

**Global Programme on**

**Prevention of Fusarium wilt (Foc)**

**Disease of Banana**

**2015-2018**

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**Global Programme on Prevention of Fusarium wilt (Foc) Disease of Banana**

**EXECUTIVE SUMMARY**

1. Fusarium wilt disease caused by *Fusarium oxysporum* f. sp. *cubense* (Foc) has been a major constraint to banana production for more than 100 years. The disease first gained prominence when it caused significant losses to Gros Michel bananas grown for export to the USA and Europe during the first half of the 20th century. To prevent the international export industry from complete collapse, Gros Michel was replaced with Cavendish bananas. However, in the last two decades Cavendish varieties recently succumbed to the disease, first in the subtropics and eventually also in the tropics. The reason for these outbreaks was the discovery of a new variant of the Fusarium wilt fungus, called Foc TR4, in Asia. Until recently Foc TR4 has been restricted to five Asian Cavendish-producing countries and Australia, but was recently discovered in the Middle East and Mozambique. This led to international concerns that the fungus is threatening bananas worldwide, and could severely endanger food security and also damage the international banana trade.

2. Banana Fusarium wilt is particularly difficult to control. The responsible fungus is soil-borne and can survive for decades in the absence of bananas, making it difficult to target with fungicides. Once susceptible bananas are planted in infested fields, the fungus infects it through the roots to cause a lethal wilt. Suckers taken from diseased areas spread the Fusarium wilt fungus over large distances, while it can be disseminated within and between fields with soil attached to shoes and plantation tools, vehicles and in irrigation water. The only means to protect bananas is to prevent the fungus from being introduced into disease-free fields through preventive measures, or by planting resistant varieties. Because of the wide host-range of Foc TR4, bananas grown as food crop and for local markets, as well as that grown for international trade, are all potential targets. Proper awareness and appropriate legislation is thus needed to secure the future of bananas worldwide

3. This This programme is designed in view of the magnitude of the risks posed by Foc TR4, as well as other races, to banana production, and considering the global mandate and strategic objectives of FAO. The programme aims to enhance international synergy and collaboration among the existing initiatives and to provide the necessary technical assistance to countries affected by and at risk of this devastating threat.

4. The programme activities have been designed around six major thematic areas as follows:

 1: Enhanced awareness and national and regional capacity at all levels

2: Surveillance, early detection and monitoring approaches and systems

3: Risk assessments, and plant health-related legislation and phytosanitary practices

4: Preparedness and prevention through strengthening national and farmer capacities

5: Disease management strategies to reduce disease impact and pathogen spread

6: Regional and international interaction, coordination and information sharing

5. The programme will be hosted at FAO headquarters and implemented in close collaboration with the participating partners from all sectors and regions. A programme steering committee consisting of representatives from FAO (Plant Production and Protection Division), Bioversity International, World Banana Forum, African Consortium on Foc TR4 and Latin America and Caribbean oversee the implementation and progress. This will be supported by an advisory committee which will consist of representatives of the collaborating institutions. For implementation of this four year programme in full a budget requirement of USD 47.200 is estimated.

 **Part I – INTRODUCTION**

6. Fusarium wilt is considered the most destructive disease of banana. The disease is not new, and was first discovered in Australia in 1876. It was, however, the decimation of Gros Michel bananas in Central America during the 1900s which earned Fusarium wilt the reputation as one of the most devastating plant disease epidemics in agricultural history. The Gros Michel epidemic started in Panama at the turn of the 20th century, and rapidly spread throughout the country, to neighbouring countries, the Caribbean and South America. Because of its historic origin in Panama the disease is often referred to as Panama disease. Gros Michel was known as a popular fruit with consumers in the USA and Europe. With the loss of banana plantations throughout Central America banana productıon expanded in West Africa in the 1920s and and together with thisalso the disease. The banana Fusarium wilt epidemic was eventually brought under control when Gros Michel was replaced with Cavendish bananas in Central America during the 1960s. This replacement brought temporary relief, as reports soon surfaced that the Cavendish banana succumbed to Fusarium wilt in the subtropics and eventually in tropical Asia. These outbreaks have now been reported from countries outside Asia, and loom to develop into a global epidemic that could threaten world banana production once again.

7. The cultivated banana, whether the sweet dessert type or the cooking type, has a major drawback compared to most other crops. Because it is seedless and reproduces vegetatively its gene pool is extremely narrow, which makes the commodity highly prone to pests and diseases. Consumer preference and international markets have further narrowed the diversity in cultivated bananas. The Cavendish banana, now commonly found in food stores around the world, makes up approximately 40% of all bananas grown on the planet. The world export market, comprising 13% of all bananas produced globally, consists almost entirely of Cavendish bananas. They are therefore grown in large monoculture plantations in Latin America as well as in the Philippines. However, Cavendish bananas are also grown in monoculture by small commercial growers for local markets. In China Cavendish bananas are produced on approximately 350 000 ha, and the variety makes up about half of the bananas grown in India, the world’s largest producer.

8. Apart from the Cavendish banana, a range of dessert and cooking banana varieties are produced in the world. Some of these such as Pisang Awak (AAB), a popular dessert type, can be found as back-yard plantings in most countries where banana is grown. Other sweet banana varieties; such as Latundan (Silk, AAB), Barangan (AAA), Prata (AAB) and Poovan (AAB); are popular in specific countries and regions only. Similarly, certain cooking bananas are popular in only some regions of the world. In the African Great Lakes region, a starchy cooking banana referred to as the East African Highland banana (EAHB) is particularly popular with consumers. However, this variety is not cultivated for food production outside of Africa. Plantains are popular in both West Africa and the Americas, but cultivars grown and production systems differ substantially between the regions.

9. Banana Fusarium wilt is caused by the soil-borne fungus known as *Fusarium oxysporum* f. sp. *cubense* (Foc). Foc consists of three races, namely, Foc races 1, 2 and 4. Foc race 1 was responsible for the Gros Michel epidemic in Central America and West Africa, and is also pathogenic to Silk, Apple and Lady Finger banana cultivars. Foc race 2 was described following the discovery of Fusarium wilt in Bluggoe bananas, and Foc race 4 causes disease to Cavendish bananas and most of the banana varieties that are susceptible to Foc races 1 and 2. Foc race 4 strains are further subdivided into “tropical” (Foc TR4) and “subtropical” (Foc STR4) strains, based on the climatic regions where they cause disease to Cavendish bananas. The race concept in Foc identification, however, is problematic. It is time-consuming and expensive to execute, and results of field screening are sometimes in conflict with greenhouse evaluations. In an effort to overcome these problems, techniques such as vegetative compatibility grouping and DNA-based analyses have been used for identification purposes.

10. Foc infects banana plants through the roots and blocks the transportation of water and nutrients in the stem. This results in yellowing of the leaves followed by plant death. The fungus can also cause disease to relatives of banana such as Abaca and Ensete, but to no other crops. A number of banana varieties, especially the wild diploids such as Calcutta 4 and KM-5, are resistant to Foc. Cavendish and EAHBs are immune to Foc race 1 and 2 isolates. The host range of Foc TR4, however, is not known. A small collection of EAHB and plantains had been evaluated for resistance to Foc TR4, but a more comprehensive testing of these bananas, as well as popular banana varieties in Latin America and Brazil, is still required.

**Part II – BACKGROUND AND RATIONALE**

11. Banana is considered the eighth most important food crop in the world, and the fourth most important in the developing world. Annual global production is more than 130 million tons, and the value of bananas entering the international export market exceeds US$ 9 billion annually. However, the greatest value of bananas is the 85% produced by small-scale growers for food and income in their countries of origin. These growers are extremely vulnerable to biotic and abiotic constraints, and seldom have the resources or finances available to protect their crops. In recent years, diseases such as banana Xanthomonas wilt has caused damage estimated between US$ 2 and 8 billion to bananas in East and Central Africa, while preventative sprays for black Sigatoka disease in Central America may account for 27% of total production costs. Damage caused by Foc race 1 to the Gros Michel export industry in Central America before 1960 was estimated at US$ 400 million, and that excluded costs associated with unemployment, abandoned villages, unrealized income and social impact. It is expected that Foc TR4 could result in far more damage globally, considering the domination of world banana production by the highly susceptible Cavendish clone, as well as its pathogenicity to many other banana varieties grown by small growers.

