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Global Banana Disease Management – Getting Serious with Sustainability and Food Security

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Abstract

Much research in understanding plant diseases has been undertaken, but there has been insufficient attention given to dealing with coordinated approaches to preventing and managing diseases. A global management approach is essential to the long-term sustainability of banana production. This approach would involve coordinated surveys, capacity building in developing countries, development of disease outbreak contingency plans and coordinated quarantine awareness, including on-line training in impact risk assessment and web-based diagnostic software. Free movement of banana plants and products between some banana-producing countries is causing significant pressure on the ability to manage diseases in banana. The rapid spread of *Fusarium oxysporum* f. sp. *cubense* 'tropical race 4' in Asia, bacterial wilts in Africa and Asia and black leaf streak in Brazil and elsewhere are cases in point. The impact of these diseases is devastating, severely cutting family incomes and jeopardising food security around the globe. Agreements urgently need to be reached between governments to halt the movement of banana plants and products between banana-producing countries before it is too late and global food security is irreparably harmed. Black leaf streak, arguably the most serious banana disease, has become extremely difficult to control in commercial plantations in various parts of the world. Sometimes in excess of 50 fungicide sprays have to be applied each year. Disease eradication and effective disease control is not possible because there is no control of disease inoculum in non-commercial plantings in these locations. Additionally, there have been enormous sums of money invested in international banana breeding programmes over many years only to see the value of hybrid products lost too soon. 'Goldfinger' (AAAB, syn. 'FHIA-01'), for example, has recently been observed severely affected by black leaf streak in Samoa. Resistant cultivars alone cannot be relied upon in the fight against this disease. Real progress in control may only come when the local communities are engaged and become actively involved in regional programmes. Global recommendations are long overdue and urgently needed to help ensure the long-term sustainable utilisation of the products of the breeding programmes.

INTRODUCTION

Banana is the developing worlds' fourth most important food crop after rice, wheat and maize with total production estimated at 106 million tonnes in 2005 (FAO, 2006). The crop is grown in more than 130 countries throughout the tropics and subtropics. Banana is a staple food for millions of people, particularly in Africa (Global Crop Diversity Trust, 2007). Banana is also the most important fruit crop in world trade with about 16 million tonnes of bananas being exported each year.

Not long ago, there was a leading article in *New Scientist* with the message that within a decade the world's most popular fruit could be wiped out in 10 years by fungal diseases rampaging through Central America, Africa and Asia. Various rebuffs and responses then ensued in the press. Nevertheless, the very severe threats posed by black leaf streak (BLS) and Fusarium wilt still remain and are getting worse as disease incursions occur in more countries. Add to them the bacterial diseases Moko bacterial wilt, bugtok, blood bacterial wilt and Xanthomonas wilt, and the viral diseases bunchy top and bract mosaic, and there is much to be concerned about. Without serious attention to the issues raised in this paper, the world's ability to ensure a bright future for banana will be compromised.

TOWARDS A GLOBAL PLAN

Many articles in the literature deal with the understanding of various diseases and the results of varietal screening, but little attention is devoted to coordinated approaches to preventing and managing diseases. Knowledge by itself achieves nothing until it is put into practice.

An example of knowledge being used to eradicate BLS, previously believed impossible, occurred recently in Australia. The disease was detected on 3 April 2001 in the middle of the Australian banana-growing area at Tully in North Queensland. What many had feared had finally occurred. Queensland's Department of Primary Industry and Fisheries (DPI&F) had been successful in eradicating small isolated outbreaks of BLS, caused by *Mycosphaerella fijiensis*, in the relatively isolated Cape York region over the years (Henderson et al., 2006), but it had been said that if the disease were to appear in a major growing area, that would be the end of the industry. Nevertheless, the DPI&F took action immediately to survey the extent of the outbreak. It was determined that the disease was present over about a 20-km diameter zone, but at very low levels. It was decided that eradication had to be attempted even though no one had ever achieved this in a production area before. There was too much at stake not to try. The industry was worth AU$ 300 million per year, and without eradication, the viability of these regional communities would be threatened. A massive coordinated programme of deleafing and fungicide application together with regular leaf disease monitoring and testing followed (Peterson et al., 2003). No positive BLS samples were found after November 2001, and it was later considered that the disease has been eradicated (Henderson et al., 2006; Peterson et al., 2005). The successful eradication of BLS was due to the rapid establishment and delimitation of the infested area, a complete ban on the movement of banana plants and their parts, including fruit, accurate detection techniques to confirm visual observations including a PCR-based test and the thorough implementation of the field management strategy. The success of this programme has demonstrated the spectacular results that can be achieved when everybody works together in unity for a common purpose.

