Ministry of Agric & Irrigation
Horticulture Sector Administration

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إدارة القطاع البستاني

PEOBP

AgroFair

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TASTE Technical Assistance for Sustainable Trade & Environment
The Netherlands

Technical Guide for the Production of Export Bananas in Sudan

March 2013

Gerardo Gutiérrez González

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Project:

Promotion of Export of Organic Banana Production from Sudan and Ethiopia (PEOBP) (CFC / FIGSB / 10)

Funded by the Common Fund for Commodities (CFC)
Implemented by Bioversity International

Assignment of Agrofair and TASTE (LOA Musa 2012 / 24)

A Quick Scan of the Banana Sector in Sudan
Implementation of a Showcase
Elements for a Practical Road Map to Export

Technical Guide for the Production of Export Bananas in Sudan

August 2012 to February 2013

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Contents

Introduction 3

1. Establishment of the banana plantation: preparatory steps 5
2. Establishment of the banana plantation: defining the production system 7
3. Establishment of the banana plantation: infrastructure 12
4. Establishment of the banana plantation: planning 14
5. Maintenance of the established banana plantation 18
6. Harvesting 29
7. Processing and packing 33
8. Monitoring and quality control in the field and packing station 42
9. Transport, logistics, distribution 45
10. Natural risks, pests and diseases 47
11. Data collection and certifications 51

Annex 1 - Soil studies for banana plantations 55
Annex 2 - Water irrigation systems for banana plantations 59
Annex 3 - Banana planting systems 62
Annex 4 - Map of Sudan 68
Annex 5 - Suggested formats 0
Annex 6 - References 75
Annex 7 - Glossary 76

Introduction

This document was prepared within the framework of the agreement between Technical Assistance for Sustainable Trade & Environment (TASTE Foundation) and Bioversity International on 21 June 2012 (LOA Musa 2012/24) concerning the participation of the TASTE Foundation and the Dutch fair trade company Agrofair in the project "Promotion of Exports of Organic Banana Production from Ethiopia and Sudan", funded by the Common Fund for Commodities (CFC).

This agreement and participation took place under an assignment under the title "A Quick Scan of the Banana Sector in Sudan. Implementation of a Showcase. Elements for a Practical Road Map to Export" which took place between August 2012 and February 2013.

The following activities took place within this framework:

- A 10 days study trip to North Peru and the Netherlands, by a delegation of Sudan and Ethiopia (totalling 9 people, including the author of this manual). During the excursion, the participants were able to observe a successful export chain functioning, of organic and fair-trade certified bananas, managed by associations of small producers, under agro climatic conditions very similar to Sudan.

- Two expert missions of TASTE and Agrofair to Sudan (in November 2012 to Sennar State and February 2013 to the State of Kassala), in which the author of this manual also participated.

- Training and coaching of banana producers and workers nearby Singa, Sennar State, and the preparation of a test shipment to Agrofair, the Netherlands, by the author of this manual.

- The organisation of a sector-wide seminar on the perspectives of banana export from Sudan. On this seminar, the author presented a summary of his experiences in Singa.

- The draft of the present manual, which took into account the lessons from the excursion to Peru and the experience of training and technical assistance to the banana producers in Singa, who collaborated with this task.

The manual aims at providing recommendations for the banana growers in Sudan who are interested in developing an efficient, profitable, and sustainable organic production chain that targets international markets in Europe and the Middle East. It encompasses the entire chain,

from land selection to the final consumer and market, taking into account safe production management and the certifications needed to guarantee an organic product of high quality and that meets food safety requirements, for the final consumers.

It summarises the author's experience in organic banana production systems, and the assistance of a supporting team of local and international professionals in this project. These experiences can now be shared with banana growers in Sudan. This will help to bring about a cultural change, which is needed to transform the current production system for local consumption to export oriented organic production.

February - March 2013

Khartoum, Sudan / Puerto Armuelles, Panama

Gerardo Gutiérrez González

Agricultural Engineer / Banana Expert

1. Establishment of the banana plantation: preparatory steps

Field selection: In order to start producing bananas, it is important to take into account some fundamental aspects when taking relevant decisions:

1. **Topography:** The land to be used should not have slopes higher than 15% to avoid complications in the design and construction of the facilities and infrastructure to be used on the farm.

2. **Accessibility of the production area:** The production area has to be accessible year round, in all seasons. If access is not guaranteed, this may jeopardize production on the farm.

3. **A study on soil structure and an analysis of soil fertility and texture:** These studies are important when taking decisions at the start of exploitation. We need to know the type of soil we have in order to design drainage and irrigation systems (structure and texture of the soil), and fertilization programmes (soil fertility). See Annex #1, Soil Studies for Bananas.

4. **Availability and quality of water:** It is important to consider not only the availability of water for the farm, but also its quality. Therefore, a study has to be conducted because it is important to know whether the water supply will be sufficient, and what type of water supply system should be used on the farm. Gravitational or flood irrigation is the most commonly used system in Sudan, although there are other alternatives, such as sprinkler irrigation, micro sprinkler irrigation, or drip irrigation. It is also important to know whether the water will be of sufficient quality to not affect the availability of nutrients in the soil, which directly affects crop development and may eventually increase the costs of the fertilization system implemented. See Annex #2, Water Irrigation Systems for Bananas.

Blue Nile River, Sennar State,

5. **History of previous production:** It is important to know how the land intended for organic banana crops was used in the past, if the farm has to be certified as **Organic**. If synthetic fertilizers or chemical pesticides were used, the land needs a transition period of 3 years before organic certification can be extended. Prior inadequate management techniques may have an impact because of the "residuality" of the products used in previous systems.

2. Establishment of the banana plantation: defining the production system

Production system: Taking into account the studies and analyses conducted prior to taking the decision to establish an organic banana farm, we have to define the practices of the production system we will implement. This should be designed by expert staff, with periodic reviews in order to make adjustments and ensure the success when planting and establishing the farm. The following aspects must be considered:

1. **Preparation of the field:** It is important to know the type of soil available for planting. We will need to remove the existing vegetation and then use a tractor with **disc plough** to plough to a depth of 30-40 cm from the soil surface, incorporating the plant residues into the soil so they become part of its organic matter. In case compaction problems exist, a **chisel plough** can be used and in case of very serious problems, a so-called **subsoiler** can be used. Next, a **disc harrow** is used to break up the large pieces left behind after ploughing, to finish mixing in the plant residues, and to prepare the field for planting.

Discs

Chisel

Sub-soiler

Disc harrow

Ploughs used for preparing the soil

2. **Variety to be used and availability:** This aspect is extremely important in Sudan because the Dwarf Cavendish banana is being used in approximately 95% of the current planted area. This variety brings about harvest management problems for the export process. Harvesting is complicated because the plant is around 2.00 metres high, which may cause damage to the banana bunches harvested.

   This variety therefore requires special bunch handling practices compared to the other higher varieties, e.g. Valery, Great Dwarf, or Williams. These should be propagated in **nurseries** specifically structured for this, and then used in commercial export-oriented farms. The material to be propagated has to be imported, with the necessary phytosanitary certificates so as to avoid risks of diseases. The investments required are high. An alternative option is to use **seedbeds**, which are areas that currently exist in Sudan for seed propagation; however, this is a very slow system for propagation. Managing this type of propagation system requires areas with good vigour and free of pests and diseases.

   One advantage of the common variety in Sudan, Dwarf Cavendish, is that because of the plant size it is possible to use slightly higher population densities, up to a recommended 2,500 plants per hectare. This allows for better use of the space relative to the size of the variety, which helps reduce the competition for space, nutrients, water, and light. This is a common problem in the current plantations and gives rise to a rapid reduction of production potential (**poor bunches**). We always have to identify varieties that provide a range of 1.50 to 1.60 bunches/production unit per year after establishment, and 28 to 32 weeks from flowering to flowering.

3. **Planting density:** This is an important aspect that depends on the variety used; it is important to remember that there are varieties of different sizes (small, medium, and large). A table is available that indicates the densities that must be used in order to avoid competition for light, water, nutrients, and space which occurs if the densities are not adequate.

Table 1. Densities to be used according to variety size

Size	Densities	Range (Plants/ha)	Varieties
Small	High	2,300 to 2,500	Dwarf Cavendish
Medium	Intermediate	1,900 to 2,200	Great Dwarf, Williams
High	Low	1,600 to 1,800	Valery

It is important to consult this table for the variety size that will be used. Let us not forget that the too high densities, not recommended, cause competition in the plantation; while on the other hand, too low densities, likewise not recommended, cause the growth of weeds in the crop area or the loss of irrigation water in the plantation due to evaporation.

Below is another table with the densities that must be used in banana plantations in Sudan, always taking into account the variety used.

Table 2. Recommended Densities for Banana Plants (Plants/ha)

Width	by	Length	Population (plants / ha)
2.00	by	2.00	**2,500**
2.00	by	2.25	**2,222**
2.00	by	2.50	**2,000**
2.00	by	2.75	**1,818**
2.00	by	3.00	**1,667**
2.25	by	2.25	**1,975**
2.25	by	2.50	**1,778**
2.25	by	2.75	**1,616**
These measures are in meters			

Only in the case of production systems with harvest programming for good market windows in Europe (January to June), densities can be used that are higher than those recommended in the table above. However, due to the high investments that these systems require (in which the bananas are planted as annual crop each year), they are not recommended for the small producers in Sudan.

4. **Planting system:** Choosing the planting system is very important; this defines how we will place the plants in the field. Four alternative arrangements are suggested: planting in squares, rectangles, equilateral triangles, or in double furrows. For further details, see Annex #3, Banana Planting Systems. The producer should be clear about these systems, which define the location of the plants.

Recently established banana plantation

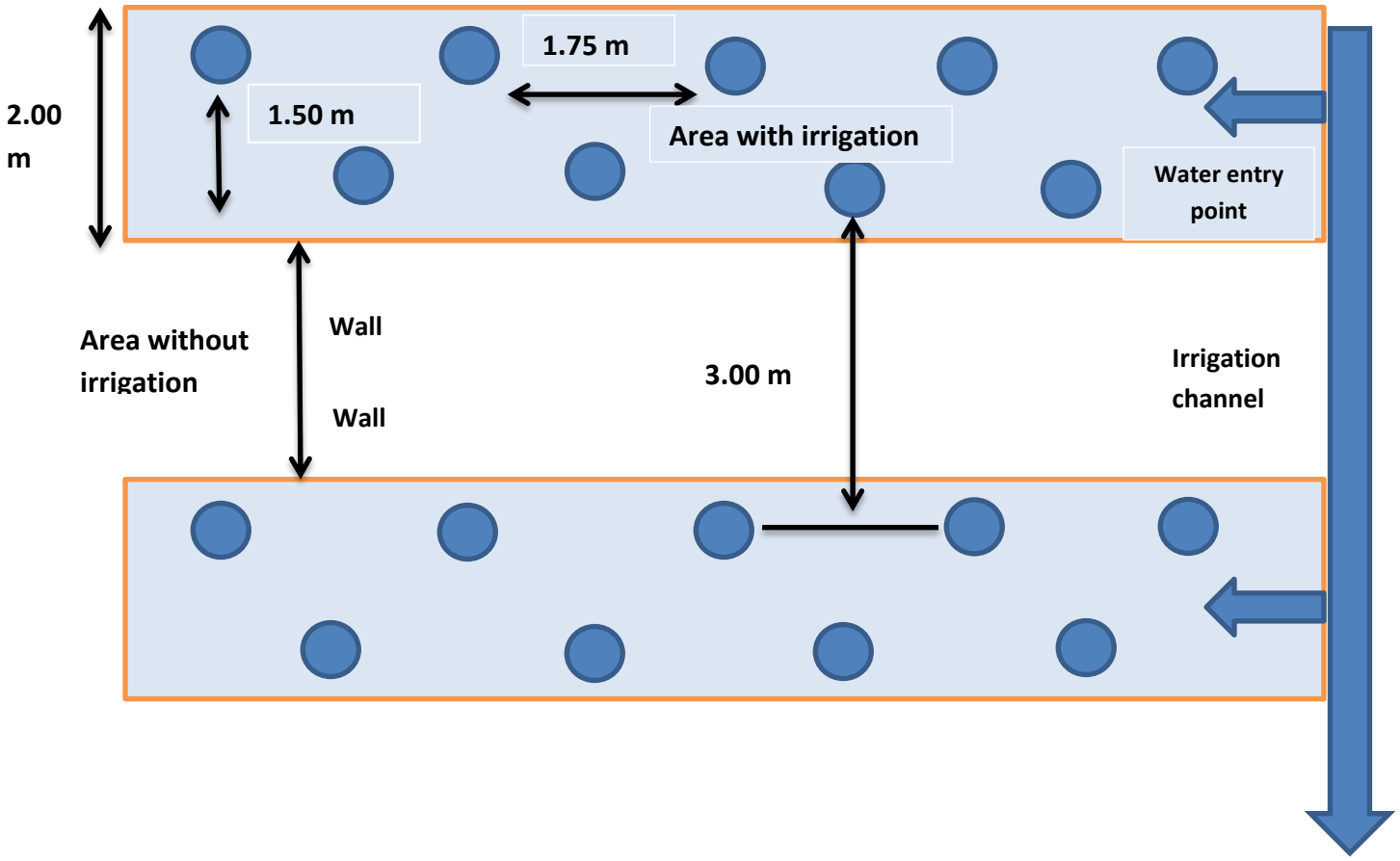
The most recommended system is in equilateral triangles, because in this system the distance between the plants is the same, meaning distribution is equidistant. This benefits competition among the plants as compared to the other systems. Besides, when using this system, it is possible to place 15% more plants in the same planted area. It is important to use a structure as a reference point when defining the master line (close to a 90° angle), which is the line that defines planting order. This reference could be a drainage canal, a road, etc.

