26-HB	1.02	55	89	121	65	101	0	4	2	1
SALUMPIKIT	1.84	53	102	126	94	139	0	6	2	1
GAMBIAKA	0.78	35	119	130	75	135	0	4	2	1
TOG6545	1.34	95	92	118	154	131	9	9	4	2
IG10	1.90	95	114	141	134	112	5	8	4	2
TOX3100-37-3-3-2-1	1.64	90	111	143	132	91	0	3	2	2
TOX3108-56-4-2-2-2	1.52	75	111	137	117	103	0	1	1	1
IDSA85	0.60	32	94	121	90	92	0	1	2	1
WAB56-50	1.57	63	72	111	72	92	0	2	2	1
WAB99-10	1.21	52	70	105	47	85	5	5	2	1
TOX3377-34-3-3-2	1.30	53	94	114	84	143	0	1	2	1
TGR75	1.41	70	108	128	126	90	0	3	2	1
WAB450-I-B-P-160-HB	1.56	60	82	106	40	84	0	2	2	1
M22	1.91	67	89	113	87	102	0	4	6	3

Table 24. Seed yield, components and scores for replicated yield trial at Manga, Low Input, 1998

Genotype	Yield (t ha^{-1})	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Drought tolerance Score	Drought recovery Score
WAB638-1 (DR2)	0.90	72	121	140	42	119	1	5	2	1
MOROBEREKAN	0.67	87	105	130	20	102	0	5	1	2
WAB340-B-B-9-L3-L1-LB	0.65	62	88	117	53	91	2	9	3	4
WAB224-16-HB	0.72	80	121	125	40	96	0	6	1	2
WAB126-15-H-HB	0.72	67	88	128	48	87	2	6	2	2
IDSA 10 (IRAT 262)	0.29	45	75	108	35	80	2	6	4	1
WAB126-18-HB	0.60	68	101	124	56	100	0	7	2	2
WAB340-B-B-10-HI	0.66	70	93	117	58	94	0	6	4	2
WAB450-24-2-5-P4-HB	0.66	55	72	109	43	92	2	8	2	2
WAB450-24-3-2-P18-HB	0.42	71	78	114	54	86	1	8	4	2
WAB450-I-B-P-133-HB	0.31	60	81	107	42	94	1	8	2	4
WAB450-I-B-P-26-HB	0.73	63	81	127	61	88	2	8	2	1
SALUMPIKIT	1.41	88	89	127	61	92	5	5	3	2
GAMBIAKA	0.45	58	114	134	40	124	5	4	4	2
TOG6545	1.47	92	92	115	130	108	9	2	3	2
IG10	2.18	93	112	134	86	112	7	1	4	4
TOX3100-37-3-3-2-1	1.70	85	115	141	78	89	0	2	2	1
TOX3108-56-4-2-2-2	1.06	83	110	144	67	99	2	4	2	2
IDSA85	0.22	43	93	112	52	93	0	9	2	2
WAB56-50	0.31	57	81	112	48	84	0	8	2	2
WAB99-10	0.38	57	74	101	36	95	5	8	2	1
TOX3377-34-3-3-2	0.60	75	102	124	40	95	0	9	2	1
TGR75	1.09	83	103	128	82	79	0		3	2
WAB450-I-B-P-160-HB	0.50	63	82	106	38	106	1	6	4	2
M22	0.59	85	85	115	45	113	0	1	4	2

Table 25. Seed yield, components and scores for replicated yield trial at Nyankpala, High Input, 1998

