Uganda Journal of Agricultural Sciences, 2001, 6: 27-36
Printed in Uganda

ISSN 1026-0919

A century of banana research and development in Uganda, 1898-1998

W. K. Tushemereirwe
Banana Programme, Kawanda Agricultural Research Institute,
P.O. Box 7065, Kampala, Uganda

Abstract

Uganda has a long tradition of cultivating the banana, an important food and cash crop in the country. The crop is believed to have to arrived in the Great Lakes Region around 500 AD but major expansion across Uganda occurred in the last 100 years. During this time, the major production constraints that emerged in other banana growing areas around the Globe finally found their way into Uganda in 1989 when the government of Uganda was overwhelmed by an outcry that the bananas were in great danger. This paper outlines efforts to address banana research programme. The paper highlights baseline banana production and utilization practices and notes soil fertility decline as the only major constraint by 1902. It also notes earliest records of the key pests and diseases of banana as; 1918 for the banana weevil, 1952 for Fusarium wilt, 1963 for *Radopholus Similis* (nematode), 1989 for black sigatoka and 1996 for banana streak virus. Arrival of weevil, fusarium wilt and *R. Simllis* has been attributed to importation of new germplasm into the country during the colonial administration. A strategy to address the constraints is described. This involves integrating technologies that prevent a build up of pests and prevent soil degradation in areas of western Uganda where black sigatoka is not a problem. In central Uganda where bananas have severely declined because of the pests and disease, the strategy provides for integration of host pant resistance with practices that improve soil fertility. On- going studies based on this strategy are highlighted.

Key words: Banana, production, research.

Background

The banana is one of Uganda's most import crops which until recently did not receive adequate research attention. Since its arrival in the country, the crop has increasingly gained importance as a staple food and source of income/ employment for millions of small holder farmers, despite the little research effort on it.

Banana may be scientifically described according to their genome groupings. They are categorised into genome groups on the basis of their ploidy levels and the genomes which they contain. Simmonds and Sherpherd (1955) suggested that edible bananas originated from two wild and seedy species, *Musa acuminata* Colla (2n=22) and *Musa balbisisana* Colla (2n=22) which are native to southeast Asia, resulting into a series of diploid, triploid and tetraploid. The resulting genome groups were classified as AA, AB, AAA, AAB, ABB, AABB, AAAB,, ABBB with the letters A and B representing the contributions of *M. acuminata* and *M. balbisisana* respectively.

The centre of origin of the banana is believed to be Indochina and South East Asia (Simmonds, 1962), the home of its wild progenitors. The earliest domestication is considered to have occurred in this region. Thereafter, the crop was introduced to the rest of the world where it gained more importance and popularity.

Simmonds (1962) described the genetic background to the development of the different types of bananas (as currently designated by genome groups). Hybridization between various sub-species of the polymorphic species *Musa acuminata* Colla led to a range of diploid, designated AA in the Simmonds classification scheme. The diploid gave rise to AAA by chromosome restitution, which occurs during meiosis. It is postulated that the domestication of a range of AAs and AAAs originally occurred in Malaysia, followed by their spread through South East Asia (Simmonds, 1962). Their spread to areas where *M. balbisiana* occurred (mainly Indian sub-continent and the Philippines) led to hybridization and appearance of the AAB, AB, and ABB types.

The speculated routes of bananas from their centre of origin to East Africa have recently been reviewed (Price, 1995; Karamura, 1998). The most widely accepted view attributes the introduction to the trade relations and contacts between Asians and East African Coastal people which dates back to 0-500 AD. These contacts produced a number of crop dispersals including bananas from Asia to Africa.

The other speculative routes suggest that the bananas could have reached East Africa via the west coast of Africa with Westward expansion of Bantu ethnic group (Mukasa, and Thomas 1970) or from North Africa through the Nile valley with the Southward expansion of Arab influence.

Whichever the route, it is believed that somatic mutations occurred in the original AAA parent plant and gave rise to the numerous East African Highland (shortened to 'Highland') cultivars. This made East Africa a centre of diversity (or secondary centre of origin) for Highland bananas (Simmonds, 1962; Price, 1995).

Legends in Uganda attribute introduction of banana to Uganda to Kintu, the tribal ancestor of Baganda (Haig, 1940; Karamura, 1988). It is believed that Kintu brought the banana from the mount Elgon vicinity (North East Uganda) in about 1000 AD and initially planted it in Busujju (Haig, 1940). The belief that bananas entered Uganda from the East is held by other Bantu tribes in Eastern and Western Uganda (Karamura 1998). Over time, the crop gained cultural importance as a food and beer crop.

