CROP PROTECTION PROGRAMME

Finger millet blast in East Africa: Pathogen diversity and disease management strategies

R8030 (ZA0482)

FINAL TECHNICAL REPORT

1 April 2001 – 30 November 2004

Project Leader
Dr. S. Sreenivasaprasad

Warwick HRI
30.12.2004

Project Collaborators
Mr. J.P. Takan, SAARI, Uganda
Prof. A.B. Obilana and Mr. E. Manyasa, ICRISAT-Nairobi
Prof. A.E.B. Brown, QUB, UK, Dr. R.Bandyopadhyaya, IITA, Nigeria
Dr. S. Muthumeenakshi, Warwick HRI.

This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID. [R8030, Crop Protection Programme]

CONTENTS

List of Tables

List of Figures

List of Appendices

List of Acronyms

AEZ	Agro-ecological zone
AFLP	Amplified Fragment Length Polymorphism
ANOVA	Analysis of variance
AUDPC	Area under disease progress curve
HRI/Warwick HRI	Warwick HRI (Horticulture Research International)
AFLP	Amplified Fragment Length Polymorphism
CM	Complete medium
CPP	Crop Protection Programme
DAI	Days after inoculation
DFID	Department for International Development
dNTP	Deoxy nucleoside triphosphate
DNA	Deoxyribonucleic Acid
EDTA	Disodium ethylene diamine tetraacetic acid
FTR	Final Technical Report
grh	grasshopper repeat in *Magnaporthe grisea*
h	Hour
HPR	Host plant resistance
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
KARI	Kenya Agricultural Research Institute
M	Molar
M. grisea	*Magnaporthe grisea*
MOA	Ministry of Agriculture
mM	Millimolar
ml	Millilitre
mg	Milligram
NARO	National Agricultural Research Organisation
NR Int	Natural Resources International
NaCl	Sodium chloride
ng	Nanogram
PCR	Polymerase Chain Reaction
PDA	Potato dextrose agar
RCB	Randomised complete block
rDNA-ITS	Ribosomal DNA-internal transcribed spacer
rpm	Revolutions per minute
SAARI	Serere Agricultural and Animal Production Research Institute
SDS	Sodium dodecyl sulphate
SSR	Simple Sequence Repeat
Tris	Tris hydroxymethyl amonimethane
UV	Ultra violet light
v/v	Volume per volume
w/v	Weight per volume
2YEG	2X yeast extract glucose medium
°C	Degrees Celsius
µl	Microlitre
µg	Microgram

Acknowledgements

This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID. Project R8030, DFID-Crop Protection Programme managed by the Natural Resources International, UK

We would like to thank Dr. F.M. Kimmins, Dr. A. Ward and Prof. J.M. Lenne for their help and support.

Grateful thanks are extended to the Director Generals of ICRISAT and NARO-Uganda and also Dr. Serunjogi, Director, SAARI for their support and co-operation in carrying out this project.

We also wish to thank Dr. Peter Esele, Dr. Beatrice Akello and other colleagues at ICRISAT-Nairobi, KARI-Kenya and SAARI-Uganda who were associated with some parts of the work.

Our primary recognition is to the farmers and key informers who co-operated patiently in the surveys for no direct reward.

Biometricians Signature

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed): Dr. Andrew Mead
Position: Research Leader
Date: 10. Dec. 2004

Executive Summary

In the semi-arid tropics of East Africa, finger millet is a staple food for millions of people. This cereal plays an important role in the dietary and cultural habits and economy of subsistence farmers in the region. Blast caused by *Magnaporthe grisea* is one of the highest priority constraints to finger millet production. Blast affects the crop at all stages of growth and most of the land-races and a number of other varieties are highly susceptible and certain forms of blast can cause failure of the grain to set and seeds to shrivel resulting in major yield losses. Major objectives were i) to characterise pathogen populations, understand the relationship between different types of blast, investigate the potential of seeds and weeds as inoculum sources and identify resistance sources, ii) to generate information on millet production in East Africa and farmers' perception of the blast disease and constraints faced in management and iii) to contribute to local capability development and dissemination of outputs to target beneficiaries to ameliorate the constraint posed by blast, thus improving the livelihoods of resource poor farmers.

Outputs

i). New knowledge on genetic and pathogenic diversity and mating compatibilities of East African finger millet blast populations generated, information on blast incidence and constraints faced in disease management gathered and tools and local capability for long-term pathogen monitoring developed.

ii). Understanding of the pathogen epidemiology particularly the potential of infected seeds and weeds in disease development and identification of various sources of resistance achieved contributing to improved disease management and the knowledge disseminated.

● Blast genotypes based on a collection of more than 300 characterised isolates were established and these showed limited genetic diversity using PCR based makers such as AFLPs and SSRs. Some of the pathogen genotypes were prevalent in both Uganda and Kenya, whilst others were restricted to one country. Considerable variation in pathogen aggressiveness was observed 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 on E11, but four of the isolates gave the highest disease on PESE 1. None of the isolates tested, however, showed clear cut differences in compatibility suggesting the role of quantitative resistance. Blast populations containing a DNA repeat element (common in Asia) were found at a low level (~ 4%) indicating recent trans-continental movement of the pathogen, possibly linked to germplasm exchanges. Isolates causing leaf, neck, and panicle blast on finger millet were genetically similar suggesting the role of same strains in different types of blast and the host resistance identified should be effective against all expressions of blast in general. Near equal distribution of mating type alleles MAT1-1 (47 %) and MAT1-2 (53 %) among blast populations in Uganda and Kenya was observed. Cross–compatibility assays have shown the high fertility status of these isolates and it is important to assess the impact on deployment and stability of host resistance.

● *M. 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, except some of the isolates from *Digitaria* sp. Weed blast isolates were capable of infecting finger millet; particularly blast isolates from wild Eleusine were as aggressive as some of the finger millet blast isolates underlining the potential of weeds to serve as inoculum sources. Seed-borne pathogen appears to contribute to disease development, with higher blast levels in susceptible finger millet varieties grown from seed lots containing higher levels of the naturally occurring pathogen. A PCR based diagnostic test has been developed which will be useful for pathogen detection in epidemiological work and seed quality assays.

● An assemblage of finger millet varieties likely to be suitable for East Africa were screened and a range of varieties with resistance to blast has been identified with the potential for immediate promotion or incorporation into breeding programmes. Baseline information on East African finger millet cropping systems and prevalence of blast, constraints to production and farmers' perception of the blast disease and its management has been generated, identifying the needs of the farmers.

● Capability strengthening and dissemination of project outputs achieved through shuttle visits by project team members to Uganda and the UK for project review and planning meetings and presentations at major conferences. SAARI pathologist Mr. John P. Takan is on target to complete his PhD research programme.

Promotion of these outputs - new knowledge and resources generated and tools and capacity developed would lay the basis for disease intervention and efficient utilisation of host resistance leading to improved blast management and enhanced finger millet production benefiting resource poor people.

Background

Finger millet (*Eleusine coracana* L.) is one of the most important cereal crops in large areas of the developing world especially Africa and India (e.g. Rao, 1986; Ekwamu, 1991). In the semi-arid tropics of Eastern Africa, finger millet is a major staple food for millions of resource poor people and is produced in a number of countries e.g. Uganda (500,000 ha), Kenya (65,000 ha) and Ethiopia (1 M ha). This cereal plays an important role in the dietary habits and economy of subsistence farmers. Staple foods prepared from the grain are major sources of minerals and nutrients (Pall, 1992) and are especially important for pregnant women, nursing mothers and children. Finger millet grain is generally sold at several times the price of other cereals.

Finger millet is used in East Africa primarily for malting and brewing, and foods in form of thin porridges. For foods in malt and thin fermented porridges, it is very nutritious containing five vitamins, 10 amino acids with especially high methionine, tryptophan and valine, and 12 mineral salts with especially very high calcium, iron, manganese, copper and sodium. These nutritional factors and also the ease of digestion are the basis for their recommended use for pregnant women, nursing mothers, children and the elderly. In brewing, it is preferred more than other malted cereals (sorghum, pearl millet and barley) by those who consume the local beers, for taste and alcoholic content. Finger millet is considered the domain of women and its successful cultivation would enhance their status at both household and community level. In cases of sufficient yield, women use it for brewing and also as a cash crop, generally managing the resulting income for the benefit of their household (FTR, R6733). Finger millet is a traditional crop and is considered important for cultural occasions such as agreement of weddings. The crop is thought to have medicinal properties for the treatment of measles, colds, anaemia and diarrhoea. Although not particularly drought tolerant, finger millet is one of the hardiest crops grown in this region and the seeds have excellent keeping qualities. This makes finger millet a very important famine reserve food. In spite of the preference for finger millet grain, its uptake, both in area and production have not been expanding but rather declining due to several production constraints including high labour requirement, weeds and the blast disease. More than 1000 germplasm accessions and some improved varieties that could be further tested and developed are available in East Africa, with different maturity groups and reaction to blast, resulting from previous collaborative breeding and evaluation in Uganda, Kenya, Ethiopia and Tanzania (Pers. Com. Tunde Obilana and Peter Esele, 2000). Project outputs can be significant for the rest of the region through ECARSAM, and outside the region as finger millet blast system is much less investigated compared to rice blast.

Blast caused by *Magnaporthe grisea* (anamorph *Pyricularia grisea*) is a major constraint to the production of finger millet, resulting in direct crop losses (Ramakrishnan, 1963; Pande *et al*., 1994). Blast affects finger millet at all stages of growth, from seedling through grain formation, symptoms being similar to those of rice blast. Most of the finger millet land-races and a number of other genotypes are highly susceptible to blast. Panicle blast (neck and/or finger) is the most destructive phase of the disease and can cause failure of the grain to set and seeds to shrivel, sometimes resulting in total loss of the panicle. *M. grisea* has a wide host range (Ou, 1985) and, historically, the principle means of deciphering pathogen variability from different hosts has been by morphological characteristics and infection assays (Mackill and Bonman, 1986). It has been suggested that the pathogenicity of the blast fungus is largely restricted to its host species of origin (Todman *et al*., 1994). Mackill and Bonman (1986), however, suggested that various weed hosts growing near cultivated plants might serve as potential sources of inoculum for the disease and provide alternate means of survival of the fungus.

A family of repetitive DNA sequences known as *Magnaporthe grisea* repeat (MGR) elements (Hamer *et al*., 1989) has been used to analyse the population structure of the rice blast pathogen in several countries (e.g. Levy *et al*., 1991, 1993; Han *et al*., 1993; Chipili *et al*., 2001). DNA fingerprinting of blast populations from different hosts using MGR probes has shown that isolates of the pathogen from finger millet are genetically distinct from isolates from other crops (Borromeo *et al*., 1993; Viji *et al*., 2000). In addition, preliminary studies on

the finger millet blast pathogen genome have shown that *M. grisea* isolates from finger millet in some countries, i.e. Japan, Nepal, India and Mali in West Africa, possess a long terminal repeated sequence *grh* (Dobinson *et al*., 1993). In this study the *grh* sequence, however, was not found in isolates from other African countries, Philippines and South America, thus implying the existence of distinct *M. grisea* populations on finger millet in various geographic locations. Moreover, genetic relatedness between the finger millet – infecting isolates and isolates from weed hosts has been little studied. It has also been observed that *M. grisea* isolates from finger millet tend to be fertile. However, there is a lack of information on the distribution of the mating types and the mating compatibilities in this region.

Recent definition of rice blast lineages, together with the pathotype diversity results have allowed a higher resolution of the pathogen population structure. Novel breeding strategies based on 'lineage-exclusion' have been tested in various rice growing regions with a view to prolonging the durability of resistant cultivars (Zeigler *et al*., 1994; Gnanamanickam *et al*., 1998; Sivaraj *et al*., 1998). The 'lineage-exclusion' method proposes bringing together into cultivars those genes that are each effective against an entire 'lineage', so that durable resistance can be achieved against all or the dominant the lineages prevalent in a region (Levy *et al*., 1993; Hamer *et al*., 1991; Correa-Victoria *et al*., 1994). Thus the 'lineage-exclusion' strategy offers considerable potential for durable blast resistance, but its success is likely to be influenced by the range of host varieties (traditional/improved) used and the extent of pathogen diversity in a geographic location (Zeigler *et al*., 1994; FTR, R6738).

Finger millet blast is common in Uganda and Kenya and is particularly severe in very wet years (Dunbar, 1969). The disease was first recorded in Uganda in 1933 (Emechebe, 1975) but very little is known of the pathogen epidemiology and diversity of the pathogen populations in this region. In Uganda and Kenya, the pathogen has been suggested to overseason not only on seed and crop debris but also on weeds and wild grasses e.g. *E. indica*, *E. africana* and *Dactyloctenium aegyptium* (Pande *et al*., 1995) and these hosts could serve as potential inoculum reservoirs. . In addition, the relative importance of the pathogen isolates which infect the seedling, neck and finger stages and those carried over as seed borne inoculum (Shetty *et al*., 1985) need to be investigated. The genetic relatedness and aggressiveness of isolates infecting the different parts of the finger millet plant and weed hosts is knowledge vital to a successful utilisation of host resistance and will aid in developing improved disease management strategies.

NARO needs-assessment exercises and interactions with farmers identified blast as a high priority constraint to finger millet production in East Africa. The major objectives of the project were to strategically characterise the blast pathogen populations as a basis to develop durable resistance; identify the major sources of inoculum and target points for disease control and identify resistance sources. Socio-economic/PRA activities will enable an understanding of the importance of the finger millet crop in the East African farming systems, farmers' perception of the blast disease problems and varietal use and characteristics, and disease management options.

References:

Borromeo, E.S., Nelson, R.J., Bonman, J.M. and Leung, H. (1993). Phytopathology 83, 393-399.

Chipili, J., Sreenivasaprasad, S., Brown, A.E., Talbot, N.J., Holderness, M., Sere, Y., Nutsugah, S.K., Twumasi, J. and Dartey, K. (2001). Characterisation of the rice blast pathogen populations in West Africa. In: *Major fungal diseases of rice Recent Advances*. Eds. S. Sreenivasaprasad and R.Johnson. Kluwer Academic, Netherlands, pp. 9-20.

Correa-Victoria, F.J., Zeigler, R.S. and Levy, M. (1994). Virulence characteristics of genetic families of *Pyricularia grisea* in Colombia. In: *Rice Blast Disease*. Zeigler, R.S., Leong, S.A. and Teng, P.S. (eds.). CAB International, Wallingford, Oxon, UK and International Rice Research Institute, Manilla, The Philippines, pp. 211-229.

Dobinson, K. F., Harris, R.E. and Hamer, J.E. (1993). Molecular Plant-Microbe Interactions 6, 114-126.

Dunbar, A.R. (1969). The annual crops of Uganda. East African Literature Bureau, Dar es Salaam, Nairobi, Kampala.

Ekwamu, A. (1991). Tropical Pest Management 37, 122-123.

Emechebe, A.M. (1975). Some aspects of crop diseases in Uganda. Department of Crop science, Makerere University Printers, Uganda, 43 pp.

Final Technical Report. R6733. DFID-CPP Project 'An investigation into the biology, epidemiology and management of finger millet blast in low-input farming systems in East Africa'. Hayden, N.J. November 1999, Submitted to DFID-CPP/N R International.

Final Technical Report. R6738. DFID-CPP Project ' Identification and characterisation of key screening sites for blast and scald resistance in West Africa'. Turner, H.C., Sreenivasaprasad, S. and Holderness, M. August 2000, Submitted to DFID-CPP/N R International.

Gnanamanickam, S.S., Lavanya, B., Sivaraj, R. and Levy, M. (1998). Lineage-exclusion resistance breeding: Pyramiding of blast resistance genes for management of rice blast in India. (Abstract). *2nd International Rice Blast Conference* 4-7 August. Ecole Nationale Supèrieure Agronomique de Montpellier, France.

Hamer, J.E., Farrall, L., Orbach, M.J., Valent, B. and Chumley, F.G. (1989). Proceedings of the National Academy of Sciences, USA 86, 9981-9985.

Hamer, J.E. (1991). Molecular probes for rice blast disease. *Science* **252**, 632-633.

Han, S.S., Ra, D.S. and Nelson, R.J. (1993). Journal of Agricultural Science 35, 315-323.

Levy, M., Correa-Victoria, F.J., Zeigler, R.S., Xu, S. and Hamer, J. E. (1993) Phytopathology 83, 1427-1433.

Ou, S.H. (1985). Rice diseases. Common wealth Mycological Institute, Kew, Surrey.

Mackill, A.O. and Bonman, J.M. (1986). Plant Disease 70, 125-127.

Pall, B.S. (1992). Biodiversity 3, 53-54.

Pande, S., Mukuru, S.Z., Odhiambo, R.O. and Karunakar, R.I. (1994). Plant disease 78, 60-63.

Pande, S., Mukuru, S.Z., King, S.B. and Karunakar, R.I. (1995). Biology of, and resistance to finger millet blast in Kenya and Uganda. Proceedings of the eighth EARSAM Regional Workshop on Sorghum and Millets. WAD Medani, Sudan 30th Oct. – 5th Nov. 1992.

Ramakrishnan, K.V. (1963). Diseases of millets. New Delhi, Indian Council of Agricultural research, 152 pp.

Rao, A.N.S. (1986). Indian Journal of Mycology and Plant pathology 16, 280-281.

Shetty, S.S., Gopinath, A. and Rajashekar, K. (1985). Indian Phytopathology 38, 154-156.

Sivaraj, R., Gnanamanickam, S.S. and Levy, M. (1998). " Lineage-exclusion" tests for blast resistance in southern India. (Abstract). *2nd International Rice Blast Conference* 4-7 August. Ecole Nationale Supèrieure Agronomique de Montpellier**,** France.

Sreenivasaprasad, S., Chipili, J. and Y.Sere. (2000). Diversity and distribution of blast pathogen *Magnaporthe grisea* lineages at some rice screening sites in West Africa. In: Proceedings of the Rice in Africa, NRI Workshop, Chatham, Dec. 6th – 8th, 1998.

Todman, A.K., Pawar, D.R. and Joshi, M.H. (1994). Mysore Journal of Agricultural Sciences 28, 45-46.

Viji, G., Gnanamanickam, S.S. and Levy, M. (2000). Mycological Research 104, 161-167.

Zeigler, R.S., Tohme, J., Nelson, R., Levy, M. and Correa-Victoria, F.J. 1994. Lineage exclusion: A proposal linking blast population analysis to resistance breeding. (Eds.) Zeigler, R.S., Leong, S.A. and Teng, P.S. Rice Blast Disease, CAB International & IRRI, pp. 267 – 292.

Project Purpose

To minimise the impact of significant pests of cereal-based systems - Characterisation and management of finger millet blast in East Africa.

Specific objectives of the project were to understand i) the genetic and pathogenic diversity of the finger millet blast populations in Uganda and Kenya through strategic characterisation, ii) the distribution of pathogen genotypes and the relatedness of strains causing different blast types (seedling, foliar, neck and finger), iii) the role of pathogen propagules on seeds and weeds and their importance in the disease cycle and as target points for disease control and iv) screen a range of finger millet accessions to identify resistance sources. The project outputs would also contribute to local capability strengthening and development of tools for long term pathogen monitoring. Achievement of the project objectives and dissemination of the outputs to target beneficiaries and stakeholders will lead to the development and promotion of improved disease management strategies, particularly utilising host resistance ameliorating the constraint posed by blast to finger millet production.

Research Activities

1. Socio-economic and disease surveys in Kenya and Uganda

In Kenya, an appraisal to elicit farmers' perception of blast disease incidence and its impact on crop loss, was done by working with farmer groups based in Nambale and Butula divisions of Busia district, in Amukura and Amagoro divisions of Teso district and in Masaba and Nyacheki divisions of Kisii district, in Western Kenya. Nambale and Butula divisions, located at altitude of 1244 and 1293 m above sea level (asl), respectively, consist primarily of agro-ecological zone LM 1 and receive average annual rainfall of about 1800 mm with a bimodal distribution pattern. The long rains (LR) occur during February to July and average about 850 mm while the short rains (SR) occur during August to December and average about 700 mm. Amukura and Amogoro Divisions, located at an altitude of 1264 and 1307 m asl, respectively, consist mainly of agro-ecological zone LM 2 and receive an average annual rainfall of 1500 mm with a bimodal distribution pattern. The LR average 650 mm and occur during February-July while the SR average 450 mm and occur in August-December. Masaba and Nyacheki divisions, located at an altitude of 1992 and 1924 m asl, respectively, consist mainly agro-ecological zone LH 2 and LH1, respectively, and receive a bimodal annual rainfall of about 2000 mm. LR average 900 mm, while the SR average about 600mm. The soils in Busia and Teso districts are moderately deep with moderate natural fertility and high humus levels. The soils in Kisii are mainly upland soils, which have moderately high natural soil fertility and high organic matter in the topsoil. While population density estimates was about 300 persons sq km^{-1} in Busia and Teso, in Kisii it was about 715 persons sq km^{-1} with household size averaging about 8 persons in all districts. Average farm sizes range from about 2 acres in Kisii to 7 acres in Busia and Teso districts.

This study was carried out to identify priority constraints affecting production in three key finger millet producing districts of Western Kenya. Information on farmers' perception of blast disease and yield losses was collected to document baseline data on finger millet production and marketing systems and determination of finger millet variety preferences, in order to prioritise research, development and policy action.

Site selection and study techniques

After preparatory surveys, two most important finger millet producing divisions in Busia (Butula and Nambale), Teso (Amukura and Amagoro) and Kisii (Masaba and Nyacheki) districts were selected for the purposes of the survey. Each divisional extension coordinator selected two active farmer groups for the meetings (Table 1), paying particular attention to representativeness of diverse finger millet production environment in the division. Generally women and men participating in each appraisal meeting represented different households and duplication of responses from same households, in cases where more than one member of household attended the meeting, was avoided during recording of farmer responses.

A combination of PRA techniques, especially focussed group discussions, key informant interviews were employed to collect information through a semi-structured questionnaire. Number of farmers reporting various options as responses was recorded in order to have a feel of where majority group members fall through descriptive statistics. To establish ranks and relative importance amongst items, participating groups used pair wise ranking matrix.

Group discussion sessions were organised for each group on separate days with each discussion session lasting about 3-4 hours. During the meetings the women and men held separate discussions whenever necessary in order to highlight gender related issues. In all sessions active participation was encouraged through probing and directing some questions to less vocal participants. To maintain a logical flow, the discussions were organised in sub-sessions: farmer group identification, household resource levels, major crop enterprises and cropping patterns, finger millet variety preferences, management practices, acreage, production, seed selection and storage, seed sources, finger millet utilisation and marketing, major finger millet production constraints, finger millet blast (knowledge of transmission and causes, level of occurrence and perceived losses), finger millet seasonal calendar and sources of technical information. At the end of each group discussion, four members of the PRA team visited selected farms to collect disease samples.

Table 1. Composition farmer groups in socio-economic and disease surveys in Busia, Teso and Kisii Districts, Western Kenya

District/division	Number of groups surveyed	Mean group membership	Mean number of members surveyed	Mean number of women surveyed	Mean number of men surveyed
Busia					
Butula	2	28	14	7	7
Nambale	2	27	21	14	7
Teso					
Amakura	2	24	18	13	5
Amagoro	2	31	16	10	6
Kisii					
Masimba	2	19	15	13	2
Nyancheki	2	33	26	18	8

The main objectives of the disease surveys were to collect finger millet blast samples from farmers' fields in the areas where the PRA was conducted (Busia, Teso, Kisii and Gucha Districts) and record the blast levels across the four districts so that variations in disease incidence can be monitored across seasons/years and sites and establish pathogen isolates for strategic characterisation. At all the sites visited in the four districts, leaf, neck and finger blast samples from the crop and also weed samples were collected. These samples, well preserved and labelled, were sent to Warwick HRI for laboratory analysis and molecular characterisation. On the whole, a total of 160 samples were collected comprising 103 finger millet crop samples and 57 weed samples, from four districts, one township in Homabay and Alupe research station (Table 2). Demographic details of the blast samples collected are shown in Appendix 1.

Table 2. Blast samples collected in Busia, Teso, Kisii and Gucha districts

District	Division	No. of sites sampled	No. of crop samples	No. of weed samples	Total no. of samples
Busia	Butula	8	20	11	31
	Nambale	9	12	14	26
Teso	Amukura	10	12	12	24
	Amagoro	15	11	9	20
Kisii	Masaba	11	13	2	15
Gucha	Nyacheki	14	17	2	19
Homabay	Township	1	3	0	3
Teso	Alupe research station	1	15	7	22
Total		**68**	**103**	**57**	**160**

In Uganda, PRA was conducted in the Teso and Lango farming systems (FS) mainly during October and November 2001 (Table 3), with follow up surveys to fill in additional information. In Teso FS three sub-counties were visited namely Kyere in Soroti district, Kapujan in Katakwi district and Putiputi in Pallisa district. In the Lango FS also three sites were visited. These were: Bata and Adwari sub-counties in Lira district and Chawente in Apac district. The sub-counties selected were some of the major finger millet growing areas across agro-ecological zones.

Table 3. The number of farmers involved in the PRA in key districts across Uganda

District	Sub-county	Male	Female	Total
Soroti	Kyere	24	13	37
Katakwi	Kapujan	27	17	44
Pallisa	Putiputi	45	20	65
Lira	Adwari	12	6	18
Lira	Batta	22	12	34
Apac	Chawente	30	6	36
Total		**160**	**74**	**234**

To determine the incidence and severity of blast on finger millet in farmers' fields in key areas of Uganda and to collect blast samples from finger millet and weeds, surveys were conducted in 15 districts mainly covering the Northern and Eastern areas where the crop is grown. Farmers' fields were sampled every five kms and depending on the location influence, varietal type or cropping system, observations were made and samples collected at more frequent intervals as necessary. For assessing the disease, a quadrant method was followed whereby in every field, three 1mX1m quadrants were covered. In each quadrant, total number of plants and the number of blast affected plants were recorded. In each quadrant, 10 heads were randomly selected to determine blast severity. For each head a proportion of spikelets affected by the disease was estimated. Values for the three quadrants were averaged for each field and for the district.

2. Molecular characterisation

Collection, isolation and preservation of *Magnaporthe grisea* isolates

In Uganda, samples were collected from farmers' fields mainly in northern and eastern regions, and also from western region. Samples were also collected from Serere Agricultural and Animal Production Research Institute (SAARI) and Ngetta Agricultural Research and Development Centre (ARDC) sites, where finger millet lines are screened for resistance to blast. Similarly, in Kenya, samples were collected from farmers' fields and blast screening nurseries at Alupe experiment station – Kenya Agricultural Research Institute (KARI). In 2003, samples were separately collected from 9 of the 16 finger millet varieties that were evaluated for reaction to blast disease under natural infection at SAARI. Sites where blast samples/*M. grisea* isolates were collected in Uganda and Kenya including the red spots indicating the blast screening sites at Serere (Uganda) and Alupe (Kenya) are shown in Appendix 2.

Finger millet and weed samples namely panicle (seed or rachis), leaf and neck were prepared for sterilisation. The leaf and neck samples showing blast symptoms were cut into small pieces and placed in plastic 90 mm petri-dishes. The seed was wrapped in a single layer of muslin cloth and tied with a rubber band, due to the small size. This was done for ease of handling during sterilisation. Prior to this, the muslin cloth was washed in tap water and dried. This was done to ease the wetting of muslin cloth and consequently the sterilisation of the seeds. The samples were sterilised by placing in 2% sodium hypochlorite solution (200 ml 4.5% bleach and 250 ml sterile distilled water) for 2 min (seed) and 1 min (leaf and neck), followed by three rinses in sterile distilled water. The first and second rinses were done for one minute, and the third rinse was done for two minutes.

After sterilising, samples were placed in 90 mm diameter Petri-dishes containing three layers of moist Whatman® No.1 filter papers. The Petri-dishes were incubated at 25° C $\pm$ 2° C with alternating 12 h white light (FL40SS.W/37) and 12 h darkness to induce growth and sporulation of *M. grisea* in a growth chamber.

After 48 h incubation, the samples were observed under a stereomicroscope for the presence of *M. grisea*. The pathogen was identified based on its morphological growth pattern and spore shape. The fungus produces greyish mycelium with conidiophores arising singly or in groups on the affected part. Conidiophores are slender, straight, greyish or dark grey, smooth bearing clusters of conidia which are typically obpyriform or obclavate, hayaline and 2-septate. Where *M. grisea* was present, conidia were picked using a moist sterile dissecting needle and placed on oatmeal agar (OMA) plates containing aureomycin (72.5 g oatmeal, Sigma, UK + 1 g yeast extract, Sigma, UK l^{-1}). Aureomycin (Chlorotetracycline hydrochloride, Sigma, UK) dissolved in 50% ethanol was added to OMA at a concentration of 25 mg l^{-1} to inhibit bacterial contamination. The plates were incubated at 25° C $\pm$ 2° C with alternating cycles of 12 h white light and 12 h darkness to induce growth and sporulation. These cultures were designated as field isolates.

Preparation of mono-conidial isolates

Mono-conidial cultures were prepared for every field isolate and used for further characterisation. A spore suspension from 10 to 12-day old culture of each field isolate was prepared and streaked onto 4% (W/V) water agar (WA) plates containing aureomycin (40 g agar-agar technical, Merck l^{-l}) with a sterile 10 µl loop (Nalgene Nunc International). The

plates were thereafter incubated at conditions described above. After 24 h, the streaks were scanned under a stereomicroscope until widely separated and germinated single conidia were found. A single germinated conidium was removed using a scalpel blade by cutting the agar closely around the conidium. The agar piece containing the spore was then lifted and placed onto antibiotic OMA plates. The plates were incubated at standard growth conditions. These cultures formed the monoconidial (single spore) isolates. Both the field and single spore isolates of *M. grisea* were preserved on filter paper pieces. Whatman® No.1 filter papers were cut into approximately 1 cm^2 and sterilized at 121° C for 15 minutes. Sterile filter paper pieces (7-9) were placed on antibiotic OMA plates and a mycelial plug from each isolate was placed at the center of the plate. The plates were then incubated under alternating cycles of 12 h white light and 12 h darkness at 25° C $\pm$ 2° C until the filter paper pieces were completely overgrown with mycelium and spores. The filter paper pieces were thereafter removed and placed in 50 mm diameter Petri-dishes (Bibby Sterilin, UK). The plates were incubated in a dessicator containing silica gel until the filter paper pieces were thoroughly dried under vacuum. The filter paper pieces colonised by the fungus were stored at –20° C until required for further use. Details of the *M. grisea* isolates; country, district, host, plant part and year of collection are shown in Appendix 3.

Molecular analyses of *M. grisea* isolates

Each mono-conidial isolate was grown in 2X Yeast Extract Glucose (2YEG) medium containing 10 g glucose and 2 g Yeast Extract l^{-1}. Mycelial plugs from an actively growing culture (8 to10-day old) on antibiotic OMA medium were placed in two 250 ml flasks containing 100 ml of 2YEG medium. The liquid cultures were grown at 25° C $\pm$ 2° C for 5 days in a rotary shaker at 150 rpm. The mycelium was harvested by filtration through a double layer of sterile muslin cloth placed in a plastic funnel. The mycelium was rinsed with sterile distilled water to remove traces of the medium. Excess water was drained by slightly squeezing the mycelium with tissue and placed in 50 ml sterile tubes. The mycelium was immediately placed in a freezer overnight. The frozen mycelium was freeze-dried for 48-72 h and stored at –20° C until further use.

Extraction of genomic DNA from *M. grisea* isolates

For each isolate 40 mg of freeze-dried mycelium were ground to a fine powder using a sterile pestle and mortar with an equal quantity of sterilised acid-washed sand, and placed in 2 ml Eppendorf tube. The DNA was extracted from the mycelial powder using DNeasy® Plant Mini Kit from Qiagen or GenElute™ Plant Genomic DNA Miniprep Kit from Sigma following the manufacturers' protocols and the buffers provided. Further details of the procedures are shown in Appendices 4 and 5.

DNA gel electrophoresis

Genomic DNA and PCR products were electrophoresed on agarose gels routinely (GIBCO BRL, Life Technologies). Amplified fragment length polymorphism (AFLP) analysis products were resolved on gels prepared by mixing synergel (Diversified Biotech) with agarose (SAG). The dimensions (length and width) of each gel tray were initially measured to determine the volume or amount of buffer to be used to prepare the gel. A gel thickness of 0.5 cm was maintained for all the gels. Further details of the procedures are shown in Appendix 6.

Amplified Fragment Length Polymorphism Analysis

Amplified fragment length polymorphism (AFLP®) was performed as described in the Invitrogen (Life Technologies) instruction Manual without radioactive labeling of the primers but with a modification in selective amplification. The AFLP® technique involves three major steps, namely:

1. Restriction endonuclease digestion of the DNA and ligation of adapters
2. Amplification of the restriction fragments and
3. Gel analysis of the amplified fragments.

Further details of the procedures are shown in Appendix 7.

Screening of AFLP primer combinations

Five *M. grisea* isolates D1/S11, K9/46, K24/127, D14/S9 and G22 were randomly selected and used to screen a total of 64 *EcoR* I/*Mse* I primer combinations. Based on the number of

bands and the level of variation ten *EcoR* I/*Mse* I primer combinations were initially selected to analyse the solates. However, as the number of bands produced by 3-nucleotide primers were limited, further screening of 2- nucleotide primers was done with ten isolates. Using the above criteria, five primer pairs (combinations) were selected and used to analyse all the isolates. The selected primer combinations included E-TC/M-CA, E-GA/M-CA, E-GT/M-CT, E-CA/M-CT and E-AC/M-CT. and the primers used are shown in Table 4.

Table 4. Nucleotide sequences of the seven primers used

Primer	Sequence
EcoR1 -1	5'-GACTGCGTACCAATTCTC-3'
EcoR1 -2	5'-GACTGCGTACCAATTCGA-3'
EcoR1 -3	5'-GACTGCGTACCAATTCGT-3'
EcoR1 -4	5'-GACTGCGTACCAATTCCA-3'
EcoR1 -5	5'-GACTGCGTACCAATTCAC-3'
Mse 1	5'-GATGAGTCCTGAGTAACA-3'
Mse 2	5'-GATGAGTCCTGAGTAACT-3

Screening *M. grisea* isolates for presence of grasshopper (*grh*) repeat element
Two primer pairs to amplify approximately 1347 bp and 836 bp fragments, designated as PES (forward and reverse) and PKE (forward and reverse) primers respectively, were designed from the grasshopper (*grh*) repeat sequence available in the database.

PESF: 5'-GCGTTCGAAGCGTTGAAACAC-3'
PESR: 5'-AGCTATATAAGCCCTAAGGTATTGC-3'

PKEF: 5'-CGGAATTCTTCAGTCACGGGAACAAGC-3'
PKER: 5'-TCCGAGGTGCACATGTGTGAAACGC-3'

PES and PKE primer pairs were used to screen the *M. grisea* isolates by PCR. For each isolate, genomic DNA dilution of 1 ng 5 μl^{-1} was prepared for use in PCR. For each primer pair and isolate, the PCR consisted of water, forward and reverse primers (each 2.5 μl), 12.5 μl of REDTaq™ ReadyMix™ (Sigma, UK) and 1 ng of specific DNA template giving a total reaction volume of 25 μl. DNA from previously characterised isolate G22 and water were used as positve and negative controls, respectively. The PCR was performed in a thermal cycler (Phoenix, Helena Biosciences) with 42 cycles consisting of denaturing at 94° C, annealing at 60° C and extension at 72° C. The first cycle consisted of 94° C for 2 min and 60° C for 1 min, followed by 40 cycles of 72° C, 94° C and 60° C each for 30 sec. Last cycle was final extension for 10 min. The PCR products were resolved on 1 % (w/v) agarose gels, run for 1.5 h. The products were viewed and results recorded as described earlier.

The PCR products were purified using QIAquick® PCR purification kit. For each isolate, 300 µl of buffer PB were added to 60 µl of the PCR products and mixed with a pipette. The mixture was applied to QIAquick® spin column placed in 2 ml collection tube and centrifuged for 1 min at 13,000 rpm. The flow through was discarded and the QIAquick® spin column was placed back into the collection tube. Each column was washed by addition of 750 µl of buffer PE and centrifuged for 1 min at 13,000 rpm. The flow through was discarded and the column placed back into the collection tube. This was centrifuged for an additional 1 min to ensure complete removal of residual ethanol from buffer PE. The QIAquick® spin column was transferred to a clean 1.5 microcentrifuge tube. To elute the DNA, 50 µl of water (Sigma, UK) were added directly to the center of each column, left to stand for 3 min at room temperature and centrifuged. The eluted DNA was stored at -20° C.

Restriction enzyme digestion of amplified grasshopper (*grh*) fragment
Enzymes *Alu* I, *Mbo* I and *Sal* I for the restriction analysis of *grh* amplicons were selected by restriction mapping of the sequence data available in the database. The *grh* amplicons from G22 (control) and isolates D1/S11, K1/15, K33/189 and K24/127 were digested with *Alu* I, *Sal* I and *Mbo* I at 37° C for 4 h. Each reaction (5 μl) consisted of 3.5 μl water, 1 μl enzyme buffer and 5 units of restriction enzyme. The digested *grh* products were resolved on 2 % (w/v) SAG using 0.5XTBE as running buffer and the results documented as previous.

Development of primers specific for *M. grisea* for diagnostic PCR
Following comparative analysis of rRNA gene block-internal transcribed spacer sequences of *M. grisea* with related fungal sequences, primers shown below were designed.

MGF: 5'-CTGTCGTTGCTTCGGCGGGCACGC-3'
MGR: 5'-ACGCCGGGACGATCCGAACGAGGTTC-3'
Diagnostic PCR and gel analysis were performed as described in previous sections.

Mating type distribution and fertility of *M. grisea* isolates
For the identification of *M. grisea* mating type alleles using PCR, two primer pairs to amplify approximately 920 bp and 840 bp fragments, designated as MAT1-1 (forward and reverse) and MAT1-2 (forward and reverse) respectively were designed from sequences provided by Dr. S. Kang, Penn State Uni., USA).