Genotype	Yield (t ha^{-1})	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Drought tolerance Score	Drought Recovery Score
WAB638-1 (DR2)	0.90	90	105	134	66	139	2	3	4	2
MOROBEREKAN	1.34	78	101	121	49	138	0	3	2	1
WAB340-B-B-9-L3-L1-LB	1.22	75	84	113	57	118	2	5	2	1
WAB224-16-HB	1.20	68	91	115	71	112	0	2	1	1
WAB126-15-H-HB	1.40	73	90	117	72	113	0	1	1	1
IDSA 10 (IRAT 262)	1.02	67	66	100	61	98	0	6	4	2
WAB126-18-HB	1.77	73	96	120	91	127	0	1	1	1
WAB340-B-B-10-HI	1.53	58	86	115	59	134	3	4	2	1
WAB450-24-2-5-P4-HB	1.27	75	80	105	65	96	0	3	1	1
WAB450-24-3-2-P18-HB	1.26	70	83	114	68	103	2	5	2	1
WAB450-I-B-P-133-HB	1.23	72	72	104	60	113	1	4	2	1
WAB450-I-B-P-26-HB	1.21	58	88	116	70	110	0	4	2	1
SALUMPIKIT	1.66	80	91	119	92	130	6	6	2	1
GAMBIAKA	0.37	73	120	147	73	132	4	4	2	1
TOG6545	0.83	90	91	116	154	123	9	9	6	3
IG10	0.90	95	119	149	110	140	9	8	6	3
TOX3100-37-3-3-2-1	2.41	77	118	147	143	92	3	4	3	1
TOX3108-56-4-2-2-2	1.15	68	112	142	125	82	0	3	1	1
IDSA85	1.51	68	87	116	90	112	0	1	2	1
WAB56-50	0.91	73	81	103	70	113	1	4	2	1
WAB99-10	1.03	55	66	100	43	99	0	5	2	1
TOX3377-34-3-3-2	1.67	73	94	117	86	125	1	1	2	1
TGR75	1.70	73	96	123	181	100	1	3	2	1
WAB450-I-B-P-160-HB	1.40	65	85	113	41	110	4	2	2	1
M22	1.34	75	89	115	90	132	2	4	6	3

Table 26. Seed yield, components and scores for replicated yield trial at Nyankpala, Low Input, 1998

Genotype	Yield ($t\ ha^{-1}$)	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Drought tolerance Score	Drought recovery score
WAB638-1 (DR2)	0.84	65	107	134	44	122	0	1	4	2
MOROBEREKAN	0.71	57	111	123	28	115	0	3	1	1
WAB340-B-B-9-L3-L1-LB	1.44	60	92	119	54	113	2	4	4	2
WAB224-16-HB	1.02	61	89	117	43	92	0	6	2	1
WAB126-15-H-HB	0.91	63	97	116	48	105	0	1	1	1
IDSA 10 (IRAT 262)	0.56	57	66	101	30	78	2	9	2	1
WAB126-18-HB	1.21	63	97	120	61	105	1	2	1	1
WAB340-B-B-10-HI	1.53	75	90	115	55	112	0	2	4	2
WAB450-24-2-5-P4-HB	1.20	70	80	103	47	96	1	5	2	1
WAB450-24-3-2-P18-HB	0.91	65	79	106	51	93	1	8	4	2
WAB450-I-B-P-133-HB	1.11	65	80	103	45	106	2	8	2	1
WAB450-I-B-P-26-HB	1.37	67	88	115	67	102	1	2	2	1
SALUMPIKIT	1.52	70	97	120	57	116	7	9	3	2
GAMBIAKA	0.45	60	122	145	43	114	3	6	4	2
TOG6545	1.56	83	93	115	130	115	9	9	5	2
IG10	1.36	83	120	147	92	129	7	6	5	2
TOX3100-37-3-3-2-1	0.85	63	115	148	82	80	0	3	2	1
TOX3108-56-4-2-2-2	0.24	63	113	141	79	103	1	6	2	1
IDSA85	1.01	60	90	116	56	103	0	1	2	1
WAB56-50	0.91	65	85	104	52	102	1	3	2	1
WAB99-10	0.44	70	68	100	32	90	3	9	2	1
TOX3377-34-3-3-2	0.89	55	96	116	37	107	1	1	2	1
TGR75	1.40	70	100	123	86	92	1	1	3	2
WAB450-I-B-P-160-HB	1.07	58	82	110	33	109	1	4	4	2
M22	1.17	73	93	115	50	110	0	1	4	2

Table 27. Replicated yield trial Aframso, High Input 1999

Genotype	Yield ($t\ ha^{-1}$)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)
WAB638-1 (DR2)	0.70				
MOROBEREKAN	1.10				
WAB340-B-B-9-L3-L1-LB	0.45				
WAB224-16-HB	1.37				
WAB126-15-H-HB	0.37				
IDSA 10 (IRAT 262)	0.13				
WAB126-18-HB	0.82				
WAB340-B-B-10-HI	0.37				
WAB450-24-2-5-P4-HB	0.23				
WAB450-24-3-2-P18-HB	0.29				
WAB450-I-B-P-133-HB	0.25				
WAB450-I-B-P-26-HB	0.48				
SALUMPIKIT	1.51				
GAMBIAKA	0.40				
TOG6545	0.45				
IG10	1.23				
TOX3100-37-3-3-2-1	0.26				
TOX3108-56-4-2-2-2	0.45				
IDSA85	0.34				
WAB56-50	0.35				
WAB99-10	0.08				
TOX3377-34-3-3-2	0.95				
TGR75	0.63				
WAB450-I-B-P-160-HB	0.35				
M22	1.17				

