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Feasibility Study Soft Red Fruits Rwanda

MAT17RW01

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1. Introduction and goals

1.1 Background

Rwanda is rapidly developing, and the agricultural evolution is seen as one of the drivers of this progress. Thanks to the climate, it is possible to grow a wide range of crops, and to meet the conditions for an excellent quality product. Furthermore, both local and international markets show a good potential for quality products.

At this moment, there is no fully developed professional soft red fruits sector in Rwanda. Therefore, related crops seem to have a good potential, however it has not yet been analysed in detail. The Dutch government has asked Delphy to analyse the (potential of the) soft red fruit sector in Rwanda.

The objectives of the study are defined here below:

- To provide an overview of the opportunities and challenges for soft red fruits production in Rwanda
- To analyse the feasibility of establishing an expertise centre / incubator with an out-grower scheme in Rwanda in the soft red fruit chain.

1.2 Approach

The following approach is put into practice for this study:

1) <u>An analysis of the potential opportunities and challenges for soft red fruits production in Rwanda:</u>
   a) The study will focus on the local climate zones which are suitable to produce soft red fruits and where soft red soft fruits have the best potential.
   b) A description of the agricultural/horticultural value chain (suppliers, farmers and markets) in Rwanda and how the chain is organised: who is involved, leading parties, product requirements, market size and pricing.
   c) Costs/investments of the hardware suitable to produce these soft fruits. Therefore, it will be necessary to identify a rough financial feasibility. Focus on investments, operational costs, maintenance, return on investment.
   d) Suggestions for risk analysis and mitigation

2) <u>An analysis of the feasibility of establishing an expertise centre/incubator with an out-grower program in Rwanda in the soft red fruits value chain</u>**.**
   The feasibility study of the expertise centre/incubator includes:
   a) The objectives of the expertise centre through identification of the farmers' needs for an expertise centre, e.g. increase of agricultural skills (integrated pest management, fertilization, water management) or demonstration/knowledge centre.
   b) Consulting location for the expertise centre.
   c) Rough evaluation of the operational costs and investments, ROI (Return on Investment) and financing structure.

d) Recommended business model for the expertise centre (stakeholders, investors, public involvement, organizational structure).
e) Risk analysis and mitigation plan.

2 Identification of potential areas

2.1 Agriculture in Rwanda

The Rwandese agricultural production is not sufficient to cover food demand. This means that Rwanda depends partly on import of foods. One in five Rwandan households is not able to fulfil the food demand. Rwanda covers an area of 2.6 million hectares. Roughly thirty per cent (30%) of this area is used for agriculture. The cultivation area is divided in hillside slopes (estimated at 660,000 ha) and marshlands (165,000 ha). Agriculture is an important part of the Rwandese economy (80-90% of the population works in agriculture). Rwandan farmers each have an average cultivation area of 0.5 hectare, generally divided in smaller plots (Dijkxhoorn, Saavedra Gonzalez, & Judge, 2016).

Rwanda is divided in five provinces with a total of thirty districts (see figure below). The provinces of Rwanda are:

- Eastern province (pink coloured in figure 1), with the regions Bugesera, Gatsibo, Kayonza, Kirehe, Ngoma, Nyagatare and Rwamagana;
- Western province (orange coloured in figure 1), with the regions Karongi, Ngororero, Nyabihu, Nyamasheke, Rubavu, Rusizi and Rutsiro;
- Southern province (blue colour in figure 1), with the regions Gisagara, Huye, Kamonyi, Muhanga, Nyamagabe, Nyanza, Nyaruguru and Ruhango;
- Northern province (yellow), with the regions Burera, Gakenke, Gicumbi, Musanze and Rulindo;
- City of Kagali (green), with the regions Gasabo, Kicukiro and Nyarugenge.

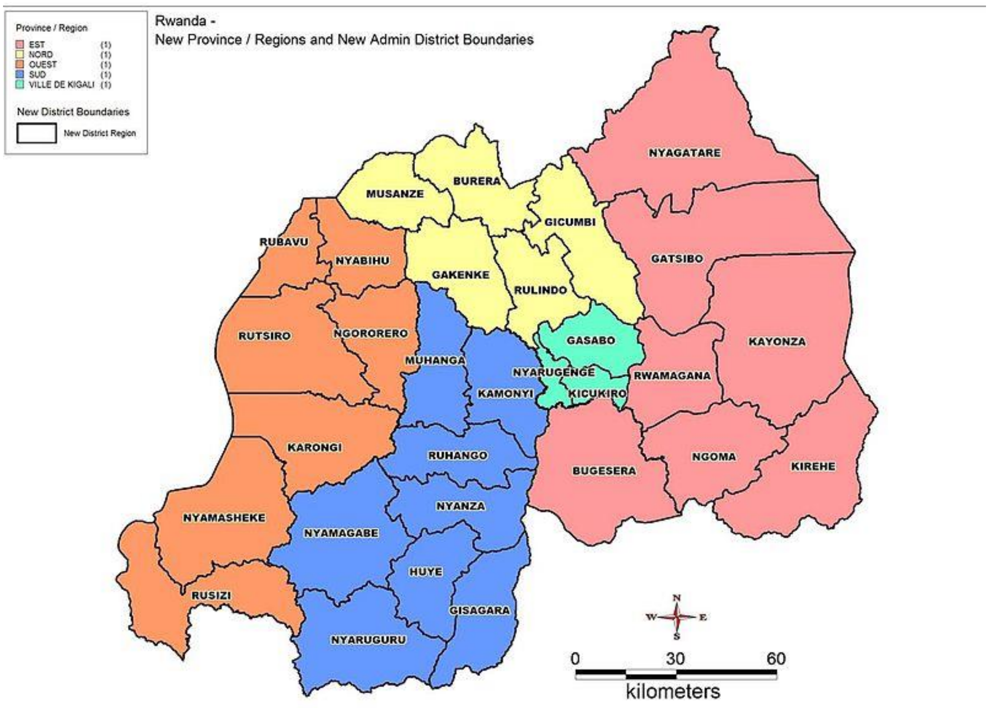


Figure 1: Provinces and regions of Rwanda (Tuyisabe, 2015)

2.2 Climate

Rwanda is located close to the equator. The climate is tropical with an average day length of 12 hours. Rwanda has three major climate zones (shown in figure 2) (Kerkhoven, Hagman, Baarveld, Elings, & Hamel, 2013):

1) North-eastern zone
   The north-eastern zone has a relatively warm and dry climate. This zone is perfect for tropical crops like groundnut and sunflower, but not suitable for strawberry cultivation.
2) South-eastern zone
   South-eastern zone of Rwanda also provides a warm climate. But this area has a more humid climate. This area is better than the north-eastern zone, but still not ideal.
3) Western zone
   Because of the higher altitudes in this zone the climate is somewhat cooler than the north-eastern and south-eastern zone. The climate is humid like the south-eastern region. Based on climate, the western zone is the most suitable region for strawberry cultivation.

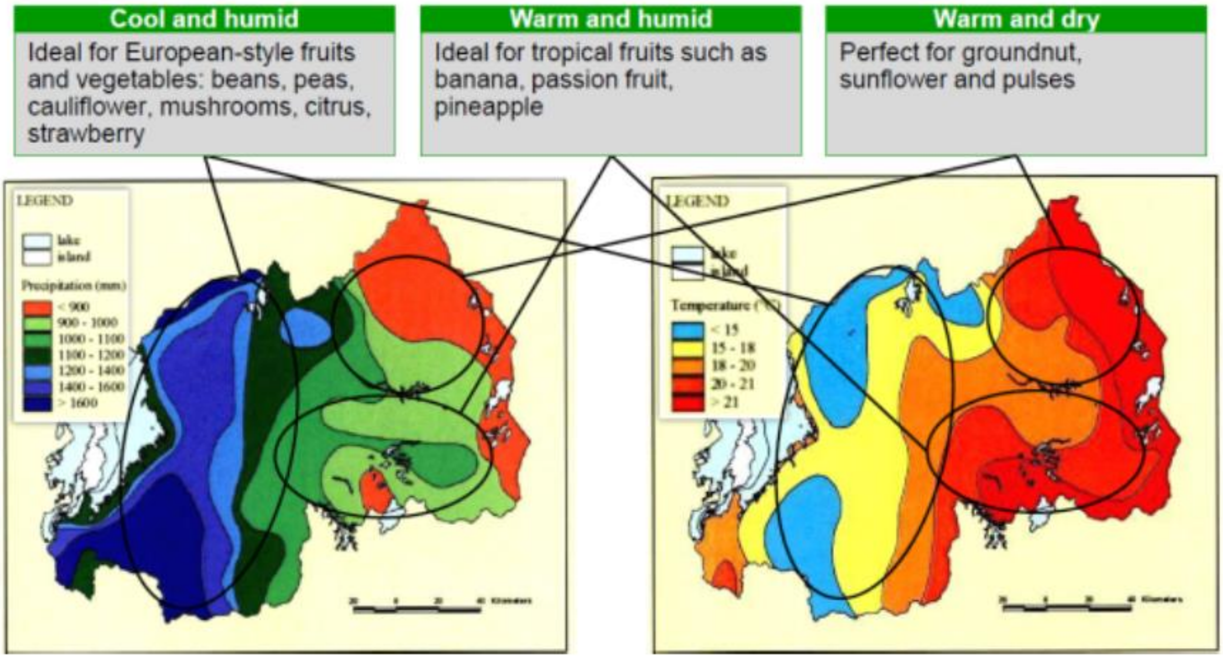


Figure 2: Climate areas Rwanda (Kerkhoven, Hagman, Baarveld, Elings, & Hamel, 2013)

Regions which are more suitable thanks to the climate are:

- Western province
  Karongi, Ngororero, Nyabihu, Nyamasheke, Rubavu, Rusizi and Rutsiro
- Southern province
  Huye, Kamonyi, Muhanga, Nyamagabe, Nyanza, Nyaruguru and Ruhango
- Northern province
  Burera, Gakenke, Musanze and Rulindo

This study focusses on 3 regions based on their variations and experiences of Holland Greentech Rwanda LTD. The selected regions are Muhanga, Musanze and Rulindo.

2.2.1 Muhanga

Figure 3 shows the temperature in the Muhanga region. The temperature never drops below 11 degrees Centigrade and varies from 11 to 14 degrees Centigrade throughout the year. The highest recorded temperatures are quite constant and vary from 30 to 33 degrees Centigrade. Average temperature of Muhanga is 21 degrees Centigrade (TotoGEO, 2017).

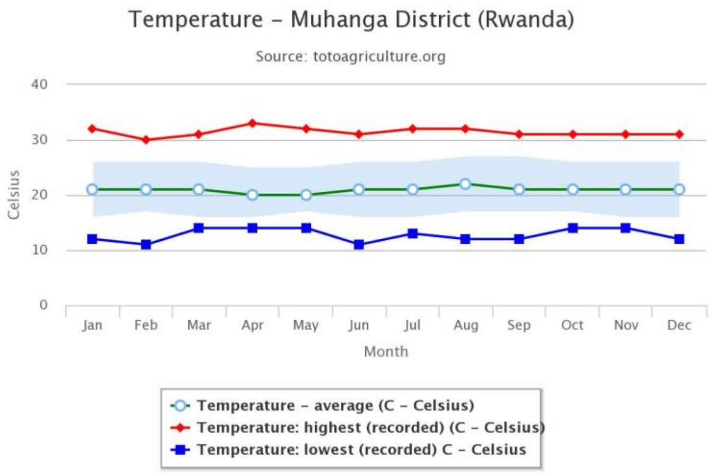


Figure 3: Temperature Muhanga

In the afternoon, the humidity in Muhanga is quite high and raises to 90-95%. As shown in figure 5, average RH is about 80% from November till May. From June to October the RH will go down to 55-65%. During the year the total precipitation is 1395 mm. The number of rainy days is varying in the period from September to May from 10 to 18 days per month. The period June-August contains 1 to 4 precipitation days per month, with a total precipitation of only 100mm (TotoGEO, 2017).

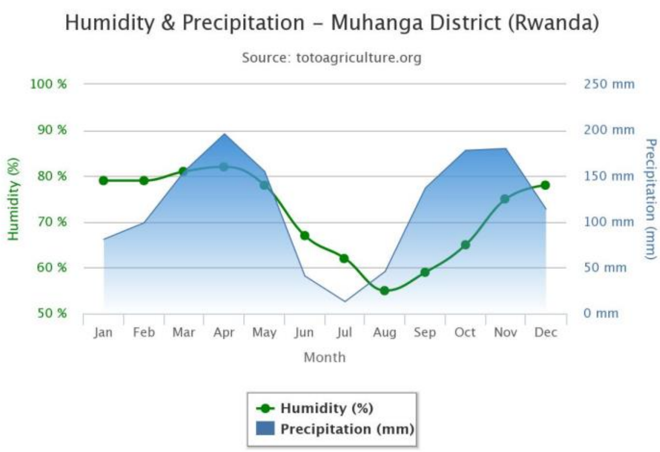


Figure 4: Humidity & Precipitation Muhanga

2.2.2 Musanze

Musanze is one of the coldest regions of Rwanda. The figure below shows the temperature of region Musanze during the year. This region has an average temperature of 17 degrees Centigrade. The lowest recorded temperatures are in July and August (3 degrees Centigrade). The highest temperatures were measured in January, February and August (29 degrees Centigrade) (TotoGEO, 2017).

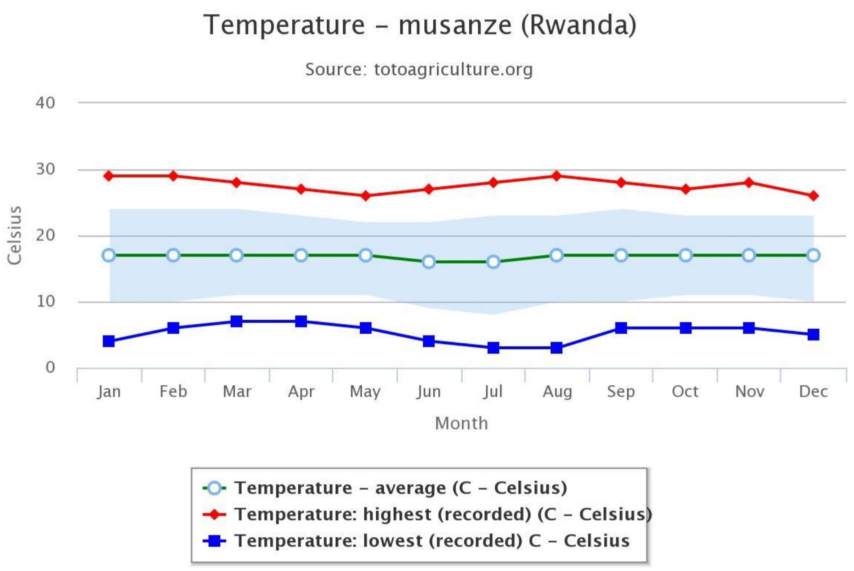


Figure 5: Temperature Musanze

The humidity in Musanze is quite high. Relative Humidity (RH) raises to 90-95% in the afternoon. The average RH from November until May is approx. 80%. From June to October the RH will drop to 55-65%. During the year, the total precipitation is 1283 mm. The number of precipitation days varies in the period September until May from 8 to 14 days per month. The period June-July-August contains 2 to 6 precipitation days per month, with only 120 mm precipitation during these three months (TotoGEO, 2017).