For the small producers in Sudan, it is possible to design a double furrow system in order to reduce the plantation area under irrigation by ensuring the best possible use of water through gravitational irrigation systems. This would be as follows:

Table 3. Distances in a double furrow system (for Dwarf Cavendish)

Witdh of paths between rows of double furrows (m)	Distance between furrows (m)	Distance between plants (equilateral triangles) (m)	Number of plants / ha
3.00	1.50	1.75	2,531

This system only applies to the Dwarf Cavendish variety. The design consists of areas under irrigation only 2.00 metres around the double furrow, and requires placing the plants in a triangle, as the following illustration shows.



3. Establishment of the banana plantation: infrastructure

Infrastructure needed: When establishing any farm, a map should be designed beforehand to define the distribution of the planting areas and the infrastructure needed for normal operations, since this also takes up space in the available area. Hence, when designing it is important to know the most adequate areas for production and for building the different facilities. A proper design and good maintenance are required to ensure adequate operations. Normally, farms have the following infrastructure:

1. **Access roads:** The roads and paths must be designed adequately and must have an efficient maintenance programme, including for the movement of inputs and, especially, products to, within, and from the farm.

2. **Storage of materials and equipment:** The design has to consider the construction of places to safely store materials and equipment, i.e. inputs, tools, or equipment used in farming activities and labour, and for harvesting and packaging. These places have to be sufficiently separated in order to ensure an adequate operation and there must also be a space, i.e. an office, where all activities are carried out related to farm control, administration, and operations.

3. **Irrigation and drainage:** These require all analyses of the land where the farming operation will be established: soil structure and texture, water quality analysis and water availability, special production areas, etc. Staff is also needed that is specialised in this type of design in order to establish the most efficient system in the different areas of the farm and for all the seasons. We should not forget that in 9 months of the year the water supply in Sudan is of vital importance for the farm operations. This is why a proper design is an important component of the farms' operating cost structure. See Annex #2, Water Irrigation Systems for Bananas. The same applies to the design of the drainage system, if needed. It is important to take into account the 3 months of rainfall, especially in August, when there is a risk of flooding.

4. **Harvesting and packaging:** These are the most important elements when designing a farm, considering the substantial investment needed. Both activities have to go hand in hand for efficiency's sake, because a packaging plant without a cableway system, or viceversa, renders the other activity inefficient. These systems have to be located and designed by specialised staff. We recommend installing one packaging plant for every 100 hectares of production (as maximum).

The same goes for the cableway system to constantly carry the harvest programmed from the different production areas to the packaging plant on a daily basis.

Cableway in the plantation

Banana bunches arrive at packing station

The purpose of this is to ensure a daily production of one 20-tonne container of organic bananas, at least 5 days a week, the 52 weeks of the year. All this must comply with export standards in a sustainable manner in terms of quality, quantity, and certification for organic production and product innocuousness for the consumer (GlobalGAP).

Bunches ready for processing

Overview packing station

4. Establishment of the banana plantation: planning

Time line for activities related to establishment and maintenance: We have to decide on the order of the planting tasks and define the practices that will be followed for the establishment and maintenance of the plantation. This should be based on a time line that is subject to periodic reviews in order to make adjustments and ensure success when implementing the farm. The tasks are as follows:

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

1. **Seed selection:** There are two alternatives to obtain the plant material that will be used in planting.

   a) Seedbeds developed in areas with good vigour and production potential, which are pest and disease free.

   b) Nurseries to propagate meristems developed in laboratories or corms extracted from areas with good vigour and production potential that are pest and disease free. We recommend analysing the first system since the nursery 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.

Nursery

Seed

2. **Seed extraction:** This is the process of extracting seed from the seedbed area. The seed must have a diameter of at least 6 inch at the base of the corm seedpiece and must be extracted carefully so as to avoid damaging it when separating it from the plant. Enough green pseudostem should be left so as to avoid dehydration, which reduces the seed's vigour.

3. **Seed transportation:** Regardless of the transportation system used or the propagation system – seedbed or nursery – it is important to not deteriorate the seed during transport. This lowers its quality and vigour. Please remember that the seed should not be exposed to the sun, has to be used as quickly as possible between the time of extraction and the time of planting, and must be located as near as possible to the planting place.

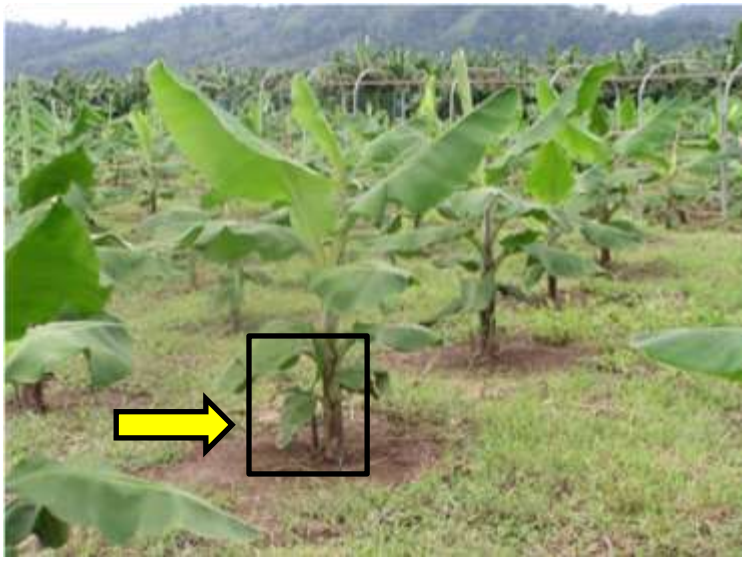
4. **Planting:** Before planting, the system that will be used must be selected, seed should be available, and soil has to be humid. When all this is in place, the following steps for planting are: 1) Cut the seed at 10 cm above the corm seedpiece and remove the growth point / bud in order to encourage emergence of the followers or offspring from the seed. Further, remove the roots to check the condition of the corm and avoid contamination in the field; 2) Place two ropes or strings marked with the distance between the furrows, one at each end and in a straight line along the width that marks where planting will proceed. Then, place another string or rope marked with the distances between plants in each furrow, forming a right angle (90°). This rope will move along as planting progresses, marking the points where the holes will be dug using a sharp tool known as a straight-edge shovel or spade. Place the seed in these holes. See Annex #3, Banana Planting Systems. If available, one dose of compost should be added (1 kg), which should be mixed at the bottom of the hole with the upper layer of earth extracted. This hole should be deep and wide enough so as to place the seed under at least 5 cm of earth. 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 water and thus deteriorate the seed. When placing the seed in the hole, the corm seedpiece has to be directed to the side from where we want the followers or offspring to emerge, while the part where it was adhered to the plant must face the opposite side. This process continues until the programmed planting has been concluded. Two to three days after the planting process, water has to be applied to avoid drought from affecting the vigour of the new plants.

5. **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.

6. **Thinning side shoots or suckers:** Two months after planting, a first selection is made of the daughters or followers of the planted seeds. These are the followers that will produce the first harvest in the established plantation. This process is based on a selection of the follower with the best vigour and location relative to the corm seedpiece, compared to the plants near the selected plant. It entails removing the other suckers to avoid competition for light, water, nutrients, and space. Weekly inspections are required until all suckers have been selected, over a maximum period of 6 weeks. Thinning the side shoots is done using a sharp spade to ensure adequate removal and avoid the shoot from sprouting again. For sanitation purposes, all the dry leaves from the lower part of the plant have to be removed as well. A semi-circular area of 20 inch has to be cleared in front of the selected follower, where fertilizers or organic manure (compost) will be applied.

7. **Follower/ daughter selection:** Five months after planting, the sucker on which successive production of the established production unit rests (called the follower, daughter, or ratoon) must be selected (see picture below and arrow).



Young mother plant and sucker

The aim of this process is to select the follower with the best vigour and location in relation to the nearby plants. In this period, the mother plant is flowering on its way to its first production. Following the selection, the other suckers are removed from the

plant in order to avoid competition for light, water, space, and nutrients with the follower that will succeed the mother plant. In this way, cyclical production is ensured. The tools used in this process are a spade and a machete, through which you can ensure that the shoots do not sprout again. The cuts have to be made from the inside out to avoid damaging the mother plant. Dry leaves at the bottom of the plant have to be removed as well. Furthermore, a semi-circular area of 20" has to be cleared in front of the selected follower, where fertilizers or organic manure (compost) will be applied.

Machete and file

5. Maintenance of the established banana plantation

Maintenance of the plantation: The established plantation should follow a time line that includes all the activities that must be carried out throughout the year. It should take into account all cultural or maintenance practices needed to have a plantation in optimal conditions, and include records substantiating compliance with them. The time line for maintenance of the farm should at least include the following activities:

1. **Desuckering for maintenance:** After having defined the follower or daughter, cyclical labour is required every 8-10 weeks throughout the year. This labour encompasses periodic selection of the followers with the best vigour and location relative to plants near the selected plant in order to maintain the original distribution. Then the rest of the suckers and followers must be removed as well, including those that have sprouted again and the suckers growing on the back of the mother plant.

Sequence of 4 successive generations

3 generations: the recently harvested plant, the follower and the new sucker

This is done to avoid the selected follower from having to compete for light, water, space, and nutrients. This is done using a sharp machete, making deep cuts from the inside out to avoid damaging the mother plant. A type of sanitation process is done by removing dry leaves from the bottom of the mother plant. Furthermore, a semi-circular area of 20 inch has to be cleared in front of the selected follower, where fertilizers and

organic manure (compost) will be applied. This practice is carried out in farm areas distributed equally, thus making it possible to register progress on a weekly basis throughout the year, in a cyclical manner. Performance of the workers and staff is also controlled to programme sufficient workers and staff for meeting the farm time line.

2. **Maintenance replanting:** Periodic inspections of the farm should be carried out in order to replace the plants lost for various reasons. This cycle should be repeated at least every two months to replace the lost plants, using the same system as the one used after planting. The difference in this maintenance phase is that the practice has to ensure the penetration of light by cutting the edges of the leaves of neighbouring plants, but no more than 25%. This builds a foliar tunnel that lets sunlight through, stimulates the seed, and promotes growth until the planted seed reaches an adequate size to continue growing individually in relation to the neighbouring plants (1.50 m). Replanting can be done in two ways by using: 1) Round seeds with a diameter of 6 inch or 2) Seeds of recently harvested plants (**bullheads**) of 1.50 m high.

Seed of recently harvested plant, or "bullhead"

3. **Fruit protection:** This is perhaps the most important maintenance process in the farm, since it defines the volume and quality of the fruit produced. This process requires trained staff. In the case of Sudan, we recommend having at least 2 weekly cycles of these practices to ensure the quality of the bunch and avoid fruit losses due to the failure to apply these practices. The tasks covered in this process are detailed below in due order.

4. **Shoring of the plants and clearance of the acorns:** This practice is aimed at anchoring the plants and thus avoiding losses due to the weight of the bunch and the plant itself. It also aims at **clearing recently emerged acorns** and avoiding hand deformations caused

by the leaf petioles of the plant itself during development, which would render them useless for export.

Clearance of main buds

Two systems can be used to shore the banana plants:

a) **Using thread** (nylon cords) manufactured specifically for this purpose in banana crops (see picture) , or

b) **Using wooden stakes or poles** to anchor the plants and thus avoid losses (see picture).

Use of nylon cords to shore banana trees

Use of wooden poles or stakes

5. **Deflowering and finger removal from bunches:** These practices occur simultaneously and involve removing the lateral fingers from each hand and removing the flowers as the hands expand and the flowers are ready to be removed. Deflowering should not be forced since this may damage the fruit, rendering it useless for export. This is one of the reasons underlying this practice of frequent visits: at least two visits to the bunch every week until its development becomes stable when the deformed or "false" hand appears. Likewise, it is necessary to remove the bracts that fall off from the bunch as it develops. These practices help improve the quality of the fruit in accordance with existing market specifications. It is therefore important to comply with the farm's programmed bunch inspection cycles. Staff performance must be reviewed to prevent any delays in these practices.

Deflowering

Removal of lateral fingers

6. **Bagging the bunches and identifying their age:** In Sudan, these practices can be done at the same time that the development of the bunch is defined with the appearance of the **deformed or "false" hand**. This is because the climatic conditions in this country make it free of pests and diseases that affect development. Bagging is done by placing a bag over the bunch that will protect it from possible environmental damages, especially those caused by the sun. The bag will therefore need to have sufficient ventilation and pigmentation to avoid damages caused by high temperatures in the bunch after it has been covered, which should not increase more than 5%. After placing the bag, the age of the bunch is identified by placing a plastic colour ribbon that corresponds to the week this work is being done in accordance with the farm programme. The bag is tied with the plastic colour ribbon and must be placed in such a way that it does not affect the development of the first hands, thus causing deformities.

Deformed or ´false´ hand

Bagging and identifying age with coloured ribbon

7. **Dehanding and removal of bunch inflorescence:** After having conducted the practices mentioned above, the last 1, 2, or 3 complete final apical hands of the bunch have to be removed, as ordered by the farm administration. Next, the inflorescence has to be eliminated from the bunch when the deformed or "false" hand appears underneath. In the deformed hand, one good finger has to be left at one extreme. Then, in the last complete hand, the same has to be done but in an opposite direction, thus leaving another finger. This maintains the nutritional activity in the bunch and avoids further rachis decomposition that may affect the crowns of the last bunch hands.

Dehanding the bunch

Removal of inflorescence

Lateral fingers removed

Hands heve been deflowered

Several hands removed

One finger left at the extreme

8. **Sucker deviation:** This practice is aimed at preventing the mother plant suckers from affecting the development of the bunch, i.e. causing scars when the leaves of the suckers enter into contact with the developing bunch. There are different ways of doing this and thus avoid damage, depending on the stage of development of the bunch or the size of the sucker one wants to deviate:

a). With a piece of water sucker: This is used only when the sucker is so large that it is not possible to deviate it through other means.

b). With a piece of dry leaf petiole: When the suckers are of a medium size, use a piece of dry leaf petiole and place it around the sucker, attaching it to the back of the mother plant, thus deviating it. This prevents contact with, and therefore damage to, the developing bunch.

c). With a piece of green leaf petiole: This is done in the same way as above, but using a piece of green leaf petiole instead. This is taken from the ones removed during the deleafing procedure for sanitation, or from a recently harvested plant.

