WORKSHOP ON

Enhancing Market Access for Tropical Fruits in East Africa and GCC countries through Quality Improvement, Proper Postharvest Handling and Pest & Disease Management

4-5 March 2015 - Khartoum, Sudan
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Introduction

In 2011, the estimated world banana and other tropical fruit production were 183.0 million tonnes and 95.0 million tonnes respectively. Besides banana, mango was the main fruit produced accounting for almost 40 percent of total production followed by pineapple 25 percent, papaya 10 percent and avocado at 4 percent. Other minor tropical fruits such as durian, rambutan, litchi, guava, and mangosteen made up about 20 percent of total tropical fruit production. Asia remains the main producer of tropical fruits, followed by Latin America and the Caribbean, Africa, and Oceania. Generally 90 percent of the fruits produced are consumed domestically with only an estimated 5 percent traded as fresh fruits and another 5 percent are processed. In recent years, there has been an increase in the export of tropical fruits, due to changing consumer trends and demands in the importing countries for fresh, safe, and quality produce.

The main tropical fruit producing countries in Africa are S. Africa, Kenya, Tanzania, Nigeria, Ethiopia and Congo. In 2011, the main tropical fruit produced in Africa were bananas (15,396,357 tonnes), mangoes (3,944,303 tonnes), papayas (1,461,441 tonnes), and pineapples (2,896,040 tonnes).

In the same year, the main producers of bananas were Tanzania (3,143,840 tonnes), Angola (2,646,070 tonnes), Burundi (1,848,730 tonnes), Cameroon (1,376,000 tonnes), Kenya (1,197,990 tonnes), Egypt (1,054,240 tonnes), and Uganda at (522,945 tonnes).

The main countries producing mangoes were Nigeria (795,000 tonnes), Kenya (636,585 tonnes), Egypt (598,084 tonnes), and (Tanzania 330,000 tonnes), while the main pineapples producers were Nigeria (705,000 tonnes), Ethiopia (340,239 tonnes), Congo (280,330 tonnes), and Mozambique (43,245 tonnes).

Meanwhile, the main producers of papayas were Nigeria at 705,000 tonnes, Ethiopia (340,239 tonnes), Congo (280,330 tonnes), and Mozambique at (43,245 tonnes).

The main tropical fruits produced in Sudan were mangoes (27,500 ha), bananas (23,000 ha), citrus (27,000 ha), guavas (6000 ha), and there had been increasing areas of papayas and pineapples.

Tropical fruits are also produced in other Arab States and GCC countries including Egypt, Sultanate of Oman, Kingdom of Saudi Arabia, United Arab Emirates and Yemen, where mangoes, bananas, papayas and pineapple are popular. Generally, the production of tropical fruits increased up to 40 percent in the period from 2000 to 2011, in these States.

As in main tropical fruit growing countries in Asia and Latin America, smallholders in Africa are also faced with issues of low quality produce, pest and diseases incidences, and poor postharvest management resulting in limited access to the market.

Besides institutional and policy support, lack in appropriate production technologies at the pre harvest, harvest and post-harvest stages along the value chain, are challenges that have to be overcome to reduce losses and poor fruit quality. A major problem with fruit production is damage caused by fruit flies, which have been identified as major pests to fresh fruit and can impact production, food security and trade in Africa. Besides this, recently there has been an initiative by FAO to mitigate and manage Panama wilt disease on bananas caused by a fungus Fusarium oxysporium cubense TR 4. This disease which has affected many countries in Asia
including China, Philippines, Malaysia and Indonesia, can be devastating to the whole banana industry if not contained. It has already been identified to affect bananas in Mozambique.

There is also the need to look at the various levels of smallholder involvement in the tropical fruit value chain to show the links between producers and buyers, identify gaps and constraints and to recommend interventions to distribute the benefits among producers and buyers.

Smallholders integration can be improved through capacity building in areas such as quality assurance, food safety, good agricultural practice, phyto-sanitary regulations, pest & diseases and postharvest management to improve competitiveness for better market access.

Cognizant of the various issues relating to tropical fruit production and market, International Tropical Fruit Network (TFNet), together with the Horticultural Section Administration, Federal Ministry of Agriculture and Irrigation, Sudan and Food and Agriculture Organization, Kingdom of Saudi Arabia, planned to organize a workshop on ‘Enhancing Market Access for Tropical Fruits in East Africa and GCC countries through Quality Improvement, Proper Postharvest Handling and Pest & Disease Management’. The workshop was held at the Grand Holiday Villa Hotel, Khartoum, Sudan from 4 to 5 March 2015.

The workshop was officially opened by Dr. Jaffar Ahmad Abdullah State Minister, Ministry of Agriculture and Irrigation, Republic of Sudan.

Fifty six participants attended the workshop comprising representatives from Ethiopia, Uganda, Kenya, Officials from the Federal Ministry of Agriculture and Irrigation Sudan, Universities, Sudan Agriculture Research Corporation, private companies and resource persons from Australia, Egypt, South Africa, Sudan, FAO Kingdom of Saudi Arabia and TFNet.

During the second day of the workshop, a field visit was organised to observe the efforts of a local company, Zadna Corporation, which is involved in the production of planting materials including mango, grapefruit and other citrus, date palm and banana.

The main objectives of the workshop are to:

- Assess issues and challenges in developing the tropical fruit industry, taking into account the impact on food security, income generation for smallholders and market access.
- Share recent information on pest and disease management in tropical fruits, especially on awareness of the impact of the wilt disease caused by Fusarium sp in bananas, including the strategies to mitigate and manage the disease.
- Share recent information on the effect of fruit flies infestation in tropical fruits, including the strategies to control and manage the pest.
- Share information on the current postharvest technologies that can improve quality and marketability of tropical fruits, as the same time, conform to quality and safety standards to meet consumer’s preferences.
- Develop a strategy and action plan including policy implementation to improve postharvest and quality management and to mitigate effects of pests and diseases (including fruit fly management and Fusarium sp. banana wilt disease), incorporating sanitary and phytosanitary (SPS) and quarantine regulations.
The seven papers presented focused on issues that characterise tropical fruit development in the region. Emphasis was given to the threat of the Fusarium wilt disease on bananas, fruit fly infestation, good practices for mango and the requirements for good quality and safe fruits for market access.

**Paper 1: Global production and market of Tropical fruits: issues and challenges**
by Yacob Ahmad, TFNet Chief Executive Officer

Yacob Ahmad provided the global scenario including main fruit types, production and the amount traded. He highlighted that banana remains the main tropical fruit produced followed by mango, pineapple, papaya and avocado and other minor fruits, with Asia as the leading producer followed by Latin America and Africa, where generally 90 percent of the fruits produced are consumed domestically with only an estimated 5 percent traded as fresh fruits and another 5 percent are processed. Even though there has not being a drastic increase in production, in recent years, there is an increase in the export of tropical fruits, due to changing consumer trends and demands in the importing countries for fresh, safe, and quality produce. The speaker listed the common issues in the production of tropical fruits such as, traditional agriculture and outdated technologies, low quality produce and lack of infrastructure, especially access to production areas and post harvest facilities. Other related issues are lack of access to technology, pests and diseases, traditional market systems and smallholder inclusion into the value chain.

He also mentioned that the main enabling factors to improve tropical fruit production and trade are to institutionalise growers into groups, prioritize research and development, effective capacity building and extension system, private sector involvement to assist farmers and providing credit facilities for smallholder. As in other agricultural commodities, to improve international trade, emphasis has to be given to issues concerning Sanitary and Phytosanitary regulations, standards and market access through bilateral or regional agreements.

**Paper 2: Quality Assurance, Food Safety and Standards for Market Opportunities in Tropical Fruits**
by Prof. Abu-Bakr Ali Abu-Gough, University of Khartoum

Prof. Abu-Bakr Ali Abu-Gough began by saying that postharvest technologies have already been developed for ensuring quality assurance, food safety and good market access for tropical fruits. He presented the various causes of postharvest losses from handling up to packaging and also the various practices available to reduce losses, including practices in packinghouse operations for exports. Dr. Abu-Bakr also discussed the effect of waxing and use of fungicide such as benomyl to improve quality and shelf life of fruits. The details of postharvest effects on produce such as temperature build up, humidity and respiration was discussed. He also stressed on the use of chemicals to hasten or slow down ripening such as ethylene absorbers.

**Paper 3: Cultural practices, postharvest practices and IPM in mango**
by Bob Williams, Department of Plant Industries, Australia

Bob Williams introduced the topic by giving an indication of the current global mango trade, when, even though, world production of mango is estimated to be around 35 million metric tonnes, the world export trade is only around 1.2 million metric tonne, around 2.5 percent of
world production. This clearly demonstrates the positive contribution of mangoes in domestic trade, the potential for growth in export trade, but also the difficulties of moving mangoes into the export trade. He said that Australia is a very small participant compared to the large producers such of India and Brazil, with only a total production of 60,000 tonnes but 8,000 tonnes (13%) are exported.

Australian producers face the same generic mango problems like all other countries such as, low productivity, biennial bearing, inconsistent flowering, pest and disease, post-harvest quality losses and market access challenges. Even though there has been significant progress in addressing some of these issues, there are challenges quite unique to Australia including high cost of inputs such as land, labour and transport.

Mr. William’s presentation provided an insight to how we should address many of the generic challenges as well as how they are minimising the impact of high inputs’ costs.

**Paper 4: The Development of the Tropical and Subtropical Fruit Sector in Kingdom of Saudi Arabia**

*by Hassan M. Ali-Dinar, Food and Agriculture Organization of the United Nations, Kingdom of Saudi Arabia*

Dr. Hassan M. Ali-Dinar gave a background of the development of the Horticulture sector in KSA through the Technical Cooperation between FAO and the Ministry of Agriculture, which began as early as 1950 and has made significant and qualitative changes through the Unilateral Trust Fund Agreement which was signed between the Ministry of Agriculture and FAO since 1981. The agreement since 1981 was renewed every 5 years until the current one (2011-2016).

It includes 15 development projects among which is the horticulture project: Development and Technology Transfer of the Horticulture Sector in Kingdom of Saudi Arabia with a budget of USD 4,514,508 through the five years. The horticulture project involves the development of crops such as citrus, grapes and tropical fruits such as mango, pineapple, figs, pitaya, guava, papaya, and carambola. Other horticulture projects in the agreement with separate budgets include development of date palm and olive in the Kingdom.

The most common tropical fruits grown in the GCC countries are mango covering about 7,300 ha, papaya estimated at 625 ha and bananas at 4,350 ha which is mainly grown in Oman. Dr. Hassan mentioned that currently, GCC countries fruit production accounts for only 25.5 percent of domestic demands, while Saudi Arabia meets 35 – 46.8 percent of overall domestic demand. Fruits are imported from neighboring and other countries to satisfy demand. This evidently shows that there is more scope for development of fruits in these countries.

He also listed out the challenges in developing the fruit industry which includes restrictive water resources, increasing soil salinity and lack of suitable rootstocks, limited knowledge of appropriate harvest and post-harvest techniques, pests and diseases problems, limited research on good agricultural practices and lack to sufficient qualified national staff.

The speaker concluded that regional cooperation can be a way to jointly address common issues and share experiences, including developing projects through South-South cooperation. Collaboration with regional and international organisations is another avenue. Besides this technical initiatives including exploring other potential fruit types that are agro-climatically suitable and the exchange of genetic resources to build up a genetic pool to be used in research and development in the improvements of currently available species.
Paper 5: Banana Fusarium disease: the return of a catastrophic plant disease
by Altus Viljoen, Department of Plant Pathology, Stellenbosch University, South Africa

Dr. Altus Viljoen gave a background on one of the most destructive diseases in agricultural history which is threatening bananas again. In the early 1900s, Fusarium wilt destroyed Gros Michel bananas in Latin America to a point where they had to be replaced by Cavendish cultivars in order to save the international export trade.

