CROP PROTECTION PROGRAMME

Integrated management of banana diseases in Uganda

R7567 (ZA0372)

FINAL TECHNICAL REPORT

1 January 2000 – 30 June 2003

Dr Mike Rutherford & Dr Simon Gowen

CABI Bioscience/University of Reading
14 July 2003

"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." R7567 Crop Protection Research Programme"

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1. EXECUTIVE SUMMARY

This project has sought to evaluate, validate, promote and disseminate banana management technologies that will reverse the decline in banana productivity in Uganda that has occurred over the last few decades. A major emphasis has been on the pest and disease problems that are unarguably the major biotic reason for the loss of production. Additionally, there are climatic, soil fertility and sociological issues associated with the problem, which have to be considered within a strategy being devised for improving banana production. The traditional banana cultivars that have become adapted to the east African highland region are severely damaged by alien pests and diseases that have arrived within the last 70 years. The evaluation of germplasm with resistance and/or tolerance to these constraints is a major component of this work (and that of the National Banana Programme). The new cultivars introduced to farmers have shown excellent levels of resistance to the leaf spot diseases. This is reflected in the greater numbers of healthy leaves remaining on plants at harvest, accepted as an appropriate although not direct means of assessing leaf spots, as compared to the local cultivars. Evidence is accumulating to suggest that these new bred cultivars also show a superior level of vigour in the field which is reflected in significantly greater weights of bunches than from those produced by the local cultivars. In the field, they would also appear to better withstand the presence of nematodes and possibly weevils. Confirmation of this has come from controlled studies in which the new cultivars have been shown to have relatively larger roots that are less damaged by nematodes. On-farm trials have shown that productivity is greatly enhanced (by 26-119%) if the plants are mulched, not only with respect to the new cultivars but also the preferred and popular local types (AAA-EA highland bananas). Whilst not a new technology, mulching is fundamental to maintaining plant vigour and is thus an essential practice that farmers' should adopt. In a trial specifically investigating leaf spot management, enhanced nutrition (mulch and manure application) was generally more beneficial in terms of not only leaf spot control but also plant growth and yield.

In farmer panel studies the new cultivars do not have the favored cooking qualities of the standard 'matooke'[1] cultivars. This could be a constraint to their uptake and adoption but in areas where banana production is badly affected by disease pressures, the new cultivars may be the only source of fruit. Furthermore, observations have indicated that acceptability has increased as the project has progressed. Acceptability is reflected, for example, in the demand for plants of the newly bred cultivars from neighbours of farmers hosting the on-farm trials. The outcome of this project is the evidence that bananas can still be a major crop in the lake regions of Uganda despite what was once considered an irreversible decline. With the new resistant germplasm farmers have the opportunity to provide fruit for household and sales to markets but the gains provided with the new cultivars will only be sustained with the appropriate levels of crop management.

1 'Matooke' is the local term for highland banana cultivars and for the steamed banana dish prepared from highland cooking bananas

2. BACKGROUND

2.1 Banana production in Uganda

Banana is the most important single crop for food and income security in Uganda. The country is the leading banana producer in Africa and ranks second only to India in terms of global production). Annual production is estimated at 9.9 million metric tonnes, more than 15% of world output, most of which is consumed locally as the major staple food across much of the country. The main cultivars grown are the endemic East African highland bananas (*Musa* AAA-EA), which constitute more than 80% of the total and are grown between 1000-2000 meters above sea level as a primary food staple and source of income in local markets. They have a high starch content and are used on a day-to-day basis for preparation of matooke [1], the staple food of Ugandans. Average consumption of matooke is more than 350 kg per capita per annum. Other cultivars are mainly the coastal hybrids of AB, AAB, and ABB genotypes, which are of exotic origin and make up less than 20% of total production. Yet over the last 44 years there has been a steady but marked decline in production of bananas in Uganda. While the area of land under bananas (c. 1.5 million hectares) is double that of 1956, banana production in traditional producing areas of central and eastern Uganda has severely declined. Here, bunch weights have dropped from 60 kg to 10kg or less, plantation life has shortened from 30-50 years to only four years, yields have fallen from 20 to only five tonnes/hectare/year and banana plot size has shrunk from 2.5 to 0.04 hectares per household. The decline in these areas has been reflected by a shift in production from central regions in particular, such as Luwero, to western Uganda. But even in these, relatively productive, regions, where cultivation of some banana types (such as those grown for juice and beer production) is increasing, here too there has been a gradual decline with yields currently at only 17 tons/ha/year respectively (compared with 60 tons/ha/year attainable on research stations).

2.2 Banana production constraints

In 1989 the Uganda National Banana Research Program (UNBRP) was established to help to reverse the decline observed in banana productivity. Baseline research conducted by the UNBRP throughout the banana growing areas identified and prioritized a number key constraints to production, including declining soil fertility, a complex of pests and diseases, post harvest problems, socioeconomic constraints and low genetic diversity (Gold et al., 1993). Black leaf streak (the original name given to the leaf spot disease now often called black Sigatoka and caused by *Mycosphaerella fijiensis*), banana weevils and parasitic nematodes are considered the most damaging of the pests and diseases, although fusarium wilt, banana streak virus and a wilt-like disorder observed in western Uganda have also contributed to the decline. Sigatoka leaf spot (*Mycosphaerella musicola)* arrived in Africa in the 1930s and has largely been displaced by black leaf streak which only arrived in east Africa in 1990 (Jeger *et al.* 1995*). Diseases constitute a major constraint not only to production of the indigenous AAA-EA types but may also be devastating on exotic bananas grown in Uganda. Indeed most of the introduced bananas currently grown by farmers, such as Bogoya (syn. Gros Michel), Sukari-Ndiizi and Kisubi (syn. Ney Poovan) Kayinja (syn. Pisang Awak) and Bluggoe, while having important roles, are highly susceptible to prevailing pests and diseases including fusarium wilt, Sigatoka leaf spots, parasitic nematodes and weevils. It is crucial that these constraints are addressed if a viable banana industry is to be sustained in Uganda.

** Jeger, M.J., Eden-Green, S. Thresh, J.M., Johanson, A., Waller, J.M. and Brown, A.E. 1995 Banana Diseases. In: Bananas and Plantains pp 317-381 (Ed) S. Gowen. Chapman and Hall, London UK*

2.3 The Uganda National Banana Research Program - Goals and Objectives

The goals and objectives of the UNBRP reflect the National Agricultural Research Organization's (NARO) strategies and objectives for the 'Medium Term Plan' for modernization of agriculture in Uganda. Improving food and income security of small-scale farmers through enhanced banana production and utilization is the overall goal of the Program. Its principal objective is to generate and disseminate appropriate environment friendly technologies and knowledge in order to improve banana productivity and utilization.

As a strategy to help achieve its objectives, the UNBRP has divided the country into three zones corresponding to three differing levels of banana production decline:

- The East and Central zone, where banana production has severely declined and many farmers have abandoned production
- The South, where banana productivity is at an intermediate level but where there is moderate decline
- The Western zone, where banana productivity remains high but there has been some decline

The program has demarcated three benchmark sites (BS), at Luwero, Masaka/Ntungamo and Mbarara/Bushenyi, to represent differing agroecological environments and reflect the three levels of decline (severe decline, intermediate decline and high level of production respectively). It is at these BS that the program is implementing the majority of it research activities to address the major constraints. The BS host a number of projects funded by different donors, including. R7567/ZA0372 'Integrated management of banana diseases in Uganda', the findings of which are reported here.

The UNBRP undertook an initial investigatory and developmental and phase of research, whereby it identified or developed a number of cultural farming technologies that show promise for alleviating specific constraints and, consequently, for increasing productivity and reversing the yield decline. It is now placing emphasis, as part of an intervention or management phase, on the evaluation, validation and transfer, to farmers, of these technologies as part of an IPM approach. The primary task of the BS (or Outreach) Project within the UNBRP is to incorporate and accelerate the movement of promising and tested technologies along various uptake pathways for promotion and anticipated adoption. Key technologies to be assessed include improved soil/water management to control soil erosion, the use of organic and mineral fertilizers and related cultural treatments to improve plant vigour, the selection and use of host-plant resistance, clean planting material, use of break crops, weevil biocontrol and herbicides. Based on their performance and farmers' responses, technologies most suitable for the different agroecological zones and farming systems will be selected and their uptake facilitated.

3. THE PROJECT

3.1 Purpose
Promotion of strategies to reduce the impact of pests in herbaceous crops in Forest Agriculture systems, for the benefit of poor people.

3.2 Objectives
Project R7567 was designed, firstly, to assist UNBRP and Ugandan banana farmers to evaluate and validate, under farmer conditions and as part of an IPM approach, improved banana crop and resource management technologies suitable for particular agroecological zones and farming systems. Performance and acceptability of the technologies would be assessed generally in terms of their ability to enhance banana plant health and productivity, but more specifically in terms of agronomic performance, their response to damaging pest and disease constraints and, crucially, how they are perceived and approved of by farmers and the extent to which they are disseminated beyond initial recipients and evaluators. A second, linked, objective was to further the dissemination and promotion of acceptable technologies to the wider farming community of Uganda, partly through exposure to the field research activities but also by other means. The latter, coupled with farmers' perceptions of the technologies and the impact these have upon potential adopters, were aspects that the project focused on increasingly during its lifetime and which are the subject of proposed follow-on research (see Appendix 1)

3.3 Intended outputs

- Series of well co-ordinated and managed trials designed, established and maintained across benchmark sites to address priority issues, including improvements in banana health, with full stakeholder liaison and farmer participation and producing valid conclusions
- Protocols for determining plant growth vigour, health, pest and disease populations established for field use
- Cultivars with different yield /growth characteristics evaluated for disease and nematode resistance under farmer field conditions
- Cultural conditions which improve plant vigour, health and productivity are evaluated and defined under farmer conditions
- Suitable practices accepted by farmers for ongoing validation for sustainable improvement of banana productivity.
- Etiology of wilt-like disorder resolved and options for control by farmers formulated for on-farm trials
- Farmer, extension service and NARS scientific staff recognition and awareness of banana pest and disease constraints and the beneficial effects of cultural farming practices enhanced through participation in on-farm trials

The above outputs, while being produced specifically for the benefit of Ugandan producers, will be equally applicable to farming systems in other parts of Africa and elsewhere where similar constraints to production prevail. Regional and international banana networks, including the Banana Research Network for East and Southern Africa (BARNESA) and the International Network for the Improvement of Banana and Plantain (INIBAP), have also indicated the need for research of this nature and are have been monitoring progress.

4. RESEARCH ACTIVITIES

4.1 Introduction

The project activities focused on addressing a number of specific aspects of technology evaluation, validation and promotion at specified BS within Uganda, principally through the establishment of researcher/farmer funded, farmer managed field trials (Table 1). A summary of each broad activity, including the reasoning behind the research undertaken, is provided below followed by an overview of the methodology applied. For a more detailed description of the latter, refer to specific protocols in the appendices.

4.1.1 Cultivar validation, promotion and dissemination

Previous on-station and on-farm evaluation trials revealed that a number of cultivars newly introduced to Uganda in 1995 are high yielding and also show resistance/tolerance to known pest and disease constraints, namely black leaf streak (*Mycosphaerella fijiensis*), Sigatoka (*M. musicola*), weevils and nematodes. Some of these cultivars, including FHIA 01 (assigned the name 'Kabana 1' by NARO), FHIA 17 (Kabana 3), FHIA 23 (Kabana 4) and Yangambi KM 5 (Kabana 5), have already undergone limited on-farm evaluation and were found to have other attributes acceptable to those farmers to whom they were introduced. However, further validation by relevant stakeholders was essential to reaffirm these attributes under more diverse, and perhaps demanding, environmental conditions and utilizing farmers' own selection criteria. Addition of mulch and manure in particular, often considered vital to good plant growth but often not applied by farmers, may be vital in promoting growth and health of these and other banana cultivars. A number of these cultivars were therefore evaluated under mulch/manure and mulch/manure-free conditions with farmers at Bamunanika subcounty, Luwero BS, central Uganda (**Trial 1**), the primary objective being was to assess agronomic performance and response to pests and diseases, and to promote dissemination to a wider farming community. Assessment of and natural dissemination of planting material were considered key components.

During an on-farm research review and planning workshop held in Kisekka subcounty, Masaka, western Uganda in July 2000, farmers expressed strong demand for, and interest in evaluating, improved exotic bananas that are both high yielding and resistant to prevailing diseases. More than 150 farmers in Kisekka applied to participate in the validation of three of the new cultivars also being validated and promoted at Luwero, Kabana 3 [2], Kabana 4 and Kabana 5 (**Trial 4**). Farmers were to evaluate how these cultivars could be used in their area. Their dissemination was also intended to provide clean planting material in areas where as fusarium wilt is prevalent and is devastating exotic types such as Gros Michel, used for juice production and brewing.

2 Referred to by local farmers as 'Ofwono', based on their observation of the relatively large bunches that can be produced.

4.1.2 Cultivar evaluation

Banana consumption in Uganda is largely limited to highland banana cultivars that are endemic to the East Africa region. Unfortunately these cultivars are limited in possibilities for utilization and in providing other products such as dessert bananas or juice. They are also susceptible to various pests and diseases such as weevils, nematodes and black leaf streak, less competitive on international markets such as those in Europe and therefore of less economic value. While exotic cultivars are important locally, particularly for dessert banana and juice production, they are also in demand for export, an important criterion in terms of foreign exchange earnings for Uganda. Local banana beer, which is primarily from the juice of exotic bananas, is also an important source of income as it is sold within rural farming communities in Uganda. The beer may be further processed into local banana gin, which may be consumed and sold within in the local community or sold to national industries for production of exportable gin (Uganda 'Waragi').

A number of other exotic banana cultivars have been more recently introduced to Uganda that again shown promise with respect to agronomic performance and resistance to known prevailing pest and disease constraints. However, these cultivars have previously undergone only on-station evaluation in Uganda, and have never been assessed on-farm and under the management and scrutiny of farmers. A second major component of the project was therefore to evaluate several of these cultivars, FHIA 25, PITA 14, PITA 17, and SABA at Luwero BS (**Trial 2**) for disease and pest resistance and agronomic performance, and to assess their acceptability to farmers primarily for cooking and brewing purposes. These were evaluated alongside a local cultivar approved of and commonly grown by farmers, Kisansa, again with and without addition of mulch.

Previous work has also shown that Cavendish cultivars are high yielding and also resistant to race 1 of the fusarium wilt pathogen, which is prevalent and often highly damaging to many exotic cultivars in Uganda. This resistance attribute is important in that Cavendish may be a potential replacement for the cultivar Gros Michel (Bogoya), grown by many farmers in Uganda but highly susceptible to race 1 and frequently suffering considerable damage. Cavendish cultivars are also widely acceptable on the international market, and may therefore provide further export potential for Ugandan farmers. However, they are susceptible to leaf spot diseases, particularly the very destructive black leaf streak, which is prevalent in lowland such as central Uganda where it causes extensive losses. In areas of higher elevation, such as western Uganda, where temperatures are lower and leaf streak is restricted, Cavendish cultivars may be appropriate for cultivation. Field trials were therefore established to evaluate a range of Cavendish cultivars, along with Kabana 3 (FHIA 17), bred specifically with black leaf streak resistance in mind, for agronomic performance and resistance to this and other diseases in Ntungamo and Mbarara (**Trial 5**).

4.1.3 Enhanced plant nutrition as an option for leaf spot management

Although a number of leafspot diseases affect bananas in Uganda, black leaf streak, caused by the fungus *Mycosphaerella fijiensis*, is the most important and damaging. The disease causes severe discoloration and leaf necrosis, reducing the effective photosynthetic area dramatically and leading to poor fruit formation and improperly filled fingers. The fruit may also ripen prematurely, a major defect often encountered in exported fruit. In Uganda, black leaf streak affects bananas as well as plantains. As the pathogen may spread by be wind or water it is very difficult to control. In regions where bananas, particularly Cavendish types, are grown for export the disease is controlled by frequent application of fungicides. However, this is costly and has led to the development of pathogen resistance to the fungicides, often rendering the practice ineffective. In smallholder, resource-poor production systems such as those in Uganda, acquisition of fungicides to treat leaf streak is severely limited due to availability and cost.

Alternative methods for managing leaf streak have been developed elsewhere, and include cultural approaches and the use of host resistance. Several reports have been published indicating that a low disease incidence in soils with high nutrient content. It has also been reported that the disease spreads faster and can cause almost total yield loss in plantations established on infertile soils. In on-station trials enhancing plant nutrition has reduced leaf spot expression by decreasing the period of maturation while the time taken for leaf tissue to be destroyed by the pathogen remains unchanged. This presented an option for farmers to manage leaf spots through enhanced nutrition of banana plants using locally available materials. Trials were established at Luwero BS (**Trial 3**) to assist farmers to assess this option. The rationale for this study is based on whether enhancing plant nutrition makes economic sense.

4.1.4 Investigation of a wilt-like disorder in western Uganda

In 1993 symptoms similar to those of fusarium wilt were observed [3, 4] on highland cooking bananas (AAA-EA) in the western highlands of Uganda. In some villages more than 70 % of farms are affected with up to 25 % of plants exhibiting symptoms. Considering the importance of these bananas the disorder was considered to be a potentially serious threat to future production of highland bananas in Uganda and to the livelihood of many smallholder farmers. The disorder was initially presumed to be a new outbreak of fusarium wilt on highland bananas. However, recent studies suggest that it is in fact distinct from fusarium wilt, in terms of etiology and symptoms, and that specific farm management practices are conducive to its development [5, 6]. Occurrence of the disorder appears to be closely linked to areas of the farm where banana refuse or farmyard manure accumulates, and it has now been found to affect exotic as well as indigenous banana types. Given current knowledge of symptomology and etiology, the disorder will be referred to in this report as a 'wilt-like disorder'.

*3 Ploetz, R.C., Jones, D.R., Sebasigari, K. & W.K. Tushemereirwe, (1994). Panama disease on East African highland bananas. Fruits **49** (4): 253-260.*

4 A similar disorder was reported in 1955 by Baldwin (unpublished)

5 Kangire, A. (1998) Fusarium wilt (Panama disease) of exotic bananas and wilt of East African highland bananas (Musa, AAA-EA) in Uganda. Thesis submitted for the degree of Doctor of Philosophy. Department of Agriculture, Reading, 304 pp

6 Kangire, A. & Rutherford, M.A. (2001) Wilt-like disorder of bananas in Uganda. Musa Disease Factsheet No. 10. Montpellier: International Network for the Improvement of Banana and Plantain

Although not directly related to other activities forming part of the project, studies were undertaken in Mbarara, Bushenyi and Ntungamo in western Uganda to investigate, firstly, the effects of specific management practices (principally the composting of household refuse prior to application) in alleviating the severity of the disorder (**Trial 6**) and, secondly, the etiology of this disorder, principally through isolation of potential pathogens and analysis of key soil and plant nutrients.

4.1.5 Post-harvest utilization and acceptability of introduced banana genotypes in Bamunanika, Luwero district

The indigenous highland bananas are highly susceptible to pests and diseases. While some of the exotic cultivars have already been shown have at least some resistance or tolerance to the most common pests and diseases they do also possess qualities that may make them suitable for particular uses. There was, therefore, a need to further evaluate them with farmers and against their own criteria in order to determine how they would be rated with regard to specific uses and needs. This was an aspect of the project research undertaken principally at Luwero, where re-establishing banana production is presently the priority, and encompassed a broad range of farmers including those not hosting the various trials. The aim this process in itself, coupled with the information obtained from it, would help to introduce and promote the cultivars to a greater number of farmers in the region, shorten the time taken for them to access preferred types and, by being personally involved in the ranking/selection process, increase their confidence in adopting these over the longer term.

4.1.6 UK-based research

A pot-based study to support the findings of the on-farm research undertaken in Uganda was completed at the University of Reading, UK. The primary objective was to evaluate and compare the responses, to migratory endoparasitic nematodes, of those exotic banana cultivars being evaluated, validated and promoted in Uganda. This involved an assessment of root growth and development in order to evaluating and identifying factors that may contribute to tolerance or resistance of the plant host to nematode damage.

4.2 Materials and Methods

4.2.1 Management, co-ordination and inputs

The project was under the overall management of CABI Biocience, UK (CAB International) and led by Dr Mike Rutherford (CABI) and Dr Simon Gowen (Dept. of Agriculture, University of Reading). UNBRP staff (KARI), led by Dr Wilberforce Tushemereirwe, was responsible for planning, co-ordinating and managing day-to-day research activities at the BS in Uganda, the majority of which were undertaken by UNBRP staff based at KARI. Field activities at the BS in Uganda were co-ordinated and managed by two BS managers, Prof. Des Ngambeki (KARI) & Dr Suleman Okech (Institute of Tropical Agriculture [IITA], Mbarara), both of whom were jointly funded by this and DFID-CPP Banana streak virus project R7529. Statistical support and advice was provided by Dr Savitri Abeyasekera, Statistical Services Centre, University of Reading (UK). Dr Richard Lamboll (Natural Resources Institute, UK) provided socioeconomic support and advice.

Note: A research team led by Dr Joseph Ssenyonga, ICIPE, has, since March 2002, been collecting comprehensive socioeconomic information for a broad spectrum of farmers in Luwero. This has encompassed farmers who have been undertaking on-farm research activities in association with UNBRP, including some of those who have participated in this project. The majority of the data has been collected by means of a formal questionnaire, and relates to household characteristics (family member gender, age etc), farming history (including with respect to banana production), sources of income and their relative importance, cropping areas land size under bananas etc.

4.2.2 Geographic focus

As indicated above, the overall objectives and outputs of the project were achieved primarily through establishment of on-farm field trials at a number of sites (Luwero, Masaka, Mbarara, Bushenyi and Ntungamo across the demarcated BS in Uganda to address specific needs of the project with respect to:

- Validation, promotion and dissemination of recently released, promising banana cultivars
- Evaluation of banana clones selected from recently introduced germplasm
- Evaluation of enhanced plant nutrition for reduction of effects of banana leaf spots
- Investigation of the etiology of, and possibilities for managing, wilt-like disorder

At each site a number of farmers hosted each trial. While individual farms varied in many respects, including underlying methods of crop management, for the purposes of data analysis each farm was considered a ‘replicate’ for a trial at a given site. All on-farm trials were successfully established at selected sites by May 2001.