MAT1-1F: 5'-TGCGAATGCCTACATCCTGTAC-3'
MAT1-1R: 5'-CGCTTCTGAGGAACGCAGACGGACC-3'
MAT1-2F: 5'-TCTGCTTGAAGCTGCAATACAACGG-3'
MAT1-2R: 5'-CATGCGAGGGTGCCATGATAGGC-3'

These primers were used to screen 328 *M. grisea* isolates from E. Africa using PCR. Genomic DNA dilution of 1 ng 5 μl^{-1} for each isolate was prepared for use in PCR. For each primer and isolate, the PCR consisted of water 4.5 μl, 1.5 μl each of MAT1-1 or MAT1-2 primers (forward and reverse), 12.5 μl of REDTaq™ Ready Mix™ (Sigma, UK) and 1 ng of specific DNA template giving a total reaction volume of 25 μl. DNA from tester isolates 4136-4-3, TH 3, and I-R-22 for MAT1-1 and tester isolates Guy 11(Leung et al., 1988), JP 15 and BR 62 for MAT1-2 provided by Prof. N.J. Talbot, School of Biological Sciences, University of Exeter, were used as positive controls in the first set of isolates. Water was used as negative control. In the subsequent PCRs, MAT1-1 and MAT1-2 tester isolates one each were used as controls. The PCR was performed in a thermal cycler (Phoenix, Helena Biosciences) with 42 cycles consisting of denaturing at 94° C, annealing at 60° C and extension at 72° C. The first cycle consisted of 94° C for 2 min and 60° C for 1 min followed by 40 cycles of 72° C, 94° C and 60° C each for 30 sec. Last, was final extension for 5 min. The PCR products were resolved on 1% (W/V) agarose gels run for 1.5 h. The gels were viewed under UV transilluminator and results recorded.

Mating compatibility and fertility of *M. grisea* isolates
To determine the fertility of the finger millet and weed isolates, standard procedures were followed. Characterised isolates were crossed with testers of opposite mating type based on the PCR results. The testers used included 4136-4-3, TH 3 and I-R-22 for MAT1-1 and Guy 11, JP 15 and BR 62 for MAT1-2. In the initial crosses (120) all the testers were crossed with opposite mating type isolates (20) and thereafter the two most fertile testers for each mating type were used for the subsequent crosses. *Magnaporthe grisea* isolates were paired with tester isolates of opposite mating type by cutting small blocks of mycelium from the edge of 7-10-day old cultures and placing them on antibiotic OMA approximately 4 cm apart. The plates containing paired isolates and testers of opposite mating type were wrapped with the parafilm and incubated at the 27° C at 12 h light and 12 h darkness for 8 days for isolate and tester to meet. There after the plates were transferred and incubated at a temperature of 20° C $\pm$1° C under continuous white light. After 5 and 10 days of incubation at 20° C$\pm$ 1° C some plates were examined under a stereomicroscope for initial perithecial formation.

The plates were observed under stereomicroscope for the presence of the perithecia, approximately four weeks (29th day) after crossing. The side where perithecia formed was recorded as tester side, monoconidial isolate side or both sides. Isolates that formed perithecia were thereafter designated as male, female or hermaphrodite according to the standard nomenclature. Male fertile (female sterile) isolates formed perithecia only on the side of the tester isolate, while female fertile isolates formed perithecia on the side of the monoconidial isolate. Isolates that produced perithecia on both sides of the tester and monoconidial isolate were considered hermaphrodites. The relative degree of fertility of each isolate was assessed by determining the number of perithecia formed in 5 mm^2 of agar surface. The number of perithecia was counted with the help of 1 mm Indxgrid (Graticules, UK) placed in the eye-piece of the stereomicroscope. For each plate, the number of perithecia was counted in 5 mm^2 (1 mm x 1 mm squares) at two separate points. Where perithecia formed on both sides of the tester and monoconidial isolate, number of perithecia was separately counted on either side. The number of perithecia was thereafter averaged. All the paired isolates were assessed for fertility 4 weeks (29th day) after crossing at fixed magnification of X300.

Fertility levels of the isolates were classified as high (>20 perithecia per 5 mm^2), intermediate (10 to 19 perithecia per 5 mm^2), or low (<10 perithecia per 5 mm^2). Isolates that did not produce perithecia were considered infertile. The presence or absence of asci and ascospores was determined by picking up to 10 perithecia, placing in a drop of water on a glass slide and squashing with a glass cover slip. The slide mounts were observed under a compound microscope. The tester isolates of opposite mating type were crossed amongst themselves and also assessed for formation of perithecia and production of ascospores. These were used as controls for each set of monoconidial isolates and tester crosses set up. Crosses between fertile hermaphroditic monoconidial isolates of opposite mating type in some districts in Uganda and Kenya were also made. In Uganda isolates from the districts of Apac, Lira, Tororo, and Mbale were crossed whereas in Kenya isolates were from Teso and Kisii districts. The crosses were incubated under the conditions described above. The viability of ascospores of some crosses was tested by picking some perithecia, placing in a drop of water on glass slide and squashing with glass cover. The slide was kept in a moist chamber and the germinated ascospores were counted after 24 h. In each slide a total of 50 ascospores were assessed.

A total of 300 crosses of monoconidial isolates of opposite mating type were made. Twenty six crosses made with tester isolates of opposite mating type with 4136-4-3 and TH 3 for MAT1-1, and Guy 11 and JP 15 for MAT1-2 and placed on the laboratory table were also tested to assess the influence of varying conditions. The plates were observed under stereomicroscope for the formation of perithecia and where present the total number of perithecia on one or both sides were separately counted. The perithecia were mounted on the compound microscope to determine the presence of asci and ascospores.

3. Pathogenicity

A number of finger millet (fm) varieties classified based on previously known reactions to infection by *Magnaporthe grisea* as resistant, moderately resistant and susceptible were used (Table 5). The ten varieties were selected to cover the full spectrum of reactions to blast, therefore, two susceptible, three moderately resistant and five resistant varieties were chosen. All the seed samples were germination tested (on damp filter paper in Petri dishes), to ensure that they had a sufficiently high level of germination, allowing for adequate seedling numbers. Due to the difficulty in obtaining large quantities of seed of the different varieties, it was very important to start with varieties, of which there was enough seed to carry out the testing.

Table 5. Finger millet varieties used for pathogenicity test on seedlings

Variety Name	Susceptibility
Seremi 1	Resistant
Seremi 2	Resistant
Seremi 3	Resistant
PESE 1	Resistant
GULU E	Resistant
INDAF 5	Moderately Resistant
OK/3	Moderately Resistant
P665	Moderately Resistant
HPB-83-4	Susceptible
E11	Susceptible

Culture of *Magnaporthe grisea* isolates

A total of 95 *M. grisea* representative isolates based on strategic sampling and characterisation from the total collection were used. Ability of more than 150 isolates to produce adequate numbers of spores was evaluated by plating on complete medium (CM) agar, under standard conditions (2 weeks at 25-27°C), before choosing the 95 isolates. M. grisea isolates on filter paper were stored at –20°C. Three weeks prior to inoculation, selected isolates plus the control isolate (K5/23) were plated onto CM in individual Petri dishes. These dishes were kept in a controlled environment at 25-27°C with a 12 hour light/dark cycle using daylight fluorescent bulbs. Two weeks prior to inoculation, each isolate was sub-cultured onto 5-10 CM plates as necessary. These plates were wrapped with parafilm and returned to the controlled environment for growth and sporulation.

Spore collection

On the morning of plant inoculation, the plates containing the growing isolates were removed from the controlled environment. A few mls of 0.01% gelatine solution was placed on each plate and the mycelium was brushed with a sterile loop to dislodge the spores. Using a Pasteur pipette, the spore suspension was collected and placed in a sterile 50 ml Falcon tube. A sample of the spore suspension was examined under a microscope to determine spore counts to produce 40 ml of 1 x 10^5 spores/ml. The spore suspensions were held at 4 ºC until they were sprayed on the finger millet seedlings.

Growth and inoculation of finger millet seedlings

Approximately 0.7 g seed of each variety was sown (0.7 g = approx. 120 seeds; at 80% germination, this was to ensure sufficient healthy seedlings in bulk in a general purpose peat-based compost. The trays of seed were kept in an environmentally-controlled area maintained at 25-27°C. They were watered as required keeping the compost moist but not wet. After five weeks (one week prior to inoculation) the seedlings were sufficiently mature to be transplanted and grouped by variety to individual sections in a 100 section seed tray. The arrangement of varieties was randomised within each tray to ensure experimental integrity. Each tray [5 varieties (20 seedlings of each) x 1 *M. grisea* isolate] was replicated three times. An example of the pathogenicity testing under controlled conditions is shown in Appendix 8. Each seedling tray was isolated from its surroundings by placing it in a large autoclave bag before inoculation and moved to a greenhouse cubicle that was only used for inoculation. An aerosol spray gun was calibrated so it sprayed 10 ml of suspension in 10 s. The Falcon tube containing the spore suspension was attached to the spray gun, and, while holding the spray head inside the autoclave bag, a 10 s spray was applied to the tray of seedlings ensuring that the leaves, tops and bottoms, were saturated in spore suspension. After spraying, the tops of the autoclave bags were tied so that the tray was sealed inside and no leaves were touching

the sides of the bag. The trays were watered prior to inoculation to prevent the seedlings suffering from moisture deficiency. The spray gun was sterilised between isolates by repeatedly spraying with 70% ethanol and sterile distilled water. The sealed trays were kept in the greenhouse cubicle at 25-27°C (under daylight bulbs as necessary) for 7-8 days.

Disease assessment

Preliminary work had shown that after one week, lesions on leaf four (counting from the bottom) were representative of the levels of infection and the following data were collected.

Lesion Number: The total number of blast lesions on 4th leaf per seedling

Disease Score: The percentage area covered by lesions (0%, 1%, 5%, 10%, 25%, 50%, 75%, 100%).

Pathogenicity of *Magnaporthe grisea* on seed heads of mature finger millet plants

Six finger millet varieties were selected for the mature plant experiments (Table 6). Each of these varieties was tested against eight *M. grisea* isolates. Two isolates were chose from each of the four isolate types namely neck, seed, leaf and weed (Table 7).

Table 6. Finger millet varieties used for mature plant pathogenicity tests

Variety Name	Susceptibility
Seremi 1	Resistant
Seremi 2	Resistant
Seremi 3	Resistant
PESE 1	Resistant
P665	Moderately Resistant
E11	Susceptible

Table 7. *Magnaporthe grisea* isolates used in the seed head inoculation and the plant part from which they were isolated

Magnaporthe grisea isolate	Isolate type
K5/23	Neck
K13/67	Neck
D5/S3	Seed
K15/80	Seed
D10/S54	Leaf
K33/189	Leaf
WS12	Weed
WS4	Weed

Growing finger millet plants to maturity

The plants were all sown and grown in a controlled temperature environment. Temperatures of 25°C were maintained in each of the glasshouse cubicles used. The seed of each finger millet variety was sown in bulk in potting compost and watered regularly. After 4 weeks the seedlings were transplanted into potting compost in 9 inch pots, three seedlings of the same variety to each pot. Ten pots of three seedlings (at least three heads to inoculate) were required for each variety/*M. grisea* isolate combination. Thus a total of 480 (10 pots x 6 varieties x 8 isolates) pots of three seedlings were set up for the inoculations. Due to the differences in maturity time (production of a mature seed head) of different varieties, the

inoculations were done on different days (Table 8). The plants were ready for inoculation when they.

Table 8. Time of inoculation of the seed heads of the finger millet varieties with *Magnaporthe grisea* inoculum

Fm variety	Inoculation date (weeks post sowing)
E11	12
PESE	15
Seremi 1	16
Seremi 2	16
Seremi 3	16
P665	18

Preparing the seed heads for inoculation
A 10 cm poly-grip bag with its bottom cut open was placed over a single seed head on each of the three plants in each pot and tied at the stems. This provided a contained environment in which to apply the inoculum. Ten pots per variety were prepared (30 heads) in this way for each of the six fm varieties and replicated for each of the eight isolates inoculated.

Collecting and spraying *Magnaporthe grisea* spore suspension
The *M. grisea* spores were collected as described in the seedling pathogenicity test. Spore suspension (200 ml) was prepared for each isolate tested. The seed head in each poly-bag was sprayed with spore suspension (10^5 spores per ml) for a duration of 5 seconds (approx. 3 ml/bag). The seed heads were sprayed to achieve complete cover with spore suspension. Some of the remaining seed heads were similarly enclosed in poly-bags and sprayed with distilled water as controls. The poly-bags were sealed (using the top seals) and the plants were maintained in the greenhouse for a further 2 days. The bags were then removed and the plants were maintained for a further 12 days to allow the blast symptoms to develop.

Disease scoring
Fourteen days after inoculation each of the sprayed seed heads were examined for infection symptoms, which included discolouring of the fingers from green to brown and detachment of seeds from the seed heads. Each seed head was classified as having no infection, partial infection or total infection:

No infection	A seed head with no infection looked as it did pre-inoculation and in the uninoculated controls i.e. green and healthy.
Partial infection	A partially-infected seed head showed signs of infection on some but not all of the fingers of the seed head. The infection may or may not have covered all of a finger on the seed head.
Total infection	A totally-infected seed head had all the fingers infected. No finger on the head showed any sign of active growth or seed set.

After disease scoring, all infected material was bagged and autoclaved before disposal.

Analysis of data
All data were prepared for analysis of variance by Genstat. The raw data were averaged between replicates and for either the different isolates or the different varieties.

4. Screening for host resistance

In order to evaluate the blast reaction of finger millet varieties grown by farmers in Western Kenya, a collection of farmer varieties was carried out in Busia, Teso, Kisii, Gucha and Kericho. A total of sixty five varieties were collected comprising of twelve from Busia, twenty five from Teso, sixteen from Kisii, six from Gucha and six from Kericho. These varieties were screened to assess their blast reaction status and identify blast resistant/tolerant and agronomically superior landraces for farmer use and as sources of resistance in breeding and varietal improvement programmes

A total of 95 finger millet entries in the trials included the 65 farmer varieties plus 30 breeding lines of known reaction to blast (susceptible and tolerant) from ICRISAT-Nairobi collection. They were grown at the Kenya Agricultural Research Institute's (KARI's) Alupe research center in Teso district of Western Kenya. The lines were screened for blast resistance under natural pathogen infection. Alupe, at altitude of 1189 m above sea level ($0^0$29'N and $34^0$08'E) has a mean annual temp of 29.0^{0}C (Max) and 15.5^{0}C (Min), and a mean annual rainfall of between 1200 – 1400 mm. The high temperatures, the rainfall and high humidity prevalent at Alupe are ideal conditions for the development of the blast pathogen.

The trial was planted in 3 replications, 2 row plots with each row 3-m long. Row to row distance of 50 cm and plant to plant distance of 10cm were maintained throughout the plots. The trial was planted in two seasons, Feb-July 2002 long rainy season (LR) and August-December 2002 short rainy season (SR). Sowing was done by hand drilling the seed in furrows and two and half weeks after emergence, the plants were thinned to leave one plant per hill. Weeding was carried out two times in each of the two seasons with the first weeding done two weeks after crop emergence and the second weeding done three weeks later. To enhance disease development, one row of a blast susceptible variety (indicator cum infector) KNE 479 was planted after every four rows of test material, following standard ICRISAT practices. All plots received 19 kg P_2O_5 and 20 kg N ha^{-1} at sowing as DAP fertilizer (18:46:0) and a further 20 kg N ha^{-1} after thinning as urea fertilizer; no pesticide treatments were given.

The three phases of the disease (leaf, neck and finger) were separately scored (visual subjective scoring). Disease incidence was scored on 0-9 scale where 0= no disease and 9 = more than 75% leaf area covered for leaf blast and 0= no disease (all panicles have no disease on neck and finger) and 9 = 81-100% panicles severely infected for neck and finger blast. Disease incidence scoring for leaf blast was done at seedling and booting stages whereas incidence scoring for finger blast was carried out at physiological maturity and at harvest. Neck blast incidence scores were also taken at physiological maturity and at harvesting. Disease severity rating (% damage) was done for leaf blast at booting stage and at harvest for finger blast. Data were also taken on grain yield, days to 50% flowering, plant heights, seedling vigour, and agronomic performance. Rainfall received during the growing seasons was 961.0 mm in the long rainy season 2002 and 636.1 mm in the short rainy season 2002/2003.

Field epidemiology work

Epidemiological field experiments were conducted at SAARI, Uganda in 2003. The institute is located 27 km south of Soroti district. The area receives bimodal rainfall pattern with the first rains starting in March to August, and second rains from September to December. The first and second rains are usually referred to as first and second season respectively. The area has sandy loam soils with tropical savannah grassland vegetation. During the experimental period a total of 1453 mm of rainfall was received in 12 months. The maximum and minimum temperatures ranged from 28.9° C - 34.6° C and from 17.5° C – 18.6° C respectively in 2003. Experiments on 1) pathogen and disease spread on a range of finger millet varieties at a single site and 2) role of seed-borne inoculum in the development of blast, were conducted. In both first and second season, the experiments were established in fields which were under fallow for 3 years. This was aimed at minimising background contamination of the pathogen. Because of the small size of the finger millet seed, the field was disc ploughed 2 times and also disc harrowed twice to achieve a fine seed bed.

Pathogen and disease spread on a range of finger millet varieties at a single site
Sixteen finger millet varieties ranging from blast tolerant/resistant to susceptible were used including some of the recently released varieties such as SEREMI 1, SEREMI 2, SEREMI 3 and PESE 1 (blast resistant, early maturing and high yielding). The experiment was planted out as randomised complete block (RCB) design replicated 4 times. The plots were hand-planted in April 17 and October 25, 2003 during the first and second rains respectively. Each plot consisted of three rows, 5 m long, planted at a spacing of 60 cm x 20 cm. The plots within a block were separated by space of 1m while the blocks were separated by 1.5 m. Finger millet seedlings were thinned to 2 plants per hill two weeks after emergence. The plots were hand-weeded three times.

Prior to disease assessment, finger millet plants in the middle row were tagged. Percentage leaf area affected was assessed on tagged ten plants on a whole plant basis using a scale of 0-75%. Leaf blast was assessed five times during the second rains beginning November 14th. A total of 20 tillers were tagged in each plot at booting and used to assess neck and head blast infection. For each plot, the number of plants with neck, and head blast were counted at weekly intervals for a total of six times. Severity of blast was assessed once prior to harvesting on a scale of 0-75%. The three rows of each plot were harvested, sun-dried, threshed and their grain yield (kg/ha) determined.

Percentage leaf area affected in ten individual plants was averaged and data from the four assessments was used to compute the area under disease progress curve (AUDPC) for each variety. Similarly the percentage incidence of neck and head blast was calculated for each variety and the 6 assessments were used to compute AUDPC. The disease and grain yield data was subjected to analysis of variance (ANOVA) to test for differences among varieties using Genstat statistical package.

Role of seedborne inoculum in the development of blast
This trial was conducted during the first and the second rains of 2003 at SAARI. The percentage of finger millet seed infected by *M. grisea* was determined by blotter method and later used to establish the plots. The treatments consisted of naturally infected seed at three levels 1%, 2.5%, 5% and uninfected seed (0%). The 2.5 % level was constituted by mixing uninfected (0%) and 5% infected seed each constituting half (0.25 g) by weight. The experiment was planted as randomized complete block design replicated 4 times. Each plot consisted of 6 rows, 5 m long, planted at a spacing of 60 cm x 20 cm and enclosed with 5 rows of maize planted at a spacing of 60 cm x 20 cm. A space of 1 m separated the finger millet rows from the maize rows all round the plot. This was done to minimize inter-plot interference and contamination from external inoculum. The trial was thinned to 2 plants per hill two weeks after emergence and hand-weeded three times.

Prior to data recording, at each growth stage, plants in the 2 middle rows were tagged and used for disease assessments. The number of plants infected by blast and severity of blast was recorded for leaf and head blast. However, for neck blast, only number of infected tillers was recorded. A total of 20 plants were tagged on each row and counts of blast infected plants were recorded starting June 16th. A total of three recordings were made. Leaf blast severity was assessed on a whole plant basis on a scale of 0-75 % starting June 18th for a total of five assessments, using 10 tagged plants, five from each row.

Similarly, the assessment of neck and head blast was done on 40 separately tagged tillers (20 from each row) in the two middle rows. The tagging was done at 50 % heading to avoid bias. The number of tillers' with neck or head infection were separately counted in each plot for a total of 6 times at weekly intervals. Using the above scale, the severity of head blast was assessed on 10 tagged plants in the 2 middle rows. The severity was assessed 4 times at weekly intervals starting August 13th. At maturity, 4 middle rows in each plot were harvested, sun-dried, winnowed to remove the trash and weighed. The plot yields were used to determine the grain yield (kg/ha). As there was high background infection in this trial, the subsequent trial was modified as below.

During the second rains, the trial was modified to include higher percentage of infected seed, after seed testing. The treatments included 0, 0.5%, 5.5% and 13.5%. The experiment was

planted as described above. The incidence of seedling blast was recorded starting at two weeks after emergence and at weekly intervals thereafter for a total of five times and this trial was not thinned to facilitate conditions suitable for early blast development. The trial was terminated after five disease assessments, to avoid the interference of background inoculum.

Outputs

i). New knowledge on genetic and pathogenic diversity and mating compatibilities of East African finger millet blast populations generated, information on the blast incidence and constraints faced in disease management gathered and tools and local capability for long-term pathogen monitoring developed.

ii). Understanding of the pathogen epidemiology particularly the potential of infected seeds and weeds in disease development and identification of various sources of resistance achieved contributing to improved disease management and the knowledge disseminated.

1. Socio-economic and disease surveys in Kenya and Uganda

Kenya

In all districts, more women farmers than men attended and participated in finger millet production and blast disease appraisal meetings (Figure1). This can be attributed to the fact that more women than men engage in farming, especially finger millet production. Farm resources under discussion at the meetings were farm sizes, family labour, hired labour and off-farm income earning opportunities. A greater proportion of participants in Kisii owned less than two acres of land while a greater proportion in Busia and Teso owned more than two acres of land (Figure 2). In all 3 districts most households had only 1-2 family members out of 8 members providing labour on a regular basis to the farm (Figure 3). This excludes school going family members who only work in the farm during weekends. While casual labour for farm work was common in all the 3 districts, permanent labour was virtually non-existent except in Teso where a few households hired them, possibly sourced from their neighbours in Uganda (Figure 4). However, off-farm income earning opportunities are more predominant in Kisii due to presence of tea and other important cash crops unlike in the other two districts.

Figure 1 Number of farmers attending the PRA meetings

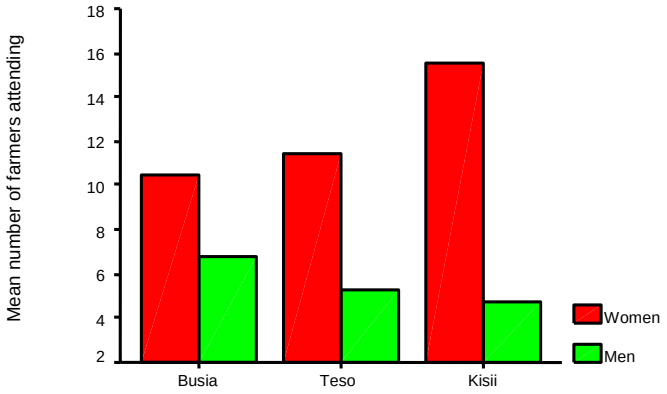
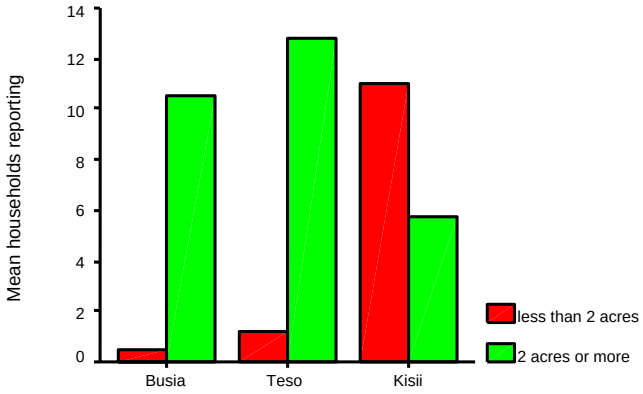


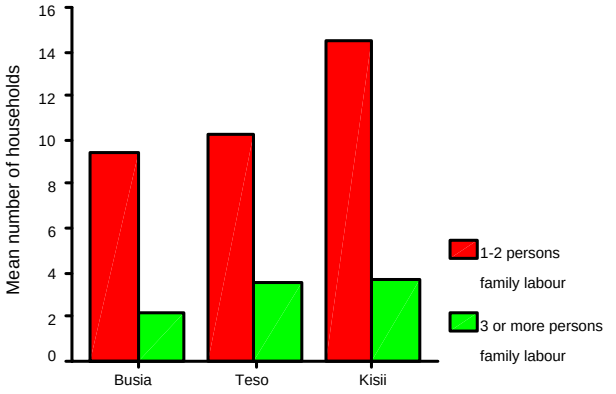
Figure 2: Categories of farm sizes

owned by PRA participants



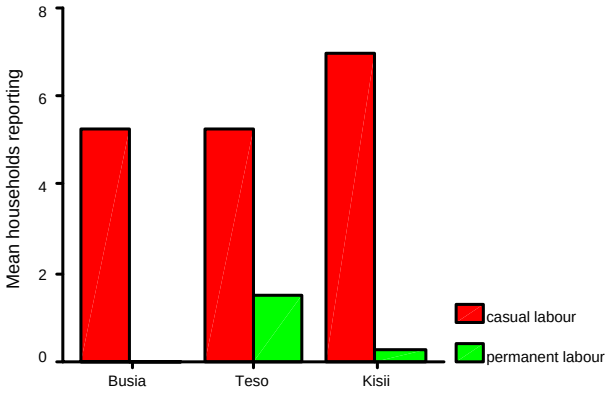
Figuer 3: Mean number of households

and categories of family labour



Figuer 4: Mean number participants

and categories of hired labour



Crop enterprises

The 12 farmer groups were asked to list the major crops grown in the area. The major crops listed by all four groups in Busia were maize, sweet potato, finger millet, beans, bananas, cassava, kales, sugarcane, bambara nuts, groundnuts and arrow roots. In Teso, crops reported as major ones by all four groups were maize, sorghum, sweet potatoes, finger millet,

beans, banana, cassava, sugarcane (industrial sugar), groundnuts, fruits and sesame and in Kisii they were maize, sweet potatoes, finger millet, beans, bananas, pyrethrum, traditional vegetables, onions, tomatoes, napier grass and irish potatoes. The other major crops cited by farmer groups in each district were sorghum, cowpea, fruits, soya beans, green grams, onions, tomatoes and sesame in Busia; local vegetables, green grams and soya in Teso; and cassava, sugarcane (chewing type), fruits, tea and wheat in Kisii. The most important food crops listed and ranked in order of importance by women and men farmers are in Table 9. Women and men alike ranked finger millet, which invariably blended with cassava to make the main staple "ugali", as the most important food crop in Teso District. While in Kisii finger millet was clearly the second most important food crop after maize, in Busia finger millet or sorghum was second to maize in importance as food crop.

Table 9. Most important food crops for women and men farmers in Busia, Teso, and Kisii districts, Western Kenya

Importance of crop	Food crop (number of farmer groups reporting)		
	Busia	**Teso**	**Kisii**
Most important:			
Women	-Maize (3)	-Finger millet (2)/ cassava (2)	-Maize (4)
		-Finger millet (3)	
Men	-Maize (2)		-Maize (3)
2nd most important			
Women	-Maize/ fingermillet/ sorghum/beans (1)	-Cassava (3)	- Finger millet (4)
Men	-Sorghum/finger millet(2)	-Cassava (3)	-Finger millet (3)
3rd most important			
Women	-Sorghum/finger millet(2)	-Maize/sorghum(2)	-Bean (3)
Men	-Maize/sorghum/finger millet/cassava (1)	-Maize (3)	-Sweet potatoes (3)
4th most important			
Women	-Cassava(3)	-Maize/sorghum/finger millet/beans (1)	-Banana (3)
			-Bananas (2)
Men	-Sweet potatoes(2)	- Sorghum (3)	

Numbers in brackets refer to the number of farmer groups reporting

Table 10 shows the importance of various crops as sources of cash for Busia, Teso and Kisii farmers. In Kisii, finger millet was clearly the third most important cash crop after tea and pyrethrum, while in Teso men ranked it higher (2nd) than women (4th) as a source of cash. In Busia, women and men ranked finger millet as most and 2nd most important cash crop, respectively.

Finger millet and its advantages

Finger millet is planted only during the LRs in Busia and Teso due to tradition – there is a strong belief that any one who sows finger millet during the short rains is doomed to die. In Kisii, however, finger millet is planted in both LRs and SRs, with the SRs being more important finger millet season as farmers reported that high rainfall and cold temperatures in LRs predispose finger millet to serious damage by diseases. Generally same varieties sown in LRs were also sown in SRs in Kisii. Finger millet was reported to have several advantages over other grains. The most important of these were higher marketability (11 groups), more nutritious "uji" for children (10 groups), use in traditional ceremonies (7 groups), meets food security requirements better (6 groups) and makes high quality beer (5 groups). Finger millet "kept hunger at bay" as it does not deplete quickly and stores for long periods of time without significant storage weevil damage.

Finger millet varieties and their characteristics

Table 11 shows various finger millet types sown in the 3 districts. There were 7 different types sown in Busia out of which three were improved types disseminated through KARI-Kakamega (Gulu – E, P224 and U15) and the others were local landraces. Teso farmer groups reported sowing only one improved finger millet type (Gulu – E) out of seven types reported, while Kisii reported only the local types despite earlier exposure to improved types by KARI-Kisii.

Table 10. Most important cash crops for women and men farmers in Busia, Teso, and Kisii districts, Western Kenya

Level of importance of crop	Cash crop (number of farmer groups reporting) Busia	Teso	Kisii
Most important			
Women	-Sugarcane/finger millet (2) -Sugarcane (3)	-Tobacco (2)	- Tea (4)
Men		-sugarcane/groundnuts/ tobacco/sunflower(1)	- Tea (4)
2nd most important:			
Women	-Maize/finger millet/kales/groundnuts(1)	-Sugarcane(2)	-Pyrethrum(3)
Men	-Maize/finger millet (2)	-Finger millet (2)	-Pyrethrum (3)
3rd most important:			
Women	-Maize/sorghum/beans/ cotton (1)	-Maize(2)	-Finger millet(3)
Men	-Maize/sorghum/beans/ groundnuts (1)	-Maize(2)	-Finger millet (3)
4th most important			
Women	-Maize/sweet potatoes/ groundnuts/coffee(1)	-Finger millet/maize(2)	-Beans(2)
Men	-Beans (2)	-finger millet/kales/beans/ pepper(1)	-Maize (2)

Numbers in brackets refer to the number of farmer groups reporting

Table 11. Finger millet types sown by participating farmer groups in Busia, Teso and Kisii districts, Western Kenya

Finger millet varieties sown (number of surveyed groups reporting)		
Busia	**Teso**	**Kisii**
1. Ikhulule (4)	1. Obokoro (4)	1. Enaikuru (4)
2. Gulu-E (3)	2. Emumware (4)	2. Enyakundi (4)
3. P224 (3)	3. Aran (4)	3. Enyandabu (3)
4. U15 (1)	4. Ebonit (3)	4. Endere (2)
5. Khayoni (1)	5. Eleurot (2)	5. Morogi (2)
6. Agriculture (1)	6. Gulu – E (1)	6. Marege(2)
7. Maderekasabale (1)	7. Eblue (1)	7. Omokomoni (1)
		8. Amatugi (1)

Attributes of major finger millet varieties are shown in Table 12 and a summary in Table 13. Varieties possessing most of the desirable qualities were Ikhulule in Busia, Emumware in Teso and Enaikuru in Kisii. Enyakundi and Marege were evaluated to possess some level of resistance to blast disease in Kisii District. Farmer groups also listed important disadvantages of the various finger millet varieties. The result showing disadvantages of each variety as cited by at least two groups is hereby summarized.

Table 12. Positive attributes of some major finger millet varieties sown in Busia, Teso and Kisii districts, Western Kenya

Positive quality	Number of groups reporting the positive quality of variety													
	Ikhulule	Gulu	P224	Obokoro	Emumware	Aran	Ebonit	Eleurot	Enaikuru	Enyakundi	Enyandabu	Endere	Morogi	Marege
High yield	2	2	1	2	3	-	1	-	4	2	2	1	1	1
Early maturity	1	2	3	1	1	4	1	1	2	2	2	2	-	1
Large panicles	1	2	1	2	-	-	1	2	-	-	-	-	-	-
Good beer	4	-	-	1	2	1	1	-	3	1	1	-	-	-
Less bird damage	4	1	-	-	1	-	-	-	-	1	1	-	-	-
Blast tolerance	-	-	-	-	-	-	-	-	-	3	1	-	-	2
Less shatter	2	1	1	-	-	-	1	-	-	-	-	-	-	-
Blends well with cassava	2	-	-	-	3	-	-	-	-	-	-	-	-	-
Good marketabilty	2	-	-	2	3	-	1	-	3	-	1	1	-	-
Good grain colour	-	1	-	-	1	-	-	-	-	-	1	-	-	-
Easy to thresh	-	2	1	1	-	1	-	-	-	-	-	-	-	-
High threshing percentage	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Sweet taste (white grain)	-	-	1	1	-	3	-	1	3	2	2	-	-	-
Less lodging	-	-	-	1	1	1	-	-	-	-	1	-	-	-

- Not reported in the site

While all four groups in Kisii rated Enaikuru as blast susceptible, late maturing varieties were Ikhulule, Obokoro and Emumware. Varieties that were susceptible to bird damage were Gulu-E, P224, Obokoro and Aran and those rated as unpalatable (especially in "uji" and "ugali") were Ikhulule and Emumware. Gulu-E, P224 and Aran were susceptible to shattering and Morogi and Aran were less marketable. The main determinant of good marketability was grain colour and red-grained types were most preferred

Table 13. Summary of positive qualities of main finger millet varieties in Busia, Teso and Kisii districts, Western Kenya

Positive quality	***Varieties reported by at least 2 groups as possessing the quality***		
	Busia	***Teso***	***Kisii***
Resistant to blast	-	-	Enyakundi Marege
High yield	Ikhulule Gulu - E	Obokoro Emumware	Enaikuru Enyakundi Enyandabu
Early maturity	Gulu – E P224	Aran	Enaikuru Enyakundi Enyandabu Endere
Makes good beer	Ikhulule	Emumware	Enaikuru
Less bird damage	Ikhulule	-	-
Resistant to shattering	Ikhulule	-	-
Blends well with cassava	Ikhulule	Emumware	-
Good market	Ikhulule	Obokoro Emumware	Enaikuru
Easy to thresh	Gulu E	-	-
Sweet taste (white grain)	-	Aran	Enaikuru Enyakundi Enyandabu

The previous section dealt with the farmers' perception of the advantages and disadvantages of various finger millet types. The farmer groups by gender were asked to rate the importance of finger millet characteristics in a scale of 1-3 (where1=low importance, 2=moderate importance, 3=high importance). Characteristics rated of high importance (means close to score 3) by women and men are summarized in Table 14. Altogether there were a total of 9 preferred characteristics. Except for high yield, which was preferred across the three districts by both women and men, there were differences in the preference of other characteristics. Resistance to blast and marketability were of high importance in Kisii, while in Busia and Teso early maturity was more important.

Table 14. Finger millet characteristics of high importance to women and men farmers in Busia, Teso and Kisii districts, Western Kenya

Preferred characteristics of finger millet	*Busia District*		*Teso District*		*Kisii District*	
	Women	*Men*	*Women*	*Men*	*Women*	*Men*
1. Early maturity	✔	✔	✔			
2. Large panicles	✔	✔				✔
3. High yield	✔	✔	✔	✔	✔	✔
4. Marketability			✔		✔	✔
5. Makes good beer				✔		
6. Less bird damage				✔		
7. Good taste				✔		✔
8. Blast resistance					✔	✔
9. Good grain colour					✔	

With the background information of the farmer groups' perception of advantages and disadvantages of various finger millet varieties as well as relative importance of the advantages, Figures 5 and 6 show the groups' responses indicating the most preferred varieties by women and men, respectively in the three districts. In Busia women preferred Ikhulule while men preferred Gulu-E, an improved variety. Ikhulule is high yielding, makes good beer, has good market and blends well with cassava but is late maturing, while Gulu-E is early maturing, high yielding and easy to thresh but susceptible to bird damage. In Teso and Kisii there were no differences in finger millet preferences between women and men.

Figure 5. Most preferred finger millet type by women farmers

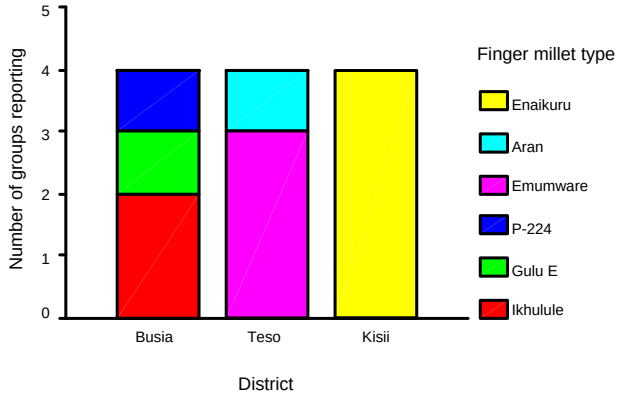
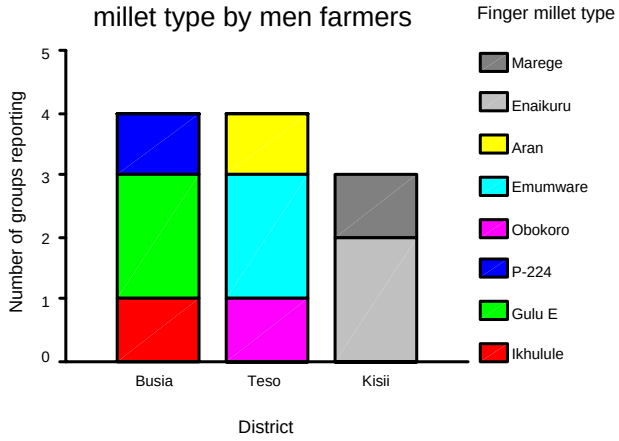


Figure 6. Most preferred finger millet type by men farmers



Twenty five percent of individual PRA participants reported loss of old finger millet varieties mainly due to lack of virgin land (3 groups), late maturity of the old varieties (4 groups) and introduction of better varieties (3 groups). Some finger millet varieties were abandoned due to low productivity, especially under prevailing low soil fertility conditions.

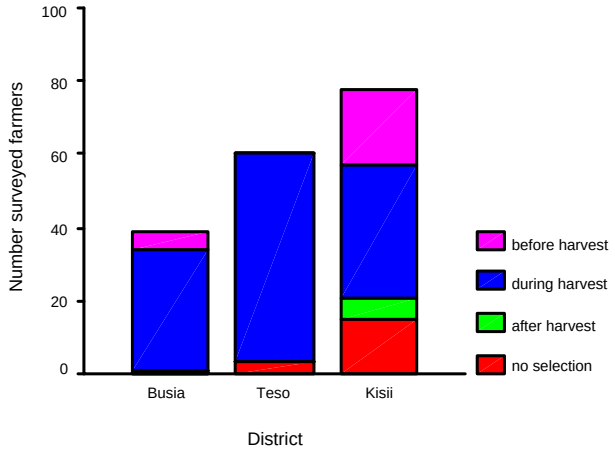
Management practices for finger millet

Improvement of any production system through identification of constraints and potential interventions should take cognisance of current production practices employed by the farmers from seed selection to utilization.