Table 28. Replicated yield trial Aframso, Low Input 1999

Genotype	Yield ($t\ ha^{-1}$)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)
WAB638-1 (DR2)	0.29				
MOROBEREKAN	0.62				
WAB340-B-B-9-L3-L1-LB	0.42				
WAB224-16-HB	1.03				
WAB126-15-H-HB	0.27				
IDSA 10 (IRAT 262)	0.15				
WAB126-18-HB	0.45				
WAB340-B-B-10-HI	0.66				
WAB450-24-2-5-P4-HB	0.10				
WAB450-24-3-2-P18-HB	0.30				
WAB450-I-B-P-133-HB	0.06				
WAB450-I-B-P-26-HB	0.28				
SALUMPIKIT	0.69				
GAMBIAKA	0.15				
TOG6545	0.32				
IG10	0.44				
TOX3100-37-3-3-2-1	0.14				
TOX3108-56-4-2-2-2	0.21				
IDSA85	0.34				
WAB56-50	0.25				
WAB99-10	0.05				
TOX3377-34-3-3-2	0.62				
TGR75	0.00				
WAB450-I-B-P-160-HB	0.41				
M22	0.75				

Table 29. Replicated yield trial Kwadaso, High Input 1999

Genotype	Yield (t ha^{-1})	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)
WAB638-1 (DR2)	0.22	109		107	119
MOROBEREKAN	0.37	96		107	136
WAB340-B-B-9-L3-L1-LB	0.44	84	107	75	108
WAB224-16-HB	0.50	85	105	88	96
WAB126-15-H-HB	0.20	92	111	87	84
IDSA 10 (IRAT 262)	0.21	72	88	84	100
WAB126-18-HB	0.35	90	105	91	98
WAB340-B-B-10-HI	0.42	86	105	77	106
WAB450-24-2-5-P4-HB	0.58	87		78	98
WAB450-24-3-2-P18-HB	0.47	86	105	72	104
WAB450-I-B-P-133-HB	0.46	69	88	65	93
WAB450-I-B-P-26-HB	0.36	85	107	77	97
SALUMPIKIT	0.35	94		157	99
GAMBIAKA	0.17	89		67	120
TOG6545	0.39	91	110	137	104
IG10	0.30	106		132	117
TOX3100-37-3-3-2-1	0.20	120		113	82
TOX3108-56-4-2-2-2	0.53	112		161	92
IDSA85	0.43	85	105	77	95
WAB56-50	0.25	71	88	71	92
WAB99-10	0.39	67	82	71	101
TOX3377-34-3-3-2	0.37	99	111	106	103
TGR75	0.30	93		213	77
WAB450-I-B-P-160-HB	0.40	85	106	77	106
M22	0.35	91	112	92	121

Table 30. Replicated yield trial Kwadaso, Low Input 1999

Genotype	Yield (t ha^{-1})	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)
WAB638-1 (DR2)	0.23	112		91	118
MOROBEREKAN	0.18	112		79	117
WAB340-B-B-9-L3-L1-LB	0.23	90	112	58	92
WAB224-16-HB	0.33	95	111	81	87
WAB126-15-H-HB	0.17	95		79	76
IDSA 10 (IRAT 262)	0.14	82	98	30	94
WAB126-18-HB	0.42	95	112	93	91
WAB340-B-B-10-HI	0.20	92	111	63	102
WAB450-24-2-5-P4-HB	0.31	95		68	96
WAB450-24-3-2-P18-HB	0.35	91	112	72	94
WAB450-I-B-P-133-HB	0.17	84	111	40	89
WAB450-I-B-P-26-HB	0.18	89	112	64	87
SALUMPIKIT	0.51	95		105	98
GAMBIAKA	0.00	93			
TOG6545	0.15	95		261	96
IG10	0.00			164	101
TOX3100-37-3-3-2-1	0.00	89			
TOX3108-56-4-2-2-2	0.00	94		133	96
IDSA85	0.00	96	111	62	91
WAB56-50	0.37	73	102	83	91
WAB99-10	0.30	87	98	36	90
TOX3377-34-3-3-2	0.34	103		77	87
TGR75	0.21			110	68
WAB450-I-B-P-160-HB	0.25	95	112	57	104
M22	0.33	95	112	63	113

Table 31. Seed yield, components and scores for replicated yield trial at Nyankpala, High Input, 1999

