Managing bacterial wilt/fruit rot disease of banana in Southeast Asia

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Bananas and plantains are an extremely important crop in Asia, a region that is recognized as the centre of *Musa* genetic diversity and at the same time a hotspot for many serious banana pests and diseases.

Moko and Bugtok in the Philippines

The term Bugtok, describes a discoloured and hard fruit even when ripe. A diseased plant may look normal, but the fruit pulp is rotten (dry), black and unfit for human consumption. The disease is caused by bacterium *Ralstonia solanacearum* (formerly known as *Pseudomonas solanacearum*). It was reported in 1965 although similar fruit hardening and rotting on Saba was reported as early as 1954. The disease affects Saba and Cardaba (ABB) cooking bananas and reached epidemic proportions in the late 80s to early 90s. The bacterium is known to be transmitted mechanically through soil on tools, but is mainly carried by insects feeding on infected flowers of cooking bananas.

Moko, another wilt disease caused by *R. solanacearum,* is known to affect commercial Cavendish plantations in the Philippines. External symptoms are the yellowing and collapse of the youngest leaves. These symptoms progress to the older leaves. Internally, the vascular tissues are discoloured and necrotic, especially near the centre of the pseudostem. The bacterium is more systemic in Moko infections, as it moves upward through the transpiration system in contrast to the slower downward movement of the bacterium (from the flower down the stem) in Bugtok infections. Advanced infection in fruiting plants may also cause fruit rotting. This seldom occurs in commercial plantation since early detection leads to early elimination of infected plants. If it does occur however, rotting of the pulp in Moko infections is similar to that of Bugtok symptoms.

The spread of Moko in commercial Cavendish plantations is mainly by way of contaminated knives used in regular desuckering and other pruning activities.

Hence, infection commences from the basal parts of the plant resulting in vascular infection that causes leaf yellowing and wilting. Fruit inoculation is practically absent in Cavendish commercial plantations, since the fruits are bagged, thus protecting them from insects. Moreover, the male buds are also removed, thus further reducing the chance of insect inoculation through the male flowers.

Moko and Bugtok are caused by the same strain of *R. solanacearum*. The observed differences in symptomology of Bugtok and Moko are due to differences of banana varieties and in the management systems under which the different varieties are produced. In the case of cooking banana production by smallholders, desuckering, fruit bagging and removal of the male bud were rarely practiced. Moreover, the male buds of cooking banana varieties are sweeter and are used as food. These seem to be more attractive to insects than the male buds of Cavendish, which are bitter and cannot be eaten.

In the Philippines, the disease Moko and Bugtok refer more to the type of symptoms and cultivar affected rather than the causal organism. Hence when *R. solanacearum* infects Cavendish in commercial plantations, people call it Moko. The same pathogen when it infects Saba is called Bugtok or other local names that describe fruit rotting. Thwaites *et al.* (2000), although recognizing that both diseases may be caused by the same pathogen, classified Moko under vascular wilt diseases and Bugtok under fruit rot diseases.

Blood disease in Indonesia

Blood disease, a similar disease reportedly caused by *Pseudomonas celebensis* (the true taxonomic identity is yet to be worked out), is a devastating banana disease in Indonesia. It was reported in Sulawesi in the 1920s, and spread to West Java in the 1980s. Recently, it has been causing damage to banana plantations in Sumatra. Like Bugtok in the Philippines, it causes significant damage to the cooking banana, Pisang kepok (syn. Saba), an ABB cooking banana and one of the most popular cooking varieties, as well as the dessert banana. This disease has practically eliminated P. kepok from the Sulawesi.

Blood disease is systemic like Moko. It is soil-borne and can be spread by contaminated pruning tools. However, field observations indicate that the fruit rotting symptoms are most common in P. kepok. This indicates that like Bugtok, disease inoculation is through the flowers. This inference is supported by the observation that a P. kepok-type cultivar, which does not produce a developed male bud is significantly less affected by Blood disease.

In an effort to understand the disease better and develop disease management tactics, several practical studies have been carried out by Indonesian sci-

entists. In a varietal screening conducted at the Indonesian Fruit Research Institute (IFRI) in Sumatra, involving artificial inoculation on potted plants in screenhouse, none of the Indonesian varieties were found to be resistant to *P. celebensis*. All varieties exhibited wilting symptom within 9 to 17 days of inoculation. Field trials, however, showed that cooking bananas such as P. kepok, Pisang raja and Pisang nangka are more seriously affected by Blood disease compared to dessert bananas such as Pisang ambon (Cavendish) and Pisang berangan. Moreover, it is a common observation that dessert bananas, grown in commercial farms, show the wilting symptom (Moko-like) whereas the cooking bananas, usually subsistence farmers' cultivars, are most affected by fruit-rotting (Bugtok symptom).

The early male-debudding programme that was adopted for Bugtok control in the Philippines was evaluated in Solok Sumatra in 2000 and was reported to be also effective for Blood disease (Djatnika 2003). Further work to evaluate control programmes and promote cultivars that are less easily infected is being pursued.

The presence of a bacterial wilt, reminiscent of Moko, in commercial Cavendish plantations in Indonesia has been recently reported in local scientific literature. While the Blood disease pathogen is distinctly different from the Moko pathogen, the relationship of Moko to Blood disease may be similar to that of Bugtok and Moko in the Philippines. As discussed earlier, Cavendish farm management may yield to wilt (Moko) symptoms rather than fruit rot symptoms (Blood disease).