Seed selection

Majority of farmers in the three surveyed districts selected seed of finger millet during harvesting (Figure 7). A good number of farmers in Kisii did not select finger millet seed or did selection before harvest. Asked to list 3 most important finger millet seed selection criteria in descending order, surveyed groups reported large panicles (6 groups), blast free (8 groups) and uniform fingers (4 groups). The selection criteria did not vary significantly by district.

Figure 7. Time of seed selection



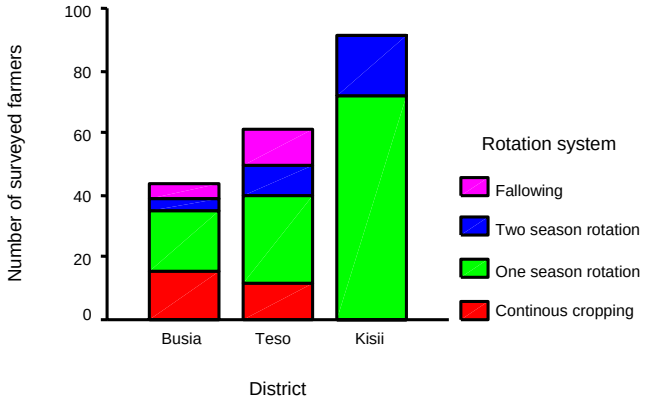
Method of planting

In Kisii almost all surveyed farmers used hand hoe for seedbed preparation, while about 50% and less than 25% of surveyed farmers in Busia and Teso Districts, respectively, used oxen-plough for seedbed preparation, while a majority of farmers in Kisii and virtually all farmers in Teso broadcasted their finger millet, line planting was the predominant practice in Busia. A small proportion of farmers in Kisii and Busia practiced line planting and broadcasting, respectively.

Fertility management

All surveyed farmers in Kisii used DAP type of inorganic fertilizers. In Busia, out of 38 farmers using various fertility improvement practices, 32%, 53% and 16% reported use of inorganic fertilizers, farmyard manure and compost manure in finger millet production, respectively. In Teso, farmers employed no soil fertility improvement practices in finger millet production, according to the survey. While sole cropping was the predominant practice in Kisii, intercropping was practiced by a majority of farmers in Teso. However, intercropping and sole cropping was equally practiced in Busia. The major intercrops were maize (reported by 8 PRA groups), sorghum (reported 6 PRA groups) and sesame (reported by 1 PRA group). Relay cropping of finger millet was an important management practice in Kisii as reported by over 50% of surveyed farmers. All surveyed farmers from Kisii employed some rotational system (except fallowing) in finger millet production, while some participants in Busia and Teso did not practice crop rotation at all (Figure 8).

Figure 8. System of rotation practiced in finger millet production



Weed management

In all the three districts the majority of surveyed farmers weeded finger millet fields once- 4 weeks after emergence. Surveyed groups were asked to list four most important weeds of finger millet. In Busia and Teso districts, most important weeds affecting finger millet were the same (Figures 9a, 9b). Kisii had had different weed types and striga was not one of them (Figure 9c).

Figure 9a. Most important weeds of finger millet in Busia District

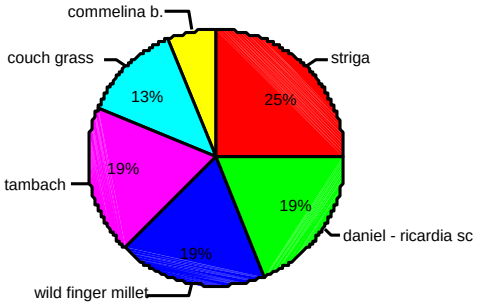


Figure 9b. Most important weeds of finger millet in Teso District

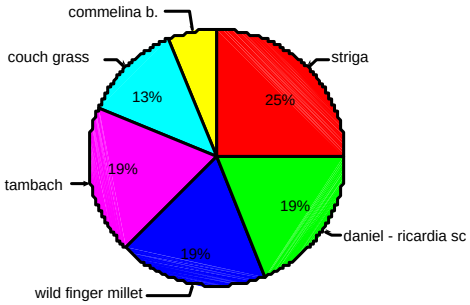
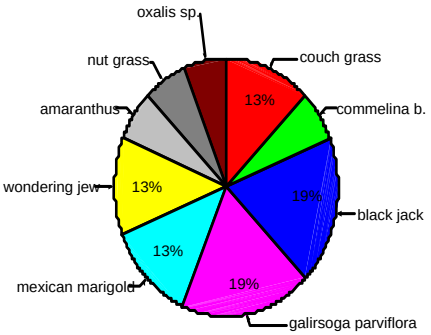


Figure 9c. Most important weeds

of finger millet in Kisii District

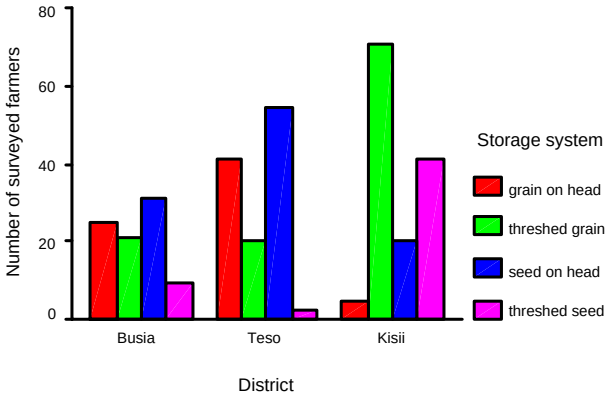


Grain and seed storage

Finger millet grain storage procedure differed by district (Figure 10). While finger millet was mainly stored in threshed form in Kisii, in Teso District, storage of finger millet grain on the head was more frequent. In Busia storage of grain on head was as important as storage in threshed form. The form of storage was a reflection of the major objective of finger millet producers. In Teso District where finger millet production was more important in meeting food security needs finger millet grain was mostly stored on the head, while in Kisii District where the main objective of farmers was to meet household cash needs grain was mostly stored in threshed form. However, storage of finger millet seed on head was important in all districts.

Figure 10. Finger millet grain

and seed storage procedures



Finger millet yield and household production

Among the farmers growing finger millet, majority in all the three districts had finger millet fields measuring less than ¼ acre (Table 15), although more farmers had larger fields in Busia and Teso than in Kisii. Estimated mean yield per acre was 323 kg in Busia, 274 kg in Teso and 396 kg in Kisii, showing that use of inorganic fertilizers and/or farm yard manure in Kisii and Busia Districts enhanced finger millet yields significantly. Mean household production was 185 kg in Kisii, 151 kg in Busia and 128 kg in Teso.

Table 15. Proportion of surveyed farmers reporting various acreages of finger millet fields in Busia, Teso and Kisii districts in 2001 and 2002 seasons

Area (acres) under finger millet	Percentage of surveyed farmers reporting in District					
	Busia		Teso		Kisii	
	2001 (N=36)	**2002 (N=51)**	**2001 (N=50)**	**2002 (N=59)**	**2001 (64)**	**2002 (N=70)**
None	52	18	14	17	17	9
Less than ¼ acre	25	47	42	47	75	80
¼ - ½ acre	17	27	36	25	8	10
More than ½ -1 acre	6	6	8	5	0	1
More than 1 acre	0	2	0	2	0	0
Total percentage	100	100	100	100	100	100

N=number of respondents

Finger millet marketing and utilisation

Separate groups of men and women were asked to cite the most important use of finger millet grain. The group responses are summarised in Figures11a and b. Women PRA participants perceived finger millet as a much more important source of cash than their male counterparts. Perhaps this is explained by the fact that finger millet is considered a woman's crop in all the 3 districts. Of the 3 districts, finger millet was a very important subsistence cereal crop in Teso District where it was least commercialised (Figure 12) and used mainly in preparing ugali (stiff porridge) and local brews and most commercialised in Kisii. Although open-air market traders and middlemen at the farm gate were the most important buyers of finger millet grain in all 3 districts, there were slight differences in finger millet grain trade (Table 16).

Figure 11a. Women's most important uses of finger millet grain

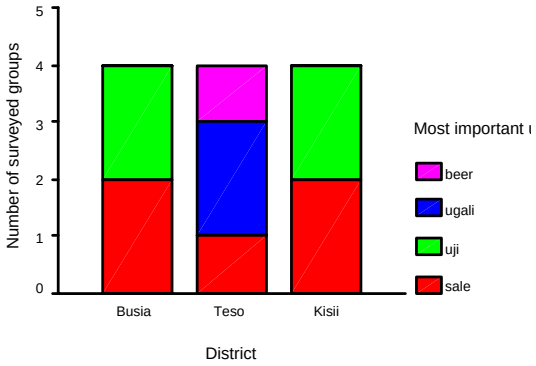


Figure 11b. Men's most important uses of finger millet grain

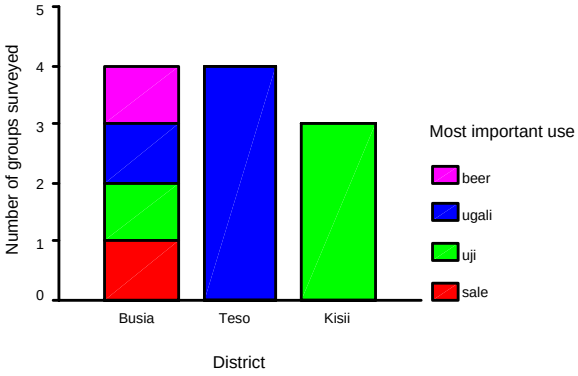


Figure 12. Relative amounts of finger millet grain sold

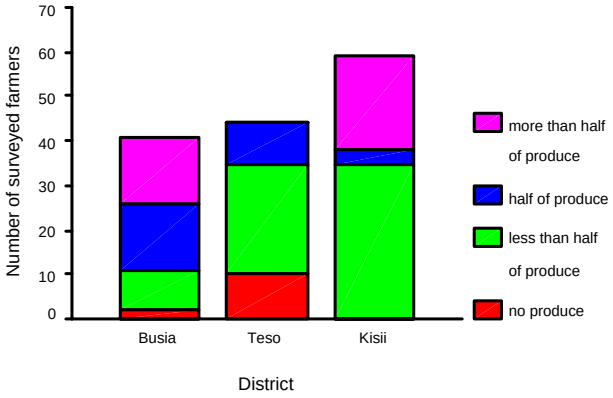


Table 16. Most important finger millet grain buyers in Busia, Teso and Kisii districts, Western Kenya

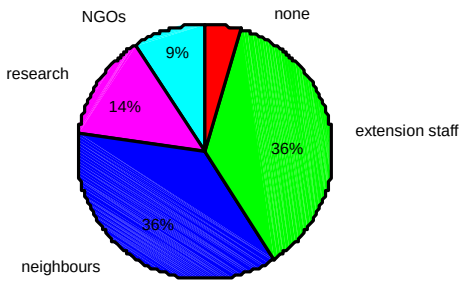
Traders	Districts		
	Busia (N)	**Teso (N)**	***Kisii (N)***
Open air market traders	✔ (3)	✔ (4)	✔ (3)
Middlemen at farm gate	✔ (2)	✔ (1)	✔ (2)
Shopkeepers in local market		✔ (3)	
Long distant traders	✔ (1)		✔ (2)

N = number of groups reporting

Sources of information

Surveyed farmers reported that local community/neighbours were as important as Ministry of Agriculture extension agents in providing information on improved finger millet production (Figure 13). Therefore, community and farmer-to- farmer information dissemination process should be strengthened and used in disseminating new information on improving finger millet production.

Figure 13: information providers on finger millet production



Finger millet seed sources

Farmers were asked about sources of local and improved finger millet seed used during 2001 and 2002 planting seasons. The results are shown in Table 17. While local seed was predominant in Teso and Kisii, improved seed was equally important as local in Busia. The main source of local seed was from own saved stock in all districts and other farmers in Busia and research sources in Kisii. The relative importance of improved varieties in Busia was associated with introduction of the varieties in a research cluster by KARI-Kakamega in early 1990's.

Table 17. Sources of finger millet seed used by surveyed farmers during 2001 and 2002 planting seasons in Busia, Teso and Kisii districts, Western Kenya

Seed sources	***Mean no. of farmers reporting per group***					
	Busia (N=4)		***Teso (N=4)***		***Kisii (N=4)***	
	2001	***2002***	***2001***	***2002***	***2001***	***2002***
Local seed						
Own saved	3.8	6.3	11.5	8.8	15.3	16.8
Other farmers	0.3	0.5	0.8	0.0	0.3	1.0
Open air market	0.0	0.3	0.5	0.3	0.5	0.8
Research	0.0	0.0	0.0	0.0	0.0	0.0
Improved seed:						
Own saved	5.3	4.3	3.3	0.3	2.0	0.0
Other farmers	0.8	2.3	0.8	0.0	0.0	0.0
Open air market	0.0	0.0	0.0	0.0	0.0	0.0
Research	0.0	0.0	0.0	0.0	0.0	2.0

N=number of groups surveyed

Finger millet production constraints

Surveyed female and male farmers were separately asked to list important constraints to production of finger millet. There were similarities on what were perceived as finger millet production constraints by both female and male farmers (Table 18). In Busia and Teso districts, the 3 most important constraints attributed to over 50% of the responses were striga weed, blast and high labour demand, especially for weeding. In Kisii District, where striga weed was non-existent, low soil fertility was cited among the three most important production constraints, in addition to blast and high labour demand. The minor constraints were birds (all districts), low soil fertility and stem bores (Busia and Teso).

Table 18. Constraints to finger millet production by gender in Busia, Teso and Kisii districts, Western Kenya

Production constraints	*Percentage of responses by District*					
	Busia		*Teso*		*Kisii*	
	Female (N=42)	*Male (N=28)*	*Female (N=46)*	*Male (N=22)*	*Female (N=62)*	*Male (N=20)*
Striga	19	19	19	18	0	0
Blast	19	19	14	14	15	14
High labour demand	14	19	19	18	15	14
Birds	10	14	5	9	11	10
Termite	5	0	0	0	0	0
Low soil fertility	10	10	10	9	15	14
Stem borers	10	14	10	9	0	0
Poor markets	0	0	10	9	7	10
Low yielding varieties	5	0	0	0	4	10
Inaccessibility of seed	10	5	5	5	7	5
Aphids	0	0	0	0	11	10
Lack of draft oxen	0	0	10	9	0	0
Drought	0	0	0	0	4	0
Frost	0	0	0	0	7	9
Inaccessible of technical information	0	0	0	0	4	5
Total	100	100	100	100	100	100

N=number of respondents

Farmers' groups were asked about strategies they employed to cope with the cited production constraints, and the results in percentages of total responses are in Table 19. While all groups had developed coping strategies against striga weed, high labour demand, low soil fertility and bird damage, they had none for blast. The farmers lacked adequate information to make informed decisions. This dearth of information is discussed later.

Surveyed groups were also asked to state the most important disadvantage of finger millet production, and 10 out of the 12 groups cited high labour demand, especially for weeding. Level of drudgery associated with weeding finger millet compared to other major cereals like maize or sorghum had no doubt led to a decrease in finger millet acreage and proportion of finger millet producers.

Table 19. Coping strategies for major finger millet production constraints in Western Kenya

Problem/copping strategy	**Percentage of responses**
Striga(N=13):	
Uproot before flower formation	69
Plant non-affected crops	15
Early planting	8
Apply farm yard manure	8
Blast(N=12):	
None	100
High labour demand (N=18):	
Use casual labour	39
Use communal labour	50
Plant small acreage	11
Low soil fertility (N=10)	
Apply farm yard manure	40
Use inorganic fertilizer	50
Use crop rotation	10
Bird damage (N=11):	
None	18
Use reflectors/used tapes	9
Scare crows	36
Bird scaring by farm labour	36

N = total number of responses

Blast disease

After a comprehensive description of blast disease and its effects on finger millet by the PRA facilitators, farmers (female and male separately) attending the meetings were asked whether they recognized the disease and its effects. About 50% of surveyed women in Busia district, 75% in Teso and 100% in Kisii reported that they were aware of the disease, with men's responses also following the same trend.

While there was no specific name given to the disease in Busia and Teso, in Kisii all the four surveyed groups called the blast "egetabo". Asked about the causes of blast, all surveyed groups in Busia and Teso districts were unaware, while in Kisii, 3 out of 4 surveyed groups reported that high blast incidences was associated with cold weather or heavy rainfall. Furthermore, knowledge about the mode of transmission of blast was completely lacking among all surveyed groups. Across the four districts, knowledge of blast and its transmission was non-existent and therefore, farmers did not adopt any specific strategies to combat the disease although one important seed selection criteria cited was healthy or disease free finger millet heads. Research and extension should intensify their efforts in disseminating information on improved finger millet production, including level of damage caused by blast and its control.

Occurrence of blast disease

Perceptions on blast disease incidences (rated as low, moderate or high) by female farmers from surveyed groups are in Table 20. In Kisii, where millet was grown in both long rains (LRs) and short rains (SRs), blast disease was most prevalent in LRs. In Busia and Teso, where finger millet was grown only during the LRs, prevalence of blast was generally moderate to high in Busia and low to moderate in Teso. Although finger millet is perceived as women's crop, the perceptions of men on blast disease followed the same trend.

Table 20. Perceptions on blast disease occurrence by female farmers from surveyed groups in Busia, Teso and Kisii districts, Western Kenya

District/season	Perceived levels of blast disease incidences (number of surveyed groups reporting)		
	Low	Moderate	High
Busia			
LRs 2001	✓ (1)	✓ (2)	✓ (1)
LRs 2002	✓ (1)	✓ (1)	✓ (2)
Teso			
LRs 2001	✓ (2)	✓ (1)	✓ (1)
LRs 2002	✓ (2)	✓ (2)	-
Kisii			
SRs 2001	✓ (2)	✓ (2)	-
LRs 2002	-	-	✓ (4)

Crop loss estimates

Surveyed groups were asked to cite the constraint that caused the greatest loss to finger millet production. Striga caused the greatest loss in finger millet production in Busia and Teso as reported by 3 and 2 groups out of 4, respectively. However, blast in Kisii caused the greatest loss in finger millet production as reported by 3 out of 4 groups surveyed. Surveyed groups were also asked to estimate percentage losses of finger millet grain caused by blast disease (Table 21). Across Districts, perceived loss of finger millet crop caused by blast was 26%. However, mean estimated crop losses caused by blast in Kisii were more than triple the losses in Busia and Teso.

Table 21. Finger millet grain losses caused by blast disease as perceived by surveyed groups in Busia, Teso and Kisii districts, Western Kenya

District (N)	Perceived losses in perecentage

	Mean	Minimum	Maximum
Busia (4)	16	10	25
Teso (4)	15	10	25
Kisii (4)	55	10	60
Total	26	10	60

N = number of groups responding

Further, individual farmers were asked to indicate whether the loss of finger millet crop by blast was low, moderate or high. The results are summarized in Figure 14a and 14b for women and men, respectively. Possible causes of higher losses by blast in Kisii than in Busia and Teso were favourable weather conditions, cropping finger millet in both seasons and more susceptible varieties.

Figure 14 a. Women's perception of grain losses due to blast disease

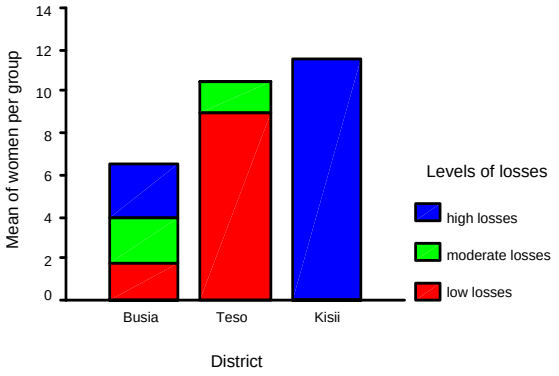
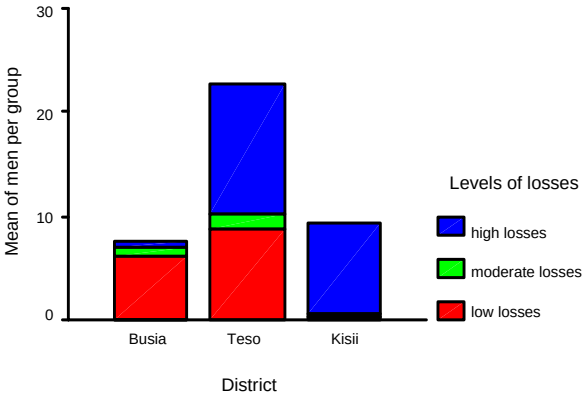


Figure 14 b. Men's perception of grain losses due to blast disease



Reaction of local and improved varieties to blast

Women and men, separately, rated in a scale of 1=low, 2=moderate and 3=high their perception of varietal susceptibility to blast. Results for varieties rated by at least 3 groups are presented in Figures 15a and b. Enaikuru, a popular variety in Kisii, was consistently rated by both women and men as highly susceptible to blast disease while Gulu-E in Busia was rated as moderately susceptible by women and lowly susceptible by men.

Figure 15a. Women's perception of varietal susceptibility to blast

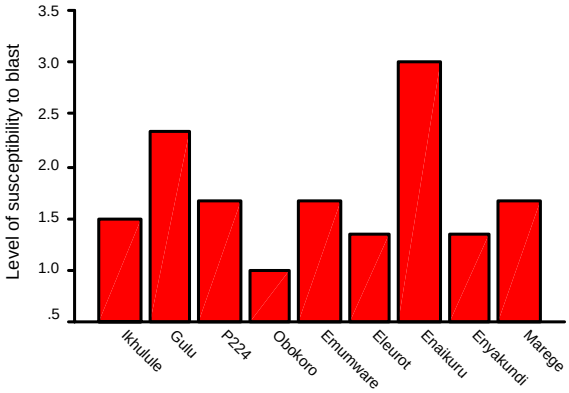
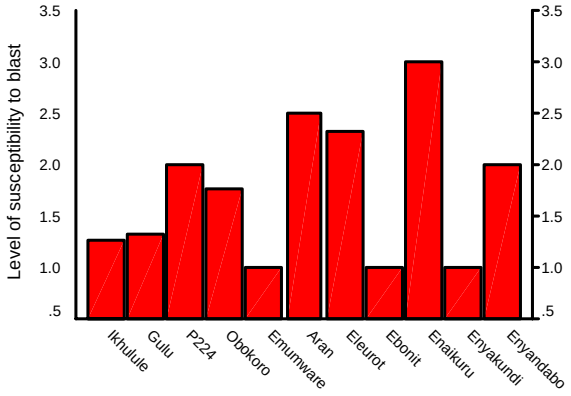


Figure 15b. Men's perception of varietal suceptibility to blast



Results of comparing farmers' perception of varietal susceptibility to blast with analysis of samples by the PRA team in Busia, Teso and Kisii are in Table 22. While farmers perceive

Enaikuru as highly susceptible to blast, the PRA team rated it as moderately susceptible. Finger millet varieties perceived by farmers to be moderately susceptibility to blast were rated to have low blast susceptibility by the PRA team.

Table 22. Blast susceptibility of finger millet varieties in Busia, Teso and Kisii: farmers' perception and project team assessment

Finger millet varieties	Farmers' perception of susceptibility by blast	Blast incidence score by project team in a scale of 0-9 (where 0=nil incidence and 9=81-100% incidence)
Ikhulule (B)	Low	3
Gulu-E (B)	Moderate	2
P224 (B)	Moderate	2
Obokoro (T)	Low	-
Emumware (T)	Moderate	2
Aran (T)	Moderate	3
Enaikuru (K)	High	5
Enyakundi (K)	Low	2
Enyandabu (K)	Moderate	-

B=Busia; T=Teso; K=Kisii.

Finger millet activity calendar

Women perform 12 out of 14 operations listed while men and children, respectively, participate in 8 and 7 operations (Table 23). Apart from women solely participating in weeding, which was invariably the most strenuous of all operations, they also participated in seed selection, drying, threshing and processing without significant help from men and children. Any improved technologies in millet production should aim at reducing the demand for labour from women who are already overburdened. The busiest months for finger millet production were January, July, August and December. Planting finger millet in the SRs (August), results in high labour demand in December, which is usually the festive season.

Table 23. Finger millet activity calendar for Busia, Teso and Kisii districts, Western Kenya

Activity	Most active members of household			Month(s) of the year the activity is performed											
	women	men	children	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Field selection	✔	✔													
Bush clearing		✔													
Seedbed preparation	✔	✔	✔												
Sowing	✔	✔	✔												
Weeding	✔														
Bird scaring			✔												
Seed selection	✔														
Seed harvest	✔	✔	✔												
Grain harvest	✔	✔	✔												
Transport	✔	✔	✔												
Drying	✔		✔												
Thresh	✔														
Storage	✔	✔													
Processing	✔														

Twelve farmer groups in Busia, Teso and Kisii Districts of Western Kenya took part in a participatory appraisal to determine production constraints, farmer preferences and prevalence of blast disease and its impact on finger millet production. The study found that finger millet, generally accepted as a woman's crop, was an important cash and food crop in the 3 districts because of its higher marketability, better nutrition and its ability to store better than other cereal grains. Its production was most commercialised in Kisii where Enaikuru was the most popular local variety due to high yielding, early maturity and good beer- and food-making qualities. In Teso, where it was least commercialised, Emumware was the most popular as it blended well with cassava to make "ugali", was high yielding and had good beer-making qualities. In Busia, a local type called Ikhulule was important for beer making and market. Improved varieties, Gulu-E and P224, were common in Busia where they were liked for their early maturity, although farmers rated them as moderately susceptible to blast disease. Farmers in Kisii rated "Marege" and "Enyakundi" varieties to have some level of resistance to blast disease. Research needs to identify varieties with resistance and develop and test adapt them in Western Kenya.

While striga weed was the most important constraint in Busia and Teso Districts, in Kisii blast disease was the most important constraint causing an estimated 60% of grain losses. Low soil fertility was also an important constraint in Kisii, while high demand for labour was cited in all 3 districts as limiting finger millet production. In Busia farmers have adopted row planting to reduce labour demand especially for weeding.

Uganda

The crops grown with millet in the Teso farming system (FS) were mainly cowpea, sorgum, cucumbers, simsim and maize, while in the Lango FS it was mainly simsim, malakwang (*Hibiscus* spp. used as a vegetable), pigeon peas, maize and sorghum. These crops were mainly grown in mixed cropping with millet.

Finger millet varieties grown varied from one location to another (Table 24); no variety was common to all sites and the farmers described various attributes preferred (Table 25). The number of varieties recorded across sites ranged from 5 to 8. All varieties in all sites were grown in the first season. In Putiputi and Adwari no varieties were grown in the second season. In other sites 2-5 varieties were grown in second season. The main reason given for growing less varieties in the second season was less reliable rains.

Table 24. Farmer grown varieties and their characteristics from farmers' experience

Districts surveyed		
	Varieties	**Attributes**
Kapujan		
1.	Eitoyo	Quick maturing
2.	Epus	Quick maturing
3.	Emorumoru	Very susceptible to draught
4.	Eirionit	Long maturing
5.	Adalaka	Does not set seed in adverse weather
Kyere		
1.	Igeresemu	Resistant to blast and drought, Does not shatter under rains, High yielding
2.	Emorumoru	Good brewing qualities, High yielding, Good grain colour
3.	Emiroit	Big heads, Good brewing quality
4.	Ebega	Early maturing, Lodges and shatters a lot.
5.	Engenyi	Drought tolerant, Early maturing
Putiputi		
1.	Erowa	Drought tolerant, Early maturing, High yielding
2.	Namata/Obeet	-
3.	Omududu	-
4.	Eitio	-
5.	Nangomi	-
6.	P224	New variety
7.	Seremi II	A new variety, Early maturing and High yielding
Chawente		
1.	Dyang adek	Long maturing, Drought resistant

2.	Kal dyang	Fairly drought resistant
3.	Oyoka	Susceptible to bird damage
4.	Ajuki nyinge	Very susceptible to bird damage, Highly susceptible to drought
5.	Otur alwete	Good eating quality, High yielding
6.	Ogwang Amicera	Early maturing, Drought resistant and Easy to harvest
Adwari		
1.	Egete	White seeded, Open handed
2.	Atunuru	Black seeded, Early maturing
3.	Ocen Amaii	Brown seeded' Closed handed
4.	Kiza	white seeded, Closed headed
5.	Seremi II	Early maturing
6.	Pese II	Shatters a lot in the field, Long maturing
Batta		
1.	Oturo Alwete	Short term, High yielding
2.	Ebaati	Yellow headed, Closed hands
3.	Omiji	Early maturing
4.	Omua	-
5.	Atunuru	Black seeded, Early maturing
6.	Oturowi	Short term

Table 25. Farmer desired characteristics of finger millet ranked in order of priority

i)	Early maturing
ii)	Whitish seeded
iii)	Good palatability
iv)	Drought tolerance
v)	Uniformity in height
vi)	Large heads
vii)	Easy to dry
viii)	Resistance to diseases especially blast
ix)	Good brewing qualities
x)	Good storability and viability
xi)	High tillering ability
xii)	High seed turnover (high yielding)
xiii)	Easy to clean
xiv)	Easy to market
xv)	None shattering
xvi)	Resistance to weeds especially striga
xvii)	Resistant to lodging
xviii)	Resistant to bird damage
xix)	Should be widely adaptable

In all the areas some varieties previously grown are not being grown now due to declining yields, entry of better varieties, susceptibility to striga, long maturity period, susceptibility to drought, shattering, poor taste and brewing qualities.

Importance of millet

The uses of millet included food as bread or porridge and for brewing alcoholic drinks, cash, animal feeds and seed. Men generally thought millet was more important for food and cash, while women thought it was important for food and brewing. In all locations, it was reported that only some of the farmers sold their millet. Farmers sold finger millet mainly to traders/middlemen and to neigbours who bought it mainly for brewing and sometimes for food and seed. The majority of the farmers saved their own seed. Others obtained seeds from the local community and other farmers. Very few farmers purchased seed from stockists. None of the farmers bought improved seed from stores. Most of the farmers in the Teso and Lango FS planed fields of 1-3 acres in size in the first rains. In the second rains however, most farmers planted fields of less than 1 acre. The yields recorded ranged between 40 and 600kg per acre in both 1st and 2nd rains, across locations.

Agronomic practices

Millet was planted by broadcasting in all locations. It was planted both as a pure crop and mixed but was commonly grown in mixed cropping. In the Teso FS it was grown mainly in

rotation following cotton, sweet potatoes, groundnuts, cassava and cowpeas and in the Lango FS following cotton, simsim, pigeon pea and maize. The order of rotation was not consistent. Some farmers especially in Teso were aware that millet should not follow sorghum because of the striga weed. None of the farmers used fertilizers or pesticides in millet production.All farmers weeded their millet. The majority weeded once, followed by those weeding twice. Farmers in Kyere reported weeding 3 times. The first weeding was commonly done 2 to 4 weeks after emergence and repeated 3 to 6 weeks when necessary. There was a wide range of weeds reported. In all locations more than 5 weed species were named as being common. Those that featured most included couch grass *Cynodon dactylon*, black jack (*Bidens pilosa*), *Commelina* spp., *Cyperus* spp., striga and spear grass among others. Others were named in the local language e.g Eladat, Eleketete, Esimama in Ateso; and Acer ayer and Kwor atara in Langi. Land preparation methods involved slashing and burning, and then ploughing using ox-ploughs or hand hoes.

Constraints to finger millet production

Men reported pests as the major constraint to millet production followed by drought, labour shortage and birds. The women reported labour constraints, drought, pests and bird damage (Table 26). As to coping strategies - for insect pests and diseases many farmers across locations had no coping strategy; adjusting planting time to overcome drought; communial work and crop rotation with root crops for weed management and pests and diseases; destroying termite mounds; bird scaring and grain storage for better price.

Table 26. Constraints to finger millet production ranked in order of importance as reported by men and women farmers across various districts in Uganda

Kyere	Kapujan	Putiputi	Adwari	Batta	Chawente
Men/women	Men/women	Men/women	Men/women	Men/women	Men/women
Drought Hailstones Insect pests Rodents and frogs Blast	Drought Insect pests Blast (Drying of heads) Labour shortage Domestic animals	Drought Weeds Pests Diseases	No ox-ploughs Lack of seed Pests and diseases Low prices Unproductive land	Pests Drought Labour Birds	Drought Birds Labour Blast Shoot fly

Finger Millet blast

All farmers in all locations except in Katakwi district were aware of millet blast. It had no local name in Katakwi. Farmers just used the phrase meaning “dry heads”. It was called “Egwetele/Ejetele” in Kyere, “Ebwetelele” and “Epepea” in Pallisa, “Obapu” in Adwari, “Kalajajwa” in Batta, and “Acanya” in Chawente. Most farmers in all locations described blast as caused by drought and late planting. In Putiputi farmers attributed the cause to a pest and sometimes soil conditions. The rest of the farmers had no knowledge of the cause. On the occurrence of blast disease symptoms farmers in almost all locations reported that blast symptoms were on the increase over the years. In Chawente the farmers did not observe any particular trend. Most farmers in all locations observed that blast was seasonal mainly appearing after flowering and/especially at maturity. In all five locations farmers pointed out 1-3 varieties which were more susceptible to blast. In Putiputi farmers reported that all varieties grown locally were susceptible. Farmers in Batta – Lira, observed that susceptibility was higher in open headed varieties compared to closed headed (compact) headed varieties. Farmers in Kyere, Kapujan and Puti-puti had no knowledge on disease transmission; in Chawente and Adwari farmers’ perception was that the disease was not transmitted from plant to plant; in Batta, farmers’ perception was that the disease was transmitted by wind, birds and also witchcraft. Thus there is a serious lack of awareness of the disease, pathogen and spread among the farmers in these areas. Crop losses attributed to blast were generally low compared to other causes. Farmers could not provide any estimates of crop losses in 5 locations. In Putiputi, however, farmers particularly women estimated 10-20% losses especially in over cultivated land.

Gender roles

The gender roles were almost similar across sites. Men were mainly involved in field selection, bush clearing, ploughing, sowing, transportation and marketing of millet. Women were mainly involved in sowing, harvesting, transportation, drying, threshing, winnowing, storage, processing and marketing. Women were less involved in field selection, bush clearing and bird scaring. Children were involved mainly in bird scaring, harvesting, transportation and drying. Children were involved in other activities as well but very rarely on field selection, clearing, sowing and marketing of the millet. Farmers in Kapujan and Putiputi reported that they had no source of technical information. Farmers elsewhere mentioned the role of community elders, friends and neighbors; also got information from radio, Agricultural Extension Workers, especially on improved agronomic practices and new varieties.

Although farmers recognized the damage and symptoms of blast disease, after careful explanation, most farmers did not know the cause, modes of transmission and control measures for blast disease. This dearth of information should be addressed urgently, particularly as most of the popular varieties are blast disease susceptible. Community based interactions observed both for source of information and seeds could be utilised for dissemination of awareness about pests and diseases and management technologies. It is important for research to evolve technologies including blast disease resistant varieties with farmer preferred qualities in order to overcome the constraints and dissemination of information on management of blast disease has potential to reduce farm level grain losses drastically.

Disease surveys

Kenya

In Busia/Teso Districts (Tables 27 and 28), finger millet is mostly broadcasted with the exception of parts of Nambale and Butula divisions in Busia district where row planting is practiced. It was established that areas where row planting is practiced have been covered by the KARI/MOA Extension crop demonstration sites. Most of the farmers plant variety mixtures; even when pure varieties were grown there was still a high degree of physical mixtures. Plant populations were high due to inadequate thinning and use of high seed rate. Knowledge of blast as a disease is absent although symptoms are known. Finger millet is grown only one season in a year (Feb-July rainy season) largely due to cultural reasons except at Alupe research station where two crops are raised in a year. There is low input use as no fertilizer is applied. Varieties planted include; Ikhulule, Namafura, Madere ka Sabale, Khayoni (all local) and P224 and Gulu-E (improved) in Busia district and Obokorit, Aran, Ebunit and Emomwari (all local) in Teso district. Finger millet blast incidence ranged from 2-3 with a mean of 2.5 and severity range of 10-70% in Busia district. The disease incidence in Teso district ranged from 1.5-4 with a mean of 2.5 and a severity range of 5-30% signifying a higher disease severity in Busia than in Teso district.

