Finger Millet Blast Pathogen Diversity and Management in East Africa: A Summary of Project Activities and Outputs

JP Takan[1,2], B Akello[1], P Esele[1], EO Manyasa[3], AB Obilana[3,4], PO Audi[3], J Kibuka[3], M Odendo[5], CA Oduori[5], S Ajanga[5], R Bandyopadhyay[6], S Muthumeenakshi[7], R Coll[8], AE Brown[8], NJ Talbot[9] and **S Sreenivasaprasad[7,*]** (1. Serere Agricultural and Animal Production Research Institute, NARO, PO Soroti, Soroti District, Uganda; 2. Present address: Warwick HRI, University of Warwick, Wellesbourne, Warwickshire CV35 9EF, UK; 3. ICRISAT, PO Box 39063, Nairobi, Kenya; 4. Present address: PO Box 52205, Ikoyi, Falomo, Lagos, Nigeria; 5. Kenya Agricultural Research Institute, PO Box 169, Kakamega, Kenya; 6. International Institute for Tropical Agriculture, PMB 5320, Oyo Road, Ibadan, Nigeria; 7. Warwick HRI, University of Warwick, Wellesbourne, Warwickshire CV35 9EF, UK; 8. Department of Applied Plant Science, The Queen's University of Belfast, Newforge Lane, Belfast, BT9 5PX, Northern Ireland, UK; 9. School of Biological Sciences, University of Exeter, Washington Singer Laboratories, Perry Road, Exeter EX4 4QG, UK)

*Corresponding author: s.prasad@warwick.ac.uk

Background and Objectives

In the semi-arid tropics of East Africa, finger millet (*Eleusine coracana*) is a staple food for millions of people. This cereal plays an important role in the diets and economy of subsistence farmers and is especially important for pregnant women, nursing mothers and children (National Research Council 1996). Blast caused by *Magnaporthe grisea* (anamorph *Pyricularia grisea*) is a major constraint to finger millet production in the region. Blast affects finger millet at all stages of growth and most of the landraces and a number of other genotypes are highly susceptible. The major objectives of the project R8030 [UK Department for International Development (DFID) – Crop Protection Programme] were to: (1) characterize the pathogen populations; (2) use this information as a basis for epidemiological studies; (3) gain an understanding of the cropping practices and the farmers' perception of the disease problems and management through socioeconomic and disease surveys; and (4) identify sources of resistance.

Genetic Diversity of Pathogen Populations

A baseline collection of nearly 300 *M. grisea* isolates was established at Warwick HRI, UK for molecular and pathogenicity characterization utilizing more than 450 finger millet and weed blast samples collected from Uganda and Kenya. The PCR (polymerase chain reaction)-based analyses were carried out to generate SSR (simple sequence repeat) and AFLP (amplified fragment length polymorphism) profiles. AFLPs revealed a higher degree of diversity and up to eight pathogen genotypes (genetic groups) were observed. Some pathogen genotypes were common to both Uganda and Kenya while others were restricted to one country (Fig. 1).

A repetitive DNA element *grasshopper* (*grh*) has been observed only in populations of *M. grisea* from finger millet in Japan, Nepal and India as well as some West African countries (Dobinson et al. 1993). Following a PCR screen of finger millet and weed *M. grisea* collections from East Africa, 13 isolates containing the *grh* element were identified. Finger millet originated in the area that now is Uganda, and the results suggest that the indigenous blast populations did not contain this element and the *M. grisea* isolates with *grh* were recent introductions.

Isolates causing leaf, neck and panicle blast on finger millet compared by AFLP analysis were genetically similar indicating that the same strains were capable of causing different expressions of blast under suitable conditions. This suggests that host resistance in general should be effective against all expressions of blast.

Reproduction of *M. grisea* is predominantly asexual. However, high fertility of isolates from finger millet in laboratory crosses has previously been observed (Yaegashi and Nishihara 1976). Based on the *M. grisea* mating type gene sequences, a near equal distribution of MAT1-1 (47%) and MAT1-2 (53%) alleles among blast populations in Uganda and Kenya was observed. Cross-compatability assays have shown the high fertility status of these isolates with the formation of perithecia bearing asci with ascospores.