Currently, Cavendish bananas make up more than 40% of all bananas grown globally in order to supply consumers worldwide. In most tropical countries, however, local banana varieties are mainly grown for food and income to small growers, thereby ensuring their livelihoods. The discovery of a new strain of the banana Fusarium wilt fungus in Asia in the 1990s, called \textit{Fusarium oxysporum} f. sp. \textit{cubense} (Foc) tropical race 4 (TR4), led to devastating losses of Cavendish bananas produced commercially in monoculture, but also to varieties planted by small growers.

Foc TR4 has a larger host range than any other race of Foc, and with a global replacement for Cavendish bananas not readily available, poses a significant threat to banana production worldwide. The fungus has been discovered in the Middle East in 2012 and soon thereafter in Mozambique.

The latter discovery was of significant concern, as banana serves as staple food to millions of people in Africa. Research efforts in Asia in the past two decades have developed somaclones of Cavendish bananas tolerant to Foc TR4 and have modified production systems to reduce the impact of the pathogen to small growers. It is, however, the intercontinental spread from Asia to Africa and the Middle East which urged the FAO and the international scientific community to develop a global programme to prevent a worldwide epidemic.

The objective of this programme is to manage Foc TR4 in areas where the disease is present, and to prevent its spread to unaffected areas by awareness raising, the introduction or legislation, and capacity development to deal with the disease. He also suggested that countries in the region be aware of the threat and formulate policies, conduct surveillances and other biosecurity activities to prevent the spread of this deadly disease.

by Dr. Kahil S. Yousif, Alzaiem Alazhari University

Dr. Kahil S. Yousif began with mentioning that post harvest losses occur mainly through lack of appropriate technologies and their subsequent transfer to producers. Post harvest management is about reducing mechanical damage by appropriate harvesting methods and proper handling, slowing down respiration by refrigeration, and other practices that can reduce water loss including packaging.

Reducing losses through recommended pests and diseases control, besides proper cultural practices is key in ensuring good quality produce. Improving postharvest management practices, should also be less costly, effective and within the reach of small farmers. This will need the establishment of cooperatives and farmers group, with participation from the private sector. Infrastructural development to improve access to production areas and provision of suitable collection centers are also important in mitigating post harvest losses.
Paper 7: Fruit fly management practices on tropical fruit in Africa
by Dr. Talal S. El-Abbassi, Plant Protection Research Institute, Egypt

Dr. Talal S. El-Abbassi began by introducing the difference species of fruit flies present and their distribution in Africa. He stressed the importance of fruit fly control in producing countries as it is a major factor in the African export markets.

*Bactrocera invadens* and *Ceratitis cosyra* are of the major constraints that in general limit tropical fruit production in Africa and mango fruits in particular. They cause up to 40–80% direct damage to mango fruits and also restrict export to large lucrative markets in Europe, the Middle East, Japan and USA.

A proposal of an international programme (a broad strategy) among African countries should be prepared to respond to the threat of these invasive pest species. Such programme must include a range of alternatives (exclusion, detection and prevention, and control).

Developing and implementing an integrated pest management (IPM) programme is highly requested to minimize the use of chemical pesticides to overcome these abovementioned problems and produce fruit fly-free and residue-free fruits to facilitate compliance with standards required for export markets. IPM is also dependant on information gathered from studies on the biology and ecology of any insect pest is key in the establishment of effective control measures that might enable us to win the battle against such pest.

Dr. Talal mentioned that the strategy of IPM programme is based on usage of all means of control procedures in a complementary way (legislative control, physical control, cultural control, biological control), Biotechnological Control sterile insect technique, wise use of pesticides and postharvest treatments). Before implementation of IPM, biological and ecological studies including geographical distribution, dominant species, life cycle and seasonal impact on insect population have to be conducted as prerequisites. Detecting or monitoring techniques normally used for fruit fly ecological assessment/studies include the use of traps and attractants.

Paper 8: A viable seed system is the basis for the successful banana postharvest value chain in Sudan
by Dr. Salah B. Bakhiet, Agricultural Research Corporation, Sudan

Dr. Salah B. Bakhiet provided information on most proper operations carried out in the production for export quality banana, starting from the seeds as basis for successful post harvest value chain. Planting material of high yielding banana cultivars suitable for export and local markets were obtained from international tissue culture laboratories. The existing plantings of these improved cultivars have shown, after being evaluated, that they can be grown and adopted by farmers successfully and provide a starting point for expansion. Each banana planting material has the potential to produce a bunch, which is identical to the mother plant. As with most of the vegetatively propagated crops, using poorly selected banana planting material can transmit serious pests and diseases, which can in turn result in considerable quantitative and qualitative yield losses.

Banana production for export in Sudan is at the threshold of new international markets in which the industry has to consistently increase productivity, export high quality fruits and reduce the high levels of fruit rejects if it is to compete on global markets and make considerable profit. He suggested recommendations which were based on the experience of the CFC banana funded project which was implemented since 2008, to promote banana production for export in Sudan.
Workshop discussion

The discussion session to deliberate on the papers presented was moderated by Dr. Sadig Hassan Omara, former State Minister of Ministry of Agriculture, Sudan, Dr. Abdul Latif Ijami, former Undersecretary of Ministry of Agriculture and Irrigation, Dr. Badreldin El-Sheikh, Director General, Horticulture Administration, Ministry of Agriculture and Irrigation, Dr. Hassan Ali Dinar, Chief Technical Advisor, FAO, Kingdom of Saudi Arabia and Yacob Ahmad, CEO, TFNet.

Generally, the discussion centred on implementation issues and financing of the various programmes in tropical fruit development in the region. Participants also suggested approaches to enhance the areas in research and development, biosecurity and sanitary and phytosanitary requirements (SPS) and capacity building in aspects of production and reduction of postharvest losses. The salient points which were raised and deliberated during the discussion session were as follows:

1. Strategic directions and plans can be listed down, but the total administrative and implementation mechanisms have to be included as part of the plan. For example in the case of prevention of the banana fusarium diseases, has to be a concerted effort with involvement of the various departments and agencies to act as a single entity. This is where having a coordinating mechanism is recommended. The private sector should also be invited for a more complete action plan.

2. Transfer of technology or extension services need to be improved with support from local research institutions such as universities, research centres and the private sector.

3. Sudan has ample natural resources such as land and water, plus human resources that can be mobilized to increase production of horticulture products for export. However, other external factors may negatively impact and reduce opportunities to further expand production both for domestic and export markets. Assistance in the form of collaborative projects between the country and international organisations should be considered and enhanced.

4. Infrastructure development to improve postharvest conditions to mitigate losses should be a continuous effort.

5. Dr. Altus reiterated that the threat of banana Fusarium disease is real and should be taken seriously. He continued by explaining the important steps that should be taken to combat the disease. Governments in the region, including Sudan, which is a high risk country, even though not affected, should take all steps to minimise the risk of the disease being introduced. He reminded that there should be a concerted effort including training of ground staff and farmers to recognise the disease, awareness campaign and formulation of policies related to enforcement of strict quarantine regulations, especially the movement of planting materials into the country. Agricultural technicians should be trained on the symptoms and visual identification of affected plants. Dr. Viljoen suggested that from now on, information on the disease should be shared among researchers, technicians and farmers with information notes, training programmes and workshops.

6. Mr. Bob Williams summarised by referring to the importance of a detailed analysis of the production system of tropical fruits. He cited that planting materials whether tissue cultured or grafted ones are important in the selection of demanded and marketable
cultivars. Ample water resources, good soil types and reduced incidences of soil borne disease are important prerequisites when selecting a commercial planting area or zone.

7. Dr. Talal emphasised on a survey to identify the different species of fruit flies in Sudan and that a National programme is needed for a holistic approach to mitigate fruit flies infestation.

8. Prof. Abu Bakar Abu Gough reiterated the need for good postharvest management practices in the production of quality and safe fruits including good infrastructure, harvesting method, time of harvest, temperature control, storage and packing. He also mentioned about pre-harvest practices that can reduce postharvest losses.
Summary and Recommendations

1. Countries in the region need to be aware and vigilant of the threat of the Fusarium wilt disease on bananas. Biosecurity measures such as movement of planting materials, equipment and personnel should be monitored and checked, since the disease has already been confirmed in Mozambique.

2. Emphasis has also to be given in the management of fruit flies through surveillance, monitoring and control including use of baits, and proper field management.

3. Preharvest and postharvest activities especially for mango need to be improved for better productivity and reducing losses, through targeted research and development, suitable varieties and enhance capacity building activities to address issues in production and integrated pest management.

4. Action plan in Sudan to reduce risk from banana Fusarium wilt disease. This includes the surveillance and enhanced quarantine and use of disease resistant planting materials. The Horticulture Sector Administration of the Ministry of Agriculture and Irrigation will be responsible in the charting of this action plan as soon as possible.


6. There has to be strengthening of the relevant institutions in Sudan especially the Horticulture Sector Administration, Ministry of Agriculture and Irrigation and the formation of a committee on commodity problems. There should also be a strong link between the Federal and State Agencies.

7. As funding appears to be a major concern, TFNet can take the lead to collaborate with other networks, FAO, countries and agencies in the region to propose projects pertaining to the issues discussed, and source for funds for implementation.

8. TFNet membership of African countries such as Ethiopia, Ghana, Kenya, Egypt and other countries in the region should be encouraged and sought.
### Programme Schedule

#### Day 1 - 04.03.2015 (Wednesday)

<table>
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| 0830 - 0900 | Registration of Participants  
|           | Introduction of Participants and Workshop Coordinators                       |
| 0900 - 0930 | Workshop Official Opening  
|           | - Welcome address by TFNet  
|           | - Welcome address by FAO, Kingdom of Saudi Arabia  
|           | - Opening address by State Minister, Ministry of Agriculture and Irrigation, Sudan |
| 0930 - 1000 | Tea / Coffee                                                               |
| 1000 - 1030 | Paper 1: Global tropical fruit production and trade – issues and challenges - TFNet |
| 1030 - 1100 | Paper 2: Quality assurance, food safety and standards for market access opportunities in the tropical fruits market - Prof. Abubaker Abougough, Sudan |
| 1100 - 1130 | Paper 3: Cultural and postharvest practices and IPM in mango – Mr. Bob Williams |
| 1130 - 1200 | Paper 4: Development of tropical and subtropical fruit in the Kingdom of Saudi Arabia – Dr. Hassan Ali-Dinar, FAO, Kingdom of Saudi Arabia |
| 1200 - 1230 | Paper 5: Banana Fusarium disease: the return of a catastrophic plant disease – Dr. Altus Viljoen, Stellenborsch University, South Africa |
| 1230 - 1400 | Lunch                                                                       |
| 1400 - 1430 | Paper 6: Post-harvest management practices in tropical fruits for better market access - Prof. Kahil Sobahi, Sudan |
| 1430 - 1500 | Paper 7: Fruit fly management practices in tropical fruits in Africa – Dr. Talal El- Abbassi, Plant protection research institute, Egypt. |
| 2000 - 2200 | Welcome Dinner                                                             |