Genotype	Yield (t ha^{-1})	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed Score	Blast score	Phenotypic acceptability score
WAB638-1 (DR2)	3.52	82	98	127	185	127	2	3	1	2
MOROBEREKAN	2.64	75	92	121	108	131	1	3	1	2
WAB340-B-B-9-L3-L1-LB	3.30	80	77	117	117	120	4	5	1	5
WAB224-16-HB	3.60	93	84	110	159	126	1	2	1	3
WAB126-15-H-HB	2.74	82	83	121	122	117	2	1	1	2
IDSA 10 (IRAT 262)	2.95	72	81	110	107	115	3	6	1	4
WAB126-18-HB	3.27	85	81	120	124	117	2	1	1	2
WAB340-B-B-10-HI	2.97	77	81	119	121	133	2	4	1	2
WAB450-24-2-5-P4-HB	2.06	77	79	117	116	111	2	3	1	4
WAB450-24-3-2-P18-HB	2.75	82	76	114	110	107	2	5	1	4
WAB450-I-B-P-133-HB	2.07	77	76	113	111	115	2	4	1	5
WAB450-I-B-P-26-HB	2.61	73	80	117	124	106	2	4	1	4
SALUMPIKIT	3.27	88	85	103	124	140	6	6	1	4
GAMBIAKA	2.68	77	93	122	128	121	1	4	1	2
TOG6545	1.62	90	80	117	137	122	7	9	1	7
IG10	1.69	85	83	119	139	117	2	8	1	8
TOX3100-37-3-3-2-1	2.67	75	90	119	136	143	1	4	1	2
TOX3108-56-4-2-2-2	4.17	87	90	118	154	79	1	3	1	2
IDSA85	2.90	88	55	119	137	116	2	1	1	4
WAB56-50	2.34	72	78	115	111	111	2	4	1	4
WAB99-10	2.37	68	67	110	104	106	2	5	1	4
TOX3377-34-3-3-2	2.50	78	66	122	122	115	1	1	1	2
TGR75	2.98	83	86	115	143	111	4	3	1	5
WAB450-I-B-P-160-HB	2.56	78	78	115	119	121	5	2	1	5
M22	2.95	78		105	137	125	2	4	1	4

Table 32. Seed yield, components and scores for replicated yield trial at Nyankpala, Low Input, 1999

Genotype	Yield (t ha^{-1})	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Blast score	Phenotypic Acceptability Score
WAB638-1 (DR2)	3.53	72	97	121	88	120	2	1	1	2
MOROBEREKAN	1.38	68	93	120	98	120	1	3	1	1
WAB340-B-B-9-L3-L1-LB	1.62	87	79	106	84	107	4	4	1	3
WAB224-16-HB	1.75	65	84	110	99	117	2	6	1	3
WAB126-15-H-HB	1.88	87	81	109	77	101	3	1	1	2
IDSA 10 (IRAT 262)	1.94	63	79	107	88	109	2	9	1	2
WAB126-18-HB	1.63	77	81	107	85	113	2	2	1	3
WAB340-B-B-10-HI	1.58	83	82	108	97	101	4	2	1	2
WAB450-24-2-5-P4-HB	0.90	57	77	106	64	100	4	5	1	4
WAB450-24-3-2-P18-HB	1.46	62	82	108	96	113	4	8	1	3
WAB450-I-B-P-133-HB	1.51	83	75	103	68	98	4	8	1	4
WAB450-I-B-P-26-HB	1.01	55	83	109	106	127	2	2	1	5
SALUMPIKIT	1.68	88	79	106	135	110	4	9	1	3
GAMBIAKA	2.27	77	89	116	96	109	1	6	1	3
TOG6545	0.66	90	83	108	108	105	6	9	1	6
IG10	1.72	85	85	110	76	105	5	6	1	5
TOX3100-37-3-3-2-1	1.59	75	84	111	125	112	2	3	1	2
TOX3108-56-4-2-2-2	2.14	87	89	117	78	106	2	6	1	1
IDSA85	1.45	88	82	119	76	113	2	1	1	2
WAB56-50	1.47	72	79	106	61	100	4	3	2	4
WAB99-10	0.94	68	67	90	97	99	6	9	2	4
TOX3377-34-3-3-2	1.57	78	85	112	126	110	3	1	1	2
TGR75	1.65	83	85	110	108	100	4	1	1	4
WAB450-I-B-P-160-HB	1.32	78	78	105	90	115	3	4	1	4
M22	1.27	78	87	112	99		2	1	1	2

Table 33. Seed yield, components and scores for replicated yield trial at Manga, High Input, 1999

