Crop Protection 80 (2016) 65–72

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Occurrence of rice blast (*Magnaporthe oryzae*) and identification of potential resistance sources in Uganda

Geoffrey Onaga*, Godfrey Asea

National Crops Resources Research Institute, P.O Box 7084, Kampala, Uganda

ARTICLE INFO

Article history:
Received 28 November 2014
Received in revised form
19 October 2015
Accepted 27 October 2015
Available online 14 November 2015

Keywords:
Rice
Magnaporthe oryzae
Epiphytotics
Resistance genes

ABSTRACT

Rice blast caused by *Magnaporthe oryzae* continues to be the most destructive disease of rice worldwide, and is a number one disease of rice in Uganda. We present the footprints of *M. oryzae* importance, distribution, incidence and severity in the rice growing agro-ecologies of Uganda for 2009/2010, and the potential mitigation measures. Our data show that rice blast affects more than 50% of the cultivated rice area on average, and ranks as the most important disease encountered in the field. Between and within agroecologies, both incidence and severity varied ($P < 0.05$) reflecting the contribution of different cropping practices on rice blast epiphytotics. The highest blast incidence and severities were recorded in Bugiri, Butaleja, Mbale and Lira farmlands, which are the ancestral rice cultivation areas in Uganda. These areas showed mean yield reductions of >30% relative to other locations, suggesting that rice production history played a significant role in rice blast outbreaks. Broadcasting and drill seeding yielded 42.4% less than transplanted rice. Growing two rice crops per year is one of the methods suggested to increase rice production in Uganda, but there was a higher disease incidence in the late season than in the early season, indicating the need for improved resistant varieties. Four blast resistance genes (*Pi9*, *Piz-t*, *Pi19* and *Piz-5*) and the cultivar Tetep had the lowest (≤4) blast severity scores in all the test locations. It could be suggested that these genes are potential resistance sources for developing varieties, which would be more relevant for the double cropping systems.

1. Introduction

Unlike large scale traditional rice producing countries in Asia and West Africa, intensive rice production started only recently in Uganda. Despite this, rice cultivation has been increasing steadily in the past 20 years, and production had more than doubled in 2010 (FAOSTAT, 2014). However, this trend has stagnated, and in some areas reversing, mainly on account of the continued considerable yield losses due to increasing challenges related to abiotic and biotic stresses.

Among the biotic stresses, rice blast is the most devastating in both lowland and upland cropping systems in Uganda (Kamwezi et al., 1997). The disease is seed borne, and was reported to affect 20–51% of seeds (Biruma et al., 2003). In favorable conditions, *Magnaporthe oryzae* can devastate the whole rice crop within fifteen to twenty days often causing yield losses of up to 100% (Musiime et al., 2005). Besides, losses may be in the form of lowered grain quality and diminished storability.

Since its first identification in 1921 (Small, 1922), limited surveys on the prevalence of *M. oryzae* have been conducted in Uganda, and no sources of resistance have been identified. In the present scenario, yield losses due to rice blast could be increasing due to changes in seasonal climatic and cropping patterns (Hepworth and Goulden, 2008) in the various agroecologies of Uganda, which could be adding to the concerns of possible devastating epidemics in the future. Hence it is important to determine the spatial distribution, including incidence, severity and seasonal fluctuations in disease occurrence for planning and developing effective control measures, such as breeding strategies specific to each situation.

Well managed cultural practices, fungicides and genetic resistance are considered to be potential remedies for rice blast, especially when applied in integration (Wang et al., 2013). However, host resistance is considered to be the most important, economically viable management strategy (RoyChowdhury et al., 2012a). Host resistance to blast commonly follows a gene-for-gene model where a single dominant R gene is effective in preventing *M. oryzae* strains that contain the corresponding avirulence (avr) gene (Silué

* Corresponding author.
E-mail addresses: geoffyonaga@gmail.com, gonaga@gwdg.de (G. Onaga).

http://dx.doi.org/10.1016/j.cropro.2015.10.028

et al., 1992).

During the past 25 years, conventional genetic analysis of resistance donors and use of advanced molecular analysis techniques have led to identification and mapping of more than 85 major blast resistance (R) genes (Ballini et al., 2008; Valent and Khang, 2010); 18 of these genes have been cloned and used for crop protection (RoyChowdhury et al., 2012b; Wang et al., 2013). Further, near-isogenic lines with known single genes for resistance have been developed in the genetic backgrounds of the *Oryza indica* variety CO39, *Oryza japonica* variety Lijiangxintuanheigu (LTH) and a universal susceptible line US2 (Kobayashi et al., 2007). These isogenic lines are useful for identification of the blast races, monitoring the shift in blast races and determining plant-specific resistance in rice breeding (Tsunematsu et al., 2000; Koide et al., 2011). Some of these R genes have been found to confer broad-spectrum resistance against *M. oryzae* strains tested (Liu et al., 2002; Jiang et al., 2012).