Formal research efforts to investigate problems of the Highland bananas did not start until the colonial days when the first research station was established at Entebbe (Entebbe Botanical Gardens) in 1898. Since then, the institutional framework through which banana research was handled has undergone transformation to improve output delivery. Furthermore, research on bananas has moved its base with the research station as it shifted to new places due to pressure from urbanisation. From Entebbe, the station moved to Kampala (current Government chemist laboratories) from which it shifted in 1939 and got a new location at Kawanda (Tothill, 1940; Jameson, 1970).

Before 1988, when commodity research programmes were initiated as a basis for doing agricultural research in Uganda, the research was conducted on scientific disciplines based at the research stations and Makerere University. This arrangement appears to have exacerbated neglect of research on bananas. In the 1960's, individual scientists based at Makerere noticed the importance of carrying out investigations on problems of growing bananas. Using financial support from the Rockefeller Foundation, trials were initiated but were interrupted by the political upheavals of the 1970s before logical conclusions (Anonymous, 1970). All this time, government did not view research on the banana crop as one of the national priorities.

The policy of basing research on commodities yielded fast results. A banana research team drawn from Kawanda and Makerere University developed a research programme which got support from the Rockefeller Foundation, International Development Research Centre and Uganda Government. The team's first priority was to analyse prevailing banana production constraints which was done through surveys backed up by on-station constraint characterisation studies. Furthermore, a Uganda government review of priority research crops that resulted in ranking the banana crop as high, favoured working on the crop. This paper summarises the historical perspectives of banana production constraints in Uganda and the research efforts to solve the problems in the last 100 years. The paper is based on the following structure: baseline information by 1898; production constraints that time; constraints that emerged in subsequent years; the minimal attempts at controlling the constraints before formation of the National Banana Research Programme (NBRP) in 1988; the massive research effort by the NBRP; achievements over the century; and the way forward.

Baseline production/utilization practices and constraints by 1898.

Production/utilization practices.

The following practices described as customary in Buganda at the beginning of this century (Johnson, 1902) are considered the baseline practices when banana research in Uganda started: Planting mostly in lines or occasional irregular clumps; holes of 1 ft in diameter and 1-1.5 ft in depth; spacing of 8-15 ft (widest in fertile soils in contrast to the practice elsewhere); suckers with the girth of 18 inches selected for planting; trimmed suckers transferred to holes and trodden in to make the plants firm; mixture of cultivars planted. Planting to harvest time ranged from 10-18 months. Sucker succession controlled to 3-5 plants of different ages, giving 3-5 bunches/mat annually; Harvested stems cut at ground level and split into individual sheath for use as mulch; desheathing done in the rainy season. Harvesting matooke mostly done by women while Mbidde by men; additional mulch using all types of grass and household refuse/kraal manure occasionally applied (though not common); plantation progressively expanded towards virgin area. Plantations kept as described were considered well managed had, longevity of plantations estimated at over 30 years.

Intercrops such as vegetables, yams, pumpkins, mayuni, bark-cloth trees, etc were common; there were no important pests or diseases of Highland bananas; Exotic banana types were unknown; and bananas were for home consumption and would be eaten as steamed matooke or katogo (boiled with beans or greens); Mbidde prepared into dried chips (Mutere) which would be boiled with beans or pounded and reconstituted into a food called Kigomba.

Interestingly, most of the cultivation and utilization practices noted at the beginning of the century are in use today. However, some utilization technologies such Mutere and Kigomba have disappeared despite their potential in preserving Matooke for use in times or areas of food shortage. The two practices deserve revival and improvement.

Production and utilization constraints.

Soil fertility decline as evidenced by reduced yield and low genetic diversity of the germplasm (Johnson, 1902) appeared to be the only production and utilization constraints but none of the two was considered a serious problem. Soil fertility was just beginning to decline and farmers knew how to use organic material amendments. Furthermore they practised shifting cultivation by progressively expanding to virgin land as the oldest part of the plantation declined.

Similarly low genetic diversity was merely a constraint to diversifying to utilization methods unknown to the local population. Consequently, it was never considered a key constraint by the local community. It had little effect on production since there were no pests/diseases to worry about.