4.2.3 Farmer participation

The philosophy of project research was, where feasible, based on applying participatory approaches at all the stages of the on-farm research and technology promotion programme, in that farmers, extension workers, NGOs, researchers and other relevant stakeholders actively interact at each stage of the on-farm research activities. Among other potential benefits, it was expected that that such an approach would enable farmers to observe the attributes of the technologies at first hand and therefore understand them more clearly and with regard to their specific needs. This, in turn, should help to promote and disseminate the technologies and also enhance the prospects for their successful uptake and long-term adoption. The following systematic approach, documented by Prof. Des Ngambeki [8], was employed:

- **Baseline surveys**

A baseline survey was carried out at Bamunanika subcounty, Luwero BS, in 1999 (prior to the project commencing) and the results presented in a planning workshop held at KARI in July 2000 [7, 8,9]. A baseline survey was also carried out in Kisekka, Masaka BS, in 1998 [10, 11, 12.]

7 Banana production systems in Uganda. Luwero Baseline Study NARO/ICIPE/IITA/ESARC

8 Background information for on-farm research – Luwero benchmark site

9 Ngambeki, D. (2001) On-farm research activities at Bamunanika subcounty, Luwero district, benchmark site July 2000–May 2001. NARO.

10 Ssenyonga J.W., Bagamba F., Gold C., Tushemereirwe W., Karamura E., and Katungi E (1999) Understanding current banana production with special reference to integrated pest management in south western Uganda in Frison E, Gold C. Karamura E. and Sikora R editors (1999) Mobilizing IPM for sustainable banana production in Africa. Proceedings of a workshop on banana IPM held in Nelspruit, South Africa, 23-28 November 1998. INIBAP, Montpellier, France.

11 Report of review and planning workshop, Kisekka, July 2000. NARO

12 Kalyebara, R., Wori, M. P. & Namaganda, J. (2002) Proceedings of stakeholders' review and planning workshops of farmer participatory research at Kisekka benchmark site, Masaka (edited by C. Nankinga &W. Tushemereirwe). NARO.

- **Research and planning meeting, KARI**

A planning meeting[13, 14] for Luwero BS, involving farmers, researchers, extension, NGOs and other stakeholders was held at KARI on 25-26 July 2000. The meeting reviewed completed and on-going banana research activities, examined baseline survey reports, assessed and ranked farmers' priority constraints and the prospects of success of potential technological interventions.

13 UNBRP (2000) Planning meeting for Luwero Bench mark site 25th-26th July 2000,Kawanda ARI, Kampala, Uganda

14 Lamboll, R. (2001). DFID/CPP NBRP Integrated Management of Banana Diseases Project (R7567): Socio-economic visit reports 18-23 June 2001.

- **Farmer participatory planning meetings**

Following the research planning meetings, researchers mobilized village communities. For each village, groups of farmers with their village local leaders selected four persons to represent each village community at farmer participatory planning meeting, held in August 2000. The planning meetings included participatory problem analysis of how farmers perceive banana problems, discussions of possible technological interventions and selection of preferred interventions to address farmers' priority constraints. Criteria to be used for selecting villages to host and farmers to participate in banana trials were also identified.

- **Farmer selection**

Using farmer criteria, a number of villages showing strong potential for banana production were selected. Farmer selection meetings were then organized parish by parish where farmers identified criteria for categorizing farmers into top, middle and bottom groups based on several criteria including farm size, coffee cultivation, house construction material e.g. brick or wood, ownership of cattle, off-farm employment and food security in a participatory manner. After discussing objectives and requirements of planned trials, a number of farmers offered to host trials that were of interest while others were randomly selected by other farmers from each group. A schedule of activities was then drawn up and agreed upon.

At Luwero a total of 59 farmers were selected initially and divided into groups according to their parishes/villages to facilitate consultation and in-depth training in trial management.

Twenty-four of the farmer groups remained active at completion of the project. Twenty of these (e.g. Kangulumira Village Farmers' Group and Milyebiri Village Farmers' Group Farmers – see Plate 1) were established as officially recognized groups by the UNBRP.

At Masaka BS, 37 farmers were selected initially to validate the performance of, promote and disseminate three promising banana cultivars, Kabana 3, Kabana 5 and Kabana 5. At Ntungamo BS and Mbarara stock farm, 18 farmers were initially selected to evaluate the newly introduced Cavendish cultivars, Grande Naine, Williams, Chinese Cavendish, along with Kabana 3 and Gros Michel (susceptible control), for their response to Sigatoka leaf spots. At Mbarara, Bushenyi and Ntungamo 10 farmers were selected to facilitate an investigation of the etiology of the wilt-like disorder.

- **Banana on-farm trial establishment**

For each trial scientists from UNBRP, with assistance from the UK-based team, developed experimental designs and prepared draft protocols. Participating farmers, with UNBRP staff, identified and prepared suitable field plots. Necessary planting materials, labour and other material necessary for crop management were made available by UNBRP and farmers.

- **Farmer training**

The training process was developed in a manner that at all stages of field research, including farmer participatory planning meetings, selection of participating farmers, trial establishment, application of treatments and general trial management, farmers not only took part in these exercises but were also trained in new concepts, ideas, technologies, methods, skills that were being applied or arose. Part of this involved formal, intensive training using a variety of methods such as:

1. Training workshops and/or seminars
2. Training of trainers
3. Farmer field schools
4. Training visits e.g. to other farms
5. Farmer-farmer interaction and information exchange
6. Farmer-researcher person to person interaction

Methods 1, 2, 5 and 6 were frequently applied to provide farmers with:

- Knowledge and skills of improved banana production technologies
- Skills required for supervision and management of on-farm trials
- Skills required to keep basic farm records of, for example, planting date, inputs applied, expenditure, flowering date, harvesting date, bunch weight.

4.2.4 Promotional activities

A broad range of activities was planned and undertaken throughout the course of the project to help to promote the cultivars and management technologies concerned. These included agricultural exhibitions, farmers open days, broadcasts on local, national and international television and radio, reports in local and national newspapers, production of videotapes, farmer competitions and presentation at national and international meetings. Full details of these and other promotional activities are provided in the Results and Discussion Section and in accompanying or specified reports and documentation.

4.2.5 Data management and analysis

Data was analyzed with the assistance and approval of biometricians at University of Reading Statistical Services Centre (URSSC), UK, and KARI, Uganda. The majority of field trial data was formally analyzed by summarizing to plot level using Excel add-on software developed by URSSC and then by SAS. Full details of the methods applied, including analysis programs, along with supplementary statistical outputs relating to individual analyses may be provided on request to the project leader.

4.2.6 Research protocols for specific on-farm trials and related activities

An outline of the manner in which field activities were undertaken is provided below in relation to the various trials undertaken and with respect to their objectives. For further details refer to the full protocol for each trial provided in the appendices.

Trials were, for the most part, researcher and farmer funded but farmer managed. UNBRP provided appropriate planting material for the establishment of all trials. Suckers were produced from multiplied tissue-culture material held at NARO laboratories, KARI, or obtained from Du Roi Laboratories, Tzaneen, South Africa. Farmers, field assistants and research scientists from NARO collected relevant data periodically from trials.

4.2.6.1 Luwero BS

As shown in Table 1 a large part of the field activities were undertaken at Luwero benchmark site, where regeneration of banana production is the primary aim of UNBRP.

<u>Data collection - general</u>

A field assistant (FA), Mr Mugerwa, was based on-site in Luwero and visited each farmer hosting trials at least once every two weeks to monitor progress, provide advice and collect data. At all trials, as relevant, farmers recorded information relating to labour inputs while both the farmer and the FA collected biological data. When the farmer alone recorded data, this was subsequently copied by the FA and transferred to UNBRP scientists at KARI at two week intervals for processing. KARI scientists and technical assistants collected data on nematode populations in banana roots and nematode and weevil damage in roots and corms respectively, and on the occurrence and severity of Banana streak virus (BSV) and fusarium wilt.

Dr Des Ngambeki, UNBRP socio-economist and co-ordinator for all research activities at Luwero benchmark site, was responsible for processing economic data. Drs Africano Kangire and Wilberforce Tushemereirwe (KARI) lead scientists for trials 1 and 2 and trial 3 respectively, were responsible for processing all biological and pest and disease data.

❖ **Trial 1. Validation, promotion and dissemination of recently released, promising banana cultivars**

<u>Overall objective:</u>

- To improve banana productivity in Luwero district

<u>Specific objectives:</u>

- To assess exotic banana cultivars for disease and pest resistance and agronomic performance against farmers’ criteria
- To multiply and disseminate planting material to farmers in Luwero district and its environs

<u>Expected outputs:</u>

- High yielding, pest and disease resistant banana cultivars identified.
- Appropriate banana cultivars recommended and selected with farmers' approval.
- Planting materials of acceptable cultivars disseminated in Bamunanika subcounty.

Trial establishment

Twenty-nine farmers from six parishes in Bamunanika subcounty, Luwero district, were selected to host the trial (Table 2) using the participatory approach described in Section 4.2.3* and focusing on those farmers who were willing to participate in the trial after a clear explanation of the trial objectives was provided. All farmers fell into a medium or low-income category according to socioeconomic strata. Trials were established on the 29 farms between 5 and 27 October 2000 at Bamunanika subcounty, Luwero district. For the purposes of disseminating planting material from the trial farms to a wider farming community, it was considered that 10 farms across the participating villages would be treated as a core set of well controlled, 'replicate' trials. The remaining 19 had a lower level of control and were principally established for the purposes of sucker dissemination.

** See also Luwero BS report for July 2000 – May 2001 for further details of stakeholder participation and selection of sites and farmers*

The trial was established as a split-plot design. A area measuring either 0.25 acres (30m x 30m) or 0.125 acres was selected as the trial site on each farm and subdivided into two equal size areas, one of which was manured and mulched as a soil fertility treatment, the other untreated (see Figure 1 and Plate 2). Each area was divided into five subplots, each planted with one of the five cultivars (Kabana 1), Kabana 3, Kabana 4, Kabana 5 or a local highland (AAA-EA) cultivar as a control (Kisansa, Mbwazirume or Mpologoma). The cultivars were randomly distributed across the five subplots within each of two plots. Ten plants were grown per cultivar per subplot, at the UNBRP recommended spacing of 3 m x 3 m.

UNBRP provided appropriate planting material for farmers. Farmers provided land for hosting the trials, labour, manure and mulch and managed the trials. Mulch and decomposed manure were applied as recommended by NARO UNBRP four months after planting. Farmers were trained in required methods of managing the trials in December 2000, as described in Section 4.2.3 and 5.1.3.

Key data collected from trial sites (by cultivar and treatment)

- Biological data (collected by farmer and FA):

Flowering date

Harvest date
Bunch weight (kg) at harvest
Number of fruit clusters at harvest

- Pest and disease data:

Number of leaves present at flowering and harvest (in relation to leaf spot damage, recorded by FA)
Weevil damage in corms at or shortly after harvest
Nematode damage in roots and populations of differing species (*Radopholus similis*, *Helicotylenchus multicinctus*, *Pratylenchus goodeyi*, *Meloidogyne* spp) at harvest
Occurrence of Fusarium wilt and BSV (ongoing monitoring)

- Sucker dissemination data (recorded by farmer):

Cultivar
Date disseminated
Number of suckers provided
Name of recipient and recipient's village, parish and subcounty
Price paid per sucker (if applicable)

- Socio-economic data

Prof. D. Ngambeki also collected data relating to demographic variables and information on farm size and crops grown on the farm (see Appendix 2 for examples of criteria employed).

- Economic assessment

From an economic point of view, investment in banana production is a long-term venture lasting between approximately 10 and 30 years, with economic returns from such an investment usually only becoming clear five or more years after crop establishment. Nevertheless, a study was undertaken using the data acquired from the promotion trial to try to identify early economic benefits using two criteria:

a) the magnitude of marginal rate of return using a partial budget analysis technique
b) consideration of farmers' perceived benefits

Farmers were trained and guided to collect the following data in record books, which was subsequently transferred to UNBRP staff for managing and analysis:

i) labour inputs – by source (family or hired), name, gender, age, number of persons who worked, number of days worked, number of hours worked per day and amount paid
ii) activities undertaken (e.g. land clearing, ploughing, planting, manure composting, carrying and application, mulching, weeding, plant pruning, intercropping, desuckering, digging trenches, general sanitation, harvesting and harvest transport)
iii) other socioeconomic data relating to inputs including: type, source, cost and rate of application of organic materials such as grass mulch, cow dung, composite manure and/or coffee husks
iv) banana harvest data, namely how the bunch was used and value (e.g. sold or consumed, food type prepared, preparation of other products such as dessert, juice or wine

For analysis, the data variables were separated into groups such as family labour, hired labour, purchased inputs etc. and appropriate standard units of measurements or coefficients used for each data set and held in metadata files.

a. Partial budget analysis and marginal rate of return (MMR)

One of the objectives of the validation and promotion trial was to make a preliminary assessment of the economic benefits to farmers of growing the improved exotic cultivars, Kabana1, 3, 4, and 5, by partial budget analysis. This was undertaken based on the data obtained for the first crop (plant crop) in 2002. Partial budget calculates the gross benefits attained from, and the gross variable costs of applying, the new management technologies. In the case of mulch application the costs relate primarily to labour and costs of acquiring mulch and manure. Incremental or marginal benefits are then compared with incremental or marginal variable costs to provide the marginal rate of return (MRR), which is expressed as the percentage of the additional costs that is recovered through the additional benefits gained from of using mulch. For further details see Appendix 3.

b. Farmers' perceived benefits

At various stages of this and other trials farmers were asked to state or provide reports on what they perceive as the benefits accruing to them from, and by being involved in the validation, promotion and dissemination of, the improved exotic banana cultivars. An assessment of post-harvest utilization and farmer preference for and acceptance of, cultivars being validated and promoted was also undertaken based on farmers' own criteria. For further details of methodology see 'Post-harvest utilization of banana in Luwero BS' below.

❖ **Trial 2. Evaluation of banana clones selected from recently introduced germplasm**

Overall objective:

- To improve banana productivity in Luwero district

Specific objectives:

- To evaluate newly introduced cultivars for disease and pest resistance, agronomic performance and acceptability to farmers, primarily for cooking and beer production.

Expected outputs:

- Cultivars with different yield/growth characteristic evaluated for disease and pest resistance under farmer conditions, acceptability to farmers determined.

Trial establishment

Farmers in Bamunanika subcounty were mobilised to facilitate selection for participation in trials. Farmer participatory planning meetings were organised in several villages where farmers and village leaders selected 13 farmers from all six parishes to host the trial (Table 3). For full details of stakeholder participation in this process and in the selection of technologies to be assessed, see Section 4.2.3 above and Luwero BS site report for July 2000-May 2001.

The trial was established on the 13 farms between 25 April and 23 May 2001. As in trial 1, these were established as a split-plot design. An area measuring 36 m x 30 m was selected as the trial site on each farm and subdivided into two equal sized plots, one of which was mulched as a soil fertility treatment, the other unmulched. Each plot was divided into five subplots, each planted with one of five cultivars, FHIA 25, SABA, PITA 14, PITA 17 and a local highland (AAA-EA) cultivar, Kisansa, as a control. The cultivars were randomly distributed across the five subplots within each of the two plots. Ten plants were grown per cultivar per subplot at the UNBRP recommended spacing of 3m x 3m.

UNBRP provided appropriate planting material for farmers. Farmers provided land for hosting the trials, labour and mulch and managed the trials. Levels of mulch and decomposed manure as recommended by NARO UNBRP were applied by farmers at or as close to four months after planting depending on availability of labour and material. Farmers were trained in required aspects of trial management as described in Sections 4.2.3. and 5.1.3.

Key data collected from trial sites (by cultivar and treatment)

- Biological data (collected by farmer and FA):

Flowering date
Harvest date
Bunch weight (kg) at harvest
Number of fruit clusters at harvest

- Pest and disease data:

Number of leaves present at flowering and harvest (in relation to leaf spot damage, recorded by FA)
Weevil damage in corms at or shortly after harvest (to be collected June 2003)
Nematode damage in roots and populations of differing species (*Radopholus similis*, *Helicotylenchus multicinctus*, *Pratylenchus goodeyi*, *Meloidogyne* spp) at harvest (to be collected June 2003)
Occurrence of fusarium wilt and BSV (ongoing monitoring)

Note: as these cultivars have been introduced to Uganda relatively recently and are in the early stages of evaluation, farmers are not permitted to disseminate planting material to other growers. Collection of dissemination data was therefore unnecessary.

- Socioeconomic data

Farmers were trained and guided to collect data as described above for the economic assessment in trial 1. Prof. Ngambeki also collected socio-economic data as described for trial 1.

❖ Trial 3. Evaluation of enhanced plant nutrition for managing banana leaf spots

Overall objective:
To improve banana productivity in Luwero district

Specific objectives:
- To determine the effect of enhanced plant nutrition and application of fungicide on development of leaf spots in EA-AAA highland banana types
- To assess relative costs and benefits associated with leaf spot control treatments

Expected outputs:
- Growth and response of cultivars to leaf spots under enhanced plant nutrition and fungicide treatments determined
- Costs and benefits to farmers determined.

Trial establishment
Twenty farmers from six parishes were selected for hosting the trial (Table 4). For details concerning stakeholder participation, choice of farmers and choice of sites see Luwero BS report for July 2000-May 2001. The trial was established on farms between 10 and 21 October 2000. An area measuring 36 m x 30 m was selected as the trial site on each farm and subdivided into four subplots, each planted with five rows of five plants, one for each of the cultivars Mpologoma, Atwalira, Nfuuka, Nakitembe and Mbwazirume (randomly allocated to subplots). Each subplot was treated with one of the following four treatments (see Figure 2):

1. No manure or mulch, no fungicide applied
2. Manure with mulch, no fungicide applied
3. Manure with mulch, fungicide applied
4. No manure or mulch, fungicide applied

Fungicide and mulch/manure application:
Triadimenol (Bayfidan EC 250), a systemic fungicide with both protective and curative effects against leaf spot diseases, was applied in liquid form to respective plots at a rate of 0.625 g a.i. per litre of water per plant. The fungicide was applied approximately 25 cm from the base of the plant after removing surrounding mulch to ensure good absorption by root tips and to reduce wastage. Fungicide application commenced in June 2001 when plants were nine months old continued at the same rate at two-month intervals throughout the trial period. Fungicide was not applied during the dry season. Farmers were required to ensure that organic nutrient treatments were applied to respective subplots. The most common methods of manure application was a ring method (applying into a circular trench around, and about 2 feet from, the banana mat), and a basket/in-situ method (premixing different materials including grass, cow dung, coffee husks and ash in a pit approx. 0.6 m x 0.6 m x 0.6 m deep and equidistant from four mats). Mixtures applied by farmers varied depending on what was available on-farm, but most applied cow dung mixed with vegetable materials. Each farmer applied an average of 710 kg of cow dung per treatment plot and 87 bundles of grass mulch per 25 mats over a period of one year.

Key data collected from trial sites (by cultivar and treatment)
- Biological data collected by farmer at flowering and harvest by farmers (with the exception of youngest leaf spotted, recorded by the FA):

Flowering date
Harvest date
Bunch weight (kg) at harvest
Number of fruit clusters at harvest

- Pest and disease data collected by UNBRP:

Number of leaves present at flowering and harvest (in relation to leaf spot damage, recorded by FA)
Weevil damage in corms at or shortly after harvest
Nematode damage in roots and populations of differing species (*Radopholus similis*, *Helicotylenchus multicinctus*, *Pratylenchus goodeyi*, *Meloidogyne* spp) at harvest
Occurrence of BSV (ongoing monitoring)

- Sucker dissemination data (recorded by farmer):

Cultivar
Date disseminated
Number of suckers provided
Name of recipient and recipient's village, parish and subcounty
Price paid per sucker (if applicable)

- Economic assessment

An economic assessment of the costs and benefits of fungicide and mulch/manure application was undertaken as described for trial 1.

Post-harvest utilization of banana in Luwero BS

Post-harvest utilization and acceptability of the exotic cultivars being assessed as part of the validation/promotion and evaluation trials at Luwero was determined under farm conditions and against farmers' own criteria at Bamunanika. Four genotypes were assessed for the validation/promotion trial, Kabana 1, Kabana 3, Kabana 4 and Kabana 5, and four for the evaluation trial, PITA 14, PITA 17, SABA and FHIA 25, along with several indigenous AAA-EA cultivars. The genotypes assessed in the promotion trial had previously been assessed in other geographic areas and been found to be potentially acceptable whereas those in the evaluation trial had never been tested before. Both farmers participating in the trials and non-participating farmers were mobilised, at parish level, through farmer group meetings held locally nearby and, in these meetings, were requested to identify and rate the cultivars with respect to the following:

(a) The major uses of bananas in the area
(b) The major characteristics they considered important for each use category
(c) Also, the farmers discussed their own experience with the exotic and other bananas and indicated the potential uses of the various cultivars according to their own criteria.
(d) Cooking is the most important use for bananas and crisp preparation from bananas is an uncommon use. Farmers cooked (by steaming and boiling) and prepared crisp from the various genotypes and tested them. Their perceptions were recorded on a 6-point hedonic scale translated into local language where 6 = strong approval and 1 = strong disapproval.

Data for each product (steamed, boiled, crisp) obtained from each consumer taste panel was collated and analyzed separately by analysis of variance (ANOVA).

4.2.6.2 Masaka (Kisekka) BS

- **Trial 4. Introduction, promotion and dissemination of approved exotic banana cultivars**

Overall objective:
To improve banana productivity in Masaka district

Specific objectives:
- To introduce and promote improved cultivars (Kabana 3, Kabana 4 and Kabana 5 (also being validated and promoted at Luwero)
- To assess the cultivars for agronomic performance and acceptability to potential consumer for various uses

Expected outputs:
- Improved cultivars introduced, validated ad promoted

Farmer selection
Farmer participatory meetings were held in Kisekka where the three banana cultivars were introduced by UNBRP scientists and also evaluated, by farmers, on the basis of taste, flavour, colour and texture of banana preparations provided. A utilization package was also made available and discussed to demonstrate the potential uses for each cultivar. As a result of the meetings, 150 farmers applied to host this trial, of which 37 were randomly selected (Table 5).