Table 27. Busia district blast disease/sample details

Site	Sample #	Crop/Weed species	Blast incidene score (0-9)	Blast severity (%)
1	1	Finger millet (P 224)	2	40-60
	2	Finger millet (Gulu E)	2	50-60
	3	Finger millet	3	60-70
	4	*Eleusine indica*	-	40-50
	5	Finger millet mixture	3	40-60
2	6	Finger millet (P224)	3	40-60
	7	*Eleusine indica*	-	-
	8	Finger millet (Gulu E)	2	20-30
	9	Finger millet	-	-
	10	Crows foot	-	-
	11	Finger millet (P224)	2	40-50
	12	Finger millet (P224)	2	40-50
	13	Finger millet (P224)	2	40-50
	14	Digitaria horizontalis	-	-
	15	*Eleusine indica*	-	-
	16	Finger millet (*Ikhulule*)	3	30-40
	17	Finger millet (*Ikhulule*)	3	30-40
	18	Finger millet (*Ikhulule*)	3	30-40
3	19	*Brancharia spp.*	-	-
	20	*Cyperus tuberosus*	-	-
4	21	Finger millet (P224)	7	90-100
	22	*Digitaria horizontalis*	-	-
5	23	Finger millet mixture	4	40-50
	24	*Eleusine indica*	-	-
6	25	Finger millet mixture	3	40-50
7	26	Finger millet (*Ikhulule)*	2	5-10
	27	Finger millet mixture	3	40-50
	28	*Eleusine indica*	-	-
	29	Crows foot	-	-
8	30	Finger millet (U-15)	2	20-30
	31	Eleusine indica	-	-
	32	*Eleusine indica*	-	-
	33	*Digitaria horizontalis*	-	-
	34	*Brancharia ssp.*	-	-
	35	Finger millet (P224)	2	10-20
	36	Finger millet (*Ikhulule*)	3	20-30
9	37	Finger millet mixture	4	40-60
	38	Finger millet (U 15)	3	20-30
	39	*Eleusine indica*	-	-
	40	*Digitaria horizontalis*	-	-
10	41	Finger millet (U15)	2	10-15
11	42	Finger millet (*Ikhulule*)	2	10-20
12	43	Finger millet mixture	5	20-40
	44	Finger millet mixture	3	30-40
	45	*Eleusine indica*	-	-
17	57	Finger millet mixture	3	20-30
	58	*Eleusine indica*	-	-
	59	*Cyperus spp.*	-	-
18	60	Finger millet mixture	2	15-20
	61	*Eleusine indica*	-	-
	62	Unknown	-	-
19	63	Finger millet mixture	2	10-15
	64	*Eleusine indica*	-	-
	65	*Brancharia spp.*	-	-
20	66	Finger millet mixture	3	15-20
	67	*Eleusine indica*	-	-
21	68	Finger millet mixture	2	10-15

- Data not recorded, but blast samples were collected

Table 28. Teso district blast disease/sample details

Site	Sample #	Crop/Weed species	Blast incidence score (0-9)	Blast severity (%)
13	46	*Eleusine indica*	-	-
	47	Finger millet (*Aran*)	3	22-30
	48	Crows foot	-	-
14	49	Finger millet mixture	3	20-30
15	50	*Eleusine indica*	-	-
	51	Crows foot	-	-
	52	Finger millet	2	15-20
	53	Finger millet	2	5-10
16	54	Finger millet	2	10-15
	55	*Eleusine indica*	-	-
	56	Crows foot	-	-
22	69	*Eleusine indica*	-	-
	70	Finger millet mixture	3	20-30
23	71	Finger millet mixture	2	10-20
	72	*Eleusine indica*	-	-
24	73	Finger millet mixture	3	20-30
	74	Finger millet mixture	3	20-30
	75	*Eleusine indica*	-	-
25	76	Finger millet mixture	2	5-10
26	77	Finger millet mixture	2	10-20
	78	Crows foot	-	-
27	79	Finger millet mixture	3	20-30
	80	*Eleusine indica*	-	-
	81	Crows foot	-	-
28	82	*Eleusine indica*	-	-
	83	Finger millet mixture	3	20-30
	84	Finger millet mixture	2	10-15
	85	*Eleusine indica*	-	-
	86	*Cyperus spp.*	-	-
29	87	Eleusine indica	-	-
	88	Finger millet mixture	2	10-15
30	89	Finger millet (*Aran*)	2	10-15
	90	Eleusine indica	-	-
31	91	Finger millet mixture	3	20-30
	92	*Eleusine indica*	-	-
32	93	Finger millet (*Aran*)	4	20-30
33	94	Finger millet mixture	3	10-15
34	95	Finger millet (*Ebunit*)	2	5-10
35	96	Finger millet	1.5	-
	97	*Eleusine indica*	-	-
36	98	Finger millet (*Emomwari*)	2	5-10
37	99	*Eleusine indica*	-	-
38	100	Finger millet mixture	3	15-20
	101	*Eleusine indica*	-	-

- Data not recorded, but blast samples were collected

In Kisii/Gucha Districts (Tables 29 and 30), seed selection is hardly done in the field. Seed is sourced from grain in storage. Farmers are aware of blast disease and call it 'Egitabu' in the local Gusii language. Most of the farmers plant variety mixtures with no inter-cropping. Where pure varieties were grown, there was still a high degree of physical mixtures. Row planting is practiced on a few farms especially in Masaba division of Kisii District. Thinning is not satisfactorily done especially in broadcast planting. The seed rate used is too high with some farmers reporting to have used 6kg in

0.5 acres. Higher blast incidences/severity are reported in Feb-July season than in August-December season. Compact panicle varieties showed low blast levels than open types irrespective of colour. Finger millet is planted twice a year. DAP fertilizer is used at planting (mixed with seed at sowing). Some farmers do top-dressing by broadcasting the fertilizer. Varieties grown in both Gucha and Kisii districts are landraces and include Enyaikuro (most prevalent), Ekinyakundi (compact panicle), Omokomoni, Enyandabu, Omorogi (all local types). Though P224 and Gulu E, improved varieties, were introduced in Ramasha area of Masaba division about 5 years ago, they have been mixed with local types to the extent that these cannot easily be identified in the fields. Finger millet blast incidence scores ranged from 1.5-8 (mean 3.6) with severity range of 5-80% in Kisii district whereas in Gucha district, disease incidence ranged from 1.5-8 (mean 3.3) with severity range of 5-80%.

Table 29. Kisii district blast disease/sample details

Site	Sample #	Crop/Weed	Blast incidence score (0-9)	Blast severity (%)
39	102	Finger millet (*Enyaikuro*)	3	20-30
	103	Finger millet	7	40-60
40	104	*Eleusine indica*	-	-
	105	Star grass	-	-
	106	Finger millet (*Enyaikuro*)	8	70-80
	107	Finger millet (*Enyangundi*)	1.5	5-10
41	108	Finger millet mixture	2	10-15
42	109	Finger millet (*Enyaikuro*)	2	10-15
43	110	Finger millet (*Enyangundi*)	4	30-40
44	111	Finger millet (P 224)	1.5	5-10
45	112	Finger millet (*Enyaikuro*)	6	60-70
46	113	Finger millet mixture	3	15-20
47	114	Finger millet (*Enyaikuro*)	2	10-15
48	115	Finger millet mixture	4	50-60
49	116	Finger millet (*Enyaikuro*)	3	15-20

- Data not recorded, but blast samples were collected

Table 30. Gucha district blast disease/sample details

Site	Sample #	Crop/Weed	Blast incidence score (0-9)	Blast severity (%)
50	117	Finger millet (*Enyaikuro*)	3	10-15
	118	*Eleusine indica*	-	-
51	119	Finger millet mixture	7	70-80
52	120	Finger millet	5	50-60
53	121	*Eleusine indica*	-	-
53	122	Finger millet mixture	2	5-10
54	123	Finger millet (*Enyaikuro*)	2	5-10
55	124	Finger millet mixture	3	20-30
56	125	Finger millet mixture	4	40-50
57	126	Finger millet (*Enyangundi*)	2	5-10
	127	Finger millet (*Enyangundi*)	1.5	10-15
58	128	Finger millet (*Enyaikuro*)	8	70-80
59	129	Finger millet (*Enyaikuro*)	1.5	5
	130	Finger millet (*Enyangundi*)	2	5-10
60	131	Finger millet (*Enyaikuro*)	1.5	15
61	132	Finger millet (*Enyaikuro*)	3	15-20
62	133	Finger millet (*Enyaikuro*)	5	40-50
63	134	Finger millet (*Enyaikuro*)	2	5-10
	135	Finger millet (*Enyaikuro*)	2	5-10

- Data not recorded, but blast samples were collected

In Homabay district (Table 31), finger millet is not an important crop though there is potential for the crop. The Ministry of Agriculture has been conducting finger millet crop demonstrations for the last two years at the local farmers training centre that is situated on the shores of lake Victoria. The varieties demonstrated have been P 224, Gulu E and U 15 (all improved). Samples collected from the demonstration plots are shown in table 31. The blast disease incidence and severity were relatively low ranging from 1.5-2 and 5-10% respectively.

Table 31. Homabay district blast disease/sample details

Site	Sample #	Crop/Weed species	Blast incidence score (0-9)	Blast severity (%)
64	136	Finger millet (Gulu E)	1.5	5-10
	137	Finger millet (P 224)	1.5	5-10
	138	Finger millet (U 15)	2	5-10

At Alupe Research Station (Table 32), blast samples were collected from the Host Plant resistance (HPR) trial and from a demonstration of elite finger millet lines. Blast samples were also collected from Eleusine indica (5) and crows foot (2) in the research fields. Disease incidence and severity were higher at the station compared to farmers' fields in Busia and Teso districts with incidence range of 2-9 (mean 3.5) and severity range of 10-90%. The range of blast symptoms seen on finger millet and also on weeds in farmers fields are shown in figure 16.

Table 32. Alupe Research Station blast disease/sample details

Site	Sample #	Crop/Weed species	Blast incidence score (0-9)	Blast severity (%)
65	139	Finger millet (KNE 479)	9	80-90
	140	Finger millet (P 224)	3	10-30
	141	Finger millet (KNE 1149)	2	10-20
	142	Finger millet (Gulu E)	2	10-20
	143	Finger millet (U 15)	3	10-30
	144	Finger millet (KNE 688)	3	10-30
	145	Finger millet (KNE 388)	4	10-40
65	146	Finger millet (KNE 741)	4	10-40
	147	Finger millet (KNE 620)	3	10-30
	148	Finger millet (KNE 629)	2	10-20
	149	Finger millet (KNE 1034)	3	10-30
	150	Finger millet (Ex-Meru)	8	20-80
	151	Finger millet (KNE 814)	3	10-20
	152	Finger millet (KNE 1015)	4	10-40
	153	Finger millet (KNE 1060)	3	10-30
	154	*Eleusine indica*	-	-
	155	*Eleusine indica*	-	-
	156	*Eleusine indica*	-	-
	157	Crows foot	-	-
	158	Crows foot	-	-
	159	*Eleusine indica*	-	-
	160	*Eleusine indica*	-	-

- Data not recorded, but blast samples were collected

Fig. 16. Blast affected finger millet in farmers' fields (1-6) and blast on wild Eleusine (7)

Uganda

Across the 15 districts surveyed in Northern and Eastern areas, blast was widely prevalent and the disease incidence and severity varied considerably (Table 33). For example, incidence ranged from 1-5 and the severity 24.2-67.5%. Dark seeded finger millet varieties were more resistant to blast compared to white seeded varieties. Similarly, compact headed varieties were more resistant to blast compared to open headed varieties. A total of 328 samples were collected from finger millet and weeds and any information on the varieties noted.

Table 33. Blast incidence and severity across key finger millet growing districts in Uganda

No.	District	No. of fields	*incidence 0-9	*severity %
1	Pallisa	20	5	41.7
2	Kumi	23	3	31.9
3	Mbale	29	3	38.7
4	Tororo	34	2	27.2
5	Iganga	6	5	42.5
6	Bugiri	4	4	67.5
7	Kamuli	10	5	39.0
8	Busia	20	3	46.2
9	Lira	31	1	24.2
10	Apac	31	2	25.0
11	Masindi	18	3	44.4
12	Nakasongola	5	3	55.0
13	Katakwi	35	3	33.3
14	Soroti-Kaberamaido	27	3	30.1
15	Soroti	35	3	36.4

*Average of the total number of fields covered in each district; blast samples were collected from each field

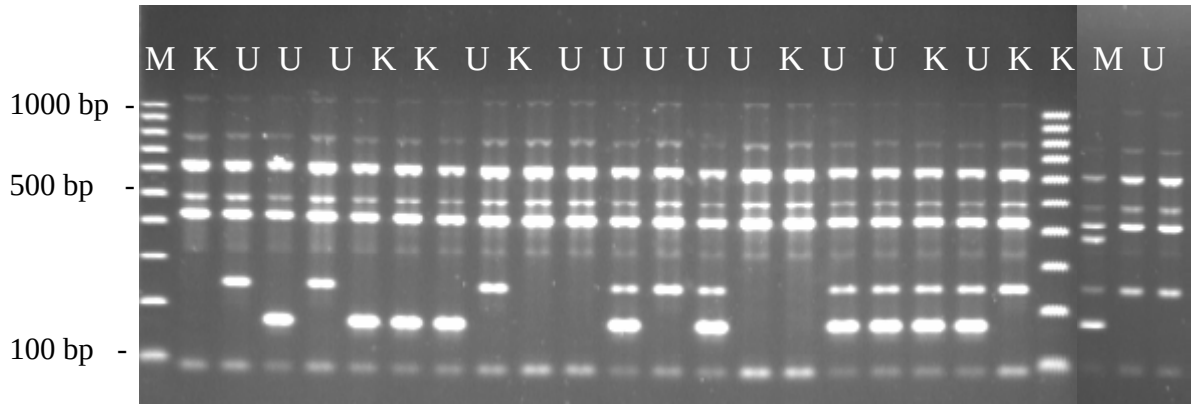
2. Genetic diversity and distribution of pathogen populations

Genetic diversity of blast populations

In Kenya, 160 blast samples were collected from the crop (leaf, neck and finger) and the weeds from key finger millet producing districts Busia, Gucha, Teso and Kisii by ICRISAT-Kenya and KARI-Kakamega. More than 300 finger millet and weed blast samples were collected from 15 districts in northern and eastern Uganda by SAARI. Using these samples, a baseline collection of more than 300 *M. grisea* isolates was established at Warwick HRI, UK for molecular and pathogenicity characterisation.

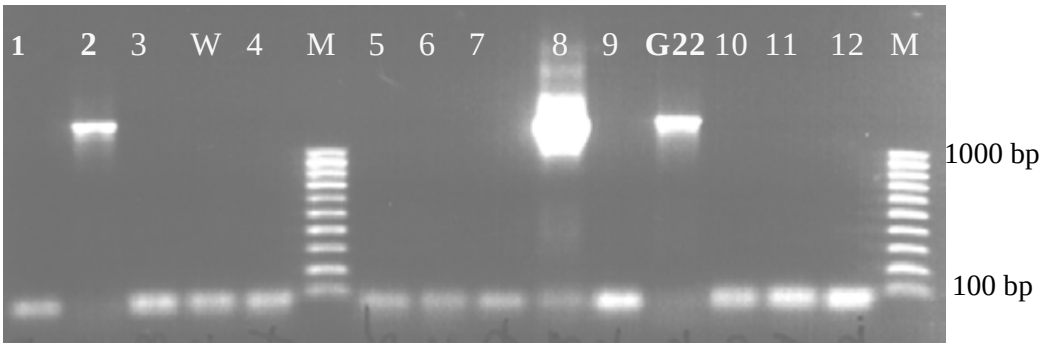
Genomic DNA extracted from mono-conidial blast cultures was used for PCR-based analyses to generate SSR (simple sequence repeat) and AFLP (amplified fragment length polymorphism) profiles. Between the two types of markers tested, AFLPs revealed a higher degree of diversity. Initially 64 AFLP primer pairs were screened and up to 15 primers were used for detailed characterisation. In general 5 - 15 AFLP markers were generated by each primer pair for each isolate (50 - 150 markers in total). Up to eight blast pathogen genotypes (genetic groups) were observed based on AFLP profiles of various isolates. Blast pathogen isolates collected from different varieties in the pathogen and disease spread experiment at the Serere site, showed mixed occurrence of pathogen genotypes and some of these belonged to the same molecular groups observed among the wider populations. These isolates were also included in the mating type distribution and compatibility assays. Some of the pathogen genotypes identified were common to both Uganda and Kenya whilst others were restricted to one country (Figure 17) suggesting the need for deploying appropriate resistance sources, taking into account the pathogen virulence diversity.

Figure 17. Representatives of blast pathogen genotypes prevalent in Uganda and Kenya



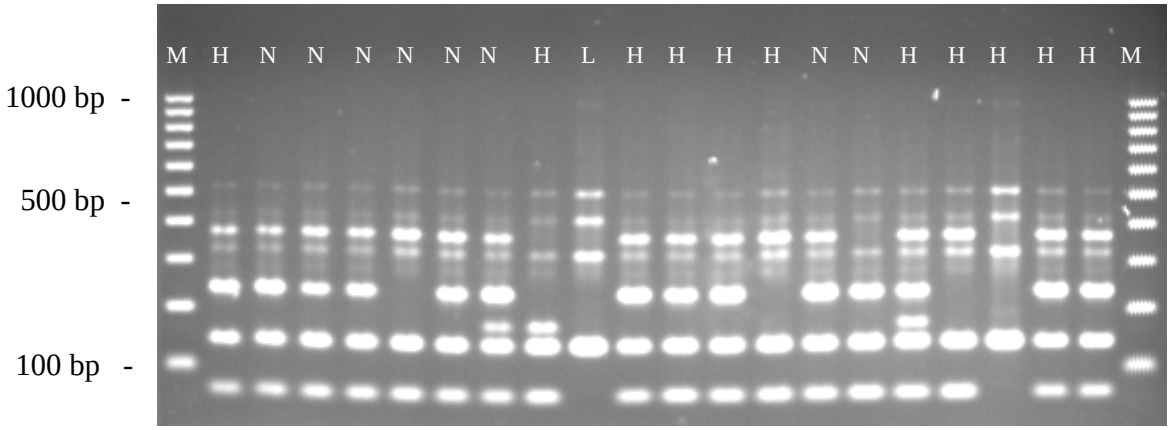
Finger millet blast populations containing a repetitive DNA element g*rasshopper* (*grh*) have been observed in Japan, Nepal and India as well as in West African countries of Burkina Faso and Mali, but not in Uganda, Rwanda and Philippines. Exploiting the DNA sequence, *grh*-specific primers were designed and following PCR screening and PCR-RFLPs and sequence analysis of finger millet and weed blast collections from East Africa 13 isolates (12 of these from Kenya) containing the *grh* element were identified (Figure 18). Finger millet is native to Africa originating in the area that now is Uganda and the low-level presence of *grh* containing blast isolates (ca. 4 %) suggests that the indigenous blast populations did not contain this element. It is likely that germplasm exchanges have led to recent trans-continental movement of the pathogen containing *grh* along with seed material. Thus there is aneed to establish procedures for ensuring seed quality during germplasm exchange and varietal diffusion in the region and beyond.

Figure 18. Identification of blast pathogen isolates containing the DNA repetitive element grasshopper



Further, isolates causing different types of blast on finger millet (L-leaf, N-neck and H-head/panicle blast) were compared by AFLP analysis (Figure 19). These isolates were not genetically distinct and belonged to same molecular groups in general indicating that the same strains are capable of causing different types of blast under suitable agro-ecological conditions. This suggests the utility of common sources of host resistance, although some differential reactions of finger millet varieties to infection by leaf, neck and finger blast isolates have been observed in the pathogenicity tests with seedling and mature plants.

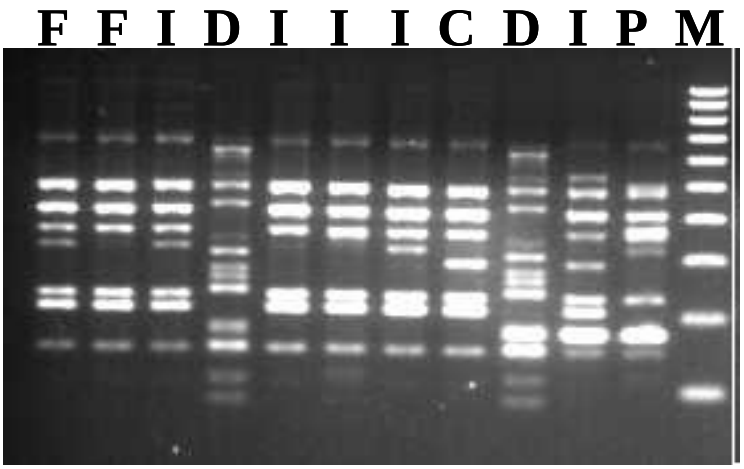
Figure 19. Relatedness of blast pathogen isolates causing different types of blast



H-head, N-neck and L-leaf blast isolates

To understand their role and relatedness to wider populations, blast isolates from weed hosts (55 isolates) were compared with isolates from finger millet (225 isolates). Blast isolates from the weed hosts except Digitaria were not genetically distinct (Figure 20) and in most cases belonged to the same genetic groups as the isolates from finger millet underlining the potential of weeds to serve as inoculum sources. Pathogenicity tests revealed that the weed blast isolates were pathogenic to finger millet varieties, with some weed blast isolates being as aggressive as some of the finger millet blast isolates.

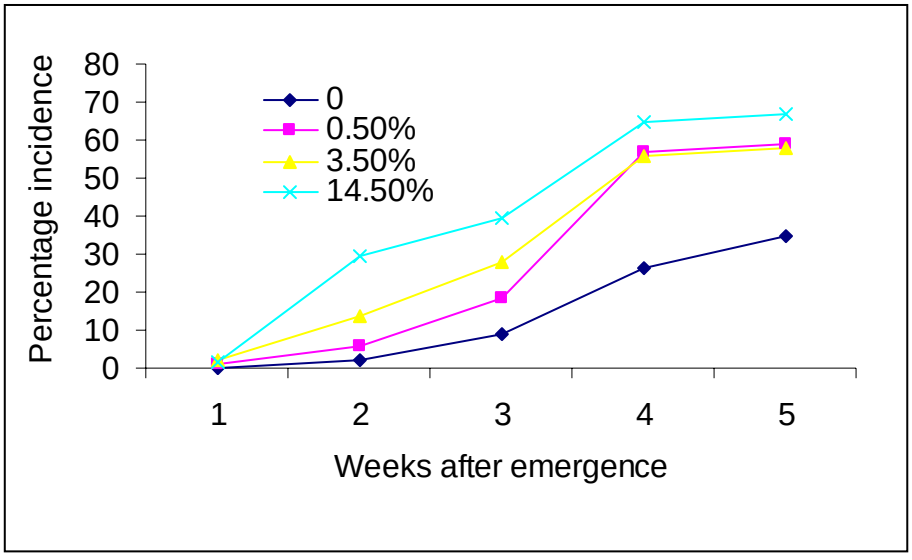
Figure 20. Relatedness of blast pathogen isolates from finger millet and various weeds



F, Finger millet; I, Wild Eleusine; D, Digitaria, C, crowsfoot; P, Pennisetum

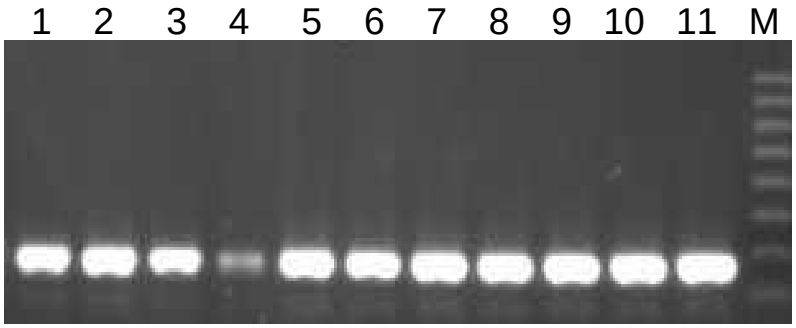
Further, field experiments carried out in Uganda suggest that seed-borne inoculum can contribute to initial blast development, as higher disease incidence was observed with seeds containing higher proportion of inoculum (Figure 21). Influence of the seed-borne inoculum on further disease development and grain yiled loss could not be fully assessed as the high background inoculum/disease levels did not permit accurate analysis of the data collected.

Figure 21. Blast incidence in rice seedlings grown from seeds naturally infected with *Magnaporthe grisea*



M. *grisea* – specific PCR, based on the ribosomal RNA gene block sequences, has been developed and a number of seed, rachis, leaf and weed samples tested blast positive in PCR assays (Figure 22). This test could serve as a useful tool for epidemiological monitoring of pathogen populations in seed and weed samples and for seed testing/quarantine, particularly as the presence of *grh* containing pathogen populations clearly suggest recent introduction of pathogen propagules from other geographic locations along with seed material during germplasm exchange/movement.

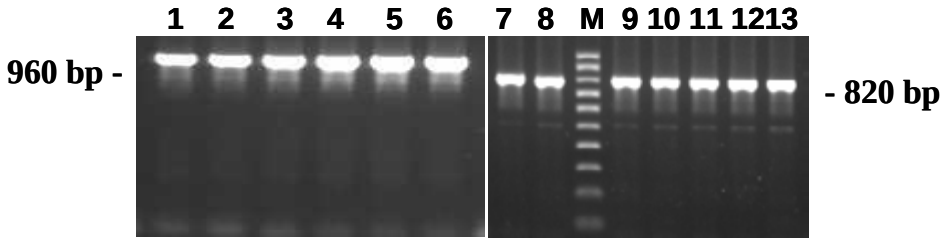
Figure 22. Diagnostic PCR test of blast isolates and disease samples using the *Magnaporthe grisea*-specific primers



1 - 11 represent a range of infected samples and fungal isolates

It is widely recognised, that *M*. *grisea* is a predominantly asexual fungus. However, high fertility of finger millet blast isolates in laboratory crosses has previously been observed. Based on the blast mating type gene sequences, PCR primers specific to mating type alleles MAT1-1 and MAT1-2 were designed. And near equal distribution of MAT1-1 (47 %) and MAT1-2 (53 %) among blast populations in Uganda and Kenya (Figure 23) was observed. Although both mating types were widely distributed, in certain districts only one mating type was dominant (e.g. MAT 1-1 in Mbale, Uganda).

Figure 23. Identification of mating type distribution in *Magnaporthe grisea* populations by PCR



1 - 6 MAT1-1; 7 - 13 MAT1-2

More than 300 crosses, using a set of tester strains, have shown the high fertility status (Figure 24) of these isolates with the formation of perithecia bearing asci with ascospores (Figure 25). The potential influence of the high fertility status of these isolates in shaping blast populations needs to be investigated, as this is critical to the successful deployment of host resistance.

Figure 24. Fertility status of *Magnaporthe grisea* populations in Kenya and Uganda

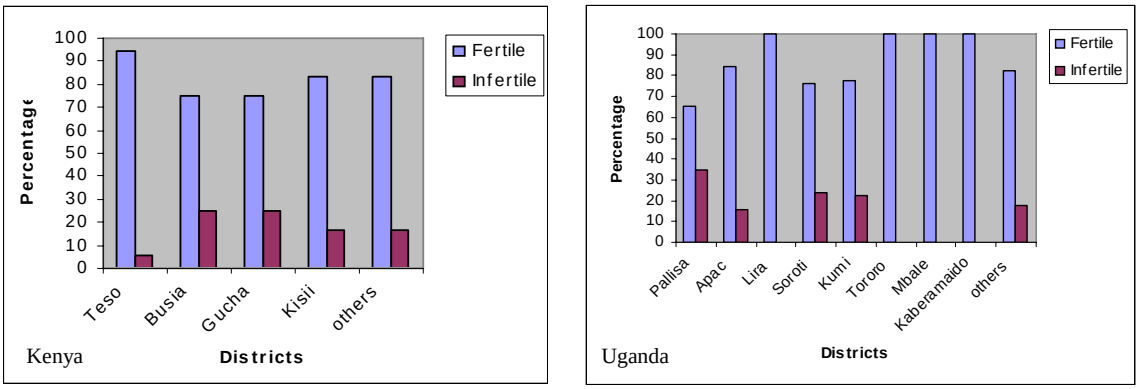


Figure 25 shows the process of crossing two *M. grisea* isolates (A) and the production of perithecia bearing asci and ascospores (B – F) and the viability of the ascospores checked by germination (G); in in-compatible interactions (H) none of these process are observed, as the two isolates fail to cross with each other.

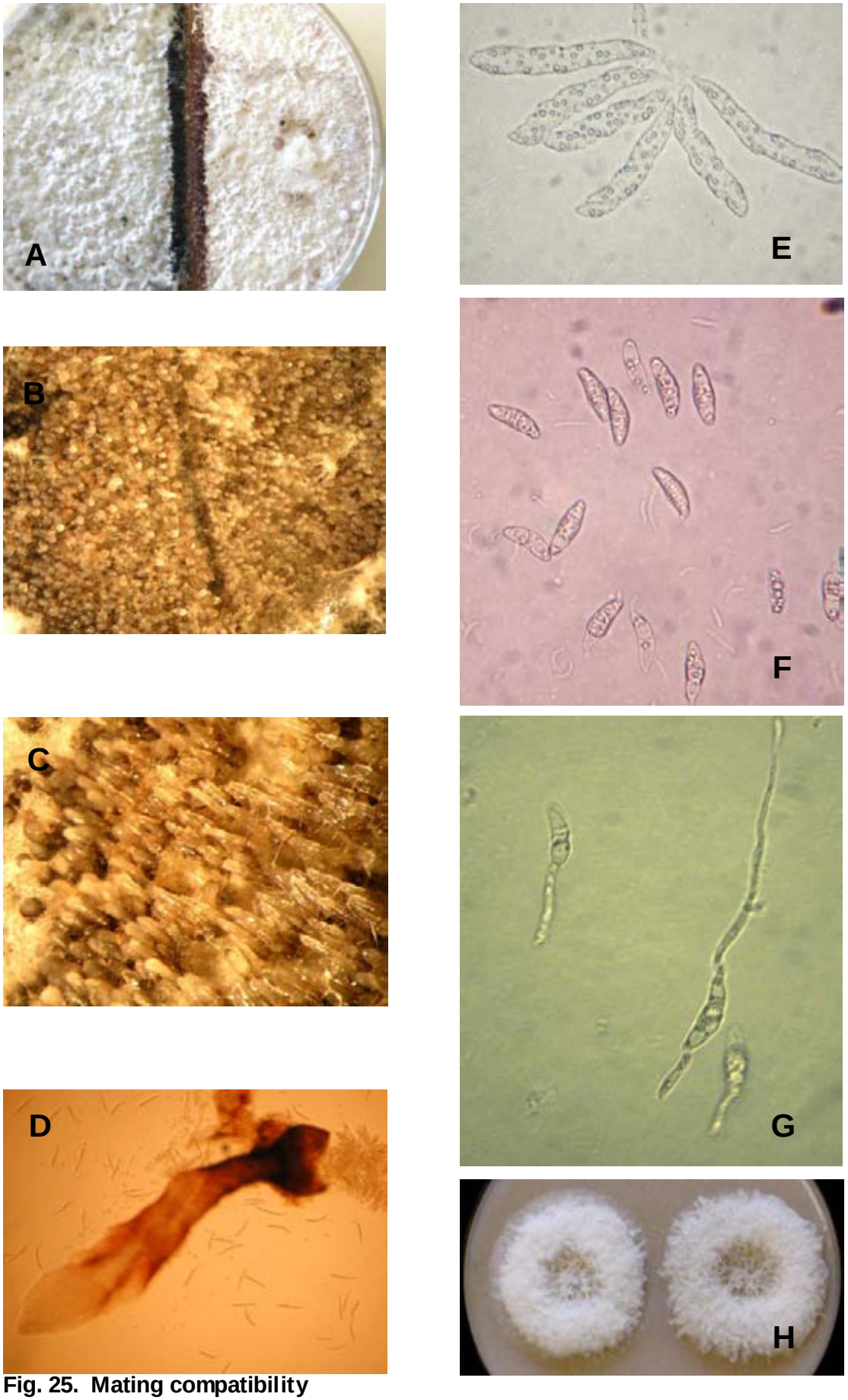


Fig. 25. Mating compatibility

3. Pathogen aggressiveness

Pathogenic variability on finger millet seedlings

There was considerable variation in the aggressiveness of *M. grisea* isolates on the seedlings of the ten finger millet varieties tested (Figure 26). The most aggressive isolates, in general, were aggressive on all ten varieties tested and, similarly, the least aggressive isolates produced low levels of disease on all the varieties. Of the ten varieties tested, E11 was the most susceptible to all the isolates (Figure 27). With the other varieties there were small differences in the disease levels recorded but, notably, Seremi 1 was the least infected, whereas Seremi 3 (rated as resistant) showed more disease symptoms than any of the varieties except E11. Similar results were observed with the second batch of isolates tested on five varieties and in this batch there were smaller differences in the disease score produced by the isolates tested (Figures 28, 29 and 30). This was particularly noticeable with the control isolates K5/23. Again, in general most isolates were either similarly aggressive or non-aggressive on the different finger millet varieties, E11 being the most susceptible and Seremi 1 the most resistant. The degree to which *M. grisea* isolates infected finger millet seedlings appeared to be random (Figures 26-30). None of the isolates from neck, rachis, leaf or seed grouped together in terms of aggressiveness. *M. grisea* isolates from weed hosts particularly *Eleusine indica* also infected the finger millet seedlings.

Pathogenicity tests on seed heads of mature finger millet plants

Of the eight isolates tested, the neck isolate K5/23 (used as the control isolate in the seedling assays) was the most aggressive with respect to seed head infection (Figures 31, 32 and 33). This and the other neck isolate K13/67 caused the most seed head infection on all six varieties. The two seed isolates D5/83 and K15/80 were generally more aggressive than the two weed isolates (WS12 and WS4) and the two leaf isolates (D10/554 and K33/189). The apparent susceptibility of the finger millet varieties with respect to seed head infection, with the exception of E11, differed from that in the seedlings leaf assays. Seremi 1, having shown most resistance in the seedling experiments, appeared the second most susceptible with regard to seed head infection especially when inoculated with the neck and seed isolates. Varieties P665 and Seremi 3 were the least infected although again the neck isolates were the most aggressive on them (Figures 31 and 33).

In general, *M. grisea* isolates were relatively more or less aggressive on all the finger millet varieties tested and no clear cut differences in compatability were observed among the various isolates and the finger millet varieties. This suggest that there was no gene-for-gene relationship between these finger millet and the pathogen as in rice blast, implying no major genes for resistance were involved in these interactions. The blast reaction rating of the finger millet varieties revealed in the tests proved to be similar to that given for the varieties prior to testing. There was no apparent grouping of isolates obtained from different plant parts; isolates obtained from wild Eleusine and other weeds were as aggressive as some of the isolates from finger millet. In the pathogenicity tests on seed heads, the neck and seed isolates tested were more aggressive than the weed and leaf isolates. The susceptibility rating of some of the finger millet varieties in the seed head tests differed from that observed in the seedling tests; E11 remained the most susceptible, but seed heads of Seremi 1 and Seremi 2 (rated resistant) were relatively more susceptible than the seedlings. Pathogenicty data in Figures 26-33 were ranked in descending disease score order; L.S.D values are given for the $P<0.05$ significance level. An example of the blast disease/lesions on finger millet seedlings under controlled conditions is shown in Appendix 9.