Arrival/recognition of major pests and diseases in Uganda

In the subsequent years, pests and diseases which were banana production constraints in other parts of the world started occurring in Uganda. Some, such as the banana weevil and *Fusarium* wilt were introduced in the efforts to diversify the germplasm through importation of unavailable types of bananas. They have since become serious problems of bananas in Uganda.

Banana weevil

The earliest record about the banana weevil (*Cosmopolites sordidus* Germ) dates as far back as 1918. It is believed the pest was imported with the bananas introduced to Entebbe Botanic Gardens in 1902-1908.

The first outbreak of the pest was reported in the area between Entebbe and Kampala. No detailed investigation was done in Uganda until in recent years but as early as 1926, there was sufficient information from other countries for a provisional control recommendation package to be put up (Haig, 1940). It included:

a) Field sanitation and mulching: Cutting harvested stems at ground level and splitting them for use as mulch; desheathing growing plants; and mulching with grass and crop residue. These practices would reduce the breeding sites of the weevil. The practices were already customary and were easy to adopt.
b) Maintaining a cover of compacted soil over the rhizome to reduce access to the weevil.
c) Detachment of infested corms from the mat and splitting them into small pieces to dry.
d) Planting clean suckers
e) Trapping the adult weevils using pseudostem pieces was suggested though its appropriateness to peasant farmers was questioned.
f) It was recommended that all the above measures be carried out uniformly over any given area to reduce migration and reinfestation.

A survey in 1957 showed that the weevil had spread to all banana growing areas in the country (Mukasa and Thomas, 1970). More serious efforts going beyond field sanitation were identified as urgent requirements.

Fusarium wilt

This disease, caused by *Fusarium oxysporum* Schlect. f.s. *cubense* (E.F. Smith) Snyd. and Hans (FOC) and also called Panama disease was first recorded in Panama (Brandes, 1919). It appears to have been introduced into Uganda on infected planting material and was first recorded in Buhweju county, Bushenyi district, in 1952 (Leaky, 1970). It attacked mainly exotic bananas such as Gros Michael (Bogoya) Kayinja and Sukali Ndizi. It has never been reported on Highland banana: Other resistant cultivars known then were Cavendish and Gonja.

Nematodes

The oldest record of banana nematodes in Uganda was in 1963 but they were not recognised as an important pest of bananas in Uganda until recently. *Radopholus similis*, a nematode species known to cause heavy damage, was first reported in Uganda in 1968 (Patel, 1968) but it is believed to have been around for a long time. A survey immediately carried out to establish the distribution of the nematodes in the country revealed they were present in all banana growing areas. Based on studies done in other countries, the following recommendations were suggested:

a) Chemical control using nematicides (though specific nematicides to use were not pointed out, Furadan was in use elsewhere).
b) Use of clean planting materials. It was suggested that clean suckers could be obtained through:
i) getting suckers from clean gardens
ii) Paring to remove infective tissue.
iii) Hot water treatment.

Efforts to disseminate these recommendations were minimal and as a result they were not widely adopted.

Black Sigatoka

The commonly observed leaf spot of bananas is caused by a mixture of air borne fungal diseases including black sigatoka (*Mycosphaerella fijensis* Morelet) which was first described in Fiji in the 1960s (Rhodes, 1964), yellow sigatoka (*M. musicola* Leach) which was first reported in Java in 1902 (Stover, 1962) and leaf speckle (*Periconiella sapientumicola* Siboe). Black and yellow sigatoka produce similar symptoms and are hard to distinguish in the field although they can be readily separated from leaf speckle.

Yellow sigatoka was the first leaf spot to be observed in Uganda around 1938 (Stover, 1962) together with leaf speckle but they were considered minor in importance (Leakey, 1970). It is now believed that the importance of leaf speckle on Highland cultivars may have been underestimated (Tushemereirwe, 1996).

Black sigatoka was first reported in Uganda in 1989 (Tushemereirwe and Waller, 1993), and is considered one of the key constraints to banana production in Uganda.

Arrival of the disease made the leaf spot complex economically important. The three diseases often occur on the same leaves (Tushemereirwe, 1996).

Matooke wilt

Highland bananas have been found to succumb to another wilt syndrome (matooke wilt) in Western Uganda highlands at altitudes above 1330 metres above sea level (m.a.s.l). This wilt was first reported in 1955 (Baldwin, unpublished) and has since been erroneously diagnosed as *Fusarium* wilt (Ploetz, *et al.*. 1995). The actual cause is yet to be established.