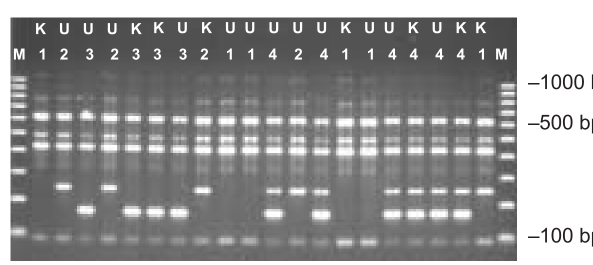

Figure 1. AFLP profiles of a set of *Magnaporthe grisea* isolates from finger millet from Uganda and Kenya. (Note: These isolates are represented by four genotypes present in both countries; U = Uganda; K = Kenya; 1–4 = Pathogen genotypes; M = Molecular marker.)

Pathogen Aggressiveness and Epidemiology

Pathogenicity tests were performed with a representative set of characterized isolates by spray inoculation (30 ml conidial suspension at 10^5 conidia ml^{-1} amended with 0.1% gelatin) of 6-week-old finger millet seedlings (SEREMI 1, SEREMI 2, SEREMI 3, PESE 1, Gulu E, INDAF 5, OK/3, P665, HPB-83-4 and E11). The experiment was carried out in three replications. Plants were incubated at 25–27°C and 7–8 days after inoculation the number of lesions per leaf and the percentage of infected area were scored.

In general, variation in pathogenicity was recorded among the *M. grisea* isolates analyzed both on a particular variety as well as in infecting different varieties. For example, in a set of 35 blast isolates, most isolates showed the highest disease score on E11, but four of the isolates gave the highest disease score on PESE 1. None of the isolates tested so far, however, showed clearly different compatibility and incompatibility reactions.

Pathogenicity tests were also carried out on seed heads of mature finger millet plants of varieties E11, SEREMI 1, SEREMI 2, SEREMI 3, PESE1 and P665 using a set of eight *M. grisea* isolates. The apparent susceptibility of the finger millet varieties to seed head infection, with the exception of E11, appeared to differ from that in the seedling assays. For example, SEREMI 1, which was relatively resistant in the seedling experiments, appeared more susceptible with regard to seed head infection especially when inoculated with isolates from neck and seeds and P665 was the least infected (Fig. 2).

Magnaporthe grisea isolates from weed hosts compared with isolates from finger millet were in general not genetically distinct and in most cases belonged to the same genetic groups as isolates from finger millet, underlining the potential of weeds to serve as inoculum sources. Pathogenicity tests revealed that the isolates from weeds were pathogenic to finger millet, with some weed isolates being as aggressive as some of the finger millet isolates. Field experiments carried out in Uganda suggest that seedborne inoculum contributes to initial blast development, as higher disease incidence was observed with seeds containing higher proportion of inoculum.

Disease and Socioeconomic Surveys

Disease surveys in Kenya identified blast as the most important and widespread disease in Busia, Teso and Kisii districts. Grain yield losses attributed to blast were estimated to be between 10 and 50%. In Uganda, blast incidence (13 to 50%) and severity (24 to 68%) varied considerably across main finger millet cultivated areas in the north and east. In both countries, the disease incidence and severity were higher during the first season (February–July) than in second season (August–December). Varieties