#### Day 2 - 05.03.2015 (Thursday)

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<td>0830 - 0850</td>
<td>Paper 8: A viable system for planting materials as the basis for successful banana postharvest value chain in Sudan – Dr. Salah B. Bakhiet.</td>
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<td>0900 - 1000</td>
<td>Workshop brief</td>
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<td>1000 - 1030</td>
<td>Tea / Coffee</td>
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<td>1030 - 1130</td>
<td>Workshop conclusion session and recommendations</td>
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<td>1130 - 1430</td>
<td>Field trip to Zadna Agricultural Corporate.</td>
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<td>1430 - 1530</td>
<td>Lunch</td>
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<td>2000 - 2200</td>
<td>Private Company Dinner and Host Country Awards</td>
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# List of Participants

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<td>Pro. Hassan Ali Dinar</td>
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<td>Bahaeldin Mohamed Khamis</td>
<td>Ministry of Agriculture, Sudan</td>
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<td>Bob Williams</td>
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<td>Daralsalam Abd. Algadir</td>
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<td>Dr. Afaf Elgozouli</td>
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<td>Dr. Salah M. Taha</td>
<td>Wheat production Project</td>
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<td>Dr. Awadalla Abdalla</td>
<td>University of Khartoum, Sudan</td>
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<td>DR. GAAFAR Aitmed</td>
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<td>Dr. Salah Babiker Bakhiet</td>
<td>Agricultural Research Corporation, Sudan</td>
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<td>Dr. Mahdi Abdurehman Ahmed</td>
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<td>Dr. Salah M. Elawad</td>
<td>Department of Agricultural Economics</td>
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<td>Ekhas Altayb</td>
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<td>Ibrahim Hassan</td>
<td>Ministry of Agriculture, Sudan</td>
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<td>Lubna Mohammed Sidahmed</td>
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<td>Mohamed Yahia Mohamed Mahgoub</td>
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<td>Prof. Hassan M. Ali Dinar</td>
<td>Food and Agriculture Organization of the United Nations, Kingdom of Saudi Arabia</td>
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<td>Prof. Dr. Talal Salaheidin ELABBASSI</td>
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<td>Sitelnafar Ibrahim</td>
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<td>Yacob Ahmad</td>
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<td>Zeinab Elsayed Eldoush</td>
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OVERVIEW ON GLOBAL TROPICAL FRUIT PRODUCTION AND TRADE: ISSUES AND CHALLENGES

By yacob@ifnet.org
International Tropical Fruits Network (TFNet)

International Tropical Fruits Network (TFNet) is an autonomous and self financing global network established under the auspices of the Food and Agriculture Organization of the United Nations whose mandate is to promote sustainable development of the tropical fruit industry globally in relation to production, consumption and trade.

- Established in 2000
- It is both intergovernmental and inter-institutional in nature.
- Membership based - County, Associate and Ordinary
- Based in Serdang, Malaysia

Objectives of TFNet

- To act as a repository and exchange of information on tropical fruits;
- To promote, co-ordinate and support research and development as well as transfer of technology;
- To facilitate the expansion of international trade of tropical fruits;
- To enhance human resource development;
- To organize generic market promotion and strengthen consumer knowledge on the nutritional value of tropical fruits;
- To sensitize and facilitate implementation of international and regional agreements on tropical fruits;
- To promote technical and economic exchanges in the tropical fruit sector.

Country Members

- Bangladesh, China, Fiji, India, Indonesia, Malaysia, Nigeria, Philippines, Sudan, Syria, Vietnam, Australia, Sri Lanka, and Saudi Arabia

TFNet Membership status 2001 - 2014

APPENDIX 3

Paper 1: Global production and market of Tropical fruits: issues and challenges
by Yacob Ahmad, TFNet Chief Executive Officer
What do we do...

- Studies, projects and consultancies
- Capacity development – workshops, symposiums, conferences etc
- Information dissemination, knowledge sharing

TFNet Website: www.itfnet.org

Background

- Tropical fruits – important to developing for nutrition, income generation, for food security, another export option
- Banana – top five commonly eaten fruit and fourth most important food crop after rice, wheat and maize
- World production in 2012 – 101 million tonnes
- Exported 17.2 million tonnes valued at USD 8.4 million
- More for domestic production, 17% (Cavendish) is internationally traded
- 80% of International trade of Cavendish banana controlled 5 multinational companies
- Now supermarket chains control 60% of trade

Source: FAO

Background

- Other major tropical fruits – 71 million tonnes in 2012
- Mangoes (39%), pineapples (23%), papaya (12%) avocado (4%), Minor fruits (22%)
- On basis of trade, the minor ones are guava, mangosteen, rambutan, durian, passionfruit, litchi, pomelo.
- 90% domestically consumed, 5% traded fresh and 5% processed.
- Global trade estimated at 8.1 million tonnes valued at USD 7.7 billion
- Additional USD 4 billion as processed products
- Asia is the main producer of tropical fruits mainly by smallholders

Source: FAO
VIETNAM: Ministry commission about promoting mango exports in global market

The Ministry of Agriculture and Rural Development will send a delegation to other countries to promote the Vietnamese mango export market.

The ministry's spokesperson said that the delegation aims to help local mango farmers improve the quality and quantity of their produce.

INDIA: Farmers in Jharkhand reap $2 million

Farmers in Jharkhand have earned $2 million from the sale of mangoes.

The state's agriculture minister said that the farmers have excelled in the mango export market.

INDIA: Mango exports to hit $100 million

Mango exports from India are set to hit $100 million this year.

The state's agriculture minister said that the export target has been set to boost the state's economy.

Total Exotics

Mango

The mango season is underway, and the fruit is already proving to be a success.

Avocado

Avocados are proving to be a popular choice among customers.

The state's agriculture minister said that the avocado export target has been set to boost the state's economy.
KODIA: Flower of grafted mango: raw-tasting boosted zucchini

AUSTRALIA: Researchers work to wipe out virus crippling banana industry

VIETNAM: Importer ‘regrets’ Australian fresh fruit ban

NEPAL: Banana production drops due to plant disease

LEBANON: New mobile phone saved banana from accidental kill

NZ: Growers confident fruit fly is an isolated event
PERU: Organic bananas afraid of Euro situation

“Last year, we exported 92% of what we produced to Europe, but this year we are reducing our volume of shipments to European destinations to 75% because we are afraid of what might happen to the Euro,” said Angeru Garcia, manager of APPICSA.

PERU: Mangoes, asparagus undergo phytosanitary controls to enter Korea, China

Peru’s Agriculture Ministry welcomed South Korean and Chinese delegations of phytosanitary organizations to discuss the entry of Peruvian mangoes and asparagus, respectively, into their markets.

USA: Binational committee formed to open for South African avocados

Executives representing the top three avocado companies in the United States and South Africa announced during Fruit Logistica in Berlin the establishment of the U.S.-South Africa Avocado Committee.
Packaging – Chinese retail market

Packaging for the export market
Niche market – immature jackfruit

Reduction of post harvest losses
- On farm packaging, good Handling
  • On farm packaging to minimize handling
  • Direct contract with supermarkets
  • Farmers groups involved
  • Quality assurance - premium
Reduction of post harvest losses
- Good handling,
- on-farm packaging

• On farm packaging to minimize handling
• Direct contract with exporter
• Exported to Singapore – air
• Quality assurance - premium

Observations:
• The market factor – products targeted to consumer group, market segmentation, expanding middle class
• Smallholders' inclusion into the value chain and the market system
• Element of price determination and market
• Postharvest losses throughout the value chain ...30 - 40% ?
• Seasonal production – glut, go for mixed crop ?
• Lack of appropriate technologies – varieties, production methods
• Increased incidences of pests and diseases
• Export markets – SPS requirements
• Competitiveness

Key issues in tropical fruit development
• Infrastructure development
• Requirements for certifiable international production, food safety and quality standards
• Smallholders integration into value chain
• Post harvest losses
• Pest and disease outbreaks – related to climate change
• Lack of appropriate production technologies
• Transfer of technology
• Compliance to Sanitary and phytosanitary regulations for the export market
• Economic viability - competitiveness

CONCLUSION
• Institutionalize growers – cooperatives, farmers groups
• Participatory approach for stakeholders
• Prioritize research and development
• Direct private sector linkage
• Capacity building for growers and other stakeholders – transfer of technology
• Availability of market information
• Credit facilities for equipment, technology
• Appropriate policy formulation – especially on SPS quarantine and biosecurity issues
• Infrastructure development
THANK YOU...
Topics:
1. Introduction.
2. Harvesting.
4. Temperature Management.
5. Control of Relative Humidity.
7. Control of Pest and Diseases.
8. Special Chemical Treatments.

1. Introduction:

A number of post-harvest technology procedures have been developed for:
- Quality Assurance
- Food Safety
- Good Market Opportunities

In the Tropical Fruits...

Many post-harvest losses are direct results of factors before harvest.

Fruits that are:
- Infected with pests and diseases,
- Inappropriately irrigated and fertilized,
- Generally of poor quality before harvesting,
**Can Never be Improved by Post-Harvest Treatments.

Very often the rate of commodity loss is faster if the quality at harvest is below standard.

Thus, the processes of attainment and maintenance of quality from production, harvesting, handling and marketing must be considered a unified system.

Post-harvest technology procedures should be adopted to:
- Minimize deterioration.
- Reduce post-harvest loss.
- Maintain quality.
- Extend shelf-life.
Harvesting refers to the gathering of the fruits from the orchard:

- at the proper level of maturity,
- with a minimum of damage,
- as rapidly as possible,
- at a minimum cost.

Harvesting at the proper level of maturity is essential for good quality produce.

Over-maturity or under-maturity will affect the quality adversely, and should be avoided.

Method of harvest should protect the produce from any injuries or bruises.

Suitable harvesting tools, hand gloves, containers and supplies are needed by the harvesters.

Careful field supervision is the most critical factor in protecting fruits from injuries.

Most fresh market tropical fruits are now harvested by hand, because human can accurately select for maturity and can handle the fruits with a minimum of damage.

Poor harvesting methods lead to deterioration of the Crop

Improvement of harvesting method reduces post-harvest losses and maintains quality
The improved harvesting method decreased respiration rate, reduced weight loss, delayed fruit ripening and senescence, improved quality and extended shelf-life of mangoes, papayas and grapefruits.

Mango fruits in the different quality grades harvested by the traditional and improved harvesting methods

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Harvesting Method</th>
<th>Quality Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V. Good</td>
<td>Good</td>
</tr>
<tr>
<td>Dr. Knight</td>
<td>Traditional</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>21.4</td>
</tr>
<tr>
<td>Abu-Samaka</td>
<td>Traditional</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Improved</td>
<td>20.3</td>
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Papaya fruits in the different quality grades harvested by the traditional and improved harvesting methods

<table>
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<tr>
<th>Harvesting Method</th>
<th>Quality Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. Good</td>
<td>Good</td>
</tr>
<tr>
<td>Traditional</td>
<td>0</td>
</tr>
<tr>
<td>Improved</td>
<td>21.6</td>
</tr>
</tbody>
</table>


Grapefruits in the different quality grades harvested by the traditional and improved harvesting methods

<table>
<thead>
<tr>
<th>Harvesting Method</th>
<th>Quality Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. Good</td>
<td>Good</td>
</tr>
<tr>
<td>Traditional</td>
<td>1.5</td>
</tr>
<tr>
<td>Improved</td>
<td>21.8</td>
</tr>
</tbody>
</table>


3. Gentle Handling:

- Horticultural products due to their soft texture should be handled gently to minimize bruising and breaking of the skin.
- The skin of horticultural products is an effective barrier to most pathogenic bacteria and fungi that cause rotting of the tissue.
- Gentle handling of horticultural products should be promoted at all stages of the marketing channel as means for reducing post- harvest losses and maintaining the quality of the produce.