Banana streak virus disease (BSV)

While the other banana viral diseases are not important in Uganda, banana streak virus disease appears to be becoming a problem in Uganda (Tushemereirwe, *et al.*, 1996) The causal organism of banana streak disease, the banana streak virus was first isolated in 1986 (Lockhart, 1986). It was first recorded in Uganda in 1996 (Tushemereirwe *et al.*, 1996) in Rakai District, where farmers reported to have been seeing similar disease symptoms since 1970.

Efforts to address the constraints before 1988 (banana research programme birth year)

Germplasm diversification

Initially, priority was given to diversification of banana germplasm in the country. In 1902, Johnson reported presence of 32 cultivars of bananas in Uganda, the majority of which he described as belonging to one group, highland banana (Haig,1940). In most reports this group was erroneously called the plantains. According to Haig (1940) the forest and scientific department of the protectorate government introduced more than 12 new cultivars from several sources between 1902 and 1908 (red-fruited dessert banana = Red bogoya from west Indies in 1902; 10 dessert banana cultivars from Ceylon in 1903; a few more cultivars from India in 1907 and Dominica in 1908). These were planted at the Entebbe Botanical Garden from which some defused into the country side. It is believed the dessert and roasting bananas were imported around this time.

Records do not show more formal introductions by scientists between 1908 and 1990. However, there are reports that world war II veterans returning from military service in mid 1940s brought with them banana planting materials which included some new cultivars. It is believed that *Fusarium* wilt was introduced into Uganda through these planting materials (Stover, 1962).

A survey in the 1930's carried out in Buganda revealed that cooking bananas accounted for 61% of the cultivars grown; 31 beer (mbidde) types; 7% roasting (Gonja) types; and less than 0.5 dessert types (Haig 1940). Another Survey (Mukasa and Thomas, 1970) in Buganda carried out in 1944 gave more or less similar results(60% cooking, 30% beer, 10% roasting, less than 1% dessert).

Technology validation

Several technology validation have been attempted before research beame a priority. these include:

Pests

a) Biological control using beetles as natural enemies (1934-5):

a) Biological control of the banana weevil using the Hysteroid beetle *Plaesius javanus* was tried on one of the islands of lake victoria but the natural enemy failed to establish (Harris , 1947).

b) Chemical control (1950's): use of chemical control for the banana weevil was introduced to Uganda in the late 1950's (Whalley, 1957). The recommended pesticides then was dieldrin and DDT and they remained widely in use until the 1970 and 80's when they were dropped in favour of Furadan.

Crop and soil fertility management

a) Use of suckers with killed meristem (Jamaican system). This involved using full grown suckers cut back just above the corm to short pieces, pushing a stick in the growing point and covering them completely when planting (Haig, 1940). New plants are formed from the buds of the sucker. Results indicated that the plant crop from this planting system produced bigger bunches. This technology was successfully validated on-station (Bukalasa) but was never adopted by farmers.

b) Controlling the mat so that only one plant is in fruiting stage at any one time. This also gave bigger bunches and plants fruited earlier. This system proved un acceptable in Buganda where a large number of bunches, even though small was preferred (Haig, 1940).

c) Validating use of inorganic fertilizers to ammend soil fertility was initiated by the Faculty of Agriculture, Makerere University, with assistance from the Rockefeller Foundation in the late 1960s. However, the political upheavals of the 1970 interfered with completion of the study (Anonymous, 1970).

It should be noted that all the technological innovations attempted were based on interest in the crop by individual scientists rather than concerted effort to address management of the crop. The banana never became a priority research crop until the 1990s.

Efforts by the banana research programme (1988-to date).

The programme was initiated by a multidisciplinary team drawn from Kawanda Research Station and Makerere University and supported by the Rockefeller Foundation and International Development Research Centre (IDRC). The team developed a research agenda involving a comprehensive analysis of production/utilization constraints as a first step. This was followed by assessment of technological interventions in use and identification of technological innovations required to address the constraints. The on-going technology dissemination and generation activities are based on the analysis of 1992-96.

Current banana production/utilization constraints and efforts to develop appropriate control measures for them.