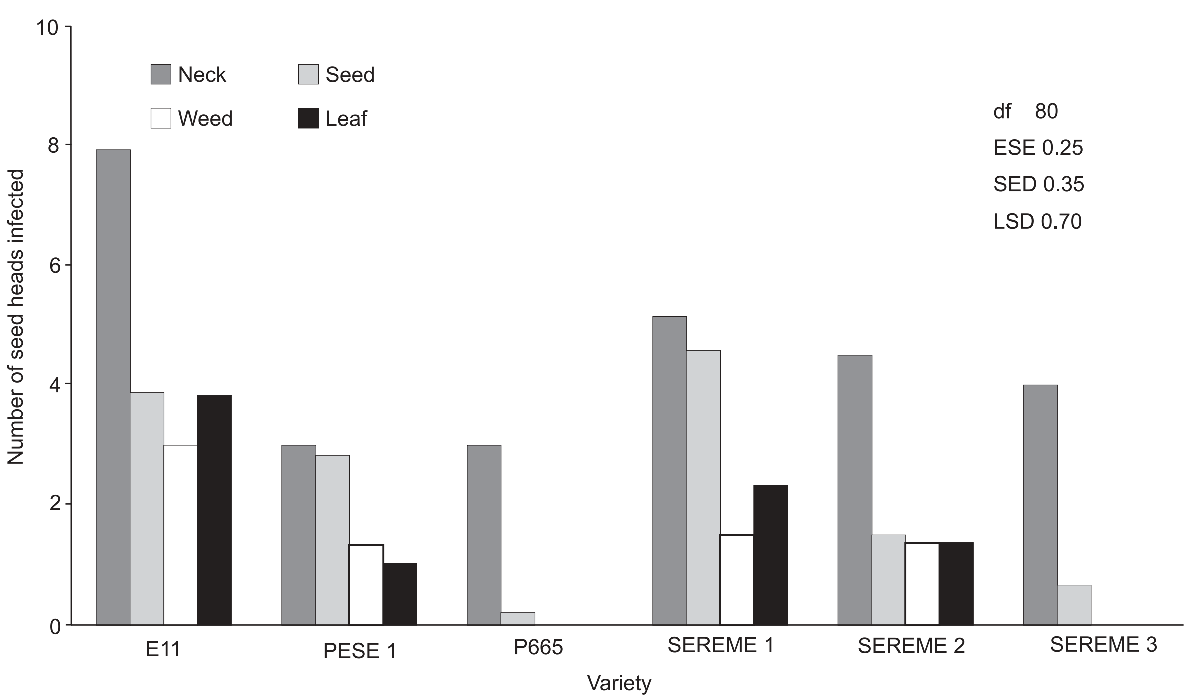

Figure 2. Variation among six different finger millet varieties in blast infection by four different *Magnaporthe grisea* isolates from finger millet neck, seed and leaf, and a weed based on the number of seed heads infected per 10 inoculated heads.

producing dark colored seeds and compact heads were more blast resistant compared to white-seeded and open-headed varieties. Blast was commonly observed on weeds such as *Eleusine indica* (most common), *Digitaria* spp, *Dactyloctenium* sp and *Cyperus* sp occurring in finger millet fields.

A participatory rural appraisal (PRA) conducted in western Kenya revealed that finger millet production was most commercialized in Kisii and least in Teso. *Enaikuru* in Kisi, *Emumware* in Teso and *Ikhulule* in Busia were the most popular local varieties. The improved varieties Gulu E and P224, liked for their early maturity, were common in Busia although farmers rated them as moderately susceptible to blast. Farmers in Kisii rated *Marege* and *Enyakundi* as having some level of resistance to blast. In Busia, farmers have adopted row planting to reduce labor intensive weeding.

In Uganda, five to eight varieties were grown depending on the location in the first season (February–July) whilst fewer varieties were grown in the second season (August–December) and some of the previously common varieties are no longer grown due to poor attributes. The majority of farmers saved their own seed and very few farmers purchased seed from stockists. Millet is commonly grown in mixed cropping, and the order of rotation varied, but some farmers, especially in Teso, were aware that millet should not follow sorghum (*Sorghum bicolor*) because of *Striga*.

Most farmers were aware of blast symptoms (in Uganda described as *Ebwetelele*, *Obapu* and *Kalajajwa* – generally meaning 'dry heads' and known as *egetabo* in Kisii, Kenya) but were not aware of the cause, modes of transmission and control measures. Both Kenyan and Ugandan farmers in general reported a lack of crop pest and disease management information. This needs to be addressed urgently and it is also important to develop blast resistant varieties with farmer preferred qualities in order to overcome production constraints. Based on PRA carried out in Kenya and Uganda, the characteristics of finger millet (and ranking) preferred by farmers are: early maturing (1); drought tolerance (2); uniformity in height (3); high tillering (4); large heads, non-shattering and high yielding (5); widely adaptable (6); easy to dry, clean and market (7); resistance to diseases especially blast, lodging and pests (8); white seeded (9); good palatability (10); good brewing qualities (11); and good storability and viability (12).