12. Fusarium wilt of banana has been reported from all banana-producing countries in the world except for the South-Pacific islands, parts of Melanesia and countries around the Mediterranean Sea and Somalia. The center of origin of Foc is believed to be Southeast Asia, where the greatest diversity in the banana Fusarium wilt pathogen can be found. Foc race 1 was discovered in Central America approximately 150 years after the crop was first introduced into the Caribbean. It is believed that the fungus was introduced with contaminated Silk (AAB) bananas planted for shade in the West Indies. The early outbreaks of Fusarium wilt could have been sporadic, which might explain why the disease was not detected at the time of introduction. Foc race 1 is now found in most countries in the Americas, Africa and Asia. Fusarium wilt was recently reported from New Guinea and Yap in the Federated States of Micronesia. Its occurrence in these countries is significant because Foc spread has crossed Wallace’s line, originally demarcating the eastern border of the disease, in the Indo-Malayan region. Another significant occurrence was the discovery of Foc TR4 in Cavendish fields outside Asia. It was found in Oman and Jordan in the Middle East, and more recently in Mozambique in Africa. While Foc TR4 has most often been associated with Cavendish monoculture, it could also threaten banana varieties planted as staple food by subsistence farmers in Southeast Asia and Africa.

13. At the turn of the 20th century, banana Fusarium wilt rapidly developed into a major epidemic in Central America because of the monoculture planting of Gros Michel bananas and the use of infected suckers to establish new plantations. This spread on Gros Michel was mirrored in western Africa, where large banana companies moved their operations to when land became unavailable in Central America. Foc, however, was introduced during two or maybe even three more events in eastern Africa, where different dessert cultivars are affected. Planting material is not the only way whereby Foc can be spread. Once introduced into a field Foc is moved to new areas with infested soil and infected plant tissue on farming implements, transport vehicles, humans and animals. Water can also play an important role in the spread of the pathogen. Conidia and chlamydospores can be present in run-off water from plantations and end up in drainage channels and rivers.

14. Banana Fusarium wilt is exceptionally difficult to control, as Foc can survive for decades as hardy chlamydospores. Once introduced into a plantation, the fungus cannot be totally eradicated. Techniques such as crop rotation, flood following, fumigation and abandonment can, however, reduce inoculum pressure. The only effective means to control the disease is to prevent the pathogen from entering production areas, or to replace susceptible varieties with resistant ones. If the fungus is newly introduced into plantations, diseased plants should be detected early, isolated and eradicated. While this strategy is possible to large commercial growers, it is not feasible to small growers and subsistence farmers. To them, the deployment of resistant varieties provides the best option to continue banana production. However, circumstantial evidence has shown that Foc TR4 is less severe in small growers’ fields planted with different banana varieties and mixed crops.

15. The development of Foc TR4-resistant bananas is urgently required. Large-scale systematic selection and field screening of natural clones and popular banana varieties is essential at national and regional levels. In addition, clones with favorable agronomic traits, developed by mutation breeding and/or somaclonal variation, as well as diploids and inbred lines developed at banana breeding programmes, need to be field evaluated against all races of Foc. A significant challenge would be the development of Foc TR4-resistant Cavendish bananas, as banana hybrids with resistance to Fusarium wilt have not been popular in the market. Cavendish bananas genetically modified for resistance to Foc TR4, and which produce fruit with characteristics similar to susceptible Cavendish bananas, are now being field tested. Negative public perception of genetically modified fruit, however, might prevent these from entering trade markets. The use of somaclonal variants of Cavendish bananas, introduced by the Taiwan Banana Research Institute during the 1980s, provides growers with the best opportunity to continue Cavendish banana production in Foc TR4-infested plantations. Somaclonal variants are often environmentally sensitive and thus require further selection and testing when introduced into new areas. Inoculum pressure would increase in fields replanted to somaclonal variants, although not as profusely as with the planting of susceptible Cavendish cultivars. As the development of resistant bananas and their deployment in affected and countries at risk of Foc TR4 takes time, preventive measures need to be promoted and employed as quickly as possible.

16. A proper knowledge of the diversity of the fungus, its distribution and movement is important in the employment of resistant genotypes in areas where the crop is grown, especially by small independent growers. Foc race 1 is known to widely occur in Asia, Africa and Latin America. It severely affects a number of sweet dessert banana varieties such as Gros Michel and Pisang Awak, but Cavendish bananas are not affected by this race. Despite its worldwide presence, the impact of Foc race 1 on banana production in recent years has been considered less serious because of the cultivation of resistant banana varieties, such as the EAHB and plantains, and often in mixed cropping systems, by small growers. The recent discovery of Foc TR4 in Oman, Jordan and Mozambique, however, raised global concerns about the potential new impact of banana Fusarium wilt on world banana production. Foc TR4 was first discovered in Malaysia and Indonesia in the 1990s, and has since been found in Australia, The Philippines, mainland China and Taiwan province. The fungus was restricted to these countries for almost 20 years, and its discovery outside Asia raised fears that it might also spread to other important banana-growing areas such as the Indian subcontinent, East and Central Africa, and Latin America. The threat of banana Fusarium wilt, once again, has surfaced as a severe threat to a crop that serves as the main source of food and livelihoods for approximately 400 million people globally.

17. An important means to minimize the threat of Foc TR4 to global banana production is firstly to stop its spread to disease-free areas, and secondly to employ disease-resistant banana varieties in Foc TR4-affected areas. Despite the availability of sterile banana tissue culture plantlets, Foc is still being moved between farms, regions and countries with infected planting materials and infested soil particles from areas where Foc TR4 is present. Once introduced into a new area, a proper understanding of the epidemiology of the pathogen, especially under different cropping systems and in different environmental conditions, would allow the development of novel realistic strategies to prevent further dissemination. Awareness needs to be raised at all levels, and phytosanitary measures improved and implemented through collaborative processes. Engagement of all stakeholders is necessary; including producers, employees, research centres, plant protection institutions and other government institutions; to minimize the spread of Foc TR4 and other important banana pathogens to clean plantations. Countries already affected and those at risk should be encouraged and supported to enhance their capacity and ability to manage the pathogen, and those not yet affected to prevent it.

**2.1. Issues to be addressed**

2.1.1. *Lack of awareness and improvement of policies and strategies*

*18.* Recognition of the threat and potential impact that an important plant pathogen such as Foc TR4 can have on future banana production is still ominously lacking within the farming communities and even among national plant protection organizations and governments. Despite many efforts by international scientific community in the past decade to raise awareness at farmer meetings, scientific conferences and in the media, producers, field workers and even government officials still know surprisingly little about the disease, and even less about its consequences once introduced into plantations.

19. In most developing countries due to lack of effective coordination among the institutions and stakeholders the disease, despite its deadly consequences, is not given sufficient attention. In most cases especially the issue of Foc TR4 is considered as a matter of large producers and industry, resulting in negligence of the disease by government authorities and institutions. This threatens sustainability of banana production in affected areas and increases the risk of spread of the pathogen into new areas.

20. Thus concerted efforts should be made to raise awareness of the stakeholders including government authorities, the banana industry, and particularly farm managers and field workers. The ideal approach for this is, in the first place, preparation of national strategies and policies through participatory processes with engagement of all relevant national institutions and stakeholders including seed production and certification institutions, plant protection organizations, research centers and producers associations.

21. Through these processes particularly the dangers associated with the movement of potentially infected planting materials and soils from areas affected by Foc TR4. Prevention of the disease depends on effectiveness of the measures taken towards eliminating such risks. Thus it is critical that the governments ensure an effective coordination among the relevant institutions and develop national contingency plans to prevent and manage the disease in advance of its occurrence.

2.1.2. *Weak* *surveillance, monitoring and early warning systems*

22. Plant disease surveillance involves the activity to search and monitor the presence of target pathogens to determine their distribution and progress. It consists of several important components such as proper planning, good surveillance equipment and systems, accurate diagnostics and data analysis, and effective communication tools. Proper surveillance is an essential component of national plant protection institutions to help authorities respond to unwanted invasions and to introduce the necessary actions to minimize their harm. Proper surveillance, supported by the necessary legislation and quarantine, could have significantly reduced the impact of Fusarium wilt to Gros Michel in Latin America during the early 1900s.

23. Disease surveys need to be conducted in countries and regions where Foc TR4 occurs and where there is a high possibility that it could be present. This is particularly important to arrest the pathogen early when newly introduced into plantations. The external symptoms of banana Fusarium wilt make the disease relatively easy to recognise, although it could be confused with other biotic and abiotic stresses that cause leaf yellowing. Scouts and surveillance teams for other important banana diseases such as Moko disease and banana Xanthomonas wilt therefore need to be trained to distinguish between bacterial wilt and Fusarium wilt. Countries where bananas are already affected by races of Foc other than Foc TR4 should be particularly vigilant and not simply accept that the tropical Foc race 4 strain is not present in their area. It is essential that accurate diagnostics support country and regional surveillance and monitoring actions, national staff are properly trained in Foc identification and characterization, and that communication channels are efficient in reporting and responding to early incursions.

