# Humidtropics Cluster 4 Project in Rwanda

**Improving Potato-Based Production Systems to Enhance Productivity, Nutrition, Income, and Gender Equality.**

**TRAINING WORKSHOP ON INTEGRATED POTATO CROP MANAGEMENT**

**Kadahenda, Rwanda**

**28-29 April 2016 and 23 June 2016**

# Workshop Report

RESEARCH PROGRAM ON Integrated Systems for the Humid Tropics

CGIAR

INTERNACIONAL CENTRO DE LA PAPA CIP

A member of the CGIAR Consortium

**June 2016**

**Kadahenda Potato Training Workshop Report**

Published by the International Potato Center (CIP)

**Contact**:

International Potato Center (CIP)

Apartado 1558, Lima 12, Peru

cip@cgiar.org . www.cipotato.org

**Table of Contents**

## Abbreviations

| | |
|---|---|
| BW | Bacterial Wilt |
| CBO | Community-Based Organization |
| CGIAR | Global research partnership for a food-secure future |
| CIP | International Potato Center |
| DLS | Diffused Light Store |
| GH | Gardens for Health International |
| IP | Innovation Platform |
| LB | Late Blight |
| NGO | Non-Governmental Organization |
| RAB | Rwanda Agriculture Board |
| Rwf | Rwanda francs |

## 1. Introduction

Potato production is on the rise in the highlands of Rwanda and this crop is one of the top priority commodities in the country, especially in the Northern and Western regions. That is why the CG Research Program (CRP) on Humidtropics is supporting Kadahenda farmers through a Cluster 4 Project titled Improving Potato Based Production Systems to Enhance Productivity, Nutrition, Income, and Gender Equality. In this project, the International Potato Center (CIP) is one of the implementing partners whose aim is to empower Innovation Platform (IP) members on various aspects of this dominant crop. To this end, CIP, in collaboration with Rwanda Agriculture Board (RAB) and a local community-based organization (CBO) called Imbaraga, convened and facilitated a two-day training workshop on 28-29 April 2016 on integrated crop management. The training included the following aspects: soil conservation and fertility management, agronomic practices, pests and diseases, post-maturity handling, and nutrition (**Annex 1**). The field demonstrations took place at a one-day training event held on 23 June 2016.

The April workshop was officially opened by the Executive Secretary of Karago Sector, Ms. Alice Uwamahoro. In her remarks, she warmly welcomed the facilitators and trainees (IP members). She announced that there is a new potato-processing factory in the district, and she urged farmers to connect with the firm to sell their production surplus. She considered that the training had come at the right time to strengthen the capacities of farmers and enable them to meet the government development goals of food security, income, and nutrition.

The training was conducted in a participatory manner combining PowerPoint lectures, group discussions, an innovative recap technique, and field demonstrations. It was attended by 34 IP members, of whom 47% were women (**Annex 2**). The photo album can be accessed through the following link: https://www.flickr.com/photos/106872707@N03/albums/72157670516788326. The methodology used in this training and – to some extent – its contents were designed and developed for the first time by Dieudonné Harahagazwe for a training of trainers conducted in Rotanda and Angonia, Mozambique in 2013-2014. They were then validated by the same scientist in Lushoto, Tanzania in 2014-2015. Currently the same package is being applied to IP members of Jedlu and Diga in Ethiopia.

This report presents the different topics covered in the training with a logical sequence from site selection and land preparation to potato storage. The report does not attempt to provide the whole contents of the course, but gives brief summaries. Wherever applicable within the text, links to full presentations made at the workshop are provided.

## 2. Training presentations

This training was technically facilitated by eight people: from CIP (Dieudonné Harahagazwe and Jean Claude Nshimiyimana); RAB (Cyamweshi Rusanganwa Athanase, Theophile Ndacyayisenga, Felix Nzeyimana, Godelieve Mukamurezi and Thomas Gakwavu); and Imbaraga (Joseph Gafaranga). The following sections summarize the topics that were covered during the training. Links to full presentations either in English or Kinyarwanda – two official languages used in Rwanda - are also provided.

### 2.1. Soil erosion control and soil fertility management

Like any other crops, potato requires good soil health characterized by its texture and structure properties. The full presentation around this topic (in Kinyarwanda language) can be accessed through this link (http://www.slideshare.net/Harahagazwe/soil-conservation-and-fertility-management).