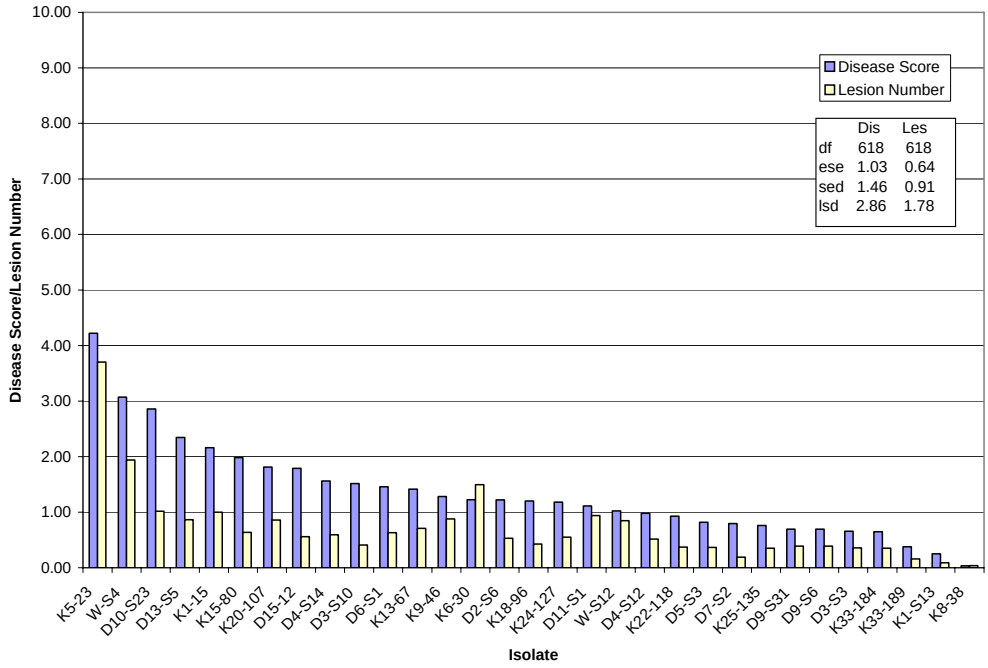


Figure 26. Infection by *Magnaporthe grisea* isolates tested against ten finger millet varieties meaned across varieties

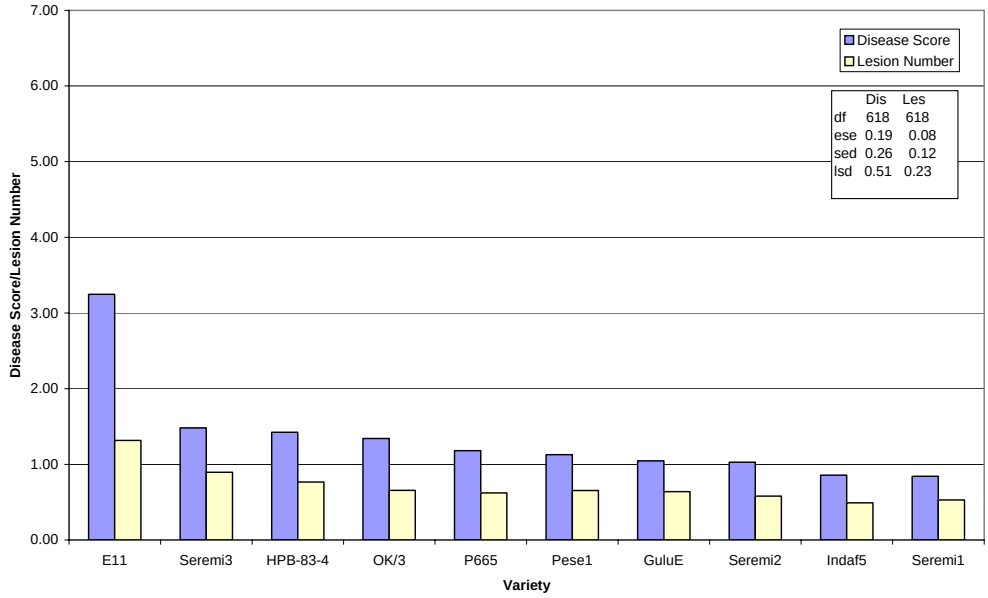


Figure 27. Finger millet variety infection meaned across all *Magnaporthe grisea* isolates for the ten varieties

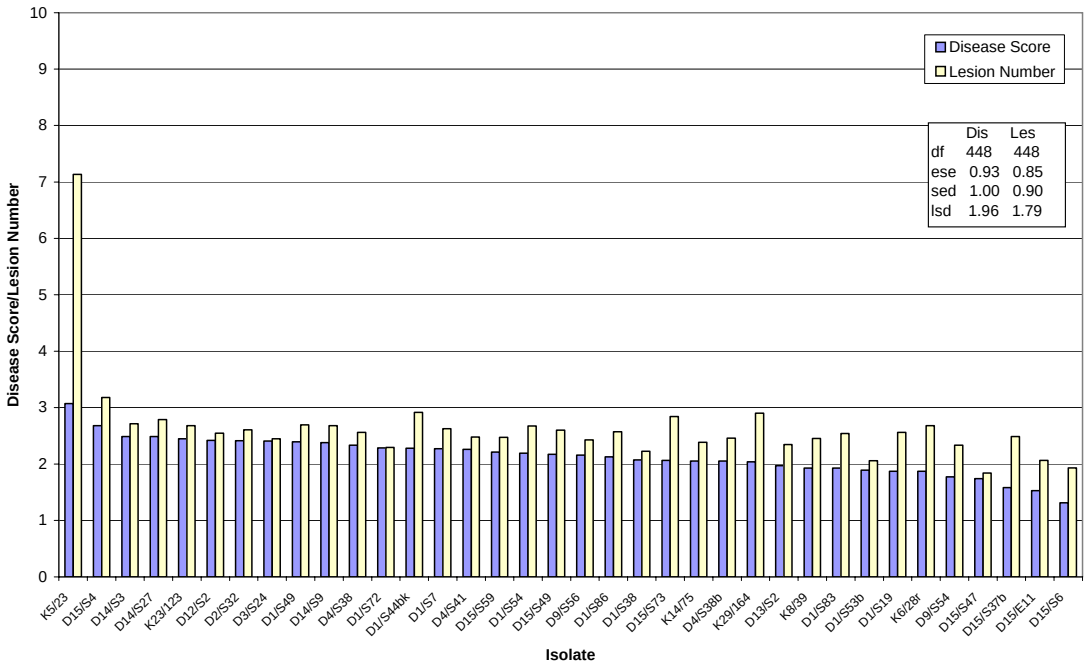


Figure 28. Infection by *Magnaporthe grisea* isolates tested against the five finger millet varieties meaned across varieties

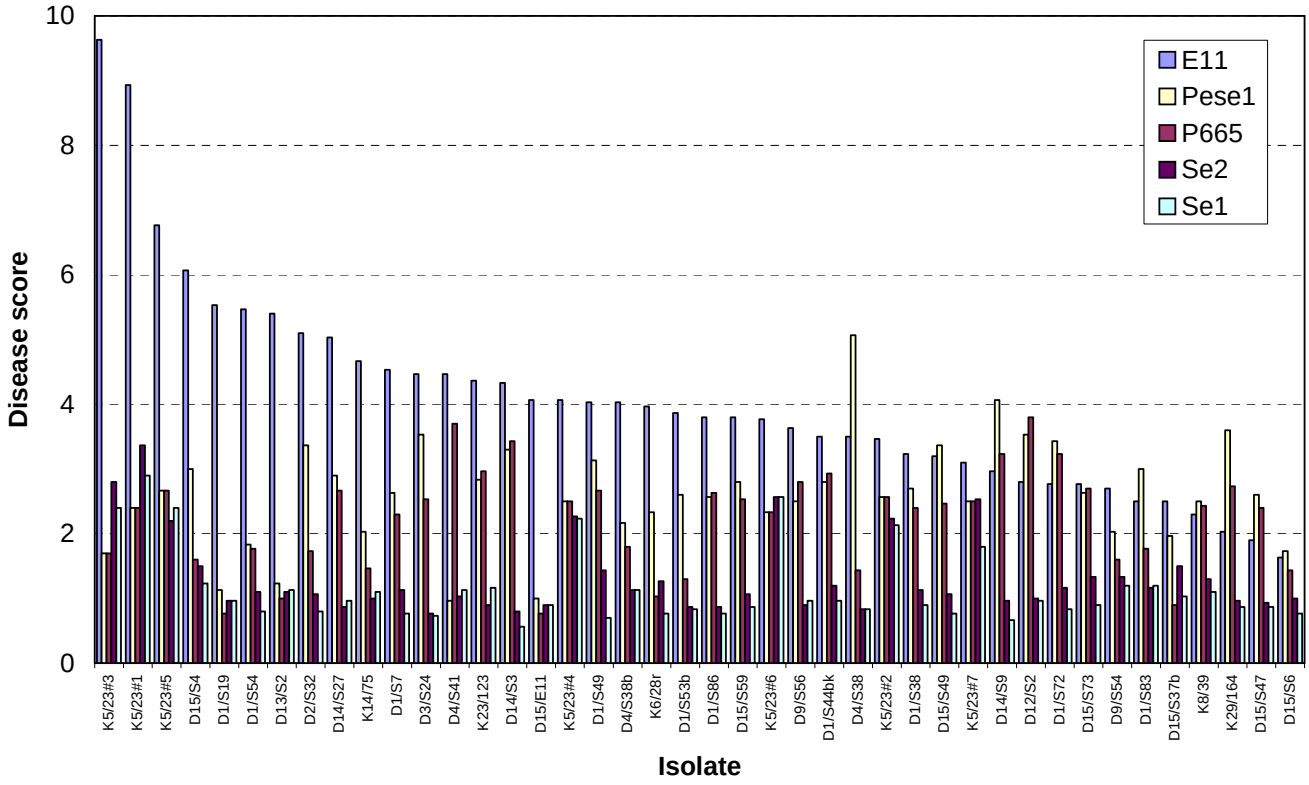


Figure 29. Disease scores for *Magnaporthe grisea* isolates tested against the five finger millet varieties showing all varieties

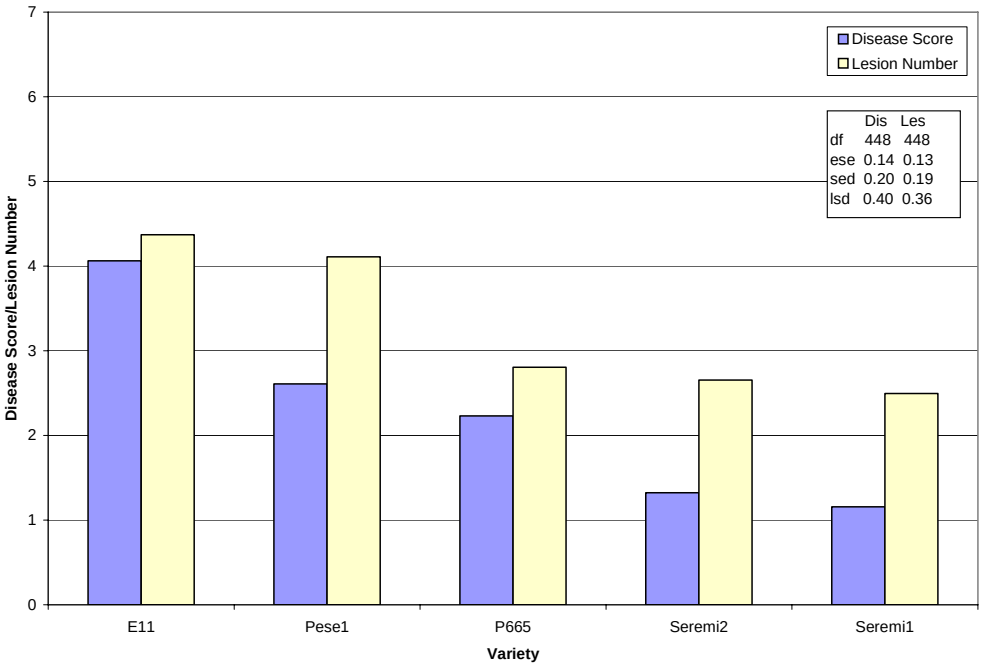


Figure 30. Finger millet variety infection meaned across all *Magnaporthe grisea* isolates for the five varieties

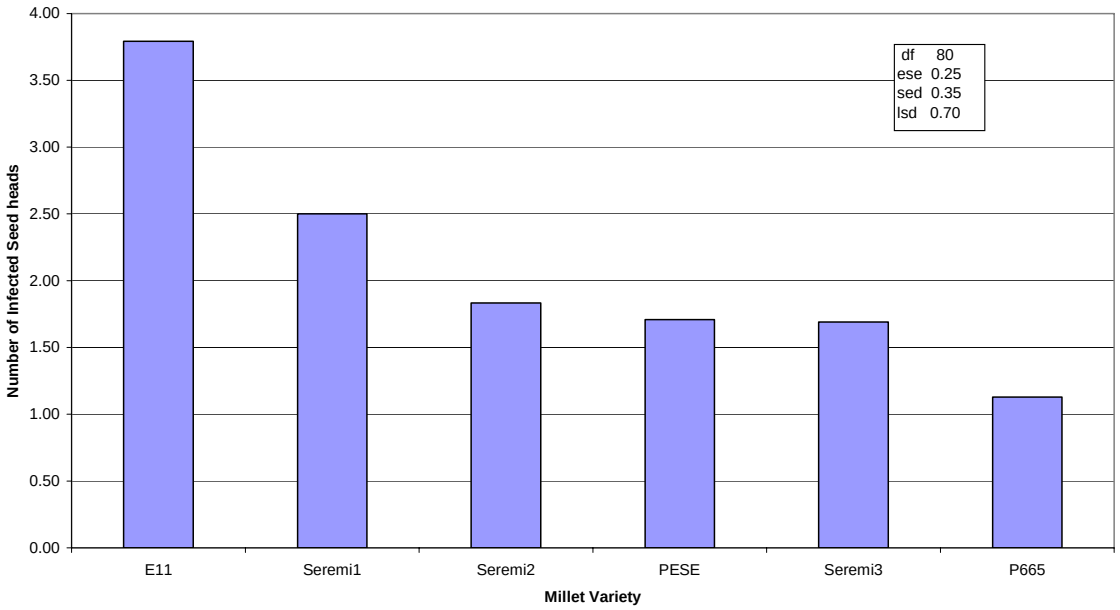


Figure 31. Number of seed heads infected per 10 inoculated heads on the different finger millet varieties

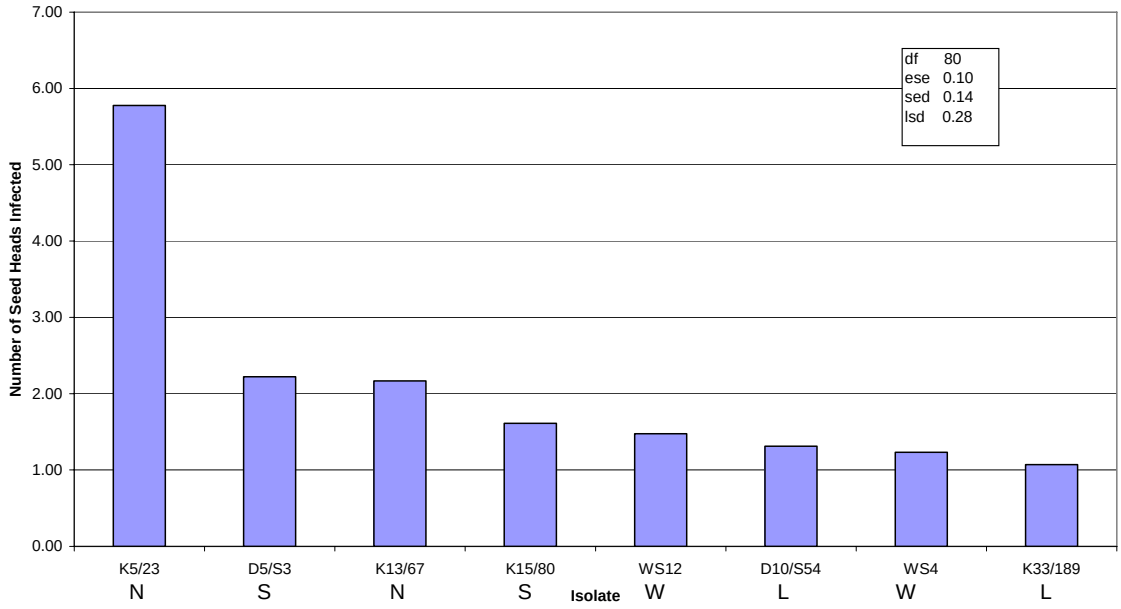


Figure 32. Number of seed heads infected per 10 inoculated heads by the eight different *Magnaporthe grisea* isolates (N = neck, S = seed, W = weed, L = leaf)

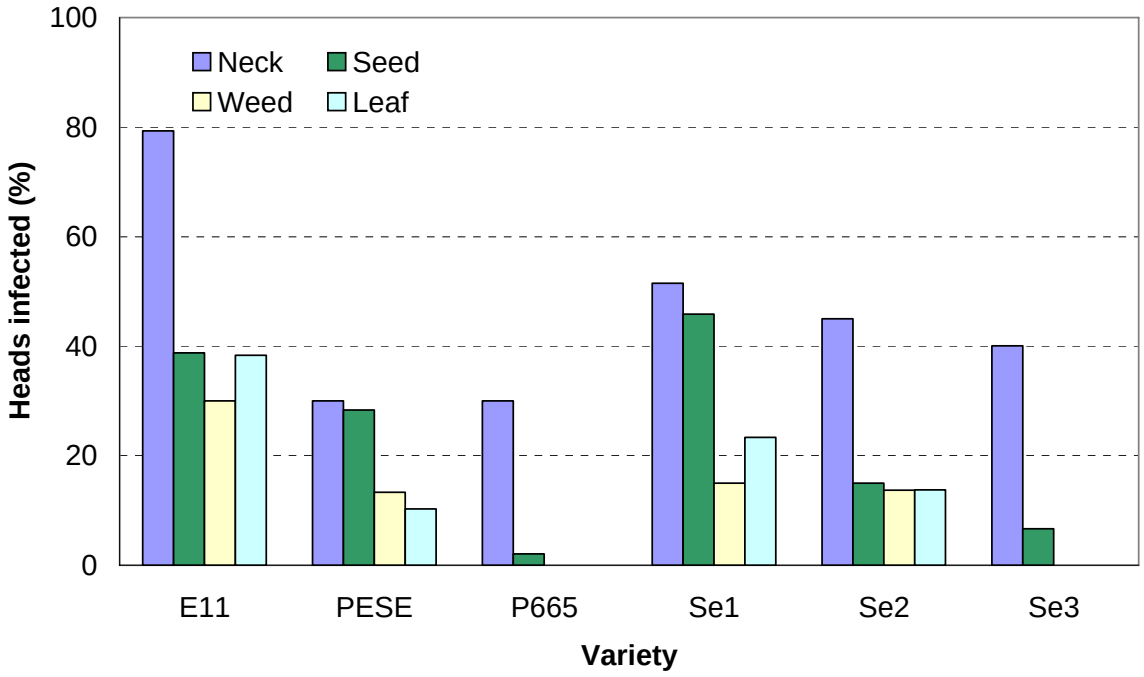


Figure 33. Percentage seed heads infected by *Magnaporthe grisea* isolates from weeds and from finger millet neck, seed and leaf

4. Identification of resistance sources

In the long rainy season (LR) (Feb-July), out of the sixty five farmer varieties, twenty nine varieties showed significant tolerance to finger blast with blast incidence scores of < 4.0 and an average severity percentage of < 40% (Table 34). Finger blast incidence range in Busia/Teso varieties was 2-6 (mean 3.4) with percentage severity range of 16.8-57.3 (mean 33.2). There was generally a higher disease prevalence in the Kisii/Gucha varieties which had finger blast incidence score range of 3.7-9.0 (mean 5.9) and percentage severity range of 35.1-91.3 (mean 64.0). This observation conforms to survey results, which showed blast incidences being higher in Kisii/Gucha than in Busia/Teso. Twenty nine out of the 37 test varieties (78%) collected from Busia and Teso districts had a low finger blast incidence of $\leq$ 4.0 with an average severity percentage of < 40%; whereas only three test varieties out of the twenty eight collected from Kisii, Gucha and Kericho districts had a finger blast incidence score of $\leq$ 4.0 and an average finger blast severity of < 40% (Table 34). Out of the twenty varieties from ICRISAT collection, fifteen varieties showed significant blast tolerance with a severity percentage of < 30 and an incidence score range of 2.0-3.7. Varieties KNE 1034 (finger blast incidence 2.0 and severity 13%) and KNE 620 (finger blast incidence 2.0 and severity 24.7%) had the lowest finger blast incidence scores and percentage severity. The test varieties Acc. no. 14 FMBP/01 WK and Acc. no. 25 FMBP/01 WK had the lowest finger blast incidence ($\leq$ 3) and percentage severity ($\leq$ 20) (Table 35). The susceptible control varieties (KNE 808, KNE 479, KAT/FM 1 and ex-Meru) and six test varieties (Acc. nos. 55, 70, 77, 68, KNE 1162 and KNE 711) had high susceptibility to finger blast with incidence score range of 7.0-9.0 and percentage severity range of 53.2-91.3%.

There was a significant negative correlation observed between grain yield and finger blast percentage severity. All the varieties with grain yield above 2.5 ton/ha recorded a finger blast incidence $\leq$ 4.0 and an average severity percentage of $\leq$ 35. Leaf blast incidences were higher at seedling stage (mean 3.0) than at booting stage (mean 2.0). Significant differences were also observed in maturity between the varieties with most varieties flowering in 60-75 (mean 67) days from date of emergence with a significant negative correlation between days to flowering and finger blast incidence. The mean plant heights ranged from 79-130 cm (mean 104cm).

During the short rainy season (SR), disease incidence and percentage severity were significantly low compared to the long rainy season (LR). This could be attributed to low precipitation and low humidity and high temperature, factors, which do not encourage optimum blast pathogen development. The finger blast percentage severity ranged from 5.9-76 (13-91.3 in the long rainy season). Forty five varieties recorded finger blast percentage severity below 30 with the three susceptible checks KNE 808, KNE 479, KAT/FM 1 and Ex-Meru recording percentage severity of 44.6, 43.3, 69.8, and 50.3 respectively. Incidence score for leaf blast at seedling, leaf blast at booting and neck blast at maturity were lower than during long rainy season with means of 2.7, 1.8 and 3.0 respectively (3.0, 2.0 and 4.0 respectively in the long rainy season) (Table 36).

Accession nos 14, 24, and 33, KNE nos. 683, 1034, 1060, 741, 1015, 810, 620, 814, 629, and S no.77 SADC had the lowest finger blast incidence (< 3.0) and percentage severity (< 20%) across the seasons (Table 37). Leaf blast incidence was higher at seedling stage (mean 3.0) than at boot stage (mean 2.0) across the two seasons. The highest grain yields (ton ha^{-1}) across the seasons were recorded on KNE 814 (2.545), Acc. no. 1 (2.456), Acc. No. 32 (2.383), KNE 810 (2.372) and Acc. No. 16 (2.339). However, due to seasonal differences in blast occurrence, only a limited degree of comparison across seasons has been possible.Multi-year and multi-site trials would provide essential support data for varietal diffusion and adaptation. Further details of the results and data from these trials are shown in Appendices 10-12.

Table 34. Farmer finger millet varieties (indigenous germplasm) with low finger blast incidence and severity (%) 2002 LR season

Accession #	Germplasm sources (Districts)	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Leaf blast severity (%) (booting)	Neck blast score (p.maturity)	Neck blast score (harvest)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 19 FMBP/01 WK	Teso	2.911	71	2.3	2.0	31.5	4.0	2.0	14.3	3.5	2.3	117.7	2.0	68
Acc. # 20 FMBP/01 WK	Teso	2.367	68	3.0	2.3	31.4	5.3	2.3	15.3	5.0	5.0	105.7	2.3	60
Acc. # 43 FMBP/01 WK	Teso	2.567	73	2.3	2.3	26.5	4.0	2.0	27.7	3.0	2.0	99.0	2.7	71
Acc. # 50 FMBP/01 WK	Busia	1.422	74	3.7	2.3	26.0	3.7	2.0	18.7	4.5	2.7	83.7	3.7	70
Acc. # 14 FMBP/01 WK	Teso	2.478	71	2.0	2.7	18.8	2.7	2.0	9.7	2.5	2.3	112.0	2.7	60
Acc. # 29 FMBP/01 WK	Teso	2.256	71	2.0	2.7	27.2	4.0	2.0	26.7	5.0	2.7	114.0	2.0	56
Acc. # 42 FMBP/01 WK	Teso	2.139	69	2.3	2.7	24.5	4.0	2.0	26.7	4.0	3.0	97.7	3.0	60
Acc. # 1 FMBP/01 WK	Teso	3.167	68	2.7	3.0	23.1	2.7	2.0	22.7	3.5	3.0	90.0	3.0	69
Acc. # 3 FMBP/01 WK	Teso	2.878	61	3.0	3.0	36.9	2.3	2.0	17.0	3.5	4.3	93.3	3.0	73
Acc. # 21 FMBP/01 WK	Teso	1.944	67	2.3	3.0	29.3	4.0	2.3	34.3	3.5	3.0	104.0	3.3	62
Acc. # 24 FMBP/01 WK	Teso	2.144	70	2.7	3.0	36.4	5.7	2.3	34.7	4.5	2.7	113.7	3.0	60
Acc. # 25 FMBP/01 WK	Teso	2.533	71	2.3	3.0	16.8	4.7	2.0	21.7	3.0	2.3	116.0	3.0	63
Acc. # 32 FMBP/01 WK	Teso	2.878	72	2.3	3.0	20.9	2.3	2.0	21.3	4.0	4.3	99.7	3.0	66
Acc. # 38 FMBP/01 WK	Teso	2.578	63	2.3	3.0	37.5	2.0	2.0	9.0	3.0	2.7	123.3	3.3	64
Acc. # 16 FMBP/01 WK	Teso	2.911	73	2.7	3.3	20.4	2.7	2.0	20.0	2.5	2.3	104.3	2.7	75
Acc. # 8 FMBP/01 WK	Teso	2.528	59	3.3	3.7	33.6	2.7	2.0	13.0	3.0	3.3	102.0	3.3	70
Acc. # 11 FMBP/01 WK	Teso	1.578	71	4.0	3.7	36.9	4.0	2.3	35.7	4.5	4.3	100.0	3.7	64
Acc. # 22 FMBP/01 WK	Teso	2.083	73	3.3	3.7	32.1	3.0	2.3	43.7	3.5	2.7	106.3	3.3	67
Acc. # 26 FMBP/01 WK	Teso	2.144	73	3.3	3.7	26.7	6.0	3.0	34.3	4.5	3.0	120.3	3.0	72
Acc. # 36 FMBP/01 WK	Teso	2.167	63	3.7	3.7	28.0	2.0	2.0	11.3	3.0	3.0	112.3	4.0	68
Acc. # 44 FMBP/01 WK	Teso	2.322	57	3.0	3.7	20.6	2.3	2.0	26.3	3.5	3.7	89.7	3.3	72
Acc. # 49 FMBP/01 WK	Teso	2.972	65	3.3	3.7	32.3	2.7	2.0	13.7	3.0	3.3	107.7	3.0	71
Acc. # 75 FMBP/01 WK	Kisii	1.800	67	3.0	3.7	35.1	2.3	1.3	2.7	3.5	3.0	115.3	4.0	67
Acc. # 58 FMBP/01 WK	Gucha	1.478	68	3.0	3.7	36.5	2.7	2.0	22.3	4.5	4.3	126.7	4.3	65
Acc. # 7 FMBP/01 WK	Teso	3.411	64	3.0	4.0	30.1	2.7	2.0	25.7	4.0	3.7	101.3	3.0	71
Acc. # 17 FMBP/01 WK	Teso	2.833	60	4.3	4.0	24.8	3.0	2.0	15.7	5.5	5.3	106.7	3.0	66
Acc. # 31 FMBP/01 WK	Teso	2.811	67	3.0	4.0	31.0	3.3	2.0	20.3	3.5	3.3	108.7	3.0	72
Acc. # 62 FMBP/01 WK	Busia	1.867	62	3.3	4.0	35.2	2.7	2.0	14.7	6.0	4.3	101.	4.0	76
Acc. # 80 FMBP/01 WK	Kisii	2.356	63	3.3	4.0	37.1	3.0	2.3	27.3	5.0	4.0	96.7	3.7	60

Table 34 (contd..)

Checks													
KNE 620 (**R**)	1.689	80	2.0	2.0	24.7	2.0	2.0	7.3	2.5	1.3	93.7	3.0	43
KNE 1034 (**R**)	1.883	80	2.0	2.0	13.0	2.0	1.7	5.3	2.0	1.3	105.0	2.3	50
KNE 479 (**S**)	0.900	46	8.3	9.0	81.4	6.7	4.3	50.0	8.0	9.0	96.0	5.0	77
KAT/FM 1 (**S**)	0.956	53	8.0	9.0	69.6	4.0	2.7	33.0	8.0	8.7	95.0	5.0	76
Mean (n=95)	**1.859**	**67**	**4**	**4**	**44.4**	**3**	**2**	**25**	**4**		**104.0**	**4**	**63**
SE±	**0.5415**	**3.7**	**0.9**	**0.9**	**11.16**	**1.1**	**0.5**	**10.4**	**1.4**		**9.4**	**0.5**	**9.84**
CV%	**29.1**	**5.6**	**25.1**	**21.0**	**25.1**	**33.6**	**23.1**	**40.9**	**35.1**		**9.0**	**14.8**	**15.6**

R- Resistant S- Susceptible; p.maturity – physiological maturity; LR- Long Rainy Season

Table 35. Finger millet varieties with high finger blast tolerance in 2002 LR season

Accession	Source district	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Leaf blast severity (%) booting	Neck blast score (p.maturity)	Neck blast score (harvest)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 14 FMBP/01 WK	Teso	2.478	71	2.0	2.7	18.8	2.7	2.0	9.7	2.5	2.3	112.0	2.7	60
Acc. # 25 FMBP/01 WK	Teso	2.533	71	2.3	3.0	16.8	4.7	2.0	21.7	3.0	2.3	116.0	3.0	63
KNE 683	ICRISAT	2.522	68	2.3	3.0	20.0	2.0	2.0	12.7	2.5	2.0	113.3	3.3	70
KNE 1034	ICRISAT	1.883	80	2.0	2.0	13.0	2.0	1.7	5.3	2.0	1.3	105.0	2.3	50
KNE 1060	ICRISAT	2.167	70	2.0	2.7	19.1	2.7	2.0	18.0	3.0	3.0	100.7	3.3	59
KNE 741	ICRISAT	2.800	71	2.3	3.3	19.3	3.0	2.0	13.3	2.0	2.3	116.7	3.7	61
KNE 810	ICRISAT	3.278	66	2.0	3.0	18.0	3.0	2.0	20.7	2.0	2.0	97.3	3.0	66
Checks														
KNE 620 (**R**)		1.689	80	2.0	2.0	24.7	2.0	2.0	7.3	2.5	1.3	93.7	3.0	43
KNE 1034 (**R**)		1.883	80	2.0	2.0	13.0	2.0	1.7	5.3	2.0	1.3	105.0	2.3	50
KNE 479 (**S**)		0.900	46	8.3	9.0	81.4	6.7	4.3	50.0	8.0	9.0	96.0	5.0	77
KAT/FM 1 (**S**)		0.956	53	8.0	9.0	69.6	4.0	2.7	33.0	8.0	8.7	95.0	5.0	76
Mean (n=95)		**1.859**	**67**	**4**	**4**	**44.4**	**3**	**2**	**25**	**4**		**104.0**	**4**	**63**
SE±		**0.5415**	**3.7**	**0.9**	**0.9**	**11.16**	**1.1**	**0.5**	**10.4**	**1.4**		**9.4**	**0.5**	**9.84**
CV%		**29.1**	**5.6**	**25.1**	**21.0**	**25.1**	**33.6**	**23.1**	**40.9**	**35.1**		**9.0**	**14.8**	**15.6**

R- Resistant S- Susceptible; p.maturity – physiological maturity; LR- Long Rainy Season

Table 36. Farmer finger millet varieties (indigenous germplasm) with low finger blast incidence and severity (%) in 2002 SR season

Accession	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Neck blast score (p.maturity)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 1 FMBP/01 WK	0.733	75	1.3	2	5.9	2.7	1.3	1.7	74.7	2.8	48
Acc. # 3 FMBP/01 WK	0.328	77	2	3.2	8.4	2	1.3	1	70.5	4	63
Acc. # 7 FMBP/01 WK	1.116	84	1.8	2.3	8.9	3	1.3	1.5	95.7	3.3	58
Acc. # 8 FMBP/01 WK	1.322	83	1.5	1.7	10.4	3	1.5	1.8	96	2.3	56
Acc. # 9 FMBP/01 WK	1.878	78	1.7	2.3	10.7	2.7	2	2	94.7	2.2	71
Acc. # 11 FMBP/01 WK	1.845	85	1.7	1.8	11.2	2.3	2	2.3	86	2.7	62
Acc. # 13 FMBP/01 WK	1.189	61	2.3	2.3	12.6	2	1.5	3.2	79	3	70
Acc. # 14 FMBP/01 WK	1.889	85	1.5	1.7	13.4	3	1.8	2.3	83	2.8	70
Acc. # 15 FMBP/01 WK	1.606	89	1.7	2	13.4	3.7	2	2.5	92.7	2.7	70
Acc. # 16 FMBP/01 WK	1.678	79	1.8	2	14.2	2.7	1.8	2.3	93.3	2.3	67
Acc. # 17 FMBP/01 WK	1.467	75	1.7	1.8	15.2	2.3	1.7	2	79.7	2.5	58
Acc. # 19 FMBP/01 WK	1.522	87	1.5	1.8	15.5	2.3	1.5	2.3	95	2.5	66
Acc. # 20 FMBP/01 WK	1.444	61	1.7	1.8	16.1	2	1.5	2	90.3	2.5	65
Acc. # 21 FMBP/01 WK	1.261	82	1.7	2	16.1	2	1.5	2	90	2.7	65
Acc. # 22 FMBP/01 WK	0.989	81	1.7	1.8	16.4	2	1.5	1.8	89	2.8	58
Acc. # 23 FMBP/01 WK	1.261	85	1.7	2.2	16.9	3.3	1.7	2.2	90	2.5	58
Acc. # 24 FMBP/01 WK	0.417	77	2	3.7	17.3	2.3	1.3	2.3	74	2.5	50
Acc. # 25 FMBP/01 WK	1.617	74	1.7	2	17.6	2.7	1.8	2	93.3	2	58
Acc. # 26 FMBP/01 WK	1.211	75	2	2.7	17.8	3	1.8	2.2	88.3	2.8	56
Acc. # 28 FMBP/01 WK	1.261	81	3.2	3.3	18	2.3	2	3.2	91	3.2	70
Acc. # 29 FMBP/01 WK	1.489	74	1.8	2.7	18.7	2.7	1.7	1.8	98.3	3	62
Acc. # 30 FMBP/01 WK	1.567	76	1.7	2	19	2	1.8	2.2	86.7	1.7	61
Acc. # 31 FMBP/01 WK	2.411	89	1.5	1.8	19.9	2	1.5	1.8	94.7	1.7	68
Acc. # 32 FMBP/01 WK	1.545	85	1.5	2.2	20.1	2.3	1.8	2.2	87.3	2	66
Acc. # 33 FMBP/01 WK	1.2	71	1.7	2.3	20.6	2.3	1.7	1.8	82.7	2.5	63
Acc. # 36 FMBP/01 WK	0.733	69	1.5	2	21	2.3	1.3	1.8	90.3	3	55
Acc. # 38 FMBP/01 WK	1.2	73	1.7	2	21.4	3	1.7	1.8	86.3	2.8	59
Acc. # 39 FMBP/01 WK	1.428	75	2	3.2	22.8	4.3	3.3	2.2	88.3	3	63
Acc. # 40 FMBP/01 WK	1.667	74	2.3	3	22.8	2	1.7	1.8	78.3	2.3	67
Acc. # 41 FMBP/01 WK	0.817	88	1.5	1.8	23.3	2	1.7	1.7	84.7	2.7	59
Acc. # 42 FMBP/01 WK	1.394	76	2	3	24.4	3.7	1.8	1.5	95	2.7	65
Acc. # 43 FMBP/01 WK	1.178	70	2.7	2.8	24.4	2	1.7	3.2	88	3.2	71

Acc. # 44 FMBP/01 WK	1.089	70	2.3	2.8	24.4	3	1.7	3.3	71.7	3.2	63
Acc. # 48 FMBP/01 WK	2.1	79	1.7	2.2	24.9	2	2	2	78.3	2	58
Acc. # 49 FMBP/01 WK	1.489	74	4	4	25.4	3	2.2	3.2	82	3	78
Acc. # 50 FMBP/01 WK	0.778	73	4.3	5.3	25.5	2.7	1.7	3.7	85	3	59
Acc. # 52 FMBP/01 WK	2.033	80	1.7	2.2	26.4	3	2	1.8	82.7	2.2	68
Acc. # 53 FMBP/01 WK	1.133	83	1.7	2.3	26.4	3.3	2.2	2.3	62.7	2.7	61
Acc. # 54 FMBP/01 WK	1.744	79	1.8	1.8	26.5	3.3	2	2.5	75	3	65
Acc. # 55 FMBP/01 WK	0.984	79	2	2.5	26.6	2.7	1.7	2.5	85	3	49
Acc. # 60 FMBP/01 WK	1.344	72	2	3	26.9	2	1.5	2.3	89	3	63
Acc. # 61 FMBP/01 WK	1.167	74	2.2	2.3	27.1	2.3	2	2.3	91.3	2.2	64
Acc. # 62 FMBP/01 WK	1.6	77	1.8	2.2	27.9	3	1.8	2.3	82.3	2.5	64
Acc. # 63 FMBP/01 WK	1.344	80	1.5	1.8	27.9	2	1.3	1.8	89.3	2.3	63
Acc. # 64 FMBP/01 WK	1.767	77	2.3	2.5	29.6	2.3	2.3	2.7	81	2.8	63
KNE 620 (**R**)	0.733	75	1.3	2.0	5.9	2.7	1.3	1.7	74.7	2.8	48
KNE 1034 (**R**)	0.417	77	2.0	3.7	17.3	2.3	1.3	2.3	74.0	2.5	50
KNE 479 (**S**)	0.778	57	7.3	8.7	43.0	4.7	3.7	7.7	83.3	3.8	63
KAT FM 1 (**S**)	0.528	68	8.3	9.0	69.8	4.0	2.0	8.3	71.7	4.0	66
Mean(n=95)	**1.193**	**77**	**2.9**	**3.6**	**31.7**	**2.7**	**1.832**	**2.1**	**84.8**	**3.0**	**61.9**
SE±	**0.327**	**10.921**	**1.073**	**1.133**	**11.870**	**0.7981**	**0.4536**	**0.9984**	**8.308**	**0.5325**	**7.630**
CV%	**27.4**	**14.3**	**36.5**	**31.7**	**37.5**	**29.2**	**24.8**	**47.5**	**9.8**	**18.0**	**12.3**

R- Resistant S- Susceptible; p.maturity – physiological maturity; SR- Short Rainy Season

Table 37. Finger Millet varieties showing low finger blast incidence and percentage severity combined across two seasons in 2002LR/SR

Accession	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Neck blast score (p.maturity)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 43 FMBP/01 WK	1.883	73	1.8	1.9	23.9	3.5	1.8	1.6	92.7	2.6	65.1
KNE 1015	1.895	78	1.7	2.0	16.1	3.2	1.9	1.5	101.8	2.6	59.8
Acc. # 50 FMBP/01 WK	1.433	68	2.6	2.1	21.0	2.8	1.8	1.9	87.0	2.9	67.3
Acc. # 14 FMBP/01 WK	2.078	75	1.8	2.1	16.5	2.7	1.9	1.7	97.7	2.3	63.6
Acc. # 29 FMBP/01 WK	1.936	72	1.8	2.2	22.4	3.3	1.9	2.0	103.7	2.0	57.3
KNE 883	1.461	75	1.8	2.2	20.8	2.0	1.8	1.7	95.8	2.8	61.0
Acc. # 1 FMBP/01 WK	2.456	73	2.2	2.3	24.8	3.0	2.0	2.3	82.5	2.8	66.8
Acc. # 32 FMBP/01 WK	2.383	78	1.8	2.3	17.2	2.7	1.9	2.7	91.3	2.8	68.2
KNE 683	2.064	79	1.8	2.3	16.7	2.8	2.0	1.7	103.0	2.8	69.6
KNE 1087	1.819	79	1.9	2.3	23.2	2.8	1.8	1.8	97.0	2.6	59.4
KNE 1060	1.714	76	1.7	2.3	17.6	2.3	1.8	2.2	95.3	2.8	62.2
KNE 741	2.161	79	1.8	2.3	17.4	2.7	1.8	1.6	105.8	2.9	63.6
KNE 810	2.372	71	1.7	2.3	16.6	2.7	1.8	1.4	88.5	2.7	62.0
KNE 814	2.545	74	2.0	2.4	17.8	2.7	2.2	1.5	104.5	2.3	67.7
S # 77 SADC	0.703	76	1.6	2.5	14.7	2.0	1.5	1.0	85.0	3.7	51.2
Acc. # 25 FMBP/01 WK	1.758	75	2.1	2.6	21.7	3.7	1.8	1.7	100.5	3.0	56.1
KNE 1149	1.636	82	1.7	2.6	21.2	2.5	2.3	1.3	93.5	2.5	68.6
KNE 1034	1.150	79	1.8	2.6	15.2	2.2	1.4	1.1	86.4	2.3	50.2
KNE 629	1.778	74	1.9	2.7	19.8	2.2	1.8	1.7	89.5	3.1	57.2
Acc. # 16 FMBP/01 WK	2.339	75	2.3	2.8	25.0	2.5	2.2	2.0	92.7	2.6	69.3
Acc. # 44 FMBP/01 WK	1.756	59	2.6	2.9	16.6	2.2	1.8	2.8	84.3	3.2	70.8
Checks											
KNE 620 (**R**)	1.211	78	1.4	1.8	15.3	2.3	1.7	1.1	84.2	2.8	45.7
KNE 814 (**R**)	2.545	74	2.0	2.4	17.8	2.7	2.2	1.5	104.5	2.3	67.7
KNE 479 (**S**)	0.839	64	7.8	8.8	62.2	5.7	4.0	7.7	89.7	4.4	69.8
KAT FM 1 (**S**)	0.742	60	8.2	9.0	69.7	4.0	2.3	7.5	83.3	4.5	71.3
Mean (n=95)	**1.539**	**71**	**3.3**	**3.9**	**37.3**	**3.0**	**2.0**	**3.0**	**95.1**	**3.2**	**63.0**
SE+	**0.4126**	**8.461**	**1.055**	**1.045**	**11.760**	**0.9261**	**0.4632**	**1.1995**	**9.00**	**0.49**	**8.27**
CV%	**26.8**	**11.9**	**32.0**	**27.1**	**31.6**	**30.8**	**22.7**	**39.5**	**9.5**	**15.4**	**13.1**

R- Resistant; S-Susceptible; p.maturity – physiological maturity; LR- Long Rainy Season; SR- Short Rainy Season

Finger millet blast occurrence (incidence and severity) was higher in the long rainy season (Feb-July) than in the short rainy season (August-Dec.) at Alupe station. This is also the case on farmer's fields in the whole western Kenya region as reported by farmers and observed in farmer's fields during the surveys. This is attributed to the favourable weather conditions (high humidity, precipitation and moderate temperatures) for blast pathogen development during the long rainy season. Varieties collected from Kisii and Gucha showed more susceptibility to blast than varieties collected from Busia and Teso districts. This also corroborates survey results, which showed high disease scores in Kisii and Gucha than in Busia and Teso districts. However, poor adaptability of varieties from Kisii/Gucha and Kericho districts (cool medium to high elevation) could have led to their poor agronomic performance at Alupe. Very early varieties had higher finger blast incidences and severity and there was a significant negative correlation between finger blast severity and grain yield during the long rainy season. Varieties collected from Busia/Teso districts had low blast levels than those collected from Kisii/Gucha and Kericho districts. The high humidity, rainfall and moderate temperatures during the long rainy season make the season ideal for natural blast screening. Farmer varieties Acc. #s 14, 29, 32 and 44 and ICRISAT germplasm lines KNE numbers 620, 629, 688, 814 and 1149 were identified with low blast levels and good agronomic performance. The identified varieties/lines can be utilised in breeding programmes to improve varieties with good agronomic traits but with low disease tolerance whereas some of the varieties could be directly utilised for farmer adoption and commercial production with some purification to eliminate any physical mixtures and enhance purity.