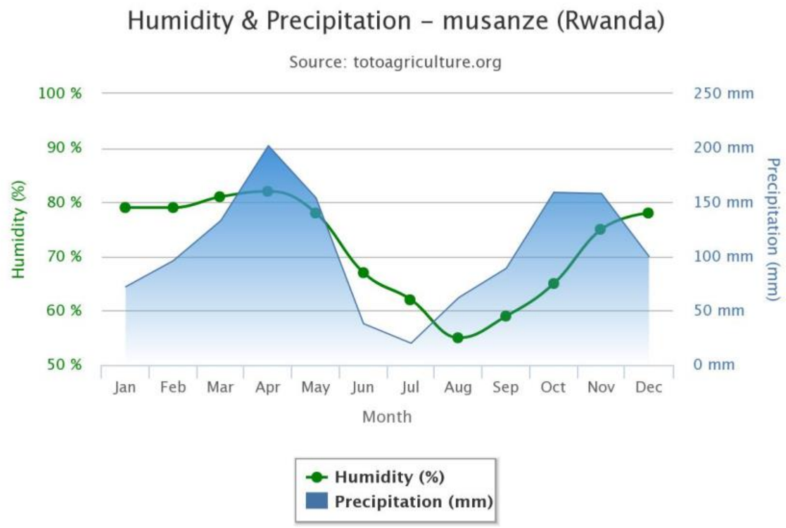


Figure 6: Humidity & Precipitation Musanze

2.2.3 Rulindo

The temperature of the Rulindo region is shown in figure 7. The temperatures in this region are comparable to those of the Muhango region (TotoGEO, 2017).

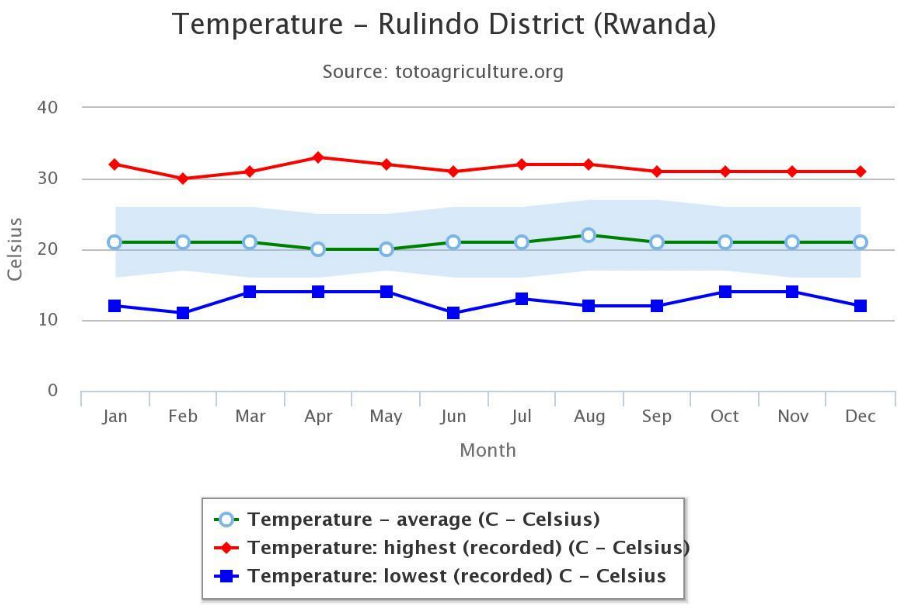


Figure 7: Temperature Rulindo

In Rulindo the RH levels raise to 90-95% in the afternoon. RH is approximately 80% from November until May (see in figure 8). From June - October the RH will go down to 55-65%. RH levels of the regions Muhanga, Musanze and Rulindo are similar. During the year the total precipitation is 1283 mm. The number of precipitation days varies, in the period September to May, from 10 to 18 days per month. The period June-August contains 1 to 4 precipitation days per month. The precipitation of this period is only 89 mm and is the lowest of the described regions (TotoGEO, 2017).

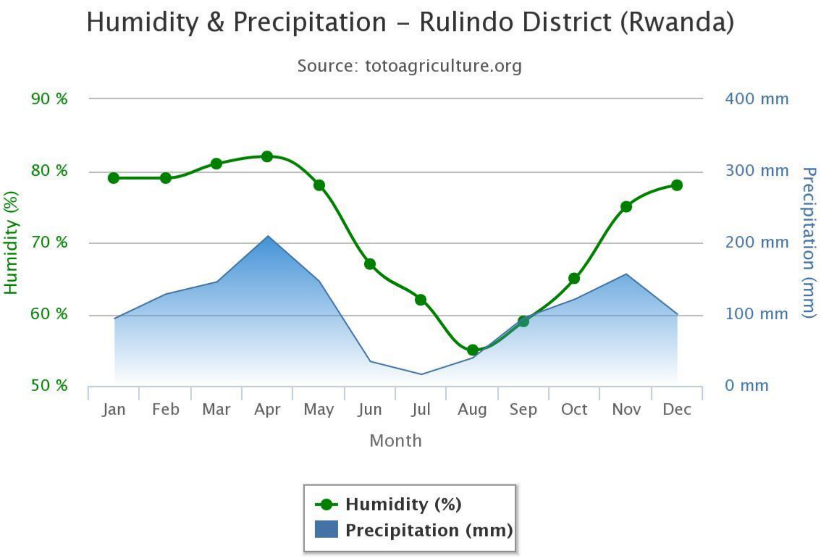


Figure 8: Humidity & precipitation Rulindo

2.3 Water

Water is a principal factor in agriculture, but also limited in Rwanda. Figure 9 pictures the water resources of Rwanda (Mikova, Makupa, & Kayumba, 2015). Irrigation is available but very limited. The total irrigation capacity in the year 2000 was 8.500 hectares (1% of the agricultural area). The estimated irrigated area in 2018 is 19.000 hectares (2,3%). The Rwanda Irrigation Master Plan (Minagri - August 2010) covers approximately 600,000 ha (70-75% of the total agricultural land) of Potential Irrigation Area, according to a number of irrigation methods, like:

- Rain Water Harvesting ponds.
- Development of marshlands with and without surface storage reservoir.
- Hill side irrigation from surface waters (rivers and lakes) with and without artificial reservoirs and from ground water resources (Kerkhoven, Hagman, Baarveld, Elings, & Hamel, 2013).

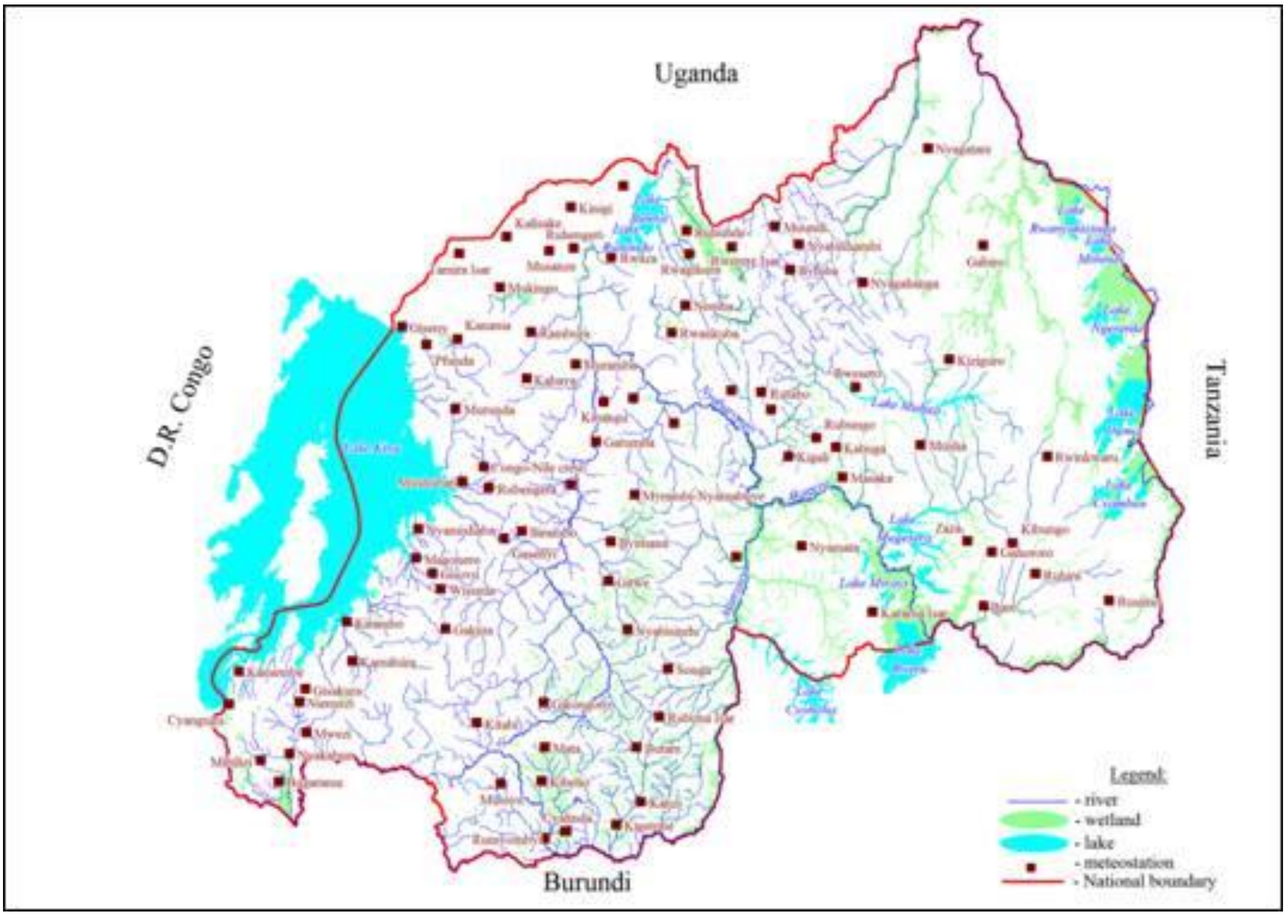


Figure 9: Distribution of water bodies in Rwanda

2.4 Soil

Most Rwandan farmers cultivate in open field and soil. Substrates or other crop techniques are rarely used. Soil erosion is a big problem for the Rwandan agriculture. The extent of this problem is reflected in the figure below. In 1990 only 27,5% of the agricultural soils were classified as 'fertile'. Al (aluminium) levels of the soil are also quite high. High levels of investment are required to upgrade the soil quality. The low productivity of Rwandan farmers is primarily due to poor soils (Rushemuka, Bock, & Gasper, 2012).

Table 1. Soil fertility classes, their characteristics and their proportion towards arable land in Rwanda — *Classes de fertilité de sols, leurs caractéristiques et leur proportion par rapport aux terres cultivables au Rwanda.*

Fertility classes	Limitation level	pH (water)	Al (meq·100 g^{-1} soil)	SEB (%)	Proportion
Fertile soils	Low	> 5.5	< 1.5	> 3	27.5
Medium fertility soils	Medium to high	> 5.2 < 5.5	> 1.5 < 3	> 1 < 3	29.6
Infertile soils	Very strong to extremely strong	< 5.2	> 3	> 1	43.2

Al: Exchangeable Aluminum — *Aluminium échangeable*; SEB: Sum of Exchangeable Bases — *Somme des Bases Échangeables*;
Sources: Rutunga, 1991; Birasa et al., 1990.

Figure 10: Soil fertility classes arable land in Rwanda

2.4.1 Muhanga

The type of soil in Muhanga is sandy clay and it contains approximately 35% clay, 50% sand and 15% silt. The texture per layer is represented in figure 11. The pH levels of the soil are mainly just below 6 and can vary per grower/location (see figure 12) (TotoGEO, 2017).

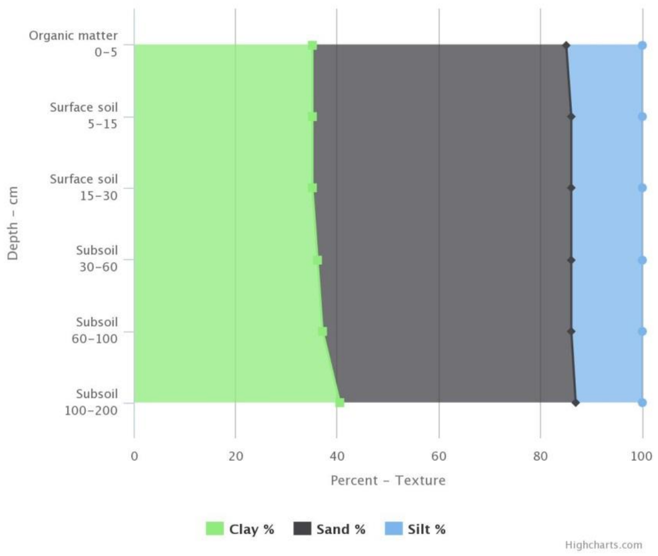


Figure 12: Soil content Muhanga

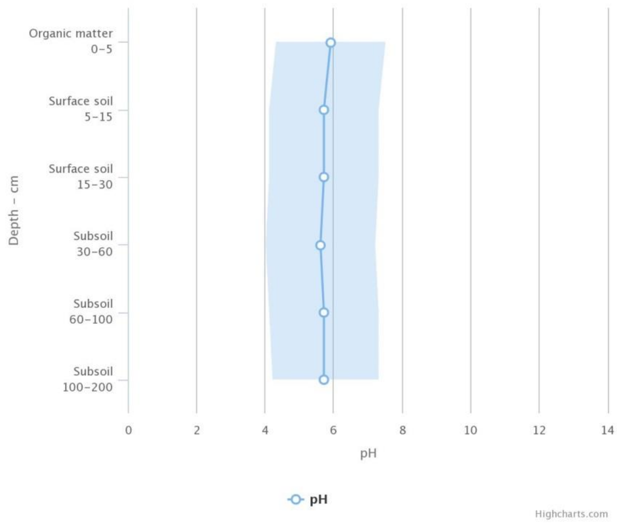


Figure 12: pH range soil Muhanga

This type of soil presents some challenges:

- Low in organic matter
- Not apt to retain moisture and nutrients
- Low in CEC and buffering nutrients
- Sandy soils dry out more rapidly

2.4.2 Musanze

The soil in Musanze contains more clay compared to the soil in Muhanga (40-45%). Other components are sand (35-38%) and silt (20-22%). The contents and pH levels of the soils in Musanze are shown in the figures below. The soils in Musanze drain poorly and have limited air spaces. The high clay content of the soil makes it hard to cultivate. However, clay holds better nutrients (TotalGEO, 2017).

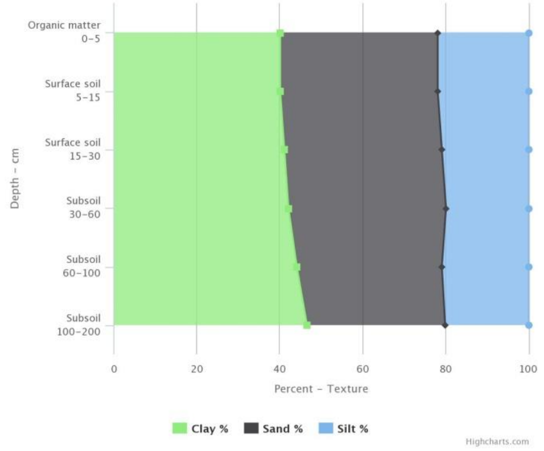


Figure 13: Soil content Musanze

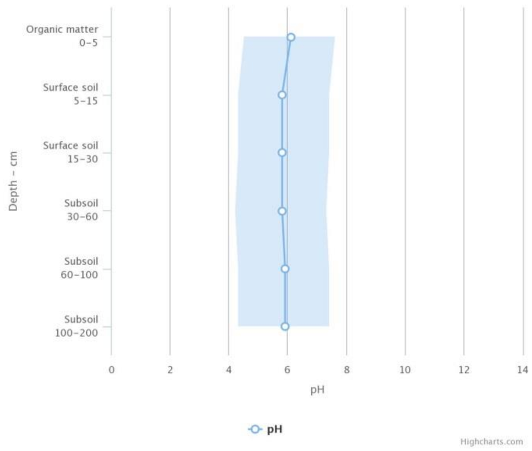


Figure 14: pH range soil Musanze

2.4.3 Rulindo

Soil in Rulindo consists of 36-40% clay, 45-50% sand and 13-14% of silt. These contents are similar to the soils in Muhanga. Both soils have sandy clay presenting the same challenges. The pH levels of the soils in Rulindo are somewhat lower than soils in Musanze and Muhanga. pH Levels in Musanze and Muhanga are close to 6,0. But in Rulindo the level is about 5,5 (TotoGEO, 2017).