With a piece of water sucker

Use of green or dry leaf petiole

9. **Solar protection of the bunches:** In Sudan, special care of the bunch must be taken against sun intensity. This is due to the existing climate in the country and the 9 summer months every year, which cause irreversible damage to the bunches protected for production. In this sense, it is necessary to implement systems to avoid damages that affect bunch production. One practice is using newspapers or parts of recently cut leaves as shade to help reduce the effect of the intense sun on the bunches intended for export. The farm supervisors must monitor this and take any necessary measures. They must also include it in the programming of the time line and follow it up throughout the year.

Use of pieces of paper or other protectors to prevent burning of the bunch

10. **Deleafing for plantation sanitation:** In any banana plantation, a process has to be implemented to remove leaves, because of their senescence (biological aging), mechanical damages, diseases, and other factors affecting them. If not, they create sanitation and health problems on the plantation caused by their decomposition or the possible dissemination of diseases caused by fungi or any other pathogens present in the environment where the plantation is located. At the moment, Sudan's climatic conditions do not favour the development of pests or diseases that may affect an organic banana plantation. Even so, at least once a month, it is necessary to program the removal of all folded leaves that are not functional for the plant, without this being excessive. This will ensure the growth of the bunches but should occur within 12 weeks after protecting the acorn, and with at least 6 clean leaves at the time of the harvest. The farm workers have to be instructed not to fold the leaves unnecessarily when performing the other farm work, and to only eliminate the parts of the leaves that are touching the bunches, which would indeed damage the appearance of the fruit that will be exported.

Sanitary deleafing of banana plants

11. **Application of water:** This is the main cost of the production of organic bananas for export in Sudan, because in the 9 months of the dry season (from October to June) there have to be efficient alternatives for irrigating the plantation. The banana growers mainly use gravitational irrigation systems and small pumps to distribute water around the farms. The main water supply source for this is the Blue Nile River in southern Sudan and the Nile River in the north. The latter is the most feasible water source in view of the low investment it requires. However, one of the priorities is to encourage investments in more efficient water application systems in the plantations, which ensure a better use of this resource. Some possible systems are sprinklers, micro sprinklers, or drip irrigation systems. These all require a high initial investment and training of the people who will use them, both in the field and at the pumping sites. But the water can be used more efficiently and irrigation may even be combined with the application of fertilizers (fertigation). Let us not forget that it is important to take into account the analyses of the availability of water and water quality, as well as studies of the soil (texture and structure), when making decisions regarding the system that will be used. Since the systems will be used regularly, there will be a need to keep records of evapotranspiration, soil permeability, and the annual behaviour of rainfall. See Annex #2, Water Irrigation Systems for Bananas.

12. **Application of fertilizers and organic manure (compost):** When producing organic bananas, it is important to conduct a soil fertility analysis when the plantation is being established. It is also important to carry out studies, at least once a year, of the existing

nutrient levels in the soil and in the plantation's leaf tissue, because year after year the plantation extracts large amounts of nutrients from the soil. It is also important to find alternatives for the fertilizers and organic manure (compost) used in order to supplement and maintain the levels required in the plantation year after year. These data can then be used to define the fertilization programme that will satisfy the plants' needs.

At the same time, it is important to conduct studies on the condition of the plant roots on the plantation so that the programmes designed will be successful. This is particularly important in view of the amount of this investment for the farm's operation. The table below gives an overview of the requirements of soil with medium fertility and an average production of 30 tonnes per hectare per year. In Sudan, it is important to analyse the different types of fertilizers available in order to make a selection, taking into account the ones permitted for organic production. Another important activity is the production of compost to help improve and/or maintain existing soil fertility, based on crop residues and fruit sub products (rachis, loose fingers, etc.). It is important to develop this practice based on the farm's sub products, which is ideal from an organic perspective. Effective Microorganisms (EM) can be added to speed up the process and for additional benefits to the soil.

Table 4. Macronutrient requirements for medium fertility soils

Kg N / ha / year	**Kg P / ha / year**	**Kg K / ha / year**	**Kg Mg / ha / year**	**Kg Ca / ha / year**
350 – 400	50	600	100	600
In the form of N	In the form of P_2O_5	In the form of K_2O	In the form of MgO	In the form of CaO

13. **Weed control:** Any production of organic bananas requires controlling weeds that **compete with the plantation for water, light, nutrients, and space.** This is why it is important to carry out inspections every two months, as a minimum, with manual weed control using a sharp **machete**. This should be combined with follow-up and records of the workers' performance in order to use human resources efficiently.

14. **Soil decompaction:** Because of the high temperatures during the dry period, the soil in Sudan becomes very hard. It must therefore be treated manually with a tool known as a hoe, to break through this hardness in front of the daughters or followers in the plantation (soil decompaction). This practice should be carried out between January and

May when the temperature peaks and when the soil is the hardest as a result of evaporation, particularly in the areas with heavy soils (clay) on the farm.

Weeds compete with banana plants

Compacted heavy soils, dry and hard

6. Harvesting

Harvesting: This is the process followed to remove the bunches from the field that meet the specifications and can thus be processed and exported (according to **age and development**). This process is closely linked to washing, fruit selection and packaging and both processes must therefore be organised as efficiently as possible. We recommend establishing the necessary infrastructure to ensure an efficient process, having bunches available for the harvest, distributing farm areas for the harvest depending on the age, implementing a system to take the bunches to the packaging plant, and having trained workers carry out these activities. The farms must also keep records to be able to control the age and the availability of fruit for the harvest, which makes it possible to estimate production as accurately as possible. These records are important because when exporting it must be possible to make periodic estimates and forecast harvests. In this way the market, and the farm's clients, can organise their own logistics based on the production currently available. Harvesting is a field process carried out in various steps:

1. **Verify that the fruit complies with specifications, diameter or calibre, and age,** based on age control conducted on the farms. This prevents the risk of premature ripening of the fruit sent to the market.

Measuring diameter, before harvesting

2. **Cut the bunch off the plant and place it on the pad on which it will be transported to the cableway.** This must be done in such a way that it ensures the best possible bunch and fruit quality and conditions, prior to being processed when it arrives at the packaging plant.

Carefully cut the bunch, place in on the pad …

… and carry it to the cableway

3. **Transportation to the packaging plant** for verification and processing, preferably using a cableway system.

Cableway to the packing station

4. The quantities of the bunches of each age received are subtracted from the controls of the bunches bagged by age, which is a practice that aims at **controlling the fruit available** for the subsequent shipping processes. Collect and count the coloured ribbons of the bunches that are harvested; compare with the number of coloured ribbons that should be tied to the bunches still in the field, according to the records.

Calibrator, length meter and age control format for coloured ribbons

5. **Reject bunches that do not meet the specifications for processing**, verifying the causes in order to take corrective measures at the farm and avoid losses in future production.

In Sudan, the harvest system has to be implemented completely, since there are no field practices nor infrastructures that enhance the quality of the harvested bunches, and thus, the benefits these bunches may generate when these are processed and packed for export. During a harvest trail in Singa, only around 20% met the quality specifications for exports (see ANALYSIS SUMMARY. October 2012). This highlights the enormous opportunities offered by implementing the necessary harvest practices and the necessary infrastructure for transportation of the harvested bunches from the field to the packaging facilities. This requires investments in training the workers and staff, and in purchasing the tools, equipment, and infrastructure needed. This would significantly increase the percentage of fruits for export, easily up to a minimum of 80% of the bunch production.

ANALYSIS SUMMARY

FRUIT AVAILABILITY IN SINGA FOR EXPORT

TAKING INTO ACCOUNT THE SPECIFICATIONS (LENGTH, CALIBRE) AND QUALITY CRITERIA OF AGROFAIR

Data	**October 17, 18 & 20, 2012**

	CHARACTERISTICS OF THE BUNCHES						**FRUIT AVAILABILTY FOR EXPORT (%)**	
FARMS	**Avrage number of banana hands per bunch**	**Average weight per bunch**	**Average calibre per hand**	**Average length of banana hands (inches)**	**Average number of banana fingers per hand**	**Average weight per hand (kg)**	**CALIBRE & LENGTH ARE OK ?**	**AGROFAIR SPECIFI-CATIONS ARE OK ?**
FAROUG	12.0	29.85	39.5	7.63	20.1	2.49	67.8%	12.6%
AMHED	10.0	19.42	39.7	7.26	16.2	1.94	65.1%	26.1%
ABDELHMID	9.0	22.71	41.5	7.91	17.9	2.52	76.7%	16.9%
AVERAGE	**10.5**	**24.58**	**40.0**	**7.59**	**18.4**	**2.34**	**69.6%**	**17.2%**

OPPORTUNITIES

1) Bunches dehanded in field (fruit protection), increase availability (calibre and length will increase)
2) Age control with ribbons at flowering (fruit protection), decreases risk of oversized or undersized fruit
3) Cultural practices in the field (maintenance), increase the availability of clean fruit
4) Improvement of the harvesting system increases fruit availability (careful handling)

Harvesting trials and analysis of fruit availability for export on 3 farms, Singa, October 2012

7. Processing and packing

Packaging plant: During this phase, the productive process of the farm in production is complemented by transforming the raw material or bunches into products ready for human consumption. This has to be done in compliance with specifications that ensure food safety and innocuousness for the consumers. The steps in this process, once the bunches, or raw material, have been taken from the field to the packaging plant are detailed below.

Banana bunches arrive at the packing station via the cableway

1. **Reception of the harvested bunches and verification of the specifications:** When the bunches arrive at the packaging plant following the harvest they have to be counted, in total and by age or ribbon colour. This is the way to control the harvested bunches and the ones still available, by age, for the next production. The most important thing is to calculate the recovery percentage of the protected bunches at the farm on a weekly basis. At the same time, the quality of the harvested bunches is controlled, and the ones that do not meet the standards in terms of measurements, specifically diameter and length, are rejected. In this phase, it is of the utmost importance to check the degree of ripening of the bunches by means of a field test. This test consists of **removing a lateral finger from the second hand from the top down**, splitting it in half and confirming that the ripening progress of the bunch has not advanced; the fruit should be whitish and odourless. It is also important to reject all bunches with defects resulting from diseases or pests, or that present any condition that is not appropriate for export processing. The

bunch is then pre-washed with water under pressure in order to remove any dirt or dust that may have adhered to it.

Ripening test

Pre-washing the bunches

2. **Dehanding of bunches:** Once the bunches have been accepted for processing, they are dehanded in a tank or tub designed for holding the bunch hands using clean, disinfected water.

Dehanding

Hands deposited carefully in tank

The hands have to be managed in such a way that they do not bump against each other during dehanding of the bunch, or when they are placed in the tank or tub. This job has to be done with a very sharp curved knife for dehanding bananas, in order to remove most of the rachis crown and thus be able to make good crowns for the clusters. It is important to proceed from the apical hand to the basal hand to avoid damages to the fruit when removing the hands and pre-classifying them in order, i.e. separating the large hands from the medium and small ones in separate tubs.

3. **Fruit selection and cluster preparation:** Once the hands have been placed in the tank or tub, with clean and disinfected water, they must be reviewed one by one, eliminating all products that do not comply with the specifications in terms of diameter, length and quality.

Fruit selection and cluster preparation

Tank to clean banana clusters

This should be laid down in the operations manual according to the destination market or brand. After eliminating all products that fall outside the specifications, the clusters are formed in a compact manner, with at least 3 fingers per cluster and up to a maximum of 7 fingers per cluster, depending on the specifications of the destination brand or market. Sufficient crown should be left to hold the fingers. The clusters should be formed as compactly as possible in order to make a nice package. All this should be done using a very sharp curved knife specifically meant to select bananas, and cutting the crown in such a way that speeds up healing and closing the tissue. The bunch hands should be placed on selection tables, which enables adequate handling of the fruit during this procedure, without damaging or scarring it. Once this procedure is completed, the clusters have to be placed in a tank or tub, with clean, disinfected water,

so as to remove all latex from the processed crowns. For this procedure to be more effective, the bunches must be completely submerged in this water for at least 15 minutes.

4. **Weighing and classifying the fruit:** Once the latex has been removed from the crowns of the clusters that have just been cut and formed, the clusters should be placed on a banana tray separated by size and in the quantities needed to form good packages. The sizes should go from small to medium to large relative to the position of the person performing this task. The different channels designed for this purpose in the tray should be used when performing this task. At the same time, the product is weighed on scales according to the specifications of the target market or brand. The standard weight established for banana boxes is 18.14 kg of green fruit upon the arrival of the shipments at their destination. However, there are destinations or brands with different weight specifications, which have to be laid down in the operations manuals used at the farms that produce organic bananas for export.

Weighing the fruit for 18.14 Kg boxes

Post harvest treatment (crowns)

5. **Post-harvest treatment:** Once the fruit has been placed on the banana trays, it is subjected to the post-harvest handling procedure. This concentrates on the area where the crowns have recently been manipulated and on the tips of the fingers where the flowers were removed, in order to control the effect of fungi that may cause rotting in these areas. There are different treatment systems; the producer has to decide which system to use based on the investment capacity. Some systems include: **a)** Application using brushes, **b)** Manual application using pumps, and **c)** Application with automatic sensor-activated systems for the discharge. Furthermore, the available organic products

for effective control have to be examined, including their compliance with organic banana production standards. The application quantities vary from system to system because the discharge volume of each system affects the concentration of the product being applied. When preparing and mixing the application, we recommend always using clean and disinfected water that has been treated with 2% alum. This guarantees disinfection and ensures the proper healing of the recently manipulated crowns. The concentration of this mixture should not exceed this limit, since this may dry up the crowns. Regardless of the system selected for application during post-harvest treatment, the operator must at all times conduct the application in such a way that all crowns and scars from flower removal receive the correct application to ensure correct treatment. The preparation tables and the products to be used have to be specified in the operations manual, according to the destination brand or market.

