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Research Application Summary

Characterization and evaluation of rice genotypes under rainfed ecosystems in Malawi and Mozambique

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Abstract

Rice (*Oryza sativa* L.) is an important crop for human consumption world wide, including in under-developed countries in Africa, Asia and Latin America where it is cultivated in small holdings. In Mozambique and Malawi rice is produced by small scale farmers in many parts of the country and by large scale farmers in a few places where there is irrigation schemes. Despite its importance, there is limited information on trait characteristics and performance under different agro-ecological conditions including their potential when grown under rainfed ecosystems. The main objective of this research was to characterize and evaluate 20 rice genotypes under rainfed ecosystems in Mozambique and Malawi. The trials were carried out in a Randomized Complete Block Design (RCBD) during 2010-2011 with three replications and 20 treatments. Data on days to flowering, number of tillers, panicle length, number of grains per panicle, 1000-grain weight, grain size, milling yield percentage, leaf length, aroma, stickiness and grain yield were assessed and analysed. Additive Main effect and Multiplicative Interaction (AMMI) analysis indicated that the yield performances of genotypes were influenced by environmental effects (69.21%), 13.4% genotypic effects and 17.39% from genotypic-environmental interaction (GEI). Mozambique rainfed ecosystem produced the highest mean yield (2.48 t/ha) while the lowest mean yield performance was from Malawi rainfed ecosystem (1.38 t/ha). Nine traits, namely number of tillers, 1000- grain weight, panicle length, number of grains per panicle, grain length, grain shape, leaf length, days to 50% flowering and days to maturity were positively correlated with grain yield in two environments. Significant differences (P<0.001) were found in grain length, although 19 of the 20 genotypes could be considered to possess extra-long grain (>7.5 mm) showing that the farmers in both countries prefer long to extra-long grains. These results can be used by breeders in their crop improvement programs in order to incorporate the desirable traits and also to correct the undesirable traits in terms of farmers preferences.

Key words: AMMI, environment effect, Malawi, Mozambique, *Oryza sativa,* yield performance

Résumé

Le riz (*Oryza sativa*) est une importante culture pour la consommation humaine sur le plan mondial y inclus les pays sous-développés en Afrique, Asie et Amérique latine où il est cultivé à de petites échelles. En Mozambique comme au Malawi, le riz est produit par les petits exploitants agricoles dans plusieurs régions et par de grands exploitants dans seulement quelques endroits où les systèmes d'irrigation ont été mis en place. Malgré son importance, il y a très peu d'information sur les traits caractéristiques et les performances sous différentes conditions agro-écologiques, y compris le potentiel lorsque cultivés dans des écosystèmes pluviaux. L'objectif principal de cette recherche était de caractériser et d'évaluer 20 génotypes de riz dans les écosystèmes pluviaux en Mozambique et au Malawi. Les essais ont été menés suivant un dispositif de bloc aléatoire complet de 2010 à 2011 avec trois répétitions et 20 traitements. Les données sur le nombre jours avant floraison, nombre de talles, longueur de la panicule, nombre de grains par panicule, poids de 100 grains, taille du grain, pourcentage du rendement à l'usinage, longueur de feuille, arôme, viscosité et le rendement en grain, ont été collectés et analysées. L'analyse de l'effet principal additif et multiplicateur de l'interaction a révélé que les rendements des génotypes ont été influencés par les effets environnementaux (69.21%), génotypiques (13.4%) et de l'interaction génotype-environnement (17.39%). Les écosystèmes pluviaux en Mozambique ont donné le rendement le plus élevé (2.48 t/ha) tandis que le plus faible rendement était obtenu au Malawi (1.38 t/ha). Neuf caractères a savoir le nombre jours avant 50% de floraison, nombre de talles, longueur de la panicule, nombre de grains par panicule, poids de 1000 grains, taille du grain, forme du grain, longueur de feuille et nombre de jours avant 50% de maturité ont eu une corrélation positive avec le rendement en grains dans les deux environnements. De différences significatives ($p<0.001$) ont été observées pour la longueur de grain quand bien même, 19 génotypes sur les 20 pouvaient être considérés comme ayant des grains extra-longs (>7,5 mm) indiquant que les agriculteurs de ces deux pays préfèrent des grains longs et extra-longs. Ces résultats peuvent être exploités par les sélectionneurs dans leurs programmes d'amélioration des cultures afin d'incorporer des traits désirables et aussi pour corriger ceux indésirables en termes de préférences des agriculteurs.