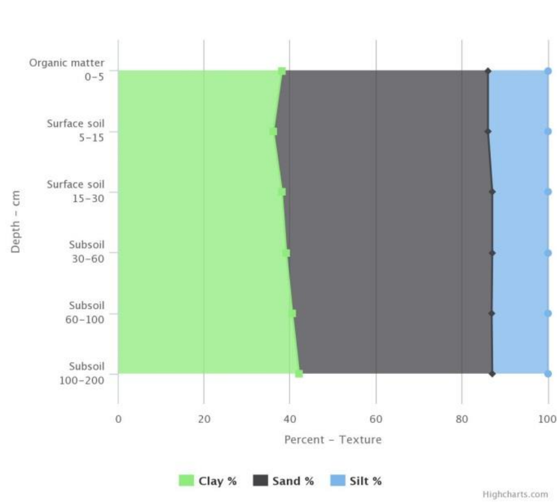


Figure 15: Soil content Rulindo

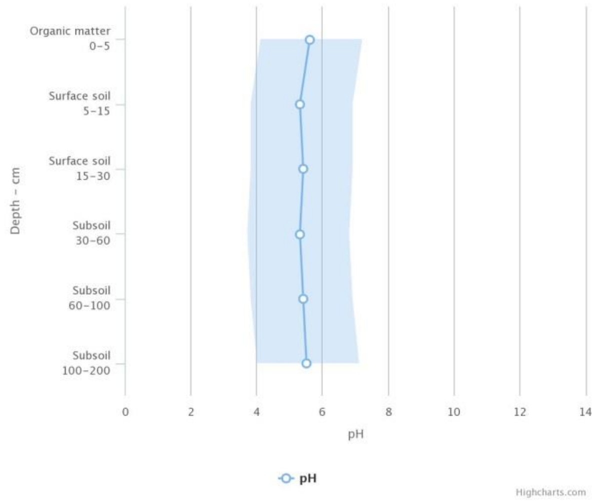


Figure 16: pH range soil Rulindo

3 Cultivation

3.1 Morphology

The morphology of the strawberry plant and the crop techniques need to be understood before starting cultivation. Strawberry plants consist of root system, crown, leaves and flowers. Figure 17 pictures a strawberry plant with a schematic overview of the morphology (Barclay Poling, 2005).

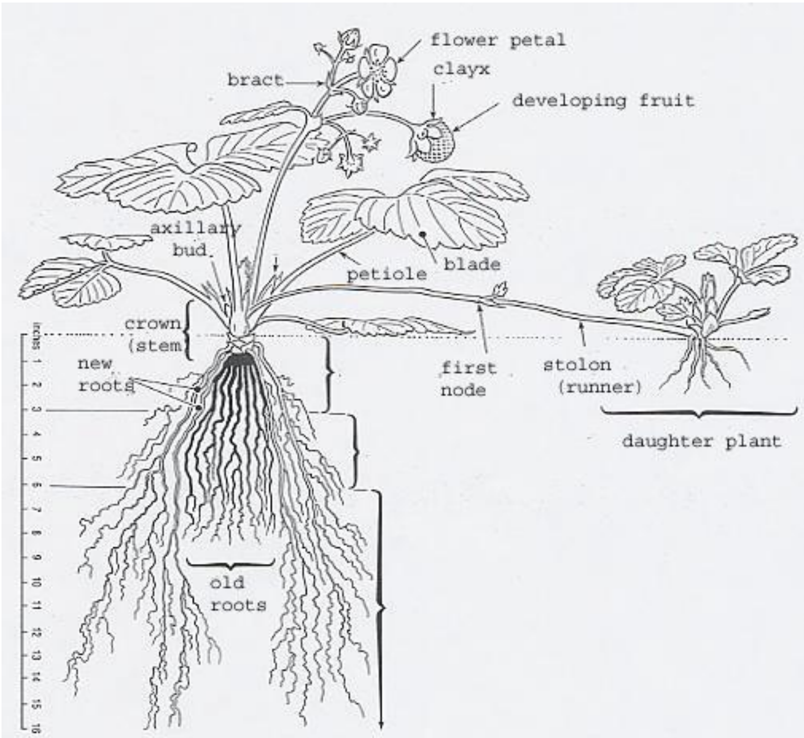


Figure 17: Strawberry morphology

Roots and Root System
The root system of a strawberry plant contains 20 - 35 primary or main roots. Secondary roots have a lifetime of a few days up to two weeks. Strawberry plants continuously form secondary roots. Rooting starts when the soil temperature is above 8 degrees Centigrade. The optimum soil temperature for root growth is 13 degrees Centigrade. Beside the structural support, the rooting system is important for water and nutrient consumption and for storage of starch. The system serves to capture water and nutrients. After the roots have captured the water and nutrients, these are transported through the plant by the plant's vascular system. Starch storage is also a significant role of the roots. The starch reserve is used during winter. The stored starch is needed for vigorous growth and flowering the following spring (Barclay Poling, 2005).

Crown
The short, thickened stem of the strawberry plant is called a crown. The crown has a growing point at the top and starts rooting from its base. Leaves, flower clusters and runners are formed from fleshy buds in the crown. Besides the main crown, the plant can develop side-crowns (shown in figure 18). These side-crowns are structurally identical to the main crown. Side-crowns will add to the yield because they have their own flower clusters. Too many side-crowns will decrease the fruit size significantly. The

Figure 18: Side-crown development

optimum number of side-crowns depends on the variety, cultivation goal and cultivation system. For crown development, a temperature above 10 degrees Centigrade is required (Barclay Poling, 2005).

Leaves

The function of the leaves is to capture the light as a source of energy for the photosynthesis process. Sugars are formed during the photosynthesis. These sugars are transported to the maturing fruits and to growing plant parts. Breathing is also an important function of the leaves as the stomata open. Strawberry leaves are trifoliate, which means the leaf is made of three separate leaflets. Leaves live from one to three months, depending on the variety, environmental circumstances and development stage of the plant. Strawberry plants should have a minimum of three fully developed leaves. Over-stimulating plant growth results in large plants with too many leaves, resulting in:

- Hindering picking: it is harder to find the fruits in a bushy plant. More time is needed for picking and mature fruits may be overseen.
- More susceptibility to diseases: large plants with a lot of leaves stimulate a micro-climate around the plant. These micro-climates are favourable for fungal diseases like Botrytis.
- Lower fruit quality: the shade of the dense leaf-cover will affect the fruit quality. The fruits are less exposed to light. The ripening and the sugar content of the fruits will be affected negatively (Barclay Poling, 2005).

Flowers

The figure here below shows the structure of the flower (left picture), the berry (middle picture) and the fruit cluster (right picture). In fact, the berry is an enlarged flower stem. The berry has many seeds imbedded on the surface (achene). The offspring of the seeds is not usable for horticultural production purpose. Primary berries are the largest berries, secondary berries ripen next and the tertiary and quaternary berries ripen at the end. The development from open flowers to ripe fruit takes 20 to 30 days depending on the climate/weather conditions (Barclay Poling, 2005).

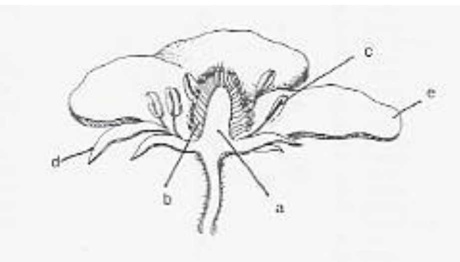
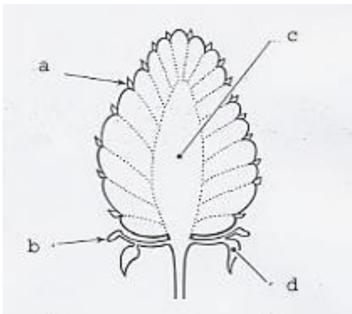
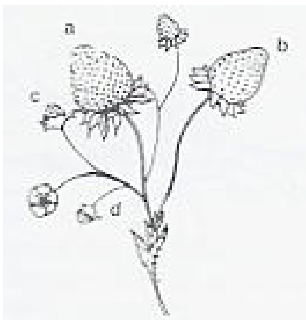
		
a: receptacle, b: pistil and fruit wall, c: anther, d: sepal, e: petal	*a: achene, b: stamen, c: receptacle & d: sepal (cap)*	*a: primary fruit, b: secundary fruit, c; tertiary fruit & d: quaternary fruit*

Figure 19: Flower and fruit development

Runners

Runners grow from the crown of the plant. The runner is the start of a daughter plant. The growth process of a daughter plant is a vegetative action and it mainly happens during longer days (more light hours). Nutrients and water are transported through the runners to the daughter plant. Later, the daughter plant will form roots of her own. A strawberry plant can carry multiple runners of multiple generations.

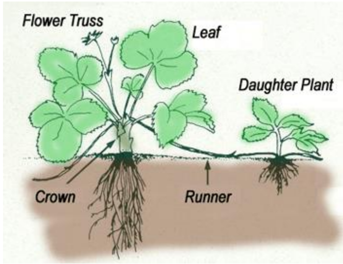


Figure 20: Runner & daughter plant

3.2 Propagation

Propagation of strawberry plants is done by clonal reproduction. Propagation requires so-called mother plants. Mother plants need to be bought from a specialized third party. If the strawberry variety is under protection of the International Union for the Protection of New Varieties of Plants (UPOV), royalty licence fees need to be paid.

Outdoor propagation

Outdoor propagation is cultivation of plants in the soil. The mother plants are planted with space between the rows (up to 1.5 meter) and spacing within the row (25-35 cm). The soil needs to be loose, so daughter plants can root. Irrigation is also important. The surface should be flat, to enable good water distribution, and slightly humid to promote the rooting of the daughter plants. Weeds, as well as the flowers in the strawberry plants, need to be removed during cultivation. The plants must use their energy to form runners instead of flowers or berries. Higher feeding levels are required for propagation than for production. Specifically nitrogen should be applied at higher levels.

Figure 23: Dutch propagation field

When the mother plant has produced runners and daughter plants there are several options:

Figure 23: Rooted daughter plants

- Harvest the daughter plants and plant them for production: If the daughter plants are planted directly in the production field, the plant will remain relatively small, will be fast in production, but will have a low first yield.
- Harvest the daughter plants and plant them in the so-called "waiting beds": Instead of planting the daughter plants directly in the production field, it is possible to plant them in waiting beds (beds of four rows). The plants are kept vegetative with relatively high nitrogen levels. The plants will be bigger and will carry more fruits, but it takes more time and effort to grow them.

Figure 23: Waiting bed

- Cut the daughter plants from the mother plant: This last option is to harvest the rooted daughter plants from the mother plants on the propagation field. The daughter plants will develop further on their own and will be more productive later. It is less work than transplanting them on waiting beds, with a similar result. But the mother plants cannot produce new runners, because the old daughter plants are still on the field. Mother plants need to be removed, so the daughter plants can fully develop.

Substrate propagation

Another option for strawberry propagation is the use of substrate. The mother plants are potted in substrate while irrigation and feeding occur by drip irrigation. In Africa, the strawberry plants can be grown outdoor or in tunnels/ greenhouses. Compared to outdoor propagation, the benefits of substrate propagation are:

- No problems with soil related pests and diseases
- Watering and fertilization is completely manageable
- Optimized climate (if advanced tech greenhouses are used)
- Higher yield in cuttings per plant and higher productivity per hectare.

Disadvantages in relation to outdoor propagation are:

- Cultivation is more expensive (higher investments in buildings, equipment and higher operating costs)
- Planting of the (tips) young plants is more difficult

This method of propagation is not suitable for strawberry cultivation in Rwanda: it is expensive, requires more knowledge and resources. But if outdoor propagation/ cultivation in the soil is not possible, it might be an option.

Figure 24: Dutch indoor runner production on substrate

When the mother plants have produced enough runners, it is time to harvest. The runners are cut from the mother plant. The next step is to cut the tips off the runners. The runners carry multiple generation of tips. The tips (figure 25) need to be planted in trays with substrate. Irrigation is critical especially in the first phase, because the tips do not have a sufficient root system yet. The substrate needs to be kept moist. Irrigation can be reduced once the root systems develop. Controlled release fertilizers can be added to the substrate. Additional feeding with other fertilizers is needed.

Figure 25: Indoor grown tips

Figure 26: Outdoor growing tray-plants

3.3 Production

Production starts with good planting material. Planting material can be propagated by the farmer himself or plants can be bought. Rwanda has one supplier of strawberry seedlings: FAIM Africa. The quality of the seedlings must analysed through trials. If the quality of the seedlings is not suitable, then planting material has to be imported from US or Europe. Outdoor field production or tunnels are the focus for Rwanda. Substrate cultivation is an option when Rwandan soils are not suitable for field production.

The strawberry plants should be planted on raised beds (about 15 cm high). The beds are 90-100 cm wide with a path of 50-60 cm. Two rows of strawberries can be planted on one bed. The distance between the rows should be 60 cm. Distance between plants in the row is generally 30 cm. When the farmers have heavy planting material, increase the distance between plants in the row to 45 cm. Plant depth is very important for the plant to survive. The correct plant depth is shown in the figure below. If farmers frequently have problems with fungal diseases, it is recommended to increase the distance between plants. Covering the beds with plastic is a good measure against weeds and spurts of fungal diseases and soiling of the plant. If plastic mulching is not possible, an organic mulch like straw is an option. Drip irrigation is recommended. Try to avoid planting where tomato, eggplant, potato, pepper, raspberry or blackberry were grown in the last three years. These crops could have built up disease pressure in the soil. Strawberry plants can produce fruits for up to four years. This emphasizes the need of a healthy soil.

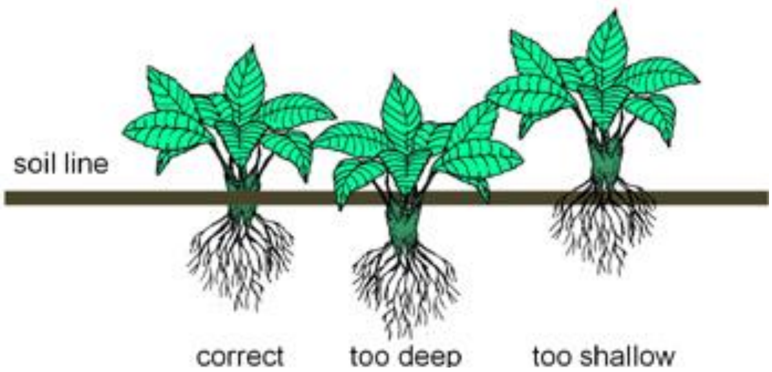


Figure 27: Plant depth strawberry

All runners need to be removed during the production phase. The plant should not waste energy by forming runners. If the plants flowers within the first three to four weeks, it is called pre-flowering. These flowers should be removed. In the first period, vegetative growth is necessary to carry out heavy production later. The plants need to be irrigated and fed properly during the production. The exact water and nutrient requirements depend on the climate, the phase of the strawberry plant and the soil availability. Honeybees or bumblebees are required for the pollination of the flowers. If there are not enough pollinators in the natural environment, they need to be supplemented.