A country wide rapid rural appraisal of 1991 and diagnostic survey/constraint characterisation studies carried out in 1992-96 to assess the prevailing banana production constraints revealed the following constraints:

1. Soil fertility decline

Farmers in traditional banana growing areas complained of soil fertility decline as a major banana production constraint. Diminishing farm size and land use intensification appeared clear contributing factors to this decline (Survey data, unpubl.). Combining the knowledge from farmers and scientists, several techniques already tested under different conditions emerged as potential recommendations which are currently being evaluated in different parts of the country:

a) Use of crop residue, household refuse and mulches for management of moisture and soil fertility. b) Use of inorganic fertilizers to improve soil fertility. c) Use of a combination of organic and inorganic fertilizers to improve soil fertility. d) Use of soil and grass bands to conserve soil and water. e) Use of water harvesting systems to trap water. f) Green manures to improve soil fertility had been suggested but recent studies at Kawanda appear to indicate they compete with bananas resulting in yield reduction (B. McIntyre, Pers. Comm.).

2. Pests (banana weevil and nematodes).

a) Banana weevil

The survey revealed that the banana weevil occurred through the banana growing areas except above 1700m asl. (Gold, *et al.*, 1994). In general, damage to the Highland bananas was most severe below 1300m asl. and decreased with elevation.

Crop sanitation appeared highly related to low weevil pest status. A study in Highland cooking bananas (cultivar Atwalira) was conducted at Kawanda 1991-5 (Rukazambuga, 1996). Results revealed that yield loss increased with crop cycle and ranged from 4% in the first cycle to 48% in the fourth cycle with corresponding decrease in plant vigour and yield. Weevil biology studies have been undertaken to serve as a basis for developing IPM components. Studies have revealed that:

Within banana stands, most banana weevils were associated with the plant, mainly leaf sheath 43% or the soil at the base mat (24%). (Gold and Night, pers. comm.). About 30% of the weevils were found in crop residues (cut corms and pseudostems) will a negligible number in leaf trash or soil away from the mats. Oviposition appeared to reduce when the weevil faced harsh conditions (Gold and Abera, per. comm.)

In addition to earlier crop sanitation recommendations, the following technological innovations appeared to have a potential and they are now at different levels of development:

i) Use of chemicals to clean planting materials. Furadan and dursban rates that make an effective solution are being tested. The method involves paring sucker and dipping it in a pesticide solution.

ii) **Use of endophytes.** Endophytes are non-pathogenic fungi living within plants in a mutualistic association. They may be toxic or repellent to herbivorous insects. Nine endophyte strains effective at killing banana weevil eggs were isolated (M. Griesbach pers. comm.). Two of these killed weevil larvae. The strains were sucessfully inoculated in and recovered from potted tissue culture plants. Lower damage was observed for inoculated plants.

iii) **Entomopathogenic fungi.** Various strains of Fungi *Beauveria bassiana* and *Metarhizium anisopliae* have been demonstrated effective in killing banana weevil adults. However, establishment under field conditions has not been achieved in Uganda (C. Nankinga, Pers. comm.). Studies to integrate this with other components are in progress.

iv) **Host plant resistance:** Work is currently centred on screening different types of bananas for resistance to the banana weevil. Data on mechanisms of resistance are also being taken. Improved materials for distribution and sources of resistance for use in the breeding programme will be identified.

v) **Use of pheromone enhanced trapping.** Pheromone lures have been shown to enhance trap efficiency by more than 18 times at Kawanda (W. Tinzaara, Pers. comm.). On-farm evaluation of the technology has just been initiated.

b) Banana nematodes

The diagnostic survey and other supplementary nematode characterisation studies Revealed that:

Four principal species affecting banana production include *Radopholus similis* (Cobb) Thorne, *Pratylenchus goodeyi* Sher & Allen, *Pratylenchus coffeae* (Zimmermann) Filipjev, Schuurmans & Stekhoven and *Helicotylenchus multicinctus* (Cobb) Golden. (Gowen and Queneherve, 1990). Another nematode which is potentially important is *Meloidogyne* spp. (Kashaija *et al.*, 1994).

The above mentioned first three genera are endoparasitic lesion-forming nematodes while *Meloidogyne* spp are endoparasitic gall-forming nematodes. With regard to damage, the importance of the nematodes is related to their feeding habit. Save for Taiwan where root-knot are the major nematode pests of bananas, the lesion-forming species (*Radopholus*, *Pratylenchus*, *Helicotylenchus*) are the most destructive (Gowen and Queneherve, 1990) and deserve more attention.