2.1.3. *Weak risk assessment and plant health legislation and phytosanitary practices*

24. The domination of Cavendish bananas in the international banana world trade and many local markets, and their large-scale monoculture production, makes this popular variety highly vulnerable to infection by Foc TR4. Multinational banana companies are mega-production factories operated for profit with modern plantation practices, optimal irrigation and fertilizer management and a skilled labour force. The companies either purchase or rent land for production, or buy produce from smaller commercial growers. Once more land is required for higher yields and better profits, such companies have the resources to move to new areas to develop farms and expand their businesses. While this expansion is enterprising and profitable, it could also lead to significant risks, particularly with the global movement and impact of destructive exotic pests and pathogens. Banana Fusarium wilt, specifically, is arguably the plant disease with the longest and most tattered history closely linked to the expansion of the international banana trade.

25. The outbreaks and destruction caused by Foc TR4 globally in the past two decades can be closely linked to the expansion of commercial Cavendish banana plantations. The first two plantations affected by Foc TR4 in Malaysia and Indonesia were intended for expansion of the international banana trade in Asia. The outbreaks in the Philippines and Mozambique can also be closely linked to international trade. Outbreaks of the disease in Mainland China and Taiwan province, Northern Australia, Oman and Jordan were discovered in Cavendish fields of local farmers. The origin and movement of Foc TR4 inside and from Asia to other countries is not yet fully understandable, but it is generally believed that infected planting material played a major role in movement of the fungus between countries. Once introduced into a country, the fungus is often rapidly disseminated and soon affects other farms in the area. Small-scale growers are most affected as they cannot move their operations away from infested land and is thus forced to replace their bananas with other, less profitable and nutritious crops.

26. The presence of Foc TR4 in five Asian countries and not in the others requires further analysis. The fungus has not been found in Vietnam, Cambodia and Thailand, despite their close proximity to severely affected countries such as Malaysia, China and The Philippines. In fact, Foc has not been discovered outside the island of Mindanao in The Philippines, despite extensive banana production on the other islands. One explanation could be that the fungus has never been moved from areas where it is present to Foc TR4-free areas. However, its absence could also be due the fact that different varieties are grown in non-affected countries neighbouring affected ones, that human traffic is very limited between affected and non-affected fields, and that production systems (monoculture vs. mixed cropping systems) differ between countries/regions affected and non-affected by Foc TR4. The pathogen, however, spreads often over much larger distances through planting materials or incidental spread through transportation or human traffic between countries, which could be related to foreign labour, service providers and experimentation.

27. Biosecurity planning to assess the potential risk, and legislation to restrict the movement of Foc TR4 nationally and internationally, has become a global necessity. This should include pre-border actions (identify exotic threats to the country’s bananas, undertake research, regulate importation of materials), border actions (implement effective quarantine, establish surveillance networks, education), and post-border actions (prepare for detection, minimise the risk of establishment and spread, education). The risk presented by Foc TR4 to global banana production is dependent on a multitude of factors that could lead to epidemics, including varietal response, source of planting material and irrigation water, the production system, the movement of people and poor awareness. To protect the fungus from entering and affecting vulnerable production systems, legislation needs to be instituted and regulated to protect banana producers, and phytosanitary practices improved to help producers protect themselves. Banana growers and producers, in partnership with their governments, then need to develop biosecurity plans for their regions, provinces and countries.

2.1.4. *Weak preparedness and capacity to respond to the disease outbreak*

28. Proactive management through preparedness and prevention is the first and potentially the only line of defence against Foc TR4. Preparedness and prevention involve a number of activities that range from pre-border control to border control to post-border control. Plant health officials and scientists need to know about exotic plant pathogens that might potentially be introduced into their countries and where they occur. Border and post-border programmes should then be invented to prevent their introduction to and spread within countries.

29. Prevention at national borders and entry points requires information on potential entry pathways of exotic pathogens, competent quarantine officials that can properly inspect imported materials and legislation that will prevent the importation of banana tissue without the necessary permits. Once border control has been breached, prevention becomes the responsibility of individual farmers, farmer organizations and the banana industry of a country. It comprises the introduction of in-country quarantine zones (when possible), the use of clean planting materials and irrigation water, the regulation of farm visitors and their vehicles, and the use of disinfectants at farm entrance gates and on-farm.

30. Preparedness involves the availability of expertise; such as the ability to detect new incursions early through surveillance system; protocols to eradicate and contain the foreign pathogen, and readiness to manage and cope with the disease. This includes knowledge of the vulnerability of banana varieties grown and cropping systems used. Integrated disease management methods need to be developed in countries where the disease is already present for future use in countries at risk, such as Latin America. Preparedness and prevention at the farm and community level goes hand-in-hand with training of staff to detect and report early intrusions, and by creating awareness of the threat of Foc TR4 and other banana diseases to national production. Vehicles and equipment should never be moved from areas affected by the disease, and all plant material should be removed from machinery, equipment, vehicles and footwear upon entry to farms. These requirements should be clearly indicated to all visitors on notice boards at control points, and will also contribute to the prevention of other banana pest and diseases such as nematodes, viruses and thrips.

31. Prevention and preparedness efforts need to be supported in a way that ability of national and regional agricultural researchers and plant protection officers to respond to incursions by Foc TR4 effectively. If not available, human capacity and infrastructure need to be developed to deal with such outbreaks. This is not an impossible task, as has been demonstrated with the introduction of scouting teams for Moko disease in Latin America and eradication strategies for Xanthomonas wilt in central Africa. The wilting and leaf yellowing symptoms of bacterial wilt diseases is somewhat similar to that of Fusarium wilt (bacterial wilt affects younger leaves first, and Fusarium wilt affects older leaves first), and training at research institutions and even farmer level to correctly distinguish between them and deal with outbreaks of Fusarium wilt needs to be conducted. This should coincide with the ability to implement contingency plans, regulatory support and the availability of information and knowledge systems.

2.1.5. *Adoption of an integrated disease management approach*

32. Once banana plantations are infested with Foc it is not possible to eradicate the pathogen. The lifetime of such a plantation, however, can be prolonged by lowering inoculum pressure in soils and by enhancing the ability of plants to tolerate/resist Foc TR4.

33, The management of banana Fusarium wilt on-farm depends intrinsically on the time and dispersal of the outbreak, the size and geography of the farm, the cultivation practices and financial position of the owners, the cultivars grown, and the movement of people and water. If localised and detected early, it is possible to stop the disease from spreading further by proper isolation and abandonment of the affected land. This, however, is not always possible to small growers who need to harvest all bunches to make ends meet. To them, rather, the best option would be to grow a resistant variety or to replace bananas with other crops. The risk on such a farm is high that the fungus will very rapidly spread on-farm and to neighbouring farms, and that the entire region will become infested by Foc.

34. In farms where Foc TR4 is well established on Cavendish monoculture plantings, little can be done to prevent the inevitable. An important component to any strategy to continue farming bananas would involve the use of resistant Cavendish somaclonal variants. Depending on land available to the farm owner, fields can be left fallow to reduce inoculum levels before planting bananas in 2-3 year cycles in a rotational system. Recent research showed that root extracts of some plants can reduce the impact of Foc to susceptible bananas. However, Foc inoculum builds up rapidly in the presence of any banana plants, whether susceptible or resistant, which would affect future crop cycles more severely.

2.1.6. Global, *regional and international coordination and planning*

35. Stakeholders share the responsibility to enhance capacity to identify, monitor and manage important plant diseases and pests. Shared responsibility and strong communication is central to any national biosecurity system, not only in early detection, but also in dealing with an incursion. Training and awareness raising form part of such communication. Information sharing, intelligence gathering and networking within and among regions, and internationally, is required to coordinate planned activities between Foc TR4-affected areas and those at risk. For this purpose regular workshops and consultations to share experiences, developments, disease occurrences, knowledge and technologies are required. Even in rural areas information technology and the media can be used to convey messages to farmers, extension officers and service providers. Contingency plans to deal with Foc TR4 at regional and local level need to be prepared and implemented with an inclusive approach, thereby ensuring the participation of all banana-related sectors, institutions and organizations.

**2.2. Beneficiaries**

36. The ultimate beneficiaries of the global programme on Foc TR4 will be banana producers in all continents, whether they are affected by Foc TR4 or not. This benefit, however, depends strongly on the successes achieved and lessons learnt in countries and regions that are currently affected by Foc TR4. Activities, thus, need to be implemented in through differentiated approaches in those countries already affected and those at different level of risk of Foc TR4. Significant efforts should be made to protect small growers, and large commercial companies should assist countries where they grow bananas to help prevent the spread of Foc TR4. A second beneficiary should be national programmes and government organizations through the process of capacity building and the implementation of improved sanitary and phytosanitary measures in banana-producing countries and regions. These capacities and systems should in future provide opportunity to prevent and manage new threats to plant health in such countries and regions.