The harvest of the strawberries starts 75 - 90 days after planting, depending on the variety. The strawberries should be harvested when the whole fruit is completely red, that is when it has reached its maximum sugar content, flavour and size. Fruits that are still white near the stalk are immature and should not be harvested. Strawberry fruits should be picked in the early morning, preferably as soon as they are dry. Fruits should be carefully handled to avoid bruising which causes disease and infections, and reduces marketability. Remove any unwanted runners after the final harvest. Cut off the old foliage to about 10cm above the crown, leave the crown and new leaves untouched. This allows sunlight into the centre of the plant, ensuring a better crop in the next season.

3.4 Cultivars

There is a big assortment of strawberry cultivars on the market. Cultivars are divided in three groups: June-bearers, ever-bearers and day neutral varieties. The division is based on the response to the photoperiod (number of hours of sunlight per day). Each cultivar is different. Differences can be in disease resistance, productivity, firmness, flavour, etcetera. It is important to find suitable varieties for strawberry cultivation in Rwanda.

June-bearers

June-bearing varieties are short-day plants. Which means they only induce flowers when the photoperiod is less than 14 hours and temperatures below 15 degrees Centigrade. When the photoperiod is shorter than 14 hours, the temperature becomes less important. Under tropical circumstances, shorter days with higher temperatures can still lead to flower induction. June-bearing varieties are very popular with European growers. June-bearing varieties produce many strawberries in a brief period. Therefore, the variables of influence need to be optimal during this period. The plants have a high fruit production for a brief period.

Ever-bearers

The photoperiod of ever-bearers can be long day or day-neutral. It depends on the temperature. Ever-bearers induce flowers and give production at the same time. By temperatures over 27 degrees Centigrade ever-bearers only induce flowers under long-day circumstances. Below 10 degrees Centigrade they become day-neutral. Between 10-27 degrees Centigrade ever-bearers are qualitative long day sensitive, but they induce flowers under short-day as well as long-day circumstances. Ever-bearers spread their production over an extended period. On the other hand, ever-bearers need more attention. The plant needs to be kept in balance, which means removing leaves and old clusters regularly and following a regular harvesting pattern.

Day-neutrals

Day-neutrals are insensitive to photoperiod. The plant will produce flower buds regardless of the day length. The most important factor which regulates flower initiation is temperature. Temperature should be below 30 degrees Centigrade. Day-neutrals should be planted yearly. They will give a high production for one year. Longer cultivation will decrease yield and fruit size dramatically. Day-neutrals generally produce smaller fruits compared to June-bearing and ever-bearing varieties.

<u>Potential varieties for Rwanda</u>

Strawberry cultivation in surrounding countries like Kenya is more developed than in Rwanda. The varieties grown in Kenya are suitable for Rwanda. The following varieties are of interest:

Figure 28: Kenyan strawberry cultivation (variety: Chandler)

Chandler

The vigorous, high-yielding, Chandler strawberry plants produce very desirable strawberries. Chandler strawberries are very large, firm, and are produced within 60 -75 days. The strawberries vary from being long and wedge-shaped to large and conical. They have a brilliant glossy red colour, and have an exceptional flavour. Chandler strawberries are good for eating fresh or shipping and are very good for freezing. However, they are not the best for processing (Kipkorir, 2015).

Douglas

Vigorous plant, clear foliage and semi-erect habit. Great fruits, of elongate conical shape and orange red colour. Firm flesh, red-coloured with pink centre, good taste and resistance to transport. Higher yield (Kipkorir, 2015).

Fern

A day-neutral variety that is high yielding with firm skin and sweet berry. Good for fresh market and processing (Kipkorir, 2015).

Aiko

Uniform, large, long fruit, of conical shape, with a pointed end, firm flesh, pale red colour, slightly sweet, very resistant to transport and high yield (Kipkorir, 2015).

3.5 Pests & diseases

Strawberry plants and strawberries are delicate and very sensitive to pests and diseases. Quick recognition of diseases and correct control methods will keep costs, labour and crop protection as low as possible.

Pests:

Mites

Tarsonemus fragariae is a small mite that causes problems in strawberry plants. The mite is hard to control, because of its hidden presence and its size. The mite attacks the young leaves. Young leaves colours bronze and later becomes brown speckled. The plant will stay compact and bushy.

Tetranchychus urticae is bigger as Tarsonemus fragariae. The spider mite is yellow to dark green and has two black spots at each side of the body. Damage of the spider mite is easy to recognize by the suction spots on the upper side of the leaves.

Thrips

Thrips are very active in African circumstances. Thrips form a pest in a wide range of crops. In strawberry, thrips are mainly found in flowers. The thrip damage is recognizable by the bronze spots on the fruits. This insect can also damage the flower, leading to misshapen fruits.

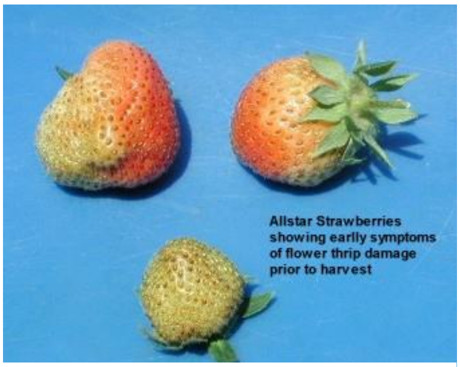


Figure 29: Thrips damage on fruits

Aphids

Aphids can be very troublesome. They feed on the sap of the plant. Aphids can cause spread of viral diseases.

Nematodes

Nematodes are small organisms in the soil that decrease yield. There are many species like Pratylenchus spp., Aphelenchoides spp. and Meloidogyne spp. Nematode pressure can be reduced by crop rotation.

Birds

Birds can damage the fruits. Using nets is a way to reduce damage.

Snails

Snails can be a problem, especially on soils with a high clay content.

Bacterial diseases & viruses:

Multiple viruses can affect strawberry. Viruses in general are transferred by aphids. Soil-bound viruses are transferred by nematodes. Viruses in strawberry are: strawberry crinkle virus, strawberry yellow-edge virus, strawberry mottle virus, strawberry vein banding virus and strawberry mottle virus.

Xanthomonas fragariae is a bacterial disease in strawberry. It is called quarantine organism by Eppo. Bacteria are spread by machines/material, water and infected plants or material. The leaves will show small oily spots. The bacteria will affect production and kill plants during cultivation.

Fungal diseases:

Leaf spot

Leaf spot is caused by the fungi Mycosphaerella fragariae, one of the most common diseases of strawberry. It starts with small dark purple spots on the upper leaf. The spots are 3-6 mm in diameter. Leaf spot can kill the leaves and the fungus could attack the petioles, runners and fruits as well. The fungi live on infected leaves and can be spread by splashing water (rain or overhead irrigation). Water can also contain spores of the fungi. Avoid overhead irrigation to limit the spread.

Figure 30: Leafspot on strawberry

Powdery mildew

The fungi Spearotheca affects strawberries worldwide. Early symptoms are upward curling leaf edges. Later, the leaves will show purple or white blotching on the upper part. Fruits can be also infected. This fungus is spread by wind. It can be controlled by removing trash from previous crops, applying fungicides and avoiding overhead irrigation.

Figure 31: Botrytis on fruit

Grey mould

Grey mould, also known as Botrytis, will attack flowers, fruit, petioles, leaves and stems. Infected flowers and fruit will die rapidly. The fungi spread over the whole fruit and cover it with masses of dry grey spores. The spores are spread by wind and water. Botrytis is common in wet and humid circumstances.

Phytophthora (leather rot)

Phytophthora is a well-known root pathogen which affects a wide range of crops. Affected plants die rapidly. The crown of the affected plants turns red to brown and rots away. Phytophthora can be introduced from old planting material with an infection or transferred during the propagation. The fungi prefer poorly drained soils, with plants under humidity stress and high temperatures. Raised beds and well drained soils are a way to prevent it.

Fusarium

Fusarium is a soil pathogen like Phytophthora. Infected plants wilt and die fast, especially when the plant has big fruit loads or is struggling. The fungi can survive in the soil for many years and prefer high temperatures. It is important to remove the infected and harvested plants. The material can be burned to make sure it will not spread the fusarium. Also avoid growing strawberries after a crop of tomatoes or eggplant.

Figure 32: Fusarium

3.6 Climate & water management

Water is important for the growth of the strawberries. 80-90% of the strawberry plant is water (leaves 90-95% and the fruits 80%). The plant uses water for photosynthesis, cooling, turgor, root pressure and for transport of nutrients. The climate has an important influence on the water management of the plant like temperature, irradiation, wind, RH and rainfall. The following figures show the irradiation and rainfall in Rwanda. The amount of rainfall and irradiation (combined with temperature) gives an impression of the required irrigation level. For instance, the region Musanze: compared to other regions in Rwanda, Musanze has low irradiation levels and a high amount of rainfall which means irrigation is less intensive than in the region Rulindo.

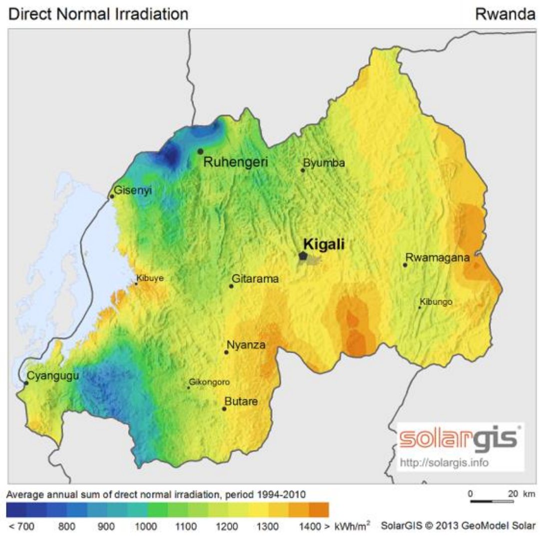


Figure 33: Irradiation levels Rwanda

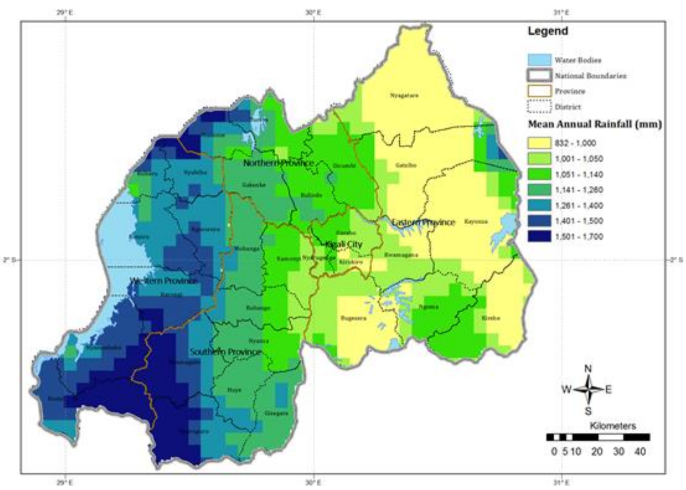


Figure 34: Rainfall Rwanda

Relative humidity is also a principal factor in the water management of the plant. The optimum RH levels for a strawberry plant are shown in the table below. Substantial RH reaches high levels during the day, which causes problems for the strawberry plant like:

- Malfunction of water transport in the plant;
- More infection of fungal diseases;
- Poor plant growth;
- Poor fruit quality (shelf life, less firmness, fungal diseases);
- Leaf scorch.

Higher RH levels during night time stimulate root pressure, which is acceptable for a brief period to transport calcium and assimilate to the non-evaporating plant parts. But an extended period of high root pressure causes problems, such as Rhizoctonia, brown sticky fruits and brown clusters.

Fase	Optimum RH
Growth	75%
Flowering/fruit set	68-72%
Night	85% >

Figure 35: Optimal RH levels strawberry

The required irrigation is described in the table below, based on radiation, stage of the strawberry plant with a plant density of 10 plants per square meter. Basically, the water requirement of strawberry plants in Rwanda will be from 3 litres up to 5 litres per square meter. When the plant is in full production this can vary from 4-7 litres per square meter.

Figure 36: Irrigation requirement based on irradiation sum

Irrigation (ml per m^2) met 10 plants per m^2 per day				
Irradiation sum	**Start flowering**	**Fruit set**	**Production**	**Mean per m^2**
500	438	750	1275	**886**
1000	1063	1688	2650	**1922**
1500	1688	2625	4025	**2957**
2000	2313	3563	5400	**3993**
2500	2938	4500	6775	**5029**

The tables below represent the required irrigation for the regions Muhanga, Musanze and Rulindo. The average temperature, an estimation of the required irrigation and the estimated rainfall are calculated per month. The irrigation and rainfall are calculated in litres of water per week. The calculation is based on equipment with an equal distribution. These figures are a theoretical balance of input (rainfall) and output (plant uptake). In practice, there are more variables of influence, like the capacity of the soil, reach of the roots, distribution of water on the plot etc.

Mainly irrigation problems exist in the months January, June, July, August, September and December. With periods of extreme temperatures (compared to the mean temperature) and heavy winds, the water requirement can be increased with 15-20%. This situation can cause problems in the month February, March and October. The irrigation needs are based on average water requirement. If the plant is in full production, the exact water requirement will increases by 7-10 litres per week.

Figure 37: Irrigation per month Muhanga

	J	F	M	A	M	J	J	A	S	O	N	D
Temperature	21	21	21	20	20	21	21	22	21	21	21	21
Irrigation	26,0	26,0	26,0	24,0	24,0	26,0	26,0	28,0	26,0	26,0	26,0	26,0
Rainfall	25,3	33,0	31,6	51,6	29,8	5,8	2,3	8,1	20,1	28,0	38,5	24,6

Figure 38: Irrigation per month Musanze

	J	F	M	A	M	J	J	A	S	O	N	D
Temperature	20	20	19	20	19	18	18	20	19	20	19	20
Irrigation	22,0	22,0	20,0	22,0	20,0	18,0	18,0	22,0	20,0	22,0	20,0	22,0
Rainfall	16,3	24,0	30,0	47,1	34,8	8,9	4,5	14,0	20,8	35,9	36,9	22,6

Figure 39: Irrigation per month Rulindo

	J	F	M	A	M	J	J	A	S	O	N	D
Temperature	21	21	21	20	20	21	21	22	21	21	21	21
Irrigation	26,0	26,0	26,0	24,0	24,0	26,0	26,0	28,0	26,0	26,0	26,0	26,0
Rainfall	21,2	32,0	32,7	48,8	33,0	7,9	3,6	8,8	22,2	27,3	36,4	22,6

Without irrigation by farmers, water management is very risky, especially when the actual plant uptake decreases (because of factors like soil capacity and when the roots cannot reach the water) or when the distribution of the rain is not equally divided. This is why drip irrigation is recommended. Overhead irrigation is not desirable. Heavy rain or overhead irrigation can damage the fruits and keep the crown of the strawberry plant wet, which implies fungal diseases.

Irrigation water is very important for strawberry plants . Generally strawberry plants are grown with relatively low EC (Electro Conductivity) levels. Irrigation water should not contain high nutrient levels. The maximum nutrient levels for irrigation water, per element, are described in the table below.

Figure 40: Water quality requirements strawberry

Element	mmol/l	Mg/l
K	5,50	215
Ca	3,25	130
Mg	1,25	30
NO3	11,50	713
SO4	1,50	144
P	1,00	31
Na	1,00	23
Cl	1,50	53
Si	0,30	18

Element	µmol/l	Mg/l
Fe-total	10,00	0,56
Mn	20,00	1,10
Zn	7,00	0,46
B	15,00	0,16
Cu	0,750,56	0,05

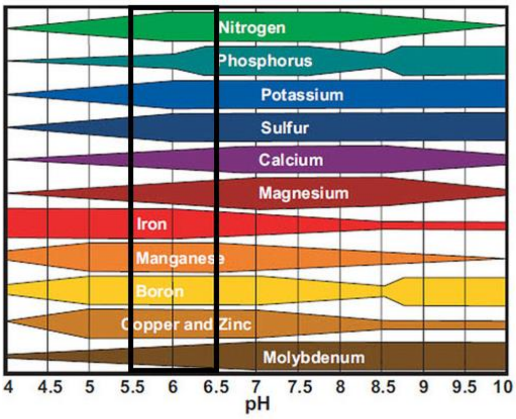
3.7 Soil management

Healthy soils are essential for sustainable strawberry cultivation. Biological balance results in less pressure of soil-related diseases like Fusarium, Phytophthora, nematodes, and in more presence of beneficial soil organisms. The Physical balance is between mineral components, water, air and organic matter. The optimal chemical balance for the soil is shown on the table below (Haifa-group, 2017).