Contribution of Outputs to developmental impact

Baseline data has been established on blast prevalence and diversity, distribution and epidemiology of the pathogen across key finger millet producing locations in Uganda and Kenya. A significant collection of characterised pathogen isolates that showed limited genetic diversity has been established. Considerable variation in pathogen aggressiveness but no differential reaction to host varieties has been recorded. Weed and seed-borne pathogen appears to contribute to initial disease development. Varieties with resistance to blast have been identified and information on East African finger millet cropping systems and constraints to production and farmers' perception of blast and management has been generated. A range of activities has been undertaken including training a SAARI pathologist to PhD level, contributing to capability strengthening at partner organisations and to disseminate the project outputs.

Outputs achieved by establishing the knowledge of the disease prevalence, pathogen diversity and epidemiology and identification of resistance sources and disease intervention points, improved capability and dissemination of knowledge to target beneficiaries as well as at a wider level contribute towards achieving the goal of minimising the impact of significant pests of cereal-based systems leading to poverty reduction.

The completed phase was mainly strategic research including identification resistance sources and strong interaction with farmers, which has generated a range of outputs that could be followed through into an adaptive phase of validation and promotion feeding into resistance deployment and development programmes. Consultations held at a wider level clearly showed the need to improve the connectivity among all stakeholders including the research, development and extension workers, finger millet producers and processors and the government agencies and policy makers. Consequently, a short promotional project proposal addressing these issues and building on the outputs generated and collaborations and the network of contacts established has been submitted to DFID-CPP, as outlined below:

Facilitating the promotion of improved and blast resistant finger millet varieties to enhance production

Expected outputs

1. Potential of improved and blast resistant finger millet varieties demonstrated/promoted.

2. Farmer community awareness about blast problems and management issues enhanced through direct interaction and wider dissemination through leaflet/pamphlet distribution.

3. Connectivity between finger millet production - supply chain and R & D/E workers – farmers – industry continuum improved through a regional workshop and distribution of workshop proceedings to R & D/ E organisations, policy makers and donors.

Proposed activities

1. Promotion/demonstration of the potential of improved and blast resistant varieties
Screening work done in Kenya and Uganda in R8030 identified a number of accessions with low blast levels and good agronomic performance. Building on the contacts developed with the farming community and local agricultural extension staff during the PRA and disease surveys conducted in R8030 both in Uganda and Kenya demonstration plots with one or more of these varieties will be set up on farm along with locally grown varieties at key sites. Farmer field days will be conducted at key stages of the crop to demonstrate the potential of the varieties in terms of blast resistance and also their general performance, yield and other important attributes. Extension staff as well local CBOs and NGOs will also be involved in targeting increased awareness of the disease management and varietal potential in the community.

2. Increasing farmer awareness of the blast disease problems and management, harvest and use of clean seed and improving grain quality
PRA work done in R8030 revealed that farmers in Kenya and Uganda did not know the cause, modes of transmission and control measures for blast disease although farmers mentioned some general contact with and role by the community, radio bulletins and extension workers. This dearth of information will be addressed building on these farmer

interaction sources. Role of blast affected weeds and seeds and the importance of collecting and using clean seed to reduce blast and other seed borne pathogens (e.g. *Bipolaris*) and also the role of leaf and neck blast in the infections appearing on heads/fingers will be explained during the farmer field days at the demonstration farms. Also the need to improve post–harvest handling of finger millet seeds, an issue raised by millet processors will be addressed. Feasibility of improved seed sowing methods notably row planting to manage weeds and reduce labour will be consulted with farmers. A simple pamphlet on blast and its management will be prepared and distributed to the participating farmers and also to wider farmer groups and extension workers and specific efforts will be made to achieve further dissemination.

3. Regional workshop to improve connectivity between finger millet production-supply chain and R & D/E workers–farmers–industry continuum and preparation and distribution of workshop proceedings to stakeholders

A regional workshop will be organised at Nairobi working in partnership with ECARSAM with a view to promote and improve communication and understanding of the mutual needs of the growers and the industry and the disease and management knowledge generated and resources identified as well as the potential to enhance finger millet production among all stakeholders. The main participants are likely to be national, regional and international partners and research, development and extension workers, grower and industry representatives including CBOs and NGOs, national co-ordinators of ECARSAM, collaborators of the proposed ECARSAM finger millet project and also representatives of the agriculture/extension ministry and media. To facilitate focused discussions one day consultations with key industry and farmers' group representatives and local CBOs in both Uganda and Kenya will be held. Workshop proceedings will be prepared and distributed to R, D & E organisations, CBOs and NGOs, policy makers, donors and the ECARSAM network.

ECARSAM co-ordinator Dr. Aberra Debelo has been consulted in developing the activities and Dr. Debelo has communicated that the proposed outputs and activities are fully in line with the interests and priorities of ECARSAM. Specific efforts will be made to ensure that the proposed CPP project and proposed ECARSAM project compliment each other and run in parallel.

Mr. Issa Wamala, Managing director of Family Diet in Uganda has planned to engage 300 farmers from Kibaale district who have agreed to grow finger millet targeting 1350 tonnes per harvest and two crops a year. Mr. Wamala contacted the project team seeking assistance to the farmers in finger millet production practices and varieties. This provides an excellent opportunity to work directly with the farming community keen to produce millet and also the processing industry to promote the outputs generated as well as to engage them in the planned activities.

Further, Warwick HRI and SAARI (also linking to ECARSAM and ICRISAT-Nairobi) are part of a consortium of 11 partners from Africa, India and Europe currently involved in developing a proposal on Improving the Potential of Finger Millet for Sustainable Food Production in Semi-Arid Africa and India (FMLINK), through molecular, agro-ecological, nutritional and farmer participatory studies, for submission to EUFP6 INCO-Dev Programme with March 2005 deadline.

If successful, these complementary projects offer excellent opportunities to build on existing collaborations and to forge new partnerships (including South-south with the EU-Inco proposal) to further develop the outputs and also paving way for their up take and adoption linking to ECARSAM and other networks.

Project Output Dissemination List

Publications:

SREENIVASAPRASAD, S., CHIPILI, J. and MUTHUMEENAKSHI, S. (2001) Diversity and dynamics of phytopathogenic fungi: Application of molecular tools. pp 21-22. In: *Proceedings of the 11th Mediterranean Phytopathological Congress*, University of Evora, Portugal. 17-20 September. 2001.

TAKAN, J.P. (2002) Characterisation of finger millet blast pathogen populations in East Africa. Ph. D First year report. Horticulture Research International/University of Exeter, UK. 42 pp.

TAKAN, J.P., MUTHUMEENASKI, S., SREENIVASAPRASAD, S., AKELLO, B., OBILANA, A. BANDYOPADHYAY, R., COLL, R., BROWN, A.E. and TALBOT N.J. (2002) Characterisation of finger millet blast pathogen populations in East Africa and strategies for disease management. Plant Pathoglogy and Global Food Security Meeting, 8-10 July, 2002, Imperial College, London UK.

TAKAN, J.P., MUTHUMEENASKI, S., SREENIVASAPRASAD, S., AKELLO, B., OBILANA, A. BANDYOPADHYAY, R., COLL, R., BROWN, A.E. and TALBOT N.J. (2003) Genetic and pathogenic diversity of the finger millet pathogen in East Africa. International Congress of Plant Pathology, February 2003, New Zealand.

TAKAN, J.P., MUTHUMEENASKI, S., SREENIVASAPRASAD, S., TALBOT N.J. AKELLO, B., OBILANA, A. BANDYOPADHYAY, R., COLL, R. and BROWN, A.E. (2003) Characterisation of finger millet blast pathogen *Magnaporthe grisea* in East Africa. Molecular Biology of Fungal Pathogens XIII Conference, July 2002, Gregynog, UK.

TAKAN, J.P., MUTHUMEENAKSHI,S., SREENIVASAPRASAD, S. and TALBOT, N.J. (2004) Molecular markers and mating type assays to characterize finger millet blast pathogen populations in East Africa. Presentation at Fungi in the Environment, BMS Annual Scientific Meeting, 13-15 September, 2004, Nottingham, UK.

TAKAN,J.P., AKELLO, B., ESELE, J. P., MANYASA, O.E., OBILANA, B.A., AUDI, O.P., KIBUUKA, J., ODENDO, M., ODUORI, C.A., AJANGA, S. BANDYOPADHYAY, R., MUTHUMEENAKSHI, S., COLL, R., BROWN, E. A., TALBOT N.J. and SREENIVASAPRASAD, S. (2004). Pathogen diversity and management of finger millet blast in East Africa: A summary of project activities and outputs. pp. 14. International Sorghum and Millets Newsletter 45, 66-69.

*TAKAN, J., MUTHUMEENAKSHI, S., SREENIVASAPRASAD, S., COLL, R., BROWN, A.E., MANYASA, E.O., OBILANA, A.B., BANDYOPADHYAY, R. and TALBOT, N.J. Molecular diversity, pathogenic variability and mating compatibility of finger millet blast pathogen populations in East Africa. Applied and Environmental Microbiology (in preparation, targeted for submission in 2005).

Internal Reports:

Quarterly/PP and Annual reports submitted to DFID deadlines during April 2001–November 2004.

SREENIVASAPRASAD, S. (2001) BTOR, visit to ICRISAT-Hyderabad and University of Madras, 1-5th Dec. 2001. Submitted to DFID-CPP.

SREENIVASAPRASAD, S. (2002) BTOR, visit to SAARI, Uganda, 10th – 18th March 2002. Submitted to DFID-CPP.

SREENIVASAPRASAD, S. and Takan, J.P. (2002) File note, Finger millet blast management, Semi-Arid Projects Cluster Meeting, 7th Jan 2002, NRI, Chatham. Submitted to DFID-CPP.

SREENIVASAPRASAD, S. (2002) File note, Project review and planning meeting, Warwick HRI, UK, 28 – 30 August 2002. Circulated to project partners.

*BANDYOPADHYAY, R., TAKAN, J.T. and SREENIVASAPRASAD, S. (2003) File note, Field experiments review and planning meeting, Kampala, Uganda, 27-29 September 2003. Circulated to project partners.

*SREENIVASAPRASAD, S. (2004) File note, Project review and planning meeting, Warwick HRI, UK, 26th March 2004. Circulated to project partners and associated collaborators.

Other Dissemination of Results:

*SREENIVASAPRASAD, S. (2003) Fungal diversity and development: Molecular biotechnological approaches. Invited lecture. Association of Microbiologists India-Chennai Chapter, 9th Dec. 2003, University of Madras, Chennai, India.

TAKAN, J.P., MUTHUMEENASKI, S., SREENIVASAPRASAD, S. and TALBOT, N.J. (2004) Characterisation of finger millet blast pathogen populations in East Africa to develop disease management strategies. Annual Students Symposium, 1-2 March 2004, Warwick HRI, Warwickshire.

*TAKAN, J. (2004) Characterisation of finger millet blast pathogen populations in East Africa. Final PhD Seminar at University of Exeter, 24 September 2004.

*SREENIVASAPRASAD, S. (2004) Fungal molecular diversity, development and interactions. August 9th 2004, Invited lecture, School of Biotechnology, Madurai Kamaraj University, India.

Key datasets generated:

*SREENIVASAPRASAD, S., MUTHUMEENAKSHI, S. and TAKAN, J. P. (2004) Dataset: List of characterised *Magnaporthe grisea* isolates associated with finger millet blast in Uganda and Kenya. Excel spreadsheet. Warwick HRI, UK.

*SREENIVASAPRASAD, S. MUTHUMEENAKSHI, S. and TAKAN, J. P. (2004) Dataset: Genetic profiles of key *Magnaporthe grisea* isolates associated with finger millet blast in Uganda and Kenya. Hardcopies and Photoeditor readable images & Excel spreadsheet. Warwick HRI, UK.

*BROWN, A.E., COLL, R., TAKAN, J.P. and SREENIVASAPRASAD, S (2004) Dataset: Pathogenicity data on *Magnaporthe grisea* isolates associated with finger millet blast in Uganda and Kenya. Excel spreadsheet and Statistical analysis data. Warwick HRI/QUB, UK.

*OBILANA, A.B., MANYASA, E.O., KIBUKA, J.G. and SREENIVASAPRASAD, S (2004) Dataset: Screening of finger millet varieties to blast resistance. Word file and Excel Tables. ICRISAT-Nairobi, Kenya/ Warwick HRI, UK.

*AUDI, P.O., ODENDO, M., ODUORI, C.A., OBILANA, A.B., MANYASA, E.O., KIBUKA, J.G., AJANGA, S., TAKAN, J.P., AKELLO, B., ESELE, P. and SREENIVASAPRASAD, S (2004) Dataset: Finger millet production, blast prevalence and constraints to blast management in Kenya and Uganda. ICRISAT-Nairobi, Kenya/SAARI-Uganda/ Warwick HRI, UK. Word file and Excel Tables.

Equipment Inventory Control Form

NRIL Project Code:	ZA0482	DFID Project Number:	R8030	Project Leader:	Dr. S. Sreenivasaprasad
Full Project Title:	Finger millet blast in East Africa: Pathogen diversity and disease management strategies				

Item No	Item	Make and Model	Serial No. (or vehicle registration and chassis Nos)*	Date purchased	Purchase price (in £)	Location (where held)	Person Responsible for Safe Keeping
Please list all equipment (with a purchase value of >£500)							
1	**None**						
2							
3							
4							
5							
6	*(add rows as needed)*						

***The serial No (or in the case of a vehicle, its registration and chassis Nos) must always be completed. The number may be the manufacturer's serial number or one generated by the inventory holder's own sequential numbering system. In the case of the later, the number must be clearly marked on the item itself.*

Inventory details:
The above inventory shows the equipment details that CPP currently holds for this project.

- Please check that the information above is correct and add any details or items of equipment that have not been included or are incorrect.
- All capital equipment remains the property of NR International. Please provide transfer/disposal recommendations for all the equipment items, as indicated in the tables below. This inventory form and recommendations must be submitted to this office by **30 November 2004.**

NRIL Project Code:	ZA	DFID Project Number:	R	Project Leader:	
Full Project Title:					

Transfer or disposal recommendation:

For each equipment item you wish to recommend transfer, please specify:

Item No	Item	Condition of Equipment (e.g good/poor)	Organisation to be transferred to (inc Registered Offices Address)	Justification for recommendations for transfer (insert footnote(s) if needed)
1				
2				
3				
4				
5				
6	*(add rows as needed)*			

For each equipment item you wish to recommend disposal, please specify:

Item No	Item	Justification for recommendation for disposal (insert footnotes(s) if needed)
1		
2		
3		
4		
5		
6	*(add rows as needed)*	

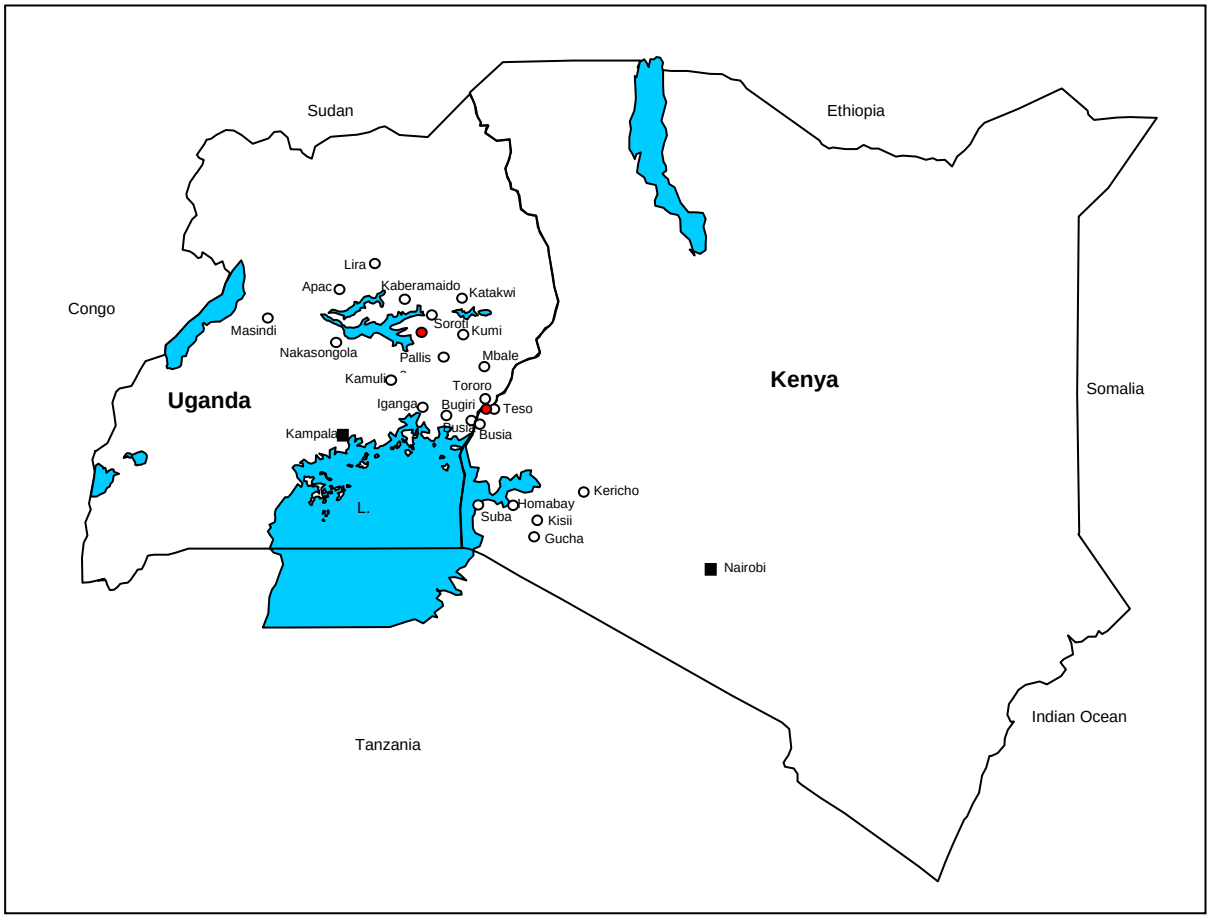
Appendices

Appendix 1. Finger millet blast samples from Kenya: demographic analysis and geographic location description

Location	*Site*	*# of Samples*	*Distance from Busia (km)*	*Altitude (m)*	*Latitude*	*Longitude*
Busia District						
Lugulu	*1*	*5*	*25*	*1294*	*$0^0$19.012N*	*$34^0$18.819E*
Lugulu	*2*	*6*	*25*	*1295*	*$0^0$18.986N*	*$34^0$18.677E*
Bulemia	*3*	*10*	*25*	*1310*	*$0^0$18.829N*	*$34^0$19.154E*
Bulemia	*4*	*1*	*44*	*1276*	*$0^0$19.816N*	*$34^0$19.145E*
Bulemia	*5*	*1*	*44*	*1286*	*$0^0$19.649 N*	*$34^0$18.688E*
Bulemia	*6*	*1*	*44*	*1286*	*$0^0$19.649 N*	*$34^0$18.688E*
Bulemia	*7*	*4*	*45*	*1280*	*$0^0$19.878N*	*$34^0$19.317E*
Nambale	*8*	*7*	*48*	*1241*	*$0^0$24.840N*	*$34^0$19.656E*
Nambale	*9*	*4*	*50*	*1222*	*$0^0$25.629N*	*$34^0$19.974E*
Nambale	*10*	*1*	*51*	*1217*	*$0^0$24.982N*	*$34^0$18.047E*
Nambale	*11*	*1*	*48*	*1241*	*$0^0$24.840N*	*$34^0$19.656E*
Nambale	*12*	*3*	*59*	*1245*	*$0^0$22.837N*	*$34^0$19.570E*
Teso District						
Kaujacto	*13*	*3*	*81*	*1268*	*$0^0$31.954N*	*$34^0$15.600E*
Kaujacto	*14*	*1*	*30*	*1268*	*$0^0$31.954N*	*$34^0$15.600E*
Kaujacto	*15*	*3*	*30*	*1268*	*$0^0$31.954N*	*$34^0$15.600E*
Kaujacto	*16*	*2*	*30*	*1271*	*$0^0$31.615N*	*$34^0$15.557E*
Nambale	*17*	*3*	*50*	*1231*	*$0^0$29.882N*	*$34^0$20.415E*
Nambale	*18*	*3*	*50*	*1231*	*$0^0$29.882N*	*$34^0$20.451E*
Nambale	*19*	*3*	*50*	*1231*	*$0^0$29.882N*	*$34^0$20.451E*
Nambale	*20*	*1*	*50*	*1226*	*$0^0$29.806N*	*$34^0$20.349E*
Nambale	*21*	*1*	*50*	*1259*	*$0^0$30.102N*	*$34^0$20.415E*
Kwangamor	*22*	*2*	*45*	*1259*	*$0^0$33.141N*	*$34^0$19.735E*
Kwangamor	*23*	*2*	*45*	*1259*	*$0^0$33.141N*	*$34^0$19.735E*

Kwangamor	*24*	*3*	*45*			
Kwangamor	*25*	*1*	*46*	*1249*	*$0^0$34.165N*	*$34^0$19.275E*
Kwangamor	*26*	*2*	*46*	*1249*	*$0^0$34.165N*	*$34^0$19.275E*
Kwangamor	*27*	*3*	*47*	*1262*	*$0^0$32.09N*	*$34^0$19.382E*
Kokare	*28*	*2*	*58*	*1191*	*$0^0$37.017N*	*$34^0$20439E*
		3	*60*	*1177*	*$0^0$36.841N*	*$34^0$19.450E*
Kokare	*29*	*2*	*62*	*1185*	*$0^0$36.841N*	*$34^0$19.105E*
Kokare	*30*	*2*	*63*	*1177*	*$0^0$36.336N*	*$34^0$18.847E*
Kokare	*31*	*2*	*57*			
Kamuriai	*32*	*1*	*35*	*1208*	*$0^0$39.648N*	*$34^0$17.827E*
Kamuriai	*33*	*1*	*37*	*1215*	*$0^0$39.633N*	*$34^0$18.030E*
Osanjai	*34*	*1*	*39*			
Osanjai	*35*	*2*	*39*	*1235*	*$0^0$40.513N*	*$34^0$18.062E*
Akichelosit	*36*	*1*	*44*	*1332*	*$0^0$41.573N*	*$34^0$20.133E*
Akichelosit	*37*	*1*	*44*	*1332*	*$0^0$41.573N*	*$34^0$20.133E*
Kokapel	*38*	*2*	*48*	*1422*	*$0^0$40.566N*	*$34^0$21.181E*
Kisii District			***(from Kisii town)***			
Ramasha	*39*	*2*	*45*	*2973*	*$0^0$53.459S*	*$34^0$51.062'E*
Ramasha	*40*	*4*	*47*	*1927*	*$0^0$53.111S*	*$34^0$56.147'E*
Ikinye	*41*	*1*	*51*	*2023*	*$0^0$52.715S*	*$34^0$55.227'E*
Ikinye	*42*	*1*	*47*	*1998*	*$0^0$53.349S*	*$34^0$57.885'E*
Ramasha	*43*	*1*	*49*	*2049*	*$0^0$53.904S*	*$34^0$58.867'E*
Ramasha	*44*	*1*		*2002*	*$0^0$53.290S*	*$34^0$58.943'E*
Ikorongo	*45*	*1*	*44*	*2046*	*$0^0$51.434S*	*$34^0$57.898'E*
Ikorongo	*46*	*1*	*45*	*2056*	*$0^0$51.608S*	*$34^0$58.191'E*
Ikorongo	*47*	*1*	*47*	*2056*	*$0^0$52.870S*	*$34^0$59.091'E*
Ramasha	*49*	*1*	*53*	*2038*	*$0^0$53.539S*	*$34^0$58.421E*
Gucha District			**(from Kisii town)**			
Nyacheki	50	2	52	1997	$0^0$53.893S	$34^0$53.489E
Nyacheki	51	1		1994	$0^0$53.893S	$34^0$53.489E
Bosi Borabu	52	1	55	1916	$0^0$53.227S	$34^0$52.767E
Bosi Borabu	53	1	65	1913	$0^0$53.550S	$34^0$52.404E
Bosi Borabu	54	1	67	1967	$0^0$54.478S	$34^0$54.469E

Bosi Borabu	55	1	67	1967	$0^0$54.478S	$34^0$54.469E
Bosi Borabu	56	1	-			
Nyacheki	57	2	53	1971	$0^0$53.079S	$34^0$53.923E
Nyacheki	58	1	56	1977	$0^0$52.007S	$34^0$53.387E
Nyacheki	59	2	58	2009	$0^0$51.638S	$34^0$52.741E
Nyacheki	60	1	62	2068	$0^0$51.054S	$34^0$51.724E
Nyacheki	61	1	64	1779	$0^0$51.818S	$34^0$51.570E
Nyacheki	62	1	68	1892	$0^0$53.459S	$34^0$51.922E
Bosi Borabu	63	2	71	1905	$0^0$53.401S	$34^0$53.208E
Homabay District						
Asego	64	3	-	1188	$0^0$31.793S	$34^0$27.811E
Teso District			***(from Busia town)***			
Alupe Research Station	65	22	10	1189	0^o29’N	34^o08’E



Appendix 2. Socio-economic and disease survey sites in Uganda and Kenya

Appendix 3. Details of *Magnaporthe grisea* isolates established and characterised from Uganda and Kenya, along with some reference isolates

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
1	D1/S11	Uganda	Pallisa	*Eleusine corocana*	Neck	2000	1
2	D4/S12	Uganda	Tororo	*E. corocana*	Panicle	2000	2
3	D7/S2n	Uganda	Kamuli	*E. corocana*	Neck	2000	3
4	D9/S6	Uganda	Lira	*E. corocana*	Panicle	2000	4
5	D10/S14	Uganda	Apac	*E. corocana*	Panicle	2000	5
6	D12/S1	Uganda	Nakasongola	*E. corocana*	Panicle	2000	6
7	K5/23	Kenya	Teso	*E. corocana*	Neck	2000	7
8	K6/27	Kenya	Busia	*E. corocana*	Panicle	2000	8
9	K9/43	Kenya	Teso	*E. corocana*	Panicle	2000	9
10	K14/74	Kenya	Teso	*E. corocana*	Neck	2000	10
11	D1/S19	Uganda	Pallisa	*E. corocana*	Panicle	2000	11
12	D2/S14	Uganda	Kumi	*E. corocana*	Panicle	2000	12
13	D4/S14s	Uganda	Tororo	*E. corocana*	Panicle	2000	13
14	D4/S26	Uganda	Tororo	*E. corocana*	Panicle	2000	14
15	D2/S6	Uganda	Kumi	*E. corocana*	Panicle	2000	15
16	D9/S31s	Uganda	Lira	*E. corocana*	Panicle	2000	16
17	D11/S1	Uganda	Masindi	*E. corocana*	Panicle	2000	17
18	D12/S2	Uganda	Nakasongola	*E. corocana*	Panicle	2000	18
19	D12/S3	Uganda	Nakasongola	*E. corocana*	Panicle	2000	19
20	K3/21s	Kenya	Teso	*E. corocana*	Panicle	2000	20
21	D4/S14n	Uganda	Tororo	*E. corocana*	Neck	2000	21
22	D5/S5	Uganda	Iganga	*E. corocana*	Panicle	2000	22
23	D6/S1	Uganda	Bugiri	*E. corocana*	Panicle	2000	23
24	D8/S15	Uganda	Busia	*E. corocana*	Panicle	2000	24
25	D9/S9	Uganda	Lira	*E. corocana*	Panicle	2000	25
26	D9/S31n	Uganda	Lira	*E. corocana*	Neck	2000	26

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
27	D11/S16	Uganda	Masindi	*E. corocana*	Panicle	2000	27
28	D15/E11	Uganda	Soroti	*E. corocana*	Panicle	2000	28
29	K3/21n	Kenya	Teso	*E. corocana*	Neck	2000	29
30	K8/37	Kenya	Busia	*E. corocana*	Neck	2000	30
31	D3/S17s	Uganda	Mbale	*E. corocana*	Panicle	2000	31
32	D3/S17n	Uganda	Mbale	*E. corocana*	Neck	2000	32
33	D5/S1	Uganda	Iganga	*E. corocana*	Panicle	2000	33
34	D7/S2s	Uganda	Kamuli	*E. corocana*	Panicle	2000	34
35	D8/S18	Uganda	Busia	*E. corocana*	Panicle	2000	35
36	D10/S5	Uganda	Apac	*E. corocana*	Panicle	2000	36
37	D13/S5	Uganda	Katakwi	*E. corocana*	Panicle	2000	37
38	K9/47	Kenya	Teso	*Dactyloctenium aegyptium*	Panicle	2000	38
39	D1/S13	Uganda	Pallisa	*E. corocana*	Panicle	2000	39
40	D1/S18	Uganda	Pallisa	*E. corocana*	Panicle	2000	40
41	D3/S10	Uganda	Mbale	*E. corocana*	Neck	2002	41
42	D4/S24	Uganda	Tororo	*E. corocana*	Panicle	2000	42
43	D10/S7	Uganda	Apac	*E. corocana*	Panicle	2000	43
44	D11/S11	Uganda	Masindi	*E. corocana*	Panicle	2000	44
45	D13/S20	Uganda	Katakwi	*E. corocana*	Panicle	2000	45
46	D14/S27	Uganda	Kaberamaido	*E. corocana*	Panicle	2000	46
47	D15/S4	Uganda	Soroti	*E. corocana*	Panicle	2000	47
48	D15/S12	Uganda	Soroti	*E. corocana*	Panicle	2000	48
49	W/S5	Uganda	Pallisa	*E. indica*	Panicle	2000	49
50	K5/25	Kenya	Teso	*E. corocana*	Panicle	2000	50
51	K8/37	Kenya	Busia	*E. corocana*	Neck	2000	51
52	K29/164	Kenya	Suba	*E. corocana*	Panicle	2000	52
53	D3/S9	Uganda	Mbale	*E. corocana*	Panicle	2000	53
54	D9/S17	Uganda	Lira	*E. corocana*	Panicle	2000	54
55	D9/S25	Uganda	Lira	*E. corocana*	Panicle	2000	55
56	D10/S9	Uganda	Apac	*E. corocana*	Panicle	2000	56

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
57	D14/S4	Uganda	Kaberamaido	*E. corocana*	Panicle	2000	57
58	W/S15	Uganda	Pallisa	*E. indica*	Panicle	2000	58
59	K1/2	Kenya	Teso	*E. corocana*	Panicle	2000	59
60	K1/15	Kenya	Teso	*E. indica*	Panicle	2000	60
61	K1/198	Kenya	Teso	*E. corocana*	Panicle	2000	61
62	K12/63	Kenya	Teso	*E. corocana*	Neck	2000	62
63	K13/67	Kenya	Teso	*E. corocana*	Neck	2000	63
64	K20/106	Kenya	Teso	*E. corocana*	Neck	2000	64
65	K20/107	Kenya	Teso	*E. corocana*	Neck	2000	65
66	K20/108	Kenya	Teso	*E. corocana*	Neck	2000	66
67	K22/118	Kenya	Busia	*E. corocana*	Neck	2000	67
68	K25/135	Kenya	Kisii Central	*E. corocana*	Panicle	2000	68
69	K33/189	Kenya	Kericho	*E. corocana*	Leaf	2000	69
70	D13/S19	Uganda	Katakwi	*E. corocana*	Panicle	2000	70
71	D13/S33	Uganda	Katakwi	*E. corocana*	Panicle	2000	71
72	W/S12	Uganda	Pallisa	*E. indica*	Panicle	2000	72
73	K9/46	Kenya	Teso	*E. indica*	Panicle	2000	73
74	K10/50	Kenya	Teso	*E. corocana*	Neck	2000	74
75	K13/69	Kenya	Teso	*E. corocana*	Neck	2000	75
76	K16/87	Kenya	Teso	*E. corocana*	Panicle	2000	76
77	K18/99	Kenya	Teso	*E. corocana*	Panicle	2000	77
78	K24/127	Kenya	Kisii Central	*E. corocana*	Panicle	2000	78
79	D3/S3	Uganda	Mbale	*E. corocana*	Panicle	2000	79
80	D3/S24	Uganda	Mbale	*E. corocana*	Panicle	2000	80
81	D5/S3	Uganda	Iganga	*E. corocana*	Panicle	2000	81
82	D7/S6	Uganda	Kamuli	*E. corocana*	Panicle	2000	82
83	D8/S10	Uganda	Busia	*E. corocana*	Panicle	2000	83
84	D10/S23	Uganda	Apac	*E. corocana*	Panicle	2000	84
85	D11/S12	Uganda	Masindi	*E. corocana*	Panicle	2000	85
86	D14/S9	Uganda	Kaberamaido	*E. corocana*	Panicle	2000	86

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
87	D14/S21	Uganda	Kaberamaido	*E. corocana*	Panicle	2000	87
88	D15/S6	Uganda	Soroti	*E. corocana*	Panicle	2000	88
89	D15/S27	Uganda	Soroti	*E. corocana*	Panicle	2000	89
90	W/S4	Uganda	Pallisa	*E. indica*	Panicle	2000	90
91	W/S16	Uganda	Pallisa	*E. indica*	Panicle	2000	91
92	K1/13	Kenya	Teso	*E. indica*	Panicle	2000	92
93	K6/28a	Kenya	Busia	*E. corocana*	Neck	2000	93
94	K6/28b	Kenya	Busia	*E. corocana*	Panicle	2000	94
95	K6/30	Kenya	Busia	*E. indica*	Panicle	2000	95
96	K8/38	Kenya	Busia	*E. corocana*	Neck	2000	96
97	K8/39	Kenya	Busia	*E. corocana*	Panicle	2000	97
98	K8/40	Kenya	Busia	*E. indica*	Panicle	2000	98
99	K9/42	Kenya	Teso	*E. corocana*	Neck	2000	99
100	K12/61	Kenya	Teso	*E. corocana*	Panicle	2000	100
101	K12/62	Kenya	Teso	*E. corocana*	Neck	2000	101
102	K13/68	Kenya	Teso	*E. corocana*	Neck	2000	102
103	K14/75	Kenya	Teso	*E. corocana*	Panicle	2000	103
104	K15/78	Kenya	Teso	*E. corocana*	Neck	2000	104
105	K15/78	Kenya	Teso	*E. corocana*	Neck	2000	105
106	K15/80	Kenya	Teso	*E. corocana*	Panicle	2000	106
107	K17/93	Kenya	Teso	*E. corocana*	Neck	2000	107
108	K18/96	Kenya	Teso	*E. corocana*	Neck	2000	108
109	K23/123	Kenya	Busia	*E. corocana*	Neck	2000	109
110	K33/184	Kenya	Kericho	*E. corocana*	Panicle	2000	110
111	D1/S38	Uganda	Pallisa	*E. corocana*	Leaf	2002	201
112	D1/S44	Uganda	Pallisa	*E. corocana*	Leaf	2002	202
113	D1/S53b	Uganda	Pallisa	*E. corocana*	Leaf	2002	203
114	D1/S72	Uganda	Pallisa	*E. corocana*	Leaf	2002	204
115	D2/S24	Uganda	Kumi	*E. corocana*	Leaf	2002	205
116	D2/S26	Uganda	Kumi	*E. corocana*	Leaf	2002	206

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
117	D2/S28	Uganda	Kumi	*E. corocana*	Leaf	2002	207
118	D3/S31	Uganda	Mbale	*E. corocana*	Leaf	2002	208
119	D4/S38	Uganda	Tororo	*E. corocana*	Leaf	2002	209
120	D9/S32	Uganda	Lira	*E. corocana*	Leaf	2002	210
121	D9/S59	Uganda	Lira	*E. corocana*	Leaf	2002	211
122	D9/S78	Uganda	Lira	*E. corocana*	Leaf	2002	212
123	D10/S54	Uganda	Apac	*E. corocana*	Leaf	2002	213
124	D10/S69	Uganda	Apac	*E. corocana*	Leaf	2002	214
215	D14/S30	Uganda	Kaberamaido	*E. corocana*	Leaf	2002	215
126	D14/S32	Uganda	Kaberamaido	*E. corocana*	Leaf	2002	216
127	D15/S40	Uganda	Soroti	*E. corocana*	Leaf	2002	217
128	D15/S41	Uganda	Soroti	*E. corocana*	Leaf	2002	218
129	D15/S48	Uganda	Soroti	*E. corocana*	Leaf	2002	219
130	D15/S49	Uganda	Soroti	*E. corocana*	Leaf	2002	220
131	D1/S31	Uganda	Pallisa	*E. corocana*	Neck	2002	221
132	D1/S35	Uganda	Pallisa	*E. corocana*	Neck	2002	222
133	D1/S44a	Uganda	Pallisa	*E. corocana*	Neck	2002	223
134	D1/S44b	Uganda	Pallisa	*E. corocana*	Node	2002	224
135	D1/S59	Uganda	Pallisa	*E. corocana*	Neck	2002	225
136	D1/S66	Uganda	Pallisa	*E. corocana*	Neck	2002	226
137	D1/S73	Uganda	Pallisa	*E. corocana*	Neck	2002	227
138	D2/S25	Uganda	Kumi	*E. corocana*	Neck	2002	228
139	D2/S32	Uganda	Kumi	*E. corocana*	Neck	2002	229
140	D4/S38a	Uganda	Tororo	*E. corocana*	Neck	2002	230
141	D4/S38b	Uganda	Tororo	*E. corocana*	Node	2002	231
142	D4/S41	Uganda	Tororo	*E. corocana*	Neck	2002	232
143	D9/S46	Uganda	Lira	*E. corocana*	Neck	2002	233
144	D9/S51	Uganda	Lira	*E. corocana*	Neck	2002	234
145	D9/S56	Uganda	Lira	*E. corocana*	Neck	2002	235
166	D9/S67	Uganda	Lira	*E. corocana*	Neck	2002	236