Only *P. goodeyi* was found beyond 1600m above sea level (asl) while *R. similis* was restricted to below 1400m asl. Species diversity was high between 1200 - 1300m asl (Kashaija *et al.*, 1994). Other factors that may influence occurrence and distribution of the crop include soils, cropping systems and banana cultivars. *R. similis* was restricted to areas below 1400m asl. The abundance of *P. goodeyi* was highest at high elevation while *H. multicinctus* was lowest at high elevation and was not found above 1600m asl. (Kashaija, 1996). Banana growing areas in Uganda lie between 950 - 2000 m asl. Yield loss attributable to nematodes in highland bananas (cultivar Mbwazirume) was as high as 51% in the fourth ratoon (Speijer, unpubl.data).

Technological components identified as appropriate and which are at various stages of validation and dissemination include:

by southwest (39.4%) and Mukono (16.5%) (Mugisha and Ngambeki, 1994).

Bananas are mainly transported to urban centres on trucks either as bunches or as fingers packed in sacks. Buying in bunches is more appealing to consumers as it helps one to determine the cultivar and fruit quality preferred (Mugisha and Ngambeki, 1994).

Marketing costs are generally high. The bulkiness and perishability of bananas, the remoteness of the producing areas relative to big markets and the scattered nature of small farms make the whole marketing machinery costly (Mugisha and Ngambeki, 1994). In the same study, Mugisha and Ngambeki established that transportation costs account for about 90% of the total marketing costs.

The export market is still undeveloped. There are a few firms involved in banana export and mainly export apple bananas, bogoya and some highland cooking bananas to a few European countries (UK, Denmark and Netherlands), Middle East (S. Arabia) and neighbouring countries (Rwanda and Kenya) (Embrechts *et al*, 1996).

Achievements

a) Identification of causes of banana production decline and shifts. The severe banana production decline and shift of the crop to other areas has been attributed to a rapid build up of pests (weevils/nematodes) which was confounded by diseases, soil fertility decline and poor plantation management. Faced with low yields and reduced plantation life as a result of these problems, farmers started replacing bananas with annual crops. The problem is now well understood and appropriate technological interventions have been identified for either validation and dissemination or generation and ultimate dissemination.

b) Barrier to improvement of Matooke (Highland) bananas. For a long time failure to grow into a mature plant by Matooke hybrid embryoes was a barrier to improving Matooke for resistance to pests and diseases. This barrier has been broken by growing the embryo on artificial tissue culture media. Improvement of Matooke types of bananas will now be possible.

c) Exotic (non-indigenous) germplasm with resistance to pests and diseases. These have been accessed, evaluated and the acceptable lines now being bulked for massive dissemination: Out of the 50 cultivars imported into the country for evaluation, one (FHIA 1) is acceptable to consumers as a cooking, two (FHIA 17 and FHIA 23) as dessert and two (KM 5 and FHIA 3) as beer bananas.

Methods of cleaning planting materials have been validated and now being disseminated: Suckers infested with weevils and nematodes can be cleaned by paring (trimming off infested tissues) the corm and dipping it in a pesticide solution or using tissue cultured planting materials. Paring alone, particularly when small suckers are selected, removes almost all nematodes and weevil eggs leaving only a few weevil larvae that will already be deep inside the corm. The three cleaning methods are being disseminated.

Technological components for integration in management of banana pests validated: Use of nematode trap crops (non-host crops) for control of the banana nematodes and pheromone lures (Cosmolure) for enhancing weevil trapping were found effective on-station and the method is being validated on-farm for end user approval.

The details of highlighted achievements are in the poster papers on bananas presented in this conference (Vol. of these proceedings).

The way forward

Analysis of the banana production constraints in Uganda revealed extremes of production decline running from central (severe decline) to the south west of Uganda (relatively high production). The areas of South Western Uganda (the districts of Bushenyi and Mbarara) have relatively high production. Masaka and Rakai appear to be intermediate between the two extremes. Banana production intensified in the two segments less than 100 years ago. A large part of these areas are at a high elevation unsuitable for several key pests/diseases. Furthermore soils appear to be slightly more fertile. Above all, the banana has become a major commercial crop and dominates the farming systems. The target here should be to sustain and/or increase the current banana production levels. Preventing a buid-up of pests and controlling soil degradation appear to be the best strategy for achieving the above target.