Genotype	Yield ($t\ ha^{-1}$)	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Blast Score	Phenotypic Acceptability Score
WAB638-1 (DR2)	0.70	85	106	142	61	105	2	3	3	1
MOROBEREKAN	0.70	92	106	131	42	89	0	3	4	1
WAB340-B-B-9-L3-L1-LB	0.90	77	85	110	54	101	0	4	4	1
WAB224-16-HB	0.95	82	87	113	64	96	0	1	4	2
WAB126-15-H-HB	0.44	75	86	107	62	80	4	1	1	1
IDSA 10 (IRAT 262)	0.53	60	84	113	66	96	0	2	6	2
WAB126-18-HB	0.90	77	87	110	83	100	0	1	3	1
WAB340-B-B-10-HI	0.66	73	87	111	61	100	0	4	1	1
WAB450-24-2-5-P4-HB	0.46	80	73	112	61	70	0	5	4	1
WAB450-24-3-2-P18-HB	0.69	77	78	110	65	93	0	3	4	1
WAB450-I-B-P-133-HB	0.34	73	75	115	63	81	0	2	5	1
WAB450-I-B-P-26-HB	0.76	80	77	110	65	87	0	4	3	1
SALUMPIKIT	1.03	93	86	112	94	116	0	6	7	1
GAMBIAKA	0.51	78	109	134	75	94	0	4	4	1
TOG6545	0.65	95	86	113	154	96	9	9	3	2
IG10	1.29	95	99	123	134	96	5	8	3	2
TOX3100-37-3-3-2-1	0.93	92	91	125	132	77	0	3	9	2
TOX3108-56-4-2-2-2	1.09	90	108	140	117	93	0	1	3	1
IDSA85	0.62	73	90	121	90	101	0	1	4	1
WAB56-50	0.59	73	74	103	72	80	0	2	4	1
WAB99-10	0.47	77	67	105	47	64	5	5	4	1
TOX3377-34-3-3-2	0.76	75	89	110	84	86	0	1	4	1
TGR75	1.40	80	92	121	126	74	0	3	3	1
WAB450-I-B-P-160-HB	0.79	87	74	107	40	79	0	2	4	1
M22	0.67	93	88	110	87	85	0	4	4	3

Table 34. Seed yield, components and scores for replicated yield trial at Manga, Low Input, 1999

Genotype	Yield ($t\ ha^{-1}$)	Germination (%)	Flowering (DAS)	Maturity (DAS)	No. panicles (m^{-2})	Plant height (cm)	Lodging score	Weed score	Blast Score	Phenotypic Acceptability Score
WAB638-1 (DR2)	0.47	92	100	123	42	130	1	5	3	1
MOROBEREKAN	0.55	70	102	117	20	116	0	5	4	2
WAB340-B-B-9-L3-L1-LB	0.56	85	88	110	53	88	2	9	4	4
WAB224-16-HB	0.99	77	84	112	40	105	0	6	3	2
WAB126-15-H-HB	0.45	92	83	110	48	89	2	6	1	2
IDSA 10 (IRAT 262)	0.35	65	84	105	35	82	2	6	3	1
WAB126-18-HB	0.63	90	88	112	56	91	0	7	4	2
WAB340-B-B-10-HI	0.60	88	89	109	58	101	0	6	1	2
WAB450-24-2-5-P4-HB	0.39	85	73	104	43	89	2	8	4	2
WAB450-24-3-2-P18-HB	0.84	88	73	112	54	92	1	8	1	2
WAB450-I-B-P-133-HB	0.30	93	70	105	42	89	1	8	3	4
WAB450-I-B-P-26-HB	0.41	92	88	115	61	84	2	8	4	1
SALUMPIKIT	0.88	88	89	112	61	113	5	5	3	2
GAMBIAKA	0.41	88	83	143	40	86	5	4	4	2
TOG6545	0.91	92	91	116	130	100	9	2	3	2
IG10	0.85	90	99	114	86	102	7	1	3	4
TOX3100-37-3-3-2-1	0.79	88	94	118	78	81	0	2	1	1
TOX3108-56-4-2-2-2	0.68	87	88	140	67	108	2	4	9	2
IDSA85	0.35	93	87	110	52	100	0	9	3	2
WAB56-50	0.74	88	68	102	48	94	0	8	4	2
WAB99-10	0.59	92	69	104	36	94	5	8	3	1
TOX3377-34-3-3-2	0.50	87	83	111	40	87	0	9	6	1
TGR75	0.88	83	94	119	82	80	0		4	2
WAB450-I-B-P-160-HB	0.75	88	96	105	38	95	1	6	3	2
M22	0.76	97	89	109	45	84	0	1	3	2