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RESEARCH ARTICLE

Evaluation of stability and yield potential of upland rice genotypes in North and Northeast Thailand

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Abstract

The planting of upland rice is one cropping option in area with limited water availability and low soil fertility in North and Northeast Thailand. The varietal selection was determined by grain yield potential, wide adaptation, and good stability. This study was aimed at evaluation of indigenous upland rice germplasm for yield and yield stability in multi-locations. Thirty-six upland rice genotypes collected from six provinces of the North and Northeast Thailand and one check variety (Sewmaejan) were assessed under five locations in the rainy seasons of 2009 and 2010. The experiment was laid out in a randomized complete block design with three replications. The genotype grain yield was highly affected by location (59.90%), followed by genotypes (G)×location (L) interaction (12.80%) and genotype (6.79%). The most suitable location for the genotype evaluation was L3 (Khon Kaen-KKU10) which associated with stability of grain yield for all genotypes. Furthermore, biplot and regression analysis indicated that genotype numbers 6 (Jaowmong 1), 10 (Neawmong 1), 18 (Neawdum 1), 19 (Leamna), 20 (Prayaleamkang), 32 (Kunwang 2), and 33 (Kunwang 3) showed great yield stability over five locations. The genotypes will be applicant for upland rice production area and parental base in breeding program.

Keywords: upland rice, yield stability, germplasm, multi-location trails, G×L interaction

1. Introduction

Upland rice is one of the most popular cropping options in slope area under rainfed condition, and accounts for about 11% of global rice production (Tuhina-Khatun *et al*. 2015), of which about 13 million ha were grown in Asia (Acuña *et al*. 2008). In Thailand, upland rice accounted for 11% of the total rice planted area (IRRI 1998), most of which located in North and Northeast Thailand (Bell and Seng 2004). Upland rice in Thailand is normally grown along upland, hilly, slope, and mountainous area which diverse in topography and environment leading to a large diverse in varieties. There is a need for the evaluation of yield potential and yield stability through multi-location testing as the basis for future upland rice production in North and Northeast Thailand, where there are considerable diversity of both genotypes and production environments.

The high water use efficiency is one of the most important attributes of upland rice (Price *et al*. 2002), and the main criteria for its selection in upland areas with low rainfall. Furthermore, upland rice is useful as a donor for breeding improved root systems and improved adaptation to water

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stress growing environments (Bernier *et al*. 2008), improved resistance to disease and insect pests (Fukuoka and Okuno 2001), and for intercropping of sugarcane to improve soil fertility and increase income (Vityakon *et al*. 2000). A large range of upland rice varieties have been used in breeding programs to improve crop adaptation. However, the screening methods for a large number of large genotypes under wide range of environments can be a potential constraint due to the high variation in genotypes, the variability of environments, and genotypes (G)×location (L) interaction (Wade *et al*. 1999; Xing *et al*. 2002; Acuña *et al*. 2008).

Evaluation of grain yield under multi-environments is one of numerous approaches to verify the stability of genotypes (Acuña *et al*. 2008). However, the interaction of genotypes and environment always contributes to the stability of rice varieties (Bose *et al*. 2012). The use of the regression coefficient to explain the response of genotypes is another approach for evaluating the stability (Eberhart and Russell 1966). Currently, the principal component method/analysis is a powerful tool for the evaluation of G×L interaction with a high degree of accuracy, while also allowing easy interpretation from single graphs (Yan *et al*. 2000, 2007; Gauch *et al*. 2008; Balestre *et al*. 2010). Moreover, the bi-plot approach is also helpful in breeding programs for the selection of a suitable environment for crop evaluation, genotypic selection for a specific location and/or stability of crop genotypes such as mung bean (Alam *et al*. 2014), maize (Fan *et al*. 2007), durum wheat (Mohammadi *et al*. 2009), and rice (Samonte *et al*. 2005). Therefore, high yielding upland rice varieties with good stability need to be identified on the basis of being area specific. Available tools do allow the identification of appropriate upland rice varieties for growing conditions where there are high G×L interaction. The objective of this study is the evaluation of the stability and yield potential of upland rice genotypes in multi-location growing environments.

These results enable us to identify suitable varieties of diverse upland rice (both glutinous and non-glutinous) with high yield performance and stability for promotion and extension to farmer in numerous upland are in North and Northeastern Thailand.

2. Materials and methods

2.1. Rice genotypes and experimental design

Thirty-six upland rice genotypes were collected from six provinces in North and Northeast Thailand (Phetchabun, Loei, Phitsanulok, Chiang Mai, Khon Kaen, and Mukdahan) provided by the Rice Germplasm Project of Khon Kaen University, Thailand (Table 1). The variety Sewmaejun was used as a standard check variety from Rice Research Department, Thailand, which high cooking quality and upland recommended. Thus, 37 genotypes were evaluated. The comparative study of the varieties was conducted in five locations in North and Northeast Thailand during the 2009 and 2010 wet-seasons, the locations being: Ban Had 2009 (BH09, L1), Ban Had 2010 (BH10, L2), Khon Kaen University Field 2010 (KKU10, L3), and Chum Phae Rice Research Center 2010 (CPA10, L4) were located in northeastern part of Thailand and Mae Hong Son Rice Research Center 2010 (MHS10, L5) was located in northeastern part of Thailand (Table 2 and Appendix A). The experiments were laid in a randomized complete block design with three replications.

Planting date was determined by the rainfall distribution at each site, and usually took place in the period between early June and early July, with harvesting taking place between late October and early November (Table 2). The plots were direct seeded using 3–5 seeds per hill, with subsequent thinning to 1 seedling per hill at 10–15 days after the seedlings had emerged. The plot size was 1.8 m×4.0 m (96 plants per plot) with a row and hill spacing of 30 and 25 cm, respectively. Fertilizer was applied at a rate of 14.6 kg ha^{-1}:14.6 kg ha^{-1}:14.6 kg ha^{-1} (N:P_2O_5:K_2O) at 30 days after seedling emergence, at the same time as weeding, with a top-dressing of 57.5 kg N ha^{-1} at 60 days after seedling emergence. The moisture condition was dependent on the rainfall at each location. Fungicide was applied at location MHS10 at 60 days after-sowing due to an outbreak of leaf blast disease.

2.2. Data collection

Tiller and panicle number per hill and plant height were collected from four hills selected at random in the middle row of each plot. Days to flowering (DTF) were based on counts of flowering plants in each plot every 3 days to determine the time of 50% flowering. Number of seeds per panicle was based on seed counts of four panicles per plot, the panicles being randomly selected. Grain yield was based on the grain harvested from the middle row of each plot (56 plants per plot); the harvested seed was then air-dried to about 14% moisture content and weighed to provide the basis of yield in terms of kg ha^{-1}. 1000-seed weight was measured.

2.3. Data analysis

The analysis of all parameters was based on a randomized complete block design with three replications in all sites. Stability analysis on a mean genotype was used to determine the genotypic consistency between sites (envi-