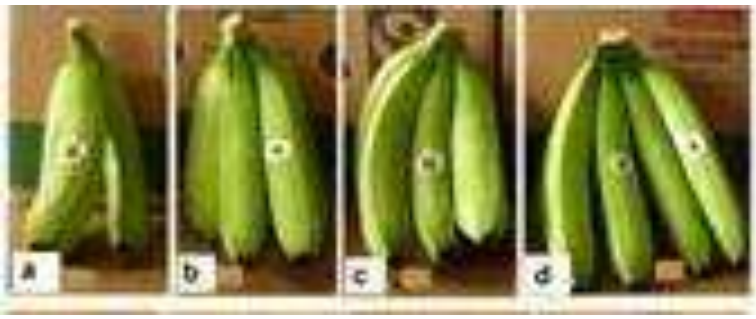
6. **Labelling:** This is done to identify the product by putting a special sticker that identifies the brand being produced on the middle of the front half of the fingers of each cluster. This can also be done according to the client's specifications. This has to be done in such a way that the stickers do not fall off, thus guaranteeing the proper identification to the consumer. The glue and all other materials used for the stickers must comply with the relevant gluing standards for safe, innocuous, and organic human consumption.

7. **Preparation of the packaging material:** This task is carried out to prepare the material that will be used for packaging by gluing the cardboard base and cover.

Prepare the boxes for the packing line

After this process, they are put together and a firm paper sheet or pad is added to separate the rows of bananas and protect them from each other. Depending on the destination of the products, a plastic bag is also introduced. This procedure should be laid down in the specifications included in the operations manual. After the material has been prepared, the packers place the fruit in the boxes.

8. **Packaging:** This is the activity through which the product is presented to the client, and consists of placing the fruit in the cardboard box using plastic bags to store the product. The plastic bags differ depending on the actual destination.



Different cluster types:

a. With one finger in front
b. With two fingers in front
c. With three fingers in front
d. With Four or five fingers in front

Generally the fruit is placed in four rows, which are separated by a paper pad that protects the fruit against possible damages that may result from poor preparation of the packages. There are different types of packages, and these should be specified in the operations manual that is used to train the workers who carry out this task. The type of package depends on the destination brand or market. There can be variations in the type of material used, i.e. different types of cardboard, plastic, paper pads for separating, etc.

Typical 18.14 kg box and pad

Cover for 18.14 kg box (organic bananas)

The most common type of packaging used for the standard boxes of 18.14 kg of bananas is known as the **conventional** packaging. It begins by placing a 1.5 inch - thick wooden spacer on each side of the box, between the box and the paper film used for separation. It has to be placed in such a way that it covers or protects the fruit between the different rows and prevents the fruit from damaging each other.

Packing: first row

Packing: second row

Before starting to actually place the fruit in the box, outside the plastic bag that will be used the medium and straight clusters are placed on the **first row** with the crowns facing the packer. This must be done taking into consideration the overlap between clusters so as to form a good package. Next, the small clusters are placed on the **second row**, likewise considering a good overlap between clusters and taking care not to place the crowns on the tips of the clusters of the first row.

Packing: third row

Packing: fourth row

Once these two rows have been formed, the spacer that was placed on the part of the box near the packer is removed. It is then protected with the paper film for separation in order to avoid damages to the fruit placed on the first row caused by the crowns of the fruit that will be placed on the **third row.** This row is formed using the large and curved clusters on the tray and leaving a good overlap between the clusters. Next, the spacer placed in front of the packer is removed and the second row is protected with the paper film for separation, taking into account that it also has to cover the separation between the tips of the third row and the **fourth row.** This row is formed by placing the large and straight clusters, with a distribution that always gives the impression of a full box and considering the overlap of the clusters placed there. After the package has been prepared, the used plastic should be reused to cover all the fruit placed in the box. This can be done by overlapping or by closing the plastic bag with rubber bands to extract the air from the vacuum packages, depending on the destination market of the final product.

Packing: close plastic bag with rubber band

Check weight before palletizing

9. **Reweighing:** Once the boxes have been packed, the weight of each box should be checked, thus ensuring compliance by using scales and reweighing all boxes that will be taken to the pallets for export. It is important to remember that the weight varies between brands, and this must be specified in the operations manual that the producer should keep in order to ensure compliance with the requirements of the different clients or brands.

10. **Loading or palletising the packed boxes:** The packed boxes have to be loaded on wooden pallets in groups of 54 units for subsequent storage in refrigerated containers.

The boxes have to be loaded carefully because at this stage the fruit can be damaged if the packed boxes are not handled carefully. The boxes have to be loaded, and the plastic cords have to be placed very tightly in the established order. Corner pieces must be used to fasten the stacks correctly and to properly form the pallets that will be stored. If necessary, further reinforcements with parts of corner pieces can be used on the boxes of the two bottom rows of the stacks. All this has to be specified in the operations manual for each brand or destination, including the order of the plastic straps needed to fasten the pallet. In general, this is at the client's request. Each pallet must bear identification with the pallet number and the brand of banana being exported, for the purpose of reporting the stored cargo when the pallets are exported.

Typical: 54 boxes per pallet (9 layers of 6 boxes

Typical: 20 pallets per container (= +/- 20 TM)

11. **Storage in refrigerated containers:** When the pallets have been prepared, they should be loaded in refrigerated containers for export. Stowage has to be done in such a way that air circulates properly throughout the cargo. This prevents fruit losses due to premature or irregular ripening as a result of poor air circulation. When the pallets have been put in place, a device should be placed on the next to last one to monitor the temperature inside the container as soon as it is closed for export. This ensures its adequate functioning as well as the cargo's safety. This must be specified further in the producer's operations manual since there may be variations among clients, brands, or destinations. When the cargo is stored, the temperature inside the container must remain between 13°C and 15°C; this way, the stored fruit will be kept green and fresh until it arrives at its destination. When preparing the refrigerated containers, it is also important to follow international export standards that concern phytosanitary permits and the like.

8. Monitoring and quality control in the field and packing station

Production controls: During the harvesting and packaging processes, there must be a person in charge of monitoring all the relevant elements of each process. This person must register the details that can later be used to take corrective measures or foresee future situations. These details can be related to: **a) Production:** bunches per box, % of waste, performance of workers in different processing areas, etc.; and **b) Quality:** the quality of the fruits selected and separated in clusters, the quality of the packages themselves, the quality of the end product, etc.

1. **Practices:** Formats and records have to be laid down, and they should be based on the procedures followed for the different practices carried out on the farms. The people in charge of the different practices on the farms – including the crops, harvesting, and packaging – must evaluate these practices and ensure compliance with the parameters defined. They have to keep records in order to identify improvement opportunities for every worker based on actual data.

2. **Finished product:** In the packaging facilities, records must be kept of the evaluation results of the finished products, as well as of the improvement opportunities and of production data that influence quality and yields. It is also important to have control graphs to ensure that production is consistent with the required quality of the finished product.

3. **Product sent to the market:** The market must have a direct line of feedback communication with the production centres with regards to the results of the product received. In this way, the necessary adjustments can be made in the processes and consistent results can thus be guaranteed for all the different shipments. Furthermore, it is important to keep historical information for every production centre.

Important note: All the processes set forth in this organic production guide for export are currently not being practiced in Sudan. These include crop practices, harvesting and packaging processes, handling and storage of the finished product ready for export, process controls and records of qualities of finished products, personnel performance, and materials used. In order to establish an efficient and sustainable organic production chain, it is important to take these issues into account. The reason is that the only way to make adequate decisions is on the basis of data and records that cover all seasons of the year. The smallholder banana producers involved in this project and consulted to date provided data verbally but with no hard evidence. In fact, these data were often inconsistent with field observations. Hence, this recommendation

is important to make it possible in the future to establish export-oriented organic banana production systems.

Another recommendation is to draft procedures and operations manuals for the organic banana growing farms in Sudan. These should specify all the processes and steps that must be followed on the farms from establishment to shipment of the final product to the markets. This actually means that the entire production chain should be efficient and sustainable. Initially, these manuals might be based on manuals for organic banana growing regions with a climate similar to that of Sudan. However, these must be continually adjusted as real data on the behaviour of the crop in Sudan become available. In view of the climate in the area, an efficient and sustainable handling of this crop requires records upon which decisions should be taken. In some cases, these data may vary widely compared to data of handling the crop in other regions with an organic production. In this sense, we suggest forming a governing institution for the technology transfer process, where stakeholders in the export-oriented organic banana production, the government, producers, universities, and others may participate. The aim is to define regulations required to achieve the objectives of exporting organic bananas from Sudan in a sustainable manner, and of implementing research, training, and development programmes for the banana sector of Sudan.

Another element that must be considered to improve the management of the organic banana production systems, and which is not being practiced in Sudan to enhance decision making, is to perform the following sampling procedures at least once a year:

1. **Analysis of soil fertility:** to determine the availability of nutrients in the soil and be able to establish programmes to help the crop maintain the expected organic production levels.

2. **Foliar analysis:** to determine the nutritional status of the crop. The samples have to be taken when the plants are flowering, which is when they need all their energy to develop the bunch.

3. **Root analysis:** because the roots' health is a very important factor to link the two analyses mentioned above. The reason is that, in Sudan, the banana plantations are mostly located along the rivers (Nile, Blue Nile, and other rivers) where there is water to develop the crops. However, this also means that every year the crops run a very high risk of flooding, especially in August. When they occur, the floods affect the root health of the plants, first because of the water stress to which the established plantation is submitted and, second, because of the significant populations of nematodes that can develop as a result. This is especially true of the *Radophulos similis* species, which has a

significant impact on banana plantations since it develops inside the banana root system.

This is a very important concept that affects the production, the operating costs, and the vigour of the plantation. It is therefore of the utmost importance to conduct these analyses in a laboratory specialised in this type of sampling. Correct interpretation of the results will ensure adequate decision making in the banana growing farms. It is important for the laboratories to establish the parameters to interpret the results, which in turn helps the producer, or the person in charge, to prepare fertilization programmes for the organic banana producing farms.

9. Transport, logistics, distribution

1. **Transportation from the production centre to the port:** There has to be a very specific coordination in place to decide on the transportation of the products from the farms or production centres to the port. The aim is to avoid risks that may affect the green life of the finished product, and to calculate the time the carrier needs to deliver the container to the facilities that have been designed to store the products before the container is taken safely to port for loading. The containers in which the products are stored have to be refrigerated at 13.5°C, which is the recommended temperature to transport bananas. The refrigeration system has to be programmed and activated once the bananas are loaded in the container, which must then be securely closed for transport.

Refrigerated containers are loaded

Storage of containers in the port

2. **Transportation from the port to the collection centres (at destination):** Once the products have been stored at the collection centres from where they will be shipped, sufficient guarantees should exist that the shipping line or company that will ship the products to the collection centres at the destination will handle the products adequately. This is meant to avoid damaging the green life of the bananas, which may result from poor handling during transportation to the market (by ship).

3. **Reception, evaluation, and distribution of the product:** When the products are received at the reception ports, it is important that the product handling operation is adequate. This ensures and preserves the best possible quality upon arrival at the collection centres, where the products will be evaluated and later distributed to the sales centres or outlets, or to the supermarkets.

Unloading the container at the distribution centre in the country of destination

4. **Market feedback to the production centres:** When the products shipped have been received and evaluated, feedback about the state and quality of the bananas and boxes received is desired. This helps the production centres to take corrective measures depending on the results, or to evaluate the processes within the chain that may be affecting the quality of the product received.

Quality control in the distribution centre – reports are sent to the producer

10. Natural risks, pests and diseases

Identification of natural or environmental risks to production: An overview has to be made of the seasons of the year when production is affected by natural phenomena that cause losses of bunches or even of the plantation. This can be done through clear and defined records, which may help us study viable alternatives to reduce or prevent their effects. For Sudan, the following risks can be mentioned:

1. **Wind:** January to May is the time of year when the effect of winds is the most marked, causing plant losses because the winds are very strong. These winds also cause too many leaves to break. We therefore recommend establishing natural barriers using trees with low-density foliage in order to reduce the strength of the winds that penetrate the plantation, but with no further effects. The barriers (windbreaks) have to be designed in a way that they reduce wind speeds.

2. **Dirt or dust:** This is a problem that occurs during the windy season, from January to May. It causes serious damage to the quality of the fruit that will be exported during transportation of the bunches from the field to the packaging plant because of the friction between the bananas caused by dirt or dust (which acts as sandpaper). When processing the bunches, these damages are hardly visible and are considered to be minor defects that are acceptable within the quality parameters.

Dust between banana fingers

Damage due to friction of dust

However, the damage worsens as the days go by after the harvest and becomes very visible during ripening prior to distribution to the supermarkets. Hence, this condition

cannot be accepted for fruit meant for export to Europe, and therefore causes a significant decrease in the usable yields of harvested bunches. We recommend finding alternatives to avoid these damages by means of plant barriers that stand in the way of dust entering the plantation. Another alternative is to use plastic bags with ventilation that act as a mechanical barrier against the dust that may adhere to the bunch.

3. **Damage due to solar radiation:** It is necessary to determine the time of the year when the intensity of the sun affects the condition of the bunches when it burns the bunch or rachis. This condition may affect up to 10% of the available production, causing significant losses; therefore, identifying alternatives to counter these effects is of upmost importance. These include using plastic bags with pigmentation to avoid direct radiation on the fruit, and in some cases protecting the hands or clusters most exposed to the sun with some kind of paper. Any rachis exposed directly to solar radiation has to be protected as well, because the parts burned by solar radiation affect the growth and green life of the bunch, causing the rejection of these banana bunches during export processes.