Trial establishment and data collection
Relatively simple trial plots were established on each farm, in October 2000, whereby three rows of five plants, one per cultivar, were planted at a spacing of 3m x 3m. The plots were managed by farmers, who also collected the majority of data with respect to cultivar performance and sucker dissemination. As in Luwero a field assistant, Sulait Ddungu, made regular visits to farmers to advise and assist with data collection.

Key data collected from trial sites (by cultivar)
- Biological data (collected by farmers)

Flowering date
Harvest date
Bunch weight (kg) at harvest
Number of fruit clusters at harvest

- Pest and disease data

Number of leaves present at flowering and harvest (in relation to leaf spot damage, recorded by FA)
Weevil damage in corms at or shortly after harvest (ongoing monitoring)
Fusarium wilt and Banana streak virus (ongoing monitoring)

- Sucker dissemination data (recorded by farmer):

Cultivar
Date disseminated
Number of suckers provided
Name of recipient and recipient's village, parish and subcounty
Price paid per sucker (if applicable)

- Farmer acceptability assessments:

Meetings were organized for farmers in 2002 at Parish level in Kisekka to review the research activities and to undertake further evaluation tests of the following commonly consumed dishes prepared from fruit of the introduced clones:

- Steamed Kabana Kabana 3
- Steamed Kabana 5
- Porridge prepared from a mixture of banana flour* and other, commonly used, flour
- Thick-porridge ('Ugali'), prepared from a mixture of banana flour and millet flour

* Banana flour was prepared from dried fruit pulp of banana cultivars such as matooke types, Kabana 3 and Kabana 4, which are not astringent.

Farmers scored the preparations based on mouth feel, taste, colour, flavour and acceptability.

4.2.6.3 Ntungamo and Mbarara sites

- **Trial 5. Evaluation of recently introduced cultivars selected for resistance to leaf spot diseases**

Overall objective:

- To enhance options for banana production in Ntungamo and Mbarara

Specific objectives:

- To evaluate Cavendish cultivars and Kabana 3 for agronomic performance and resistance to leaf spots, particularly BLS

Expected outputs:

- Agronomic performance of cultivars assessed and relative resistance to leaf spots determined

<u>Farmer selection</u>
Initially 18 farmers were selected in Ntungamo benchmark site and one at Mbarara stock farm, based partly on their willingness to participate, to host this trial (Table 6). Those farmers at Ntungamo represented all parishes of Ntungamo subcounty.

<u>Trial establishment and data collection</u>
The trial was established between 1 and 26 April 2001 as a completely randomised design. An area measuring 12 m x15 m was selected as the trial site on each farm and planted with five rows of banana suckers, each row comprising six plants of one of the following five cultivars: Chinese Cavendish, Grande Naine, Williams (all Cavendish types were obtained from Du Roi Laboratories, S. Africa), Kabana 3 and Gros Michel (known susceptibility to fusarium wilt). The cultivars were randomly allocated to the five rows but the allocation kept uniform across all farms. Suckers were derived from tissue culture material and planted at a 3 m x 3 m spacing. UNBRP provided appropriate planting material for farmers. Farmers provided land for hosting the trials, all other inputs and managed the trials. Normal farm management practices were maintained throughout the trial.

Farmers collected the following data with the assistance of a FA, Steven Turyeija. Farmers and the FA recorded data relating to flowering and harvest. NARO scientists collected disease data.

<u>Key data collected from trial sites (by cultivar)</u>

- Biological data collected (by farmers and FA):

Flowering date

Harvest date
Bunch weight (kg) at harvest
Number of fruit clusters at harvest
Number of leaves present at harvest

- Disease data (by cultivar)

Number of leaves present at flowering and harvest (in relation to leaf spot damage, recorded by FA)
Fusarium wilt and Banana streak virus (ongoing monitoring)

4.2.6.4 Mbarara, Ntungamo and Bushenyi sites

- **Investigation of the etiology of, and effects of specific management practices on, a wilt-like disorder**

Overall objective:

- To enhance banana production in affected highland areas of western Uganda

Specific objectives:

- To investigate the effects of specific management practices in alleviating the severity of the disorder
- To further investigate the etiology of the disorder, principally through isolation of potential pathogens and analysis of key soil and plant nutrients

Expected outputs:

- Effects of composting household refuse prior to use as mulch and removal of symptomatic plant parts on expression of the disorder (**Trial 6**)
- Relationship between soil and plant nutrient composition, presence of organic household refuse and occurrence of the disorder determined

<u>Farmer selection</u>
In May 2001, 10 farmers in Mbarara, Bushenyi and Ntungamo districts were initially selected to host field trials, the first of two components of the overall investigation, based primarily on occurrence of the disorder and their willingness to participate. Farmers were taught UNBRP-approved methods of composting organic household refuse and compost application by UNBRP scientists, including a soil scientist based at KARI, partly through practical demonstration at each farm. The practice recommended involved three compost pits, each approximately 2.m x 1 m x 1 m deep, excavated on-farm. Refuse was added to the first pit and allowed to decompose for several weeks before being transferred to the second and subsequently the third where it reached the required level of decomposition and was suitable for application.

<u>Trial establishment</u>
Trials were established on 9 August 2001 on farms where the disorder had been prevalent for several years and were it was causing at least moderate damage. At each farm an area adjacent to the homestead was selected as the trial site was selected, where the disorder was prevalent and where normal farm management of applying raw organic household waste (primarily banana fruit peelings and other fruit or vegetable matter) as mulch, was practised. The area was subdivided into two adjacent, equal sized plots each having at least 72 banana plants.

On 9 August the (baseline) incidence and severity (see Table 8) of wilt was assessed on 72 randomly selected and marked plants in each of the two plots at all farms. Subsequently, farmers applied composted, as opposed to raw, refuse to one of the two plots at rates recommended by UNBRP while applications of raw refuse continued as before on the second plot. Periodic visits were made to each farm and the incidence and severity of wilt re-assessed by KARI scientists. At harvest farmers, assisted by a FA (Robert Muhwezi), recorded bunch weights and, for plants exhibiting symptoms of the disorder, removed and destroyed the pseudostem bearing the bunch and the section of corm immediately beneath it in both plots.

<u>Data collected from trial sites</u>
Severity of wilt symptoms (0-3 scale)
Bunch weight (kg) at harvest

<u>Isolation and identification of organisms in plant material</u>
On each occasion that visits were made to farms affected by wilt disorder, samples of corm and pseudostem exhibiting discoloration of the vascular system were obtained from symptomatic and asymptomatic plants. Isolation of fungal and bacterial organisms present in the tissues was undertaken in Uganda and at CABI Bioscience, UK and, where applicable, the organisms identified.

<u>Nutrient analysis</u>
On several occasions (December 2000, June 2001 and February 2002) during the course of the project, and partly due to the costs involved in nutrient analysis, a small number of samples of soil and banana corm, sucker and leaf material was collected from affected and unaffected areas of farms in Mbarara, Ntungamo and Bushenyi where the disorder was present. Analyses** of, total nitrogen, potassium, calcium and magnesium were undertaken at the NSRU, Chemistry and Biochemistry Laboratory, University of Reading to determine if any differences were apparent and whether, and on what, a more comprehensive analysis should be undertaken.

** |Full details of analysis methodology may be provided on request.

Based on these preliminary results, systematic collection of soil, corm and sucker material from affected and unaffected areas of four farms* was undertaken and analyses of soil pH and potassium, calcium, magnesium and total nitrogen levels in soil and corm and sucker tissues applied. At each farm two areas were selected, one adjacent to the homestead where the disorder was prevalent and a second, at least 50–100 m from the first, where the disorder was absent and had never been observed by the farmer. At each location, three banana plants approximately 10 m apart were selected (in the case of the affected area, plants exhibiting wilt severity between grade 2 and grade 3 were selected). For each plant, three soil samples were obtained from a depth of 5-20 cm at three points 50 cm from the edge of the mat and equidistant from each other. The samples were pooled and mixed thoroughly and a 500 g subsample retained for analysis. An emerging sucker approximately 50 cm long was removed and a cylindrical section from 10 to 20 cm from the apex removed for analysis. One of the three plants was uprooted and a section of corm 10 x 5 x 3 cm removed for analysis from approx. half way down the corm and 10 cm from the side. Samples were collected between in November 2002.

* Includes some farms at which composting trials were also undertaken

4.2.7 UK-based research

Study of root systems of triploid and tetraploid banana cultivars with different levels of susceptibility to migratory endoparasitic nematodes (University of Reading)

For full experimental protocol see Appendix 4

Objectives

- To evaluate and compare the responses to nematodes of some of the exotic banana cultivars now being promoted in Uganda
- To compare the growth and development of root of these cultivars and evaluate these factors that may contribute to tolerance of nematode damage
- To make a morphological and anatomical study of different cultivars to identify features that might contribute to nematode resistance and /or tolerance

Methodology

Eight banana cultivars were used in studies of resistance and tolerance to nematodes, Kabana 1 (FHIA 01), Kabana 3 (FHIA 17), Kabana 4 (FHIA 23), Kabana 5 (Yangambi Km5), FHIA 03, FHIA 25, Williams and Kisansa. The FHIA cultivars excepting FHIA 25 are tetraploid with different ancestries. Yangambi km 5 is recognized as a cultivar with good disease resistance and resistance to nematodes. Williams is a Cavendish cultivar included in this study because of its known susceptibility to nematodes and Kisansa is an East African matooke cultivar.

Plants derived from tissue culture and thus confirmed as free of pests and diseases were used in all experiments (except for those roots collected from Uganda for anatomical study).
Plants were grown in a glasshouse and in polytunnels during the summer months.
Nematode inoculations were with pure cultures of *Radopholus similis,* or within mixtures with *Helicotylenchus* spp and *Pratylenchus* spp, the principal nematode pests of bananas.
At sampling, plants were weighed and components of the root systems were measured and categorized. Nematode damage was assessed visually using a lesion index. Nematodes were then extracted from sub-samples of roots of treated plants using established methods.
For morphological and anatomical studies, roots were fixed, stained and sectioned using standard techniques. Analysis was made of the numbers of cells with phenolic contents as this is an indication of resistance mechanisms.

5. OUTPUTS

5.1 Results and discussion

5.1.1 On-farm research trials and related activities

5.1.1.1 Luwero BS

- **Trial 1. Validation, promotion and dissemination of recently released, promising banana cultivars**

- Plant growth and yield

Tables 9-11 show the performance in terms of yield (bunch weight and number of fruit clusters) and time to maturation (harvest) of the Kabana and local cultivars for the first crop (plant crop). Higher bunch weights were obtained as a result of mulch addition in all cultivars, with an average increase of 10.7 kg or 83% (Table 9). Increases were significant (P<0.01) for all cultivars with the exception of Kabana 5. This cultivar, unlike Kabana 1, Kabana 3 and Kabana 4 which are the products of a dedicated breeding programme, is a natural cultivar [*Musa* AAA] originally obtained from Democratic Republic of Congo). Mbwazirume, which had the lowest bunch weight without mulch (4.5 kg), showed the greatest increase under mulch (264%). Bunch weights increased by at least 49 % (Kabana 5), with Kabana 1, Kabana 3 (see Plate 3) and Kabana 4 (26-33 kg) all having yields under mulch approximately 1.5 to 2.5 times those of Kabana 5, Kisansa and Mbwazirume (13-19 kg). Of the Kabana types, Kabana 4 showed the most improvement due to mulch, easily outperforming Kabana 1 and 3 (although mean bunch weights were similar for Kabana 3 and 4). The increased bunch weights were reflected by some increase in the number of fruit clusters formed at harvest (Table 10), although differences were not significant (P<0.05) and the relevance of any change in terms of fruit use or marketing potential is not clear at this stage.

Addition of mulch, on average, slightly reduced the time taken for plants to reach harvest, from 543 to 524 days, although variation was found in the response of differing cultivars with maturation time being either reduced (Kabana 3, 4, Kisansa and Mbwazirume) or, in some cases (Kabana 1 and Kabana 5), extended (Table 11). The two AA-EA cultivars, Kisansa and Mbwazirume, had relatively long maturation periods without mulch but showed the greatest reduction (56 and 70 days respectively) when mulch was applied. The largest increase was for Kabana 5, at 33 days, although it did have the shortest maturation period without mulch, almost three months shorter than Kabana 4 and Kisansa.

- Pests and diseases

With the exception of Kisansa, addition of mulch increased the number of leaves retained at harvest in all cultivars (Table 12), although leaf number was generally low (maximum of 7, in Kabana 5). This again generally reflects the increases observed in bunch weights, and may be an indication of improved plant vigour due to the enhanced nutrition. However, a reduction in leaf number may, and in these trials is being, used as an indication of leaf spot damage. In this trial the Kabana types, selected by breeders and/or for validation by UNBRP with leaf spot resistance in mind, had many more leaves at harvest than either Kisansa or Mbwazirume (only 3 and 2 leaves respectively), both of which generally show at least some level of susceptibility to leaf spot pathogens in Uganda (Plate 3).

BSV was observed in this trial, but incidence and severity were both very low. Fusarium wilt was not observed. It is anticipated that monitoring for both diseases will continue at the trial sites following completion of this project.

Two assessments of weevil damage were carried out, in March 2002 (first crop) and March/April 2003 (second crop = first ratoon crop), on corms of recently harvested (or in some cases dead) plants (Tables 13 and 14). In the first assessment weevil damage levels, expressed as percent of corm area with weevil tunnels, was very low in all cultivars and across both mulched and unmulched plots, despite some variation being observed between cultivars and mulched/unmulched plots. In the second assessment, while variation between cultivars and treatments was again observed, some general increase in damage was observed across the cultivars and both the mulched and unmulched plots, with mulched plots having slightly higher levels than unmulched. However, damage levels were again, overall, very low. Kabana 5, known to be relatively resistant to weevil damage, had the least damage at both assessment stages while the local cultivar Kisansa had the highest in mulched plots in 2003. While some increase in damage has been seen between the first and second crops, and may be related to mulch application, it is too early to make draw conclusions from these results.

Two assessments of nematode damage to, and nematode populations in, roots of recently harvested (or in some cases dead) plants were carried out, in March 2002 (first crop, Tables 15-18) and March/April 2003 (second crop = first ratoon crop) (Tables 19-22). Recording the incidence of heavily lesioned and dead roots is a valuable indication of root health and is an indication of the intensity of nematode damage. The results of the 2003 assessment indicate that the exotic cultivars were relatively less damaged than the two east African highland cultivars, and would suggest that these new cultivars will show greater tolerance to nematodes than the local types.

Analysis of plant roots revealed some differences between cultivars in counts of the parasitic nematode *Radopholus similis* (cultivar differences in response to *R. similis* have been reported previously). Mulched plots generally had higher *R. similis* counts than unmulched plots but mulching had no apparent effect on populations of *H. multicinctus* or *Meloidogyne* spp. *Pratylenchus goodeyi* was not recovered from roots at any farm in this study. It can be concluded that the FHIA types (Kabana 1, 3 and 4) and Yangambi Km 5 (Kabana 5) are no more susceptible to nematodes than the east African cultivars and are possibly less so. The results from the pot studies in controlled conditions (see 5.1.2) show that the FHIA hybrids and Yangambi are less susceptible than a standard nematode susceptible Cavendish cultivar.

Note: Although field observations showed that, generally, significant yield increases were found in mulched plots, it was also evident that some farmers had not managed their fields as anticipated or applied mulch as recommended. More comprehensive analysis of the data available should allow the effects of variation in management and other factors on the variables outlined here to be determined.

- Dissemination of planting materials by farmers

Tables 23-26 show figures for the dissemination of suckers of the exotic cultivars, Kabana 1, 3, 4 and 5, and the two local cultivars, Kisansa and Mbwazirume, by farmers hosting trial 1 at Luwero. When considering the data, it is important to consider that each farmer grew either Kisansa or Mbwazirume, not both, while every farmer grew Kabana 1, 3, 4 and 5. A total of 7396 banana suckers (from a total trial plot area of approximately seven hectares) was disseminated between January 2001 and May 2002 (averaging 435 per month), 7012 being exotic types and 384 local types (Table 23). This is equivalent to 16 suckers and one sucker per farmer per month respectively. These were obtained by 265 recipient farmers (beneficiaries) in 2001 and 50 in 2002. This number is considerably high given that less than 2000 plants were established at the trial sites in late 2000. Kabana 3 and Kabana 5 were in greatest demand (each c. 2400 suckers to c. 80 beneficiaries), followed by Kabana 4 (1244 to 46 beneficiaries). It is not known why Kabana 4, which is very similar to Kabana 3, did not attract as much demand. Only 38 farmers obtained suckers of Kisansa and Mpologoma, perhaps because farmers are already aware of their characteristics and/or already grow them, or alternatively because they much have experienced of heard of the attributes of the exotic types and wish to try them for the first time or increase plant numbers.

Suckers of the six cultivars were disseminated to farmers from 23 identified parishes (details of the recipient parish(es) of 226 suckers is unknown) (Table 24). Although greater demand was received from farmers in parishes where the trials are sited, such as Kibirizi and Kyampisi, probably because people are more readily exposed to the technologies than in other areas, it is an important to note that many recipients were also from parishes beyond trial parishes. A large number (2742) were also obtained by UNBRP and distributed to farmers in Luwero as part of a GATSBY-funded project to help expand banana cultivation in central Uganda and Luwero in particular.

Three trial farmers, Kasozi A, Mwanje Raphael and Mulyazawo M, provided considerably more suckers (914, 721 and 705 respectively) than most other farmers (Table 25). Mwanje and Mulyazawo also happened to produce the two heaviest bunches (65 and 57 kg respectively) over this period of all farmers, both from Kabana 3 and under mulched conditions. These three farmers each provided between 124 and 186 suckers of Kabana 3 in 2001 alone. The popularity of Kabana 3 is reflected by the fact that it was obtained from trial farmers on a total of 172 occasions (c. 10 times per month), in comparison with Kisansa and Mbwazirume on only 27 and 26 occasions (26).

It will be of considerable interest to determine whether the trends in demand from trial farmers shown here continue after 2001 (particular as more farmers are now growing them and the number and geographic range of potential suppliers has widened), whether new farmers seek them, whether farmers who have already obtained them continue to grow them, how they are used and perceived and what returns are gain These are aspects that form part of a proposed follow-on phase of research to commence in mid-2003. It has been encouraging to observe that many of the farmers hosting the trials have expanded the area of cultivation of some the cultivars beyond the trial plot, using planting material derived from the trial plot (Plate 4).

- Economic assessment

a. Partial budget analysis and marginal rate of return (MMR)

Table 27 shows estimates obtained in terms of benefits and costs incurred through application of mulch and manure to Kabana 1, 3, 4 and 5. The average bunch weight attained in 2002 across these four cultivars with and without mulch was 15.38 and 26.25 kg per plant respectively. This corresponds to 6150 and 10660 kg/acre/year respectively. The mean farm gate price, which applies to bunches produced either with or without mulch (separation of the two was impractical for farmers) was 62 Ugsh per kg, giving gross values for cultivating these bananas with and without mulch of 382k and 662k7 Ugsh respectively and, therefore, an additional 280k Ugsh through using mulch. This gain corresponds to 66.8% of the additional variable costs incurred (an additional 419k), the marginal rate of return (MMR).

As the marginal rate of return is greater than the current bank lending rate in Uganda of 18%, the enterprise of exotic bananas in Luwero would appear to be economically viable. Due to high long-term initial investments in the establishments of the banana plot, the net economic benefits of mulching two years after crop establishment are still below those of the costs. However, the difference between the benefits and costs is expected to decrease and probably reach zero in the fourth year when the use of mulch will be expected, financially, to pay off.

The farm gate price of exotic bananas at Luwero benchmark site averaged only 48 Ugsh/kg over the last year, which is still low in comparison with to that East African highland cooking bananas (averaging 84 Ugsh/kg over the same period). However, following a series of farmer participatory dissemination activities including farmers' open days and agricultural exhibitions, at which the improved cultivars were promoted, the price of exotic bananas apparently increased considerably. This, coupled with these results, suggest that the farmers will, with time, obtain net benefits from growing exotic banana cultivars with mulch.

Note: No attempt was made at this stage to define the MMR for the four cultivars individually.

b. Farmers' perceived benefits
Initial information on the Luwero farmers perceptions of the Kabana banana being assessed was obtained through the exotic banana farmers' group annual report for 2001/2002, in which they unanimously agreed that they benefited in terms of hard cash obtained from sale of fresh bananas, suckers and local beer and gin prepared from the banana fruit. They pointed out that the cash had improved their household income and enabled them to meet their cash needs in terms of clothing, scholastic materials for children, radios, metallic drums required for brewing gin and house construction and improvement. They also appreciated the agronomic qualities of the exotic cultivars as they considered that they are tolerant to drought and can thrive on poor soils, are not susceptible to banana pests and diseases, most importantly, because they produce bigger bunches of 20 kg up to 60 kg. This 'proved' them to be a reliable source of food security.

Bamunanika Farmers' Group also produced a poster for exhibiting at the Bamunanika farmers' Open Day, Sept 2002, in which they highlighted their major benefits of the cultivars and their own participation as follows:
- The cultivars provide food security
- Cultivars such as Kabana 3, 4 and 5 could be used in a number of ways (had a multipurpose nature), in terms of the ability to produce a range of banana products such as food, flour, chips, porridge, kalo, juice, ripes, local beer and gin
- The farmers are putting their land to maximum use and getting higher yields from smaller banana plots
- The farmers have earned recognition by others and are receiving many visitors who are admiring their work.

From focus group discussions and/or interviews, exotic banana farmers pointed out similar perceived benefits from growing the exotic bananas. They did, however, also point out that there are five challenges facing them with respect to the exotic bananas, namely.
1. The exotic banana cultivars are still relatively new and not known to many farmers
2. Market outlets of the exotic bananas are still limited
3. They take a longer period from flowering to maturity (500days)
4. Plots where manure and mulch are not applied produce very small bunches
5. Their management is labour intensive yet their market value of harvest from the first cycle was very low (Ugshs 48 per kg as compared to 84 to 100 Ugshs per kg for local cultivars)

❖ **Trial 2. Evaluation of banana clones selected from recently introduced germplasm**

- Plant growth and yield

Although some harvest data is now available, it has not been possible to formally analyze this as yet. However, preliminary summary analysis (Table 28) of bunch weights indicates that these have also been increased in the more recently introduced cultivars by at least a few kg due to the addition of mulch. Formal analysis of data available from flowering stage shows that was little change in the number of clusters on developing bunches (Table 29) which, at least at this stage, suggests that the increases in bunch weight are due to cluster/finger filling as opposed to an increase in cluster number. Addition of mulch had very little effect on time taken for plants to reach flowering, which averaged 450 days (Table 30).