Mots clés : AMMI, effet de l'environnement, Malawi, Mozambique, *Oryza sativa*, rendement

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Introduction

Rice in Mozambique is produced by small scale farmers on less than 0.5 ha in many parts of the country, but also by large scale farmers in few places in irrigation schemes (Agrifood Consulting International, 2005; Minag, 2010). In Malawi, this crop is grown solely by smallholder farmers in fields less than 1.0 ha on average (Mzengeza, 2010). In both countries, rice is grown under three ecosystems: the irrigated lowland occupies 15%, while the combined rainfed lowland and rainfed upland ecosystems occupy 85% of the rice area. The varieties grown in these ecosystems are mostly landraces, which on average yield only 1.2 t/ha (Mzengeza, 2010). When choosing which varieties to grow, farmers consider not only the yield but other traits that may add value to their crop (Witcombe and Virk, 1997). According to Tripp *et al.* (1997) landraces are widespread and popular among farmers and are an important part of agriculture because their genetic variability provide several other important traits (Kobayashi *et al*., 2006). This variability complements and broadens the gene pool for advanced genotypes (Berrocal-Ibarra *et al*., 1993; Modi, 2004). Therefore, estimation of genetic diversity between different landraces in any crop of interest is very important in any plant breeding programme (Perrino *et al.,* 1991; Kobayashi *et al*., 2006). For these reasons, the main objective of this research was to characterize and evaluate 20 rice genotypes under rainfed ecosystems in Mozambique and Malawi.

Material and methods

A study was carried out under field conditions in two sites. The first site was at Lifuwu Rice Research Station in Salima-Malawi (altitude is 500 masl, latitude of 13° 40' South and longitude of 34° 35' East). The area receives an annual mean rainfall of 1200 mm and has minimum and maximum temperatures of 19°C and 29°C, respectively. Soil pH of the area is around 7–8. The second site was at Muirrua Rice Research Station located in Zambézia Province, District of Nicoadala - Mozambique lying between latitude of 16° 17' South and 17° 32' South, and longitude 35° 12' and 37° 35' East. The mean temperatures of the district are around 20°C minimum and 26°C maximum, while the annual rainfall is 1,300 mm (PEDD – Nicoadala, 2007). The trial was conducted under rainfed ecosystems during 2010-2011 growing season. Sixteen of the twenty genotypes (*Marista, Nassope, Rafik, Djanibwere, Djissa, Gorongosa, Paula, Niwaio, Nene, M'finico, Chibiça, Chencherica, Chupa, Mocuba, Mucandara redondo, Singano*), were sourced from famer's field in Mozambique, Muirua, whereas four genotypes (*Kilombero, Nunkile, Faya and Mtupatupa*) were obtained from Malawi, Lifuwu. The experimental layout was a RCBD with three replications and 20 treatments (genotypes). Sowing was done by dibbling in 2 m x 5 m per plot, consisting of seven rows with 30 cm left between the rows. Two seeds of each genotype were planted per hole, and after germinations, plants were thinned to one at the three leave stage to facilitate the determination of the number of tillers per plant. Plants were kept as under farmers' conditions (without irrigation) and weed control was done by hand weeding. Data collection on grain yield components and growth parameters were assessed using the Standard Evaluation System for Rice (IRRI, 2002). Data were analysed using General statistics using GenStat 14th Edition software.

Results and discussions

Additive Main effect and Multiplicative Interaction (AMMI) analysis showed significant differences ($P<0.001$) among genotypes, environments as well as interactions between environments and genotypes. Environmental effects contributed to 69.21% of the total sum of squares, while genotypic effects and genotypic environmental interaction (GEI) effects contributed to 13.4% and 17.4%, respectively. A large sum of squares for environments indicated that environments were diverse, with large differences and distinctness of intrinsic factors among environmental means causing most of the variation in grain yield (Blum, 1988). The first principal component axis (PCA 1) of the interaction captured 49.07% of the interaction sum of squares in 36.84% of the interaction degrees of freedom. Similarly, the second principal component axis (PCA 2) explained a further 31.47% of the GEI sum of squares. The mean squares for the PCA 1 and PCA 2 were significant (P <0.001) and cumulatively contributed to 80.44% of the total GEI. Similar results were obtained by Bansal *et al*. (2000).

The best genotype performance was registered in Mozambique site (2.483 t/ha), while the best Malawi site registered 1.38 t/ha. The poorest yielding genotype was recorded for Rafik (0.18 t/ha) in Malawi, where all the 20 genotypes performed below the overall across sites mean (2.80 t/ha) (Fig. 1). The analysis of variance for each character revealed that the genotypes in the present study differed amongst themselves (P<0.001). According to Kobayashi *et al*. (2006) this indicates genetic variation among the genotypes for yield. The effect of yield components and growth parameters showed significant differences in the interaction between sites and genotypes (SxG), environments and genotypes (GxE), environments (E), genotypes (G) (P<0.001) and blocks (B) (P<0.05), thus showing high genetic variability among the twenty genotypes, and the interaction with the environments and sites.