**2.3. Partners and stakeholders**

37. The Global Programme will be coordinated by the FAO, and executed with partners and stakeholders in countries and regions affected and at risk of Foc TR4. The Programme acknowledges and values the existence of ongoing local, regional and international activities and initiatives on Foc TR4 in the countries at stake, and will aim to compliment these in aspects where the FAO has a comparative advantage and facilitate an international collaboration platform. In doing so and for implementation, the following will be considered as guiding principles:

* Ensuring synergies and complementarities, and avoid duplication
* Open consultation, transparency and neutrality towards all stakeholders
* A focus on local and regional activities to empower smallholder producers
* Attention to national needs for improved systems and capacity building
* The design of strategies and determine priorities according to regions and cropping systems
* The presence of Foc races other than Foc TR4, as well as other major diseases of banana
* Respect to government rights and nationally sensitive issues

38. The Programme will consist of national, regional and international partners. These include centres involved in research and development, regional and international networks, and national and international agricultural organizations. Collaborating partners will be expected to ensure a beneficial interaction with all stakeholders in the banana sector, including producers and their associates, national research centres and plant protection institutions, as well as other government institutions. Existing linkages between FAO and the African Consortium on Foc TR4 (AC4TR4), the World Banana Forum and Bioversity International; as well as the hosting of the secretariats of the IPPC, intergovernmental group on tropical fruits and bananas and ITPGRFAat FAO headquarters; is considered as an important asset for the Programme. The partners, however, will not be limited to these, and will include individual national and government institutions, Universities, international organizations, networks, non-governmental establishments and private sector, especially those with significant experience and capacities to deal with banana Fusarium wilt internationally

39. Partners foreseen to collaborate for the execution of the Programme will include:

* FAO including its decentralized offices
* National governments and research institutions, particularly from affected countries
* Regional and international networks and initiatives, particularly from countries at risk
* Producer organizations, industry and NGOs
* Universities and agricultural research centres
* International agricultural organizations

**2.4. Strategic approach and countries covered**

40. The magnitude of numerous independent international activities, and the challenges associated with addressing the global spread of Foc TR4, requires proper coordination and synergies among research groups, extension scientists, national plant protection organizations and national government institutions to warrant an apt and useful conclusion to prevent significant losses to a crop that is providing food and income to millions.

41. Banana is grown in a wide range of geographies and under different production systems. The Programme will address the differences among banana-growing countries and regions in Asia, Africa and the Americas by taking into account the risks posed by Foc TR4 to each area, and then address the threat of the fungus to each of the respective countries/regions according to their production systems. At large, banana-growing areas can be divided into:

* Countries where Foc TR4 is already established and affects production
* Countries where Foc TR4 is newly introduced with limited effect on production
* Countries at immediate risk of Foc TR4
* Countries potentially at risk Foc TR4

**2.5. Past and related work**

42. Many activities on Foc TR4 have been initiated since the discovery of the fungus in Asia in 1990. These include surveys to study pathogen diversity, epidemiology, host range evaluations, breeding resistant varieties and disease management in the Asia-pacific region. In regions and continents where the disease is not yet found, preventative actions such as awareness campaigns and cultivar evaluations were initiated with support from Asian scientists.

43. The reports of Foc TR4 first in Oman and Jordan, and soon afterwards in Mozambique, stimulated unprecedented international interest. International and regional networks, such as Bioversity International’s ProMusa networks BAPNET, BARNESA, MUSALAC, Innovate Plantain and MusaNet organized symposiums and workshops globally with a focus on banana Fusarium wilt; while the GCIARs Root, Banana and Tuber (RTB) programme, the Australian Centre for International Agricultural Research (ACIAR), the International Atomic Energy Agency (IAEA) and other international research organizations initiated research projects focusing on Foc TR4. The African Consortium for Foc TR4 (AC4TR4) was established following the introduction of Foc TR4 into Africa, and the WBF formed a Foc TR4 Task Force to advocate international awareness against this disease. The FAO has sponsored workshops in South Africa, East Africa, Central America and the Caribbean. A strong focus of many research projects globally is the development of Cavendish varieties resistant to Foc TR4.

**2.6. FAO comparative advantage**

44. The strategic objectives of the FAO include the increased resilience of livelihoods to threats and crises, sustainable intensification of crop production, and facilitation of international mechanisms and standards for ensuring more efficient agricultural and food systems. In this context, the food chain crises have been identified as an important area of work focusing also on preventing, preparing for and responding to high impact trans-boundary plant pests and diseases. The work of the FAO on trans-boundary plant pests and diseases and related emergency operations is coordinated underthe Emergency Prevention System (EMPRES) and the Food Chain Crises (FCC) Framework, which aim to assist countries in addressing emerging challenges that threaten food security and livelihoods. High impact trans-boundary plant pests and diseases are considered one of the major challenges to food security. Fusarium wilt of banana, particularly caused by Foc TR4, is considered as a significant risk to small-holder banana producers in Asia, Africa and the Americas, as well as to commercial producers that supply jobs to the rural populations and fruits to local and export markets.

45. The International Plant Protection Convention (IPPC), whose secretariat is hosted at the FAO, is a forum that promotes development of phytosanitary standards and measures for the prevention of spread of non-indigenous plant pests and diseases. It strives to implement international standards for various aspects related to disease prevention, such as pest risk analysis, surveillance, reporting, phytosanitary measures and capacity building. These aspects are all particularly relevant to prevent the international movement of Foc TR4, a pathogen transmitted by the national and international movement of infected planting materials and/or soil particles attached to field tools, shoes and vehicles. The role of the IPPC secretariat, therefore, is considered an indispensable asset for effective design and implementation of the Programme. Similarly the presence of secretariats of the World Banana Forum, the Intergovernmental Group on Tropical Fruits and the International Treaty on Plant Genetic Resources for Food and Agriculture at FAO would contribute immensely to the programme for the activities concerning their respective fields.

46. The objectives of the Programme are also directly linked with the visions and missions of several divisions within the FAO. These include the Plant Production and Protection Division, Trade and Markets Division, Technical Cooperation Department and the Office of Partnerships, Advocacy and Capacity Development.

**Table 1.** Countries included in the Banana Foc TR4 Global Programme. Grouping is based on the risks posed by Foc TR4 to banana in all of the countries.

|  |
| --- |
| Countries already affected by Foc TR4 |
| Australia | Mozambique |
| China mainland | Oman |
| Indonesia | Philippines |
| Jordan | Taiwan Province of China |
| Malaysia |  |
|  |
| Countries at immediate risk of Foc TR4 |
| India | Tanzania |
| Pakistan | Zimbabwe |
| Bangladesh | Zambia |
| Sri Lanka | Malawi |
| Nepal | South Africa |
| Vietnam | Kenya |
| Cambodia | Egypt |
| Thailand | Sudan |
| Uganda | Democratic Republic of Congo |
| Rwanda | Burundi |
|  |
| Countries at risk of Foc TR4 |
| Angola | Honduras |
| Cameroon | Costa Rica |
| Guinea | Ecuador |
| Ghana | Panama |
| Nicaragua | Guatemala |
| Venezuela | Columbia |
| Ivory Coast | Suriname |
| Nigeria | Madagascar |
| Brazil | Papua New Guinea |
| Angola | Mexico |
| Guyana | Argentina |
| Bolivia | Paraguay |
| Dominican Republic | Haiti |
| Bahamas | Jamaica |
| Cuba | Puerto Rico |
| Gabon | Equatorial Guinea |
| Congo | Morocco |



**Figure 1.** Countries affected by Foc TR4 (red), at high risk (orange) or at risk (green).

**Part III – PROGRAMME FRAMEWORK**

**3.1. Goal**

47. Contribute to global food security and improvement of livelihood resilience through the prevention and management of Foc TR4 and sustainable production of bananas

**3.2. Objectives**

48. To enhance sustainable banana production by minimizing the risks and impacts of Fusarium wilt disease, particularly Foc TR4, through prevention, containment and management.

**3.3. Outcomes**

49. The three outcomes of the FAO Global Programme on the prevention of Fusarium wilt (Foc TR4) disease of banana are:

* Improved prevention of spread of Foc TR4 into banana-growing countries and regions
* Improved preparedness and integrated management of Foc TR4 at field level
* Enhanced International synergy and collaboration

**3.4. Outputs and activities**

50. The Programme envisions achieving its objectives by means of six outputs that are also aligned with the FAO Strategic Framework. Activities will be executed according to the risks posed by Foc TR4, the banana production systems and capacity available in banana-growing countries and regions.