The most striking observation in this trial was the performance of FHIA 25 in comparison with the other cultivars. The average bunch weight was 40 kg with mulch (and 38 kg without), whereas those for Kisansa, PITA 14, PITA 17 and SABA ranged from 11 to 14 kg with mulch. Plants produced 11 as opposed to 5-6- clusters, an important consideration in terms of sale of produce at local markets by cluster and not bunch.

- Pests and diseases

The number of leaves at flowering was generally similar (Table 31) with and without mulch but generally low in Kisansa, PITA 14, PITA 17 and SABA, an indication of relatively high levels of susceptibility to leaf spot disease. Leaf number was much higher in FHIA 25 (avg. 10 per plant) suggesting much greater resistance to the disease and likely to be very conducive to the high bunch weights attained. Previous on-station reports have shown FHIA 25 and SABA to be very resistant to fusarium wilt and no symptoms of the disease were observed on any plants in the trial *. BSV was noted on a few plants of all cultivars on nine farms and, although levels were very low the disease will be monitored. Collection of weevil and nematode data was planned for June 2003 and will be analyzed and findings reported subsequently.

- General observations of farmer perceptions of cultivars

As evidenced elsewhere in this and accompanying reports, farmers hosting the trials and their colleagues are both surprised by, and very enthusiastic about, the vigorous growth and high yields shown by FHIA 25 to date (Plate 5). The cultivar is also generally shorter at maturity than other cultivars and, given the heavy bunches that may be produced, makes harvesting easier and should also make plants less prone to toppling. Farmers have also informally reported that they find FHIA 25 palatable and a good producer of juice, while PITA 14 and PITA 17 are already being utilized as roasting bananas. They have already formed farmer groups to collectively collect juice and produce local dry gin from these cultivars, an important source of income for the local community.

- *Symptoms similar to wilt were recorded on one plant but, given that this was Kisansa and that the symptoms were slight, it is highly unlikely that they were due to fusarium.*

❖ Trial 3. Evaluation of enhanced plant nutrition for managing banana leaf spot diseases

- Plant growth and yield in relation to leaf spot

The number of leaves remaining at harvest is a good indicator of levels of leaf spot damage, hence its use in the trials undertaken in this project. Unfortunately farmers also used the same variable to estimate maturity of the banana fruits (a fact realized only recently), which may compromise accuracy of the indicator in estimating the leaf spot damage. Nevertheless, the results for this trial clearly show that application of fungicide helped treated plants to retain more leaves at harvest, therefore confirming its effectiveness in reducing the damage due to leaf spots (Table 33). This in turn enabled the detection of effects due to nutrition and /or fungicide treatments on yield loss associated with the disease.

The trends shown by the data for this trial are very encouraging in terms of the positive effects of enhancing nutrition through application of organic materials (manure and mulch) as a soil amendment on yield (bunch weight, (Table 32) and leaf survival (Table 33) in the highland bananas. This was true for all cultivars either with or without fungicide and across both the first and second cropping cycles. Comparison of values for difference between treatments shows that most are very similar to eachother (and not significantly different at P=0.05). This indicates that the benefits associated with enhanced nutrition in terms of yield and leaf number are at least as good as those of fungicide application. Indeed in many cases enhanced nutrition had a more beneficial effect than applying Bayfidan in reducing the effects of leaf spot and increasing on yield bananas.

Combining organic materials with fungicide generally had the greatest effect but this has drawbacks in terms of imposing two costs on farmers where one is already difficult to afford. Moreover, the difficulties associated with obtaining fungicides in Uganda and the inconveniences and disadvantages of their application would also work against using the combination. These results suggest that amending soil with organic materials to control banana leaf spots is a suitable alternative to fungicide application for smallholder farmers and, as reported below, a viable option.

It was interesting to note that the farmers have already discovered the benefit of applying additional nutrients to the soil as a measure to both manage leaf spots and increase agronomic performance of the crop. They are now able to state confidently that applying manure and mulch, though initially expensive, has the benefits of reducing leaf spots while at the same time increasing bunch yield to marketable levels. One challenge now is how to facilitate dissemination of this information, a subject of proposed follow-on research.

- Dissemination of planting materials by farmers

Tables 34-37 show figures for the dissemination of suckers of the local cultivars Mbwazirume, Mpologoma, Atwalira, Nakitembe and Nfuuka by farmers (unlike trial 1, all farmers grew all six cultivars). A total of 2990 banana suckers (from a total trial plot area of approximately 8.4 hectares) were disseminated between January 2001 and March 2002 (Table 34), an average of 199 per month or 12 suckers per farmer per month. This compares with 16 Kabana suckers disseminated per farmer per month from the promotion trial sites *. These were obtained by virtually the same number of recipients (253 in 2001 and 11 in 2002) as in the promotion trial. The demand for all of the cultivars, in terms of number of suckers obtained and number of recipients, was similar in 2001 and 2002 with the exception of Mpologoma, where demand was about 65% of that for each of the other types.

** Unfortunately no data can be found relating to the rate of sucker production of Kabana and AAA-EA banana types*

Suckers of the six cultivars were disseminated to farmers from only six parishes as opposed to 23 in the promotion trial (Table 35). As with Kisansa and Mbwazirume in trial 1 this may again be because farmers are already aware of their characteristics and/or already grow them and therefore prefer to try, if anything new, the exotic types. Demand, on a monthly basis, also fell from 235 in 2001 to just 57 in the first 3 months of 2002 (Tables 34 and 35), although this is in the dry season when planting is generally limited. It will be of interest to see how these numbers may have changed with the onset of the rains in May/June and to look more closely at comparative demand for the Kabana and local types in trials 1 and 3 on a monthly basis throughout the year. The number of suckers provided by each farmer varied widely (Table 36), with two farmers not providing any at all (reason unknown at this stage), as did the number of occasions on which suckers were obtained (Table 37).

- Economic assessment

A partial budget analysis of costs and benefits associated with enhanced plant nutrition for the plant crop was undertaken as described for trial 1 and a marginal rate of return (MMR) determined (Table 38). Mean bunch weights per plant per year across the five AAA-EA cultivars for plots without enhanced nutrition or fungicide, without enhanced nutrition and with fungicide, with enhanced nutrition but no fungicide and with both nutrition and fungicide were 11.25, 14.32, 15.60 and 18.54 respectively. These would provide between 4500 and 7416 kg/acre/year and amount, at a farm gate price of 87Ush/kg, to gross values of 391k, 498k, 542k and 645k Gush respectively. 351.7 kg.

When equated with estimated variable input costs of 615 k Ugsh, the marginal rates of return (MRR) for enhancing nutrition in the manner described, with and without associated fungicide application at the given rates, of 22.8 % and 23.5 %. The similarity of these rates indicates that that, economically, the use of fungicide has little bearing on the benefits gained from enhanced nutrition, although it is important to remember that the direct costs of fungicide application have not been taken into account in the calculations. The MRR are also much lower than those found through the addition of mulch/manure for the Kabana bananas in trial 1 (66.8) and are much closer to the local bank lending interest rate of 18%. Although the market price obtained per kg for the AA-EA types was higher, this was outweighed by a much greater average increase in bunch weight (73% as opposed to 12% without fungicide for the AAA-EA types), higher yields overall and lower additional costs for the mulch/manure inputs. Although the mulch/manure treatments and perhaps initial soil nutrient conditions may differ considerably between the two trials (and of across farmers hosting the same trial), this does suggest, at least at Luwero, that the initial capital investment required for providing suitable nutritional conditions for plant growth would be less for the Kabana types, income generated would be much higher and net economic benefits would be attained much more quickly. Nevertheless, and although these studies were limited in terms of the variables taken into consideration, the findings in the two trials still suggest that applying nutrition is still a viable economic enterprise in Luwero for both the Kabana and the EA-AAA types. A more in-depth analysis, taking a broader range of factors into consideration (e.g. costs of transporting the two banana types to markets and post-harvest food preparation) and looking at later harvests, is now required.

Note: No attempt was made at this stage to define the MMR for the five cultivars individually.

Post-harvest utilization of banana in Luwero BS
The focus group discussions identified the major uses of bananas in the area and ranked them in order of their importance as shown in the Table 39. Cooking was rated the most important use followed by juice/beer production. This implies that according to this community, cooking bananas were similarly the most desired. The rank in Table 39 was similar in five of the six parishes of Bamunanika subcounty, Luwero district except in one parish, Kyampisi, where crisp was considered more important than roasting bananas. The evaluation and testing activities have also been prioritized in the same order.

For every use category, farmers identified attributes, which they considered important. The farmers still ranked the attributes in order of importance as indicated in Table 40. The listed attributes were similar in the 6 parishes though they used different local terminologies to describe them. All the farmers indicated that taste and texture were important for cooking bananas (see Plates 6-8 also). For the juices/beer, taste and mouth feel were important. Farmers said that some banana genotypes produce juice, which is slimy and dark and hence not acceptable. Tables 39 and 40 enabled us to design a suitable questionnaire for subsequent test panels.

A. Study group 1 - farmers hosting promotion trial 1

A.1 Uses of the genotypes
Farmers shared their individual experiences with the various introduced banana genotypes with respect to their potential uses. They listed the cultivars and discussed the uses they had discovered per genotype in their own homes. This was usually a lengthy debate among the farmers and only a consensus was recorded. Tables 41-46 show the uses the farmers agreed upon based on their experiences. In these tables, code 1 = low level of approval, 2 = satisfactory, 3 = high level of approval, U = tried and found unsuitable and NT = not tried. There are slight differences from parish to parish. Many of the use recommendations were similar across the parishes.

Since the farmers had earlier identified the major uses of bananas in the area, local cultivars used for the same purposes were included to enable the farmers make comparisons. Pisang Awak (Kayinja), Kisansa and a plantain (Gonja) were included for this reason. All the six focus groups considered Kabana 1 and Kabana 5 as juice/beer bananas and Kabana 3 and Kabana 4 as cooking bananas. They however said that it is possible to produce juice and beer from both Kabana 3 and Kabana 4, although it has a bad smell (which they described as having a Bogoya [Gros Michel] flavour).

A.2 Consumer taste panels
Results from the panel tests for cooked genotypes from the promotion trial are presented in Tables 47 and 48. The results indicate that Kabana genotypes were considered significantly ($P<0.05$) inferior to the East African highland-cooking banana Kisansa when either steamed or boiled. Texture and colour of the cooked product were generally the least liked attributes of the Kabana bananas, with Kabana 5 being the worst. Matooke consumers cherish the golden yellow appearance and a sufficiently soft texture of cooked bananas as opposed to the grey-dark brown appearance of the cooked Kabana bananas. However, the consumers scored Kabana 1, Kabana 3 and Kabana 4 as acceptable (overall score 4 or above), while Kabana 5 was considered to have the least acceptable attributes when cooked. Scores for Kabana genotypes were higher when the fruit was boiled rather than steamed into a traditional matooke. Kabana 3 and Kabana 4 are becoming very popular cultivars among farming communities as they possess the combined attributes of resistance to disease, high yield and fair cooking qualities in comparison with local cultivars that succumb to pests and diseases despite having highly approved of cooking qualities.

B. Study group 2- farmers hosting evaluation trial 2

B.1 Uses of the genotypes
With reference to earlier use categories the farmers had identified (Tables 39 and 40), the genotypes in this trial type were also assigned potential use categories and the same scoring as in Tables 41 to 46 was applied. The local cultivars used for the same purposes were again included to enable the farmers make comparisons. Pisang Awak (Kayinja), Kisansa and a plantain (Gonja) were included for this reason.

The six focus groups considered FHIA 25, SABA and PITA 14 as juice/beer bananas (Plate 9) and PITA 14 and 17 as acceptable roasting bananas (Tables 49-52). They however said that it is possible to obtain juice and beer from PITA 17 also but yields are low. All genotypes assessed in this trial were considered unsuitable for cooking. Scores were the same in the two parishes of Kiteme and Sekamuli. However, the farmers said that the genotypes were suitable for use as crisps when semi-ripe.

B.2 Consumer taste panels
Results from the panel tests for cooked genotypes from the evaluation trial are presented in Tables 53 and 54. The results indicate that all the exotic genotypes were considered significantly ($P<0.05$) inferior to the East African highland cooking banana Kisansa when either steamed or boiled. All were scored as unacceptable when steamed. FHIA 25 had a soft texture that was approved of by the consumers. The major problems with PITA 17, PITA 14 and SABA were appearance (colour) and texture. When steamed, the pulp of these types turned dark brown, an unappealing appearance to matooke eaters. The golden yellow appearance and a soft texture are clearly absent in the genotypes. All of the genotypes also had an astringent taste, characteristic of local juice bananas (hence the farmers refer to them as mbidde, a general term for juice bananas). When boiled, scores for all the genotypes improved. All the genotypes were rated as fairly acceptable. However, astringency remained the major factor for all the four genotypes. Astringency is highly correlated with tannin levels in bananas[15].

15 Nowakunda, K (2001). Determination of consumer acceptability on introduced exotic/hybrid bananas in Uganda. MSc. thesis, Makerere University, Kampala, Uganda.

C. Other post harvest utilization methods
Farmers at the Bamunanika benchmark site have been trained in banana drying and utilization of dried bananas. The farmers have been trained in the use of low cost solar dryers to dry the bananas. Dried banana chips can be reconstituted or reduced into flour that can be used for porridge or paste and many confectionary products. The objective of this training is to enable farmers learn to diversify the utilization base of the bananas so as to obtain secondary products and hence secondary markets. The drying will also make use of some of the introduced genotypes that are not suitable for traditional uses.

Future activities will focus on training farmers in dryer construction and production of banana based products other than those known traditionally.

5.1.1.2 Masaka (Kisekka) BS

- **Trial 4. Introduction, promotion and dissemination of approved exotic banana cultivars**

For various reasons it has been very difficult to obtain farmer data for the trial undertaken in Masaka district, and no data has been made available as yet on dissemination of suckers by trial farmers and little on the acceptability of the cultivars being assessed. Data on agronomic performance and response to leaf spot is available for a section of the original 37 farmers and is reported here.

- Plant growth and yield

Yields of the three cultivars introduced, Kabana 3, 4 and 5, differed markedly with respect yield expressed as bunch weight (Table 55), although the trend was similar to that shown where mulch was applied in trial 1 at Luwero (37, 45 and 15 kg at Masaka as opposed to 34, 33 and 14 kg with mulch and 21, 14 and 9 kg without at Luwero). This obviously suggests that environmental and/or farm management conditions at Masaka are similar to those under enhanced nutrition at Luwero but considerably more favorable to banana production of these improved types, and possibly other banana types, than those normally prevailing at Luwero (i.e. without mulch). Kabana 5, as at Luwero with or without mulching, has produced relatively small bunches and, unless bunch size improves over time or it finds a niche market and therefore demands a high price it may not have a bright future in relation to some of the other banana investigated during the project. However, the post-harvest study showed that, while it is unfavorable to farmers for cooking, it is an excellent juice producer, a use that was ranked highly by farmers. Kabana 3 and 4, with which yields and favorable to farmers for a variety of uses including cooking (steaming and boiling), as whole fingers with groundnut, as whole fingers, as crisps or (despite its unfavorable odour) for juice production.

All three cultivars took longer to mature to harvest than at Luwero (with and without mulch) but the periods, all more than 620 days, were not too dissimilar (Table 55). Kabana 5, which was relatively quick to mature at Luwero and much quicker than Kabana 4, was again the quickest at 628 days followed Kabana 3 at 654 days (526-533 at Luwero) and Kabana 4 at 664 day (594/567 at Luwero). These longer growth periods may explain the increased bunch weights at Kisekka for Kabana 3 and 4 but not Kabana 5.

- Pests and diseases

The number of leaves (averaging 11 per plant) present at harvest indicates low levels of leaf spot damage, and was very similar for all three cultivars (Table 55). However, many more leaves were present than for the same cultivars validated at Luwero. This was likely due to increased prevalence of BLS at Luwero, which has a lower altitude and environmental conditions much more favorable to the causal pathogen, *Mycosphaerella fijiensis*.

Neither fusarium wilt nor BSV have been observed on any of the cultivars, and no plants have been damaged by banana weevils since planting in 2001.

- Farmers perceptions of cultivars

In April 2002 several meetings[16] were held with in Kisekka to, among other issues, review research progress, obtain feedback from farmers and demonstrate the uses of various products of local and exotic banana types. As farmers had previously requested that training sessions and meetings be held at parish or village level other than subcounty level, the meetings were held at the homes of volunteering farmers. One was held at the home of Habib, who was hosting a promotion trial. The plot is an exciting demonstration of the performance of exotic bananas in the subcounty and, at the time of the meeting, had huge bunches of Kabana 3 that could be viewed by the meeting participants. Habib reported having already given suckers of the exotic bananas to 33 other farmers. Most enthusiasm was expressed for Kabana 3 - according to one farmer in the group its suckers were selling like a 'hot cakes'. Other comments made by the group were that Kabana 3 and Kabana 5 produced bunches at an interval of approximately 12 months, with bunch weights of between 65 and 82 kg.

During the meeting a tasting session was held to enable farmers to assess, on the basis of taste, flavour, texture, and softness, steamed bananas (‘muwumbo', steamed fingers and mixed with groundnut sauce or beans (‘katogo') and porridge made from fruit of the cultivars.

Generally the porridge and the taste of the cooked bananas impressed the farmers although the local types still had a superior taste as food. Further analysis will be done on scored attributes to give a detailed report on the farmers' perception on eating these exotic bananas.

The farmers also indicated that there is a need to distribute suckers to other farmers who are not hosting the trials, and that farmers need more training in, and demonstration of, the utilisation of products of the exotic bananas.

16 Kalyebara, R., Wori, M. P. & Namaganda, J. (2002) Proceedings of stakeholders' review and planning workshops of farmer participatory research at Kisekka benchmark site, Masaka (edited by C. Nankinga & W. Tushemereirwe). NARO.

5.1.1.3 Ntungamo and Mbarara sites

- **Trial 5. Evaluation of recently introduced cultivars selected for resistance to leaf spot diseases**

- Plant growth and yield

Despite vigorous growth of plants in all Cavendish trials, many had not reached a sufficient stage of maturity to allow data associated with harvest to be collected, analyzed and interpreted before project completion. The data presented here therefore represents only part of what will become available. Furthermore, considerable variation in the data available across cultivars and farms has had to be taken into consideration in the statistical analysis. Nevertheless, valid and clear findings are emerging as shown in Table 56.

Kabana 3 outperformed the three Cavendish banana types and Gros Michel in terms of bunch weight and number of clusters formed at harvest (difference significant at P=0.05). Williams and Grande Naine also produced good bunches (27 kg), but the yield for Chinese Cavendish was lower (22 kg) and similar to that for Gros Michel (18 kg) which, unlike the Cavendish types and Kabanan 3, is highly susceptible to Sigatoka leaf spots. The number of fruit clusters formed at harvest ranged from 12 in Kabana 3 down to eight in Gros Michel. Some difference was found between cultivars in the number of days from planting to harvest, but differences were not significant (P=0.05) with the average period being 635 days.

Mean bunch weight and number of clusters in Kabana 3 were very similar to those for the same cultivar grown under mulched conditions in promotion trial 1 at Luwero (33.5 kg and 11 clusters) and for bunch weight in the promotion trial at Kisekka (36.8 kg). The period from planting to harvest was very similar to that at Kisekka but about three months longer than that in the promotion trial at Luwero.

- Pests and diseases

At flowering more than twice as many leaves were present than at Luwero probably, as at Kisekka, due in part to the lower prevalence of BLS at Ntungamo and Mbarara. The number of leaves was similar to that at Kisekka (11 per plant) although there was some variation between cultivars, from Kabana 3 with 12 to Gros Michel with 10, possibly due to Sigatoka leaf spots. However, at harvest the number of leaves in all cultivars had fallen to 7 or 8 in all cultivars. This is an indication that by harvest all cultivars were damaged by leaf spot diseases to the same extent, and perhaps by yellow Sigatoka which is much more prevalent and destructive in these higher altitude areas than BLS. If due to Sigatoka, and this has not been confirmed, the results suggest Kabana 3 and the Cavendish types may be more resistant to the disease than is Gros Michel prior to flowering but succumb between flowering and harvest. Although leaf damage was similar at harvest, the loss of leaf photosynthetic area at a later stage of plant development, as in Kabana 3 and Cavendish, may not have as detrimental an effect on bunch development and may account, to some extent, for the higher yields shown.

- Farmers' opinions on the cultivars

When interviewed, farmers who had harvested and tasted the Cavendish cultivars as a dessert banana showed high preference for, and were excited by, these types (Plate 10). They confirmed that the cultivars were as good, if not better, than Gros Michel (Bogoya), currently one of the most popular dessert bananas grown in Uganda. They also expressed a desire and willingness to expand the area of production on their farms. This is very important in terms of income generation (perhaps even in terms of export by these farmers) and farmer livelihoods, as Gros Michel have been a major income earner in Ntungamo, Mbarara and Masaka districts when sold as a dessert banana. However, it is highly susceptible to leaf spots and fusarium wilt, both of which may cause major damage and have done so in many areas already.

5.1.1.4 Mbarara, Ntungamo and Bushenyi sites

- **Investigation of the etiology of, and effects of specific management practices on, a wilt-like disorder**

- Effects of composting household refuse prior to use as mulch and removal of symptomatic plant parts on expression of the disorder **(Trial 6)**.

Observations for the wilt disorder trials appear to show that incidence of wilt-affected plants and the severity of wilt symptoms have declined on plots of all farms where the recommended management practices (rouging affected stools and proper composting of household refuse) have been applied. Plants originally affected were showing signs of recovery in terms of wilt symptoms and general vigour and more flowered plants were observed. This trend was also commented on by farmers who felt that the disorder had decreased markedly and that composting and rouging should be continued (Plate 11). However, data acquired from the plots is insufficient for analysis at this stage and would not provide conclusive results. It was also noted that some farmers did not apply the recommended treatments and therefore no reduction in wilt decline was observed. Of 18 farmers originally selected only 10 have continued the treatment applications as expected.