Some will say that Australia is different and that such approaches will not work in developing countries. However, Bioversity International's regional banana and plantain network for Asia and the Pacific (BAPNET) is showing just what can be done to overcome severe banana bunchy top problems in the Philippines through clean planting material schemes (INIBAP, 2005). Interestingly, success has been possible due to a partnership between a large private-sector banana export company, which has large-scale tissue-culture facilities, and public-sector providers of expertise. The message here is that big export companies can be engaged to help smallholders with disease control.

There is no organisation that has within its charter the capacity to implement a 'global plan' as I have suggested, but perhaps the international consortium of banana stakeholders that are involved in the Pesticide Reduction Plan for Banana (PRPB; Kema, 2006) could take on board such a global plan.

Surveys/Monitoring – Where is the Disease Now?

A global strategy firstly depends on sound information on the current distribution of disease, including information about any important strain differences and main dispersal pathways that would affect control options. This requires that competent disease-identification and sample-handling procedures are in place. In Asia, an ACIAR-funded Fusarium wilt project, which includes such a survey component in Indonesia and Papua New Guinea, started in 2006. Similar small surveys are being conducted in Malaysia, China, the Philippines and Thailand, coordinated again by Bioversity International. This work could be used as a model at the global level.

Quarantine – Prevention is Better than Cure

There are still many regions of the banana-growing world that are free of many of the major banana diseases, as well as many locations within affected regions that are still disease free. These regions can potentially be kept free of the major diseases via stringent quarantine and clean planting material schemes.

Crucial to effective plant health measures should an important disease gain entry is raising exotic disease awareness among banana growers as well as research and extension personnel. These people need to know what the symptoms of exotic diseases look like and have appropriate resources at their disposal to diagnose the pathogen quickly. Opportunities exist to develop posters and disease field guides, as well as more sophisticated web-based/CD diagnostic software, such as that developed recently for taro (Carmichael et al., 2007). To ensure people are well informed, training is needed urgently in the risk assessment of the impact of imported banana materials and products. Such training could also be developed for use on line.

Contingency Plans – In the Event of an Exotic Disease Outbreak

Should quarantine be breached and a disease outbreak occurs for the first time (including outbreaks of new disease strains) in a country or region, there is enormous benefit in having a strategic plan outlining the required course of action. A contingency plan contains the correct set of steps that must be followed to contain/eradicate the incursion. It should state exactly who (individuals/organisations) is responsible for each set of actions and the lines of command. During outbreaks, time and resources need to be managed and confusion needs to be minimised. The day-to-day field work will be variable and somewhat unpredictable, but the directions from supervisors need to be clear. Contingency plans lay down the authority channels and the range of acceptable practices to use. Valuable time is saved by everyone knowing what has to be done beforehand, and the plan followed is not one which has involved rushed decisions.

The contingency plans usually include an initial survey to determine the extent of the outbreak as well as the precautions necessary to prevent any further spread of the disease during the survey process. During the survey, disease samples are collected to define the pathogen and its variability. Immediate action may be taken on surveys to reduce the amount of disease inoculum, which could include destroying host plants and the implementation of quarantine to stop further disease spread. Some form of regular

disease monitoring will be required after the initial survey to monitor control or eradication measures implemented. Investigations should be made to determine exactly how quarantine was breached, which may provide useful information to prevent further incursions.