Damage due to strong solar radiation – burning of bunches

4. **Floods:** The rainy season in Sudan from July to September, but particularly in August, presents flood risks to the banana plantations. It is therefore important for the export banana farms to take preventive measures to avoid this risk. One idea is to build retaining walls (banks, dykes) in the areas that border rivers. Besides causing production losses, floods also bring nematode infestation to affected areas, since floods are their

most effective means of propagation. Nematodes affect the adequate root functioning of the plantation and therefore the efficient extraction of nutrients from the soil. This, in turn, reduces the growth of the plant and the bunch during flowering.

Inundation in the banana plantation

Protection wall or dyke against flooding

5. **Pests and/or diseases:** The climatic conditions in Sudan are not favourable for the development of pests or diseases. Because of the prolonged dry season (9 months), so far neither fungi nor insects have developed that may infringe upon the development of the plant or bunch. In any event, it is important to keep the bunches or plants under observation in order to avoid the development of pests or diseases that may pose a risk to production for export.

Nematodes – microscopic worms in the soil, affect the root system

There is only information – but no evidence yet – about problems caused by the borer root nematode, or *Radophulos similis spp*. This nematode is a problem because of the floods that occur every year during the rainy season, from July to September, when the

rivers that supply water to irrigate the crops during the dry season overflow. We therefore recommend carrying out yearly root sampling campaigns or, at least, once the farms recover from a flood, analysing the state of the roots and assessing the damage caused by nematodes and their populations. At the same time, this sampling is helpful to determine the total number of existing roots, as well as the quantities of good roots and damaged ones. This analysis can be combined with the results of the foliar and soil analyses to measure the efficiency of nutrient extraction from the soil, as well as the growth and development of the plantation.

11. Data collection and certifications

1. **Control of expenses and costs:** The farms have to establish a cost control system to determine the real production costs in the different units:

   a) Per hectare of labour (crop)
   b) Per protected bunch (fruit protection)
   c) Per harvested bunch (harvest)
   d) Per box produced (packaging/ farm total)

   Establishing this system helps the farm be more efficient in its operations, since it relates the labour performed to the materials used. This is the correct way to manage the efficient use of the existing resources, i.e. **labour input / materials,** during production (**crop, harvesting, and packaging**). In all seasons of the year, the necessary adjustments must be made to enhance the available production per season and to ensure that the raw material generates the largest possible volume of quality products for export. When carrying out this analysis, it is very important to ensure **correct practices** that lead to good yields and high quality. It is also important to purchase quality **products and tools** for adequate use on the farm and to ensure a competitive price.

2. **Carrying out programmed tasks:** The farms need to follow a time line of the tasks to be carried out throughout the year, preferably in a weekly format. Reviews should be conducted periodically, at least monthly, to make the necessary adjustments and perform all the tasks without affecting the quality of the export product. This is also helpful to make sure that the farm has the necessary materials, manpower, budget, and the like throughout the different seasons of the year.

3. **Compliance with projections:** Any banana producing farm must have a time line or an estimate concerning how its operations are evolving in terms of the projected weekly production volumes throughout the year, as well as a time schedule for the work that needs to be done. Compliance and efficiency have to be monitored in order to make the necessary adjustments and comply with the projections. We recommend conducting reviews at least once a month to analyse compliance and the evolution of the projections prepared by the farm administration, and to make any necessary adjustments.

4. **Performance / yields / productivity:**

a). Of personnel: These records are important so that the farms can efficiently use their manpower, because at the moment there are no records of this in Sudan, meaning there is no evidence regarding the performance of workers. These records can be used to define the number of workers the farm needs to ensure a performance that is efficient, on time, and with the quality needed for a guaranteed production of raw material for export.

b). Of materials and tools: In order to maximise an efficient use of resources, it is necessary to keep records of the correct use of the materials, tools, and equipment used for the farm work. The reason is that these items account for around 70% of the operating costs. If these items are not effectively controlled, the operating costs of the farm may increase merely because of the lack of control or records. Moreover, this helps us determine the costs, performance, and quality of the materials and tools used as compared to the production we expect to export. It is vitally important in Sudan to support this because, at present, there are no factories that produce the materials, tools, and equipment used in the banana industry. This means the entire operation becomes more expensive, since all materials, tools, and equipment have to be imported.

5. **Compliance with certifications:** This aspect is important in order to develop the system of organic bananas for export, especially to Europe. This is why in this document we emphatically suggest implementing registers and controls of the activities conducted on the farms within the framework of exporting organic bananas to Europe. This is not only important to monitor the performance of the farm. Maintaining registers is also a mandatory requirement to comply with different certifications, since it provides evidence of the adequate management of organic production and compliance with other standards in Sudan. To date, no 'culture of keeping records' has been observed in the banana plantations visited or involved in the project. The main certifications that are required for exporting organic and fair-trade bananas to Europe are detailed below.

a). Organic production: This is an important certification for all farms that plan to export food products, particularly to European and US markets. This certification covers a series of parameters and standards to certify farms. There are programmes that offer financial and technical assistance and training for the countries interested in establishing an organic food chain, such as the PIP COLEACP programme (http://pip.coleacp.org/en). The ACP countries have the advantage of being eligible for this type of assistance or support for the successful implementation of these programmes. I recommend applying for these programmes so that Sudan can be considered a potential producer of organic

food products. More information on the page of the International Federation of Organic Agriculture Movements (IFOAM): http://www.ifoam.org/. The European market has special regulations for organic production and labelling. More information on: http://ec.europa.eu/agriculture/organic/home_en.

Box: fair-trade and organic label for the EU market, fairtrade code, organic certification body

Fair-trade and organic labels on the bananas

b). Fair Trade: This certification guarantees that the traded product complies with fair trade principles for the benefit of all participants in the commercial chain, from the producer to the consumer. This certification encompasses a series of parameters and standards that include annual controls to verify compliance, and the correct use of the premiums granted to the participating small producers or their associations. More information on http://www.fairtrade.net/ and http://www.flo-cert.net/flo-cert/.

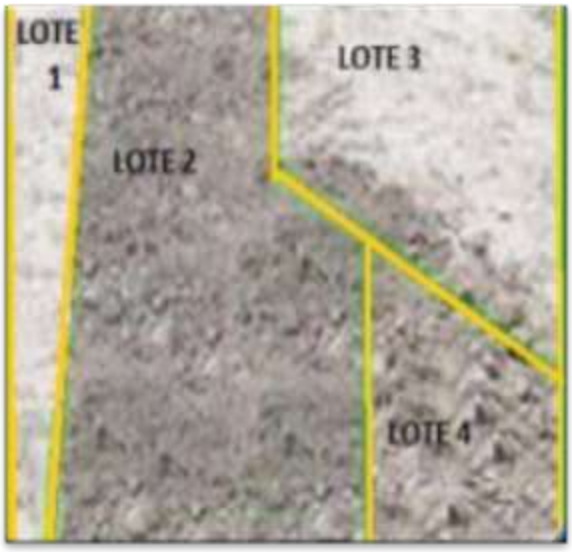
c). GlobalGAP: This standard offers guarantees to the clients that a product is safe for consumption and regulates all production parameters at the participating farms. Under this system, it should be possible to verify the records of all systems or programmes established for the production and their due compliance (traceability). Without this certificate, it is virtually impossible to export food products to Europe or the US. More information on http://www.globalgap.org.

A N N E X E S

Annex 1 - Soil studies for banana plantations

The following analyses and studies have to be conducted: **Fertility, Texture (Analysis), and Structure (Study).** This should be done in the following way:

1. **Walk around the field to determine homogeneous areas.** During this walk, a field sketch has to be drawn in order to determine the places where samples will be taken in representation of the mapped areas.



Division of the area in different homogeneous lots for sampling, according to soil characteristics

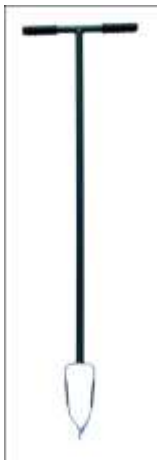
2. **Taking samples from identified areas.** These are taken from the upper 30 cm of soil. The walk is made by zigzagging in each area in order to take representative subsamples (15 to 20). Then, these are mixed to homogenise the sample so it is representative of the area, and in order to obtain a parameter of **soil fertility** and of the **texture at different depths (see the soil drill)** of the area where the new plantation will be established. The samples must be sent to a competent laboratory for the necessary analyses.

1. Take the soil sample

2. Collect the soil sample

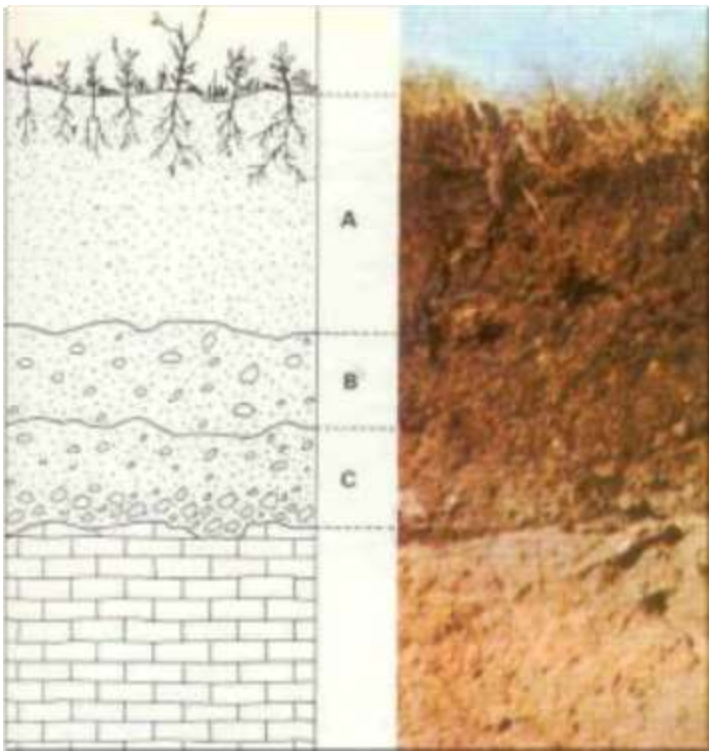
3. Mix it with samples from the same homogeneous area

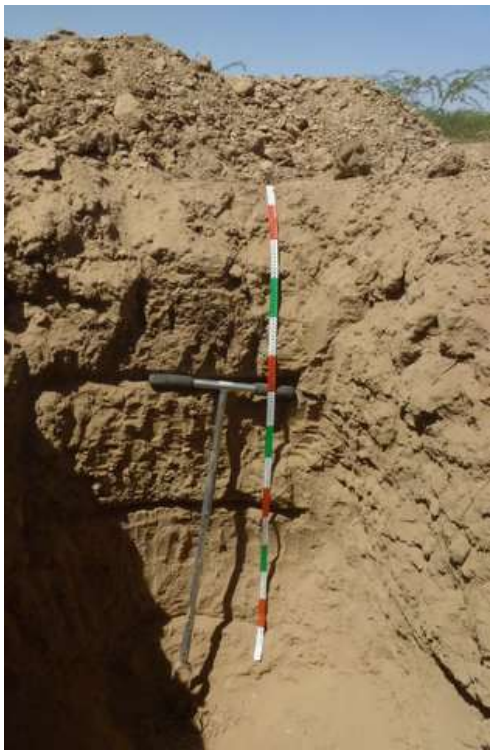
4. Prepare to take the sample to the laboratory



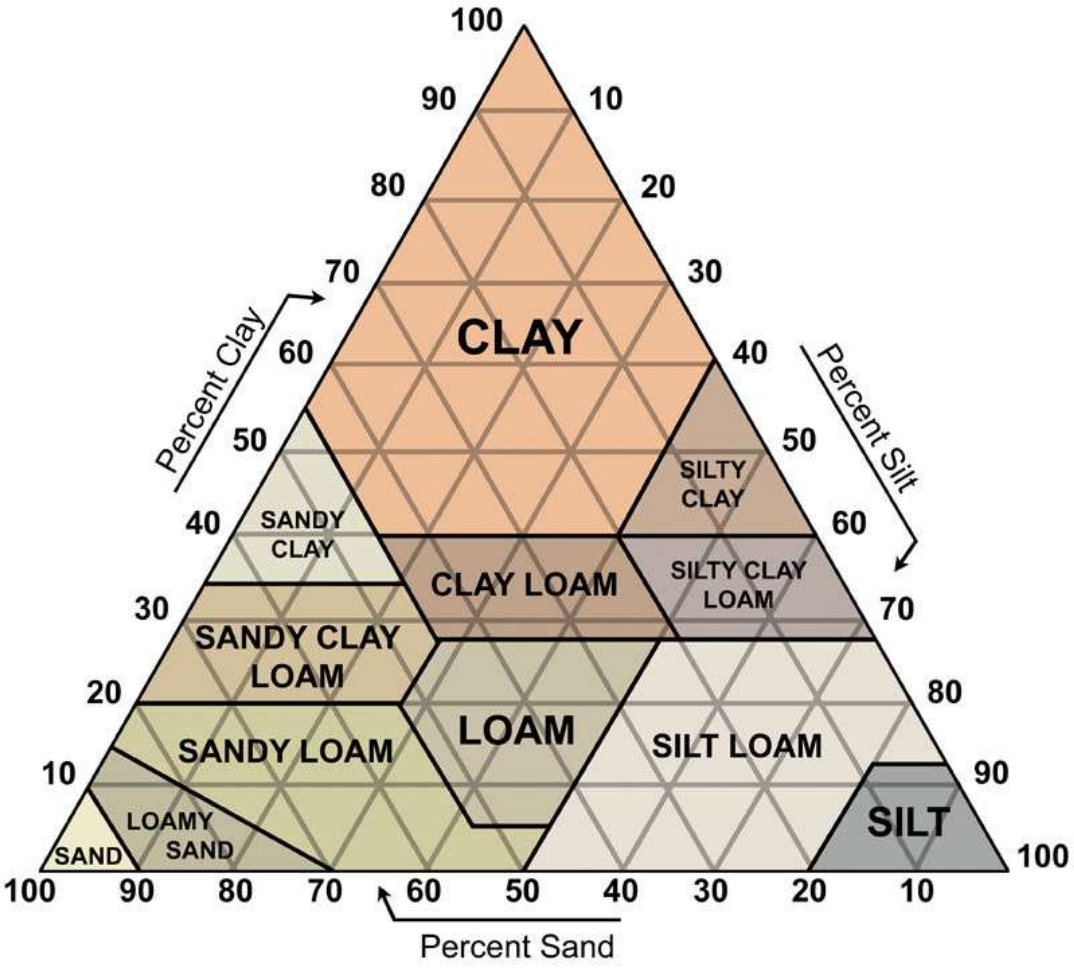
Manual soil drills to take soil samples at different depths

3. **Pit system.** This system is used to have an idea of the structure and texture of the soil at different depths, 1.20 - 1.50 metres in the case of bananas. The **soil profile** is used when designing the water drainage and irrigation systems that will be used on the farms, and also helps to examine the organic material available, especially in the surface soil layer. At certain times, this system can also be used to observe the growth and distribution of the root system of the plantation.