4. Temperature Management:

- Good temperature management is the single most important tool that we have to maintain post- harvest quality and to extend shelf-life horticultural products.
- Proper temperature management begins with temperature protection in the field, which involves:
  1. Harvest during the cool early morning hours.
  2. Shading the harvested fruits to minimize warming and sunscald.
  3. Quick handling and cooling to minimize high temperature exposure.
5. Control of Relative Humidity:

- Most horticultural crops store best in an environment that has a relative humidity of 85-95%.
- Such high humidity retards wilting and maintains the better conditions.
- Relative humidity can influence:
  1. Water loss.
  2. Decay development.
  3. Some physiological disorders.
  4. Fruit ripening.

Relative humidity control can be achieved by one or more of the following procedures:

1. Addition of moisture to the air by use of humidifiers.
2. Regulation of air movement and ventilation.
3. Use of moisture barriers; such as:
   - Insulation of storage rooms.
   - Polyethylene liners in containers.
   - Plastic films for packaging.
   - Waxing of fruit.

Topics:

1. Introduction.
2. Harvesting.
4. Temperature Management.
5. Control of Relative Humidity.

6. Preparation of Tropical Fruits for Marketing:

- Horticultural commodities may be prepared for market and packed:
  1. In the field (Field packing).
  2. In simple packing stations.
  3. In packinghouses.

- Packinghouse Operations include:
  1. Receiving.
  2. Washing.
  3. Drying.
  4. Waxing.
  5. Sorting.
  7. Sizing.
  8. Packaging.

Preparation of Mangos for Marketing:

- Heat Treatment
- Dumping
- Washing
- Electronic Sizing
- Sorting
- Grading
- Packaging
7. Control of Pest and Diseases

➢ Post-harvest procedures, leading to the maximum physiological life of a commodity, are often those which minimize fungal rots.

➢ Maintaining a fruit at high vitality, enhances its natural disease resistance and ability to heal wounds.

Principles of disease control include:

➢ Prevention: “Prevention is better than cure”.

➢ In most instances, control of post-harvest wastages should commence before harvest, in the field or orchard.

- Propagating materials should be virus free and bacterial free.
- Sources of infection should be eliminated and sprays for the control of the causal organisms or vector should be applied.

Careful handling during harvesting can minimize mechanical injury and can reduce subsequent wastage due to microbial attack.

Chemical protection by using fumigation or fungicide treatment.

Heat treatment in the form of either moist hot air or hot water dips (50 – 55°C) have some commercial application for control post-harvest pest and diseases in papayas and mangoes.

Retardation of Microbial Growth can be employed through:

a. Temperature Control:
   - Low temperature handling and storage is the most important physical method of post-harvest wastage control.

b. Modified Atmosphere:
   - Very low O₂ and high CO₂ can slow down and control fungal growth.

c. Fumigation: [Such as sulfur dioxide (SO₂)].

d. Radiation:
   - Ionizing radiation are effective in inhibiting microbial growth, but can cause physiological damage.

The effect of waxing and fungicide treatment (Benomyl) on quality and shelf-life of mangoes and grapefruits was evaluated.
Waxing the fruits decreased respiration rate, reduced weight loss, delayed fruit ripening and senescence, retained ascorbic acid, improved quality and extended shelf-life of mangoes, guavas, papayas, limes and grapefruits.

Effect of waxing and fungicide treatment on quality of mango fruits

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Treatment</th>
<th>V. Good (%)</th>
<th>Good (%)</th>
<th>Fair (%)</th>
<th>Poor (%)</th>
<th>Unmarketable (%)</th>
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<td>Dr. Knight</td>
<td>Untreated</td>
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<td>37.0</td>
<td>33.2</td>
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<td></td>
<td>Waxed</td>
<td>19.7</td>
<td>31.0</td>
<td>31.8</td>
<td>13.9</td>
<td>3.6</td>
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<td></td>
<td>Waxed + Fungicide</td>
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<td>36.5</td>
<td>20.6</td>
<td>11.4</td>
<td>1.2</td>
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<td>28.9</td>
<td>31.2</td>
<td>39.6</td>
<td>10.2</td>
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<td></td>
<td>Waxed</td>
<td>21.6</td>
<td>32.7</td>
<td>28.3</td>
<td>16.3</td>
<td>4.1</td>
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<td></td>
<td>Waxed + Fungicide</td>
<td>24.1</td>
<td>36.1</td>
<td>23.4</td>
<td>14.7</td>
<td>1.7</td>
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Effect of waxing and fungicide treatment on quality of ‘Foster’ grapefruits

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Quality Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>V. Good (%)</td>
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<tr>
<td>Untreated</td>
<td>5.0</td>
</tr>
<tr>
<td>Fungicide</td>
<td>5.5</td>
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<tr>
<td>Waxed</td>
<td>13.5</td>
</tr>
<tr>
<td>Waxed + Fungicide</td>
<td>14.0</td>
</tr>
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The effect of paper and polyethylene package lining on quality and shelf-life of bananas, mangoes and papayas was evaluated.

- Package lining significantly delayed fruit ripening, maintained quality and extended shelf-life of banana, mango and papaya fruits.
- Weight loss was reduced in papayas by:
  - Paper lining ............... 9.5 %.
  - Film lining .................. 20.8 %.
- Banana fruit ripening was delayed by 6 - 7 days in the perforated and sealed polyethylene film package lining with GA3 treatment (100 ppm). (Osman and Abu-Goukh, 2008).
- Banana fruit ripening was delayed by 8 - 12 days in the perforated and sealed polyethylene film package lining with KMnO4 (0.5 g).

Package lining and KMnO4 significantly delayed fruit ripening, maintained quality and extended shelf-life of mango fruits.

- Control
- Perf. Film
- Perf. Film + 1g KMnO4
- Perf. Film + 2g KMnO4

15 days at 18 ºC


8. Special Chemical Treatments:

- A number of chemicals may be applied to fruits in order to obtain a desirable post-harvest effect.

1. Chemicals that hasten ripening:
   - Ethylene and compounds that release ethylene, such as Ethrel (Ethaphon).
   - Growth retardants that inhibit growth and ripening.
     - Such as: Gibberellins (GA3), Maleic hydrazide, 2,4,5-T.
   - Ethylene absorbents and Inhibitors.
     - Such as: KMnO4, ‘Purafil’, 1-MCP.

2. Ethylene gas was 100 times more effective than acetylene in inducing fruit ripening of bananas.

- Control
- 10 ppm Ethylene
- 1000 ppm Acetylene


1. Chemicals that hasten ripening:

- Effect of Ethylene, Acetylene, Ethrel in aqueous solution and Ethylene released from Ethrel on fruit ripening and quality of bananas, mangoes and guavas was evaluated.

Ethylene gas released from ethrel was more effective than ethrel in aqueous solution in enhancing the climacteric peak and inducing fruit ripening in bananas, mangoes and guavas.

Effect of ethylene gas released from Ethrel on banana fruit ripening


2. Growth retardants that inhibit growth and ripening.

- **GA3 (100 & 200 ppm)** and waxing on guavas reduced respiration rate, weight loss, fruit softening, peel color development, maintained quality, delayed fruit ripening and extended shelf-life 6 - 8 days.

- **2,4,5-T (500 & 1000 ppm)** and waxing on limes reduced respiration rate, weight loss, fruit softening and degreening, retained ascorbic acid, maintained quality, delayed senescence and extended storage life.

- **Maleic hydrazide (250, 500 & 1000 ppm)** and waxing on guavas, delayed respiratory climacteric, reduced weight loss, fruit softening and peel color development, maintained quality, delayed fruit ripening and extended shelf-life 7 – 10 days.


3. Ethylene absorbents and Inhibitors:

- These delay ripening and senescence because they remove the ethylene produced by the fruit or inhibit ethylene action.
- They are usually placed in close proximity to the commodity and leave no residue on it.
- Examples are:
  - Potassium permanganate.
  - ‘Purafil’ (Potassium permanganate-impregnated in alumina or vermiculite).
  - 1-Methylcyclopropene (1-MCP).

1-Methylcyclopropene (1-MCP) significantly reduced respiration rate, weight loss, fruit softening, peel color development, retained ascorbic acid, maintained quality, delayed fruit ripening and extended shelf-life of mangoes and bananas.

1-MCP (250 & 500 ppb) delayed mango fruit ripening 4 - 7 days (without waxing) and 6 – 9 days (with waxing).

1-MCP (62.5, 125 & 250 ppb) delayed banana fruit ripening 12, 16 and 20 days, respectively, compared with the control.

Post-Harvest Technology Procedures
Paper 3: Cultural practices, postharvest practices and IPM in mango  
by Bob Williams, Department of Plant Industries, Australia

Presentation Overview

1. Global Picture of Mango Production and export  
2. The Australian Mango Industry  
3. Challenges  
   a. Disease  
   b. Productivity  
   c. Market access

Global Mango production

Major Mango Varieties in Australia

Kensington Pride  
R2E2  
Honey Gold  
Calypso

NT Production over Past 22 years

Australian Mango Industry 1990-2012

NT Mango Industry 1990-2012
Significant influences over past 10 years

- Increased plants of new varieties
- Smaller growers moving out – larger growers becoming more professional.
- Improved infra-structure to attract and retain producers. Eg roads, transport, labour accommodation, agribusiness suppliers.
- Change of attitude of industry players.

Major Production Regions 2012

Trends into the next 10 years

Current status of exports

Common Issues.
Common Issues.

Point of Difference

<table>
<thead>
<tr>
<th>Rank</th>
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<td>2,610</td>
</tr>
<tr>
<td>2</td>
<td>Brazil</td>
<td>778</td>
</tr>
<tr>
<td>3</td>
<td>China</td>
<td>656</td>
</tr>
<tr>
<td>4</td>
<td>Mexico</td>
<td>609</td>
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<tr>
<td>5</td>
<td>Egypt</td>
<td>445</td>
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<tr>
<td>6</td>
<td>Thailand</td>
<td>381</td>
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<td>7</td>
<td>Syrian Arab Republic</td>
<td>354</td>
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<td>8</td>
<td>India</td>
<td>250</td>
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<tr>
<td>9</td>
<td>Philippines</td>
<td>210</td>
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<tr>
<td>10</td>
<td>Pakistan</td>
<td>250</td>
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</tbody>
</table>
First Challenge – Disease.

The traditional approach.
- Pre-harvest fungicide treatments
- Post harvest fungicide dip

Concerns.
- Only focused on the disease post flowering.
- Increased pressure on the fungicide.
- Fungicide resistance.
- Fungicide residues in fruit.
- Some fungicides do not meet CODEX standards.
- Consumers.

Progress

Demonstrate the role of inoculum reduction in disease management
Integrate inoculum reduction.
Strategies with fungicide sprays in an integrated system.
Improve the efficiency of current postharvest fungicide dips by a reduction on orchard fruit infection.
First Challenge – Disease. Progress

Pathologist and Breeders working together

- Inoculum Reduction Strategies.
  - Pruning
  - Alternative treatments in the vegetative stage

First Challenge – Disease. Progress

Pathologist and Agronomists working together

Natural stalk-end rot developments during ripening, in fruits harvested from plants grown under different soil K levels

Pathologist and Plant Physiologists working together

Focus on how the plant is functioning:
- Understand the aetiology of the pathogen at all stage of the plant's phenology.
- Target fertiliser programs that impact on the plant's defence mechanisms when the pathogen is weakest.
- Use plant activators to compensate for the impact of fertiliser on defence mechanisms.

First Challenge – Disease. Progress

Thinking about the SYSTEM and not the issue.