**Figure 2.** Framework of the Global Programme on Foc TR4

**GOAL**

Contribute to global food security and improvement of livelihood resilience through the prevention and management of Foc TR4 and sustainable production of bananas

Outcome 3. Enhanced Int. synergy and collaboration

Outcome 2. Improved preparedness and integrated management of Foc TR4 at field level

Outcome 1. Improved prevention of spread of Foc TR4 into banana-growing countries and regions

**OUTCOMES**

OUTPUT 6

Regional and international interaction, collaboration and information sharing enhanced

OUTPUT 5

Integrated management strategies improved and implemented to reduce disease impact and pathogen spread

OUTPUT 3

Risks assessed, and plant health-related legislation and phytosanitary practices enhanced

OUTPUT 4

Capacities strengthened for improved preparedness and prevention

OUTPUT 2

Surveillance, early detection and monitoring approaches and systems improved

OUTPUT 1

Policies and strategies improved and awareness levelenhanced at alllevels for improved prevention

**OUTPUTS**

3.1. Map the distribution and assess the potential impact of Fusarium wilt disease to global banana production

3.2. Assess the status of national phytosanitary legislation and identify needs for improvement

3.3. Improve and introduce legislation for the movement of disease-free planting materials

3.4. Support government efforts to implement effective plant health legislation and phytosanitary standards

* 1. Provide policy and technical support for national and regional surveillance and monitoring mechanisms
	2. Strengthening national and regional disease surveillance and diagnostic capacities
	3. Conduct national and regional surveys for Foc TR4 in affected countries and high-risk areas

1.1. Advocacy and awareness-raising among decision makers and farmer communities

1.2. Strengthen national crop and disease management strategies and plans

1.3. Support coordination among stakeholders through participatory processes for development and implementation of contingency

* 1. Support national authorities to develop, implement and sustain practices that prevent introduction of Foc TR4 onto farms
	2. Strengthen human resources capacity of national institutions in disease prevention and management
	3. Introduce Foc TR4 training programmes for farmers and farm workers in prevention and management of Foc/,
	4. Strengthening of infrastructure of national institutions in disease surveillance, prevention and management
	5. Identify, select and disseminate Foc TR4-resistant banana varieties
	6. Promote the use of Foc TR4-resistant bananas in collaboration with national programmes through seed campaigns and field demonstrations
	7. Promote integrated disease management practices to prevent spread and limit damage caused by Foc TR4 to banana plantations
	8. Organize national and regional conferences, technical workshops and meetings
	9. Promote international collaboration and networking to manage Foc TR4 globally
	10. Support technical field studies and consultations for management of Foc TR4 at field level
	11. Facilitate knowledge sharing and dissemination

**ACTIVITIES**

**Outcome 1. Improved prevention of spread of Foc TR4 into banana-growing countries and regions**

**Output 1. Policies and strategies improved and awareness level enhanced at all levels for improved prevention**

*51. Activity 1.1. Advocacy and awareness-raising among decision makers and farmer communities*

* Hold awareness-raising meetings for high-level policy-makers, technical decision-makers and farmer communities at national level to inform them of Foc TR4, including its current status, impacts and actions needed for prevention and management, giving also due attention to other locally important diseases such as bacterial wilt, buncy top disease and black Sigatoka.
* Prepare awareness and information material regarding identification, impact status, risks in affected countries and countries at risk to address audiences in their language and by considering their production systems.
* Carry out web-based advocacy and promotion of good agricultural practices to prevent the introduction and spread of Foc and other important banana pathogens.

*52. Activity 1.2. Develop and strengthen national crop and disease management strategies and plans*

* Provide policy support for coordination among national and regional institutions for prevention and management of Foc TR4, and for implementing national and regional contingency plans should it be introduced into new areas.
* Develop tools and guides for development of national, regional and farm level policies and strategic plans
* Organize policy-makers’ meetings to assess institutional settings and coordination arrangements for preparation and implementation of national and regional strategies and contingency plans.
* Assess and strengthen the ability of countries at risk to prepare for and respond to Foc TR4 incursions.
* With national and regional policy maker platforms, develop mechanisms for networking and information sharing among institutions.

*53. Activity 1.3. Support coordination among stakeholders through participatory processes for the development and implementation of contingency plans*

* Collect information on agro-ecological systems, agricultural landscapes, social vulnerability, and political and administrative structures of banana-growing countries.
* Organize national and regional meetings for development of the most appropriate policy options, strategies and actions needed for risk reduction, prevention and control of Foc TR4 through development of contingency plans considering also other important banana diseases such as bacterial wilt, bunchy top disease and black sigatoka.
* Support countries in implementing contingency plans through capacity building, infrastructure development, regulatory support and information and knowledge systems.
* Review and update contingency plans based on the existing status of the disease, as well as the latest information from field surveys and global analyses.
* When necessary, carry out required rapid response operations in collaboration with national authorities.

**Output 2. Surveillance, early detection and monitoring approaches and systems improved**

*54. Activity 2.1. Provide technical support for national and regional surveillance and monitoring mechanisms*

* Hold national and regional meetings to assess the status and coordinate future surveillance systems (i.e. regularity, units carrying out surveys, methodology, information sharing, responsibilities, limitations and constraints).
* Provide technical and policy support to agree with national authorities on:
	+ The most appropriate structure for the establishment of sustainable and coordinated multi-institutional surveillance and monitoring teams;
	+ National focal point(s) or approach(es) to ensure quality of national survey data and its transmission to concerned parties nationally and internationally;
	+ The type and level of survey information to be officially shared and exchanged regionally or internationally considering national and international regulations; and
	+ Long-term surveillance and monitoring programmes and identification of lead institutions.
* Coordinate targeted surveillance arrangements for the early detection of Foc TR4 and other important banana pest and pathogens, identifying a national focal point to coordinate national activities in context of the Programme.
* Facilitate the strengthening of national and regional networks for disease surveillance and monitoring, diagnosis and international information sharing.

*55. Activity 2.2. Strengthening national and regional disease surveillance and diagnostic capacities*

* Assess national surveillance material, infrastructure and human capacities.
* Strengthen regional epidemiological surveillance systems by:
	+ Conducting regional workshops to harmonize surveillance protocols, survey work plans, national responsibilities and compilation of available information in banana-growing areas.
	+ Providing the necessary field survey support equipment to surveillance teams.
* Train relevant national staff on field surveys and disease diagnostics, based on protocols developed in the Asia/Pacific.
* Develop a Plant Health Toolbox that provides detailed, web-based diagnostic information to assist with the rapid identification of Foc TR4, as well as other important banana pathogens for accurate diagnosis in the event of an unwanted incursion.

*56. Activity 2.3. Conduct national and regional surveys for Foc TR4 in affected countries and high-risk areas*

* Conduct targeted surveillance to detect and combat incursions of Foc TR4 and other important banana pathogens supported by appropriate diagnostics.
* Collect additional information during surveys such as the variety affected, other pests and diseases present, production systems, planting history and soil characteristics based on protocols developed in the Asia/Pacific.
* Introduce tools such as web, mobile and remote sensing tools to detect and report early incursions of Foc TR4 into banana-producing regions, considering also national and regional regulations.
* Establish an information dissemination system to issue recommendations on disease status and recommended actions for prevention and control of any outbreaks addressed to relevant stakeholders.

**Output 3. Risk assessed, and plant health-related legislation and phytosanitary practices enhanced**

*57. Activity 3.1. Update mapping of the distribution and assess the potential impact of Fusarium wilt disease to global banana production*

* Assess the global distribution of races of Foc and map current distribution of Foc TR4 and other important banana pathogens and pests in Asia-Pacific, Africa, the Latin America, the Caribbean and the Middle East.
	+ Assess banana production systems and agricultural practices in countries affected and at risk of Foc TR4.
	+ Assess status and performance of major banana varieties against Foc TR4
* Review trade routes, political and social connections, business associations and the movement of migrant workers between Foc TR4-affected and non-affected countries.
	+ Assess the potential risks posed to banana production areas by Foc TR4 by considering the sources of risk (entrance points), their consequences (establishment and spread) and the likelihood that those consequences may occur (review the risks) based on international standards.
* Identify and disseminate measures to minimize the risks of Foc to national and regional banana production, and improve response to incursion by pre-emptive planning also considering other important pests and diseases of banana
	+ Determine key countries and regions
	+ Institute measures and practices to minimise risks and reduce impact if incursions happen

*58. Activity 3.2. Assess the status of national phytosanitary legislation and identify needs for improvement*

* Undertake baseline assessments on the current status of national and regional phytosanitary legislation in relation to Foc TR4 in countries at high risk using international standards and tools developed through International Plant Protection Convention and in collaboration with National and Regional Plant Protection Organizations.

*59. Activity 3.3. Improve and introduce legislation to prevent movement of infected planting materials*

* Organize national and regional meetings to assess country situations in terms of the status of systems available, production of clean planting material, multiplication and distribution of resistant varieties, coordination and information exchange within countries and regions.
* Asses and improve existing legislation on the movement of banana plants and parts thereof nationally, regionally and internationally, and strengthen border interception capabilities.
* Support development and implementation of legislation and phytosanitary regulations that would prevent the introduction of plants and other risky materials from affected countries.
* Harmonise legislation and regulations on Foc and other important banana diseases between countries, regions and internationally.
* Adopt systems and mechanisms for the efficient and effective distribution, communication and uptake of information on plant health.
* Monitor and strengthen the integrity of the plant health systems.