Integrated management of the crop covering conservation of the natural resources used for production and integrated pest management appear to be the best way forward for these segments. This should be supplemented by a research effort to establish the threshold damage levels of banana pests and diseases so that management inputs are designed to keep the damage below the threshold. New pest/disease and natural resource management components will be introduced in these areas to supplement the recommendations currently in use.

The severely declined banana production areas are represented by central Uganda but they stretch to western Uganda (Masindi, Hoima, Kibale etc) and Eastern Uganda (Iganga, Kamuli, Palisa etc). These are all low elevation areas where pests and diseases thrive best. Pest pressure has built-up to levels which severely reduce productivity and plantation life. Additionally farmers face labour problems and are not able to implement pest and crop management recommendations. The target should be to reverse production decline in these areas. Use of host plant resistance in this segment appears the only viable strategy since most farmers may not be able to implement IPM to reduce the pest levels. It should be noted that unless all farmers carry out the recommended weevil management practices uniformly, re-infestation of fields where IPM measures are practised will occur quickly making the control efforts futile.

Integrating natural resource and crop management for banana cultivars resistant to pests/diseases appears to be the best way forward. In the absence of improved highland cultivars, improved exotic cultivars, such as FHIA 01, appear promising. This hybrid should be disseminated to farmers in this segment. The long-term strategy, is to improve the Matooke bananas for resistance to pests/diseases and use the improved matooke hybrid to replace the present stands.

Finally marketing and processing of bananas appear not to have received the attention they deserve. More effort will be directed to these important post production areas. A potential area to look into is use of sun dried bananas as a raw material for a variety of banana products.

Referennces

Adupa, R. and Ngambeki, D.S., 1994. Demand and consumption of bananas in Uganda. *African Crop Science Conference Proceedings*, Vol. 1: 379-383.

Anonymous, 1970. Interim Report on the Makerere Banana (Matooke) manurial trials - 1968 - 1970. (unpublished). Makerere university. Kampala.

Bagamba, F., 1994. Resource allocation efficiency in a banana based cropping system in Uganda. MSc. Thesis. Makerere University, Kampala.

Brandes, E.W., 1919. Banana wilt. *Phytopath.*, 9: 939-389.

Embrechts, J., Bananuka, J.A. Couveur, Y., Bagamba F. and Lallemand, D., 1996. *Banana subsector review*, Republic of Uganda. Commissioned by the European Union (STABEX), Service Contract No. SC/26/96. October, 1996.

Gold, C.S., Kiggundu, A and Abera, A.M., 1997. Farmer Banana Cultivar Selection Criteria in Uganda. In: E. Adipala, J.S. Tenywa, M.W. Ogenga-Latigo (eds). *African crop science proceedings; Pretoria 13-17 January 1997.* Makerere Univesity, Kamapala. pp 139-157.

Gold, S.C., Speijer, P.R., Rukazambuga, N.D. and Karamura, E.B., 1994. Assessment of banana weevils in East African highland banana systems and strategies for control. In: Valmayor, Davide, Stanton, Treverrow, and Roa (eds). *Proceedings of a conference-workshop on nematodes and weevil borer affecting bananas in Asia and the Pacific.* Serdang, Selangor, Malaysia 18-22 April 1994, INIBAP. pp. 191-203.

Gowen, S. and Queneherve, P., 1990. Nematode parasites of Bananas, Plantains and Abaca. In: M.luc, R.A. Sikora and J. Bridge (eds). *Plant parasitic Nematodes in Subtropical and Tropical Agriculture.* CAB International, Wallingford, pp. 431-460

Haig, N.S., 1940. Bananas. In: J.D.Tothill (eds) 1940. *Agriculture in Uganda.* Oxford University press.

Harris, W.V., 1947. The banana borer. *East African agricultural Journal*, 13, 15-18.

Jameson, J.D., 1970. *Agriculture in Uganda.* Second Edition. Oxford University, London. 395 pp.

Johnson, H.H., 1902. The Uganda protectorate, Department of agriculture, Uganda, 1908. *Banana cultivation practices.* (unpublished). pp.673.

Kangire, A., Gold, C.S., Karamura, E.B., and Rutherford, M. A., 1996. Fusarium wilt of banana in Uganda, with special emphasis on wilt-like symptoms observed on East African highland cooking cultivars (*Musa*, AAA-EA). *ACTA Horticulturae* (in Press).