Design and objectives of the soil profile studies (pits)



Triangle for the analysis and classification of the soil texture, determined by the percentages of the components clay, sand and silt

Annex 2 - Water irrigation systems for banana plantations

In Sudan, irrigation is normally based on gravitational irrigation systems or flooding, since there is water available from the rivers near the existing banana plantations. However, this does not mean that this type of system is correct, the cheapest, or the most water-efficient option. Hence, we suggest other, more efficient alternatives for applying and using water, but with initial investment costs that are much higher than those of a traditional system.

1. **Sub-foliar sprinkler system (micro sprinklers or sprinklers).** This system requires large water volumes and pumping systems for uniform distribution of the water, with the necessary pressure to ensure good application. This can also be used to apply fertilizers directly to the crops through the system, which is not very efficient since we would actually be applying in areas that do not need nutrition.

Water intake

Sprinkler

So called "fertigation" system – fertilizers are mixed in irrigation water

2. **Drip application system.** This is the system that requires the highest investment, but enjoys the most efficient performance in terms of use and application of available water. This system can be used to apply fertilizers directly at the bottom of the plants.

Drip irrigation in a new banana plantation

Drip irrigation in the same plantation (now producing)

3. **Gravitational irrigation or flooding.** This is the most readily available system. However, it is less efficient in terms of use and application of water, since it needs a good levelling of the areas for correct application, as well as large volumes of water to ensure adequate application. This is because part of the water is lost due to filtration in the areas without crops, and also due to evaporation. Besides, the actual process of irrigating is slow.

Water pump, intake from the river

Irrigation by flooding

4. **Water intake for crop irrigation, and the place where samples should be taken to determine the quality and availability of water (capacity).** The water has to be analysed by laboratories that are specialised in this type of work. Likewise, water availability and total capacity have to be gauged with experts in order to get proper recommendations with regards to the most adequate system that should be implemented. This should also take into account the results regarding the slope and the structure and texture of the soil. Regardless of the system that will be implemented, it is important to provide training to the workers who will be responsible for watering concerning adequate use and management, because in Sudan this resource may become less readily available in the future if not used properly. Let us not forget that this is an essential resource in view of the existing climatic conditions in the region. It is therefore a very valuable resource in the food chain of the area, which may also be a determining factor for job generation and food production.

Annex 3 - Banana planting systems

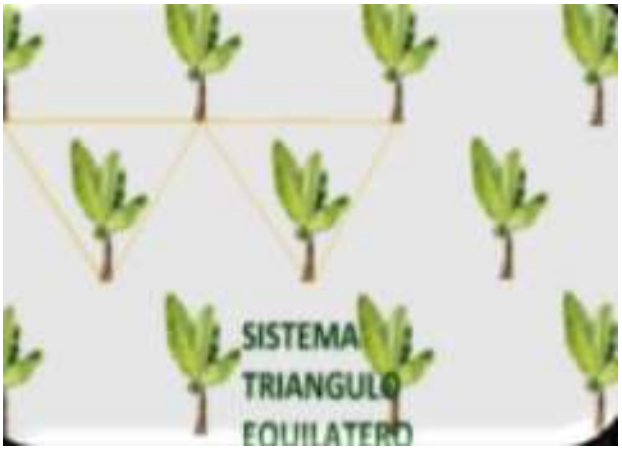
After defining the variety that we will use and the plant density we will apply in the production areas, we have to define the planting system we will use. This refers to the way in which the plants will be placed in order to ensure the best possible use of the land and soil, as well as the best possible development of the plantation. This, in turn, will ensure good yields during successive generations of the banana plants in the plantation. We must remember to first define the master line on which planting will be based, using any structure as a reference point. This defines the planting order, which has to be as close as possible to a 90° angle.

Master line (can be a road, a canal etc.)

Once the master line has been set, we need to define the order in which the plants will be arranged. The following alternatives can be used: planting in squares, in rectangles, in an equilateral triangle system or in double rows.

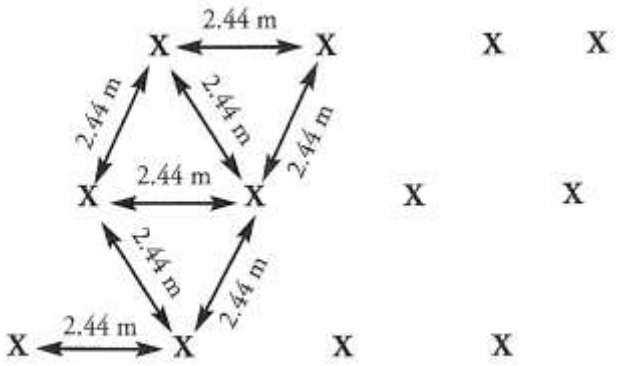
Planting in squares

Planting in rectangles



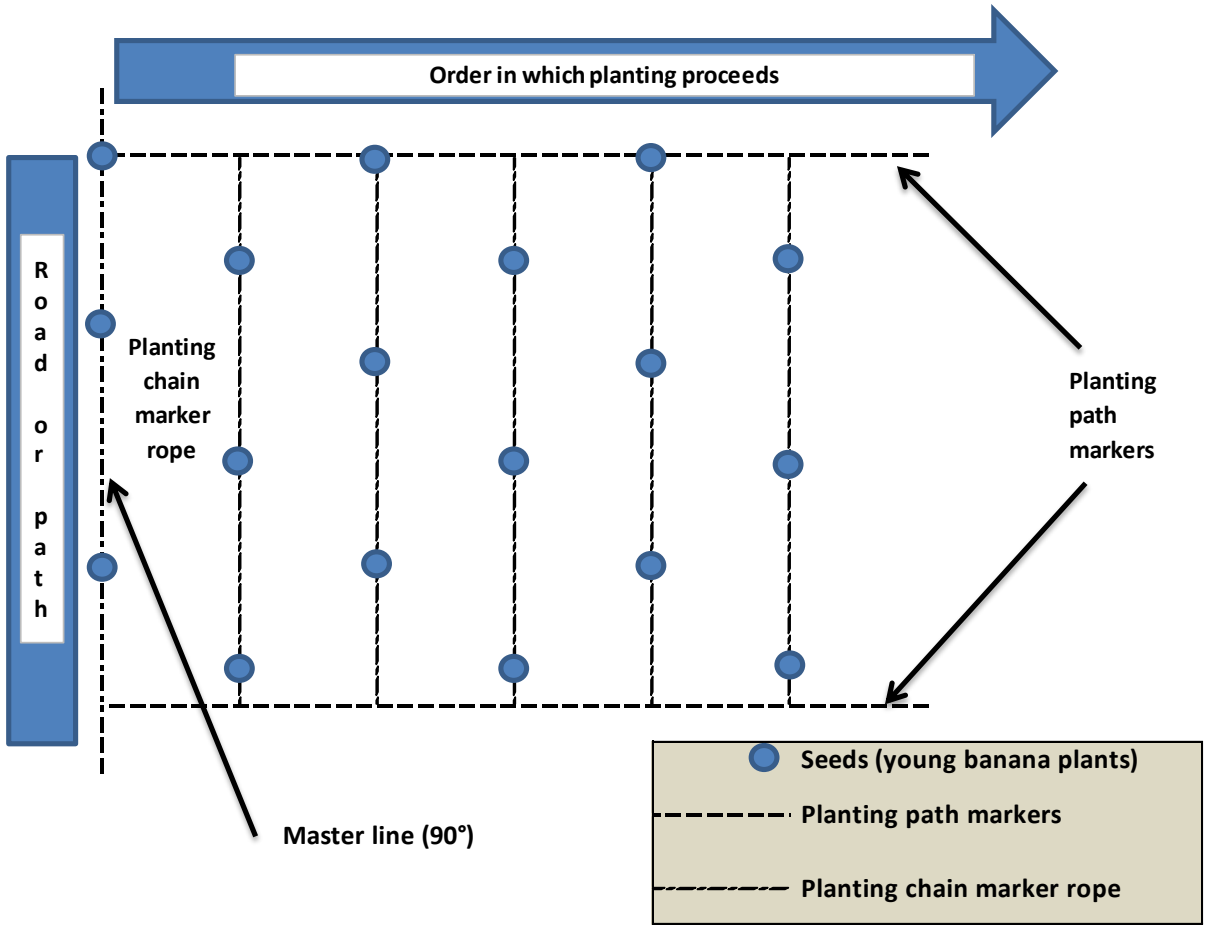
Equilateral triangle system – each plant has the same distance

Double rows – at planting (above) and producing (below)



In order to arrange the plants adequately, we have to use two strings or ropes marked with the distance between the furrows, one on each side of the area that will be planted. These are known as **planting path markers** and should be fixed. We need another rope with the distance between the plants in each furrow, which is known as the **planting chain marker** and moves across the planting area to define the precise locations of the holes where the seeds will be planted. See the following diagram.

Diagram showing the use of ropes for planting



1. Square and rectangular planting

In order to calculate the number of plants per hectare according to the planting system, the producer or person in charge of calculating the seeds needed per production area that will be planted has to use the following formulas (the same formula is used for calculating Square and Rectangle planting):

Production units / hectare	$\frac{100}{a} \times \frac{100}{b}$

Where	
a	**= Distance between furrows (metres)**
b	**= Distance between plants in furrows (meters)**
100	**= Length of a hectare (metres)**
100	**= Width of a hectare (metres)**

Calculation	**# Furrows x Hectare =**	**100/a**
	# Plants x Furrow =	**100/b**

For example :

Density calculation for square and rectangular systems					
Hectare	Metres		Distances	Quantities	
Length -->	100	2.00	Between furrows	50	Furrows x Hectare
Width -->	100	2.00	Between plants	50	Plants x Furrow
Production units / hectare ==>			2500		

2. Planting in a equilateral planting system

Equilateral triangle or Staggered arrangement planting, which is the most recommended planting system to use:

$$h = \frac{a\sqrt{3}}{2}$$

Where
h = Traingle height (metres)
a = Distance between plants (metres)

Calculation	# Furrows x Hectare =	100/h
	# Plants x Furrow =	100/a

Density calculation for the equilateral triangle or staggered system (production units / hectare)					
Hectare	Metres		Distances	Quantities	
Length -->	100	1.73	Between furrows	58	Furrows x Hectare
Width -->	100	2.00	Between plants	50	Plants x Furrow
Production units / hectare			2887	Triangle height	

The example above shows that the equilateral triangle or staggered system makes better use of the land that will be planted, because of the equidistance between the plants. In this case, we can have up to 15% more plants in the same planting area, which translates into a higher production. We therefore recommend this system for Sudan.

3. Double furrow planting

The objective of this system is to manage higher population densities (**Production units / Hectare**) according to the variety we are planning on using and the type of density we want. It requires adjusting the spacing between rows or furrows, between plants, and between double furrows. This system is mostly used when working with high-demand markets in order to sell the largest amount of products during periods of high demand, thus taking advantage of the higher price normally paid during these periods.

This is known as programmed harvest. However, its implementation costs are high because the high densities require annual renewal of between 15% and 20% of the farm production area. On the other hand, the return on investment is high since this system enables access to the best market prices of the year. These periods normally occur between January and June (first semester). The densities for this system are calculated as follows:

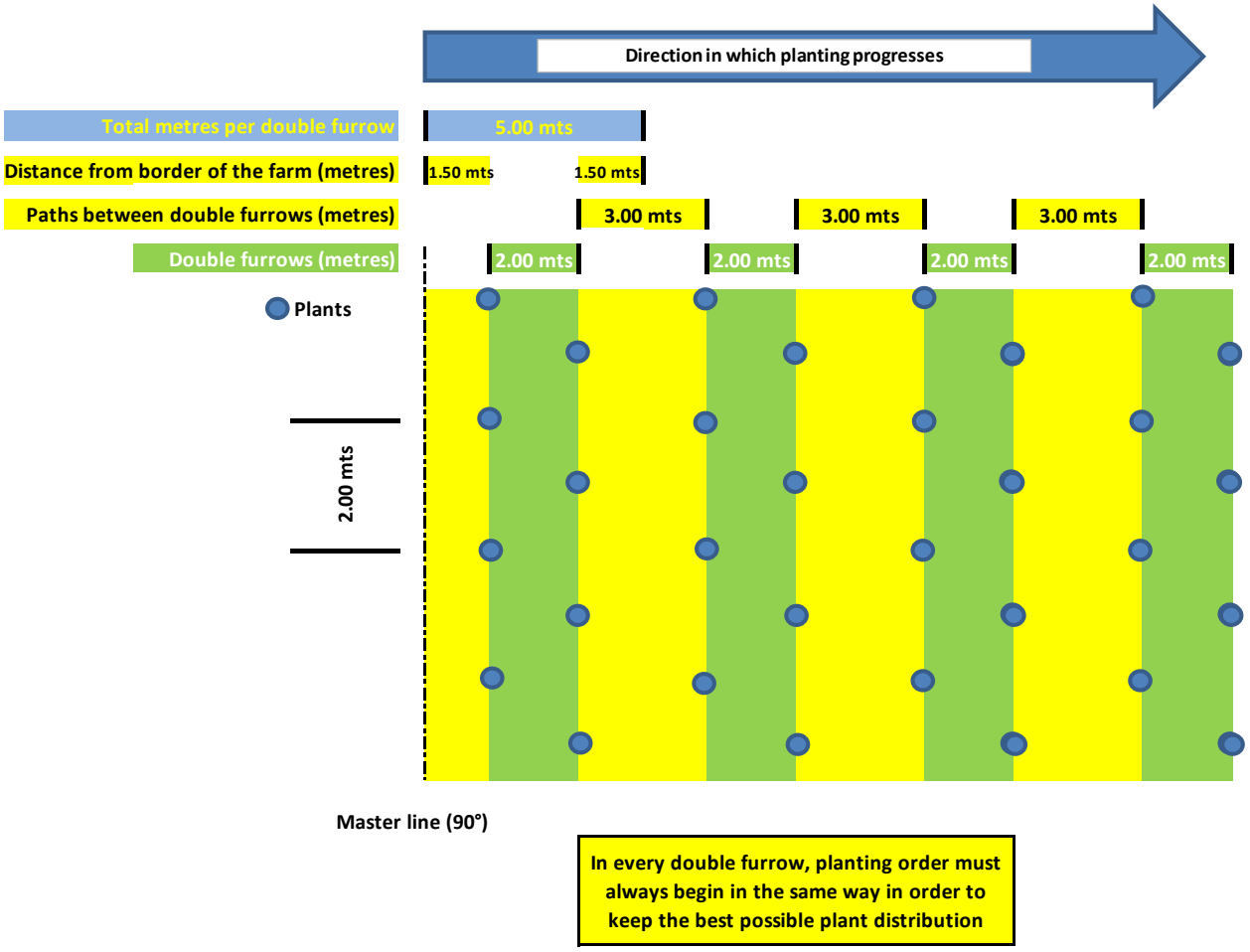
Density calculation for the double furrow system

	Distances	Metres	Distance per double furrow	Plants per furrow (production units PU)	Double furrow in one hectare
a	Between double furrows	3.00	5.00	99	20
			(a+b)	(100/c)*2)-1	(100/(a+b))
b	Between furrows	2.00			
c	Between plants x furrow	2.00			

PU/Ha	1980
(((100/c)*2)-1)*(100/(a+b))	

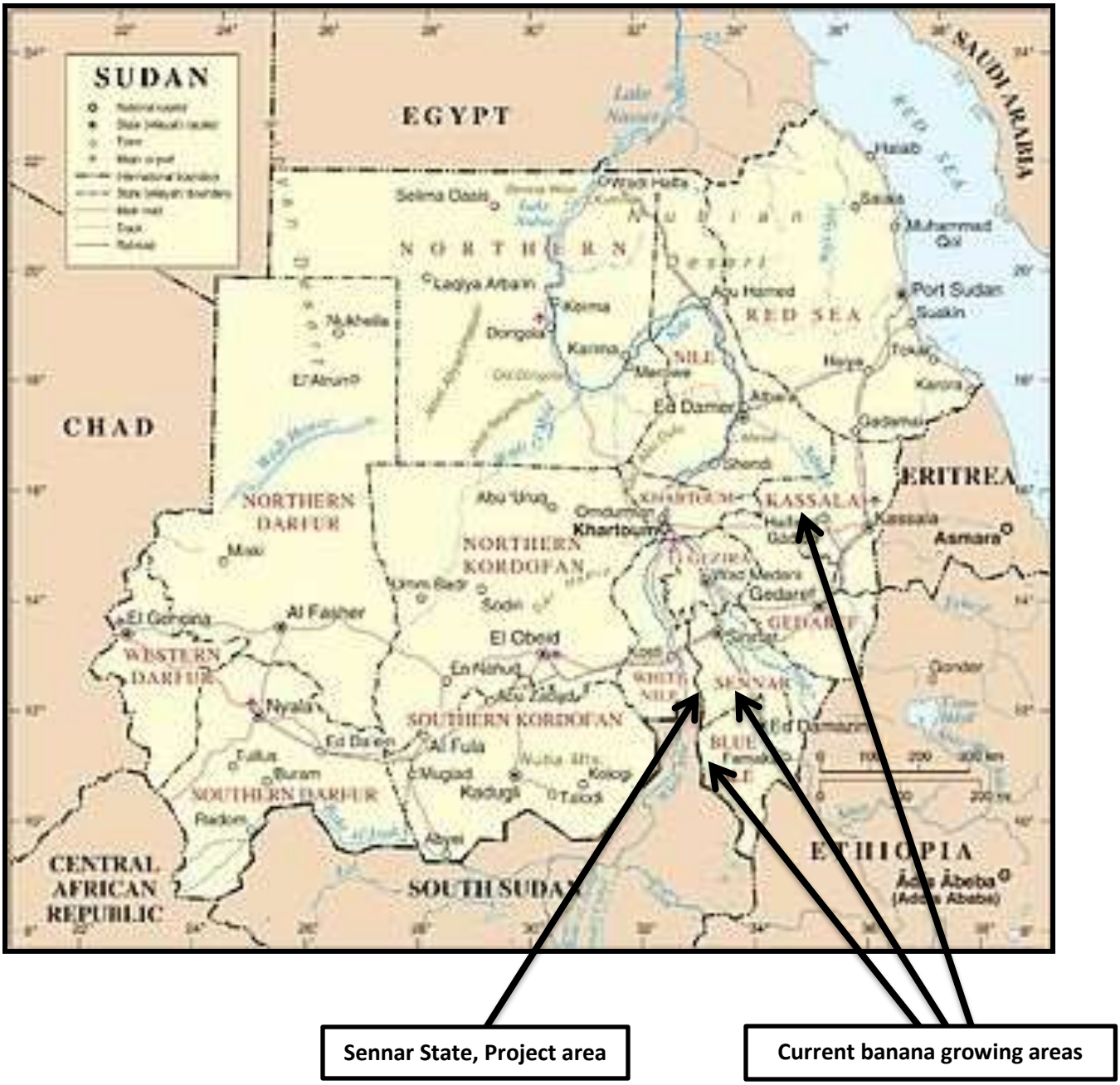
One plant must be substracted from the plants x furrow, when the equilateral triangle planting is used	A hectare is 100 metres long x 100 metres wide
PU are the Produdtion Units per hectare that will be planted	

If one follows the same example of a distance between plants of 2.00 metres, the plantation would turn out as follows:



Note that the plants are organised in an equilateral triangle in each double furrow. The same order has to be kept at all times when starting to plant another double furrow. In this way, the distribution of the plants is as equidistant as possible. Remember that this system is used to manage high densities.

Annex 4 - Map of Sudan



Annex 5 - Suggested formats

1. Programmed maintenance practices at the farm

CULTURAL PRACTICES & MAINTENANCE ACTIVITIES - EXAMPLE

PROGRAM - 2013

	JAN				FEB				MAR					APR				MAY				JUN					JUL				AUG				SEP					OCT				NOV				DEC				
WEEK NUMBER -->	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
PRACTICE/ACTIVITY																																																				
BAGGING RIBBON :																																																			
DEHANDING FALSE +2																																																			
DEHANDING FALSE +3																																																			
DESUCKERING	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	O	O	O	O	0	0	0	0	0	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X
REPLANT	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X										O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X									
DELEAFING	O	O	O	O	X	X	X	X	O	O	O	O	O	X	X	X	X	O	O	O	O	X	X	X	X	X	O	O	O	O	X	X	X	X	O	O	O	O	O	X	X	X	X	O	O	O	O	X	X	X	X	X
FERTILIZATION																																																			
FERTILIZER																																																			
COMPOST																																																			
WATER APLICATION	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X														O	X	O	X	O	X	O	X	O	X	O	X	O
SOIL DECOMPACTATION	O	O	O	O	O	O	O	O						X	X	X	X	X	X	X	X																														
WEEDS CONTROL	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X
SUN PROTECTION																																																			
SUCKER DEVIATION																																																			
ANALYISIS																																																			
SOIL																																																			
LEAVES																																																			
ROOTS																																																			
CERTIFICATES																																																			
FLO-CERT (Fair Trade)																																																			
GlobalGAP																																																			
ORGANIC PRODUCTION																																																			
REVIEWS																																																			
PROGRAMS																																																			
COSTS																																																			
PRODUCTION																																																			

2.