In Australia, Plant Health Australia has the responsibility of working with plant industries to develop contingency plans for important pests and diseases. Prior to the formation of Plant Health Australia, the Queensland Banana Industry Protection Board had developed contingency plans for outbreaks of banana pathogens including *M. fijiensis* and *Fusarium oxysporum* f. sp. *cubense* 'tropical race 4'. As part of the proposed global plan of attack on diseases, generic contingency plans could be developed for consideration/fine-tuning by each banana-growing country.

No One Banana Cultivar Is Perfect

"The only satisfactory long-term answer to control is the use of resistant cultivars" is often touted as the solution to banana disease problems. Many problems result from such a mindset, and there is need for greater attention to holistic approaches covering exclusion/control measures.

Every cultivar has its own set of advantages and disadvantages (Daniells, 2000). New cultivars are only part of the solution. Some cultivars will be resistant to some diseases/strains, but not to others. Thus some cultivars may have an application in some situations and not others. In addition, new diseases/strains may be introduced that affect cultivars resistant to indigenous pathogens/pests. As a result, the emphasis may shift from one disease to another disease, creating a new set of problems for growers.

Resistant cultivars may give a false sense of security so that insufficient attention is placed on the importance of quarantine and cultural practices. Farmers and scientists cannot afford to be complacent just because they are growing a resistant variety. Quarantine measures still need to be implemented and clean planting material still used by the local industry.

There is also a risk of breakdown of resistance to a certain disease under high disease inoculum pressure. Disease inoculum reduction is important to ensure longevity of genetic resistance.

Resistance Breakdown

The first report of a breakdown in resistance to BLS was from the island of Rarotonga in the Cook Islands. The bred hybrid 'T8' (AAAA, syn. '61-882') had been rated as highly resistant to BLS in trials conducted at Totokoitu Research Station in 1978-83 (Fullerton, 1990). However, this resistance broke down in 1989 (Fullerton and Olsen, 1993). At the same time, the diploid cultivar 'Paka', which was a parent of 'T8' suffered a similar breakdown of resistance. At the time, it was believed that a shift in pathogenicity had occurred resulting in 'T8' and 'Paka' becoming completely susceptible, and this may have been because of the failure of a single gene for resistance. Strains of *M. fijiensis* that overcome the resistance in 'T8' and 'Paka' have also been detected in Samoa (Fullerton and Olsen, 1993).

In December 2006, severe foliar disease symptoms consistent with BLS were seen on hitherto resistant 'Goldfinger' (AAAB, syn. 'FHIA-01', 'SH-3481') in Samoa for the first time. Leaf disease samples subsequently collected and PCR-tested by Queensland DPI&F have confirmed the disease as BLS. The youngest leaf spotted (YLS) for unbunched plants was leaf six, and the youngest leaf with 33% of lamina destroyed by

disease was leaf eight. Very few functional leaves were left on plants with bunches nearing harvest. When 'Goldfinger' was first evaluated at Nu'u in the early 1990s, unbunched plants had in excess of 15 good leaves. The YLS reported at this time was 17-18.

Therefore, there are implications for the deployment of BLS-resistant cultivars. Strategies to delay the shift in pathogenicity of local populations of *M. fijiensis* require investigation, including (i) regular deleafing every 1-2 weeks to select against the proliferation of such strains of the pathogen; (ii) removal of highly susceptible cultivars to reduce overall disease inoculum levels; and (iii) regular monitoring of strains isolated from known BLS sites. Enormous sums of money have been invested in the world banana-breeding programmes over many years only to see the value of hybrid products lost too soon. Global recommendations are long overdue and urgently needed that help ensure long-term sustainable utilisation of the products of the breeding programmes. Resistant cultivars alone can not be relied upon for the control of BLS. It should become routine to use integrated management practices when growing a resistant cultivar to prevent a breakdown in resistance. Resistant cultivars should not be grown under very high inoculum conditions without any other control measures being taken as this may compromise the resistance.