Figure 42: Chemical set points soil

Soil parameter	Optimal values
pH	5.8 to 6.5
Organic matter	2% to 3%
Phosphorus	67 – 90 (available kg/ha)
Potassium	315 – 360 (exchangeable kg/ha)
Magnesium	280 (exchangeable kg/ha)
Zinc	11.2 – 13.5 (available kg/ha)
Boron	1.7 – 2.25 (available kg/ha)

Figure 41: pH influence to pH



Nutrient consumption depends on their availability and pH level. The ideal pH level for strawberry is between 5.5 and 6.5. Consumption of macronutrients is more difficult at a pH level below 6.0 (as pictured in figure 36). In balanced soil (biological, chemical and physical) the strawberry plant needs the following macronutrients for cultivation:

- Nitrogen: 80 kg per hectare (25 kg period before flowering, 30 kg flowering until harvesting, 25 kg harvesting period)
- Phosphorus: 50 kg per hectare
- Potassium: 100-200 kg per hectare (100 kg for sandy soils and up to 200 kg for clay soils)
- Magnesium: 100 kg per hectare.

Analysing plant samples is helpful to check on nutrient status. The sufficient range of the nutrients is described below (percentage or ppm dry matter content) (Campbell & Miner, 2000):

- Nitrogen 3,0-4,0 %
- Phosphorus 0,2-0,4 %
- Potassium 1,1-2,5 %
- Calcium 0,5-1,5 %
- Magnesium 0,2-0,5 %
- Sulphur 0,1-0,4 %
- Iron 50-300 ppm
- Manganese 30-300 ppm
- Zinc 15-60 ppm
- Copper 3-15 ppm
- Boron 25-50 ppm

Plant samples are mostly taken of the leaves; however, fruit samples are possible as well.

3.7.1 Soil type

Strawberry performs better when the soil pH is slightly low, between 5.5-6.5. The PH of most soils in Rwanda, as shown in the map, is somewhat too low, except some soils at the north-western and south-western regions. The PH level of those soils is low but agricultural lime can be applied to neutralize or minimize the acidity (Mucyo, 2017).

Strawberries will respond positively to a high content of organic matter. In general, strawberry growth accelerates when the organic matter of the soil is between 2%-3% (Mucyo, 2017).

As shown on the map, many regions have optimum contents of organic matter, and in Rwanda, farmers are used to apply manure or compost every time they are planting their crops, which is a good practice because soils always benefit from organic matter (Mucyo, 2017).

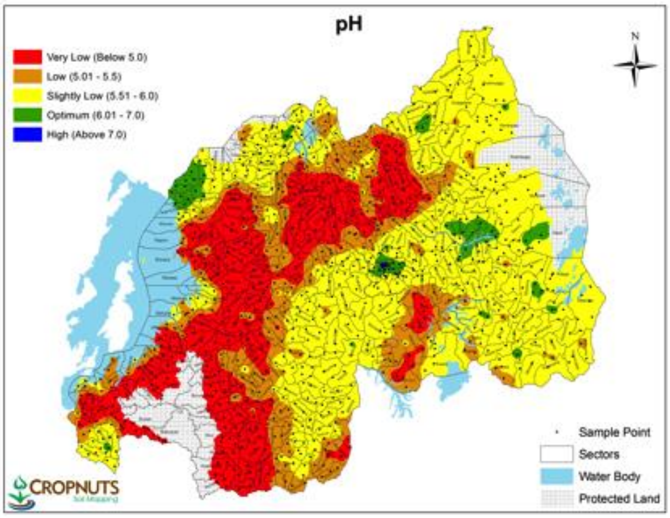


Figure 43: Overview pH Rwanda

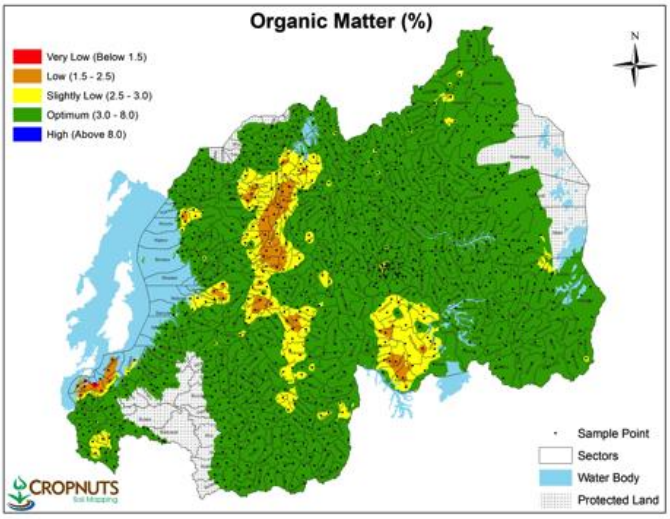


Figure 44: Overview organic matter content Rwanda

3.7.2 Macro-nutrients

Strawberry plants need macro-nutrients for growth. This section describes them.

Nitrogen (N)

Insufficient nitrogen levels can be observed when the plant leaves discolour to light green to yellow green. Nitrogen deficiency mostly starts in the growing point of the plant. Nitrogen is a mobile element in the plant and important for:

- production of proteins
- building up of chlorophyll
- vegetative growth

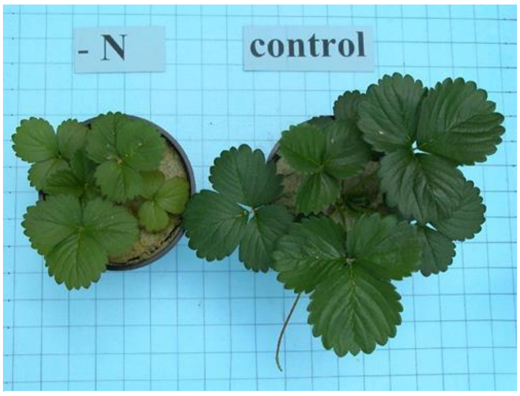


Figure 45: Nitrogen deficiency **Ongeldige bron**

Phosphorus (P)

Phosphorus is extremely mobile in the plant, but immobile in the soil. Deficiency results in lagging growth and purple colouring of the lower leaves. Phosphorus is essential to:

- produce proteins
- regulate respiration and assimilation
- promote the root system
- promote fruit ripening

Figure 46: Phosphorus deficiency **Ongeldige bron opgegeven.**

Strawberry likes a low level of available Phosphorus in the soil (67-90 kg/ha is approximately 22-30ppm considering the layer of 30cm of soil). The soil map below shows that the optimum Phosphorus needed by strawberries can be found in north-eastern regions, some regions of north-western province and southern province (Mucyo, 2017).

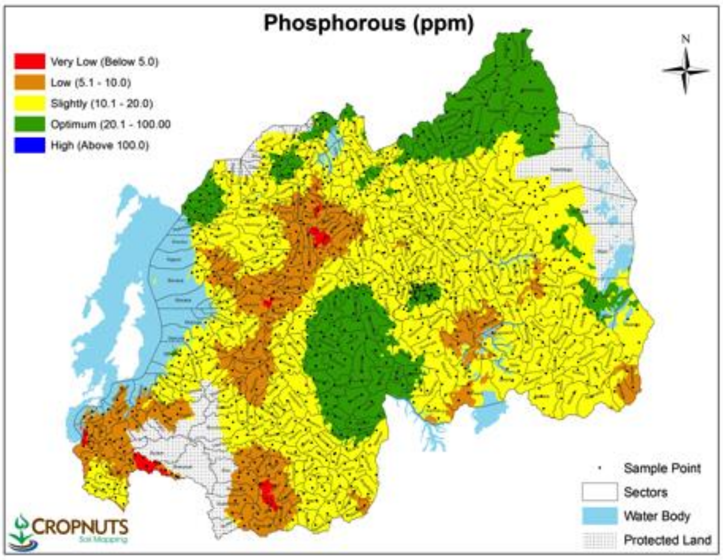


Figure 47: Phosphorus level Rwanda

Potassium (K)

Potassium is, like Phosphorus, extremely mobile in the plant, but potassium is also mobile in the soil. Shortage of potassium results in brown/yellow leaf edges. Potassium is important, especially in fruit production, it takes care of:

- Stimulating the carbohydrate balance
- Stimulating firmness
- Regulating the water balance (stomata opening)
- It is an important for nutrient transport in the plant.

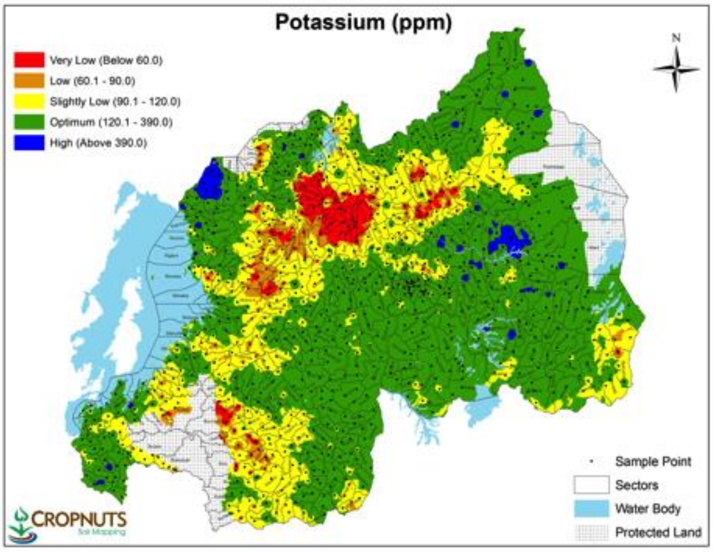


Figure 49: Potassium level Rwanda

Figure 49: Potassium deficiency **Ongeldige bron**

Strawberry requires a slightly low content of potassium (315-360 kg/ha is approximately equal to 105-120 ppm considering the layer of 30 cm of soil profile). Based on the soil map above, it can be concluded that the level is suitable in most of the regions in Rwanda, except in some of the regions in the Northern Province and other regions in south-western province with low levels of Potassium (Mucyo, 2017).

Calcium (Ca)

The element calcium is immobile in the plant. Calcium consumption and transport are especially essential for the start of the cultivation. Lack of calcium causes tip burn and damages the area of the plant leaves. The use of calcium is:

- to form the plant cell walls
- to maintain the chemical processes in the plant.

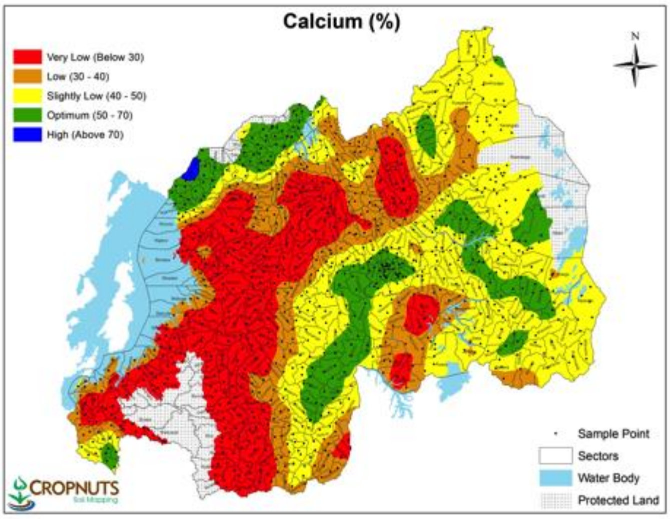


Figure 50: Calcium deficiency **Ongeldige bron opgegeven.**

Figure 51: Calcium level Rwanda

The Calcium level in the areas Rulindo and Muhanga is low. Using agricultural lime will increase the pH level and will add calcium to the soil. Using agricultural lime is essential for the pH management, it increases the calcium stock and improves the soil structure.

Magnesium (Mg)

Lack of magnesium results in yellowing of the older leaves. Magnesium is a mobile element and the older leaves will be emptied first. The plant needs magnesium:

- To build up chlorophyll
- To activate enzymes in transposition of nitrogen to protein
- To contribute to the energy balance of the plant.

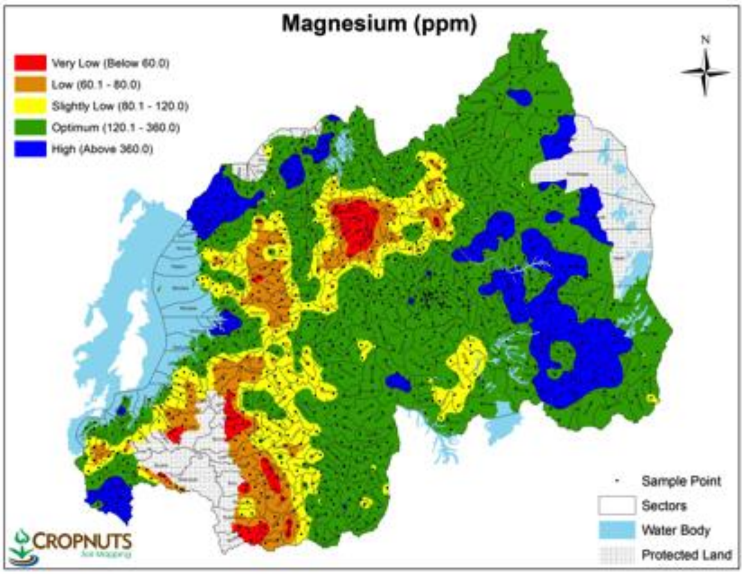


Figure 53: Magnesium deficiency **Ongeldige bron opgegeven.**

Figure 53: Magnesium level Rwanda

Strawberry requires a slightly low level of Magnesium in the soil (280 kg/ha is approximately equal to 93ppm considering a layer of 30cm of soil profile). The soil map above shows that the optimum magnesium levels are in the western province South and North regions of Rwanda. In general, Rwanda has a high content of Magnesium (Mucyo, 2017).

Sulphur (S)

Sulphur is essential to build proteins. Sulphur deficiency causes yellowing of the leaf nerves. Sulphur deficiency is not common in strawberry. As shown in the figure, Sulphur levels in Rwanda are quite adequate. Maintenance fertilizing is recommended.

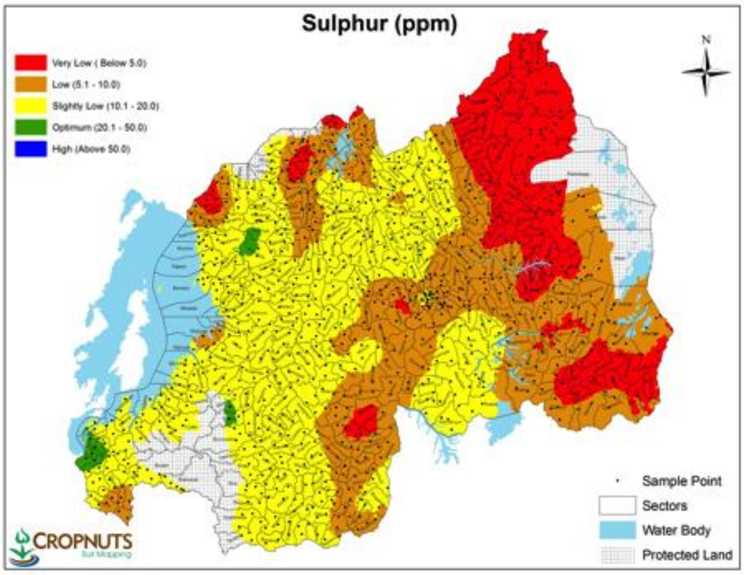


Figure 55: Sulphur level Rwanda

Figure 55: Sulphur deficiency **Ongeldige bron opgegeven.**

3.7.3 Micro-nutrients

This section describes the micro-nutrients for strawberry plants.