Moko and Bugtok management in the Philippines

The dynamics of the bacterial wilt/fruit rot pathogens have long been sufficiently understood to design a practical and effective disease management system. The effective management of Moko by commercial Cavendish plantations in Central America as well as in the Philippines is based on the etiological and epidemiological studies carried out by company researchers as early as in the 60s and 70s.

Implementing a rational and cost-effective disease management system is easier to achieve in a well-organized and coordinated commercial plantation than in very dispersed, numerous, small-scale farms. Commercial companies have the technical and financial capabilities, as well as strong incentives, to implement an effective disease management system. By contrast, the broad-ranging socio-economic status, motivations and support systems of small-scale

The disease management system for Bugtok and Moko in the Philippines is based on the traditional concepts of disease control:

- Regular disease scouting and early detection
- Eradication of infected plants and treatment of affected soil
- General sanitation to reduce insect infestation
- Quarantine
- Debudding tools
- De-budding and bagging (part of general commercial production practices)
- Use of healthy planting materials(tissue culture) and improved production system.

growers make it difficult to implement a comprehensive disease prevention and eradication programme.

In the Philippines, while insect transmission through the floral parts was scientifically demonstrated decades ago, removal of male buds as a disease control tactic for small scale farmers did not get serious attention until just seven years ago when the Bugtok epidemic hit the heartland of Mindanao where the banana chip industry thrives. Farmer's demonstration trials were carried out to show to small-scale farmers as well as to local government officials and extension workers the value of this simple control practice. One such study was conducted in the southern Philippines where the Bugtok epidemic had practically devastated the small-scale Saba production catering to the banana chip industry, as well as other processed products. The results of the farmer trials (Tables 1 and 2, Figure 1) were enough to convince farmers and local government alike to implement a sustainable Bugtok management system through extensive extension activities.

Table 1. Prevalence of Bugtok before implementation and after implementation of management practices (six months and 1 year) (n=50 farms).

	Prevalence (%)		
Management practices	**Before**	**6 months**	**12 months**
Untreated control	82	89	96
Sanitation	86	65	40
Debudding	91	52	22
Debudding+Sanitation	82	39	11
Debudding+Sanitation+Desinfect tools	88	34	6
Debudding+Sanitation+Desinfect tools+bagging	78	23	0

Data taken from G.C. Molina 1996.

Table 2. Percentage control of Bugtok before implementation and after implementation of management practices (six months and 1 year) (n=50 farms).

	Disease control (%)		
Management practices	**Before**	**6 months**	**12 months**
Untreated control	-	-	-
Debudding	-	43	76
Sanitation	-	24	54
Debudding+Sanitation	-	53	86
Debudding+Sanitation+Desinfect tools	-	61	93
Debudding+Sanitation+Desinfect tools+bagging	-	70	100

Data taken G.C. Molina 1996.

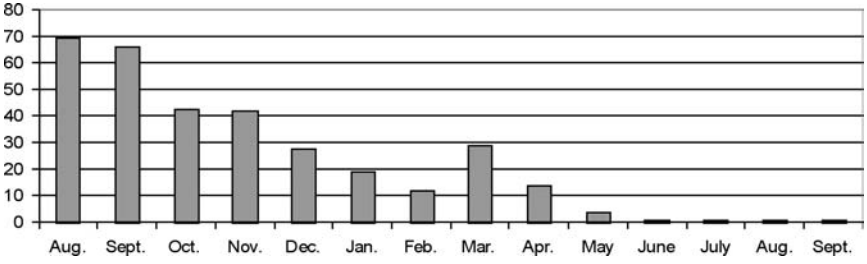

Figure 1. Bugtok prevalence in 5 farms with high disease pressure over the 12 months following the implementation of IPM (August 1997 to September 1998, Camiguin) (From Opina *et al.* 1999)

With time and official backing, the management tactics have become a part of routine cultural practices. Most of the Saba growers regularly practice debudding and some bigger farms also practice fruit bagging, which is less popular because of the costs and practicalities of bagging very tall plants. While Bugtok cannot totally be eradicated the effects are reduced.

Another technology, which is now widely practiced in India, China, and the commercial Cavendish plantations in the Philippines and has significantly improved pest and disease management in Asia, is the wide use of healthy seedlings through tissue culture. Commercial plantations in the Philippines commonly use tissue culture in their annual cropping system, and in establishing new plantations. The management of Fusarium wilt Race 4 through tissue culture in Taiwan has served as a model in this respect. The practice has significantly reduced other pests and diseases such as Banana Bunchy Top Virus, nematodes, Moko and even Sigatoka diseases.

The major thrust is now focused on bringing this technology to small-scale farmers. A cost-effective clean seedling system for small-scale farmers is now being developed in the Philippines, Indonesia, Sri Lanka and other developing countries. Increasing numbers of small-scale farmers are now using tissue culture and the control of seedling-borne diseases like bacterial wilt is expected to improve.

In conclusion, the studies in the Philippines show that control and/or eradication on farm is possible one year after implementation of management practices but a lot of team work, resources, commitment and dedicated leadership are needed on the part of the implementers to ensure management practices are comprehensively adopted.