Fruit quality cannot be improved after it has been harvested.

All "ologists" need to understand:
- how the plant is reacting to interventions to achieve maximum performance.
- What the consumer is looking for.
Challenge Two: Improve on Farm Productivity.

- Low Productivity
- Biennial Bearing
- Uniformity of:
  - Flowering
  - Fruit set
  - Fruit Retentions
- Efficiency in Harvest
  - One past harvest v's 3 passes
  - Mechanisation of harvest

Challenge Two: Improve on Farm Productivity.

- Orchards design
  - Higher density
  - Wider production window on individual farms
  - Netted farms
  - Alternative harvesting and packaging systems
- Wider geographic production region

NT RD&E Strategies

Expanded production window:

- New varieties - NMBP plus others
  - Potentially an additional 100,000 trees.
  - Greater yields, higher pack out
- New Rootstocks.
  - Stocks impacted on yield, growth rates, canopy & profit
  - Opportunity with selected stocks to enhance new scion varieties
    and orchard systems
  - Link key production & market parameters’ with selected stock
    attributes - as for other mature fruit industries!

Challenge 2: Alternative On Farm Production Options.

1. Expanded production window:
   - Climate.

   The Madden-Julian Oscillation (MJO) is the major fluctuation in tropical weather on weekly to monthly timescales. The MJO can be characterized as an eastward moving "pulse" of cloud and rainfall near the equator that typically recurs every 36 to 90 days.
1. Expanded production window:
- Agronomic practices
  - Investigate the role of N in flower induction
- Crop Modeling.
  - Develop a growth model for mango to predict plant responses to various interventions to manipulate flushing, flowering and fruit maturity.
- Vegetation Inhibitors.
  - Evaluate and understand the modes of action of the various synthetic promoters and critical factors influencing performance of vegetative initiation and inhabitation.

1. Expanded production window:
- Floral Induction.
  - Evaluate and understand the modes of action of the various synthetic promoters and critical factors influencing performance of floral induction.
- Development of molecular tools
  - To detect FT expression and confirm the role of this gene in mango. This work will be conducted at Berrimah Research Farm, in collaboration with research teams in China.

Vegetative Inhibitors

Ethephon for hardening off vegetative growth.

Floral Induction

Potassium Nitrate for floral induction.

Potential Influences on Fruit Maturity

- Synthetic Promoters
  - PBZ
  - KNO3
- Genetic
  - Regional Rootstock x Scion Trails
  - Rootstock germplasm
- Physical
  - Canopy Management
  - Pruning
  - Circling
- Environmental
  - Soil
  - Aspect
  - Rain
- Climatic Factors
  - Heat units
  - MJO
- Agronomic
  - Role of Nitrogen
  - Role of irrigation

Mango Phenological Cycle
Challenge 3 Improve Market Access

<table>
<thead>
<tr>
<th>Country</th>
<th>Fruit Fly Treatments</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>✓</td>
<td>VHT Protocol</td>
</tr>
<tr>
<td>Japan</td>
<td>✓</td>
<td>VHT Protocol</td>
</tr>
<tr>
<td>Korea</td>
<td>✓</td>
<td>Property Freedom for MSW</td>
</tr>
<tr>
<td>China</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>✓</td>
<td>No other insects</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>UAE</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
<td>Post-harvest dip with dimethoate for FF</td>
</tr>
</tbody>
</table>

Commercial harvest of mangoes in Australia

Mature Firm Green
- Dry matter >14% <16.5%
- Flesh colour as per industry standard

Steps in the logistics of Mango

<table>
<thead>
<tr>
<th>Process</th>
<th>Time Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest, hold and cool fruit</td>
<td>Day 1</td>
</tr>
<tr>
<td>Package fruit</td>
<td>Day 2</td>
</tr>
<tr>
<td>Cool fruit to 14°C</td>
<td>Day 3</td>
</tr>
<tr>
<td>Transport fruit to Disinfestation Facility</td>
<td>Day 8</td>
</tr>
<tr>
<td>Disinfestation process</td>
<td>Day 10</td>
</tr>
<tr>
<td>Sea freight to China at 14°C</td>
<td>Day 31</td>
</tr>
<tr>
<td>Ripening on arrival</td>
<td>Day 35</td>
</tr>
<tr>
<td>Distribution to supermarket</td>
<td>Day 36</td>
</tr>
</tbody>
</table>

Fruit Fly Market Access

Summary of export requirements from Australia

Vapour Heat Treatment (VHT) for fruit fly is mandatory for all mangoes being exported to China, Korea and Japan.

<table>
<thead>
<tr>
<th>Country</th>
<th>VHT Irradiation Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand</td>
<td>✓</td>
</tr>
<tr>
<td>Japan</td>
<td>✓</td>
</tr>
<tr>
<td>Korea</td>
<td>✓</td>
</tr>
<tr>
<td>China</td>
<td>✓</td>
</tr>
<tr>
<td>USA</td>
<td>✓</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>✓</td>
</tr>
<tr>
<td>Singapore</td>
<td>✓</td>
</tr>
<tr>
<td>UAE</td>
<td>✓</td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
</tr>
</tbody>
</table>

Does this actually happen with mature hard green mangoes?

New Zealand:
Irradiation dose rates
- ICA 55 recommends
  - 150 Gy for Fruit fly only
  - 300 Gy for Mango Seed Weevil plus fruit fly
- All mango varieties
What research data is this market access protocol based on?

The evidence that mangoes are a host of Fruit Fly!

Researchable Questions.

1. Are mature hard green mangoes a host of fruit fly?
2. At what stage of maturity do mangoes become susceptible to fruit fly?
3. What is the correlation between fruit fly pressure and fruit maturity?

Testing the accepted

- Two pest species
- Mangoes 4 Varieties
- Four production areas
- Fruit fly trapping program to determine populations pressure.
- Fruit collection at harvest.
- No field treatments to manage fly populations.
- Caged trails

- So far assessed over 110,000 commercially harvested fruit
- Collect untreated fruit at shed
- Measure maturity / fruit quality on sub-sample
- Hold 12-14 days at 22°C
Method: fruit assessments

Fruit quality assessments for each batch of fruit collected

Method: fruit assessments

Cutting fruit to assess presence/absence of fruit fly larvae

Conclusions

Total fruit assessed over four years. >110,000

The evidence to date;

When mangoes are harvested at the mature hard green stage, without any skin damage (cuts, cracks, scratches), the two Fruit Fly species within Northern Territory, appear not to favour the fruit at this stage or the eggs are not able to develop.

Commercial harvest of mangoes in Australia

Mature Firm Green
- Dry matter >14% <16.5%
- Flesh colour as per industry standard

Defects
NO defects

Class 1 Export grade

Fruit Fly Market Access
An Alternative Option

What have we learned?

Market access principles need to be based on commercial practices.

Key Learnings

Think of the production system and not the issue.

All participants in the research team need to understand the production systems and how the plant is functioning.
Systems Research

Thanks to the research teams in
  • Pakistan, Sri Lanka, Philippines, Indonesia, Cambodia and Australia.
  • Australian Centre for International Agricultural Research (ACIAR).

Come across
THE DEVELOPMENT OF THE TROPICAL AND SUBTROPICAL FRUIT SECTOR IN KINGDOM OF SAUDI ARABIA (1981-2016)

Hassan M. Ali-Dinar
FAO-UN, Kingdom of Saudi Arabia
Saleh A. Algahtani
Jazan Agriculture Research Centre, Ministry of Agriculture, Kingdom of Saudi Arabia
Ali A. Aljaleel
Najran Horticulture Research Centre, Ministry of Agriculture, Kingdom of Saudi Arabia

Success Stories Through the Technical Cooperation Programme (1981-2016)

Within the Horticulture Sector, properly functional research and specialized centres have been developed:
- Najran Horticulture Research Center (citrus)
- Jazan Agriculture Research Center (tropical fruits)
- The National Date Palm Research Center
- The Olive Research Unit at Al Jouf
- Ulaa Citrus Propagation Centre
- Integrated Farm Systems and Extension Centres (Eastern Region, Central Region, Northern Region, Southern Region) (date palm, citrus, grapes, mango, pitaya, pineapple, figs, olive)
- Pilot Extension Farms (Ulaa, Baha) (citrus, grapes, pomegranate)

Production, Areas and Tree Population

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Area (Ha)</th>
<th>Production (MT)</th>
<th>Tree Population (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mango</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>5,130</td>
<td>125,000</td>
<td>600,000</td>
</tr>
<tr>
<td>Oman</td>
<td>1,072</td>
<td>10,199</td>
<td></td>
</tr>
<tr>
<td>UAE</td>
<td>972</td>
<td>4,200</td>
<td>120,000</td>
</tr>
<tr>
<td>Papaya</td>
<td></td>
<td>6,314</td>
<td>220,470</td>
</tr>
<tr>
<td>SAUDI ARABIA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oman</td>
<td>304</td>
<td>1,760</td>
<td></td>
</tr>
<tr>
<td><strong>Banana</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oman</td>
<td>4,372</td>
<td>58,762</td>
<td></td>
</tr>
</tbody>
</table>
Fruit Imports

Saudi Arabia (2011-2012):
- Mango (3.9%) of sharing global imports
- Mango (62,279 MT) (Yemen: 59.29%, Pakistan: 20.28%, India: 9.61%, Egypt: 4.21%, and Kenya: 3.94%)
- Banana (306,173 MT)
UAE (2011-2012):
- Mango (5.2%) of sharing global imports

TECHNICAL COOPERATION PROGRAMME 2011 – 2016

Sub-programme
- Sustainable Agriculture Production and Good Agriculture Practices (GAP)
- Establishment of an International Date Palm Centre
- Development of Olive Production and Processing Techniques
- Development and Technology transfer of the Horticulture Sector in KSA
- Support of Sustainable Rural Development Programme

Najran Horticulture Research Centre

Propagation Nurseries
More than 1,823,250 disease free grafted citrus trees were distributed to farmers since 2007
A new nursery with a capacity of 250,000 grafted citrus trees per year

Citrus Gene banks
125 citrus cultivars were introduced and considered one of the largest in the middle east and the largest in the Gulf States

Research and Production Technologies
- Organic manure application

Capacity Building
- Study tours to train Saudi Nationals were conducted to more than 15 countries worldwide, located in Europe, USA, South East Asia, Middle East and North Africa.
- More than 3000 researchers, agricultural engineers and farmers were trained since 2007.
### Mango Gene Bank

It includes 50 mango cultivars introduced worldwide.