- Isolation and identification of organisms in plant material

As found in previous, similar work, only the fungal organism *Fusarium pallidoroseum* (syn. *Fusarium semitectum*) was isolated from symptomatic corm and pseudostem tissues. *F. oxysporum*, the causal agent of fusarium wilt of banana, was not found nor were any bacterial organisms. This adds further support to the opinion that the disorder is not caused, at least wholly, by a pathogenic organism.

- Relationship between soil and plant nutrient composition, presence of organic household refuse and occurrence of the disorder determined

Preliminary analyses of pH, total nitrogen, potassium, calcium and magnesium in soil and banana corm, sucker and leaf samples suggested that some correlation did exist between the levels found in soil and occurrence of the disorder, particularly with respect to pH and levels of calcium and magnesium, where levels were higher in affected plants and surrounding soil (data not shown). In one case, a severely affected Gonja plant exhibiting accumulation of white exudate on the surface of developing suckers and necrosis of leaf margins (Plates 12-14), key symptoms of wilt disorder, levels of calcium and potassium showed a clear downward trend in tissue samples of a sucker removed from the plant and exhibiting heavy, moderate and no exudate respectively. No clear correlation was apparent with respect to leaf nutrient composition and expression of symptoms of the disorder in any of the samples obtained.

Analysis of nutrients in soil and plant (corm and sucker) samples collected systematically from four farms in November 2002 clearly revealed clear correlation with location on the farm and expression of wilt symptoms. Potassium, calcium and total nitrogen levels in corms and suckers were all significantly higher ($P<0.05$), on some farms considerably, in tissues of wilted as opposed to wilt-free plants (Table 59 and Figures 5, 6, 8, 9, 11, 12). Soil potassium (Tables 57, 58 and Figure 4) was also significantly higher ($P<0.001$) at locations with as opposed to without wilt. Soil pH, calcium and total nitrogen levels were slightly higher across the four farms in soils from wilt as opposed to wilt-free locations but not significantly ($P=0.05$) (Tables 57 and 58, Figures 3, 7, 10). Any correlation between magnesium levels in soil or plants and wilt was not apparent (Tables 57 and 59, Figures 13-15).

It is clearly feasible that the increased levels of potassium, calcium and nitrogen are responsible for the symptoms being expressed, perhaps due to a toxic effect or nutritional imbalance. It has been very difficult to find information on levels of these nutrients to be expected in corm and sucker tissues, nor on symptoms that may result from excesses or imbalances. However, levels of calcium above 4 g/100g (well above those found in the systematic samples) may cause leaf margin necrosis* very similar to that referred to above for the Gonja plant, in which calcium levels in the heavy exudate sucker tissues were 4.5 g/100g.

** Lahav, E. (1995) Banana nutrition. pp 258-316 in: Bananas and Plantains (Ed) S. Gowen. Chapman and Hall, London UK*

The next logical step in trying to determine the cause of this disorder would be to try to reproduce the symptoms observed in the field under controlled conditions in which these, and perhaps other, nutrients are applied. Analysis of nutrients in a more comprehensive range of samples (across more farms for example) and of any changes in soil and plant nutrient levels over time at farms where the effects of composting on wilt levels are being monitored would are advisable.

5.1.2 UK-based research

Study of root systems of triploid and tetraploid banana cultivars with different levels of susceptibility to migratory endoparasitic nematodes (University of Reading)

For a full report of the findings of this study, see Appendix 4

- *Are there differences in nematode susceptibility between the cultivars being promoted in Uganda?*

The studies confirmed that the triploid *Musa* AAA cultivar Yangambi km 5 was resistant (less susceptible) to nematodes, a fact established elsewhere. However in longer term study the cultivar Kabana had larger root systems and lower overall nematode burdens than other FHIA cultivars and Kabana 5. When a known susceptible cultivar, the Cavendish clone Williams, was included in the evaluations this cultivar was found to be the most susceptible.

- *Are there differences in root mass between cultivars?*

FHIA tetraploid cultivars had greater root fresh weights than did Williams and Yangambi km 5.
A positive linear correlation was observed between the root system mass and the nematodes. Kabana 4 and YgKm5 had the lowest number of nematodes per root system and the susceptible cultivar Williams the greatest. There was a tendency for cultivars with greater above ground weight to have greater root weight. The cultivars Kabana 3 and FHIA 25 had greater root and shoot weights compared to the other FHIA cultivars and YgKm5 and Williams.

Nematodes reduced the shoot fresh and dry weight. The nematodes' effect on above ground weight differed among cultivars. YgKm5 and Kabana 3 nematode-infected plants had similar shoot weight to control plants suggesting perhaps some level of tolerance.

- *Are there any differences in root morphology and anatomy between the different banana cultivars studied?*

All of the cultivars had similar structural morphology. The FHIA tetraploids and Kabana 4 have thicker primary roots than do the triploid cultivars. The matooke cultivar Kisansa had the thinnest roots of those studied. The cultivars resistant to *R. similis* differed from the tolerant and susceptible cultivars in the cell area and cell wall thickness. Kabana 3 had thinner walls than the tolerant/resistant Kabana 1 and YgKm5. The resistant cultivars had higher number of pre-formed phenolic cells than the susceptible cultivars. Furthermore this number increased after nematode infection.

Conclusions

This study has confirmed that the FHIA cultivars and the cultivar Yangambi km 5, which the UNBRP is promoting as substitutes for the disease susceptible East African highland cultivars have characteristics conferring tolerance and/or resistance to nematodes.

It would appear that there are several possible mechanisms operating which include biochemical factors in the cells (phenolics), cell wall thickness and overall root mass and plant vigour. No cultivar tested showed immunity to nematodes. This study involved only one population of *R. similis* and work elsewhere has shown that this nematode has populations with differing pathogenicity even within relatively confined geographical areas.

5.1.3 Farmer training

It was anticipated that evaluation of the cultivars and other management technologies would yield better results if farmers fully participated in the entire evaluation process and, as a consequence, would form a nucleus for further technology development and dissemination within the geographic areas of research. Given the nature of the aims of the project and the implications of its findings on future farming methods in Uganda, the project strived to maximise participation by farmers and to establish close working relationships and frequent interaction between farmers and scientists in particular. This involved, for example, farmers participating in the planning and implementation of field trials, including selection of precise technologies to be assessed. Farmers also received sustained sensitisation and training in general trial management, pest and disease recognition, technology application, collection of data and keeping records. A number of farmers were also trained as trainers and subsequently provided training, under the supervision of UNBRP staff, of fellow farmers.

5.1.3.1 Farmer training meetings at Luwero/Bamunanika Benchmark site 2001

Since December 2000 a series of farmer participatory training meetings, workshops and seminars have been held. The main objectives of these were to:

a) Impart knowledge and skills related to improved banana production technologies
b) Impart to farmers participating in the research appropriates skills in:
    - Supervision and management of on-farm trials
    - Basic farm record keeping
    - Developing an enterprise budget
c) Enable farmers to fully understand and appreciate the research objectives and various treatments being applied
d) Educate farmers about the objectives and benefits of group formation, including farmer to farmer training on improved banana production technologies and joint produce marketing ventures.

5.1.3.2 Training methods employed

A range of training methods was used. In each case a training method was chosen according to specific themes and/or topics concerned. The training methods used included workshops and/or meetings conducted at parish or subcounty levels in a participating manner. Train and visit method was used for topics of practical nature like manure application methods, banana mat management and farm record keeping. In many instances farmers received basic training which was then followed up by supplementary practical demonstration training activities. Practical training was implemented through farmer-researcher-extension interaction in a farmer's own field or with a group of farmers at their respective villages.

Four trainers were trained to handle some of the practical application aspects of new skills for farmers and these are from time to time being utilized by researchers or being called upon by farmer groups themselves. One strategy of training involves farmer to farmer communication and information flow. This impresses on every participating farmer, firstly, to train as many non-participating farmers as possible he can find and, secondly, to provide two free banana suckers for every sucker that was sold. This process has since been strengthened by the formation of village farmer groups (see below) that provide non-participating farmers a more organized forum for exchange of information and opportunities for training. A summary of major training meetings held in Bamunanika during 2001 is provided in Table 60.

5.1.3.3 Village farmer group formation

Twenty-four village farmer groups were formed in 2001. The goal and objectives of the majority of these are:

Goal: To have a united voice in addressing problems, hunger and poverty

Objectives:

- To mobilize resources and combine efforts for the promotion of improved technologies for the banana production
- To mobilize labour and capital resources for joint undertakings of difficult and/or high energy banana management activities
- To create a forum and possess greater bargaining power with respect to banana marketing opportunities

5.1.4 Other promotional activities

A number of other pathways were utilized to help to promote the new technologies to farmers and other stakeholder. These included competitions for participating farmers, exhibitions, shows and open days, visits for non-participating farmers to those hosting trials, newspaper features, radio and television broadcasts and preparation of video tapes.

5.1.4.1 Farmer competitions

Organizing and holding competitions for banana farmers in Bamunanika was a major activity in 2002. The objectives of these were to:

- Mobilize and motivate farmers to undertake and promote improved management practices for the production of bananas as a source of food and income
- Promote the formation of farmer groups, self help spirit and joint mobilization of materials and financial resources for sustainable banana production
- Promote farmer to farmer communication and dissemination of improved banana technologies

All farmers hosting banana on-farm trials (including that not involved in R7567) competed. Teams of judges visited individual farmers and farmer groups who were assessed on their ability to manage their trials appropriately against a list of criteria. The outcome of the competitions was good in that more than 60% of farmers assessed showed excellent performance, with 4 % of farmers from each trial group receiving prizes. In addition, 32 farmers were awarded prizes for showing a good understanding of the objectives of the trial research and maintaining a good 'control' plot. A list of prizewinners within the various categories assessed is provided in Appendix 5.

5.1.4.2 Exhibitions, shows and open days

- **Agricultural exhibitions**

To help promote and raise awareness of the improved technologies, farmers hosting on-farm trials in Kibanyi, Sekamuli, Kikabya, Kiteme, Kyampisi and Mpologoma parishes attended two national agricultural exhibitions and four district exhibitions at Masaka, Mukono, Lubiri/Mengo and Luwero (Wobulenzi). These exhibitions highlighted the qualities and multipurpose potential of the exotic cultivars, particularly Kabana 3 and Kabana 4. An account of the farmers' activities at the one day agricultural exhibition held at Wobulenzi, at which farmers displayed and demonstrated the new production skills that they had acquired, is provided in Appendix 6.

- **Bamunanika farmers' open day (27 Sept. 2002)**

An open day was held at Bamunanika in September 2002 (Appendix 7). The purpose of the open day was to promote banana production, utilization and commercialization in Luwero and neighboring districts. The open day brought together all farmers participating in all banana trials as well as non-participating farmers, civic and political leaders, traders and processors amongst others. More than 2000 visitors attended the event, at which the Minister of Agriculture Animal Industry and Fisheries was guest of honor, accompanied by the minister of agriculture for Buganda Kingdom. Activities included a field tour to trial sites around the subcounty, live demonstrations of the improved banana technologies a display of plants bearing large bunches (80 and 45 kg for Kabana 3 and Mpologomo respectively) and banana products (beer, juice, ripe bananas and flour products such as pancakes, banana meal, porridge, bread and crisps) and posters relating to Kabana 1, 3, 4 and 5, PITA 14, 17 and the indigenous cutlivars.

- **Bamunanika farmers' open day (Dec. 2002) - promoting communication to non-participating farmers**.

A second open day was held in Bamunanika to promote and demonstrate communication tools being used by farmers to disseminate banana production technologies from farmer to farmer/contact farmers and to adopters. It was organized along four major communication themes, one at each of four centers. A range of communication tools was demonstrated in relation to the following:

- well managed banana production plots
- evidence for, and exhibits of, the effects of improved banana production technologies demonstration on how to produce a number of banana products
- methods of farmer to farmer training and achievements and evidence of farmer to farmer training

Channels of developmental communication included posters, drama and songs.

- **Feedback from farming communities in Luwero district with respect to exhibitions, shows and open days**

The demonstrations and information made available at the agricultural exhibitions, shows and open days has made many farming communities in sub-counties neighboring Bamunanika aware that farmers living under similar environmental, agroecological and socioeconomic conditions have been able to greatly increase the level of banana productivity on their farms, as could be seen by the size of the bunches alone, and have become greatly motivated by the knowledge. As a result, farmers from sub-counties such as Katikamu, Zirobwe and Kalagala have visited banana farmers in Bamunanika and been impressed by the good performance of bananas planted on trial plots. This has led to heavy demand for suckers as planting materials, especially of Kabana 3 and Mpologoma.

As a result of the excellent presentations made by Bamunanika banana farmers at the Agricultural Exhibition, political, civic and religious leaders (e.g. Luwero district local government leaders) have commended that the banana on-farm research programme being undertaken carried out in Bamunanika and have appealed for, and encouraged, non-participating farmers to use the improved production technologies to ensure food security and improve their household incomes.

- **Farmers' views on participation in on-farm trials and related activities**

Farmers who participated in the promotional activities at the Bamunanika farmers' open day in September 2002 summarized their views of the event (see Appendix 8) in a very positive manner. Among other points or suggestions made, they felt that they benefited greatly through general interaction, by being able to teach other farmers recommended agronomic practices, learning much themselves and having a market for their bunches and suckers (Kabana 3, 5 and FHIA 25 being the most admired). They reported that the market price of bananas and suckers increased after the open day. They felt that they gained popularity and were re-energized with respect to management of their own banana plots. They suggested that open days be held annually and at villages where farmers.

Throughout the project farmer groups have provided reports (see Appendices 9-11) on how they view their involvement in field trials and related promotional activities. They highlighted three 'lessons' that have been learnt through their participation as follows:

- It has been realized that the perceptions and management of the trials by participating farmers are greatly enhanced when those farmers are challenged to explain their trial outputs to large, non-participating, farming communities.
- Exposing farmers participating in on-farm research to a large mixed audience has acted as an incentive in internalizing the various options of mat management and alternative uses of exotic banana cultivars.
- It has been shown that promotion and dissemination of banana production technologies not only depends on the excellent performance technologies under evaluation in trials and interaction between researchers/extension workers and participating farmers, but also on publicizing findings of the work and interacting closely with people from other walks of life (e.g. local government leaders, business communities, schools and the general public).

5.1.4.3 Promotion through mass media exposure

To date promotion of the new technologies, particularly the improved cultivars, by mass media coverage has included 17 feature articles in local and national newspapers, six radio broadcasts, four television lectures, a television documentary and two video recordings. For full details refer to Appendices 12 – 15.

5.1.5 Dissemination outputs

Dissemination outputs from the project have been extensive. They include reports submitted to CPP/DFIA, minutes of meetings, overseas visit reports, factsheets, presentations at meetings and workshops, workshop proceedings, a radio broadcast, press release and Internet WebPages. Many of these are in addition to the promotional outputs highlighted under Section 4.3.5 above and have mostly been prepared and disseminated by both the UK and Uganda scientific teams. A full list of dissemination outputs, including those cited in this report, is shown in Appendix 16, may of which are held electronically. Where possible they will be provided upon request by the project leader or (depending on output) by members of the UK or Ugandan project teams either in electronic or hard format.

6. CONTRIBUTION OF OUTPUTS TO DEVELOPMENTAL IMPACT

The project has, through an on-farm participatory approach, helped the UNBRP and Ugandan banana farmers to evaluate and validate improved banana crop and resource management technologies applicable to a range of agroecological zones and farming systems in Uganda, and to promote and disseminate these, with the assistance of participating farmers, to a wide farming community. The outputs have provided comprehensive new information relating to the agronomic, biological and socioeconomic aspects of technology development, validation, promotion and dissemination. This will enable farmers and other stakeholders to make more informed decisions on the suitability of the new technologies and whether they are applicable to their individual needs. They have provided a much better understanding of the performance of local and exotic cultivars under both existing and improved farm management practices, particularly in relation to plant health and productivity. They have enabled farmers to experience and assess the attributes, including of post-harvest products, of the cultivars and management approaches at first hand and enable them to decide whether they would be appropriate and beneficial to their aspirations. They have facilitated the dissemination of extensive planting material to a broad range of beneficiary farmers who will continue the validation, promotion and, hopefully, onward dissemination process, many of whom will be monitored over coming years. Indications from the research are that at least some of the technologies have received strong approval, have been taken up and may be adopted over the long-term as a basis for improved and sustainable future banana production and livelihoods in Uganda. This is particularly true in Luwero, where the recent decline in banana production has been dramatic but where this project and other initiatives are helping to reverse the downward trend and revitalize production. Across the geographic areas of research, farmers are actively and independently forming groups or clubs to provide a forum for discussion, facilitate internal decision-making and influence policy-makers to ensure that the technologies are applied and promoted effectively. Reports received during field visits (and highlighted in this and accompanying documentation) of farmers being able to buy clothes for their family, pay school fees, improve on and build new homes and subsequently extend their areas of banana production as a result of the extra income already generated through use of the new technologies are testimony to this.

TABLES (R7567)

Note: in tables where formal statistical analyses are presented, SE (standard error) and/or CV (coefficient of variation) values have been calculated but, for table simplicity, are not presented.

Table 1 Summary of field trials undertaken as part of project R7567 'Integrated management of banana diseases in Uganda'

Site	Trial no.	Objective of trial	Planting date	No. cultivars assessed and type	No. farms
Luwero	1	Cultivar validation, promotion, dissemination	October 2000	5 (FHIA types, KM5)	29
	2	Cultivar evaluation	April/May 2001	5 (FHIA 25, SABA, PITA 14, PITA 17, Kisansa)	10
	3	Enhanced plant nutrition	October 2000	5 (AAA-EA types)	20
Masaka	4	Cultivar validation, promotion, dissemination	October 2000	3 (FHIA types, KM5)	37
Ntungamo & Mbarara	5	Cultivar evaluation	April 2001	5 (Cavendish, FHIA 17, Gros Michel)	18
Mbarara, Bushenyi & Ntungamo	6	Investigation of wilt-like disorder	May 2001	Not applicable	10
Total					**124**

Table 2 Farmers participating in the validation, promotion and dissemination trial, Luwero BS

Farm no. and farmer name	Parish	Village	Planting date
1. Abdul Kasozi	Mpologoma	Kangulumira	11/10/2000
2. Joseph Katende	Mpologoma	Mpologoma	11/10/2000
3. Joyce Nagita	Mpologoma	Mpologoma	10/10/2000
4. Godfrey Lubega	Mpologoma	Kangulumira	11/10/2000
5. Semakula Moses	Mpologoma	Mityebiri	6/10/2000
6. Efrance Naluyima	Mpologoma	Mityebiri	6/10/2000
7. Yusuf Kasirye	Kibanyi	Kibanyi	10/10/2000
8. Hussein Matovu	Kibanyi	Kalwe	24/10/2000
9. Ndikora Stanslus	Kibanyi	Kawuke	24/10/2000
10. R. Nguyeneza	Kiteme	Kiteme	16/10/2000
11. B. Sebandeke	Kiteme	Kasolo	19/10/2000
12. Katende	Sekamuli	Kakola	20/10/2000
13. Raphael Mwanje	Sekamuli	Kito	19/10/2000
14. Kakoza Deo (dropped?)	Sekamuli	Kito	19/10/2000
15. Nakitende Florence (dropped?)	Sekamuli	Kito	19/10/2000
16. Elias Sentamu	Sekamuli	Nakulabye	16/10/2000
17. Milly Nabalinde	Kibirizi	Kibirizi	23/10/2000
18. Justin Mulwana	Kibirizi	Kibirizi	23/10/2000
19. Moses Kasozi	Kibirizi	Nkuruze	23/10/2000
20. Mugambi Kalazi	Kibirizi	Nkuruze	23/10/2000
21. L. Tomusange	Kibirizi	Kisanga	25/10/2000
22. Sowedi Kijambu	Kibirizi	Kisanga	25/10/2000
23. Kavuma Sekanyolya	Kibirizi	Kisanga	26/10/2000
24. Robert Semakula	Kyampisi	Kakira	5/10/2000
25. Fred Gongebwa	Kyampisi	Magogo	24/10/2000
26. Mulyazawo	Kyampisi	Magogo	24/10/2000
27. Jamil Kigongo	Kyampisi	Buto	26/10/2000
28. Kasim Sekweyama	Kyampisi	Lutete	26/10/2000
29. Kaqqwa Emmanuel	Mpologoma	Kiyunga	
30. Kizito Mulengera	Kyampisi	Kakira	27/10/2000

Table 3 Farmers participating in the evaluation trial, Luwero BS

Farm no. and farmer name	Parish	Village	Planting date
104. Kabunga Viola	Kyampisi	Ndalimu	26/04/2001
105. Mubiru Joseph	Kyampisi	Kikabya	26/04/2001
106. Kisawuzi	Sekamuli	Wabuyinja	25/04/2001
107. Kiwagu J.	Sekamuli	Kasiribiti	25/04/2001
108. Semiryango Damiano	Kibanyi	Kidolindo	28/04/2001
109. Serwada Denis	Kibanyi	Kanjuki	30/04/2001
110. Sendaula Kassim	Kibanyi	Kyanika	28/04/2001
111. Ssetimba Vicent	Kiteme	Butalyamisa	04/05/2001
112. Muwonge Matiya	Kiteme	Malungu	04/05/2001
113. Musasizi	Kiteme	Buwanuka	30/04/2001
114. John Kigozi	Mpologoma	Mpungu	30/04/2001
115. Nakamya	Kibirizi	Ggavu	23/05/2001
116. Gladys Nakito	Kibirizi	Busamba	30/04/2001