Global Food Security and Sustainability – The Price of Free Trade

A global strategy should address unrestricted movement of banana plants and products, including fruit, between banana-producing countries. It is often not appreciated that many important banana diseases could potentially be spread via banana fruit plus associated leaf trash and packaging. People are often dismissive of the threat posed by movement of banana fruit because of the low occurrence of disease in exported fruit, but the telling issue is the sheer scale of exports, which can number in the hundreds of thousands of cartons per year, which greatly multiplies the risk of disease entry and establishment.

Mycosphaerella fijiensis has been shown to infect banana fruit (Fullerton, 2006), but sporulation in the minute peel lesions, which would have great quarantine significance, has not yet been demonstrated. PCR tests of leaf samples showed that *M. fijiensis* was present in fragments of leaf trash found in cartons of banana fruit imported into New Zealand from the Philippines (Casonato, 2006). It seems likely that the Moko and blood bacterial wilt pathogens can be spread via diseased fruit (Jones and Diekmann, 2000; Satou et al., 2006), but further study seems warranted. Freckle infects leaves and fruit of several banana cultivars, including Cavendish in Southeast Asia (Jones, 2000; Jones and Stover, 2000), and could also be present on fragments of leaf trash in exported banana cartons. Virus pathogens may also be present in the rind of banana fruit (Thomas and Iskra-Caruana, 2000), but for spread to occur, vectors would need to feed on discarded peel or whole fruit and then transfer the virus to a nearby host.

Much further study is required on the subject to better understand the risks. In the mean time, movement of such material, which could have such catastrophic consequences to banana industries, should not be permitted.

All too often, authorities have a blasé attitude to the risks associated with the movement of banana plant parts and products, risking the spread of exotic diseases to more banana production areas, greatly reducing world production capacity. Representations by banana organisations and regional/international organisations need to be made to the relevant governments of banana-producing countries immediately to have

their policies changed in favour of food security and sustainability. Agreements urgently need to be reached between governments to halt the movement of potentially infected/infested banana plants and products between banana-producing countries (except as certified disease-free in-vitro plants, which are considered tried and tested) before it is too late and global food security is irreparably harmed. Globalisation of trade has become important in recent years, but increased trade must be undertaken responsibly. It would be globally irresponsible to jeopardise food security and the ability to produce bananas in sustainable systems, which include minimal pesticide usage. The World Trade Organisation has adopted the principle of managed risk and does not support the prohibition of imports through a nil-risk policy. However, agricultural commodities are very different from non-agricultural commodities, and the trade imperative should not reign supreme when food security and sustainability are at risk.

Involving the Whole Community – Integrated Area-Wide Management Programmes

BLS has become extremely difficult to control in commercial plantations in various parts of the world. Fungicide resistance is a common problem, and sometimes in excess of 50 fungicide sprays have to be applied each year. The eradication of BLS in Australia, mentioned earlier, was possible because all the disease inoculum, which occurred on either commercial plantations, backyard plantings or nearby feral plants, was destroyed or removed. Many countries do not believe they could be successful in a similar eradication, because they do not believe it is possible to exercise control over inoculum in small-holder plantings. If the disease in small-holder plots cannot be controlled, inoculum is continually being produced that will affect nearby large commercial plantings. If that were not the case, progress in control in larger plantations could be made using such strategies as the regular application of protectant fungicides plus frequent deleafing. Unless countries, such as those in the Americas, try to do something about BLS control in small-holder plantings, no real progress will ever be made to overcome the present control constraints in commercial plantations. The local communities need to be engaged and become actively involved in regional control programmes, such as Landcare®. Landcare® is a uniquely Australian partnership between the community, government and business that does things practical about protecting and repairing the environment. Under Landcare®, more than 4000 volunteer community groups are tackling land degradation all over Australia. The Landcare® approach has also been successfully adopted in the Philippines (Metcalfe, 2004). It should be adaptable to community gardening and associated disease management.

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