In this regard, we conducted a field survey, yield loss assessment and field evaluation of 33 rice blast differential lines in 2009/10 rice cropping seasons to address the importance, distribution, incidence, severity and the influence of cropping practices on rice blast in Uganda. Our data provide the first field report on the effect of rice blast on rice production in Uganda and indicate the potential resistance sources for developing varieties which would be adapted to the double cropping system.

2. Materials and methods

2.1. Field surveys on rice blast importance, distribution, incidence and severity

The study was conducted in 2009/10 first (early) and second (late) rice cropping seasons in the rice growing agro ecological zones of Uganda, delineated and characterized by Wortmann and Eledu (1999). The second season is the period of longer rains while the first season is when most parts of the country receive short rains. The areas were selected based on rice production, agro-ecological classification and accessibility. These include the Northern moist Farmlands which encompasses the districts of Lira, Soroti, Dokolo and Apac. North-western Farmlands-Wooded Savannah comprises the districts of Gulu and Amoro. The districts of Kumi and Pallisa are found in the Southern and Eastern Lake Kyoga Basin. Iganga, Mbale, Butaleja and Bugiri districts represent the Lake Victoria Crescent and Mbale Farmlands. Hoima, Kibaale and Masindi district are found in the Western Mid-altitude farmlands and Semiliki flats. Luweero, Nakaseke and Mukono are located in the Central Wooded Savannah. Western Medium-High Farmlands comprise the district of Kamwenge.

In each agro ecological zone, rice production areas were identified by the extension staff. Accessible rice production fields in a radius of 30.0 km around each district center were investigated. At least two major rice growing districts were purposefully selected in each agro-ecology, except for the Western Medium-High Farmlands, which was represented by one district. Within each district, 5–10 large scale rice farms were visited. Interviewers were agents of the National Agricultural Research System (NARS). Interviewers had to fill in a three level questionnaire, including: i) Questions related to rice production constraints, ecology and land use; ii) at the plot level, information related to area and cropping practices (variety, preliminary cultivation, fertilizer type and dosage); iii) the extent of rice disease incidence and severity. The interviewers used guiding pictures of symptoms for each of the constraints that were not obvious to farmers, including nutrient deficiencies and toxicities, salinity, acidity, heat stress, pests and diseases, among others. To increase the degree of precision, interviews were conducted at the rice production fields, where most constraints were directly observed and compared with farmers responses prior to scoring. For specific constraints (Fig. 2), the frequencies of each score (High, medium, low) were calculated, followed by computing a weighted relative importance score. The score weights were allocated as follows: 3 for high, 2 for medium and 1 for low, and the relative importance scores for specific constraints were computed by summing the weighted scores (frequency of score*specific weight).

Disease incidence was recorded in each field as % infected plants, and the average incidence from the sampled fields in each of seven agro-ecologies was noted. More extensive disease surveys were conducted on farmers' fields in five representative large scale rice producing districts of Lira, Bugiri, Masindi, Kamwenge and Pallisa to determine the disease severity. Rice diseases were identified not only visually but were also confirmed through microscopic observations for rice blast, sheath blight and brown spot; ELISA and isolation and re-inoculation tests for rice yellow mottle virus (RYMV); and PCR detection for bacterial blight and bacterial leaf streak. Rice blast severity was defined on 0–5 scale, according to the disease severity at the plot level (Mackill and Bonman, 1992), and average scores were converted to a percentage scale ranging from 0 to 100 (0–4.9%; 5–24.9%; 25–49.9%; 50–74.9%; 75–100%). A score of 0 indicated no disease and normal growth, while 5 indicated high severity. The most frequent disease score was considered as the single severity level for a given location. Data on field disease severity, incidence, the effect of cropping practice, percentage of land area under rice production and season, were subjected to analysis of variance (ANOVA) using CropStat, Version: 7.0.2007.3. Field severity data were also subjected to nested analysis of variance, based on 3 hierarchical levels [agro-ecology, district and field (farm)], using MINITAB release 15 version 15.0.0.1, 2007 (Minitab Inc, Pennsylvania, USA). The blast severity levels in the sampled districts were used to generate a disease severity map using the GIS software Arc GIS 10.0 (Environmental Systems Research Institute, Inc. Seattle, WA, and U.S.A).

2.2. Rice blast impact on overall grain yield, and grain yield as a function of cropping practice

Yield estimates were conducted in farmers' fields in the aforementioned five representative large scale rice producing districts. We used local farmer preferred rice varieties for each location along with three planting methods, transplanting, drill planting and broadcasing. Because broadcasting is the dominant planting method in most traditional rice growing areas, rice grain yield was

Fig. 1. Randomized complete block field layout of the screening plots of rice differential lines for resistance against *M. oryzae*.