Table 4 Farmers participating in the enhanced plant nutrition trial, Luwero BS

Farm no. and farmer name	Parish	Village	Planting date
31. Mr. Pascal Mpoza	Kyampisi	Luteete	10/10/2000
32. Mr. Haluna Yiga	Kibanyi	Kalwe	11/10/2000
33. Mr Umaro Lubega	Kibanyi	Kibanyi	11/10/2000
34. Mr. Derrick Lukwago	Kibanyi	Kibanyi	11/10/2000
35. Ms. Anne Nakiwala	Kiteme	Kiteme	12/10/2000
36. Mr. Kikonyogo Salonga	Kyampisi	Magogo	13/10/2000
37. Mr. Joseph Kaggwa	Mpologoma	Kakira	13/10/2000
38. Mr. Edward Wamala	Mpologoma	Kangulumira	13/10/2000
39. Mr. James Serubiri	Mpologoma	Mityebiri	14/10/2000
40. Mr. Yusuf Mukasa	Mpologoma	Buto	14/10/2000
41. Mr. Senabulya	Mpologoma	Mityebiri	14/10/2000
42. Mr. Alosius Mugenzi	Kibanyi	Bugabo	16/10/2000
43. Mr. Kakooza	Sekamuli	Kito	16/10/2000
44. Mr. Mukumbya	Kyampisi	Buto	16/10/2000
45. Mr. Kato Moses	Sekamuli	Kito	17/10/2000
46. Mr. Waswa Sewagudde	Kibirizi	Kibibi Kisogozi	20/10/2000
47. Mr. A. Kibuye	Kibirizi	Nkuruze	20/10/2000
48. Mr. Ssali Moses	Kiteme	Kikonda	21/10/2000
49. Mr. Kanyike E	Kiteme	Kasolo	21/10/2000
50. Mr. Kyobe	Kiteme	Kyotamugavvu	21/10/2000

Table 5 Farmers participating in the promotion trial, Kisekka, Masaka

Farm no. and farmer name	Parish	Village	Planting date
1. Munaugunda	Kiwangala	Kiwangala	October 2000
2. Kayinga Francis	Kiwangala	Kyanukuzi	October 2000
3. Bakabulindi Hasain	Kiwangala	Migongo	October 2000
4. Kayira Augustin	Kiwangala	Kavule	October 2000
5. Luswata Joseph	Kiwangala	Kanku	October 2000
6. Kabagamba Lei	Kiwangala	Lukindo	October 2000
7. Mawegye Abdu	Kiwangala	Lukindo	October 2000
8. Kisauzi Habibu	Ngereko	Kibumbi	October 2000
9. Bukenya Evalisto Salongo LC1	Ngereko	Ngereko	October 2000
10. Mrs. Bizimungu	Ngereko	Ngereko LC1	October 2000
11. Jane Musazi	Ngereko	Ngereko	October 2000
12. Naluga Milly	Ngereko	Manja B	October 2000
13. Kayondo Godfrey	Ngereko	Buyoga	October 2000
14. Ssempala Willy	Ngereko	Buyoga	October 2000
15. Wasswa Milton	Ngereko	Buyoga	October 2000
16. Ssetuba S	Busubi	Kalagala	October 2000
17. Mary Itiman	Busubi	Kalagala	October 2000
18. Silvia Kalanzi	Busubi	Kalagala	October 2000
19. Sebowa Joseph	Kankamba	Kankamba	October 2000
20. Ssemanda Daneil	Kankamba	Kiseka	October 2000
21. Ssula Paul	Kankamba	Kiseka	October 2000
22. Sulait Ddungu	Kankamba	Bukumbura	October 2000
23. Daudi Kavuma	Kankamba	Bukumbura	October 2000
24. Siraji Zziwa	Kikenene	Buyiki	October 2000
25. Siza Kimbugwe	Kikenene	Kikenene	October 2000
26. Kasamba J.W.	Kikenene	Nakawanga	October 2000
27. Sseremba M	Kikenene	Lubanda	October 2000
28. Namatovu Gerad	Kikenene	Lubanda	October 2000
29. Lubambula	Kikenene	Nakawanga	October 2000
30. Resty Bukenya	Nakalembe	Nakalembe	October 2000
31. Swaifu Sebanakita	Nakalembe	Nakalembe	October 2000
32. Posiano Lubega	Nakalembe	Nakalembe	October 2000
33. Ndagire	Nakalembe	Nakalembe	October 2000
34. Namwandu Katende	Nakatete	Ddongwa	October 2000
35. Kalule Fugensio	Nakatete	Ddongwa	October 2000
36. Namuyimba Edward	Nakatete	Bunyere	October 2000
37. Kaluna Matovu	Nakatete	Ddegeya	October 2000

Table 6 Farmers participating in the Cavendish evaluation trial, Ntungamo and Mbarara

	Farm no. and farmer name	District	Planting date
1.	Asimwe Ssezi	Ntungamo	12-Apr-01
2.	Bettie Mucunguzi	Ntungamo	11-Apr-01
3.	Bintabara Fred	Ntungamo	12-Apr-01
4.	Caleb Turyahikayo	Ntungamo	12-Apr-01
5.	E Baribuganda	Ntungamo	14-Apr-01
6.	Eriya Karanzi	Ntungamo	12-Apr-01
7.	Fred Bitaba	Ntungamo	12-Apr-01
8.	George Buriima	Ntungamo	12-Apr-01
9.	Jackson Beinomwe	Ntungamo	12-Apr-01
10.	John Magambo	Ntungamo	12-Apr-01
11.	Magret Bweeme	Ntungamo	11-Apr-02
12.	Perezi Katumba	Ntungamo	11-Apr-01
13.	Robina Bankinika	Ntungamo	12-Apr-01
14.	Semei Turyaija	Ntungamo	14-Apr-01
15.	Tumwine Kamugarwize	Ntungamo	12-Apr-01
16.	Yorukamu Bankuratire	Ntungamo	26-Apr-01
17.	UNBRP stock farm	Mbarara	1-Apr-01

Table 7 Farmers hosting trials on wilt-like disorder of bananas at Mbarara, Ntungamo and Bushenyi.

Farmer	District	Subcounty	Parish	Village
A.Bariyo	Bushenyi	Bitereko	Busheregenyi	Kyantonde
E.Mbeine	Bushenyi	Mitooma	Ijumo	Kirambi
Beshobeho	Mbarara	Birere	Namuyanja	Namuyanja
Rutobera	Mbarara	Birere	Namuyanja	Rwempazi
J.Bagwa	Bushenyi	Mitooma	Rukararwe	Kamukaruka
S.Bahindi	Bushenyi	Ruhiinda	Rushoroza	Mitooma
Rutembeya	Bushenyi	Ruhiinda	Rushoroza	Nyakahandagazi

Table 8 Grades applied for assessment of severity of wilt-like disorder

Grade	Wilt symptoms observable
0	Plant appears healthy and may have a healthy, normally developing bunch
1	Some reduction in overall plant vigour apparent, bunch reduced in size
2	Obvious reduction in pseudostem girth, bunch size and fullness of fingers, plant stunted. Some vascular discoloration within pseudostem sheaths, outer leaf sheaths drying.
3	Plant stunted, pseudostem thin, leaf sheaths dry, leaves distorted. Size of bunch and finger fullness greatly reduced. Fingers unpalatable. Extensive vascular discoloration within pseudostem sheaths. Plant possibly toppling.

Table 9 Weight (kg) of bunches produced by banana cultivars with and without mulch application in promotion trial at Luwero

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	17.5	21.2	13.7	9.1	11.2	4.5	12.9
Mulch	26.2	33.5	33.3	13.6	18.7	16.4	23.6
Difference	**8.6*******	**12.1*******	**19.6*******	**4.5 ns**	**7.5******	**11.8******	
% (increase)	50	58	143	49	67	264	83
Mean	21.9	27.2	23.5	11.3	15.0	10.5	18.2
Sig. diff. between means: Treat. x cv. = ns, Treat. = ***, cv = ***							
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively							

Table 10 Number of fruit clusters per bunch produced by banana cultivars with and without mulch application in promotion trial at Luwero

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	7.8	11.1	8.7	7.1	6.0	5.8	7.8
Mulch	8.7	11.2	13.1	7.7	7.2	5.2	8.9
Difference	**0.9 ns**	**0.1 ns**	**4.4 ns**	**0.6 ns**	**1.3 ns**	**- 0.6 ns**	
Mean	8.3	11.1	10.9	7.4	6.6	5.5	8.3
Sig. diff. between means: Treat. x cv. = ns, Treat. = *, cv = ***							
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively							

Table 11 Time taken (number of days from planting) for banana cultivars to reach harvest (first crop) with and without mulch application in promotion trial at Luwero

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	497	533	594	487	600	545	543
Mulch	511	526	567	520	544	475	524
Difference	**+14 ns**	**-7 ns**	**-27 ns**	**+33 ns**	**-56 ns**	**-70 ns**	
Mean	504	530	580	504	572	510	533
Sig. diff. between means: Treat. x cv. = ns, Treat. = ns, cv = ns							
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively							

Table 12 Number of leaves remaining at harvest (first crop) with and without mulch application in promotion trial at Luwero

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	6.0	5.5	3.7	6.4	3.5	0.5	4.3
Mulch	6.8	5.9	5.1	7.0	3.2	2.0	5.0
Difference	**0.78 ns**	**0.35 ns**	**1.38 ns**	**0.57 ns**	**- 0.25 ns**	**1.50 ns**	
Mean	6.4	5.7	4.4	6.7	3.4	1.3	4.6
Sig. diff. between means: Treat. x cv. = ns, Treat. = ns, cv = ***							
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively							

Table 13 Weevil damage (as % surface area, XT) in corms of harvested plants with and without mulch application in promotion trial at Luwero (March 2002)

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	0.72	1.44	No data available	0	0	0.33	0.68
Mulch	0.53	0.44	No data available	0.05	0.90	1.39	0.50
Mean	0.60	0.84	No data available	0.04	0.64	0.97	0.56

Table 14 Weevil damage (as % surface area, XT) in corms of harvested plants with and without mulch application in promotion trial at Luwero (March-May 2003)

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	1.15	1.25	0.71	0.04	0.85	3.17	0.95
Mulch	1.01	1.48	1.93	0.22	2.60	0.85	1.27
Mean	1.08	1.37	1.36	0.14	2.02	1.85	1.13

Table 15 Nematode damage (no. dead roots as % of total roots) in harvested plants with and without mulch application in promotion trial at Luwero (March 2002)

Treatment	**Cultivar**						**Mean**
	Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	11.84	8.96	9.64	10.08	13.51	12.01	10.69
Mulch	3.89	8.27	3.21	4.03	16.08	5.28	6.33
Mean	6.43	8.49	5.27	5.96	15.28	7.52	7.73

Table 16 Number of *Radopholus similis* nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2002)

Treatment		**Cultivar**						**Total**
		Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	No. observations (farms)	8	8	8	8	5	3	40
	No. farms with nematodes	1	3	1	2	1	1	9
Mulch	No. observations (farms)	17	17	17	17	11	6	85
	No. farms with nematodes	2	3	2	1	2	1	11

Treatment	**Nematode count per 100g roots (for farms with nematodes present only)**						**Mean**
	Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	2500	306	500	375	500	7500	1407
Mulch	1042	1972	1958	250	4417	14500	3227

Table 17 Number of *Helicotylenchus multicinctus* nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2002)

Treatment		**Cultivar**						**Total**
		Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	No. observations (farms)	8	8	8	8	5	3	40
	No. farms with nematodes	6	5	5	5	3	2	26
Mulch	No. observations (farms)	17	17	17	17	11	6	85
	No. farms with nematodes	10	10	10	8	7	4	49

Treatment	**Nematode count per 100g roots (for farms with nematodes present only)**						**Mean**
	Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	3736	3483	3167	3433	5778	8375	4112
Mulch	4525	9942	1942	10208	4298	3250	5895

Table 18 Number of *Meloidogyne* spp. nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2002)

Treatment		Cultivar						Total
		Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	No. observations (farms)	8	8	8	8	5	3	40
	No. farms with nematodes	1	0	4	2	0	0	7
Mulch	No. observations (farms)	17	17	17	17	11	6	85
	No. farms with nematodes	5	5	8	9	3	1	31

Treatment	Nematode count per 100g roots (for farms with nematodes present only)						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	250	None present	875	250	None present	None present	2275
Mulch	883	433	2823	1000	1250	333	1367

Table 19 Nematode damage (no. dead roots as % of total roots) in harvested plants with and without mulch application in promotion trial at Luwero (March 2003)

Treatment	Cultivar						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	7.95	10.32	9.20	7.26	15.27	17.16	10.10
Mulch	8.71	5.97	9.44	7.53	11.48	16.59	8.96
Mean	8.34	7.87	9.34	7.40	13.09	16.88	9.49

Table 20 Number of *Radopholus similis* nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2003)

Treatment		Cultivar						Total
		Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	No. observations (farms)	23	21	21	23	14	8	110
	No. farms with nematodes	3	1	3	0	3	2	12
Mulch	No. observations (farms)	24	27	26	24	19	8	128
	No. farms with nematodes	4	1	5	3	2	2	17

Treatment	Nematode count per 100g roots (for farms with nematodes present only)						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	833	333	1250	None present	1778	583	1090
Mulch	1188	667	2433	1333	2333	917	1652

Table 21 Number of *Helicotylenchus multicinctus* nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2003)

Treatment		Cultivar						Total
		Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	No. observations (farms)	23	21	21	23	14	8	110
	No. farms with nematodes	14	10	11	10	9	5	59
Mulch	No. observations (farms)	24	27	26	24	19	8	128
	No. farms with nematodes	14	18	19	13	14	5	83

Treatment	Nematode count per 100g roots (for farms with nematodes present only)						Mean
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
No mulch	1810	1992	1553	2358	2713	4783	2275
Mulch	3039	2831	3765	1994	3780	5867	3292

Table 22 Number of *Meloidogyne* spp. nematodes found in roots of plants with and without mulch application in promotion trial at Luwero (March 2003)

Treatment		**Cultivar**						**Mean**
		Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	No. observations (farms)	23	21	21	23	14	8	110
	No. farms with nematodes	5	4	4	5	5	2	25
Mulch	No. observations (farms)	24	27	26	24	19	8	128
	No. farms with nematodes	8	7	8	8	3	2	36

Treatment	**Nematode count per 100g roots (for farms with nematodes present only)**						**Mean**
	Kabana 1	**Kabana 3**	**Kabana 4**	**Kabana 5**	**Kisansa**	**Mbwazirume**	
No mulch	267	563	229	567	617	208	433
Mulch	583	405	526	531	4806	563	875

Table 23 Dissemination, by cultivar, of banana suckers to beneficiaries during 2001 and 2002 (to 30 May) by farmers hosting promotion trial, Luwero BS

Cultivar	**No. suckers**			**No. beneficiaries**		
	2001	**2002**	**Total**	**2001**	**2002**	**Total**
Kabana 1	742	203	945	60	13	73
Kabana 3	1543	900	2443	67	13	80
Kabana 4	702	542	1244	39	7	46
Kabana 5	1429	951	2380	67	11	78
Total exotic cvs	***4416***	***2596***	***7012***	***233***	***44***	***277***
Kisansa	75	70	145	16	6	22
Mbwazirume	239	0	239	16	0	16
Total local cvs	***314***	***70***	***384***	***32***	***6***	***38***
Total	**4730**	**2666**	**7396**	**265**	**50**	**315**

Table 24 Number of banana suckers disseminated to different parishes during 2001 and 2002 (to 30 May) by farmers hosting promotion trial, Luwero BS

Parish	Cultivar						Total
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
Bukima	14	0	0	0	0	0	14
Bulanzi	5	5	0	0	0	0	10
Bwaziba	3	3	0	0	4	0	10
Bwazibu	11	8	0	0	4	0	23
Kalagala	4	0	4	5	0	0	13
Katikamu	0	0	0	30	0	15	45
Kibanyi	21	0	0	6	0	0	27
Kibirizi	143	158	98	235	3	45	682
Kiteme	0	20	0	90	0	0	110
Kyampisi	314	336	250	357	54	35	1346
Lunyolya	3	9	0	3	0	0	15
Mpologoma	61	276	206	228	60	0	831
Nambi	20	23	8	20	4	0	75
Nazigo	10	10	0	10	0	0	30
Nsotoka	8	10	0	0	0	0	18
Ntenjeru	7	10	7	10	6	0	40
Ntunda	16	16	0	0	0	0	32
Research sites	128	1175	494	941	0	0	2742
Ssekamuli	80	72	30	140	0	144	466
Zirobwe	27	3	0	3	5	0	38
Kayindu	0	18	0	0	0	0	18
Kawanda	55	188	24	302	0	0	569
Nnambi	15		0	0	5	0	20
Unknown	0	103	123	0	0	0	226
Total	**945**	**2443**	**1244**	**2380**	**145**	**239**	**7396**

Table 25 Number of banana suckers, by cultivar, disseminated during 2001 and 2002 (to 30 May) by farmers hosting promotion trial, Luwero BS

Farmer	2001							2002						Total
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwaz-irume	2001 total	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	2002 total	
Abdul Kasozi	53	148	90	84	13	0	388	30	162	134	190	10	526	914
Gonjebwa Fred	68	78	18	48	15	18	245	0	0	0	0	0	0	245
Karanzi Mugambi	17	19	4	23	0	0	63	0	0	0	0	0	0	63
Kasirye Yusuf	0	127	10	50	0	0	187	0	80	80	0	0	160	347
Katende Frank	16	31	20	52	0	0	119	0	0	0	0	0	0	119
Katende Joseph	0	50	0	0	0	0	50	0	50	50	92	0	192	242
Kavuma Sekanolya	2	23	17	0	0	0	42	0	0	0	0	0	0	42
Kigongo Jamil	36	37	46	89	0	0	208	0	0	0	0	0	0	208
Kijambo Sowedi	52	52	17	89	8	0	218	0	20	20	40	0	80	298
Matovu Hussein	42	52	0	90	0	0	184	0	0	0	0	0	0	184
Moses Kasozi	3	2	0	0	3	0	8	0	72	48	88	0	208	216
Mulengera Kizito	0	0	0	0	0	0	0	0	10	0	0	0	10	10
Mulwana Justin	70	105	49	55	0	45	324	0	0	0	0	0	0	324
Mulyazawo	137	186	108	163	32	17	643	52	0	0	0	10	62	705
Mwanje Raphael	130	124	122	144	0	129	649	0	26	46	0	0	72	721
Nabalinde Milly	9	3	3	13	0	0	28	0	100	120	0	0	220	248
Nagita Joyce	0	0	0	50	0	0	50	0	0	0	42	0	42	92
Naluyima Efrance	0	127	25	34	0	0	186	55	0	0	215	0	270	456
Ndikora Stanslus	21	98	0	148	0	0	267	0	0	0	0	0	0	267
Nguyeneza R	0	5	0	0	0	0	5	0	0	0	0	0	0	5
Sebandeke B	0	24	0	140	0	0	164	0	0	0	0	0	0	164
Sekweya Kasim	45	31	9	35	2	0	122	46	92	40	2	0	180	302
Semakula Moses	10	39	61	0	0	0	110	10	90	4	282	44	430	540
Semakula Robert	25	51	55	69	2	0	202	10	198	0	0	6	214	416
Sentamu Elias	0	106	42	50	0	30	228	0	0	0	0	0	0	228
Tomusange L	6	25	6	3	0	0	40	0	0	0	0	0	0	40
Total	**742**	**1543**	**702**	**1429**	**75**	**239**	**4730**	**203**	**900**	**542**	**951**	**70**	**2666**	**7396**

Table 26 Number of occasions, by cultivar, on which beneficiaries received banana suckers during 2001 and 2002 (to 30 May) from farmers hosting promotion trial, Luwero BS

Farmer	Cultivar						Total
	Kabana 1	Kabana 3	Kabana 4	Kabana 5	Kisansa	Mbwazirume	
Abdul Kasozi	12	19	15	16	6	0	68
Gonjebwa Fred	10	10	3	6	3	3	35
Karanzi Mugambi	5	4	1	5	0	0	15
Kasirye Yusuf	0	5	3	2	0	0	10
Katende Frank	2	2	1	3	0	0	8
Katende Joseph	0	3	2	3	0	0	8
Kavuma Sekanolya	1	2	2	0	0	0	5
Kigongo Jamil	8	7	6	10	0	0	31
Kijambo Sowedi	14	16	9	13	2	0	54
Matovu Hussein	2	2	0	2	0	0	8
Moses Kasozi	1	4	2	2	1	0	10
Mulengera Kizito	0	2	0	0	0	0	2
Mulwana Justin	7	9	5	6	0	5	32
Mulyazawo	22	25	16	20	7	3	93
Mwanje Raphael	7	10	8	11	0	13	49
Nabalinde Milly	2	3	3	3	0	0	11
Nagita Joyce	0	0	0	2	0	0	2
Naluyima Efrance	1	4	2	5	0	0	12
Ndikora Stanslus	2	2	0	3	0	0	7
Nguyeneza R	0	1	0	0	0	0	1
Sebandeke B	0	3	0	8	0	0	11
Sekweya Kasim	15	15	5	7	1	0	43
Semakula Moses	3	8	5	4	4	0	24
Semakula Robert	4	10	2	2	3	0	21
Sentamu Elias	1	4	2	2	0	2	11
Tomusange L	1	2	1	1	0	0	5
Total	**120**	**172**	**93**	**136**	**27**	**26**	**574**

Table 27 Partial budget analysis for plant crop of trial 1, promotion of exotic bananas in promotion trial at Luwero, using partial budget analysis (NB. Income from sales of suckers and wine not included)

Item	Treatment		
	No mulch	**Mulch**	**Increase due to improved Technology**
A: Benefits			
Average bunch weight of exotic bananas (kg/plant/year)	15.38	26.65	11.27 (+73%)
Banana production (kg/acre/year) **(B)**	6,150	10,660	4,510
Farm gate price exotic banana cultivars (ush/kg) **(C)**	62	62	-
Gross value of exotic bananas (ush/acre/year) **(= B x C)**	382,069	662,253	**280,184**
B: Variable costs			
Family labour man-hours per treatment per year	75.6	140.63	65.03
Cost of family labour ush/treatment/year (200 ush/hr)	15,120	28,126	13,006
Hired labour man- hours/treatment/year	16.95	20.31	3.36
Cost of hired labour ush/treatment/year	12,928.95	14,865.16	1,936.21
C: organic materials – inputs			
Cow dung kg/treatment/year	-	900	900
Cost of cow dung ush/treatment /year	-	40,000	40,000
Grass, mulch bundles per treatment per year	-	59	59
Cost of grass mulch ush/treatment /year	-	5,000	5,000
D: total variable cost /treatment /year	28,048.9	87,991	59,942
Total variable cost/acre/year	196,343	615,938	**419,595**
Margin rate of return of investments on exotic bananas and improved mulch % per treatment per year (= marginal benefit divided by marginal cost)			66.8%
MMR per acre per year			**66.8%**

Table 28 Weight of fruit bunches produced by banana cultivars (first crop) with and without mulch application in evaluation trial at Luwero