Varietal Screening for Blast Resistance

A wide range of varieties including 65 farmer varieties and 30 germplasm accessions from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Nairobi, Kenya were screened for their reaction to blast under natural infection in repeated trials during the February–July and August–December seasons in 2002 at Alupe, Teso district. The trials were planted in three replications, in two-row plots, each row 3 m long. Susceptible variety KNE 479 was used as infector rows while KNE 620 and KNE 1034 were used as resistant checks and KNE 479 and KAT/FM1 as susceptible checks. Leaf, neck and finger blasts were scored separately using a scale of 1 (no disease) to 9 (more than 75% disease). Early-maturing varieties had higher finger blast incidence and severity and there was a significant negative correlation between finger blast severity and grain yield during the long rainy season. Among the ICRISAT germplasm lines, KNE 620, KNE 629, KNE 688, KNE 814 and KNE 1149 and farmer variety accessions 14, 29, 32 and 44 were identified with low blast levels and good agronomic performance. The identified varieties/lines can be utilized in breeding programs whilst some could be promoted for commercial production.

Conclusions and Perspectives

A baseline collection of characterized pathogen isolates showed limited diversity for AFLPs. Some of the pathogen genotypes were common to Uganda and Kenya whilst others were restricted to one country. Considerable variation in pathogen aggressiveness but no differential reaction to host varieties was observed. Isolates from weeds were capable of infecting finger millet and seedborne pathogen appears to contribute to initial disease development. Varieties with resistance to blast have been identified and a database on East African finger millet cropping systems and prevalence of blast, constraints to production and farmers' perception of blast and its management has been generated. Current finger millet production practices demand extreme hard work; consequently new production technologies need to be identified and developed. The knowledge and resources generated from this project lay the basis for improved disease intervention and efficient utilization of host resistance.

Acknowledgments. This publication is an output from a research project funded by the DFID for the benefit of developing countries. The views expressed are not necessarily those of DFID. Project R8030 was funded by the DFID-Crop Protection Programme and managed by the Natural Resources International, UK. The authors thank FM Kimmins, A Ward and JM Lenné for their help and support.

References

Dobinson KF, Harris RE and **Hamer JE.** 1993. Grasshopper, a long terminal repeat (LTR) retroelement in the phytopathogenic fungus *Magnaporthe grisea*. Molecular Plant Microbe Interactions 6:114–126.

National Research Council. 1996. Finger millet. Pages 39–58 *in* Lost crops in Africa. Vol. I, Grains. USA: Board on Science and Technology for International Development, National Research Council.

Yaegashi H and **Nishihara N.** 1976. Production of the perfect stage in *Pyricularia* from cereals and grasses. Annals of the Phytopathological Society of Japan 42:511–515.

Entomology

Methods for Rearing *Heliocheilus albipunctella* in the Laboratory and Eliminating the Pupal Diapause

SV Green[1], **O Youm**[2,3,*], **DR Hall**[1], **Y Maliki**[2] and **DI Farman**[1] (1. Natural Resources Institute (NRI), University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK; 2. ICRISAT, BP 12404, Niamey, Niger; 3. Present address: The Africa Rice Center-WARDA, BP 320, Bamako, Mali)

*Corresponding author: o.youm@cgiar.org

Introduction

The millet head miner *Heliocheilus albipunctella* is one of the most damaging pests of pearl millet in the Sahel. During the past 15 years, considerable progress in the development of pest control measures has been achieved through increased knowledge of the ecology of this heliothine moth (Nwanze and Youm 1995, Kadi Kadi et al. 1998, Youm and Owusu 1998a, 1998b). Future research to improve control of the millet head miner could be enhanced through the development of reliable artificial rearing techniques. Moreover, the improved rearing techniques could be used for the assessment of biological control agents and for supporting millet breeding programs to advance head miner integrated pest management (IPM).

Breeding populations of *H. albipunctella* were established at the Natural Resources Institute (NRI), University of Greenwich, UK from eggs collected from Niger at the end of the 1996, 1997 and 1998 field seasons. Previous authors have reported difficulty in rearing *H. albipunctella* (Gahukar et al. 1986), and the process has remained problematic. However, from 1996 to 1998 we effectively increased the number of generations reared in each successive year, and the 1998 population was sustained until the end of the project, which was terminated after 15 months.

Methods and Results

Heliocheilus albipunctella cultures were maintained under environmentally controlled conditions. Relative humidity was kept at a constant 60%. A photoperiod of 14 h light and 10 h dark, with photophase light intensity changes, was used, and temperatures were maintained at 31°C and 27°C, respectively. Under this temperature regime few pupae entered diapause. The information