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
147	D9/S70	Uganda	Lira	*E. corocana*	Neck	2002	237
148	D10/S50	Uganda	Apac	*E. corocana*	Neck	2002	238
148	D10/S61	Uganda	Apac	*E. corocana*	Neck	2002	239
150	D10/S65a	Uganda	Apac	*E. corocana*	Neck	2002	240
151	D10/S65b	Uganda	Apac	*E. corocana*	Node	2002	241
152	D10/S75	Uganda	Apac	*E. corocana*	Neck	2002	242
153	D10/S86	Uganda	Apac	*E. corocana*	Neck	2002	243
154	D15/S47	Uganda	Soroti	*E. corocana*	Neck	2002	244
155	D15/S50	Uganda	Soroti	*E. corocana*	Neck	2002	245
156	D15/S52	Uganda	Soroti	*E. corocana*	Neck	2002	246
157	D15/S59	Uganda	Soroti	*E. corocana*	Neck	2002	247
158	D1/S42	Uganda	Pallisa	*E. indica*	Panicle	2002	248
159	D1/S49	Uganda	Pallisa	*Digitaria horizontalis*	Leaf	2002	249
160	D1/S64	Uganda	Pallisa	*E. indica*	Panicle	2002	250
161	D9/S35	Uganda	Lira	*E. indica*	Leaf	2002	251
162	D9/S50	Uganda	Lira	*E. indica*	Panicle	2002	252
163	D9/S54	Uganda	Lira	*D. aegyptium*	Panicle	2002	253
164	D10/S38	Uganda	Apac	*D. horizontalis*	Leaf	2002	254
165	D10/S53b	Uganda	Apac	*E. indica*	Panicle	2002	255
166	D10/S56	Uganda	Apac	*Pennisetum purpureum*	Leaf	2002	256
167	D10/S71	Uganda	Apac	*E. indica*	Leaf	2002	257
168	D10/S73	Uganda	Apac	*D. scalarum*	Leaf	2002	258
169	D10/S83	Uganda	Apac	*E. indica*	Panicle	2002	259
170	D15/S37	Uganda	Soroti	*D. horizontalis*	Leaf	2002	260
171	D15/S37b	Uganda	Soroti	*E. indica*	Leaf	2002	261
176	D15/S38	Uganda	Soroti	*Cynodon dactylon*	Leaf	2002	262
173	D15/S42	Uganda	Soroti	*D. horizontalis*	Leaf	2002	263
174	D15/S45	Uganda	Soroti	*Isachne kiyalaensis*	Leaf	2002	264
175	D15/S46	Uganda	Soroti	*D. aegyptium*	Leaf	2002	265
176	D2/S31	Uganda	Kumi	*Oryza sativa*	Panicle	2002	266

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
177	K7/26n	Kenya	Busia	*E. corocana*	Neck	2002	267
178	K8/36n	Kenya	Busia	*E. corocana*	Neck	2002	268
179	K9/38n	Kenya	Busia	*E. corocana*	Neck	2002	269
180	K11/42n	Kenya	Busia	*E. corocana*	Neck	2002	270
181	K13/47n	Kenya	Teso	*E. corocana*	Neck	2002	271
182	K14/49n	Kenya	Teso	*E. corocana*	Neck	2002	272
183	K15/53n	Kenya	Teso	*E. corocana*	Neck	2002	273
184	K16/54n	Kenya	Teso	*E. corocana*	Neck	2002	274
185	K20/66n	Kenya	Teso	*E. corocana*	Neck	2002	275
186	K21/68n	Kenya	Teso	*E. corocana*	Neck	2002	276
187	K22/70n	Kenya	Teso	*E. corocana*	Neck	2002	277
188	K24/73n	Kenya	Teso	*E. corocana*	Neck	2002	278
189	K26/77n	Kenya	Teso	*E. corocana*	Neck	2002	279
190	K28/83n	Kenya	Teso	*E. corocana*	Neck	2002	280
191	K29/88n	Kenya	Teso	*E. corocana*	Neck	2002	281
192	K30/89n	Kenya	Teso	*E. corocana*	Neck	2002	282
193	K31/91n	Kenya	Teso	*E. corocana*	Neck	2002	283
194	K35/96n	Kenya	Teso	*E. corocana*	Neck	2002	284
195	K36/98n	Kenya	Teso	*E. corocana*	Neck	2002	285
196	K38/100n	Kenya	Teso	*E. corocana*	Neck	2002	286
197	K40/106n	Kenya	Kisii	*E. corocana*	Neck	2002	287
198	K45/112n	Kenya	Kisii	*E. corocana*	Neck	2002	288
199	K48/115n	Kenya	Kisii	*E. corocana*	Neck	2002	289
200	K54/123n	Kenya	Gucha	*E. corocana*	Neck	2002	290
201	K56/125n	Kenya	Gucha	*E. corocana*	Neck	2002	291
202	K62/133n	Kenya	Gucha	*E. corocana*	Neck	2002	292
203	K63/135n	Kenya	Gucha	*E. corocana*	Neck	2002	293
204	K64/138n	Kenya	Homabay	*E. corocana*	Neck	2002	294
205	K65/139n	Kenya	Alupe/Teso	*E. corocana*	Neck	2002	295
206	K65/140n	Kenya	Alupe/Teso	*E. corocana*	Neck	2002	296

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
207	K65/142n	Kenya	Alupe/Teso	*E. corocana*	Neck	2002	297
208	K65/143n	Kenya	Alupe/Teso	*E. corocana*	Neck	2002	298
209	K1/4w	Kenya	Busia	*E. indica*	-[a]	2002	299
210	K9/39w	Kenya	Busia	*E. indica*	-	2002	300
211	K4/22w	Kenya	Busia	*E. indica*	-	2002	301
212	K5/24w	Kenya	Busia	*E. indica*	-	2002	302
213	K7/28w	Kenya	Busia	*E. indica*	-	2002	303
214	K8/31w	Kenya	Busia	*E. indica*	-	2002	304
215	K8/32w	Kenya	Busia	*E. indica*	-	2002	305
216	K15/50w	Kenya	Teso	*E. indica*	-	2002	306
217	K16/55w	Kenya	Teso	*E. indica*	-	2002	307
218	K20/67w	Kenya	Teso	*E. indica*	-	2002	308
219	K22/69w	Kenya	Teso	*E. indica*	-	2002	309
220	K23/72w	Kenya	Teso	*E. indica*	-	2002	310
221	K27/81w	Kenya	Teso	*D. aegyptium*	-	2002	311
222	K28/82w	Kenya	Teso	*E. indica*	-	2002	312
223	K28/85w	Kenya	Teso	*E. indica*	-	2002	313
224	K29/87w	Kenya	Teso	*E. indica*	-	2002	314
225	K30/90w	Kenya	Teso	*E. indica*	-	2002	315
226	K38/101w	Kenya	Teso	*E. indica*	-	2002	316
227	K40/104w	Kenya	Kisii	*E. indica*	-	2002	317
228	K50/118w	Kenya	Gucha	*E. indica*	-	2002	318
229	K52/121w	Kenya	Gucha	*E. indica*	-	2002	319
230	K65/154w	Kenya	Alupe/Teso	*E. indica*	-	2002	320
231	K65/156w	Kenya	Alupe/Teso	*E. indica*	-	2002	321
232	K65/159w	Kenya	Alupe/Teso	*E. indica*	-	2002	322
233	K65/160w	Kenya	Alupe/Teso	*E. indica*	-	2002	323
234	K1/2p	Kenya	Busia	*E. corocana*	Panicle	2002	324
235	K3/16p	Kenya	Busia	*E. corocana*	Panicle	2002	325
236	K4/21p	Kenya	Busia	*E. corocana*	Panicle	2002	326

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
237	K8/30p	Kenya	Busia	*E. corocana*	Panicle	2002	327
238	K8/35p	Kenya	Busia	*E. corocana*	Panicle	2002	328
238	K12/43p	Kenya	Busia	*E. corocana*	Panicle	2002	329
240	K24/74p	Kenya	Teso	*E. corocana*	Panicle	2002	330
241	K26/76p	Kenya	Teso	*E. corocana*	Panicle	2002	331
242	K34/95p	Kenya	Teso	*E. corocana*	Panicle	2002	332
243	K38/100p	Kenya	Teso	*E. corocana*	Panicle	2002	333
244	K39/102p	Kenya	Kisii	*E. corocana*	Panicle	2002	334
245	K41/108p	Kenya	Kisii	*E. corocana*	Panicle	2002	335
246	K44/111p	Kenya	Kisii	*E. corocana*	Panicle	2002	336
247	K46/113p	Kenya	Kisii	*E. corocana*	Panicle	2002	337
248	K47/114p	Kenya	Kisii	*E. corocana*	Panicle	2002	338
249	K49/116p	Kenya	Kisii	*E. corocana*	Panicle	2002	339
250	K52/8p	Kenya	Gucha	*E. corocana*	Panicle	2002	340
251	K55/124p	Kenya	Gucha	*E. corocana*	Panicle	2002	341
252	K56/125p	Kenya	Gucha	*E. corocana*	Panicle	2002	342
253	K57/126p	Kenya	Gucha	*E. corocana*	Panicle	2002	343
254	K58/128p	Kenya	Gucha	*E. corocana*	Panicle	2002	344
255	K60/131p	Kenya	Gucha	*E. corocana*	Panicle	2002	345
256	K64/136p	Kenya	Homabay	*E. corocana*	Panicle	2002	346
257	K64/137p	Kenya	Homabay	*E. corocana*	Panicle	2002	347
258	K65/150p	Kenya	Alupe	*E. corocana*	Panicle	2002	348
259	D1/S41	Uganda	Pallisa	*E. corocana*	Panicle	2002	349
260	D1/S50	Uganda	Pallisa	*E. corocana*	Panicle	2002	350
261	D1/S52	Uganda	Pallisa	*E. corocana*	Panicle	2002	351
262	D1/S60	Uganda	Pallisa	*E. corocana*	Panicle	2002	352
263	D1/S63	Uganda	Pallisa	*E. corocana*	Panicle	2002	353
264	D1/S68	Uganda	Pallisa	*E. corocana*	Panicle	2002	354
265	D2/S32	Uganda	Kumi	*E. corocana*	Panicle	2002	355
266	D9/S62	Uganda	Lira	*E. corocana*	Panicle	2002	356

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
267	D9/S66	Uganda	Lira	*E. corocana*	Panicle	2002	357
268	D9/S69	Uganda	Lira	*E. corocana*	Panicle	2002	358
269	D9/S76	Uganda	Lira	*E. corocana*	Panicle	2002	359
270	D10/S42b	Uganda	Apac	*E. corocana*	Panicle	2002	360
271	D10/S47	Uganda	Apac	*E. corocana*	Panicle	2002	361
272	D10/S52	Uganda	Apac	*E. corocana*	Panicle	2002	362
273	D10/S63	Uganda	Apac	*E. corocana*	Panicle	2002	363
274	D10/S67	Uganda	Apac	*E. corocana*	Panicle	2002	364
275	D10/S77	Uganda	Apac	*E. corocana*	Panicle	2002	365
276	D10/S88	Uganda	Apac	*E. corocana*	Panicle	2002	366
277	D13/S38	Uganda	Katakwi	*E. corocana*	Panicle	2002	367
278	D13/S42	Uganda	Katakwi	*E. corocana*	Panicle	2002	368
279	D15/S47	Uganda	Soroti	*E. corocana*	Panicle	2002	369
280	D15/S56	Uganda	Soroti	*E. corocana*	Panicle	2002	370
281	E11p-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	401
282	E11p-1-2	Uganda	Soroti	*E. corocana*	Panicle	2004	402
283	E11n-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	403
284	E11n-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	404
285	E11p-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	405
286	E11p-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	406
287	Gul-2-1	Uganda	Soroti	*E. corocana*	Leaf	2004	407
288	Gun-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	408
289	Gun-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	409
290	Gup-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	410
291	Gup-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	411
292	Odyl-2-1	Uganda	Soroti	*E. corocana*	Leaf	2004	412
293	Odyl-2-2	Uganda	Soroti	*E. corocana*	Leaf	2004	413
294	Odyl-2-3	Uganda	Soroti	*E. corocana*	Leaf	2004	414
295	Odyp-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	415
296	Odyp-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	416

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
297	Pep-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	417
298	Pep-1-2	Uganda	Soroti	*E. corocana*	Panicle	2004	418
299	Pen-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	419
300	Pen-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	420
301	Pep-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	421
302	Pep-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	422
303	P665n-1-1	Uganda	Soroti	*E. corocana*	Neck	2004	423
304	P665p-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	424
305	P665l-2-1	Uganda	Soroti	*E. corocana*	Leaf	2004	425
306	P665n-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	426
307	P665n-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	427
308	P665p-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	428
309	P665p-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	429
310	Secn-1-1	Uganda	Soroti	*E. corocana*	Neck	2004	430
311	Secp-1-2	Uganda	Soroti	*E. corocana*	Panicle	2004	431
312	Secn-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	432
313	Secn-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	433
314	Secp-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	434
315	Secp-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	435
316	S2p-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	436
317	S2n-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	437
318	S2n-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	438
319	S2p-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	439
320	S2p-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	440
321	S3p-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	441
322	S3p-1-2	Uganda	Soroti	*E. corocana*	Panicle	2004	442
323	S3n-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	443
324	S3n-2-2	Uganda	Soroti	*E. corocana*	Neck	2004	444
325	S3p-2-1	Uganda	Soroti	*E. corocana*	Panicle	2004	445
326	S3p-2-2	Uganda	Soroti	*E. corocana*	Panicle	2004	446

Serial No.	Isolate	Country	District	Host	Plant part	Year of collection	DNA No.
327	S1n-2-1	Uganda	Soroti	*E. corocana*	Neck	2004	447
328	S1p-1-1	Uganda	Soroti	*E. corocana*	Panicle	2004	448
329	5008	Ghana		*O. sativa*	Leaf	2001	450
330	5009	Ghana		*O. sativa*	Leaf	2001	451
331	5081	Ghana		*O. sativa*	Leaf	2001	452
332	6005b	Ghana		*O. sativa*	Leaf	2001	453
333	6007c	Ghana		*O. sativa*	Leaf	2001	454
334	60011a	Ghana		*O. sativa*	Leaf	2001	455
335	60035	Ghana		*O. sativa*	Leaf	2001	456
336	60059	Ghana		*O. sativa*	Leaf	2001	457
337	IB-54*			*O. sativa*			458
338	Mg-70-6**			*O. sativa*			459
339	MG-R***			*O. sativa*			460
340	G22*	Japan		*E. corocana*			
341	Guy 11*	French Guyana		*O. sativa*			
342	TH 3*	Thailand		*O. sativa*			
343	JP 15*	Japan		*O. sativa*			
344	BR 62*	Brazil		*E. indica*			
345	I-R-22*			Buff mutant - laboratory			
346	4136-4-3*			Laboratory strain, weeping love grass			

* Isolates were provided by Prof. N.J.Talbot, University of Exeter, UK; ** Isolate from Prof. A. Ellingboe, University of Winconsin, USA;
*** Isolate from Dr. J.E. Hamer, Purdue University/Paradigm Genetics, USA.

Isolates from Ghana were provided by Dr. S. Sreenivasaprasad, Warwick HRI, University of Warwick
[a]Weed isolates were isolated from either the neck or
panicle.

Isolates 329-346 were previously characterised and were used for comparison and reference

Appendix 4. DNeasy Plant Mini Kit protocol (Qiagen)

Buffers AP3/E and AW were supplied by Qiagen as concentrates and appropriate amount of ethanol (100%) was added to each prior to initial use.

400 μl of buffer AP1 (lysis buffer) and 4 μl of RNase A stock solution (100 mg ml^{-1}) were added to the mycelial powder in a 2 ml tube. The tube was vortexed vigorously until no more tissue clumps were visible (clumped tissue do not lyse efficiently and will result in a lower DNA yield). After vortexing, the tubes were incubated at 65° C for 10 min in a water bath and mixed 3 times during the incubation to lyse the cells. Thereafter, 130 μl of buffer AP2 (precipitation buffer) was added to the lysate, mixed, and incubated on ice for 5 min. To remove any precipitate and the sand, the lysate was centrifuged for 5 min at maximum speed (14,000 rpm). After centrifugation, the lysate was applied to the QIAshredder spin column and centrifuged for 2 min at maximum speed. The QIAshredder removes most of the precipitate and cell debris and allows the liquid with the DNA to flow through into the collection tube. The flow through (approximately 350 – 400 μl) was transferred to a new tube and 1.5 volumes of buffer AP3/E (binding buffer) was added to the cleared lysate and immediately mixed by pipetting. The mixture was applied to the DNeasy® mini spin column and centrifuged for 1 min at 8, 000 rpm. After centrifugation, the flow-through was discarded and where necessary the step repeated to accommodate the remaining mixture. The DNeasy® column was placed in a new 2 ml collection tube and 500 μl of buffer AW (washing buffer) was added to the DNeasy® column and centrifuged for one min at 8000 rpm. After discarding the flow-through, the step was repeated with a 2 min centrifugation at maximum speed to remove the buffer completely.

The DNeasy® column was then transferred to 1.5 ml Eppendorf microcentrifuge tube and 200 μl of preheated (65° C) water (Sigma, UK) was directly added onto the DNeasy® membrane (care was taken not to damage the membrane). The tubes were incubated for 5 min at room temperature and centrifuged for 1 min at 8,000 rpm to elute the DNA. After centrifugation, the eluate was loaded onto the DNeasy® membrane and the elution repeated. After the second elution, DNeasy® column was discarded and the DNA stored at –20° C. Sterile distilled water (Sigma, UK) was used to elute and store DNA instead of buffer AE as some of the buffers can interfere with downstream reactions such as restriction enzyme digestion, ligation and Polymerase Chain Reaction (PCR).

Appendix 5. GenElute Plant Genomic DNA Miniprep Kit protocol (Sigma)

As some of the DNA samples following the Qiagen method were not suitable for PCR amplifications, these isolates was re-extracted using the GenElute™ Plant Genomic DNA Miniprep Kit (Sigma). This protocol was also used to isolate DNA of 48 isolates obtained from SAARI in 2003 and the *M. grisea* isolates from rice used for comparative analysis. Prior to initial use of the Wash Solution, 72 ml of 95%-100% ethanol was added to 30 ml of the concentrate.

To a finely ground mycelial powder in 2 ml centrifuge tube, 350 μl of lysis solution A and 50 μl of lysis solution B were added. For each tube, the contents were thoroughly mixed by vortexing and inverting. The mixture was incubated at 65° C in a water bath for 10 min. During the incubation the tubes were inverted twice to dissolve the precipitate. After incubation, 130 μl of the precipitation solution were added to the mixture, mixed completely by inversion and placed on ice for 5 min. The mixture was centrifuged at maximum speed of 14,000 rpm for 5 min to pellet the cellular debris, proteins and polysaccharides. The supernatant was carefully pipetted, transferred into the filtration column and centrifuged at maximum speed for 1 min. This was done to remove any residual cellular debris carried over. The filtration column was discarded while the collection tube containing the flow-through was retained. To each collection tube containing the lysate, 700 μl of binding solution was directly added to the flow-through liquid and mixed thoroughly by inversion.

Prior to the binding process, the Binding Column, placed into a collection tube, was prepared by adding 500 μl of preparation solution to each column and centrifuged for 1 min. The column preparation maximizes the binding of DNA to the membrane resulting into more consistent yields. The flow-through liquid was discarded. To bind the DNA, 700 μl of the lysate were applied to each column and centrifuged at maximum speed for one min. The flow-through liquid was discarded while the collection tube and the binding-column were retained. This process was repeated with the remaining lysate. The binding column was transferred to a fresh 2 ml collection tube and washed by applying 500 μl of diluted Wash Solution. The column was centrifuged at maximum speed for 1 min and the flow through was discarded while retaining the collection tube. The washing was repeated with 3 min centrifugation at maximum speed to dry the column. The binding column was transferred to a fresh 2 ml collection tube. To elute the DNA 200 μl of pre-warmed water (65° C) was applied directly to the binding membrane, allowed to stand for 5 min, and centrifuged at maximum speed for 1 min. The elution was repeated by applying the first eluate into the binding column. After the second elution, the binding column was discarded and the eluate containing the genomic DNA was stored in freezer.

Appendix 6. DNA gel electrophoresis

Agarose powder was weighed into a conical flask and an appropriate amount of 0.5X Tris Borate-EDTA (TBE) [89 mM Tris Borate (pH 8.3) and 2 mM EDTA] supplied by National Diagnostics was added. The agarose was melted by heating in a microwave up to 3 min. The gel solution was swirled every 40 seconds to achieve uniform melting by boiling and then simmered for 30 seconds. Adding distilled water to a pre-determined weight compensated any water loss. The gel solution was allowed to cool to approximately 50° C and poured into a gel tray. Prior to this, ethidium bromide solution (10 mg ml^{-1}) supplied by GIBCO BRL, Life Technologies was added to each gel at 0.25 μg ml^{-1}. The combs were placed and the gel was allowed to set for 1 h.

For AFLP analysis, SAGs were prepared as above with 0.5 X TBE. The amount of synergel and agarose powders for each gel was calculated as instructed by the manufacturers (Diversified Biotech). Agarose concentration was generally fixed at 0.7% (W/V). Synergel concentration is obtained by subtracting 0.7% from the gel percentage and multiplying by 0.5; because synergel sets more rapidly than agarose alone, the gels were allowed to cool to approximately 55° C before pouring into a tray.

DNA samples and PCR products were resolved on 0.8% or 1% (w/v) agarose gels (as appropriate). The gels were electrophoresed in a constant electric field and strength, in horizontal configuration. Both the gel and the running buffer contained ethidium bromide, the DNA intercalating fluorescent dye at 0.25 μg ml^{-1}. For loading the samples, gel loading solution (Sigma, UK) was added to each sample as required.

A dilution of 1:10 (2 μl DNA + 18 μl sterile distilled water) of each genomic DNA sample was prepared in 1.5 ml microfuge tube. For each sample, 2 μl of gel loading solution (Sigma, UK) were mixed with 5 μl of diluted DNA and loaded into the wells of the gel. Similarly, 2 μl of Low Mass DNA marker (Sigma, UK) were mixed with 2 μl of gel loading solution and loaded into the first and last wells. The gel was run for approximately 1.5 h at 60 V and the DNA samples were viewed on a UV (ultra violet light) transilluminator. The band intensity of each sample was compared with that of a known quantity of the Low Mass DNA marker and an estimate of the DNA was recorded based on similarity in the intensity of fluorescence of the bands. Approximate DNA concentration (ng μl^{-1}) in each sample was calculated.

Appendix 7. AFLP analysis protocol details

Digestion of DNA and ligation of adapters
Magnaporthe grisea genomic DNA was digested with *EcoR* I/*Mse* I [1.25 units μl^{-1} each in 10 mM Tris-HCL (pH 7.4), 50 mM NaCl, 0.1 mM EDTA, 1 mM DTT, 0.1 mg ml^{-1} BSA, 50%(v/v) glycerol, 0.1%Triton® X-100] restriction endonucleases simultaneously in a reaction volume of 25 μl. Appropriate volume (μl) of genomic DNA equivalent to 250 ng was pipetted into 1.5 ml Eppendorf tube and distilled water added to obtain 18 μl, as required. A master mix consisting of 5 μl of 5X reaction buffer [50 mM Tris-HCL (pH 7.5), 50 mM Mg-acetate, 250 mM K-acetate] and 2 μl EcoR I/Mse I per reaction was prepared. To each tube, 7 μl of the master mix were added. The mixture was gently mixed and centrifuged to collect the contents. The mixture was incubated in a 37° C water bath for 4 h. Thereafter the mixture was incubated for 15 min at 70° C to inactivate the restriction endonucleases. The tubes were centrifuged briefly to collect the contents and then placed on ice.

To each tube containing digested DNA, 24 μl of adapter ligation solution [*EcoR* I/*Mse* I adapters, 0.4mM ATP, 10mM Tris-HCL (pH 7.5), 10mM Mg-acetate, 50 mM K-acetate] and 1 μl of T4 DNA ligase [1 unit ul^{-1} in 10 mM Tris-HCL (pH 7.5), 1 mM DTT, 50 mM KCL and 50% glycerol (v/v)] were added. The mixture was gently mixed, centrifuged and incubated at 20° C $\pm$ 2° C for 4 h. A dilution of 1:10 of ligated template DNA was made with TE buffer [10 mM Tris-HCL (pH 8.0), 0.1 mM EDTA]. The unused aliquot of the ligated template DNA was stored at –20° C.

Amplification of restriction fragments
Amplification of restriction fragments was done in two phases, pre- and selective amplification. Pre-amplification of diluted ligated template DNA was performed as follows. A master mix consisting of 20 μl of pre-amplification primer mix, 2.5 μl of 10X PCR buffer plus Mg [200 mM Tris-HCL (pH 8.4), 15 mM MgCl2, 500 mM KCl] and 0.5 units of *Taq* DNA polymerase per reaction was prepared. To each tube 23 μl of the master mix were added. Thereafter, 2.5 μl of diluted ligated template DNA was added to each specific tube giving a reaction volume of 25.5 μl. The contents were mixed and centrifuged briefly. For pre-amplification, 20 cycles of PCR were performed by, denaturing at 94° C for 30 seconds, annealing at 56° C for 1 min and extending at 72° C for 1 min. A dilution of 1:50 of the pre-amplified template DNA was prepared with TE buffer. Both the unused and diluted pre-amplified template DNA was stored at –20° C.

Initially, the use of *Taq* polymerase in selective amplification involved addition of primers (*EcoR* I and *Mse* I), dNTPs, 10xPCR buffer with $MgCl_2$, water and *Taq* in 2 separate master mixes, Mix 1 and Mix 2. To eliminate the burden of preparing 2 master mixes, RED*Taq*™ ReadyMix™ containing 1.5 units of *Taq* DNA polymerase, $MgCl_2$, KCL, gelatin, Tris-HCl and dNTPs was used as a suitable substitute. Preliminary selective amplification with five selected primer combinations was done using ten isolates used to screen the 2-nucleotide primer pairs. The preliminary results of using RED*Taq*™ ReadyMix™ in selective amplification were comparable with standard *Taq* polymerase. The RED*Taq*™ ReadyMix™ was thereafter adapted for use in selective amplification for all the isolates. Use of REDTaq™ ReadyMix™ reduced the time and probably the cost of selective amplification as well.

Selective amplification was performed by preparing a master mix consisting of *EcoR* I and *Mse* I primers each1.08 μl, 2.84 μl of water, and 10 μl REDTaq™ ReadyMix™. To each 0.2 ml thermotube (AB gene), 15 μl of master mix and 5 μl of specific diluted pre-amplified DNA were added giving a total reaction volume of 20 μl. The contents were mixed by flicking manually and thereafter collected by a brief spin in a centrifuge. The PCR was performed in a thermal cycler (Phoenix, Helena Biosciences) in a total of 33 cycles consisting of denaturing at 94° C, annealing at 65° C, 56° C or 63° C, and extension at 72° C. The first cycle consisted of 94° C for 30 sec, 65° C for 30 sec and 72° for 1 min, followed by a second cycle of 94° C for 2 min, 65° C for 1 min and 72° C for 1.5 min, and 30 cycles of 94°C, 56° C and 72° C each for 1 min. The last cycle consisted of 72° C for 5 min, 63° C for 1 min and 72° C for 1.5 min. The PCR products were collected and stored at -20° C for further analysis.

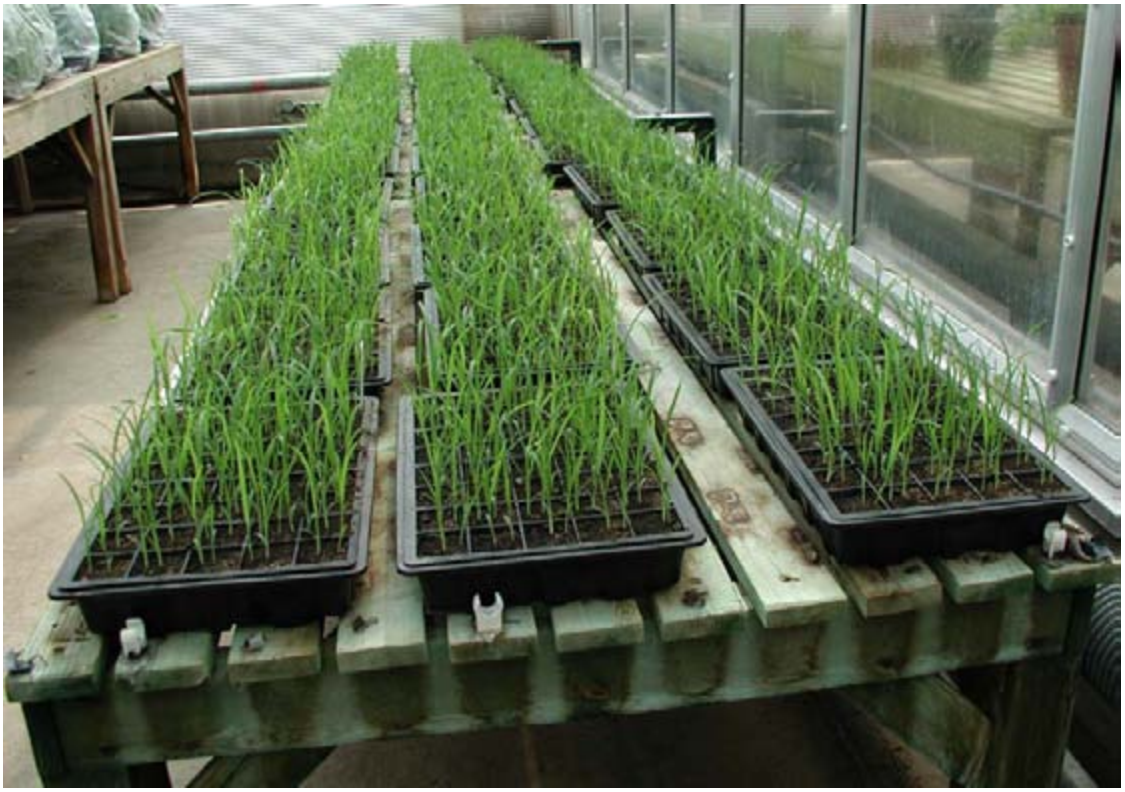
Appendix 7 (contd)

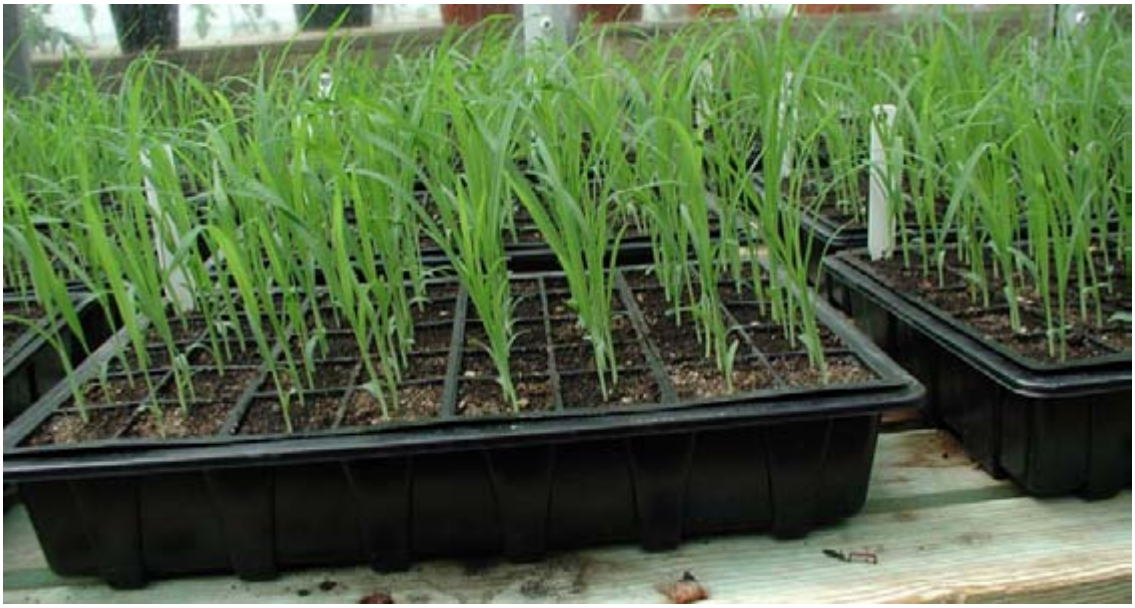
Eectrophoresis of AFLP products

AFLP® selective amplification products were resolved on 1.5% SAGs with 0.5X TBE as running buffer. Prior to this, SAGs of various percentages were screened to determine the appropriate gel strength and run time at 100 V. SAGs of 1.25, 1.5 and 2.0% were run for 4 h; 1.5, 2.0 and 2.5% for 3 and 3.5 h to assess the level of resolution of the products. Based on clear and good band separation, 1.5% SAG and 3 h electrophoresis were chosen for resolving the selective amplified products unifromly.

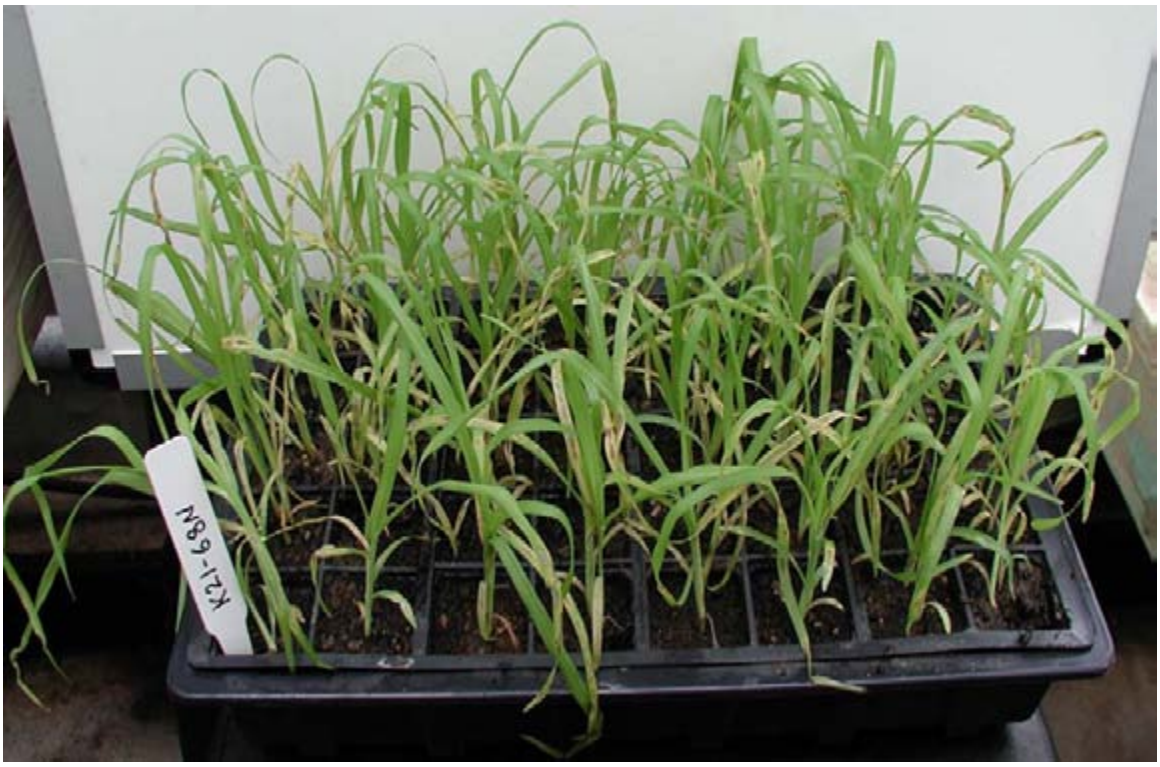
For each sample, 5 μl of selective amplification products were loaded into each well. In the first and last well, a 100 bp PCR marker (Sigma, UK) mixture consisting of 3 μl of marker DNA, 5 μl water (Sigma, UK) and 2 μl of gel loading solution was loaded. The fingerprint patterns were viewed on a UV transilluminator (BioDoc-It™ System) and printed on video graphic printer UP-895 CE (Sony). Electronic images of the fingerprint profiles were saved for further analysis.