Treatment	**Cultivar**					**Mean**
	FHIA 25	**Kisansa**	**PITA 14**	**PITA 17**	**SABA**	
No mulch	38	9	9	8	13	15
Mulch	40	14	11	11	14	20
Difference	**2**	**5**	**2**	**3**	**1**	**18**
Mean	39	12	10	10	13	

Table 29 Number of fruit clusters per bunch produced by banana cultivars (first crop) with and without mulch application in evaluation trial at Luwero

Treatment	**Cultivar**					**Mean**
	FHIA 25	**Kisansa**	**PITA 14**	**PITA 17**	**SABA**	
No mulch	11.9	5.8	5.7	4.8	4.9	6.6
Mulch	11.0	5.9	5.8	4.8	5.0	6.5
Difference	**- 0.9 ***	**0.1 ns**	**0.1 ns**	**0.0 ns**	**0.1 ns**	**- 0.1**
Mean	11.5	5.9	5.7	4.8	4.9	6.5
Sig. diff. between means: Treat. x cv. = ns, Treat = ns, cv = *** Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively						

Table 30 Time taken (as number of days from planting) for banana cultivars to reach to flowering with and without mulch application in evaluation trial at Luwero

Treatment	**Cultivar**					**Mean**
	FHIA 25	**Kisansa**	**PITA 14**	**PITA 17**	**SABA**	
No mulch	453	469	462	427	437	450
Mulch	481	471	457	409	436	451
Difference	**27.6 ns**	**2.3 ns**	**-5.3 ns**	**-18.2 ns**	**-1.3 ns**	**1.0**
Mean	467	470	460	418	437	451

Sig. diff. between means: Treat. x cv. = ns, Treat = ns, cv = *

Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 31 Number of leaves at flowering (first crop) with and without mulch application in evaluation trial at Luwero

Treatment	**Cultivar**					**Mean**
	FHIA 25	**Kisansa**	**PITA 14**	**PITA 17**	**SABA**	
No mulch	9.0	4.4	7.5	5.6	5.8	6.5
Mulch	11.1	5.0	6.0	5.3	6.1	6.7
Difference	**2.1 ***	**0.6 ns**	**- 1.5 ns**	**- 0.3 ns**	**0.4 ns**	**0.3**
Mean	10.1	4.7	6.8	5.5	5.9	6.8

Sig. diff. between means: Treat. x cv. = ns, Treat = ns, cv = ***

Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 32 Yield, expressed as bunch weight, of EA-AAA banana cultivars with and without enhanced nutrition (mulch and manure addition) and fungicide application (for leaf spot control) at Luwero BS

Cultivar		Planted crop			First ratoon		
		No Fungicide	Fungicide	**Difference**	No Fungicide	Fungicide	**Difference**
Atwalira	No Nutrition	10.4	13.2	2.7***	11.0	13.5	2.5*
	Nutrition	14.1	16.2	2.1*	16.3	20.9	4.6**
	Difference	3.7***	3.1***	0.6ns	5.3**	7.4***	- 2.1ns
Mbwazirume	No Nutrition	9.3	12.8	3.5***	9.6	11.8	2.2ns
	Nutrition	13.5	16.4	2.9**	14.7	19.5	4.7*
	Difference	4.2***	3.6***	0.6ns	5.2**	7.6***	- 2.48ns
Mpologoma	No Nutrition	16.0	18.6	2.6*	10.9	13.6	2.7ns
	Nutrition	20.9	24.7	3.8**	18.4	25.8	7.4*
	Difference	4.9***	6.0***	- 1.2ns	7.6*	12.3**	- 4.7ns
Nakitembe	No Nutrition	9.9	13.4	3.5***	9.8	13.7	3.9*
	Nutrition	14.6	17.6	3.0**	17.4	18.3	0.9ns
	Difference	4.7***	4.2***	0.5ns	7.6**	4.7*	3.0ns
Nfuuka	No Nutrition	11.0	13.4	2.4*	9.0	15.0	6.0*
	Nutrition	14.9	18.0	3.1**	16.2	20.0	3.8*
	Difference	3.9***	4.6***	- 0.67ns	7.1**	5.0*	2.2ns

Differences were calculated as ‘with’ (fungicide or nutrition) minus ‘without’ (fungicide or nutrition).
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 33 Leaf spot damage, expressed as number of leaves remaining at harvest, in EA-AAA banana cultivars with and without enhanced nutrition (mulch and manure addition) and fungicide application (for leaf spot control) at Luwero BS

Cultivar		Planted crop			First ratoon		
		No Fungicide	Fungicide	**Difference**	No Fungicide	Fungicide	**Differenc e**
Atwalira	No Nutrition	2.3	2.7	0.4ns	2.1	3.7	1.6ns
	Nutrition	2.3	3.1	0.8*	2.3	3.2	0.9ns
	Difference	0	0.4ns	- 0.4ns	0.1ns	- 0.5ns	0.7ns
Mbwazirume	No Nutrition	2.1	3.6	1.5**	2.4	2.9	0.5ns
	Nutrition	2.7	3.4	0.7ns	2.2	3.5	1.3ns
	Difference	0.6ns	- 0.2ns	0.8ns	- 0.1ns	0.6ns	- 0.7ns
Mpologoma	No Nutrition	3.2	3.5	0.3ns	2.7	3.6	0.8ns
	Nutrition	3.6	3.9	0.4ns	3.6	4.5	0.9ns
	Difference	0.4ns	0.4ns	0	0.9ns	0.9ns	0
Nakitembe	No Nutrition	2.0	3.4	1.4*	2.5	3.1	0.7ns
	Nutrition	2.1	3.3	1.2*	3.5	3.6	0.1ns
	Difference	0.1ns	- 0.1ns	0.2ns	1.0*	0.5ns	0.5ns
Nfuuka	No Nutrition	3.0	2.6	- 0.4ns	2.8	2.1	- 0.8ns
	Nutrition	3.4	4.1	0.6ns	3.2	3.4	0.2ns
	Difference	0.4ns	1.4*	- 1.0ns	0.4ns	1.3ns	- 0.9ns

Differences were calculated as ‘with’ (fungicide or nutrition) minus ‘without’ (fungicide or nutrition).
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 34 Dissemination, by cultivar, of banana suckers to beneficiaries during 2001 and 2002 (to 30 May) by farmers hosting enhanced plant nutrition trial, Luwero BS

Cultivar	No. suckers			No. beneficiaries		
	2001	**2002**	**Total**	**2001**	**2002**	**Total**
Atwalira	570	53	623	53	3	56
Mbwazirume	602	25	627	52	2	54
Mpologoma	345	19	364	39	2	41
Nakitembe	625	25	650	48	2	50
Nfuuka	676	50	726	57	2	59
Total	**2818**	**172**	**2990**	**253**	**11**	**264**

Table 35 Number of banana suckers distributed to different parishes during 2001 and 2002 (to 13 March) by farmers hosting enhanced plant nutrition trial at Luwero BS

Parish	Cultivar					Total
	Atwalira	**Mbwazirume**	**Mpologoma**	**Nakitembe**	**Nfuuka**	
Kibanyi	190	198	96	197	242	923
Kibirizi	47	30	50	54	40	221
Kiteme	99	101	95	82	101	478
Kyampisi	117	103	69	141	119	549
Mpologoma	150	172	15	148	217	702
Sekamuli	20	23	39	28	7	117
Total	**623**	**627**	**364**	**650**	**726**	**2990**

Table 36 Number of banana suckers, by cultivar, disseminated during 2001 and 2002 (to 13 March) by farmers hosting enhanced plant nutrition trial, Luwero BS

Farmer	2001						2002						Total
	Atwalira	**Mbwazirume**	**Mpologoma**	**Nakitembe**	**Nfuuka**	**2001 total**	**Atwalira**	**Mbwazirume**	**Mpologoma**	**Nakitembe**	**Nfuuka**	**2002 total**	
Kaggwa Joseph	67	61	8	68	73	277	0	0	0	0	0	0	277
Kanyike E	7	10	7	7	4	35	0	0	0	0	0	0	35
Kato Moses	20	23	39	28	7	117	0	0	0	0	0	0	117
Kibuye A	37	20	46	42	28	173	0	0	0	0	0	0	173
Lubega Umaro	85	80	30	100	90	385	40	25	10	25	50	150	535
Mugenzi Alosious	32	54	29	32	60	207	0	0	0	0	0	0	207
Mukasa Yusuf	0	0	0	0	0	0	0	0	0	0	0	0	0
Ssali Moses	11	35	58	15	37	156	13	0	9	0	0	22	178
Wamala Edward	0	0	0	0	0	0	0	0	0	0	0	0	0
Yiga Haluna	0	0	0	0	0	0	0	0	0	0	0	0	0
Lukwago Derrick	33	39	27	40	42	181	0	0	0	0	0	0	181
Nakiwala Anne	68	56	21	60	60	265	0	0	0	0	0	0	265
Salongo Kikonyogo	66	66	46	56	75	309	0	0	0	0	0	0	309
Senabulya	68	87		60	128	343	0	0	0	0	0	0	343
Mukumbya	51	37	23	85	44	240	0	0	0	0	0	0	240
Waswa Sewagudde	10	10	4	12	12	48	0	0	0	0	0	0	48
Serubiri James	15	24	7	20	16	82	0	0	0	0	0	0	82
Total	**570**	**602**	**345**	**625**	**676**	**2818**	**53**	**25**	**19**	**25**	**50**	**172**	**2990**

Table 37 Number of occasions, by cultivar, on which beneficiaries received banana suckers during 2001 and 2002 (to 13 March) from farmers hosting enhanced plant nutrition trial, Luwero BS

Farmer	Cultivar					Total
	Atwalira	Mbwazirume	Mpologoma	Nakitembe	Nfuuka	
Kaggwa Joseph	14	12	3	14	15	58
Kanyike E	1	1	1	1	1	5
Kato Moses	5	5	5	3	1	19
Kibuye A	5	3	6	4	2	20
Lubega Umaro	7	7	3	7	7	31
Lukwago Derrick	7	6	6	7	8	34
Mugenzi Alosious	1	3	2	1	2	9
Mukasa Yusuf	0	0	0	0	0	0
Mukumbya	6	6	3	5	7	27
Nakiwala Anne	5	4	3	5	5	22
Salongo Kikonyogo	4	4	3	4	5	20
Senabulya	8	10	0	6	11	35
Serubiri James	2	3	3	3	2	13
Ssali Moses	4	3	6	2	6	21
Wamala Edward	0	0	0	0	0	0
Waswa Sewagudde	1	1	1	1	1	5
Yiga Haluna	0	0	0	0	0	0
Total	**70**	**68**	**45**	**63**	**73**	**319**

Table 38 Partial budget analysis for plant crop of trial 3, enhanced plant nutrition for EA-AAA bananas in on-farm trials at Luwero, using partial budget analysis (NB. Income from sale of suckers not included)

Item	Treatment		
	No nutrition	Nutrition	Increment due to nutrition
A. Benefits			
Average bunch weight (kg/plant/year)			
No fungicide	11.25	15.60	1.39 (+12%)
Fungicide	14.32	18.54	4.22 (+29%)
Banana production (kg/acre/year) **(B)**			
No fungicide	4500	6240	1740
Fungicide	5728	7416	1688
Farm gate price of highland bananas (ush/kg) **(C)**	87	87	-
Gross value of bananas (ush/acre/year) **(= B x C)**			
No fungicide	391,500	542,880	**151,380**
Fungicide	498,336	645,192	**146,856**
B. Variable costs			
Family labour man-hours per treatment per year	50.24	102.26	52.22
Cost of family labour ush 200per hour/ treatment per year	10,048	20,452	10,444
Hired labour man hours per treatment per year	12.4	19.8	7.4
Cost of hired labour ush per treatment per year.	9,920	15,840	5,920
C. Organic materials – inputs			
Cow dung kg per treatment/year	-	710	710
Cost of cow dung ush per treatment/year	-	20,000	20,000
Grass mulch bundles per treatment	-	87.5	87.5
Cost of grass mulch ush per treatment	-	15,000	15,000
Total variable costs ush per treatment per year	19,960	71,292	51,364
Total variable costs per acre per year	239,520	855,504	**615,984**
Net benefits per treatment per year	2753	-ve	
Marginal rate of return (MRR) of investment on nutrition in highland bananas per acre per year:			
No fungicide			**23.5%**
Fungicide			**22.8%**

N.B. apart from the interaction effect, the direct costs of fungicides have not been included in these calculations.

Table 39 Major uses (ranked 1-5, highest to lowest) of bananas as listed by farmers (a total of 182 farmers from six parishes participated of which 102 have trials)

Use	Rank
Cooking (steaming, boiling)	1
Juice/beer production	2
Desert (for eating when ripe)	3
Roasting	4
Crisp	5

Table 40 Attributes per use category as identified by farmers at Bamunanika, Luwero (a total of 182 farmers participated as above)

Use category	Important attributes
Cooking	Taste and flavour, texture, colour,
Juice/ beer production	Taste and flavour, sliminess/mouth feel, yield, colour
Dessert (for eating when ripe)	Taste and flavour, texture
Roasting (when semi-ripe)	Taste, texture
Crisp (deep frying in cooking oil when raw or semi-ripe	Taste, crispness (should become brittle when ready)

Table 41 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Mityebiri, Mpologoma parish, Bamunanika benchmark site, Luwero (43 farmers participated of which 31 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with groundnuts (katogo)	Roasted (semi-ripe)	Juice yield	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	1	2	2	2	2	3	2	3
Kabana 3	2	3	1	3	U	2	2	3
Kabana 4	2	3	1	3	U	3	2	3
Kabana5	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	NT	NT	NT	3	3	3	NT	NT

Table 42 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Kibirizi centre, Kibirizi parish, Bamunanika benchmark site, Luwero (37 farmers participated, 27 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice yield	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	1	2	2	2	2	2	2	3
Kabana 3	2	2	1	2	U	2	2	3
Kabana 4	2	3	1	U	U	3	2	3
Kabana 5	1	1	1	3	3	3	2	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	1	2
Kayinja	NT	NT	NT	2		3	NT	NT

Table 43 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Kibanyi centre, Kibanyi parish, Bamunanika benchmark site, Luwero (32 farmers participated, 21 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice yield	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	1	2	2	2	2	3	2	3
Kabana 3	2	3	1	U	U	2	2	3
Kabana 4	2	2	1	U	U	3	2	3
Kabana5	1	1	1	3	3	3	3	2
Gonja	1	1	3	NT	NT	NT	3	2
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	NT	NT	NT	2	3	3	NT	NT

Table 44 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Kiteme centre, Kiteme parish, Bamunanika benchmark site, Luwero (38 farmers participated, 25 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	1	2	2	2	2	3	2	2
Kabana 3	2	3	1	U	U	2	2	3
Kabana 4	2	3	1	U	U	3	2	3
Kabana5	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	NT	NT	NT	2	3	3	NT	NT

Table 45 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Sekamuli centre, Sekamuli parish, Bamunanika benchmark site, Luwero (49 farmers participated, 32 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	2	2	2	2	2	3	2	3
Kabana 3	2	3	1	U	U	2	2	3
Kabana 4	2	3	1	U	U	3	2	3
Kabana5	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	NT	NT	NT	1	3	3	NT	NT

Table 46 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Community centre, Kyampisi parish, Bamunanika benchmark site, Luwero (39 farmers participated, 19 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
Kabana 1	1	2	2	2	2	3	2	3
Kabana 3	2	3	1	U	U	2	2	3
Kabana 4	2	3	1	U	U	3	2	3
Kabana5	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	NT	NT	NT	2	3	3	NT	NT

Table 47 Farmers' scores for sensory attributes of steamed fruit of genotypes

Cultivar	Taste	Flavour	Texture	Colour	General acceptability
Kabana 1	4.1	4.0	2.2	3.0	4.0
Kabana 3	5.0	5.1	3.3	3.0	5.2
Kabana 4	4.9	5.0	3.3	3.1	5.1
Kabana5	2.3	3.5	2.0	2.5	3.0
Kisansa	6.0	6.0	5.9	6.0	6.0
CV(%)	14.04	15.7	17.6	12.9	15.9
LSD(0.05)	0.420	0.341	0.211	0.412	0.321

Table 48 Farmers' scores for sensory attributes of boiled fruit of banana genotypes

Cultivar	Taste	Flavour	Texture	Colour	General acceptability
Kabana 1	5.1	5.0	3.2	4.5	5.1
Kabana 3	5.5	5.2	5.3	5.0	5.5
Kabana 4	5.4	5.1	5.5	5.1	5.3
Kabana5	3.1	3.5	3.2	4.5	3.1
Kisansa	5.9	6.0	5.7	6.0	5.7
CV(%)	11.6	16.4	18.1	14.8	19.3
LSD(0.05)	0.200	0.204	0.411	0.326	0.342

Table 49 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Mityebiri, Mpologoma parish, Bamunanika benchmark site, Luwero (35 farmers participated, 11 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
PITA 14	1	2	2	2	2	3	2	3
PITA 17	1	1	2	1	1	2	2	3
SABA	1	1	1	3	3	3	2	3
FHIA25	1	2	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	U	U	1	2
Kayinja	1	1	NT	3	3	3	2	3

Table 50 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Community center, Kyampisi parish, Bamunanika benchmark site, Luwero (50 farmers participated, 22 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
PITA 14	1	1	2	2	2	3	2	3
PITA 17	2	1	2	1	1	2	2	3
SABA	1	1	1	3	3	3	2	3
FHIA25	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	U	U	1	1
Kayinja	1	1	NT	3	3	3	2	3

Table 51 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Kibanyi center, Kibanyi parish, Bamunanika benchmark site, Luwero (27 farmers participated, 18 have trials)

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
PITA 14	1	1	2	2	2	3	2	3
PITA 17	1	1	2	1	1	2	2	3
SABA	1	1	1	3	3	3	2	3
FHIA25	1	1	1	3	3	3	NT	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	NT	NT	2	2
Kayinja	1	1	NT	3	3	3	2	3

Table 52 Farmers' assessment of post-harvest utilization and acceptability of introduced and traditional cultivars at Kibirizi centre, Kibirizi parish, Bamunanika benchmark site, Luwero (31 farmers participated, 19 have trials).

Cultivar	Steamed (muwumbo)	Whole fingers mixed with G/nuts (katogo)	Roasted (semi-ripe)	Juice Yields	Alcohol		Crisps	
					Tonto	Waragi	Raw	Semi-ripe
PITA 14	1	2	2	2	2	3	2	3
PITA 17	1	1	2	1	1	2	2	3
SABA	1	1	1	3	3	3	2	3
FHIA25	1	2	1	3	3	3	2	NT
Gonja	1	1	3	U	NT	NT	3	3
Kisansa	3	3	1	U	U	NT	2	2
Kayinja	1	1	NT	3	3	3	2	3

Table 53 Farmers' scores for sensory attributes of steamed fruit of banana genotypes

Cultivar	Taste	Flavour	Texture	Colour	General acceptability
PITA 14	2.4	3.1	1.2	1.1	2.3
PITA 17	2.3	3.2	1.3	1.2	2.5
SABA	2.5	2.1	1.5	1.1	2.3
FHIA25	2.1	2.5	5.5	2.5	2.7
Kisansa	6.0	6.0	5.9	6.0	6.0
CV	15.7	17.2	14.9	16.2	17.8
LSD	0.500	0.304	0.401	0.360	0.420

Table 54 Farmers' scores for sensory attributes of boiled fruit of banana genotypes

Cultivar	Taste	Flavour	Texture	Colour	General acceptability
PITA 14	3.0	2.8	1.4	1.4	3.1
PITA 17	3.4	3.2	1.5	1.5	3.5
SABA	3.3	3.2	1.1	2.2	2.3
FHIA25	2.7	3.5	5.1	2.5	2.3
Kisansa	5.7	5.8	5.7	6.0	6.0
CV	15.7	17.0	16.1	12.7	18.1
LSD	0.502	0.405	0.500	0.520	0.422

Table 55 Growth (maturation period), yield (bunch weight) and number of leaves present at harvest in Kabana 3, Kabana 4 and Kabana 5 at Kisekka BS

Cultivar	Bunch weight (kg)	No. days from planting to plant harvest	No. leaves at harvest
Kabana 3	36.8	654	11.4
Kabana 4	45.1	664	11.2
Kabana 5	14.6	628	11.8
Level of sig. diff. between means in column	**	ns	ns
No. obs.	19	18	19

Bunch weights for Kabana 4 and 5 were sig. diff. at 1% (P = 0.002)
Bunch weights for Kabana 3 and 5 were sig. diff. at 5 % (P = 0.014)
No evidence of sig. diff. was found between Kabana 3 and 4
No sig. diff. in days to harvest or number of leaves
at harvest were found between the three cultivars.

Significance levels: symbols ns, *, ** and *** denote that differences between values in column are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 56 Growth and yield of Cavendish cultivars (Chinese Cavendish, Grande Naine and Williams), Kabana 3 and Gros Michel at Ntungamo and Mbarara

Cultivar	Bunch weight (kg)	No. of fruit clusters at harvest	No. days from planting to plant harvest	No. leaves at flowering	No. leaves at harvest
1. Kabana 3	32.2	11.67	625	11.87	7.87
2. Williams	27.2	9.51	643	10.38	7.75
3. Grande Naine	27.1	8.54	618	10.63	7.93
4. Chinese Cavendish	21.8	8.25	642	9.89	7.75
5. Gros Michel	18.4	8.41	644	9.58	7.54
Level of sig. diff. between means in column	***	***	ns	***	ns
	5 sig. lower than 1-3 (***) 4 sig. lower than 1-3 (*) 3 sig. lower than 1 (*) 2 sig. lower than 1 (*) 2 and 3 not sig. diff. 4 and 5 not sig. diff.	2-5 sig. lower than 1 (***) but not sig. diff. from eachother		5 sig. lower than 1-3 (*) 4 sig. lower than 1 and 3 (*) 3 sig. lower than 1 (***) 2 sig. lower than 1 (***)	
Significance levels: symbols ns, *, ** and *** denote that differences between values in column are non-significant or significant at 5, 1 and 0.1 % levels respectively					

Note: data obtained from the single stock farm trial at Mbarara and the 18 farm trials at Ntungamo, the former being more comprehensive, was initially analysed separately. However, as the trends shown were similar the combined data was analysed and the results are as shown above

Table 57 Table or means across four farms for soil pH and levels of potassium, calcium, magnesium and total nitrogen (g per 100g dry matter) in soils from wilt and wilt-free locations

Location	pH	Potassium	Calcium	Magnesium	Total nitrogen
Wilt	6.94	0.096	0.139	0.029	0.231
Wilt-free	6.68	0.037	0.137	0.031	0.214
Difference	0.26 ns	0.060 ***	0.002 ns	- 0.002 ns	0.017 ns
Significance level for farm x location interaction	ns	***	ns	ns	**

Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Table 58 Levels of potassium and total nitrogen (g per 100g dry matter) in soils obtained from wilt and wilt-free locations of four individual farms (where significant farm x location interaction was found)

Farm	Potassium			Total nitrogen		
	Location		Difference	Location		Difference
	Wilt	Wilt-free		Wilt	Wilt-free	
1	0.133	0.037	0.096 ***	0.365	0.250	0.115 ***
2	0.127	0.037	0.090 ***	0.247	0.280	- 0.033 ns
3	0.092	0.054	0.038 **	0.215	0.248	- 0.033 ns
4	0.033	0.019	0.015 ns	0.097	0.078	0.019 ns

Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively

Note: This table shows that the significant interaction is due to the location effect (difference) being much greater for farms 1 & 2 than farms 3 & 4.