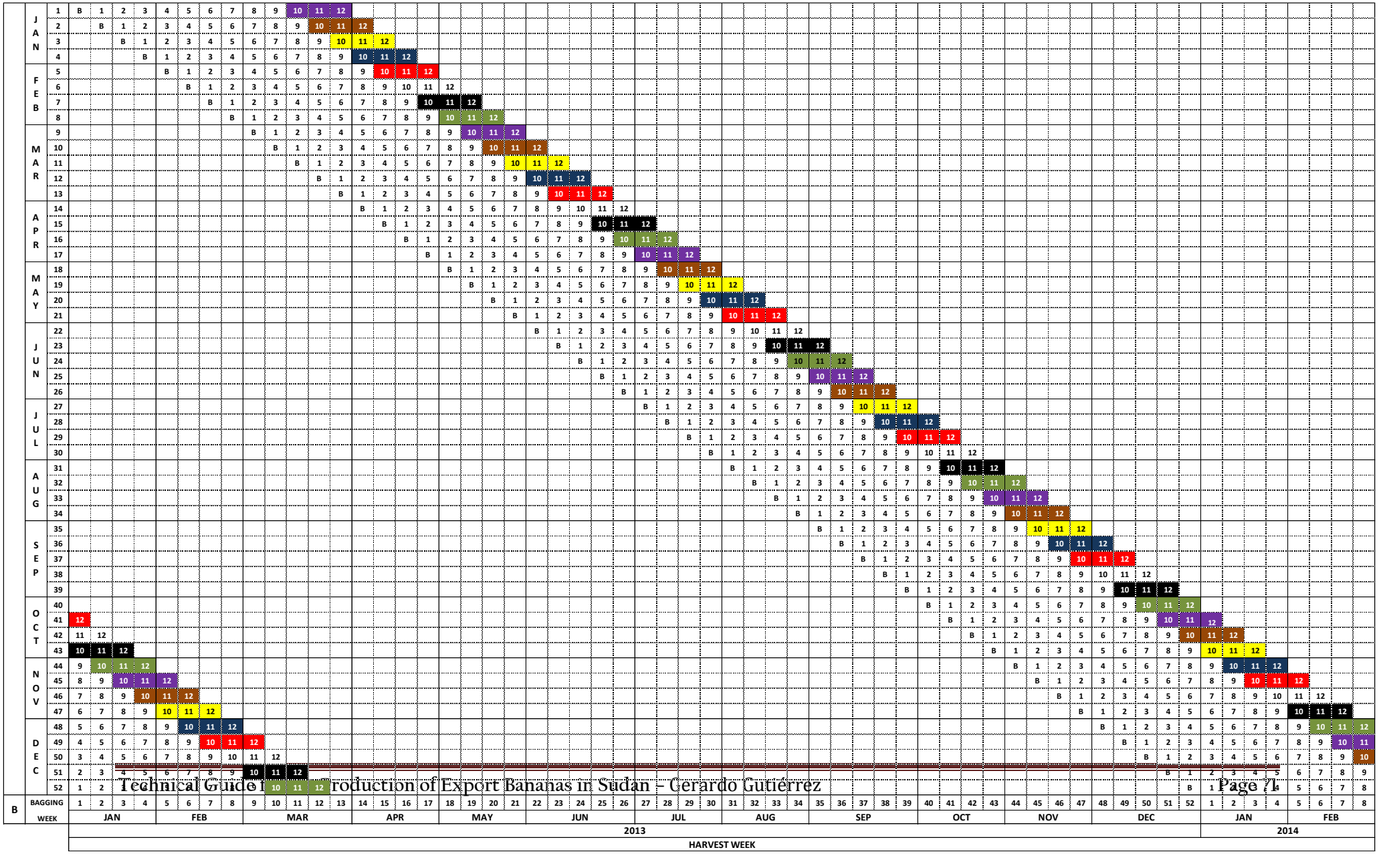
BAGGING ORDER CALENDAR - SUDAN

2013 - 2014

BAGGING WEEK		LABOUR DAYS						HOLIDAY	HARVEST WEEK	
		Sa	Su	Mo	Tu	We	Th	Fr		
OCTOBER 2012	41	6	7	8	9	10	11	12	1	JANUARY 2013
	42	13	14	15	16	17	18	19	2	
	43	20	21	22	23	24	25	26	3	
NOVEMBER 2012	44	27	28	29	30	31	1	2	4	
	45	3	4	5	6	7	8	9	5	FEBRUARY 2013
	46	10	11	12	13	14	15	16	6	
	47	17	18	19	20	21	22	23	7	
DECEMBER 2012	48	24	25	26	27	28	29	30	8	
	49	1	2	3	4	5	6	7	9	MARCH 2013
	50	8	9	10	11	12	13	14	10	
	51	15	16	17	18	19	20	21	11	
	52	22	23	24	25	26	27	28	12	
JANUARY 2013	1	29	30	31	1	2	3	4	13	
	2	5	6	7	8	9	10	11	14	APRIL 2013
	3	12	13	14	15	16	17	18	15	
	4	19	20	21	22	23	24	25	16	
FEBRUARY 2013	5	26	27	28	29	30	31	1	17	
	6	2	3	4	5	6	7	8	18	MAY 2013
	7	9	10	11	12	13	14	15	19	
	8	16	17	18	19	20	21	22	20	
MARCH 2013	9	23	24	25	26	27	28	1	21	
	10	2	3	4	5	6	7	8	22	JUNE 2013
	11	9	10	11	12	13	14	15	23	
	12	16	17	18	19	20	21	22	24	
	13	23	24	25	26	27	28	29	25	
APRIL 2013	14	30	31	1	2	3	4	5	26	
	15	6	7	8	9	10	11	12	27	JULY 2013
	16	13	14	15	16	17	18	19	28	
	17	20	21	22	23	24	25	26	29	
MAY 2013	18	27	28	29	30	1	2	3	30	
	19	4	5	6	7	8	9	10	31	AUGUST 2013
	20	11	12	13	14	15	16	17	32	
	21	18	19	20	21	22	23	24	33	
JUNE 2013	22	25	26	27	28	29	30	31	34	
	23	1	2	3	4	5	6	7	35	SEPTEMBER 2013
	24	8	9	10	11	12	13	14	36	
	25	15	16	17	18	19	20	21	37	
	26	22	23	24	25	26	27	28	38	
JULY 2013	27	29	30	1	2	3	4	5	39	
	28	6	7	8	9	10	11	12	40	OCTOBER 2013
	29	13	14	15	16	17	18	19	41	
	30	20	21	22	23	24	25	26	42	
AUGUST 2013	31	27	28	29	30	31	1	2	43	
	32	3	4	5	6	7	8	9	44	NOVEMBER 2013
	33	10	11	12	13	14	15	16	45	
	34	17	18	19	20	21	22	23	46	
SEPTEMBER 2013	35	24	25	26	27	28	29	30	47	
	36	31	1	2	3	4	5	6	48	DECEMBER 2013
	37	7	8	9	10	11	12	13	49	
	38	14	15	16	17	18	19	20	50	
	39	21	22	23	24	25	26	27	51	
OCTOBER 2013	40	28	29	30	1	2	3	4	52	
	41	5	6	7	8	9	10	11	1	JANUARY 2014
	42	12	13	14	15	16	17	18	2	
	43	19	20	21	22	23	24	25	3	
NOVEMBER 2013	44	26	27	28	29	30	31	1	4	
	45	2	3	4	5	6	7	8	5	FEBRUARY 2014
	46	9	10	11	12	13	14	15	6	
	47	16	17	18	19	20	21	22	7	
DECEMBER 2013	48	23	24	25	26	27	28	29	8	
	49	30	1	2	3	4	5	6	9	MARCH 2014
	50	7	8	9	10	11	12	13	10	
	51	14	15	16	17	18	19	20	11	
	52	21	22	23	24	25	26	27	12	
JAN 2014	1	28	29	30	31	1	2	3	13	

3. Age control from flowering (bagging) until harvest date

AGE CHART - SUDAN (2013 -2014)
PRODUCTION CONTROL



4. Control of practices carried out

LABOUR CONTROL REPORT (Example) | **Month: March 2013** | **FARM area (hectares) 150.00**

LABOUR: Fruit protection | **PERSON IN CHARGE Gerardo Gutiérrez**

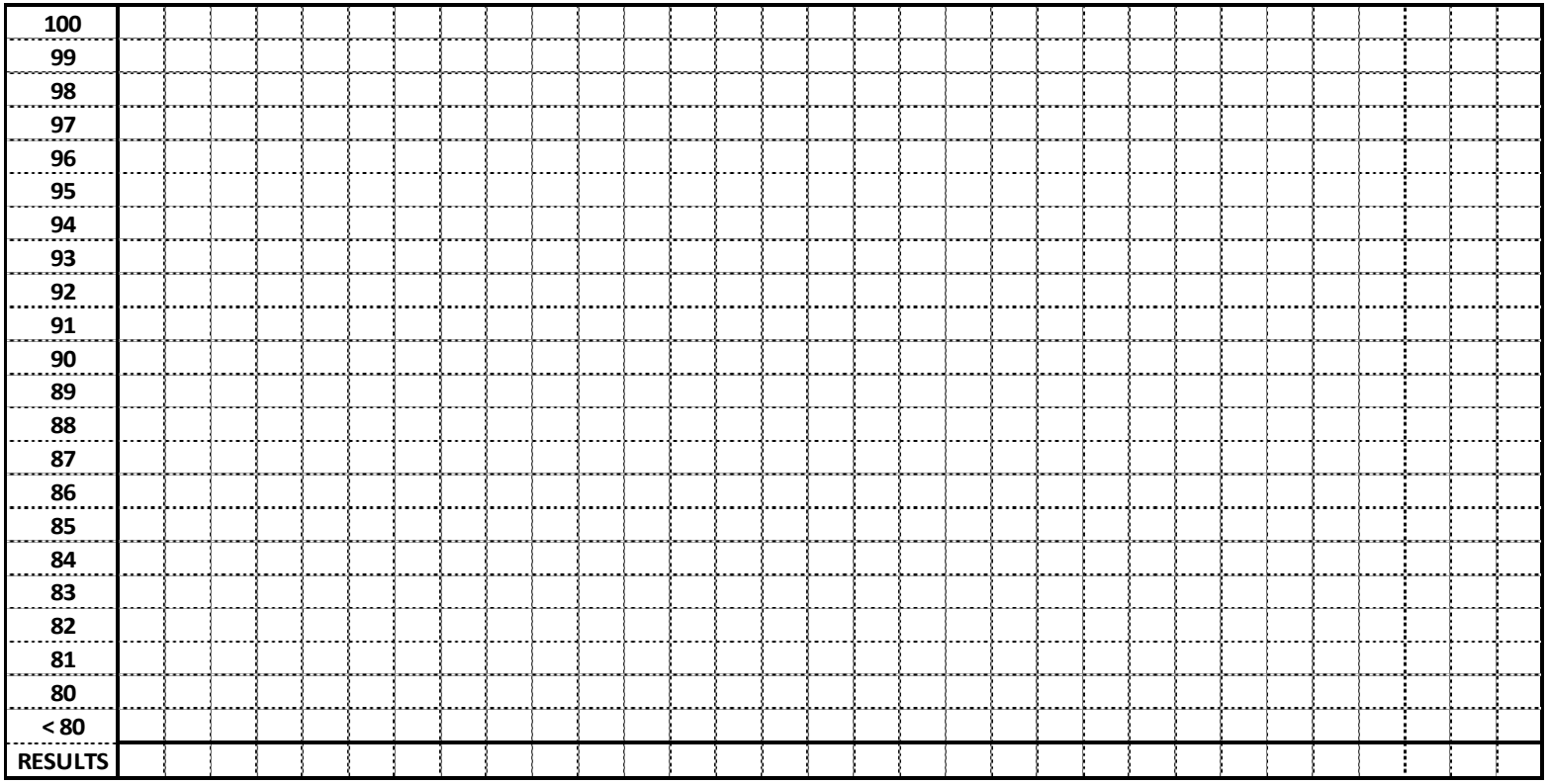
		Hectares		Bucnhes or acorns		Bunches or Acorns / hectare		% Progress		Units at work		Yield per working unit		Money spent		Cost per unit		AREAS completed	AREAS at work
Date	Day	DIA	ACUM	DIA	ACUM	DIA	ACUM	DIA	ACUM	DIA	ACUM	DIA	ACUM	DIA	ACUM	DIA	ACUM		
dd/mm/yy	S	50	50	2500	2500	50.0	50.0	33.3%	33.3%	10	10	250	250	300.00	300.00	0.1200	0.1200	A,B,C	D,E,F
	S	50	100	2600	5100	52.0	51.0	33.3%	66.7%	10	20	260	255	300.00	600.00	0.1154	0.1176	D,E,F	G,H,I
	M	50	150	2300	7400	46.0	49.3	33.3%	100.0%	10	30	230	247	300.00	900.00	0.1304	0.1216	G,H,I	A,B,C
	T	50	200	1800	9200	36.0	46.0	33.3%	133.3%	10	40	180	230	300.00	1200.00	0.1667	0.1304	A,B,C,	D,E,F
	W	50	250	1900	11100	38.0	44.4	33.3%	166.7%	10	50	190	222	300.00	1500.00	0.1579	0.1351	D,E,F	G,H,I
	T	50	300	1600	12700	32.0	42.3	33.3%	200.0%	10	60	160	212	300.00	1800.00	0.1875	0.1417	G,H,I	A,B,C
Week		300		12700		42.3		200.0%		60		212		1800.00		0.1417			

Observations	**This type of report is useful for controlling any type of labour in the field**
	The farm's administration defines the reporting period, which can be weekly, monthly, quarterly, per semester, or anually
	The mony spent should include any social benefits

5. Data records and graphs

LABOUR GRAPH | **MONTH:**

QUALITY OF THE END PRODUCT AT THE FARM | **PERSON IN CHARGE:**



Observations	**This format can be used for work carried out, costs, and quality of the work performed** **The period is monthly, but monitoring can also be done every quarter, semester, or year** **In the RESULTS axis, the result is filled in and represented in a graph (80 points being a bottom line in this example)**

6. Registry for rainfall (and other records)

RAINFALL RECORD

MONTH
PERSON IN CHARGE:

millimetres	RESULTS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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0																																

DAYS

Observations	**This format can be used for rainfall, tenmperature, sunlight hours, wind, dust storms, etc.**
	The period is monthly, but monitoring can be every quarter, semester or year
	In the RESULTS axis, the result is filled in and represented in a graph

Annex 6 - References

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4. F.E. Rosales, S.C. Tripon and J. Cerna (Editors), 1998. Producción de Banano Orgánico y/o ambientalmente amigable. Reports of the international workshop at EARTH, Guácimo, Costa Rica.

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Annex 7 - Glossary

1. **Alum:** astringent salt based on aluminium sulphate that is used to disinfect the water used in banana processing
2. **Apical hand:** the smallest hand
3. **Banana tray:** equipment to hold the bananas that will be packed
4. **Basal hand:** the largest hand
5. **Bract:** the purple cover that coats the bananas during flowering, which comes off when the bunch develops
6. **Chronological age:** the age of the plant in days from planting until harvest
7. **Cluster:** a group of bananas joined by a crown which is packed for sale
8. **Cluster overlap:** adequate placement to form a package by correctly placing the clusters and using the space in the box
9. **Cluster preparation:** preparing and forming the clusters for packing
10. **Compact cluster:** a cluster that has the same amount of bananas on each side (2/2 or 3/3**)**
11. **Compost:** plant or animal compounds that are mixed in order to produce organic matter that is later applied in banana plantations to improve soil fertility in an organic way
12. **Corm:** the daughters or followers removed from the banana plants that will be grown in nurseries and later transplanted in the field
13. **Corm seedpiece:** the place of the banana seed where the buds are located, and from which the future followers that will be selected after planting the seed will develop
14. **Crown:** the plant tissue that connects a banana bunch to the rachis
15. **Cyclical production:** the production sequence of mother plant-follower or daughter-granddaughter
16. **Deformed or "false" hand:** a bunch that starts to grow and develop, but no longer produces any good banana hands

17. **Diameter or calibre:** the thickness of the bananas when harvested calculated by measuring the 3 middle fingers of the hand

18. **EM (Effective Microorganisms):** a compound of microorganisms that enhance the availability of nutrients in the soil for the plants

19. **Emergence:** germination

20. **Evaporation:** the loss of water due to intense sun on the soil

21. **Evapotranspiration:** the loss of water due to intense sun on the plants, which occurs through the leaves

22. **Fertigation:** the application of fertilizers through a water irrigation system, by sprinklers or drip irrigation

23. **File:** a tool used for sharpening

24. **Fingers:** term used for bananas in a bunch or box

25. **Flowering period**: appearance of the acorn or bunch

26. **Flowering to flowering:** a process to measure the speed of bunch generation in a production unit, from mother plant to follower/daughter, which is sequential and measured in weeks

27. **Foliar tunnel:** a way to ensure sun exposure in order to induce germination of the seeds replanted in a plantation under production

28. **Follower (daughter plant or offspring):** the immediate sequence stemming from one production unit (or Mother plant)

29. **Fruit estimate:** a calculation of the production available for export in a certain period of time

30. **Fruit protection:** a series of processes that ensures an optimal quality and high yield bunch for export

31. **Fruit specification:** a set of qualities that a product must have in order to be sold

32. **Functional leaf:** a clean leaf that is adequate for synthesizing nutrients in order to develop and fill the bunch of a plant

33. **Granddaughter plant:** the future sequence stemming from one production unit (or Mother plant)

34. **Growth point/ bud:** the bud that defines the growth of a plant; the bunch grows from the acorn

35. **Hands:** groups of bananas joined to the rachis

36. **Hoe:** a tool used for weeding and other field labour

37. **Innocuousness (safety) for the consumer:** when consumption of the food product does not carry any risks

38. **Latex:** a liquid released by a banana plant or its components

39. **Leaf petiole:** the structure of a leaf that connects it to the pseudostem

40. **Machete:** a long knife used in banana plantations

41. **Master line:** the reference line to start a new planting process

42. **Meristems:** plants or seeds generated in laboratories and further developed in nurseries under controlled conditions

43. **Mother plant:** a production unit

44. **Packaging line:** the process of placing clusters in banana boxes

45. **Packaging separator:** piece of equipment used to ensure the correct separation of packaging lines without damaging the fruit

46. **Pedicel:** a structure connecting the banana to the crown

47. **Physiological age:** the age of the plant in days considering its vigour in development from planting until harvest

48. **Preclassification:** placing the hands according to size in order to facilitate the classification and weighing processes

49. **Production unit:** a plant that is producing, which is the basis for estimating future production

50. **Pseudostem:** a set of leaf petioles that form the trunk of a banana plant

51. **Rachis:** the structure to which the banana hands that form the bunch are connected

52. **Raw material:** bunches ready to be processed

53. **Removal of inflorescence or main bud:** the process whereby the main growth point of a plant is eliminated

54. **Semi-circular clearing:** a clean area for applying fertilizer or compost in front of the production followers or daughters

55. **Shovel:** a tool used in banana plantations for planting

56. **Soil permeability:** the ease with which water infiltrates the soil

57. **Spade:** a type of shovel used in banana plantations when selecting the followers or daughters of the mother plants

58. **Sticker:** adhesive label used to identify the brand of exported bananas

59. **Vigour:** the development potential of plants

60. **Weeds:** plants and undergrowth that should not be there and that compete with the crop for light, water, nutrients, and space