Appendix 8. Pathogenicity testing of blast pathogen isolates on finger millet varieties





Appendix 9. Finger millet seedlings showing blast symptoms following inoculations



Appendix 10. Entries in Finger Millet HPR Trial at Alupe 2002 (long rainy season, Feb-July)

Accession	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Leaf blast severity (%) booting	Neck blast score (p.maturity)	Neck blast score (harvest)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 1 FMBP/01 WK	3.167	68	2.7	3.0	23.1	2.7	2.0	22.7	3.5	3.0	90.0	3.0	69
Acc. # 3 FMBP/01 WK	2.878	61	3.0	3.0	36.9	2.3	2.0	17.0	3.5	4.3	93.3	3.0	73
Acc. # 7 FMBP/01 WK	3.411	64	3.0	4.0	30.1	2.7	2.0	25.7	4.0	3.7	101.3	3.0	71
Acc. # 8 FMBP/01 WK	2.528	59	3.3	3.7	33.6	2.7	2.0	13.0	3.0	3.3	102.0	3.3	70
Acc. # 9 FMBP/01 WK	2.744	60	3.0	3.3	41.2	2.3	2.0	5.3	3.0	2.7	112.7	3.0	68
Acc. # 11 FMBP/01 WK	1.578	71	4.0	3.7	36.9	4.0	2.3	35.7	4.5	4.3	100.0	3.7	64
Acc. # 13 FMBP/01 WK	2.700	59	5.3	6.0	34.1	2.7	2.0	32.7	6.5	5.3	98.0	3.0	67
Acc. # 14 FMBP/01 WK	2.478	71	2.0	2.7	18.8	2.7	2.0	9.7	2.5	2.3	112.0	2.7	60
Acc. # 15 FMBP/01 WK	1.433	71	3.7	3.7	45.9	4.3	2.0	26.0	5.0	4.3	95.7	3.7	56
Acc. # 16 FMBP/01 WK	2.911	73	2.7	3.3	20.4	2.7	2.0	20.0	2.5	2.3	104.3	2.7	75
Acc. # 17 FMBP/01 WK	2.833	60	4.3	4.0	24.8	3.0	2.0	15.7	5.5	5.3	106.7	3.0	66
Acc. # 19 FMBP/01 WK	2.911	71	2.3	2.0	31.5	4.0	2.0	14.3	3.5	2.3	117.7	2.0	68
Acc. # 20 FMBP/01 WK	2.367	68	3.0	2.3	31.4	5.3	2.3	15.3	5.0	5.0	105.7	2.3	60
Acc. # 21 FMBP/01 WK	1.944	67	2.3	3.0	29.3	4.0	2.3	34.3	3.5	3.0	104.0	3.3	62
Acc. # 22 FMBP/01 WK	2.083	73	3.3	3.7	32.1	3.0	2.3	43.7	3.5	2.7	106.3	3.3	67
Acc. # 23 FMBP/01 WK	1.767	65	4.3	4.3	57.3	6.0	3.7	54.0	4.5	4.3	106.3	3.7	55
Acc. # 24 FMBP/01 WK	2.144	70	2.7	3.0	36.4	5.7	2.3	34.7	4.5	2.7	113.7	3.0	60
Acc. # 25 FMBP/01 WK	2.533	71	2.3	3.0	16.8	4.7	2.0	21.7	3.0	2.3	116.0	3.0	63
Acc. # 26 FMBP/01 WK	2.144	73	3.3	3.7	26.7	6.0	3.0	34.3	4.5	3.0	120.3	3.0	72
Acc. # 28 FMBP/01 WK	2.356	77	3.0	3.3	44.7	4.7	2.0	43.7	5.0	3.0	108.3	3.7	49
Acc. # 29 FMBP/01 WK	2.256	71	2.0	2.7	27.2	4.0	2.0	26.7	5.0	2.7	114.0	2.0	56
Acc. # 30 FMBP/01 WK	2.128	63	4.3	4.3	38.0	5.3	2.0	15.3	6.0	5.7	102.3	3.0	64
Acc. # 31 FMBP/01 WK	2.811	67	3.0	4.0	31.0	3.3	2.0	20.3	3.5	3.3	108.7	3.0	72
Acc. # 32 FMBP/01 WK	2.878	72	2.3	3.0	20.9	2.3	2.0	21.3	4.0	4.3	99.7	3.0	66
Acc. # 33 FMBP/01 WK	2.122	74	3.0	4.0	42.8	2.3	2.3	34.3	3.5	3.3	96.3	3.0	66
Acc. # 36 FMBP/01 WK	2.167	63	3.7	3.7	28.0	2.0	2.0	11.3	3.0	3.0	112.3	4.0	68
Acc. # 38 FMBP/01 WK	2.578	63	2.3	3.0	37.5	2.0	2.0	9.0	3.0	2.7	123.3	3.3	64
Acc. # 39 FMBP/01 WK	2.428	61	3.0	3.3	42.9	2.0	2.0	7.0	2.5	2.7	104.7	3.0	68
Acc. # 40 FMBP/01 WK	2.089	65	2.7	4.3	35.9	2.0	1.7	7.3	3.0	2.3	104.7	4.0	72
Acc. # 41 FMBP/01 WK	2.350	69	2.0	3.3	40.3	2.3	2.0	6.7	2.5	2.0	123.7	3.7	57
Acc. # 42 FMBP/01 WK	2.139	69	2.3	2.7	24.5	4.0	2.0	26.7	4.0	3.0	97.7	3.0	60
Acc. # 43 FMBP/01 WK	2.567	73	2.3	2.3	26.5	4.0	2.0	27.7	3.0	2.0	99.0	2.7	71
Acc. # 44 FMBP/01 WK	2.322	57	3.0	3.7	20.6	2.3	2.0	26.3	3.5	3.7	89.7	3.3	72
Acc. # 48 FMBP/01 WK	1.178	62	2.7	3.0	48.5	2.0	2.0	13.0	4.5	2.3	102.3	3.7	61

Appendix 10. (contd)

Acc. # 49 FMBP/01 WK	2.972	65	3.3	3.7	32.3	2.7	2.0	13.7	3.0	3.3	107.7	3.0	71
Acc. # 50 FMBP/01 WK	1.422	74	3.7	2.3	26.0	3.7	2.0	18.7	4.5	2.7	83.7	3.7	70
Acc. # 52 FMBP/01 WK	1.200	66	4.7	5.0	54.9	2.3	2.0	24.0	4.5	4.7	95.3	3.7	70
Acc. # 53 FMBP/01 WK	1.167	59	5.7	6.0	60.7	3.3	3.7	51.0	5.5	5.3	95.3	4.3	61
Acc. # 54 FMBP/01 WK	1.372	65	5.3	3.7	52.4	4.0	2.0	22.7	4.5	5.3	104.7	4.0	66
Acc. # 55 FMBP/01 WK	0.800	57	9.0	9.0	91.3	4.0	3.0	42.0	7.0	9.0	103.3	4.7	59
Acc. # 60 FMBP/01 WK	1.094	64	6.7	6.3	75.3	3.0	2.0	12.3	5.0	6.7	113.0	4.3	70
Acc. # 61 FMBP/01 WK	1.011	60	6.3	6.3	64.6	5.3	3.0	37.3	7.0	6.7	114.0	4.7	72
Acc. # 62 FMBP/01 WK	1.867	62	3.3	4.0	35.2	2.7	2.0	14.7	6.0	4.3	101.	4.0	76
Acc. # 63 FMBP/01 WK	1.050	63	5.5	6.5	60.9	5.0	2.3	28.3	7.0	6.0	93.3	5.0	71
Acc. # 64 FMBP/01 WK	1.433	65	6.7	6.7	88.2	3.3	2.7	19.3	5.0	7.0	103.3	4.7	67
Acc. # 65 FMBP/01 WK	1.144	63	6.3	6.3	73.3	4.0	2.3	32.7	6.5	6.3	104.7	4.7	57
Acc. # 66 FMBP/01 WK	0.606	65	3.3	5.3	59.1	2.7	2.0	32.3	4.0	4.3	103.0	5.0	64
Acc. # 67 FMBP/01 WK	0.922	55	3.0	6.7	67.1	2.3	2.0	11.0	3.5	3.3	102.7	4.7	75
Acc. # 68 FMBP/01 WK	0.889	64	6.0	7.7	65.6	5.3	2.7	45.0	6.0	6.7	111.7	5.0	67
Acc. # 69 FMBP/01 WK	1.033	66	5.0	5.0	55.1	3.3	3.3	30.7	4.5	6.0	111.3	4.3	60
Acc. # 70 FMBP/01 WK	1.306	69	4.7	7.3	68.8	3.0	2.0	16.3	5.0	4.3	118.0	4.0	46
Acc. # 71 FMBP/01 WK	1.306	67	5.3	5.0	62.9	3.7	2.0	20.3	6.5	6.7	111.0	4.3	71
Acc. # 72 FMBP/01 WK	1.378	63	4.0	5.0	62.5	3.0	2.0	19.0	4.5	5.0	113.3	4.7	66
Acc. # 73 FMBP/01 WK	1.194	64	5.0	5.3	69.3	4.7	2.7	27.7	5.5	6.0	116.3	4.7	64
Acc. # 74 FMBP/01 WK	1.050	62	5.0	6.3	68.0	5.3	2.3	18.3	6.0	4.3	118.0	4.7	70
Acc. # 75 FMBP/01 WK	1.800	67	3.0	3.7	35.1	2.3	1.3	2.7	3.5	3.0	115.3	4.0	67
Acc. # 76 FMBP/01 WK	1.744	69	2.7	4.0	64.0	3.0	2.0	19.3	3.5	3.3	106.0	3.3	65
Acc. # 77 FMBP/01 WK	1.567	52	6.0	7.3	56.9	2.7	2.0	22.0	7.0	7.3	97.7	4.3	70
Acc. # 78 FMBP/01 WK	1.789	67	4.3	4.7	57.1	3.0	2.0	38.7	5.5	5.3	115.3	4.0	62
Acc. # 79 FMBP/01 WK	1.600	60	4.7	4.7	53.7	2.3	2.0	27.0	5.5	5.7	107.7	4.0	60
Acc. # 80 FMBP/01 WK	2.356	63	3.3	4.0	37.1	3.0	2.3	27.3	5.0	4.0	96.7	3.7	60
Acc. # 81 FMBP/01 WK	2.811	63	4.7	5.0	36.0	4.7	2.3	48.0	6.0	4.7	102.0	3.3	66
KNE 479	0.900	46	8.3	9.0	81.4	6.7	4.3	50.0	8.0	9.0	96.0	5.0	77
KNE 808	0.861	64	6.0	6.7	74.6	4.3	3.0	38.7	7.5	6.3	99.0	4.7	70
U 15	2.356	58	5.0	5.0	35.5	2.3	2.0	11.3	6.0	6.7	96.3	3.3	57
P 224	2.000	63	5.0	5.0	55.6	3.3	2.3	31.0	5.0	4.3	80.7	3.7	66
SEREMI 2	2.289	60	3.3	4.0	44.2	2.7	2.0	21.7	5.0	4.7	100.0	3.3	68
Market local	1.500	70	3.3	3.7	42.2	2.3	2.3	16.7	3.5	2.7	105.3	4.0	64
KAT FM 1	0.956	53	8.0	9.0	69.6	4.0	2.7	33.0	8.0	8.7	95.0	5.0	76
Acc. # 56 FMBP/01 WK	1.078	59	5.0	6.0	63.9	3.3	2.7	29.3	5.5	5.3	104.3	5.0	72
Acc. # 58 FMBP/01 WK	1.478	68	3.0	3.7	36.5	2.7	2.0	22.3	4.5	4.3	126.7	4.3	65
Acc. # 59 FMBP/01 WK	1.939	68	3.3	4.3	43.9	2.3	2.0	13.3	3.5	3.3	118.0	4.3	65
Gulu E	2.144	68	2.7	4.0	44.8	3.0	2.7	47.3	3.5	3.3	96.7	3.3	60

Appendix 10. (contd)

KNE 388	1.167	76	2.3	2.7	37.3	3.0	2.3	28.0	3.0	2.7	104.7	3.7	52
KNE 392	1.800	75	2.3	2.3	26.8	2.0	2.0	21.3	3.0	2.3	108.7	2.7	62
KNE 620	1.689	80	2.0	2.0	24.7	2.0	2.0	7.3	2.5	1.3	93.7	3.0	43
KNE 629	1.711	63	2.3	3.7	28.4	2.0	1.7	3.7	3.0	2.3	93.0	4.0	52
KNE 1149	1.728	80	2.0	3.3	22.3	2.7	2.7	32.7	3.0	2.0	99.7	3.0	71
S # 1752 SDFM	0.333	70	2.0	3.0	57.9	1.0	*	30.0	*	2.0	79.0	3.0	83
KNE 814	3.211	69	2.7	3.0	24.9	2.7	2.3	18.0	4.0	2.0	114.3	3.0	64
KNE 688	2.522	68	2.3	3.0	20.0	2.0	2.0	12.7	2.5	2.0	113.3	3.3	70
KNE 1163	2.600	69	2.3	2.7	27.0	3.3	2.7	36.0	3.5	2.7	110.3	3.0	61
KNE 711	1.678	48	6.3	7.0	53.2	3.7	3.7	28.7	5.5	7.7	101.7	4.3	75
KNE 1034	1.883	80	2.0	2.0	13.0	2.0	1.7	5.3	2.0	1.3	105.0	2.3	50
KNE 1087	2.378	74	2.3	2.7	29.5	2.3	2.0	32.0	3.0	2.7	104.0	3.0	61
KNE 1060	2.167	70	2.0	2.7	19.1	2.7	2.0	18.0	3.0	3.0	100.7	3.3	59
KNE 883	1.933	70	2.3	3.0	25.2	2.0	2.0	14.0	2.5	2.3	102.7	3.3	64
S # 77 SADC	1.078	75	1.3	2.3	20.9	2.0	1.7	8.0	2.5	1.0	94.7	3.7	40
KNE 1162	1.611	61	6.3	8.3	57.3	3.0	2.7	14.0	7.0	7.3	86.7	4.3	56
KNE 741	2.800	71	2.3	3.3	19.3	3.0	2.0	13.3	2.0	2.3	116.7	3.7	61
KNE 1015	2.467	73	2.0	2.7	21.9	3.3	2.3	28.7	3.0	2.3	107.7	3.0	64
KNE 689	0.700	68	3.5	5.0	53.9	2.0	2.0	55.0	6.0	5.0	98.0	3.5	81
KNE 810	3.278	66	2.0	3.0	18.0	3.0	2.0	20.7	2.0	2.0	97.3	3.0	66
S # 261	0.200	62	5.0	5.0	57.8	5.0	2.0	67.0	*	3.0	130.0	5.0	60
Ex. Meru	0.667	80	6.7	8.0	82.2	4.0	3.0	42.3	4.5	4.3	112.7	4.7	36
Mean	**1.859**	**67**	**4**	**4**	**44.4**	**3**	**2**	**25**	**4**		**104.0**	**4**	**63**
SE±	**0.5415**	**3.7**	**0.9**	**0.9**	**11.16**	**1.1**	**0.5**	**10.4**	**1.4**		**9.4**	**0.5**	**9.84**
CV%	**29.1**	**5.6**	**25.1**	**21.0**	**25.1**	**33.6**	**23.1**	**40.9**	**35.1**		**9.0**	**14.8**	**15.6**

P. maturity – physiological maturity

Appendix 11. Entries in Finger Millet HPR Trial at Alupe 2002 (short rainy season, Aug-Dec)

Accession	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Neck blast score (p.maturity)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 1 FMBP/01 WK	1.744	79	1.8	1.8	26.5	3.3	2.0	2.5	75.0	3.0	65
Acc. # 3 FMBP/01 WK	1.639	81	3.0	3.3	32.5	3.0	2.3	2.5	80.0	3.0	69
Acc. # 7 FMBP/01 WK	1.878	69	2.3	3.3	30.1	3.3	1.8	2.7	76.7	2.7	66
Acc. # 8 FMBP/01 WK	1.311	79	2.7	3.0	34.3	2.7	1.8	3.0	71.7	3.0	61
Acc. # 9 FMBP/01 WK	1.733	82	2.3	2.8	31.9	2.0	1.7	2.0	80.7	2.8	67
Acc. # 11 FMBP/01 WK	1.250	69	2.7	4.0	33.3	3.0	1.5	3.3	85.7	3.2	62
Acc. # 13 FMBP/01 WK	1.422	79	4.7	5.7	36.8	3.7	2.7	5.3	70.7	3.0	63
Acc. # 14 FMBP/01 WK	1.678	79	1.8	2.0	14.2	2.7	1.8	2.3	93.3	2.3	67
Acc. # 15 FMBP/01 WK	1.217	77	1.8	2.3	38.2	3.0	2.2	3.0	75.0	2.8	61
Acc. # 16 FMBP/01 WK	1.767	77	2.3	2.5	29.6	2.3	2.3	2.7	81.0	2.8	63
Acc. # 17 FMBP/01 WK	1.456	78	4.3	5.7	55.0	2.7	2.0	4.7	74.0	2.8	60
Acc. # 19 FMBP/01 WK	2.033	80	1.7	2.2	26.4	3.0	2.0	1.8	82.7	2.2	68
Acc. # 20 FMBP/01 WK	2.100	79	1.7	2.2	24.9	2.0	2.0	2.0	78.3	2.0	58
Acc. # 21 FMBP/01 WK	1.133	83	1.7	2.3	26.4	3.3	2.2	2.3	62.7	2.7	61
Acc. # 22 FMBP/01 WK	1.428	75	2.0	3.2	22.8	4.3	3.3	2.2	88.3	3.0	63
Acc. # 23 FMBP/01 WK	1.178	76	2.5	3.2	43.1	3.3	2.5	2.8	78.0	2.5	59
Acc. # 24 FMBP/01 WK	1.451	84	1.7	2.0	37.8	2.0	2.0	2.0	93.7	2.8	58
Acc. # 25 FMBP/01 WK	0.984	79	2.0	2.5	26.6	2.7	1.7	2.5	85.0	3.0	49
Acc. # 26 FMBP/01 WK	1.394	76	2.0	3.0	24.4	3.7	1.8	1.5	95.0	2.7	65
Acc. # 28 FMBP/01 WK	1.167	83	1.7	2.3	32.1	4.3	1.7	1.7	98.7	3.0	56
Acc. # 29 FMBP/01 WK	1.617	74	1.7	2.0	17.6	2.7	1.8	2.0	93.3	2.0	58
Acc. # 30 FMBP/01 WK	1.233	92	2.5	2.8	38.5	3.7	2.0	2.3	77.0	2.8	66
Acc. # 31 FMBP/01 WK	1.550	76	2.2	2.3	31.9	2.7	1.8	1.8	86.7	2.5	62
Acc. # 32 FMBP/01 WK	1.889	85	1.5	1.7	13.4	3.0	1.8	2.3	83.0	2.8	70
Acc. # 33 FMBP/01 WK	2.411	89	1.5	1.8	19.9	2.0	1.5	1.8	94.7	1.7	68
Acc. # 36 FMBP/01 WK	1.344	72	2.0	3.0	26.9	2.0	1.5	2.3	89.0	3.0	63
Acc. # 38 FMBP/01 WK	1.567	76	1.7	2.0	19.0	2.0	1.8	2.2	86.7	1.7	61
Acc. # 39 FMBP/01 WK	1.667	74	2.3	3.0	22.8	2.0	1.7	1.8	78.3	2.3	67

Appendix 11. (contd)

Acc. # 40 FMBP/01 WK	1.228	80	3.2	3.7	36.5	2.0	1.8	2.5	83.7	3.2	61
Acc. # 42 FMBP/01 WK	1.600	77	1.8	2.2	27.9	3.0	1.8	2.3	82.3	2.5	64
Acc. # 43 FMBP/01 WK	1.200	73	1.7	2.0	21.4	3.0	1.7	1.8	86.3	2.8	59
Acc. # 44 FMBP/01 WK	1.189	61	2.3	2.3	12.6	2.0	1.5	3.2	79.0	3.0	70
Acc. # 48 FMBP/01 WK	1.344	80	1.5	1.8	27.9	2.0	1.3	1.8	89.3	2.3	63
Acc. # 49 FMBP/01 WK	1.539	73	3.0	3.2	42.0	2.0	2.0	2.7	85.0	3.2	63
Acc. # 50 FMBP/01 WK	1.444	61	1.7	1.8	16.1	2.0	1.5	2.0	90.3	2.5	65
Acc. # 52 FMBP/01 WK	0.850	79	3.0	3.7	39.1	2.3	1.7	2.8	80.0	3.0	57
Acc. # 53 FMBP/01 WK	0.811	60	4.7	6.3	47.0	2.7	2.0	5.3	74.3	3.5	61
Acc. # 54 FMBP/01 WK	1.006	77	2.2	2.5	30.3	2.3	1.5	3.2	86.3	3.0	72
Acc. # 55 FMBP/01 WK	0.839	64	3.7	7.7	76.0	2.3	2.2	6.0	84.3	3.3	54
Acc. # 60 FMBP/01 WK	0.866	69	5.0	5.7	44.1	2.0	1.5	3.0	96.7	3.0	63
Acc. # 61 FMBP/01 WK	0.733	73	4.3	5.0	46.8	3.3	2.5	2.3	90.7	3.3	54
Acc. # 62 FMBP/01 WK	1.178	70	2.7	2.8	24.4	2.0	1.7	3.2	88.0	3.2	71
Acc. # 63 FMBP/01 WK	0.578	75	5.0	5.3	47.1	2.7	2.2	4.7	81.3	4.2	62
Acc. # 64 FMBP/01 WK	0.739	69	4.7	5.3	60.6	2.3	1.8	4.8	93.7	4.0	66
Acc. # 65 FMBP/01 WK	0.922	82	5.0	5.7	58.2	2.7	1.8	3.7	88.3	3.5	60
Acc. # 66 FMBP/01 WK	0.889	94	4.0	5.0	49.3	2.7	1.7	3.3	85.3	3.7	58
Acc. # 67 FMBP/01 WK	0.745	78	2.3	3.2	38.5	2.7	1.3	3.2	99.0	3.7	57
Acc. # 68 FMBP/01 WK	0.600	81	6.0	7.0	63.9	3.3	1.8	5.7	96.0	3.5	52
Acc. # 69 FMBP/01 WK	0.778	73	4.3	5.3	25.5	2.7	1.7	3.7	85.0	3.0	59
Acc. # 70 FMBP/01 WK	1.133	74	4.0	6.0	33.9	2.0	1.5	4.2	93.3	3.0	53
Acc. # 71 FMBP/01 WK	1.017	72	3.7	4.3	44.5	2.7	1.7	3.7	86.7	3.3	60
Acc. # 72 FMBP/01 WK	0.611	73	4.0	4.2	45.1	3.3	1.7	3.7	87.0	4.3	64
Acc. # 73 FMBP/01 WK	0.794	72	4.7	5.0	34.5	3.0	1.8	3.7	89.3	3.5	61
Acc. # 74 FMBP/01 WK	0.711	72	4.3	5.7	34.1	3.0	1.8	4.7	91.3	3.7	56
Acc. # 75 FMBP/01 WK	1.200	71	1.7	2.3	20.6	2.3	1.7	1.8	82.7	2.5	63
Acc. # 76 FMBP/01 WK	0.778	75	1.7	2.5	42.6	2.0	1.5	2.0	80.0	2.3	67
Acc. # 77 FMBP/01 WK	0.917	73	4.0	6.0	47.6	2.3	1.8	4.3	72.7	3.2	64
Acc. # 78 FMBP/01 WK	0.916	70	4.7	5.3	48.0	3.0	1.8	5.0	84.3	3.3	54
Acc. # 79 FMBP/01 WK	0.983	67	4.5	4.8	40.8	3.3	1.7	4.7	90.3	3.2	62
Acc. # 80 FMBP/01 WK	1.089	70	2.3	2.8	24.4	3.0	1.7	3.3	71.7	3.2	63

Appendix 11. (contd)

Acc. # 81 FMBP/01 WK	1.489	74	4.0	4.0	25.4	3.0	2.2	3.2	82.0	3.0	78
KNE 479	0.778	81	7.3	8.7	43.0	4.7	3.7	7.7	83.3	3.8	63
P 224	1.089	68	4.0	4.7	39.9	3.3	1.7	4.2	73.7	2.3	58
SEREMI 2	1.634	65	2.3	3.0	35.6	3.0	1.5	2.7	81.3	2.7	77
Market local	1.211	75	2.0	2.7	17.8	3.0	1.8	2.2	88.3	2.8	56
KAT FM 1	0.528	68	8.3	9.0	69.8	4.0	2.0	8.3	71.7	4.0	66
Acc. # 56 FMBP/01 WK	0.600	83	4.7	6.3	57.2	2.7	1.8	5.0	78.7	4.0	68
Acc. # 58 FMBP/01 WK	0.789	85	2.7	3.3	37.4	2.3	1.5	2.7	95.0	3.3	58
Acc. # 59 FMBP/01 WK	1.116	84	1.8	2.3	8.9	3.0	1.3	1.5	95.7	3.3	58
Gulu E	1.145	82	2.3	3.3	32.4	3.0	1.7	1.8	92.0	2.3	55
KNE 388	0.733	69	1.5	2.0	21.0	2.3	1.3	1.8	90.3	3.0	55
KNE 392	0.817	88	1.5	1.8	23.3	2.0	1.7	1.7	84.7	2.7	59
KNE 620	0.733	75	1.3	2.0	5.9	2.7	1.3	1.7	74.7	2.8	48
KNE 629	1.845	85	1.7	1.8	11.2	2.3	2.0	2.3	86.0	2.7	62
KNE 1149	1.545	85	1.5	2.2	20.1	2.3	1.8	2.2	87.3	2.0	66
S # 1752 SDFM	1.673	74	2.8	3.3	33.9	2.7	2.0	3.0	80.0	2.8	61
KNE 814	1.878	78	1.7	2.3	10.7	2.7	2.0	2.0	94.7	2.2	71
KNE 688	1.606	89	1.7	2.0	13.4	3.7	2.0	2.5	92.7	2.7	70
KNE 1163	1.167	74	2.2	2.3	27.1	2.3	2.0	2.3	91.3	2.2	64
KNE 711	1.261	81	3.2	3.3	18.0	2.3	2.0	3.2	91.0	3.2	70
KNE 1034	0.417	77	2.0	3.7	17.3	2.3	1.3	2.3	74.0	2.5	50
KNE 1087	1.261	85	1.7	2.2	16.9	3.3	1.7	2.2	90.0	2.5	58
KNE 1060	1.261	82	1.7	2.0	16.1	2.0	1.5	2.0	90.0	2.7	65
KNE 883	0.989	81	1.7	1.8	16.4	2.0	1.5	1.8	89.0	2.8	58
S # 77 SADC	0.328	77	2.0	3.2	8.4	2.0	1.3	1.0	70.5	4.0	63
KNE 1162	1.010	72	7.0	8.3	36.0	2.7	2.0	5.3	74.3	3.3	71
KNE 741	1.522	87	1.5	1.8	15.5	2.3	1.5	2.3	95.0	2.5	66
KNE 1015	1.322	83	1.5	1.7	10.4	3.0	1.5	1.8	96.0	2.3	56
KNE 689	0.899	88	4.3	5.3	46.4	3.3	2.2	3.7	89.3	3.3	57
KNE 810	1.467	75	1.7	1.8	15.2	2.3	1.7	2.0	79.7	2.5	58
S # 261	0.566	73	4.0	5.3	46.5	2.3	1.7	5.0	85.7	4.0	58
Ex. Meru	0.690	75	6.0	7.3	50.3	3.7	2.2	6.7	94.3	3.7	51
Mean	**1.193**	**77**	**2.9**	**3.6**	**31.7**	**2.7**	**1.832**	**2.1**	**84.8**	**3.0**	**61.9**
SE±	**0.327**	**10.921**	**1.073**	**1.133**	**11.870**	**0.7981**	**0.4536**	**0.9984**	**8.308**	**0.5325**	**7.630**
CV%	**27.4**	**14.3**	**36.5**	**31.7**	**37.5**	**29.2**	**24.8**	**47.5**	**9.8**	**18.0**	**12.3**

P. maturity – physiological maturity

Appendix 12. Entries in Finger Millet HPR Trial at Alupe combined across two seasons in Seasons 2002

Accession	Grain yield ton ha-1	Days to 50% flowering	Finger blast (p.maturity)	Finger blast score (harvest)	Finger blast severity (%)	Leaf blast score (seedling)	Leaf blast score (booting)	Neck blast score (p.maturity)	Plant height (cm)	Plant aspect score	Thresh %
Acc. # 1 FMBP/01 WK	2.456	73	2.2	2.3	24.8	3.0	2.0	2.3	82.5	2.8	66.8
Acc. # 3 FMBP/01 WK	2.258	71	2.9	3.1	34.7	2.7	2.2	3.1	86.7	2.8	71.2
Acc. # 7 FMBP/01 WK	2.644	67	2.7	3.6	30.1	3.0	1.9	2.8	89.0	2.8	68.8
Acc. # 8 FMBP/01 WK	1.919	69	2.9	3.3	33.9	2.7	1.9	2.5	86.8	3.0	65.4
Acc. # 9 FMBP/01 WK	2.239	71	2.7	3.0	36.6	2.2	1.8	2.0	96.7	2.9	67.4
Acc. # 11 FMBP/01 WK	1.414	70	3.3	3.8	35.1	3.5	1.9	3.1	92.8	3.3	63.2
Acc. # 13 FMBP/01 WK	2.061	69	5.0	5.8	35.4	3.2	2.3	4.7	84.3	3.0	65.2
Acc. # 14 FMBP/01 WK	2.078	75	1.8	2.1	16.5	2.7	1.9	1.7	97.7	2.3	63.6
Acc. # 15 FMBP/01 WK	1.325	74	2.8	3.0	42.1	3.7	2.1	3.0	85.3	3.1	58.3
Acc. # 16 FMBP/01 WK	2.339	75	2.3	2.8	25.0	2.5	2.2	2.0	92.7	2.6	69.3
Acc. # 17 FMBP/01 WK	2.145	69	4.3	4.7	39.9	2.8	2.0	4.5	90.3	2.8	62.7
Acc. # 19 FMBP/01 WK	2.472	76	1.8	2.0	29.0	3.5	2.0	1.6	100.2	2.1	67.9
Acc. # 20 FMBP/01 WK	2.233	74	2.3	2.2	28.1	3.7	2.2	3.1	92.0	2.1	59.3
Acc. # 21 FMBP/01 WK	1.539	75	1.8	2.5	27.9	3.7	2.3	2.0	83.3	2.9	61.6
Acc. # 22 FMBP/01 WK	1.756	74	2.7	3.4	27.4	3.7	2.8	1.9	97.3	2.9	65.0
Acc. # 23 FMBP/01 WK	1.472	70	3.3	3.5	50.2	4.7	3.1	3.1	92.2	2.9	57.2
Acc. # 24 FMBP/01 WK	1.798	77	2.0	2.4	37.1	3.8	2.2	2.0	103.7	2.7	59.1
Acc. # 25 FMBP/01 WK	1.758	75	2.1	2.6	21.7	3.7	1.8	1.7	100.5	3.0	56.1
Acc. # 26 FMBP/01 WK	1.769	74	2.7	3.2	25.6	4.8	2.4	1.9	107.7	2.8	68.3
Acc. # 28 FMBP/01 WK	1.261	80	2.3	2.7	38.4	4.5	1.8	2.1	103.5	3.2	52.5
Acc. # 29 FMBP/01 WK	1.936	72	1.8	2.2	22.4	3.3	1.9	2.0	103.7	2.0	57.3
Acc. # 30 FMBP/01 WK	1.681	78	3.4	3.4	38.2	4.5	2.0	3.9	89.7	2.9	64.8
Acc. # 31 FMBP/01 WK	2.181	72	2.6	3.0	31.4	3.0	1.9	2.4	97.7	2.8	67.3
Acc. # 32 FMBP/01 WK	2.383	78	1.8	2.3	17.2	2.7	1.9	2.7	91.3	2.8	68.2
Acc. # 33 FMBP/01 WK	2.267	81	2.3	2.7	31.3	2.2	1.9	2.2	95.5	2.3	66.6
Acc. # 36 FMBP/01 WK	1.756	67	2.8	3.3	27.4	2.0	1.8	2.2	100.7	3.4	65.7
Acc. # 38 FMBP/01 WK	2.072	70	2.0	2.5	28.2	2.0	1.9	1.7	105.0	2.4	62.4
Acc. # 39 FMBP/01 WK	2.047	68	2.7	3.0	32.8	2.0	1.8	1.9	91.5	2.6	67.2

Appendix 12. (contd)

Acc. # 40 FMBP/01 WK	1.658	73	2.9	3.8	26.2	2.0	1.8	2.0	94.2	3.6	66.3
Acc. # 41 FMBP/01 WK	1.919	72	1.8	2.9	29.5	2.5	1.8	1.5	111.0	3.3	59.1
Acc. # 42 FMBP/01 WK	1.869	73	1.9	2.3	26.1	3.5	1.9	2.1	90.0	2.6	61.9
Acc. # 43 FMBP/01 WK	1.883	73	1.8	1.9	23.9	3.5	1.8	1.6	92.7	2.6	65.1
Acc. # 44 FMBP/01 WK	1.756	59	2.6	2.9	16.6	2.2	1.8	2.8	84.3	3.2	70.8
Acc. # 48 FMBP/01 WK	1.261	71	2.0	2.3	38.2	2.0	1.7	1.8	95.8	2.8	62.0
Acc. # 49 FMBP/01 WK	2.255	69	3.1	3.3	37.1	2.3	2.0	2.8	96.3	3.0	66.9
Acc. # 50 FMBP/01 WK	1.433	68	2.6	2.1	21.0	2.8	1.8	1.9	87.0	2.9	67.3
Acc. # 52 FMBP/01 WK	1.025	73	3.8	4.2	47.0	2.3	1.8	3.3	87.7	3.3	63.8
Acc. # 53 FMBP/01 WK	0.989	60	5.2	6.2	53.8	3.0	2.8	4.7	84.8	3.9	61.0
Acc. # 54 FMBP/01 WK	1.189	71	3.7	3.1	41.3	3.2	1.8	3.7	95.5	3.4	68.8
Acc. # 55 FMBP/01 WK	0.820	60	7.8	8.3	83.6	3.2	2.6	6.5	93.8	4.0	56.9
Acc. # 60 FMBP/01 WK	0.980	67	5.8	6.0	59.7	2.5	1.8	4.4	104.8	3.5	66.6
Acc. # 61 FMBP/01 WK	0.872	67	5.3	5.7	55.7	4.3	2.8	4.2	102.3	4.0	63.0
Acc. # 62 FMBP/01 WK	1.522	66	3.0	3.3	29.8	2.3	1.8	3.2	94.7	3.4	73.5
Acc. # 63 FMBP/01 WK	0.767	69	5.2	5.8	52.6	3.6	2.3	4.6	87.3	4.5	65.7
Acc. # 64 FMBP/01 WK	1.086	67	5.7	6.0	71.6	2.8	2.3	5.3	98.5	4.3	66.4
Acc. # 65 FMBP/01 WK	1.033	72	5.7	6.0	65.8	3.3	2.1	4.6	96.5	3.9	58.5
Acc. # 66 FMBP/01 WK	0.747	80	3.7	5.1	54.2	2.7	1.8	3.4	94.2	4.3	61.1
Acc. # 67 FMBP/01 WK	0.833	67	2.7	4.8	52.8	2.5	1.7	2.6	100.8	4.2	66.0
Acc. # 68 FMBP/01 WK	0.744	72	6.0	7.3	64.7	4.3	2.3	5.4	103.8	4.3	59.5
Acc. # 69 FMBP/01 WK	0.906	70	4.7	5.2	40.3	3.0	2.5	4.3	98.2	3.5	59.5
Acc. # 70 FMBP/01 WK	1.219	72	4.3	6.6	51.3	2.5	1.8	3.7	105.7	3.3	49.2
Acc. # 71 FMBP/01 WK	1.161	70	4.5	4.7	53.7	3.2	1.8	4.8	98.8	3.8	65.1
Acc. # 72 FMBP/01 WK	0.995	68	4.0	4.5	53.8	3.2	1.8	3.8	100.2	4.5	64.9
Acc. # 73 FMBP/01 WK	0.994	68	4.8	5.1	51.9	3.8	2.3	4.5	102.8	3.9	62.6
Acc. # 74 FMBP/01 WK	0.881	67	4.7	5.8	51.1	4.2	2.1	3.7	104.7	4.2	63.1
Acc. # 75 FMBP/01 WK	1.500	69	2.2	2.9	27.8	2.3	1.5	2.2	99.0	3.1	64.9
Acc. # 76 FMBP/01 WK	1.261	72	2.1	3.1	53.3	2.5	1.8	2.3	93.0	2.8	65.8
Acc. # 77 FMBP/01 WK	1.242	63	5.0	6.7	52.2	2.5	1.9	4.8	85.2	3.6	66.9
Acc. # 78 FMBP/01 WK	1.353	69	4.5	5.0	52.5	3.0	1.9	4.7	99.8	3.6	58.2
Acc. # 79 FMBP/01 WK	1.292	64	4.6	4.7	47.2	2.8	1.8	4.4	99.0	3.5	61.4
Acc. # 80 FMBP/01 WK	1.722	67	2.8	3.3	30.8	3.0	2.0	3.1	84.2	3.3	61.9

Appendix 12. (contd)											
Acc. # 81 FMBP/01 WK	2.150	69	4.3	4.3	30.7	3.8	2.3	3.7	92.0	3.0	72.0
KNE 479	0.839	51	7.8	8.8	62.2	5.7	4.0	7.7	89.7	4.4	69.8
KNE 808	0.761	69	5.0	5.5	59.6	3.8	2.4	4.5	94.5	4.2	63.4
U 15	1.692	67	4.4	4.4	33.9	2.3	2.0	4.8	82.3	3.3	63.8
P 224	1.544	65	4.5	4.8	47.8	3.3	2.0	3.8	77.2	2.8	62.1
SEREMI 2	1.961	62	2.8	3.3	39.9	2.8	1.8	3.2	90.7	2.9	72.5
Market local	1.356	73	2.6	3.1	30.0	2.7	2.1	1.8	96.8	3.3	59.8
KAT FM 1	0.742	61	8.2	9.0	69.7	4.0	2.3	7.5	83.3	4.5	71.3
Acc. # 56 FMBP/01 WK	0.839	71	4.8	6.2	60.5	3.0	2.3	4.2	91.5	4.5	69.3
Acc. # 58 FMBP/01 WK	1.133	77	2.8	3.5	36.9	2.5	1.8	2.8	110.8	3.8	61.4
Acc. # 59 FMBP/01 WK	1.528	76	2.6	3.2	26.4	2.7	1.7	2.3	106.8	3.8	61.8
Gulu E	1.645	75	2.4	3.6	38.6	3.0	2.2	2.3	94.3	2.7	57.3
KNE 388	0.950	73	1.8	2.3	29.6	2.7	1.8	1.8	97.5	3.3	53.3
KNE 392	1.308	82	1.8	2.0	25.1	2.0	1.8	1.5	96.7	2.5	60.5
KNE 620	1.211	78	1.4	1.8	15.3	2.3	1.7	1.1	84.2	2.8	45.7
KNE 629	1.778	74	1.9	2.7	19.8	2.2	1.8	1.7	89.5	3.1	57.2
KNE 1149	1.636	82	1.7	2.6	21.2	2.5	2.3	1.3	93.5	2.5	68.6
S # 1752 SDFM	1.338	73	2.6	3.3	39.9	2.3	2.0	2.4	79.8	2.9	66.3
KNE 814	2.545	74	2.0	2.4	17.8	2.7	2.2	1.5	104.5	2.3	67.7
KNE 688	2.064	79	1.8	2.3	16.7	2.8	2.0	1.7	103.0	2.8	69.6
KNE 1163	1.883	72	2.3	2.4	27.0	2.8	2.3	2.1	100.8	2.4	62.4
KNE 711	1.470	65	4.7	5.1	35.6	3.0	2.8	5.0	96.3	3.7	72.3
KNE 1034	1.150	79	1.8	2.6	15.2	2.2	1.4	1.1	86.4	2.3	50.2
KNE 1087	1.819	79	1.9	2.3	23.2	2.8	1.8	1.8	97.0	2.6	59.4
KNE 1060	1.714	76	1.7	2.3	17.6	2.3	1.8	2.2	95.3	2.8	62.2
KNE 883	1.461	75	1.8	2.2	20.8	2.0	1.8	1.7	95.8	2.8	61.0
S # 77 SADC	0.703	76	1.6	2.5	14.7	2.0	1.5	1.0	85.0	3.7	51.2
KNE 1162	1.311	67	6.7	8.3	46.6	2.8	2.3	5.3	80.5	3.8	63.2
KNE 741	2.161	79	1.8	2.3	17.4	2.7	1.8	1.6	105.8	2.9	63.6
KNE 1015	1.895	78	1.7	2.0	16.1	3.2	1.9	1.5	101.8	2.6	59.8
KNE 689	0.813	80	4.0	5.2	49.4	2.8	2.1	3.7	92.8	3.3	66.4
KNE 810	2.372	71	1.7	2.3	16.6	2.7	1.8	1.4	88.5	2.7	62.0
S # 261	0.475	70	4.3	5.3	49.3	3.0	1.8	3.3	96.8	4.3	58.8
Ex-Meru	0.678	77	6.3	7.7	66.2	3.8	2.6	4.4	103.5	4.2	43.8
Mean	**1.539**	**71**	**3.3**	**3.9**	**37.3**	**3.0**	**2.038**	**3.0**	**95.1**	**3.2**	**63.0**
SE±	**0.800**	**8.461**	**1.055**	**1.045**	**11.760**	**0.926**	**0.463**	**1.200**	**9.00**	**0.49**	**8.27**
CV%	**28.3**	**11.9**	**32.0**	**27.1**	**31.6**	**30.8**	**22.7**	**39.5**	**9.5**	**15.4**	**13.1**

P. maturity – physiological maturity