*60. Activity 3.4. Support government efforts to implement effective plant health legislation and phytosanitary standards*

* Organize workshops to identify the support needed by countries at high risk of Foc TR4 in designing and implementing legislation.
* Adopt phytosanitary legislation, regulations and approaches where possible within the framework of the International Plant Protection Convention.
* Establish an integrated national and regional approach to plant health training and awareness supported by research.
* Support introduction and implementation of the international standards related to plant health for surveillance, prevention and management of Foc TR4.

**Outcome 2. Improved preparedness and integrated management of Foc TR4 at field level**

**Output 4. Capacities strengthened for improved preparedness and prevention**

*61. Activity 4.1. Support national authorities to develop, implement and sustain practices that prevent the introduction of Foc TR4 onto farms*

* Increase vigilance of government institutions regarding Foc TR4 by providing data on its economic and social impacts as well as those of other important diseases such as bacterial wilt and BBTV in countries where they are present.
* Identify and strengthen entrance and transmission points with higher risks of becoming paths for introducing plants or other materials which are potential carriers of destructive banana pathogens
* Develop and distribute posters, brochures and information material about diseases at border points, enterprises and producer organizations.
* Training and capacity building at national institutions on the use of clean certified planting materials:
	+ Promote and allow banana and plantain propagation materials from countries where Foc TR4 and other destructive plant pathogens are present, only to enter through intermediate quarantine stations.
	+ Promote use of tissue culture plantlets and only if accompanied by a certificate of pathogen-indexing.
* Develop fact sheets and guidelines, and organise farmer field schools for sharing methods to prevent and manage Foc TR4 on-farm.

*62. Activity 4.2. Strengthen human resources capacity of national institutions in disease prevention and management*

* Train technical personnel on the entrance paths of Foc TR4 and other destructive diseases such as bacterial wilt, BBTV and black Sigatoka.
* Train plant protection officers and extensionists, production technicians and state services to identify Foc TR4 and banana Fusarium wilt, its biology, epidemiology, prevention and management
* Prepare technical material and protocols on early detection, containment and eradication of plants diagnosed as infected with Foc.
* *Activity 4.3. Introduce training programmes for farmers and farm workers in prevention and management of Foc* Train producers and farmers through field-based programmes such as farmer field schools and demonstrations for:
	+ Detection and containment of Foc TR4
	+ Use of disease free tissue culture based planting materials
	+ Selection and use of superior banana varieties with disease resistance
	+ Proper sanitation of vehicles, shoes and field equipment
	+ Eradication of banana plants affected by Foc and highly destructive banana diseases
	+ Farm management practices that minimizes spread of the disease
* Involve national and regional institutions with mandates to control pests and diseases in training programmes.

*63. Activity 4.4. Strengthen infrastructure capacity of national institutions in disease surveillance, prevention and management and tissue culture propagation materials production*

* Provide support for strengthening of infrastructure of national institutions to design and execute projects and activities in planning, surveillance, disease prevention and disease management in the sectors of
	+ research
	+ plant protection,
	+ extension and
	+ seed production
	+ planning

**Output 5. Integrated management strategies improved and implemented to reduce disease impact and pathogen spread**

*64. Activity 5.1. Identify, select and disseminate Foc TR4-resistant banana varieties*

* Prepare guidelines and conduct workshops on the identification, selection and evaluation of banana varieties against Foc TR4.
* Field selection and testing of popular banana varieties for resistance to Foc TR4 in affected countries.
* Provide training in banana tissue culture and the development, selection and deployment of tolerant/banana somaclones for disease resistance,
* Disseminate disease-free and Foc TR4-resistant banana varieties for evaluation in countries at risk.
* Identify and promote certified tissue culture laboratories for the production of banana plants free of banana pathogens and pests.

*65. Activity 5.2. Promote the use of Foc TR4-resistant bananas in collaboration with national programmes through field demonstrations*

* Facilitate the evaluation of Musa germplasm for resistance/immunity to Foc TR4 in countries where the disease is present.
* Develop information lists of banana varieties resistant and susceptible to all races of Foc.
* Develop guidelines and mechanisms of sharing and evaluating Foc TR4-resistant banana plants developed by mutation breeding (somaclonal variation, mutagenesis), traditional breeding and genetic modification.
* Promote Foc TR4-resistant varieties by means of field demonstration plots and information sharing (farmer days, brochures).
* Advocate the use of clean planting materials by involving producers and industry in the regulation process

*66. Activity 5.3. Develop and promote integrated disease management practices to prevent spread and limit damage caused by Foc TR4 to banana plantations*

* Introduce on-farm sanitary and phytosanitary practices to prevent the introduction (warning signs, vehicle and foot baths) and spread (early identification, destruction and burning of diseased plants) of Foc TR4 in farmer fields.
* Provide scientifically sound recommendations to farmers to improve soil health and suppress banana Fusarium wilt by means of soil amendments, biological control and crop rotation, depending on production systems and the level and extent of field infestation.
* Where possible, develop quarantine zones between Foc TR4-affected and non-affected areas within and between regions in infected countries.
* Restrict the movement of soil, appliances, vehicles and field equipment from quarantine areas for use in non-Foc TR4 infested fields.
* Introduce proper sanitary practices and signs at farm entrances, and control the movement of visitors and field workers.

**Outcome 3. Enhanced international collaboration and synergy among the institutions and initiatives working for the improvement of the banana sector**

**Output 6. Regional and international interaction, coordination and information sharing enhanced**

*67. Activity 6.1. Organize national and regional conferences, technical workshops and meetings*

* Organize regional consultations, workshops and experience sharing events
* Publish issues that need public attention through appropriate means.

*68. Activity 6.2. Promote international coordination and networking to manage Foc TR4 globally*

* Exchange scientific information, dissemination of publications and work programmes between regions and internationally
* Sharing and dissemination of knowledge and programme activities through web-based forums, also linking and collaborating with existing information resources
* Organize international technical workshops to facilitate knowledge exchange and collaboration.
* Develop and promote policy and technical guidance on prevention and management of the disease to assist countries develop their national and regional strategies.

*69. Activity 6.3. Support technical field visits and consultations for field management of Foc TR4*

* Identify local and international experts in the diagnosis and field management of Foc TR4
* Enable bilateral technical visits on field management for prevention and management of the disease.
* Provide technical advice and guidance to producers with regard to on-farm biosecurity and developing risk mitigation measures.

**3.5. Sustainability**

70. The sustainability of the global programme depends on national and regional capacity development, legislation and awareness to deal with current and future incurrences. The proposed duration of the programme (4 years) is sufficient to advance international collaboration and to initiate coordinated multistakeholder interventions at national level but the support of decision makers and governments is critical for sustaining these efforts beyond the programme period. The programme is intended to stimulate additional projects in the global battle against Foc TR4, such as the development of resistant bananas and methods to lower soil inoculum. Most importantly spread of the disease within and between countries would be prevented or slowed down through enhanced awareness at global and local levels and engagement of all stakeholders in the programme. This would be a major advancement for long term impact.

**Part IV – IMPLEMENTATION ARRANGEMENTS**

**4.1. Work plan**

71. The global programme on Foc TR4 requires a multidisciplinary and well-coordinated action plan involving the stakeholders concerned. These include government officials, national agricultural organizations, national plant protection organizations, universities, regional networks, international institutions, private industry and producers. The programme also needs to place emphasis on the potential risk of Foc TR4 to banana-producing regions, production systems, available capacity and human resources, and international movement of people and agricultural products.

4.1.1. *The programme framework*



**Figure 3.** Schematic illustration of activities required for a Global Foc TR4 programme.

72. One of the key activities of the programme is to accurately assess where Foc TR4 poses a risk to banana production nationally, regionally and internationally based on scientifically sound information. Such an assessment requires baseline data, including information on the susceptibility of banana varieties to Foc TR4, the movement of people and planting materials between countries, and the availability and quality of biosecurity / phytosanitary systems. This information is partly available at national government organizations and research organizations, whereas additional information will need to be generated at national and regional research level. Risk consists of two components:

* Risk of introduction: Source of planting material, biosecurity legislation, phytosanitary capacity at borders of entry, movement of stakeholders in the banana industry between countries and general awareness.
* Risk of spread: On-farm biosecurity measures, control points to farm and plantations, on-farm sanitary practices, source of planting materials, source of irrigation, movement of workers and visitors on-farm.

73. Risk assessment requires specialised skills of trained personnel. If such skills are not available at national programmes, these should be acquired through capacity building actions. Risk assessment is closely linked to knowledge of the national and regional occurrence of Foc TR4, which could be obtained through national and regional surveillance programmes. The outcome of such surveillance, in combination with risk to banana production, will determine the level and nature of legislation to be introduced in countries. Awareness raising is needed to help governments introduce and apply national legislation on the safe movement of planting materials and the protection of banana farmers in their countries.