Iron (Fe)

Iron is immobile in the plant. Deficiency will first occur in the younger leaves. Iron consumption is strongly sensitive to pH level. High pH levels will negatively affect the iron consumption. The role of iron in the strawberry plant is:

- Important to build up chlorophyll enzymes
- Important to build up enzymes that control respiration.

Figure 57: Iron deficiency **Ongeldige bron**

Manganese (Mn)

The symptoms of manganese deficiency are similar to iron deficiency. Difference is in mobility, manganese is more mobile compared to iron. Manganese consumption is more difficult with higher pH levels. The main function of manganese is the production of enzymes required for:

- Photosynthesis
- Protein metabolism
- Mitosis.

Figure 57: Manganese deficiency (Haifa-group, 2017)

Zinc (Zn)

Zinc is a mobile element in the plant. Deficiency starts with a pale colour of the leaf. After a while, a green halo appears around the borders of the young leaves. The leaf size will also decrease. The role of zinc in the plant is:

- Connect CO2
- Build up RNA and DNA
- Activate enzymes
- Build up carbohydrates

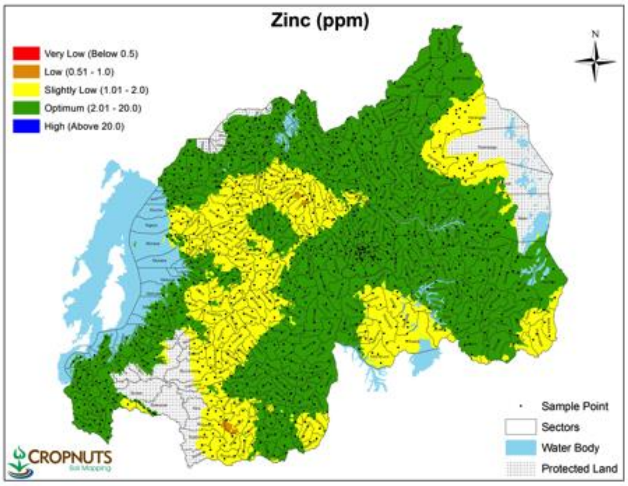


Figure 59: Zinc level Rwanda

Figure 59: Zinc deficiency **Ongeldige bron opgegeven.**

The Zinc level present in the soil is optimum for strawberry (11.5-13.5 is approximately equal to 3.7-4.5ppm considering the layer of 30cm of soil profile). The soil map above shows that the Zinc level is optimum in most of the regions in Rwanda, except some of the regions in the Western Province, a small part of the southern province and eastern province (Mucyo, 2017).

Copper (Cu)

Copper is immobile and deficiency mainly appears in the middle leaves. Leaf necrosis or partial necrosis is an effect of copper deficiency. Copper is needed to:

- To build up chlorophyll
- As a Component of enzymes.

The figures below show the copper levels of Rwanda and copper deficiency.

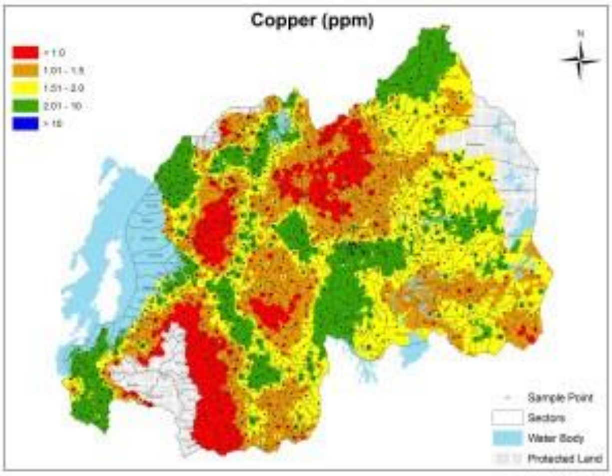


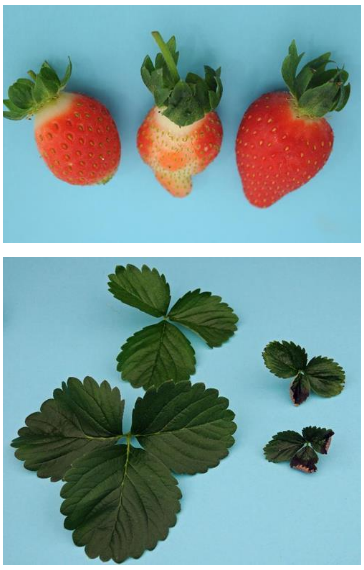
Figure 61: Copper level Rwanda

Figure 61: Copper deficiency

Boron (B)

Boron deficiency hardly occurs in strawberry. Toxicity of boron is more frequent. Purple coloured leaf edges and brown tips on the leaf edges are symptoms of boron toxicity. Boron is immobile and important for the strawberry plant, because :

- It induces enzyme mitosis
- It controls the water balance of the plant
- It transports carbohydrates
- It stimulates flowering and fruit setting.



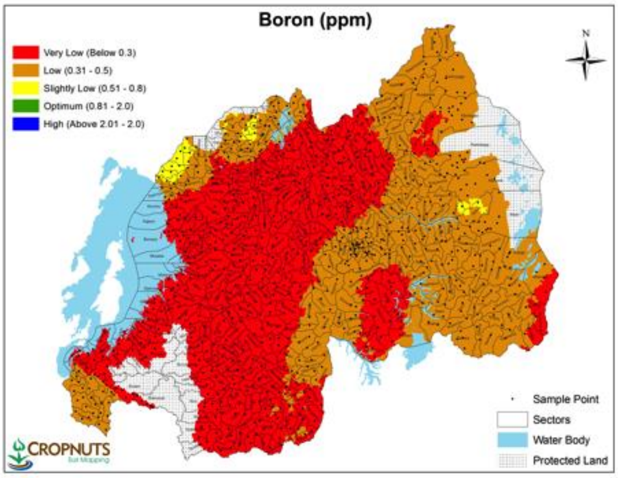


Figure 63: Boron level Rwanda

Figure 63: Boron deficiency **Ongeldige bron opgegeven.**

Strawberries require a Boron level which is slightly low (1.7-2.25 is approximately equal to 0.57-0.75ppm considering the layer of 30cm of soil profile). In the soil map below, except the regions of north-western part and another region in Eastern province with a slightly low content, it is obvious that Rwanda has either very low or low contents of Boron (Mucyo, 2017).

Selenium (Se)

Selenium is not known as an essential element. Its function is also unknown, it might improve firmness. The effect of Selenium is known by overdosing of the element. Overdosing selenium causes albino fruits.

Molybdenum (Mo)

Deficiency of molybdenum hardly occurs. Molybdenum is mobile and causes a decrease of growth in the young stage of the plant. Leaves become stiff and curl up. Brown leave edges are noticeable. Molybdenum is important to build up enzymes that the plants use for:

- Nitrogen fixation
- Production of assimilates.

3.7.4 Nutrient management

The nutrient balance is essential for a well performing strawberry crop. The nutrients such as calcium, boron are quite low in comparison to the other elements. It depends on the region, however phosphorus, potassium, sulphur and copper deserve some attention as well. In Muhanga and the Rulindo district, pH levels are also quite low. Future strawberry farmers in those regions need to pay attention to these levels.

4 Production

4.1 Production plan

The farmer can buy or propagate the planting materials himself. It is affordable if good quality planting material can be bought from other farmers in Rwanda. Buying planting material from surrounding countries, US or Europe is very expensive due to transport costs and import duties. Transport can cause problems as well, because of the fragility of the plants, especially when the plants are bare-rooted.

It is recommended to start with buying planting material of one of the varieties mentioned in this study. The purchased planting material is the mother material for propagation. Chandler is a major variety in the neighbouring countries and therefore probably easy to obtain. Chandler can be harvested two or three times a year and has a life time of three years. The first-year potential is about 25.000 kg of fruit per hectare. The second year the potential is approximately 17.500 - 20.000 kg per hectare. The third and final year the harvest would be around 10.000 - 12.500 kg per hectare. These volumes are reasonable and achieved by Kenyan farmers. Potential is not the same as actual yield, as explained in the figure on the right. Chandler needs 60-75 days after planting to produce fruit. During this period the plant should be focussed on vegetative development. Therefore flowers (pre-flowering) and runners should be removed. The harvesting period will take about 4-6 weeks. After harvesting the plants should be mown at a height of 10cm. The plant will make new leaves and initiate new flowers for the next production. This will take approximately another 60-75 days. It is essential to fertilize the plants after mowing.

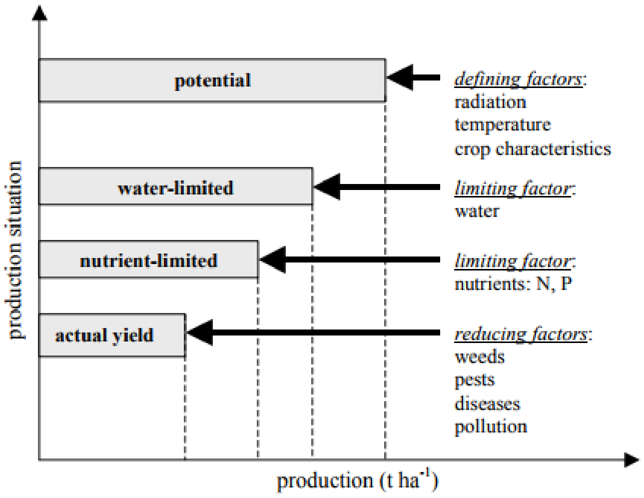


Figure 64: Determine actual yield

Irrigation is necessary for a successful strawberry production. It increases yield and helps the plant overcome the warm and dry period during June, July and August. On the other hand, there are periods of heavy rainfall, which are not suitable for a production period. It is important to plan the growing and harvesting periods of the crop carefully. The planting schedule depends on the crop rotation of the farmer, availability of the planting material and demands of the customers. The ideal periods of planting are months with a high amount of rainfall. If irrigation is not possible, it might be possible to grow day-neutral varieties from September to May. In this case, farmers have to buy and plant new planting material every year, which increases the risk of the crop.

The ideal period for propagation starts in September. This gives a long period of moderate amounts of rainfall and gives enough time to propagate material to be planted in April. Probably the best option would be to have a small area with mother plants and harvest the daughter plants after a few months. The daughter plants should be planted on waiting beds (December/January) and grown to become planting material. Those can be transplanted in April. The mother plants can be kept and used yearly for new daughter plant production. Farmers should plant new strawberry plants every year, to keep equal production.

Some farmers in Rwanda are currently producing strawberry. They use a local variety or multiply with seeds of fruits. The latter is not recommended: the offspring of the seed have a large variation. Plants multiplied by seeds are more susceptible for diseases and the yields are lower. Farmers have only basic education with limited knowledge on growing strawberries. Farmers grow strawberries in open fields, mostly without irrigation systems. Cultivation in tunnels or greenhouses with irrigation is limited. Pests and diseases like thrips and fusarium are the major problems for Rwandan farmers (Tuyishime, 2017). Training on skills and demonstration of cultivation techniques is essential for successful introduction of strawberry cultivation in Rwanda, to prevent mistakes like:

- Growing daughter plants in the production field
- Crop rotation with crops susceptible for diseases like fusarium
- Excessive use of nitrogen to boost production
- Too intensive agriculture, damaging the soil
- Use of non-suitable varieties.

4.2 Production systems

The following table describes the levels of production technology . Most farmers in Rwanda are level 1. The higher the technology level, the higher the potential for fruit quality and production.

Figure 65: Technology levels strawberry cultivation

Technology level	Description
1	Outdoor cultivation in the soil
2	1 + drip irrigation
3	2 + fertigation system
4	3 + tunnel or plastic greenhouse with side opening
5	4 + substrate cultivation
6	5 + hand-controlled screens, windows
7	6 + recirculation system and water reservoir
8	High tech atomized greenhouse; with screens, CO2, ventilation system and misting

Explanation technology levels:

1. Outdoor cultivation. This level is not recommended for strawberries. The lack of control and the risk for farmers is quite high. It would affect the production and quality of the fruits.
2. Outdoor cultivation with drip irrigation. Technology level 2 is accepted for strawberry production. Irrigation should be controlled.
3. Outdoor cultivation with drip irrigation + fertigation. Adding fertigation improves quality and yield. Farmers can manage the nutrition of the plants.
4. Tunnel or plastic greenhouse cultivation. This level would be more ideal if water supply is not a problem. It reduces pests in the crops and protects crops against heavy rainfall on the fruits and prevents the plants from being wet for an extended period.
5. Cultivation on substrate in tunnel or greenhouse. Using substrate makes the cultivation more controllable. It also reduces the risk of soil-related pathogens like fusarium.
6. Greenhouse with hand-controlled technology. The walls of the greenhouse can be covered with insect netting, when greenhouses have roof ventilation. This will decrease pest pressure and make ventilation controllable. A moveable light screen will also take away heavy irradiation and would improve quality. Controllable ventilation also helps against fungal diseases.
7. Greenhouse cultivation with recirculation system and water reservoir. A recirculation system is especially important in terms of water and nutrient saving. In the months June to August it also gives a sufficient amount of irrigation water and boosts production when other farmers are low in production because of the lack of water.
8. High tech greenhouse cultivation. High tech greenhouses are not recommended. Greenhouses are too hard to control, require specialized companies for maintaining the installations and are very expensive.

5 Post-harvest

5.1 Harvesting

The strawberries should be harvested every second or third day, depending on the maturation rate of the fruits. Strawberry has very delicate fruits. They need to be picked with care to avoid pressure points on the berries. The calyx of the berry may not be removed when harvesting. The berry should be pinched from the cluster. Harvesting should be done in the early morning. Harvested berries may not stay on the field and be exposed to the sun. The best move is to bring the harvested strawberries to the post-harvest area. Another option is to keep the harvested berries in the shade during harvesting. In the figure below is a timeline of the berries, with the early stages/most unripen fruits on the left and the most developed/ripe fruits on the right of the picture. The two most red strawberries on the right are the sweetest ones, but probably too ripe for sale. Those fruits will damage fast and have a shorter shelf-life. Red/orange fruits are a better option. Even a small green tip on the berry is not a problem.

Figure 66: Timeline berry development

5.2 Post-harvest

The best quality fruits should be packed separately. Those fruits can be packed in carton boxes, that contain 150 or 250 grams of quality fruits. Quality depends on fruit size, shape, and colour. Other qualities can be packed in trays or small baskets. There are several options for post-harvest storage, depending on the strategy, size and facilities of the farmer. Currently, Rwandan farmers do not have post-harvest facilities. Post-harvest options are (Tuyishime, 2017):

- Direct distribution

  Direct distribution is a good option for small farmers. The fruits can be picked early morning and transported the same day to the market. It is important to keep the fruits out of the sun. Because of this action the fruits can be sold the same day as they were harvested.
- Storage in refrigerator

  Small farmers can use household refrigerators to store the berries. Harvesting of the field should be divided in two days (harvesting 50% of the field at day 1, the second 50% at day 2 and repeat the cycle). By splitting up the harvest, the required space in the refrigerator is limited. Strawberries should be kept on 4 degrees Centigrade. Pre-cooling before selling also improves the appearance of the berries on the market.
- Up-scaling post-harvest facilities

  Large, specialized farmers can set up their farm to strawberry production. Because of the production on a large scale, cooling facilities became more profitable. Large/specialized farms can distribute major customers like processing industry, supermarkets, hotels etc. When those companies have the facilities, it is possible to buy the strawberries of small farmers and sell them to the major customers.
- Direct processing

  Direct processing to jam, juice etc. conserves the product and makes the post-harvest less delicate.