### Mango introductions over the past years

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
<th>Cultivars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>11</td>
<td>Tommi Atkins, Palmer, Julie, Zoll, Kent, Haden, Kelfir, Sabiria, Apple, Borebus, Kittshener</td>
</tr>
<tr>
<td>1983</td>
<td>5</td>
<td>Glenn, Van Dyke, Najwa, Otto, Sensation</td>
</tr>
<tr>
<td>1984</td>
<td>12</td>
<td>Hindi Khass, Parie, Bulk Heart, Zibda, Vajr Klein, Hindi Bonemarra, Goliuk, Awaise, Yemenia, Karabau, Neilum, Taymour</td>
</tr>
<tr>
<td>1989</td>
<td>4</td>
<td>Kingston, Osso, Florigen, Nam Dog My</td>
</tr>
<tr>
<td>2007</td>
<td>8</td>
<td>11-1, Turpentine, Kansar, Benshan, Royal Special, Mallka, Valencia Bright, Langra</td>
</tr>
<tr>
<td>2010</td>
<td>7</td>
<td>Kubania, Goose Neck, Dibsha, Mabruka, Aromanis, Sukarrie, Naoumi</td>
</tr>
<tr>
<td>2011</td>
<td>3</td>
<td>Vazlie, Kazalla, Imperial</td>
</tr>
</tbody>
</table>

### Other tropical fruits

- Pineapple (Perola, Jupi, Hawaii, Red Spanish)
- Guava (FAO, Jazan)
- Figs (Brown Turkey, Local, Mailly)
- Cashew
- Carambola
- Sapote
- Annona
- Papaya (Solo, Somali, Jordanian)
Research and Production Technologies

Research on production aspects particularly flowering and fruit set and adaptability of rootstocks to environmental stresses are major in addition to harvest and post harvest.
Major Constraints/ Challenges

• Restricted water resources
• Increasing soil salinity
• Lack of proper rootstocks to reduce salinity hazards
• Limited knowledge of appropriate harvest and post-harvest techniques
• Pests and diseases (Fruit fly and mango die back)
• Limited research on good agricultural practices
• Lack of sufficient qualified national staff
The Way Forward

- Regional cooperation to address jointly the major common problems and share experience
- Promote South-South cooperation and develop joint projects that address the common major problems
- Liaise with regional and international organizations for potential support to address common problems
- Explore potential fruit crops that tolerate the existing environmental conditions and of added value to fruit growers
- Exchange of relevant genetic resources
Paper 5: Banana Fusarium disease: the return of a catastrophic plant disease
by Altus Viljoen, Department of Plant Pathology, Stellenbosch University, South Africa

Banana Fusarium wilt
Return of a catastrophic plant disease

Altus Viljoen
Department of Plant Pathology, Stellenbosch University, South Africa

The Gros Michel era: 1866-1962

Panama disease in Central America

What is killing our bananas?

Infection biology and symptomology

Sustainable Gros Michel production?

Plantation management:
• Plant nutrition
• Irrigation
• pH adjustment of soil
• New tillage practices
The battle continues …

1947: Costa Rica ran out of new land
1950: UFC intensifies research:
• Chemical control revisited
• Cover crops
• Deep cultivation
• Flood fallowing

Fusarium wilt of Cavendish bananas

Gros Michel converts to Cavendish

Fusarium wilt: Races in Foc

Race 1
• ‘Gros Michel’ (AAA), ‘Silk’ (AAB), ‘Pony’ (AAB), ‘Pisang Awak’ (ABB)

Race 2
• ‘Bluggoe’ (ABB)

Heliconia

Race 3

Cavendish (AAA), ‘Pisang Mas’ (AA), cvs susceptible to Foc races 1 and 2

Race 4
• “tropical”
• “sub-tropical”

Foc TR4 (VCG 01213/16) in Asia

Banana Fusarium wilt in The Philippines

• The Philippines is the second largest exporter of bananas
• Cavendish cultivars accounting for about 51% of national banana production, Saba 29%, Lakatan 10% and Latundan about 11%.
• More than 80% of the bananas (and 99% of the Cavendish cultivars) are produced in Mindanao.
• 2001: Cavendish bananas in the highlands severely affected by Fusarium wilt
• 2003: Sporadic cases observed in lowlands
• 2005: Significant increase in lowlands
• 2013: Small-scale growers severely affected
Fusarium wilt was first discovered in Fanyu of Guangzhou in 1998.
The disease now occurs in all of the main production areas.
The cost of Fusarium wilt estimated to be more than 500 million Yuan/year.

Reasons for Fusarium wilt epidemics:
1. Large scale monoculture of bananas
2. Expansion of the international trade
3. Domination of trade with Cavendish bananas
4. Disregard of quarantine regulations
5. Movement of plants, people and equipment

But it is Africa where the cause is most urgent. While Europe attempts to promote the interest of small growers, big banana companies are moving operations to countries that Europeans can buy bananas from. Cavendish plantations are now expanding across the African continent.

Dan Koeppel – Banana: The fate of the fruit

Introduction of Foc TR4 into Africa
• Farm developed in 2009 near Namialo, a dry region in northern Mozambique
• No other banana farm in a radius of 100 km, with only pockets of volunteer bananas (cooking type)
• Water deficit was experienced in 2012, with Farm 2 being particularly affected
• Symptoms first observed in Feb 2013
• Water from Monapo River feeds into two ponds for sprinkler irrigation
• Considerable pedestrian movement of people from local communities through farms
• Farm personnel were rotated between fields
• International staff is replaced fairly regularly

Metocheria farm, Mozambique

On-farm movement of Foc TR4

Foc TR4 in Mozambique: Feb 2015

Impact of Foc TR4 in Africa

Regional strategy meetings on Foc TR4
**Action plan for Foc TR4 in Africa**

**Goal:**
To control the current disease outbreak of banana Fusarium wilt (Foc TR4) in Mozambique and to prepare other African countries that rely on banana for food security and income generation, against similar incursions.

**Objectives:**
1. Arrest and contain the spread of Foc TR4 in Mozambique and surrounding countries
2. Strengthen the capacity of NARS to sustainably manage the disease in Africa
3. Institute mechanisms to coordinate and communicate AC4TR4 activities in Africa
4. Carry out research to generate new information and technologies for sustainable management of Foc TR4

---

**Managing Fusarium wilt: Metocheria**

---

**Somaclone resistance to Foc TR4**

<table>
<thead>
<tr>
<th>Farm name</th>
<th>Planting date</th>
<th>Variety</th>
<th># seedlings</th>
<th>PD incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phil Fresh Fruits</td>
<td>Oct 2012</td>
<td>GCTCV 219</td>
<td>3800</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G Naine</td>
<td>200</td>
<td>79.5</td>
</tr>
<tr>
<td>Bancud Farm</td>
<td>Oct 2012</td>
<td>GCTCV 219</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G Naine</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>Lapiz Farm</td>
<td>Oct 2012</td>
<td>GCTCV 219</td>
<td>1800</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G Naine</td>
<td>200</td>
<td>76</td>
</tr>
</tbody>
</table>

---

**Awareness raising**

**BARNESA meeting**

BARNESA STEERING COMMITTEE MEETING ON Foc TR4
Golf View Hotel, Entebbe, Uganda
26th to 28th October 2014
Distribution of Foc VCGs in Africa

Evaluation of African bananas in Asia

Results: Mindanao, Philippines

Movement of Foc TR4 – illegal plants!

Prevention of banana Fusarium wilt

- Can be achieved by means of enhanced awareness, legislation, regulation, quarantine and avoidance
- These actions take place before Foc enters countries and farms, or once it has been introduced into countries
- The activity chosen to deal with Fusarium wilt depends on the availability, affordability, geographical area and production systems under threat
- Successful prevention depends on a proper knowledge of the disease and its management
- Protecting bananas against Foc TR4 is the responsibility of a number of stakeholders, including national and regional authorities, research scientists, extension officers and producers

Cavendish banana production in Sudan
Pre-border activities

- Assess national biosecurity legislation and regulations
- Assess a country’s ability to prevent and respond to incursions of Foc
- Obtain sufficient knowledge on Foc and means to deal with it
- Raise awareness about Foc TR4 among policy makers, government and quarantine officials, the public, researchers, producers and other stakeholders
- Develop standardised training manuals, identification and surveillance protocols, and methods to deal with Foc incursions nationally and regionally
- Develop national capacity and infrastructure to deal with incursions
- Train plant health officials, scientists, extension officers, border control and quarantine people, and producers on Foc identification and management
- Distribute posters, brochures and information materials on Foc TR4 and other races
- Prepare technical materials on the prevention, detection, containment and eradication of Foc-affected plants
- Introduce an emergency fund to rapidly respond to incursions
- Develop an entrance risk analysis and identify high-risk entry points
On-border activities
• Evaluate quarantine measures and strengthen border control
• Include Foc TR4 as quarantine pest on national lists
• Develop legislation and phytosanitary regulation for bananas and/or parts of bananas introduced from Foc TR4-affected countries or countries at risk
• Strictly control the importation of banana and plantain plants and plant parts from countries affected or at risk of Foc TR4 through national quarantine stations
• Request in vitro plants to be accompanied by certificates for disease indexing
• Identify and strengthen high risk entry points for banana plants infected with Foc
• Train scientists in the use of reliable diagnostics for Foc TR4 identification

Post-border, off-farm activities
• Map the distribution of Foc TR4 and other Foc races in banana-growing countries
• Gather epidemiological data to establish means of introduction and spread
• Assess, train and introduce surveillance systems and teams in-country
• Introduce legislation to regulate the movement of banana planting materials and other risky materials within country borders
• Set up quarantine zones to prevent the movement of infected planting materials and other possible risky materials in-country
• Collaborate nationally and regionally to prevent the introduction of Foc TR4 in the region
• Organise training workshops and expert consultations with Fusarium specialists

Farm-border activities
• Obtain clean planting and propagation material from reputable sources, preferentially tissue culture bananas
• Put up highly visible and clearly understandable signs at farm entrances to notify visitors about farm biosecurity
• Clean all vehicles by hosing-off clay and plant parts and disinfection before entering or leaving farm gates
• Manage visitors and vehicles entering farm borders:
  • Allow visitors only by appointment and upon signing in
  • Disinfect shoes and vehicles of visitors
  • Use only on-farm vehicles and provide boots to visitors
• Enquire about the employment history, nationality and movement of all farm workers
• Avoid sharing farm machinery, equipment and field tools
• Strictly control access of contractors and service providers
Less than 5% of the funding has gone toward post-harvest areas of concern.

Horticultural producers in developing countries are mostly small farmers rarely organized into formal cooperative or association.

Reasons for horticultural produce deterioration and developed technologies.

Deterioration

Developed Technology

Losses of fruits and vegetables estimated in the range 30 - 80%.
Respiration

Refrigeration

High water content

- Humidification
- Curing
- Packaging

Susceptibility to pathogens

- Protective spraying
- Field cleaning
- Systemic fungicide

Easily bruised mechanical damage

- Good harvest practices
- Transport
- Packaging
- Good packing house operations

To employ new technologies, the scale of operation of business and cost is essential.

Proposed points of intervention that are less costly, effective and within reach of small scale farmers.
Deterioration

Proposed Technology

Respiration

- Evaporative cooling
- Zero Energy Cool Chambers (ZECC) Prof. Roy model.
- Solar – driven cold store (FRC) Ammonia water absorption system.

High water content

- Shading
- Early or late day harvesting
- Curing.

Susceptible to pathogens

- Hot air, water treatment Sanitation.

Mechanical damage

- Stackable plastic – containers
- Improved harvesting
- Training of harvesters
- Field packing
INTRODUCTION

Fruit flies belonging to Family Tephritidae are considered the most important insect pests that cause enormous damage for a wide host range of horticultures all over the world. More than 950 species are of economic significance in Africa. Some of these species are accidentally introduced from other regions, in particular from Asia. So far, four Asian species belonging to the genus Bactrocera invaded Africa, two of these were introduced in recent years and the risk for other introductions is great.