Table 59 Table or means across four farms for levels of potassium, calcium, magnesium and total nitrogen (g per 100g) in banana sucker samples obtained from wilted plants (wilt location) and wilt-free plants (wilt location)

Suckers from	Potassium	Calcium	Magnesium	Total nitrogen
Wilted plant/wilt location	10.78	0.475	0.256	2.471
Wilt-free plant/location	8.99	0.379	0.260	1.675
Difference	1.79 *	0.096 *	- 0.004 ns	0.796 ***
Significance level for farm x location interaction	ns	ns	ns	ns
Significance levels: symbols ns, *, ** and *** denote that differences are non-significant or significant at 5, 1 and 0.1 % levels respectively				

Table 60 Major farmer training meetings held at Bamunanika, Luwero BS, during 2001

Activity	Topics/themes covered	Number of farmers trained	Trainers	Location	Time of training
1.Training of trainers	Plot management Farmer understanding of trial Soil fertility management Farm record keeping	6 trainees	2 researchers 6 trainers	Bamunanika community centre	Feb. 2001
2. Trainers teach farmers	Plot management Farmers understanding of trial Soil fertility management Farm record keeping	135 farmers hostingt 4 trials planted in Oct. 2000	6 trainers	24 separate village meetings	Feb./Mar. 2001
3. Preparation for planting new cultivars	Farmers sensitization and mobilizaton Participatory farmer selection meetings	200 farmers mobilised in 18 new villages Farmers at selection meetings	3 researchers 1 extension 4 researchers 2 NGOs	18 village meetings 4 parish meetings	March 2001 March 2001
4. Planting new trials	Training new farmers in plot establishment Planting new trials	48 soil management farmers 15 farmers (new exotic cultivars)	2 researchers 2 technicians	18 village meetings	April 2001
5. Promoting farmer group formation	Farmer mobilisation Training farmers in benefits, goals, rules and regulations of group formation Promotion of farmer to	135 farmers of all trials planted in 2000	2 researchers	24 separate village meetings	May 2001

	farmer interaction				
6. Promoting use of organic materials	Uses and benefits of organic and inorganic fertilisers Practical demonstrations of, and discussions on, methods for applying organic materials Promoting soil fertility & moisture management	135 farmers involved in all trials planted during 2000	2 researchers 4 trainers	24 separate village meetings 24 separate village meeting	June 2001 July 2001
7. Promotion of farmers training other non-participating farmers	Roles and responsibilities of trial participatory farmers to host communities Functions and responsibilities of banana farmers village groups for neighboring villages/parishes	135 farmers trained 24 banana farmers groups trained	1 researcher 4 trainers 1 researcher 4 trainers	24 villages 24 villages	August 2001 August 2001
8. Preparation of farmers' competitions in banana management	Motivating farmers to maintain high standards of plot management Motivating banana Farmers groups to train non-participating farmers Promotion or disseminating banana production technologies	135 farmers trained 24 banana farmer groups trained	1 researcher 2 technicians	24 villages	Sept. 2001
9. Discussing farmers	Reviewing areas of trial management	135 farmers trained	1 researcher	24 villages	Oct. 2001

competitions and schedules	Reviewing areas of competition Discussing competition guidelines	24 banana farmers groups trained	1 researcher		
10. Farmers own assessment of benefits	Keeping and using farm records as a business enterprise Farmers forum for banana marketing strategies	135 farmers	1 researcher	24 villages	Nov. 2001
11. Training new trial farmers	Plot management Farmers understanding of trials Farmer record keeping	53 new farmers whose trials planted April 2001	1 researcher 2 trainees	18 villages	Dec. 2001

FIGURES (R7567)

Figure 1 Layout for validation, promotion and dissemination trial at Luwero BS

FHIA 01	KM 5	Kisansa, Mbwazirume or Mpologoma	FHIA 23	FHIA 17
KM 5	FHIA 23	FHIA 17	FHIA 01	Kisansa, Mbwazirume or Mpologoma

Mulched and manured subplot (shaded)
Untreated subplot (unshaded)

Figure 2 Layout for enhanced plant nutrition trial at Luwero BS

No nutrition, no fungicide	Nutrition, fungicide
No nutrition, fungicide	Nutrition, no fungicide

Figures 3 - 15
pH of soils and potassium, calcium, nitrogen (total) and magnesium levels in soils, corm tissues and sucker tissues obtained from wilt/wilt-free locations and wilted/wilt-free banana plants respectively

Key to figuress:

F = farm number (1-4)
+ = location of farm where wilt is present (in case of soils) or plant samples were obtained from symptomatic banana plant (in case of corms and suckers)
- = location of farm where wilt is absent (in case of soils) or plant samples were obtained from wilt-free banana plant (in case of corms and suckers)

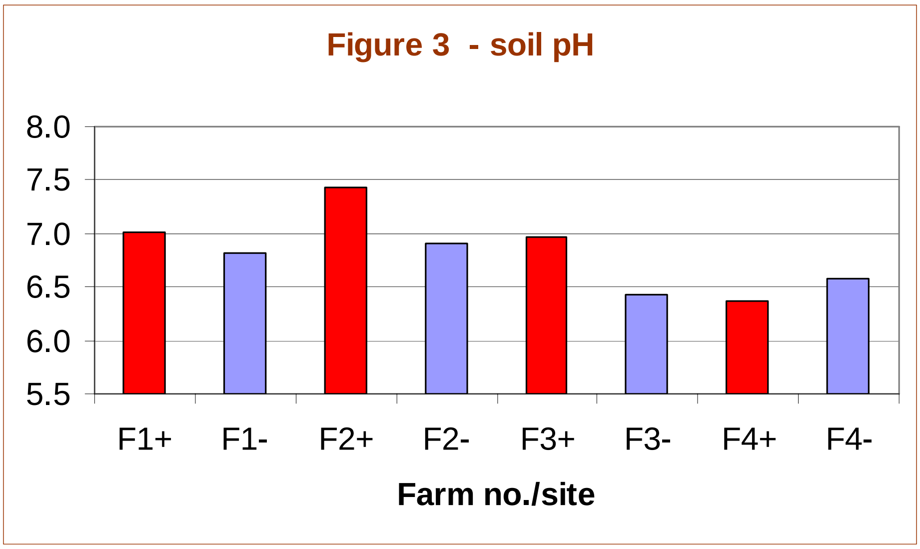


Figure 4 - soil potassium (g/100g)

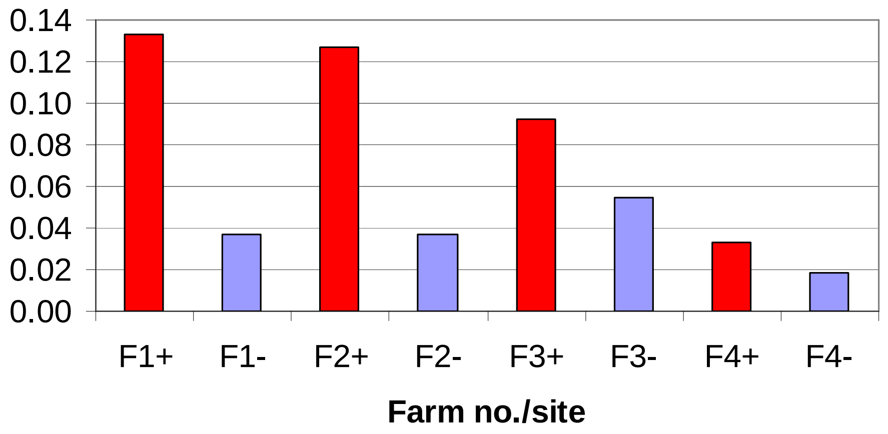


Figure 5 - corm potassium (g/100g dry matter)

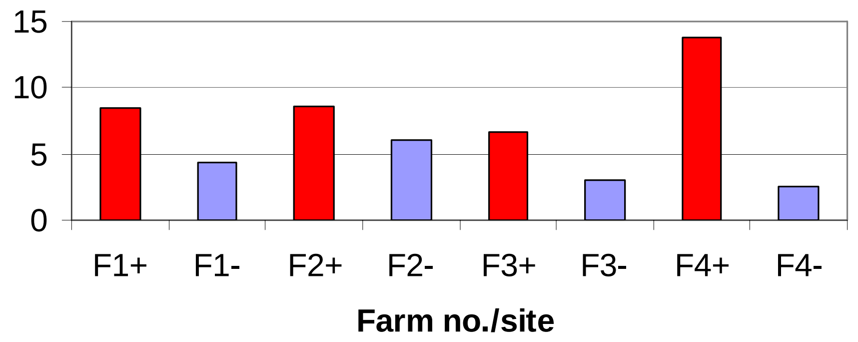
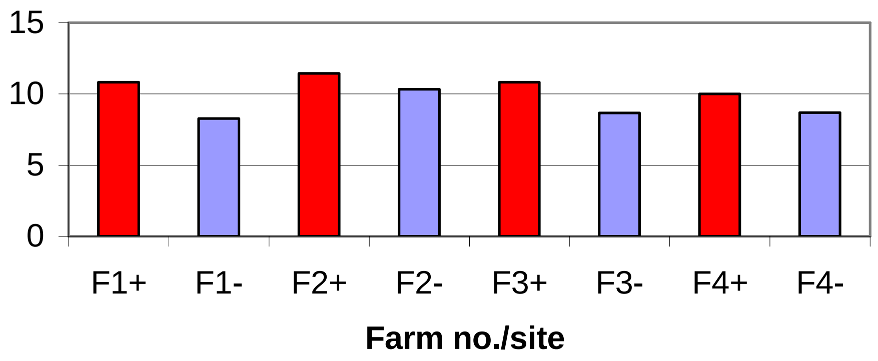


Figure 6 - sucker potassium (g/100g dry matter)



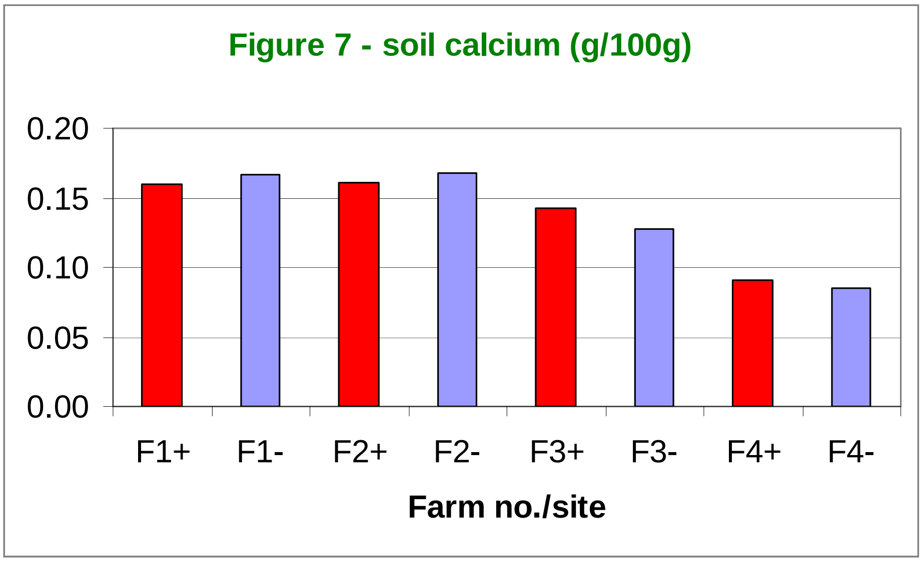


Figure 7 - soil calcium (g/100g)
0.20
0.15
0.10
0.05
0.00
F1+
F1-
F2+
F2-
F3+
F3-
F4+
F4-
Farm no./site

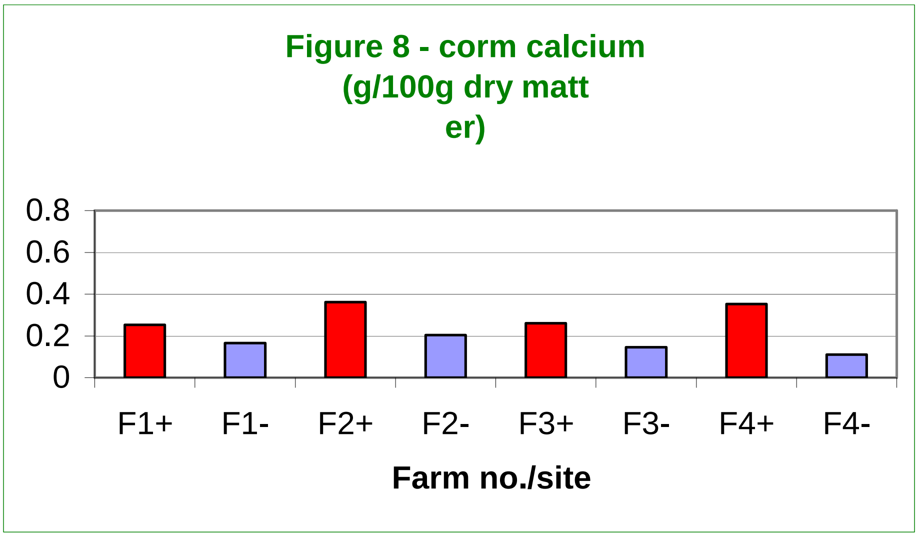


Figure 8 - corm calcium
(g/100g dry matt
er)
0.8
0.6
0.4
0.2
0
F1+
F1-
F2+
F2-
F3+
F3-
F4+
F4-
Farm no./site

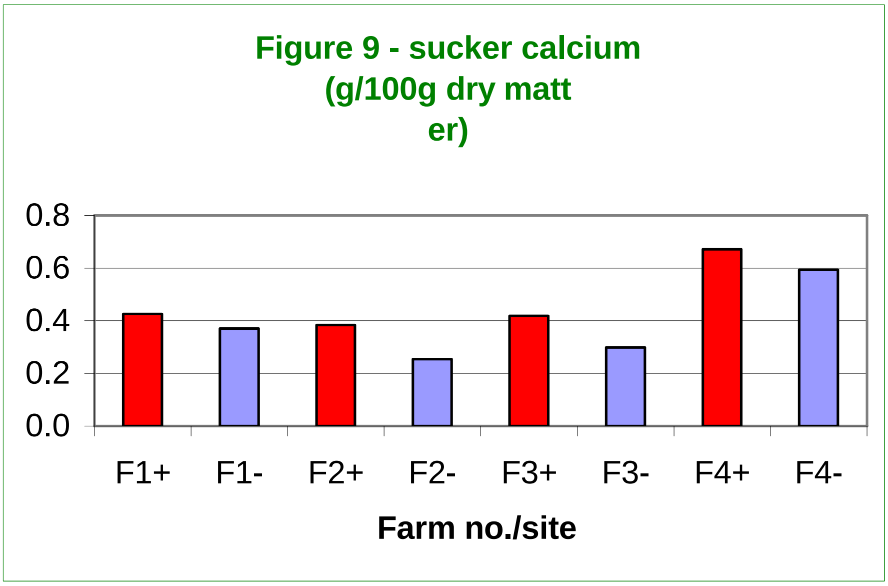


Figure 9 - sucker calcium
(g/100g dry matt
er)
0.8
0.6
0.4
0.2
0.0
F1+
F1-
F2+
F2-
F3+
F3-
F4+
F4-
Farm no./site

Figure 10 - total soil nitrogen (g/100g)

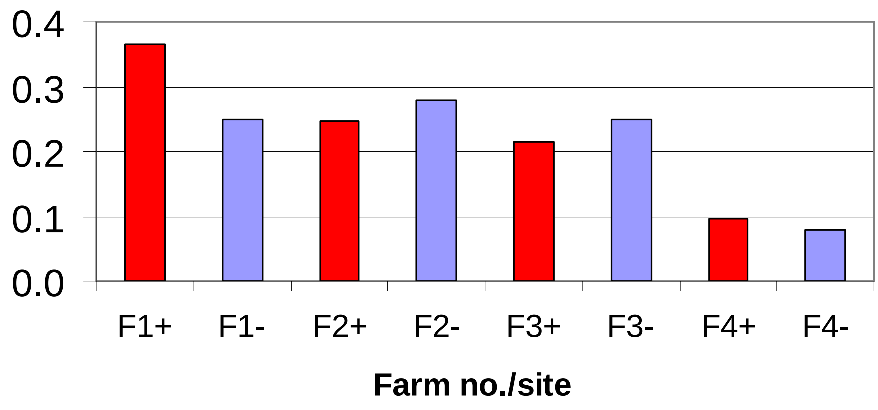


Figure 11 - corm nitrogen (g/100g dry matter)

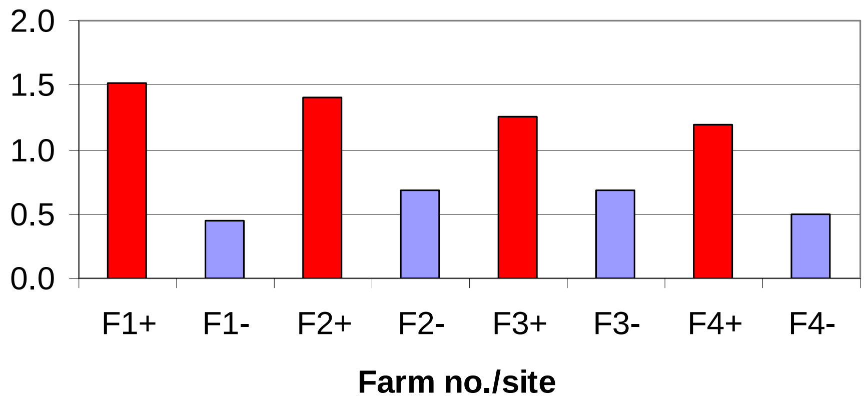


Figure 12 - sucker nitrogen (g/100g dry matter)

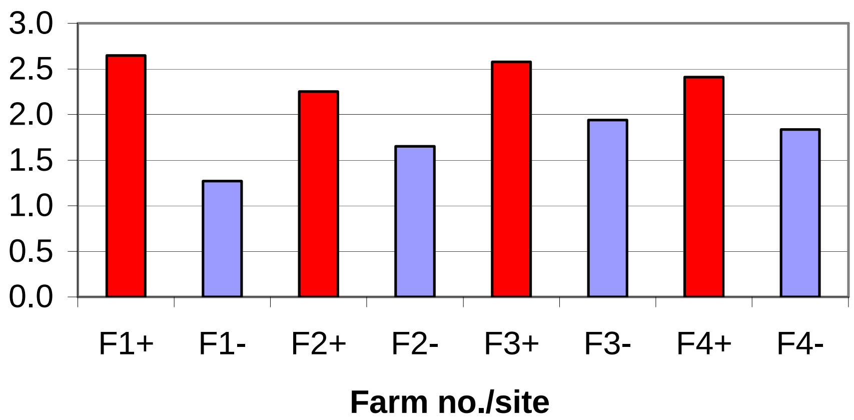


Figure 13 - soil magnesium (g/100g)

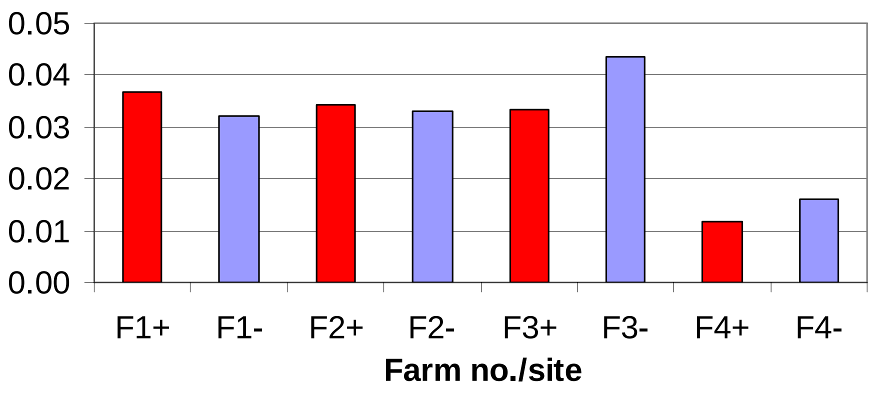


Figure 14 - corm magnesium (g/100g dry matter)

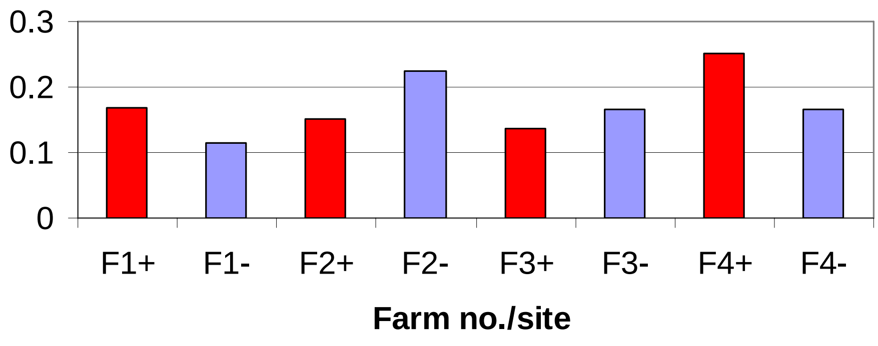


Figure 15 - sucker magnesium (g/100g dry matter)