5.3 Distribution

Next step of post-harvest is transporting the yield to the customer. Distribution takes into account variables of influence. First the climate: the climate of Rwanda is not ideal for the transportation of berries. The temperatures are high, with high irradiation of the sun. It makes the strawberries weaker and more vulnerable to pressure points, rotting and formation of fungi like botrytis. The second variable is the road quality. The main roads are adequate if driven carefully. But is not possible to reach the farms by using only main roads. Dirt roads mostly connect the farms to the main roads. Those roads are very bumpy and especially in the rainy season hard to drive. Bumps, vibrations and hard braking will bring lots of pressure on the fruits, which will damage or even squash some fruits. The third variable is transportation time. The transportation time from farmer to market is relatively high. The road quality and the crowded traffic in the city's increase the transportation time. This can cause problems when the strawberries are transported uncooled. Distribution of the yield is an important variable to the success of the strawberry cultivation. Measures to improve distribution are:

- Limit transportation distance
  Short transport to more local markets instead of city markets can be interesting for small farmers. Selling prices are probably lower as at city markets, but it reduces risk.
- Prevent bumps and vibrations
  Damping of shocks and vibrations can help to keep the fruit quality on acceptable level. By putting damping material on the floor of the truck can limit shocks and vibrations. Straw or blankets can be used for damping. It is also important to keep the boxes with strawberries horizontal. Small amount of fruits per box limits pressure on the lower fruits.
- Avoiding rush hours
  Early morning transport avoids rush hours and decreases the transporting time. The climate in the early morning is also more favourable for transport. But driving dirt roads becomes more challenging because of darkness.
- Cooled transport
  Best but most expensive option is cooled transport. This makes it possible to transport the strawberries at any time during the day. Transport can be organized for many small farmers to distribute their product to the city.

5.4 Marketing and Sales

In despite of all difficulties in cultivation, strawberries could be a profitable product for Rwandan farmers. However, a sustainable revenue model needs to be available before starting to grow strawberries. It takes about 70 days for the crop to mature and produce the first fruits. But because the fruits are highly perishable (stay fresh for 3-4 days after harvesting when stored well in right conditions) it is necessary to start looking for market early enough to avoid incurring losses. Demand is readily available in major urban markets and tourism industry like supermarkets, hotels, processing industry, local markets and export to neighbouring countries.

The most suitable customer depends on the farmer (his entrepreneurial skills), the location of the farm, production, quality and network of the farmer. Another option is to realize a central market place in Kigali or Musanze. Farmers can deliver their fruits to this market place and this organisation is responsible for the post-harvest, sales and presentation of the fruits in the shelves.

The packaging of the fruits also needs attentions. Packaging is not only for damage protection during the transport of the strawberries but it can also be used for marketing (concepts), information sharing or market data. Examples from various types of packaging are given below:

Figure 67: Examples of consumer packages for strawberries

6 Financials

6.1 Investments

The investment estimation is made for a **1-acre advanced plastic tunnel with drip irrigation and fertigation (almost 4,050 m2)**. The estimation excludes Rwandan import duties and local costs for levelling of the field and it includes building costs.

Tunnel support poles	€	700		
Tunnel metal arches	€	33.200		
Plastic foliage	€	3.700		
Drip system	€	2.100		
Drip irrigation main pipes	€	800		
Support rope leaves	€	100		
Support band for trusses of fruits	€	300		
Investments for tunnel:			€	40.900
Fertigation unit	€	3.000		
Water pulse	€	1.000		
Water tanks	€	1.500		
Water infrastructure	€	1.500		
Spraying equipment	€	200		
Cold storage	€	1.500		
Installations:			€	8.700
Labour:			€	2.000
Total investment sum			**€**	**51.600**

By using gutters as cultivation technique, the total investment for a 1-acre tunnel has to be increased with another € 20,000.

The total investments for a 1-acre tunnel is between € 50,000 – € 70,000 (depending on cultivation technique with or without gutters). Import duties and local costs are not part of this estimation.

6.2 Revenues and Operational Costs

Commercial cultivation of strawberries in Rwanda is limited, figures on local production yields and operational costs are not available. A combination of practical experiences of the Kenyan strawberry cultivation and the Dutch standards has been used for the estimation of the Operational Costs, Although the Kenyan strawberry production is increasing and improving very fast these last years, there are still some reference figures available which can be used for these estimations.

The Operational Costs are calculated with 2 production rounds a year. 3 rounds production may be possible with June bearing varieties. Prices are related to Kenyan local prices. Delivery from the port of the company. Moderate production is taken into account because this would be a start-up. The production can increase with 20% when there is more experience in growing. Planting material choice for tray plants. The Rwandan company FAIM Africa has planting material available.

The average revenue for strawberries in Kenya is around KES 400 per kg. The Kenyan strawberries are sold in nets of 150 grams or 250 grams. For the Rwandan market prices are carefully estimated with an average revenue of € 3,00 (KES 375) per kg:

Production (kg/acre):		
1st planting		12.141
2nd planting		8.094
Total production per year (kg)		**20.235**
Revenu per kg	€	3,00
Total revenues per year per acre	**€**	**60.704**

The Operational Costs are presented in the table below. The Operational Cost are based on references in Kenya:

Plantmaterial:			
1st planting	€	4.860	6 plants per m2, € 0.20 per plant
2nd planting	€	4.860	6 plants per m2, € 0.20 per plant
Crop protection	€	1.620	
Fertilizers	€	1.620	
Bumble bees	€	810	
Packing materials	€	2.430	
Labour Costs	€	2.230	
Management & overhead	€	6.000	
Operational Costs	**€**	**24.430**	
EBITDA	**€**	**36.274**	

Notes have to be made on the planting material, fertilizers and water. The quality of the plants is crucial for good production: a good plant has four well distributed clusters of flowers. The prices are based on the availability of high quality material in Rwanda. FAIM Africa Ltd is a nursery which provides strawberry seedlings. FAIM Africa has been interviewed for this study. During the interview, FAIM Africa showed pictures and some samples of the seedlings. The presented samples of the seedlings are good quality. The seedlings have to be tested in practise to determine whether the quality is suitable for professional strawberry farming. If not, the material has to be imported from Europe or US and then pricing will be tripled.

Delphy

Nutrients are hardly available on the Rwandan market. Farmers have to buy them from Kenya which increases the prices (import duties, transport costs etc). Prices range from 1,000 RwF to 10,000 RwF per kg depending on the type of fertilizer. The fertilizer costs in this estimation are based on the average prices in Kenya. Although precise information for fertilizer costs in Rwanda is not available, it is reasonable to keep in mind that those costs will be much higher in practise. To define the exact impact of the fertilizer costs, a business case should be developed.

Water from rivers or marshlands is free of cost when pumped directly from the source by the farmer; but when the water is collected from the public water supply network (treated water), the cost is RwF 323 per cubic meter. The necessity to use public water is related to the poor quality of the water available in rivers or marshlands. When developing a business case for strawberry cultivation in Rwanda pay careful attention to water: its availability, quality and costs.

6.3 Fixed Costs

Part of the financial feasibility of the strawberry cultivation in Rwanda are the fixed costs for a sustainable use of the buildings, machineries and equipment. The fixed costs can be divided into:

- Depreciation
- Interest Costs
- Maintenance Costs

The yearly costs are related to the total investment sum. In this estimation, they are calculated with a percentage of the total investment sum:

	%	Costs/year
Depreciation	10,0%	€ 5.160
Interest	5,0%	€ 2.580
Maintenance	4,0%	€ 2.064

The estimated interest rate seemed to be relative low; in Rwanda the bank interest rates are 25 - 30%. To develop a business case for strawberry cultivation, a lot of attention should be given to the financial structure. Bank loans are very expensive and they have a large impact on the feasibility of the business case. Alternatives for financing are contributions of private capital or own capital, involvement of investment funds or donor funds.

The maintenance of the buildings and equipment is essential for the crop. Lack of watering the plants due to broken irrigation has disastrous consequences for the strawberry crops. It is recommended to also hire an employee who will be responsible for the maintenance and who will alert on problems in the operation.

6.4 Economic Result

The business case for a 1 acre strawberry crop in Rwanda looks like a very financially economical perspective as shown in the summary below:

Total Sales	€	60.704
Costs of the Crops (excl Labour)	€	16.200
Labour Costs workers	€	2.230
Management	€	2.500
Maintenance Costs	€	2.064
Overhead Costs	€	3.500
Gross Margin	**€**	**34.210**
Payback period (years)		2

The payback period is less than 2 years which is very fast. The presented finances are rough indications and further refinement or analysis for a specific business case have to be made on:

- Import duties and transport costs for the buildings and installations
- Costs of fertilizers
- Costs of water and availability of water
- Financial structure and costs related to the finance instrument

7 Strawberry Demonstration Centre

7.1 Opportunities and Challenges for strawberry cultivation

The Rwandan climate and soil are very suitable for the cultivation of strawberries, especially in the Rulindo, Musanze and Muhange regions. The present strawberry production in Rwanda is small scaled and the fruits are mostly used for own consumption. The number of commercial strawberry farms is limited. A summary will be made of the challenges and opportunities for strawberry cultivation in Rwanda based on the local conditions, the cultivation and product features and the local market:

Challenges:

- The cultivation of strawberries is complicated because of the fragility of the fruits, the sensitiveness of the plants and fruits for many diseases and the low salt tolerance. Thus, the farmers' skills and knowledge on agriculture and strawberry cultivation need to be really high. Measurements also have to be taken for irrigation and soil management. Training and education on these skills and knowledge are needed for a sustainable entrepreneurship of strawberry cultivation in Rwanda.
- The availability of propagation material is limited. Most of the Rwandan farmers use seeds for growing strawberries which results in bad quality plant materials (diseases), very small fruits and low yields. When strawberry cultivation will be established more commercially, farmers should have to use plant materials instead of seeds to cultivate good fruits and obtain production yields. Therefore, good quality of the propagation material is essential. At this moment only one supplier of propagation material is active in Rwanda, namely FAIM Africa. The strawberry variety supplied by FAIM Africa fits well in the Rwandan conditions. The number of plants available at this company is limited, however the quality of the plants is really good and suitable for the local conditions. The variety that FAIM Africa sells is suitable for the local climate conditions of Rwanda.
- There are few suppliers for the strawberry industry; the availability of fertilizers and other inputs is insecure, and the costs are high and fluctuating. As strawberry plants are very sensitive for diseases and unbalance in nutrients, the production cannot depend on unreliable supplies. Thus, good storage management and on time purchases are required at farmers' level.
- The lack of conditioned facilities on the farm and during the transport to the market. When the fruits are not be harvest and sold to market the same day, refrigeration is necessary to keep the fruits well-conditioned. The strawberries are very fragile and sensitive, not only during cultivation but also during post-harvest. Farmers should be aware of the fragility of the fruits after harvesting and will have to invest in refrigerating.

Opportunities:

+ The climate and the soil are very suitable for the cultivation of strawberries with low temperatures during the night. Low night temperatures improve fruit quality. The Musanze region is for instance a suitable area for strawberry cultivation.
+ Fresh strawberries are an exclusive and thus an expensive product in Rwanda. The target market for the fresh fruits are mostly the expats, hotels and restaurants. Because of their

short shelf life and their fragility, the fruits are less suitable for the export market. A second market opportunity is the processing industry for jams and juices. However, good market research and identification of sales partners and their product requirements are crucial for success.

Comments
All topics mentioned above result in an overall conclusion that strawberries offer cultivation and market opportunities for farmers, however the financial risks due to the sensitiveness of cultivation and post-harvest process, the high cost of propagation materials and inputs have to be considered properly. To spread financial and cultivation risks, it is recommended to combine the strawberry cultivation with less delicate fruit and vegetables like tomatoes.

The primary investments on strawberry cultivation are high for Rwandan farmers. Starting capital is needed on irrigation, post-harvest equipment (refrigerator) and inputs. Access to capital, like loans has to be organised or contributed via equity. While the actual income of farmers is low, this would be a challenge for them.

The strawberry cultivation is still in its infancy in Rwanda. This specific fruit is an opportunity for the Rwandan agriculture. However, the number of farmers which are suitable and equipped for strawberry cultivation should be limited on the short term.

A Demonstration Centre for strawberries is very useful as an instrument for several challenges the future Rwandan strawberry farmers are facing at, such as:

- training farmers skills on agriculture practises and knowledge of strawberry cultivation
- facilitating soil analyses and advice on nutrients, diseases and pest control
- demonstration of several cultivation techniques for strawberries
- secure access to cultivation and post-harvest equipment, inputs and propagation materials
- facilitating sales and market place

In the next paragraphs the composition and feasibility of such a centre is investigated in more details.

7.2 Scope of Strategy of a Demonstration Centre

The establishment of a Demonstration Centre is essential if Rwanda wants to expand and improve the cultivation area of strawberries. The strategy of such a centre is developed in this paragraph. Even though developing a strategy can be considered an art, it requires a systematic process that helps taking all main steps into consideration: at first, the mission, vision and values need to be developed or reaffirmed. In a second step, the concrete goals and outcomes that would represent the achievement of the vision need to be determined.

The first step in the strategy development for this Strawberry Demonstration Centre will be the crafting of the mission, vision and value statements. Based on the analysis of the local conditions and the needs for a sustainable strawberry cultivation, the identified mission and vision for the Strawberry Demonstration Centre are:

Mission (*what do we stand for?*) of the strawberry expertise centre could be:

- Leading and sustainable example of the complete value chain (from planting materiallto fork) for strawberries in Rwanda
- Thorough knowledge centre on propagation, cultivation, post-harvest and sales of strawberries in Rwanda

Vision (*what are we going for?*) of the strawberry expertise centre could be:

- Sustainability
- Reliable
- High knowledge level
- Innovative for Rwandan cultivation standards

Figure 68: Mission and Vision for the strawberry Demonstration Centre

The values needed for a strawberry Demonstration Centre have been elaborated with the Canvas business model. This tool is developed by Alexander Osterwalder & Pigneur in 2010. The business model Canvas is a powerful tool to map your business on a transparent and clear way, to scrutinise the coherence and to communicate the essentials. In this specific case the Canvas Start Up business model is used. This model differs a little from the standard Canvas business model because the starting point of this model is a new business or business development.

Scope for the Value Proposition Design of the Strawberry Demonstration Centre:
A value proposition is a promise of value to be delivered. It is the primary reason why a prospect should buy from you. The design used here below matches the customers' needs and jobs-to-be done and helps them solve their problems. In this specific case the (future) strawberry farmers in Rwanda have been identified as the Customers. The value map represents the position and shows the Customers the value of the Strawberry Demonstration Centre.