Fruit fly management practices on tropical fruit in Africa

Prepared by
Prof. Dr. Talal S. El-Abbassi
Plant Protection Research Institute
Cairo, EGYPT

Fruit flies of major importance in Africa

Indigenous Species
- Ceratitis (Capitata) capitata - Mediterranean fruit fly
- Ceratitis (Pardalaspis) ditissima - Cocoa fruit fly
- Ceratitis (Pardalaspis) punctata - Natal fruit fly
- Ceratitis (Pardalaspis) bremi
- Ceratitis (Pardalaspis) rosa
- Ceratitis (Pardalaspis) fasciventris
- Ceratitis (Pardalaspis) colae
- Ceratitis (Ceratolaspis) cosyra
- Ceratitis (Ceratolaspis) quinaria
- Ceratitis (Ceratoplaspis) silvestrii
- Bactrocera (Daculus) oleae - Five spotted fruit fly

Invasive Species
- Bactrocera (Zeugodacus) cucurbitae - Melon fly
- Bactrocera (Bactrocera) invadens
- Bactrocera (Bactrocera) latifrons
- Bactrocera (Bactrocera) zonata - Malaysian fruit fly
- Bactrocera (Bactrocera) ciliates - Lesser pumpkin fruit fly
- Bactrocera (Bactrocera) vertebratus - Jointed pumpkin fly

The Geographical distribution and presence of these four invasive Bactrocera species in Africa have been studied and illustrated in the following figs.
Many fruit fly species are serious pests of agriculture throughout Africa and represent a threat to the agriculture and ecology of many countries.

Because of the threats the pests would constitute to the agricultural systems of foreign countries, certain countries would restrict or prohibit the entry of host produce from the African countries, thereby eliminating many current (and potential future) African export markets.

In Africa horticulture is recognized to become a major source of income for smallholders and various national development. However, the expansion of fruit production and export is greatly increasing the risk of transferring African fruit flies both within Africa and to other regions of the world; heavy fruit fly infestation seriously reduces the quantity of marketable fruit and increases production costs.
In the absence of government efforts to control exotic fruit fly pests, losses and damage to private and commercial crops would provoke independent control efforts. Lacking the resources or capability to use sophisticated program techniques, such as detection trapping, sterile insect technique, and regulatory controls, the growers or homeowners could be expected to rely predominantly on chemical pesticides. Those efforts could result in continually increasing, uncoordinated, and less controlled use of pesticides.

A proposal of an international program (a broad strategy) among African countries should be prepared to respond to the threat of these invasive pest species.

Such program must include a range of alternatives (exclusion, detection and prevention, and control).

Chemical pesticides have been extensively used for controlling these insect pests for a long time which caused many environmental problems like (high pesticide residues in edible fruits – developing resistant strains of pests against pesticides – disturbing the natural balance and the environmental pollution).

Bactrocera invadens and Ceratitis cosyra are of the major constraints that in general limit tropical fruit production in Africa and mango fruits in particular. They cause up to 40–80% direct damage to mango fruits and also restrict export to large lucrative markets in Europe, the Middle East, Japan and USA.

Developing and implementing an integrated pest management (IPM) programmes is highly requested to minimize the use of chemical pesticides to overcome these aforementioned problems and produce fruit fly-free and residue-free fruits to facilitate compliance with standards required for export markets.

To achieve these goals

Understanding and extensive studies on the biology and ecology of any insect pest is considered the corner stone to establish effective control measures that might enable us to win the battle against such pest.
A- The biological studies include the following points:

- Knowledge of population cycles
- Studies on various developmental stages of subjected insect species
- The length of time required for the Tephritidae fruit flies to complete their life cycles in relation to weather conditions
- Distinguishing between the different fruit fly species in larval stage

B- Ecological Studies include the following points:

1) Geographical distribution of economic fruit flies allover the country through:
   - Finding the relationship between weather factors represented in (Maximum and minimum day temp. and daily relative humidity).
   - Survey for all favorite, wild and alternative hosts.

2) Diagnosing symptoms of infestation by fruit flies at various plant hosts.

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C) Detecting and monitoring system:

1- Trap catch for fruit flies:
   - Selecting appropriate and effective trap for catching flies
   - Using effective attractants (sex attractants, food attractants, lures and dispensers).

2- Collecting infested fruits from various locations and hosts to be incubated under laboratory conditions

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2- Collecting infested fruits from various locations and hosts to be incubated under laboratory conditions
B- Ecological Studies include the following points:

3- Identification of captured flies into traps or flies emerging from infested fruits.
N.B. identification of various fruit fly species by inspecting larvae in infested fruit needs well trained and experienced staff.

D) Determination of hot spots, seasonal peaks and No. of generations per year.

The program should focus on effects of both chemical and non-chemical control methods on the physical environment, human health and safety, socio-economic, cultural and visual resources, and biological resources.

An integrated program would offer the greatest flexibility for responding to fruit fly pest outbreaks.

Developmental Goal

To increase the level of production and quality of fresh fruit and fleshy vegetables, leading to enhanced availability for local consumption, increased exports and higher farmer’s incomes.

To upgrade the technical knowledge and understanding of the impact of fruit flies on production and export of fresh fruits and fleshy vegetables by plant protection, quarantine, extension services staff and the private sector.

IPM Strategy

The strategy of IPM programme is based on usage of all means of control procedures in a complementary way (legislative control, physical control, cultural control, biological control, Biotechnological Control sterile insect technique, wise use of pesticides and postharvest treatments).

It would be characterized by cooperative integrated efforts to control (suppress, eradicate, or otherwise manage) invasive exotic fruit fly pests. It would utilize principles of integrated pest management (IPM).

The integrated program appears to offer the best combination of short-term risk and long-term benefit to agricultural resources and the environment, when compared to no action or a non-chemical program.
1- Legislative control (continued)

- Apply restricted quarantine laws at all country borders to avoid entrance of fruits infested with fruit flies into territories.
- Avoid transfer of infested fruits from area to another within the country (internal quarantine procedures) especially free areas.
- Issuance of pronouncements to growers to apply proper sanitary procedures which safeguard the environment and protect fruit hosts from insect infestation like getting rid of infested, cracked and fallen fruits.

2. Physical Control

Physical control involves physical actions taken to eliminate fruit fly hosts or host produce. Fruit stripping and host elimination are two principal physical control methods. Fruit stripping is employed when fruit fly larvae are found. The physical elimination of fruit fly hosts, when possible and appropriate, may be especially helpful in the elimination of small, isolated infestations.

Except in very limited circumstances, host elimination is unacceptable because of environmental considerations, time and resource constraints.

Bagging is inexpensive and easy to apply and guarantees nearly complete protection from fruit flies. It is ideal for small-scale growers who do not use pesticides.

Bagging is practiced in Malaysia for exporting Carambola and also widely practiced to protect mangoes in Thailand and Philippines.

Fruits can be easily protected against fruit flies by bagging them in paper bags. The bag provides a physical protection to the fruit by preventing adult female flies from laying eggs.

3. Cultural Control

Cultural control reduces pest populations through manipulation of agricultural practices. In general, agricultural practices are modified to make the crop environment as unfavorable as possible for the insect pest.

Cultural control methods frequently include: clean culture, special timing, trap cropping, use of resistant varieties, crop rotation, varying plant locations, and manipulation of alternate hosts.

Collecting and burying host fruit left after harvest, destroying damaged fruit, and removing unwanted or wild alternate hosts in and around fields are often recommended for suppressing fruit fly infestations.
Harvesting the fruit before it reaches a stage of ripeness highly susceptible to fruit fly attack. Although this technique theoretically could reduce fruit fly populations, it is not likely to do so for a variety of reasons. First, some fruits lose flavor when harvested too early, as they will not ripen fully. Second, the development of most fruit flies generally coincides with the development (growth) of their host crops. Third, it is doubtful that enough control could be exercised over commercial agricultural practices to make the technique effective or worthwhile.

Reduce populations:

If fruit flies are present in your field prior to crop ripening, you can try to reduce their population by attracting the adults to a poisoned bait. This can be done by spraying a protein-bait–insecticide mixture onto nearby non-crop plants, windbreaks, or a border of corn plants.

5. Biotechnological Control

Biotechnological control would involve the use of genetic engineering techniques to control fruit fly pests. Currently, there are four primary areas of genetic engineering that show promise for control of insect pests:

1. bio-engineering of crop plants (insertion of specific genes into the plants to improve plant characteristics such as pest resistance),
2. improvement of insect-infecting viruses,
3. production of genetic mutations of the pest (thereby affecting its reproductive capabilities) by radiation or other means, and
4. gene probe techniques to screen for insecticidal properties in microorganisms.

4. Biological Control

Biological control (or biocontrol) is a pest control strategy making use of living natural enemies, antagonists or competitors, and other self-replicating biotic entities.

In spite of its advantages, biological control has major limitations which influence its suitability for control programs, including; lack of immediate results; potential lack of effectiveness; logistical difficulties; and incomplete or unavailable information about rearing techniques.
Biotechnology is being developed for use against fruit flies, but has not been used extensively because of a number of constraints:

1. The technology is still relatively undeveloped;
2. Some control mechanisms have not been developed;
3. Insect-infecting viruses have not been proven effective, nor are they available commercially for fruit fly control;
4. Screening done for new strains of bacteria against fruit flies is only the first step in basic research and development of insect-infecting microorganisms; and
5. The information relative to the environmental impacts of bioengineered organisms is incomplete and unavailable.

6. Sterile Insect Technique

Sterile insect technique (SIT) involves the release of sterilized fruit flies into infested areas where they mate with the feral fruit flies, producing only infertile eggs. SIT has been used successfully and/or developed as a control method for the Medfly, Mexican fruit fly, Caribbean fruit fly (Carib fly), and the melon fly. SIT may be used as a component of an overall detection and prevention strategy, or it may be used as a component of suppression or eradication programs.

7. Chemical Control Methods

A. Male Annihilation Technique (MAT)

This technique is being used successfully for suppressing population of the peach fruit fly in Egypt (National area wide program for extermination of peach fruit fly in Egypt)

1. This technique is used to reduce the No. of males to the least level.

2. Fiber blocks (5 × 5 × 0.5 cm) are saturated with a mixture of the male sex attractant (Methyl eugenol) and a technical insecticide (fenetrothion) at a rate of 4:1. Each block is loaded with 10 ml of this mixture.

3. Blocks are distributed at a rate of 1 block per acre (i.e. the distance between each two successive blocks is Ca. 65 meters.)
- Several materials with insecticidal properties in conjunction with an improved bait attractant have been tested against several species of economic tephritid fruit flies.

- Phloxine B is a photoactive dye which is toxic to certain insect species added to an attractant bait evoked a high degree of mortality in Medfly and other fruit fly species.

**B-Bait spray Application Technique (BAT)**

1-This technique is currently used for controlling most species of fruit flies.
2- In this technique, a food attractant material is mixed with an insecticide. Concentration of the attractant material depends on the type of this material. For instance, in case of Buminal (a protein hydrolysate) the efficient concentration is 10%.

- Recently new safer insecticides (Spinosad) has been developed for area-wide control of fruit flies.

- These latter treatments offer environmentally friendly alternatives to present organophosphate formulations for eradication or suppression of fruit flies without adverse effect on non-target organisms (honey bees, predators and parasites).
C. Soil Treatments
- Soil treatment with certain chemical insecticides (such as Diazinon, Chlorpyrifos and Fenthion) directly to the soil within the drip line of host plants immediately after fruit fly larval detection induces significant control against fruit flies.
- Because of the nature of the chemicals and/or the method of delivery, there is no potential for drift, runoff, or leaching.
- Generally, no more than three applications are made.

D. Mass trapping
*Ceratitis spp.* can not be controlled using MAT due to many technical and scientific concerns. Therefore Mass trapping is being used in some areas. This technique depends on distributing traps loaded with female attractant lure mounted in sachets in fruit orchards at a rate of 21 traps per acre. These traps are supposed to be effective for a period of approximately 4 months.