Karamura, D.A., 1998. Numerical Taxonomic studies of the East African Highland bananas (Musa AAA-East Africa) in Uganda. A Ph.D Thesis, University of Reading, UK.

Kashaija, I.N., 1996. *Factors influencing Nematode population densities and root damage on Banana cultivars in Uganda.* Ph.D. Thesis, University of Reading, UK.

Kashaija, I.N., Seijer, P.R., Gold, C.S. and Gowen, S,R., 1994. Occurrence, distribution and abundance of plant parasitic Nematodes of Bananas in Uganda. *African crop Science Journal,* 2: 99-104.

Leaky, A.L.C., 1970. Diseases of bananas. In: J.D. Jameson (Ed.). *Agriculture in Uganda.* Second Edition. Oxford University Press. 395 pp.

Lockhart, B.E.L. 1986. Purification and serology of a bacilliform virus associated with banana streak disease. Phytopathology 76 (10): 995-999.

Mugisha, J. and Ngambeki, D.S., 1994. Marketing system of the Uganda banana industry. In: E. Adipala; M.A. Bekunda, J.S. Tenywa; M.W. Ogenga-Latigo. and J.O. Mugah (eds). *Africa Crop Science Conference Proceedings.* Africa Crop Science Society, Kampala, Uganda, pp. 384-387.

Mukasa, S.K. and Thomas, D.G., 1970. In: J.D. Jameson (eds) 1970. *Agriculture in Uganda.* Oxford University press pp 395.

Namaganda, J. M., 1996. Nematode parasites of Banana-root crop systems in Uganda. Ph.D. Thesis, Reading University, UK.

Patel, M.D., 1969. Account of *Radopholus similis* and its occurence in Uganda Technical communication No.24.

Ploetz, R. Jones, D., Sebasigari, K. K. and Tushemereirwe, W. K., 1995. Panama disease on East African Highland bananas. *Fruits*, 49 (4): 253-260.

Price, N.S., 1995. The origin and development of banana and Plantain cultivation. In: S. Gowen (eds). Banana and Plantains. pp 1-12. . Chapman and Hall, London.

Rhodes, P.L., 1964. A new banana disease in Fiji Commonwealth phytopathological news, 10: 38-41.

Rukazambuga, N.D., 1996. The effect of banana weevil (*Cosmopolites sordidus* Germar) on the growth and productivity of bananas (Musa AAA) and the influence of host vigour on weevil attack. Ph.D Thesis. University of Reading, UK.

Simmonds, N.W., 1962: The evolution of Bananas. Longman,London.

Simmonds, N.W. and Shepherd, K., 1955. The taxonomy and origins of the cultivated bananas. *Linnean Society of Botany* 55: 302-312.

Stover, R.H., 1962. Intercontinental spread of banana leaf spot (*Mycosphaerella musicol* a Leach). *Tropical Agriculture, Trinidad* 48. (4): 351-360.

Stover, R.H. and Waite, B.H., 1960. Studies on Fusarium wilt of Bananas V. Pathogenicity and distribution of *F. oxysporum* f. *Cubense* races 1 and 2. *Canadian Journal of Botany,* 38: 51-61.

Su, H.J., Hwang, S.C., Ko, W.H., 1986. Fusarial wilt of Cavendish bananas in Taiwan. *Plant disease*, 70 (9).

Tothill, J.D., 1940. *Agriculture in Uganda*. Oxford University Press. Oxford, UK.

Tushemereirwe, W. K., Gold, C. S., Speijer, P. R. and Holderness, M., 1993. Banana foliar disease in Uganda: Preliminary results from a diagnostic survey. *African Crop Science Jounal*, 2: 145-149.

Tushemereirwe, W. K. and Waller, J. M. (1993). Black leaf streak (*Mycosphaerella fijiensis*) and associated disease of bananas in Uganda. *Plant Pathology*, 42:471-472.

Tushemereirwe, W.K., 1996. Factors influencing expression of leaf spot diseases of highland bananas in Uganda. Ph.D Thesis, Reading University, UK.

Tushemereirwe, W.K., Karamura, E.B. and Karyeija, R., 1996. Banana Streak Virus (BSV) and associated filamentous virus (unidentified) disease complex of highland bananas in Uganda. *Informusa*, 5:9-12

Whalley, P.E.S., 1957. The banana weevil and its control. *East African agricultural Journal*, 23, 110-12.