Relationships between yield and yield components and growth parameters. Correlation analysis of yield, yield components and growth parameters was done in both ecosystems (Malawi and Mozambique rainfed). Under Malawi rainfed ecosystem, the performance of genotypes was below average. Water deficit and high temperature probably caused stress to the crop in this study. Panicle length (-0.5), grains per panicle (-0.31), grain shape (-0.40), days to 50% flowering (-0.7), days to maturity (-0.6) and leaf length (-0.5) showed significant negative correlation with yield. Bansal *et al*. (2000) reported that yield per plant was negatively correlated with the number of productive tillers, and 1000-grain weight, under rainfed conditions. On the other hand, Feil (1992) found opposite results under an irrigated ecosystem. Under Mozambique rainfed ecosystem, the number of tillers per hill (0.42), grains per panicle (0.48), weight of 1000 grains (0.44) and grain shape (0.28) had positive and significant correlations with yield. Rice grain yield has been reported to be

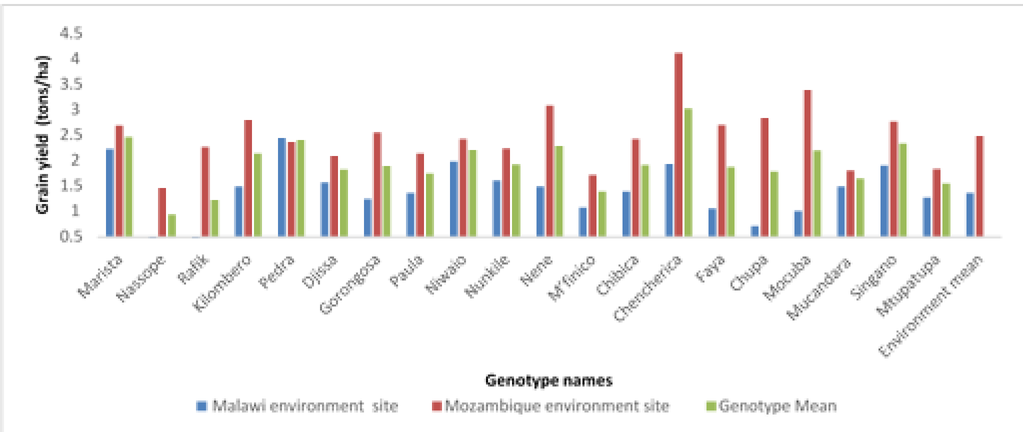

Figure 1. Grain yield (t/ha) of twenty rice genotypes grown in two environments (Malawi and Mozambique)

positively correlated with plant height, panicle length and panicle weight (Reddy *et al*., 1997; Samonte *et al*., 1998), number of grains per panicle and 1000-grain weight (Geetha *et al.,* 1994; Samonte *et al*. 1998).

Grain and milling quality characteristics of the twenty rice genotypes. The analysis of variance, revealed significant differences between genotypes (p<0.001), indicating that the genotypes were highly diversified. However, there were no significant differences in grain length between environments (P = 0.479) and between genotype and environment interaction was also not significant (0.991). Gupta *et al*. (2006) reported that the ability to increase grain yield depends on several yield components including grain size and grain number per plant or per unit area. Most of the varieties had significant differences in grain size, although they could be considered to possess extra-long grain (>7.5 mm), indicating that the genotypes preferred by farmers in both Mozambique and Malawi have similar grain length characteristics. The grain length for genotype *Mfinico* was 7.606 mm in Malawi rainfed and 6.918 mm in Mozambique rainfed. The genotypes *Chencherica* (10.85 mm), *Nene* (10.80 mm), *Singano* (10.87 mm), *Kilombero* (10.19 mm), *Mocuba* (10.4 mm) and *Faya* (10.03 mm), had the highest genotypic mean. The genotypes *Faya* showed highest (60%) milling yield, while *Marista* had the lowest (20.2%). The genotypes *Niwaio* (55%), *Chincherica* (50%), *Marista* (56%) and *Gorongosa* (48%) are those which shattered much. Juliano (1993) reported that the hull (husk), constitutes about 20% of the unhulled rice weight although values ranged from 16 to 28 %.

Conclusions

The results obtained in this study indicated adequate genetic variability in the material studied. The rainfed ecosystems reduced grain yield, although the genotypes *Chincherica, Mocuba, Nene Chupa* and *Kilombero* performed well in Mozambique rainfed conditions (above 2.5 t/ha) while *Petra*, *Marista*, *Chencherica*, *Nunkile* and *Djissa*, were superior in Malawi (above 1.5 t/ha). The sites (Mozambique and Malawi) and the ecosystems (Mozambique rainfed and Malawi rainfed) played an important role in phenotypic expression of grain yield, yield components and growth parameters. The correlation analysis revealed that the number of tillers per plant, panicle length, number of filled grains per panicle, weight of 1000 grains, grain length and days to maturity were the most important yield components. In terms of grain quality characteristics the genotypes *Marista*, *Niwaio*, M'finico, *Mucandara redondo* had medium grain shape (2.1 – 3 mm), while all other genotypes were slender (>3 mm). The genotypes *Faya* (60%), showed the highest milling yield percentage in comparison to *Marista* (20.2%), which showed the lowest milling yield percentage of whole grain.

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