8. Postharvest Treatments
Export of fresh fruits and vegetables to various countries require conducting certain post harvest treatment to ensure that the consignments are free from infestation. More attention has been paid to apply natural control techniques for controlling insect pests and diseases in fruits and vegetable as safe alternatives to chemical treatments. Type of applicable natural method technique and time of application is dependant on host and pest. These natural techniques could be summarized as follows:

---

### Comparison between Medfly and Peach Fruit Fly

<table>
<thead>
<tr>
<th>No.</th>
<th>Item Of Comparison</th>
<th>Medfly</th>
<th>Peach Fruit Fly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mean Larval Duration</td>
<td>6-8 Days</td>
<td>9-10 Days</td>
</tr>
<tr>
<td>2</td>
<td>Flight Range</td>
<td>Up to five Mile</td>
<td>Up to 20 Miles</td>
</tr>
<tr>
<td>3</td>
<td>Pre-Oviposition period</td>
<td>4-7 days</td>
<td>15-23 days</td>
</tr>
<tr>
<td>4</td>
<td>Range of required temperatures</td>
<td>15-30 C</td>
<td>25-35 C</td>
</tr>
<tr>
<td>5</td>
<td>Mean Adult longevity</td>
<td>55.2 days (Males)</td>
<td>41.0 days (Males)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>B. cucurbitae</th>
<th>B. invadens</th>
<th>B. latifrons</th>
<th>B. zonata</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name</td>
<td>Melon fly</td>
<td>West Africa</td>
<td>Kenya &amp; Tanzania</td>
<td>Egypt &amp; Libya, Reunion &amp; Mauritius &amp; countries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>West &amp; East Africa (19 countries)</td>
<td>West &amp; East Africa (27 countries)</td>
<td>2 countries</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hosts</td>
<td>&gt;500 hosts</td>
<td>46 hosts</td>
<td>15 hosts</td>
<td>&gt;500 hosts</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46 hosts</td>
<td>12 melonae</td>
<td>3 cucurbitae</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Life cycle: Duration</td>
<td>14-27 days</td>
<td>31 days</td>
<td>46 days</td>
<td>34-56 days</td>
</tr>
<tr>
<td></td>
<td>Larval duration</td>
<td>6-11 days</td>
<td>11.1 days</td>
<td>8.5 days</td>
<td>9-10 days</td>
</tr>
<tr>
<td></td>
<td>Pupal duration</td>
<td>6-9 days</td>
<td>12.4 days</td>
<td>10.2 days</td>
<td>9-10 days</td>
</tr>
<tr>
<td></td>
<td>Pre-oviposition period</td>
<td>10-16 days</td>
<td>10-11 Days</td>
<td>10-11 Days</td>
<td>10-23 days</td>
</tr>
<tr>
<td>4</td>
<td>Flight Range</td>
<td>2 Km</td>
<td>Not studied</td>
<td>200 meters</td>
<td>Up to 30 Km</td>
</tr>
<tr>
<td>5</td>
<td>Sex Attractant</td>
<td>Cuelure</td>
<td>Methyl Eugenol</td>
<td>Alpha-ionol + cad oil</td>
<td>Methyl eugenol</td>
</tr>
</tbody>
</table>

Trees are sprayed with a quantity 100-150 ml of bait mixture. Only trunks near from trees canopy are sprayed. Be sure that the spray solution will not contact fruits. Trees are treated by spraying a tree row and leaving a row without treatment, or spraying a row and leaving two rows without treatment depending on level of infestation.
A- Immersion of fruits in warm water path at a temperature 46-48 °C for an hour. This technique is recommended for mango fruits and sufficient to kill all immature stage of *Bactrocera zonata* inside fruits of present.

B- Expose fruits to hot water vapor until temperature of fruit pulp reaches 46.2 °C, then keeping temperature at this level for 30 minutes. This method is recommended for treating mango and guava fruits against *Bactrocera zonata*.

C- Cold treatment: This technique is recommended for treating citrus and pomegranate fruits. Fruits should be kept at constant temperature at 1.7°C for continuously 14 days. This technique is sufficient to kill all immature stage of *Bactrocera zonata* inside treated fruits.
THANK YOU
A viable system for planting materials as the basis for the successful banana postharvest value chain in Sudan

By: Salah B. Bakhiet (PhD)
ARC - SUDAN

Introduction and background

- Banana production in Sudan is practiced for a long time, but the first tangible export began in 2008.
- Production is entirely on the fertile silt loamy soils irrigated from rivers or underground water using surface irrigation.
- The total area under banana production is increasing from 17353 hectare in 2003 to 26260 hectare in 2011
- The main banana cultivar grown in Sudan is Dwarf Cavendish.

Table 1: Bunch weight (kg)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>MP</th>
<th>FR</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asdia</td>
<td>29.74 d</td>
<td>31.60 e</td>
<td>35.43 c</td>
</tr>
<tr>
<td>CHC</td>
<td>34.98 c</td>
<td>36.13 d</td>
<td>39.53 b</td>
</tr>
<tr>
<td>DuRoi-52</td>
<td>38.36 b</td>
<td>39.82 c</td>
<td>39.53 a</td>
</tr>
<tr>
<td>GN</td>
<td>40.14 a</td>
<td>41.47 b</td>
<td>43.30 a</td>
</tr>
<tr>
<td>GNN</td>
<td>40.54 a</td>
<td>42.73 a</td>
<td>44.99 a</td>
</tr>
<tr>
<td>SE±</td>
<td>0.4 0.4</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Number of days from planting to flowering, and shoot to shoot between cycles/week

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>MP</th>
<th>FR</th>
<th>SR</th>
<th>MP-FR/week</th>
<th>FR-SR/week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asdia</td>
<td>315 ab</td>
<td>454</td>
<td>594</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>CHC</td>
<td>322 a</td>
<td>472</td>
<td>614</td>
<td>21</td>
<td>20</td>
</tr>
<tr>
<td>DuRoi-52</td>
<td>299 b</td>
<td>444</td>
<td>597</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>GN</td>
<td>318 a</td>
<td>440</td>
<td>595</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>GNN</td>
<td>323 a</td>
<td>441</td>
<td>597</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>SE±</td>
<td>5.8 8.6</td>
<td>9.3</td>
<td></td>
<td>5.3</td>
<td></td>
</tr>
</tbody>
</table>
Planting and field establishment

This is the process that encompasses the selection, extraction, transportation of the planting seed and actual planting in the prepared land.

Seed selection

Successful banana production requires strict hygiene controls and practices. The practices start from recognizing the importance of using pests and diseases free planting materials.

- There are two alternatives to obtain plant material that will be used in the field planting.
  - a) Seedbeds which are pest and disease free and developed in areas had good vigor and production potential.
  - b) Tissue culture to propagate meristems developed in close system laboratory and nursery and considered as uniform and pest and disease free planting material.

• The small holding banana growers preferring the first system since the tissue cultured based system requires substantial investment in structures and control management, which the plants need for their development before being taken to the field for planting. Nevertheless, huge plantations are started recently to be established with tissue cultured planting material.

The corm

Tissue cultured plants can be guaranteed free of pests and diseases

Tissue cultured plants Ready for field planting
**Seed extraction**

This is the process of extracting seed from the seedbed area. The seed must be healthy and has a diameter of at least 6 inch at the base of the corm seed piece. It must be extracted carefully so as to avoid damage when separating from the plant. Green part of the pseudostem should be left so as to avoid dehydration, which reduces the seed’s vigor.

**Conventional Suckers**

For maximum benefit, clean planting materials need to be combined with clean soils.

**Suckers from obsolete plantation**

**BBTV**

**Banana Weevil**

**Nematodes**
Seed transportation

- Regardless of the transportation system used to carry the seedbed or Tissue cultured seedlings — it is important to keep the seed healthy by handle it with care during transport.
- The seed should not be exposed to the sun, and must be located as near as possible to the planting field, and has to be planted as quickly as possible after the time of extraction.

Planting

- Fallowing for 6-24 months without a non-host cover crop can break nematodes and banana weevil borer cycles.
- The planting hole should be deep and wide enough so as to place the seed under at least 5 cm of earth surface.
- If available, a single dose of compost (1 kg) should be added and mixed with the upper layer of extracted soil at the bottom of the hole before planting.
- After placing the seed in the hole, the covered hole has to be tamped down very well in order to eliminate airbags that may accumulate illness factors and thus deteriorate the seed viability.
- One to three days after planting process, irrigation has to be applied to avoid negative drought effect on vigor of the new plants.

Replanting

- Three weeks after planting, the area has to be inspected in order to count how many seeds have failed to emerge and to replace them.
- The idea is to avoid irregular growth in the plantation or areas without plants due to losses during planting (2-3% is a normal loss).
- A good planting process can reduce this average, which reflects a proper control and follow-up when establishing the plantation.

The CFC Banana Funded project experience

- Introduce of a high yielding banana cultivars, suitable for exports and local market has been decided.
- Grandnain, Grandnegra, Audia of Williams, Chinese Cavendish and Dwarf Cavendish selection cultivars have been received from Du Roi Lab. in RSA. Four additional selected clones of GN namely Marianne, MH13, CV902 and Bambo were also introduced from Vitropic in France.

New banana plantation with clean tissue cultured plants

- A nursery of Horticulture Department was ready to receive more TC plants ordered for field planting. (A documented report has been written under the title: Handling tissue cultured plants).
- The transplanted seeds have given intensive care for at least 45 days before field planting.
- Evaluation trial for comparing different elite banana cultivars was conducted in Kassala.
Three months old

Well established 7 months banana plants

Five months old

Bunch performance of GN

Irrigation technology
• Quality (value chain) starts in the field and goes through the supply chain:

```
FARM   HARVESTING   PACKING   LOADING
TRANSPORTATION   DISCHARGE   DISTRIBUTION
```

• To guarantee the quality of the final product, understanding and controlling every single process in the supply chain (HACCP) is needed.

Post harvest practices

Post-harvest and marketing group have studied the current post-harvest practices and infrastructure to identify possible opportunities for improved quality banana. Before this training has to take place, a guideline report has been prepared under the title: Post-harvest trial in Kassala.

Training

• Training materials developed to support export quality for bananas.
• Training has been conducted in the existing fields on bunch selection, hand thinning and tagging for maturity. Also post harvest and packaging demonstrations were undertaken.

Bunch selection

Lower hands thinning
• Initial plans for export production from the existing fields have been prepared.
• An Export trial as part of post harvest was planned to be undertaken.
• Refrigerated truck, cartons and a team of labours with mobile tools were used in this trial.

Exportable fruits

Quarantine Inspection

Loading fruits in returnable crates

Harvesting trials and analysis of fruit availability for export

Post harvest trials
• Post harvest trials using organic substances (Citrex – alaun and clorine) against banana crown rot disease were conducted in collaboration with the post harvest division (FRC).
• A scientific paper with applicable findings was prepared (not published).
interventions

- Viable seed system together with good agricultural practices were applied.
- Bunch selection and fruit protection in the field were practiced.
- Proper harvest time and harvest process were identified (using caliper).
- Quarantine measures is always done before backing.
- De-handing, organic treatments and packing in the filed were practiced.
- Refrigerated trucks were used for transport to export market and local market.

Banana export is taking place

- Ongoing banana export initiated by private sector based on high seasonal production has been supported and followed up.

Sudan banana export and values (2005-2014)

Export Trial to Europe

Lessons learnt

Using pads
Washing before dehandling

Knives for dehaning and clustering

Fruit preparation and clustering

Sizing up clusters

Using trays

Spraying disinfectant
Piston machine for carton stick up

Packaging of the fruits

Vacuum pump

Deflating air from the bag
Challenges

- Banana sector needs substantial scientific and technical support to become successful sustainable exporter.
- The export infrastructures as proper farming system, packing houses, inputs, cold transport, heat treated pallets, internal control and market identification are not all in place at present.