74. The programme also aims to enhance national and regional capacities to prevent and combat Foc TR4. This involves training on-farm, at national research organizations, and of policy makers. A major component of such training will be to prevent Foc TR4 from introduction into regions and countries, and if present already, onto disease-free farms. Preparedness and preventative actions should not only by limited to Foc TR4, but to all important pathogens and pests of banana including virus diseases such as BBTV, bacterial diseases such as Xanthomonas wilt and Moko disease, and leaf diseases such as freckle and black Sigatoka. The introduction of quarantine measures, appropriate national legislation and proper awareness are all vital components to ensure healthy crops in production areas. Prevention of diseases on-farm is strongly dependant on the production system and affordability of preventative measures of farmers.

75. The strategic approach of the programme places emphasis on sharing of experiences and knowledge nationally, regionally and internationally. A significant amount of knowledge had been generated and applied in Asian countries affected by Foc TR4, including knowledge on the epidemiology, host range and improvement of bananas, and the management of the pathogen on affected farms. This knowledge should be shared with countries where the disease has been newly introduced and/or countries and regions that are at risk of the banana Fusarium wilt fungus being introduced. Sharing of knowledge and experiences could lead to the development of contingency plans and the coordination of regional activities through collaboration and networking.

4.1.2. *Production systems*

76.Prioritised actions needed in banana-producing countries according to the risk of being affected by Foc TR4are depicted in Table 3. Cavendish bananas are highly susceptible to Foc TR4. When planted in monoculture, the fungus spreads rapidly in plantation and eventually infiltrates irrigation systems. The rapid spread of Foc TR4 in Cavendish plantations have often been associated with contaminated water, whether it is the source of irrigation, such as rivers or dams, or run-off water in plantations following heavy rains. Other means of spread is movement in soil attached to shoes and in plantation tools. The protection of large-scale Cavendish plantations, therefore, should be one of the first lines of defence in preventing Foc TR4 from being introduced into production areas. Once such plantations are affected, Foc TR4 often spreads rapidly to farms of small-scale farms in the region.

77. An important aspect of large-scale Cavendish banana production, particularly for export, is the intensive production system and infrastructure, skilled labour and financial capacity available to farm and/or company owners. Plantation workers and managers are well trained in the early identification and treatment of production constraints, and this provides an opportunity also for banana Fusarium wilt to be scouted early. Although the disease produces external symptoms similar to that caused by bacterial corm rot and wilt diseases, Armillaria root root and nematode damage, the internal symptoms are very distinct. The early detection of banana Fusarium wilt in Cavendish export plantations in Latin America and The Philippines, therefore, could allow the introduction of eradication and isolation methods to stop the disease from progressing. This, however, is not the case everywhere. Several subtropical Cavendish banana-growing areas such as South Africa and Brazil are already affected by Foc STR 4, a related but less virulent form of the banana Fusarium wilt fungus. In these areas it would be more difficult to detect Foc TR4 early when introduced as such detection is only possible by means of fungal diagnostics.

78. Cavendish bananas are not only produced by large-scale growers. In countries such as China, India, Philippines and in southern Africa, bananas are often produced on small farms of 5-10 ha of Cavendish bananas. Their capacity to respond is far less plausible than their large-scale counterparts. The small growers seldom have the financial means to use tissue culture plantlets, introduce the required sanitary practices to prevent their farms from becoming contaminated, or employ skilled labour and transport their own produce. For these producers, Cavendish somaclonal variants might bring some relieve if adapted to local environmental conditions and if the yield and taste is sufficiently acceptable to continue banana production. The incidence of banana Fusarium wilt is known to increase in somaclonal variants when planted in Foc TR4-infested fields over time, so replanting will have to be more regular.

**Table 2.** Impact of Foc TR4 and activities needed for management in different banana production systems

|  |  |
| --- | --- |
| **Impact** | **Production systems** |
| **Large-scale Cavendish monoculture** | **Small-scale Cavendish monoculture** | **Small-scale farming with diverse banana culture** | **Subsistence farming with mixed crops** |
| Primary location | Central & South America, South & West Africa, Philippines, Australia | China, Philippines, India, Pakistan, Middle East, southern Africa | Asia-Pacific region, India | Africa, Asia-Pacific |
| Markets | Export and local markets | Local markets | Local markets | Households, local trading |
| Vulnerability | High | High  | Intermediate to high | Intermediate to high |
| **Activity** | **Management of Fusarium wilt Foc TR4** |
| Prevention | Farm gate control, awareness | Awareness | Awareness | Awareness |
| * Field sites
 | Find clean production areas | - | - | - |
| * Planting material
 | Tissue culture plants | Tissue culture, clean suckers | Clean suckers | Clean suckers |
| * Sanitation
 | Disinfectants, foot and vehicle baths | Disinfectants, foot baths | - | - |
| Early detection | Eradication and abandonment | Eradication and isolation | Eradication | Eradication |
| * Diagnostics
 | Symptoms and pathogen | Symptoms and pathogen | Symptoms | Symptoms |
| * Containment
 | Isolation and killing of affected plants | Isolation of affected plants | - | - |
| * Future production
 | No further production in affected area | Replace bananas in affected area | Resistant varieties or other crop | Plant other crops |
| * Monitoring
 | Producers and extension officers | Producers and extension officers | Producers and extension officers | Producers and extension officers |
| * Systems management
 | Improve sanitation, production practices, drainage and awareness | Improve sanitation, production practices and awareness | Improve production practices, sanitation and awareness | Improve production practices and awareness |
| Management | Abandon land | Planting of somaclonal varieties | Resistant varieties | Replace with other crops |
| * Soil
 | Fallow periods, fumigants | Soil management (biologicals) | - | - |
| * Water
 | Clean source, filtration and drainage | Clean source and drainage | Improve drainage | - |

**Table 3.** Prioritised activities to be executed in banana-producing countries according to the risk of being affected by Foc TR4

|  |  |
| --- | --- |
| **Activities** | **Risk status** |
| **Countries where Foc TR4 is well established** | **Countries where Foc TR4 is newly introduced** | **Countries at high risk of Foc TR4 introduction** | **Countries at risk of Foc TR4 introduction** |
| Policies, strategies and awareness enhanced  |  |  |  |  |
| *Advocacy and awareness raising* |  |  |  |  |
| *Strengthen disease management strategies* |  |  |  |  |
| *Coordinate contingency plans* |  |  |  |  |
|  |  |  |  |  |
| Surveillance, early detection and monitoring |  |  |  |  |
| *Provide policy and technical support for surveillance* |  |  |  |  |
| *Strengthen surveillance and diagnostic capacity* |  |  |  |  |
| *Conduct national and regional surveillance* |  |  |  |  |
|  |  |  |  |  |
| Risk assessment and phytosanitary legislation |  |  |  |  |
| *Map the distribution of banana diseases* |  |  |  |  |
| *Assess status of phytosanitary legislation* |  |  |  |  |
| *Improve and introduce phytosanitary legislation*  |  |  |  |  |
| *Implement plant health legislation* |  |  |  |  |
|  |  |  |  |  |
| Capacity building for preparedness, prevention |  |  |  |  |
| *Implement practices that prevent Foc TR4 on farm* |  |  |  |  |
| *Strengthening of human capacity and infrastructure* |  |  |  |  |
| *Coordinate contingency plans among stakeholders* |  |  |  |  |
|  |  |  |  |  |
| Disease management to reduce Foc TR4 impact |  |  |  |  |
| *Identify and disseminate Foc TR4-resistant plants* |  |  |  |  |
| *Promote the use of Foc TR4-resistant plants* |  |  |  |  |
| *Introduce integrated disease management* |  |  |  |  |
|  |  |  |  |  |
| Regional and international coordination |  |  |  |  |
| *National and regional meetings* |  |  |  |  |
| *International collaboration and networking* |  |  |  |  |
| *Field visits and consultations* |  |  |  |  |

Required Optional Not needed

79. Circumstantial evidence in Asia has shown that not all banana varieties grown for home consumption and local markets are susceptible to Foc TR4. Mixed production systems, where banana is grown with crops such as cacao and trees for instance, also develop less disease that Cavendish monoculture. This provides a significant opportunity to small growers, as they seldom have the financial means to prevent the spread of banana Fusarium wilt or abandon their land for new, disease free farms. If these growers cannot continue farming bananas, they will be forced to replace their bananas with less profitable crops which might have a significant financial impact on small plots of 0.5-2 ha. It is these producers, in particular that need to be most protected against the global spread of Foc TR4.

4.1.3. *Actions according to risk*

80. Impact of Foc TR4 and activities needed for its management in different banana production systems are depicted in Table 2. Once a reliable risk assessment has been made, and the distribution of Foc TR4 has been mapped, contingency plans for the prevention and management of banana Fusarium wilt should be introduced and implemented according to the status of the disease. These contingency plans should consider the situation within countries, as in some areas within affected countries the disease may be widely distributed while in others it may still be localised. For instance, Foc TR4 has been found only on one island in the Philippines, but it is already distributed widely on that island. The other islands in the country, thus, should be considered areas of high risk of introduction. In Mozambique the disease is limited to a single farm which is located a long distance from any other banana production area. This could significantly reduce the spread of the fungus to uninfested fields if the necessary preventative measures are introduced in the country and region.