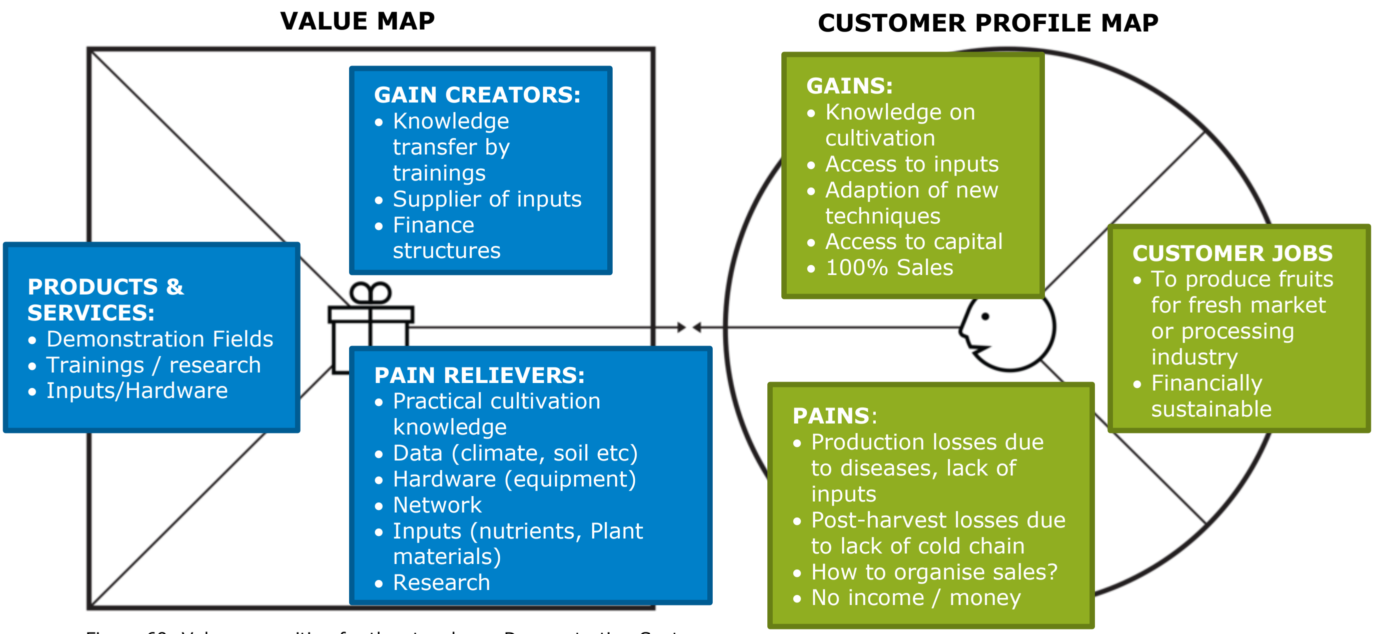


Figure 69: Value proposition for the strawberry Demonstration Centre

For the design of the value proposition, the (future) strawberry farmer is identified as the main customer of the Demonstration Centre. After all, the purpose of the Demonstration Centre is to offer services to the farmers to develop a more sustainable and improved strawberry cultivation in Rwanda. The figure shows on the right side the main issues the farmers are struggling with and their expectations. the solutions and services that the Demonstration Centre could offer are shown on the left. Most of the topics are still mentioned during the analyses of the challenges and opportunities in paragraph 5.1.

A value proposition could be designed by matching the issues on the Customer Profile map with the possibilities on the Value map. The scope of the value proposition for the Demonstration Centre for strawberries can be summarized as:

"Your specialist for all topics and inputs related to the Rwandan Strawberry Value Chain"

Scope of the Canvas Business Model for the Demonstration Centre Strawberry

In the figure on the next page the Canvas Business model has been designed for the Demonstration Centre strawberry.

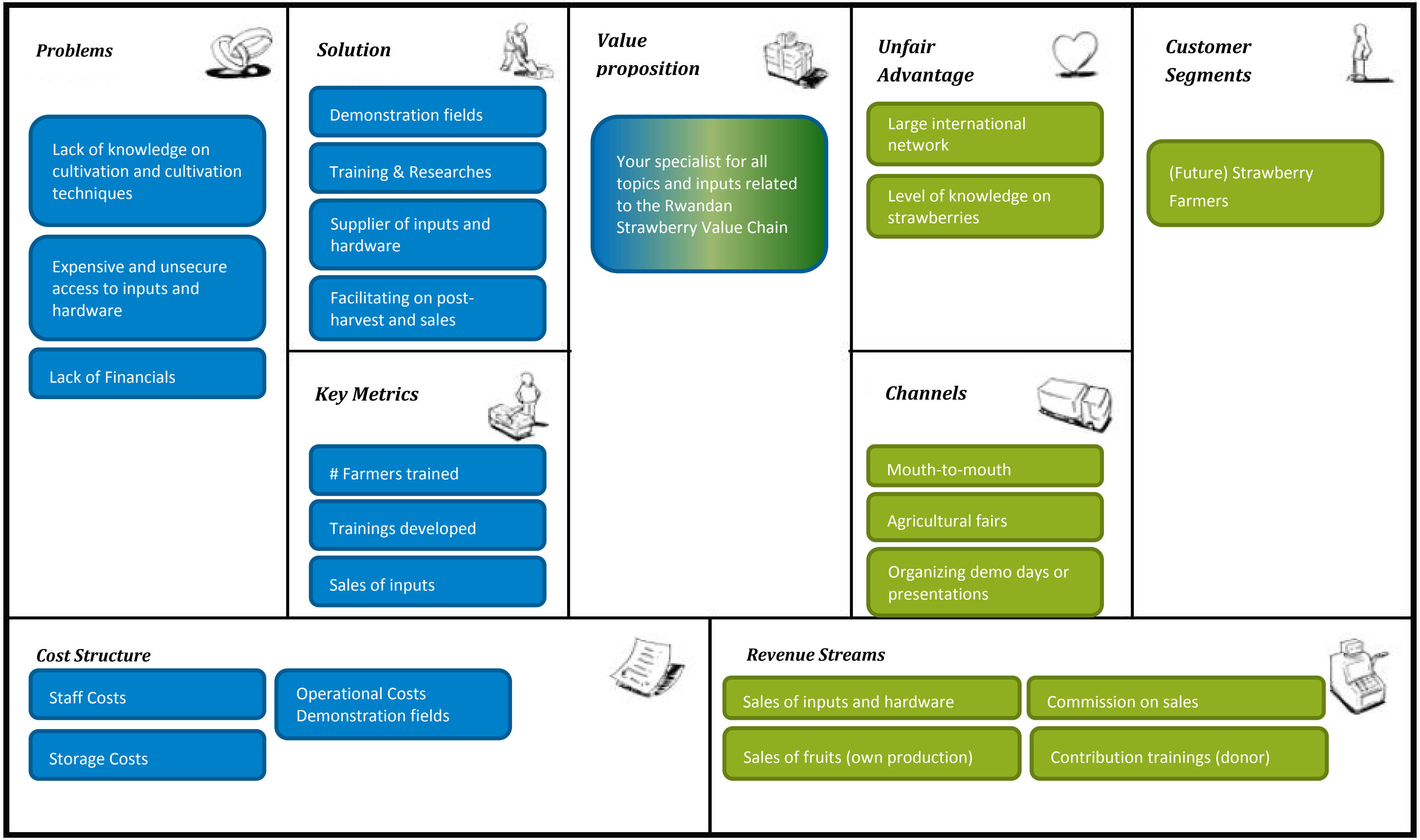


Figure 70: Canvas Business Model for the strawberry Demonstration Centre

Balance between the services offered and the Revenue Streams (income) is essential for the sustainability of this centre. The main role of the Demonstration Centre should be to acquire and spread knowledge by means of demonstration fields, researches, trainings, farm visits etc. However, Rwandan farmers are not used to pay for this type of services. Actually, they are used to be paid for their presence at trainings. This standard or culture cannot be changed within the coming years. So, to be realistic: the revenue stream for trainings and education should be limited (at most contributions by donors or funding) and other sources of income should also be researched . Other possible revenue streams can be the sales of propagation or plant materials and sales of inputs and equipment, like post-harvest, storage, sales and distribution of the fruits (own production on the demo fields and a central marketplace).

The research centre can also be extended to include other fruit crops like tomatoes, cucumber, sweet pepper and eggplant; it can also include other berries like raspberry, blueberry and blackcurrant.

By refining the strategy for the Demonstration Centre the balance between Services and Revenue Streams are crucial for the sustainability and financial stability.

7.3 Strategy Break Down

The next step in the process is to breakdown the strategy for the coming years in concrete goals and actions. The main parameter for the success of the Demonstration Centre is to start with realistic goals and expectations within a given timeframe. The strategy break-down is used for this purpose. The scope of the break down is detailed in the figure on the next page.

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Long term: 3-5 years

Mission:
- Leading and sustainable example of the complete value chain (from plant material to fork) for strawberries in Rwanda
- Thorough knowledge centre on propagation, cultivation, post-harvest and sales of strawberries in Rwanda

Goals: (*What will be achieved in 2023?*)

MARKET
- Being the expertise centre on strawberries
- Entrance gate to inputs and equipment for strawberry cultivation
- Closely involved by innovations on strawberry cultivation in Rwanda
- Profitable and sustainable strawberry project

ORGANISATION
- Well educated and skilled trainers
- Strong partnership and entrepreneurship

FINANCIAL
- Break-even profit & loss
- At least 50% of revenue streams from private sector

Mid-term: 1-3 years

- Entrepreneurial management and skilled staff members for cultivation and training
- Recognized as the knowledge and expertise centre on the strawberry value chain in Rwanda & establishment of demo centre
- Establishment of profitable strawberry production (within the demo centre)
- Being the supplier of inputs and equipment that is necessary for strawberry cultivation
- Development of sustainable revenue streams (switch from donors to private income)

Short term: < 1 year

- Structure of cooperation determined
- Manager appointed
- 2 trainers trained
- Design demonstration fields available
- Location(s) demonstration fields identified
- Equipment has been ordered
- Market research
- Financial feasibility calculations
- Appointments with suppliers/partners
- Storage management
- Budgets (CAPEX, OPEX) estimated
- Set up (donor) funding

Figure 71: Scope of the strategy break down for the Demonstration Centre

7.4 Potential Partners

The potential partners for the Strawberry Demonstration Centre are identified in this paragraph. All companies have been interviewed and have expressed their interest in the establishment of a strawberry Demonstration Centre in Rwanda. Interviewees have not yet been clearly informed about their role and the structure of the management and supervision of the centre. The identified potential partners are:

Local private partners:

FAIM Africa (https://faimafrica.co) is established and owned by an American private investor. The core business of FAIM Africa is a tissue culture lab and nursery. Their main fruits are bananas, passion fruit, Tamarillo, pineapple and bamboo. Besides this product range FAIM Africa also propagates some other fruits like strawberries. Their strawberry variety is Sweet Charlie (origin America). Although this variety is not indicated on our preferred list, this variety also seemed suitable for the Rwandan climate. The growing conditions of Sweet Charlie are similar to those of the Chandler variety. FAIM Africa has the planting materials and could assist in the improvement of the strawberry cultivation in Rwanda.

Mr Raphael Rurangwa is a private investor and entrepreneur, with a large network in the national governmental offices and Rwandan. Mr Rurangwa owned a site of 10 hectares in the Musanze area, nearby the volcanos. However, the Rwandan government has appointed most of this site for nature reserve. Which means that there are just 2-3 hectares left for agriculture. Mr Rurangwa is therefore considering the purchase of a new site in the region, which could be used for the Demonstration Centre. Mr Rurangwa also works closely with an agronomist of Nyirangarama who has been involved in strawberry cultivation and processing for juices and jam. The establishment of a guesthouse nearby the site in Musanze is also interesting.

Rwanda Best (www.rwandabest.com) is established and managed by Jean Claude Ruzibiza. Rwanda Best is located between Kigali and Musanze and started as a small-scale poultry farm. The farm expanded slowly. Its expansion is not restricted to poultry activities only, but also includes Agriculture. Mr Ruzibiza owns a site of almost 7 hectares in this neighbourhood. In 2015 Rwanda Best, in collaboration with the Dutch government, established a greenhouse with improved technologies and customized to the local circumstances under the SMART programme. Mr Ruzibiza is an innovative agricultural entrepreneur with agricultural skills and also a commercial vision. Rwanda Best has land available for the development of a Demonstration Centre.

Sina Gérard (www.sinarwanda.com) is Rwanda's foremost agri-business entrepreneur. His entrepreneurship is broadly oriented: restaurants, bakeries, a juice and wine factory, a school and extensive land holding. The company is located at Nyirangarama in Rulindo District. Mr Gérard is focusing on driving agricultural change. He already has begun producing strawberries. Involvement of this entrepreneur in the development and commercial introduction of strawberry cultivation in Rwanda should add value to and strengthen the business concept.

Rwandan Agricultural Education Institutes:
The Demonstration Centre could strengthen the national educational institutes by offering internships and practical training programmes on skills and knowledge. Students get insight on all aspects of agricultural entrepreneurship which not only consists of cultivation and cultivation techniques but also on subjects like planning, management and sales.

International Business Partners

Holland Greentech (HGT) is a company, that started in Rwanda and sells equipment and inputs, and provides technical support and training for the high-quality horticulture sector. The company has its headquarters in Rwanda, but also operates in Uganda, Zambia and Kenya. It provides state-of-the-art technology and expertise from the Netherlands on cultivation and on handling of fresh produce adapted to the prevailing conditions in East Africa. The efficient and effective use of inputs, water and energy are key to the sustainable development of the horticultural sector.

Delphy (www.delphy.nl) has world-wide expertise on developing and implementing cultivation and cultivation techniques in the food and flower sector. Therefore, Delphy is the company in knowledge and expertise for our partners in plant sectors, worldwide. Delphy has a team with experts in the cultivation of strawberries and implementation of cultivation techniques for strawberries in Eastern Africa. The first part of this report has been elaborated with the knowledge and expertise of this team.

Suppliers of post-harvest equipment and cold storages (like Geerlofs or Kloosterboer) are preferred as partners in the development of a Demonstration Centre. Post-harvest equipment and cold storages are hardly available in Rwanda. The post-harvest process needs to be developed for high quality products and sustainability, especially in the strawberry sector.

7.5 Pitfalls and success factors

The establishment of a Demonstration Centre for strawberries is necessary for the improvement of the level of agricultural knowledge of Rwandan farmers. Because farmers will be the main target group for the Centre, the income will be limited, because:

- The number of commercial strawberry farmers will be very limited. The investments and operational costs for sustainable commercial strawberry cultivation are relative high. The actual income of Rwandan farmers is minimum, the knowledge on agricultural practises is limited and therefore, transfer to strawberry cultivation too risky and financially irresponsible. The revenue stream of sales from inputs and equipment is limited.
- Rwandan farmers are not used to pay for trainings and knowledge transfer. For the moment, farmers have access to knowledge for free. Nowadays most of the trainings and the development of training programmes are paid by donors or donor funding. This culture will not change within the coming years. The Demonstration Centre must not expect any income for trainings from the private sector and should focus on funding for financing these trainings in the first years.

An opportunity could be collaboration with existing Demonstration Centres or Centres “under construction” for agriculture cultivation. This could result in strengthening the knowledge on cultivation of agricultural products, more financial sustainability and risk spreading. Initiatives like the current programmes under the name “SEAD programme”, Mulindi Horticultural Centre of Excellence and/or collaboration with the HortInvest programme are of interest for this Demonstration Centre.

In addition, experiences from similar Centres in Kenya and Guatemala teach us that the development of a Demonstration Centre represent a long journey, often a period of 4 up to 7 years. This is the estimated period for such a centre to reach its break-even point in case of donor-funded initiatives with a local partner that already has an existing business. Therefore, the initiators have to be very critical on the sustainability of the Centre, their services and the partners.

Based on these findings an alternative could be to focus on the establishment of a commercial strawberry farm that also offers practical training programmes and demonstration fields. In this case the core activity would be a sustainable strawberry farm. This farm has to break even after 2 years. The training and demonstration fields are side-activities that add value to the agribusiness sector. The strategy and strategy break-down for this option however, will differ from the ones presented in this report.

The composition of the ownership and decision-making structure are crucial in the establishment of the Demonstration Centre. Too many captains will sink the ship. The same applies to operations and managing a company. The mission and vision for the Demonstration Centre have to be endorsed by the partners. All involved parties have to be open and clear about their expectations and inputs in the Demonstration Centre.

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