81. Countries already affected by Foc TR4 need to urgently and effectively determine the exact distribution of the disease, and implement the necessary legislation to prevent the disease from spreading to new areas, regionally and internationally. This requires surveillance actions and awareness ranging in affected countries, their neighbours and all countries considered to be at high risk. Countries at high risk do not only include the neighbours of affected countries, but also those between where significant stakeholder movement from affected countries is taking place. For instance, Foc TR4 has not been found in Thailand, Cambodia and Vietnam despite the presence of the disease in neighbouring countries. One way of explaining this paradox is because of different cultivars being grown in the neighbouring countries, but another is that stakeholder movement for trade and other agri-businesses is mostly focussed on Cavendish-associated enterprises. For this reason, regions such as the Indian subcontinent and Latin America, both that are a long distance away from Asia, Africa and the Middle East, should be considered countries at risk.

82. Disease management and preventative measures would be mostly limited to countries affected and those at high risk of Foc TR4, respectively. Countries not affected and those less at risk, however, should learn and benefit from activities implemented in areas where Foc TR4 occurs. Africa and the Middle East could now benefit from somaclones developed in Asia and Australia, although these still have to be tested in the newly affected regions. Efforts to screen international germplasm, particularly those of importance for food security and income generation in resource-poor communities and developing countries, need to form an integral part of a global programme on Foc TR4. The outcome of such research needs to be communicated at different levels to all stakeholders to ensure uptake by farmers in affected areas and preparedness in unaffected areas.

**4.2. Institutional arrangements and coordination**

83. The Global Programme on Foc TR4 programme will be coordinated and implemented by the FAO through its national and regional offices in collaboration with its partners. The programme is considered as a framework for improved governance of banana Fusarium wilt at the global level in synergy with existing initiatives, with a view to enhance international collaboration and to provide assistance to countries and regions affected by or at risk of Foc TR4. At country level, the ministries of agriculture will act as government counterpart institutions responsible for policy and decision making, and the national research organizations and universities will provide support for implementation.

84. International and regional research organizations and networks; such as CGIAR centres (Bioversity, IITA), AC4TR4 and BAPNET; will provide support for research needs, training and capacity building in synergy with ongoing local and FAO initiatives, liaise with all stakeholders and promote local ownership of programme activities. Technical guidance will be provided by the programme partners and international consultants. Enhancement of legislation tools and related activities will be supported through regional and national plant protection organizations such as AU-IAPSC, NEPPO and OIRSA under the guidance of IPPC.

85. The operational and managerial implementation of the Global Programme on Foc TR4 will be from FAO headquarters. This will be overseen by a programme management committee coordinated by a manager / officer designated by management of FAO. To ensure geographic and technical inclusiveness this committee would include representatives Bioversity International, the Asia Pacific banana improvement community, African consortium on TR4, World Banana Forum and Latin America and Caribbean.

86. This committee would oversee the progress made and advocate for the programme at all levels to promote implementation of the principles and recommendations established. It would also identify and monitor implementation of the necessary measures to ensure that activities are carried out in a proper and timely manner as per the work plan, donor requirements and the overall vision and priorities of the programme and of FAO. An advisory committee will support the management committee and FAO in making decisions and refining and prioritising activities at global and local levels for effective execution of the programme. This committee would include representatives from participating institutions and major banana producing countries.

**4.3. Technical support and programme staff**

87. Technical and operational support for the Global Programme on Foc TR4 will be provided through the following human resources:

* Lead technical coordinator, based at headquarters of FAO: responsible for overall technical coordination of the programme.
* Assistant technical officer or consultant, based at headquarters: assists the lead technical coordinator, liaison with regional and subregional technical officers, and liaison with collaborating partners and responsible for the preparation of specific project proposals.
* Operation officer, based at headquarters: operational and administrative support to the entire programme.
* Information and communication expert, based at headquarters.
* Subject matter specialists (consultants) in the regions: plant pathologists, horticulturists, GIS specialists, extension officers, web/ database/ information technology specialists.
* National focal points for surveillance and monitoring activities, sanitary and phytosanitary activities and disease management.

**4.5. Budget requirement**

88. FAO would continue its internal efforts in providing assistance to countries. However for this global programme external resources are needed and an effort would be made to attract funding for implementation of this programme in full or partially. In doing this, also recently popular modalities such as public – private partnerships, south – south cooperation or multilateral funding will be explored.

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| Table 4. Estimated budget by output and by beneficiary countries, based on the presence of Foc TR4 and by level of risk of being affected by Foc TR4 (000 USD) |
| Output | Countries affected | Countries at high risk | Countries at risk | Coordination | TOTAL |
| Output 1: Policies and strategies improved and awareness levelenhanced at alllevels for improved prevention  | 1400 | 2500 | 2000 |   | 5900 |
| Output 2: Surveillance, early detection and monitoring approaches and systems improved | 2200 | 3200 | 2200 |   | 7600 |
| Output 3: Risk assessed, and plant health-related legislation and phytosanitary practices enhanced | 1700 | 2500 | 1600 |   | 5800 |
| Output 4: Capacities strengthened for improved preparedness and prevention  | 2200 | 3300 | 2700 |   | 8500 |
| Output 5: Integrated management strategies improved and implemented to reduce disease impact and pathogen spread  | 4900 | 2600 | 2100 |   | 9600 |
| Output 6: Regional and international interaction, coordination and information sharing enhanced | 1100 | 2100 | 1600 | 5400 | 9800 |
| Total | 13500 | 16200 | 12200 | 5400 | 47200 |

**Annexes**

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| Annex 1. Implementation plan of a global programme on Foc TR4 |
| Output/Activity | Already affected by Foc TR4 | At high risk of Foc TR4 | At risk of Foc TR4 |
| Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 | Year 1 | Year 2 | Year 3 | Year 4 |
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| Output 1: Policies and strategies improved and awareness levelenhanced at alllevels for improved prevention  |
| Activity 1.1. *Advocacy and awareness raising* | X | X |  |  | X | X | X |  | X |  |  | X |
| Activity 1.2. *Strengthen disease management strategies* | X | X | X | X | X | X |  |  |  |  | X |  |
| Activity 1.3. *Facilitate coordination and contingency plans*  | X |  |  |  | X | X |  |  |  |  | X |  |

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| Output 2: Surveillance, early detection and monitoring |
| Activity 2.1. *Provide technical support for surveillance* | X | X |  |  | X | X |  |  | X |  |  |  |
| Activity 2.2. *Strengthen surveillance and diagnostic capacity* |  | X |  |  |  | X |  |  |  | X |  |  |
| Activity 2.3. *Conduct national and regional surveillance* | X |  |  |  | X | X |  | X | X |  |  | X |
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| Output 3: Risk assessment and phytosanitary legislation |
| Activity 3.1. *Map the distribution of banana diseases* | X | X |  |  | X | X |  |  | X |  | X | X |
| Activity 3.2. *Assess status of phytosanitary legislation* | X |  |  |  | X |  |  |  | X |  |  |  |
| Activity 3.3. *Improve and introduce phytosanitary legislation* |  | X |  |  |  | X |  |  |  | X |  |  |
| Activity 3.4. *Implement plant health legislation* | X | X | X | X | X | X | X | X | X | X | X | X |

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| Output 4: Capacities strengthened for improved preparedness and prevention |
| Activity 4.1. *Implement practices that prevent introduction of Foc TR4 on farm* | X | X | X | X |  | X | X | X |  |  |  |  |
| Activity 4.2. *Strengthening of human capacity and infrastructure* | X | X |  |  |  |  |  |  |  |  |  |  |
| Activity 4.3. *Carry out training programmes for farmers and farm workers in prevention and management of Foc such as farmer field schools and farmer study groups* | X | X |  |  |  | X | X |  | X | X |  |  |
|  |
| Output 5: Disease management to reduce Foc TR4 impact  |
| Activity 5.1. *Identify and disseminate Foc TR4-resistant varieties*  | X | X |  |  |  | X | X |  |  |  |  |  |
| Activity 5.2. *Promote the use of Foc TR4-resistant varieties* |  | X | X |  |  |  | X |  |  |  |  |  |
| Activity 5.3. *Introduce and promote integrated disease management practices* | X | X | X | X |  |  | X | X |  |  |  | X |
|  |
| Output 6: Regional and international coordination |
| Activity 6.1. *National and regional meetings* | X | X | X | X | X | X | X | X | X | X | X | X |
| Activity 6.2. *International collaboration and networking* | X |  | X | X | X |  | X | X | X |  |  | X |
| Activity 6.3. *Field visits and consultations* |  | X |  |  | X |  |  |  |  |  | X |  |
| Activity 6.4. Coordination and knowledge management | X | X | X | X | X | X | X | X | X | X | X | X |

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