#### 2.1.1. Soil erosion and control measures

Land degradation is one of the main factors that affect crop productivity in northwestern Rwanda. This is characterized by severe soil erosion and declining soil fertility as consequences of the topography as shown in Fig. 1.

**Fig. 1**. Formation of rill and gully erosion in Kadahenda cell: steep topography, the nature of Kadahenda soil and climate conditions are the main factors enhancing soil erosion in the area. Photo Kadahenda cell, Nyabihu district-Western Rwanda (Photos: RAB/ Cyamweshi).

Soil erosion is defined as the washing or blowing away (by water or wind) of the top layer of soil (dirt). This is a serious problem for farmers. Crops are the food that farmers grow. If the soil has eroded, the crops will not grow very well. Although soil erosion is a natural occurrence on all land, there are certain factors that can accelerate erosion, making it more noticeable and problematic.

While there are many different factors that can cause soil erosion, most can be broken down into two main categories: **erosion by water and erosion by wind**.

This training module focused only on soil erosion by water because the erosion by wind is not common in Rwanda in general or in the Kadahenda highlands in particular. During the training, the facilitator presented the different forms of erosion by water and its consequences. He also presented practical techniques to control the erosion, such as bench terraces, contour trenches, and radical terraces.

The facilitator placed emphasis on radical terraces that are being promoted in Rwanda (Fig. 2). Newly established radical terraces should be protected at their risers and outlets, especially in the first or second year of establishment. After establishing a terrace, a riser is shaped and grasses or shrubs/trees are planted soon after. Napier grass is commonly planted and used as forage for livestock. Risers on radical terraces are seen as a new production niche for forage as a result of land shortage and a strict zero-grazing policy currently in place. Radical terraces have the potential of improving farmers' livelihoods and increasing the resilience of a degraded environment.

**Fig. 2**. Complete radical terraces (left) and terracing taking place (right) in Nyabihu District, Rwanda (Photo: RAB/ Cyamweshi).

### 2.1.2. Soil fertility management

Soil fertility refers to the ability of a soil to sustain plant growth, i.e. to provide plant habitat and result in lasting constant yields of high quality. It is the component of overall soil productivity that deals with its available nutrient status, and its ability to provide nutrients out of its own reserves and through external applications for crop production. A fertile soil has the following properties: it is rich in nutrients necessary for basic plant nutrition, including nitrogen, phosphorus, and potassium. These can be supplied by using mineral fertilizer and by other agricultural practices such as the use of green manure, cover crops, etc.

After defining the concept of soil fertility, the facilitator presented the current annual losses in Rwanda: 945,200 t of organic matter, 41,210 t of N, 280 t of P and 3,055 t of K. In view of these losses, he described different techniques that can be used to improve soil health and fertility, including the following:

(i) Liming. Lime is an excellent soil acidity control tool and is available in Rwanda, where travertine and burned lime are produced. Lime is not a fertilizer but a soil amendment. The primary purpose of lime is to stabilize soil acidity. However, it also regulates the level of magnesium, calcium, copper, zinc, phosphorus, and bacteria found in soil. Utilization of lime together with organic and inorganic fertilizers was found most effective. Agronomic investigations have shown that the use of 2.5 to 4 tons per hectare reduces soil acidity and the associated aluminum toxicity and significantly increases the yield of maize, wheat, bean, soybean, and Irish potato.

(ii) Use of manure and compost (20 to 30 t/ha) is needed with a residual effect of two to three cropping seasons, depending on the quality of the manure/compost (Fig. 3).

**Fig. 3.** Manure distribution for soil improvement (Photo: RAB/ Cyamweshi).

(iii) Use of green manure and cover crops. In the Kadahenda highlands, the biomass of *Alnus acuminata* is the species most used for this purpose. Not only does it help to increase the rate of organic matter in the soil but it is also reported to be rich in nitrogen.

**Fig. 4.** Alnus biomass being incorporated into the soil before potato planting in Kadahenda (Photo: RAB/Musana).

(iv) Use of inorganic fertilizers. The facilitator explained that investing 20% of total potato production costs in fertilizers generates a yield increase of around 50%. This means that growing potatoes without fertilizers in the environment of Kadahenda is a waste of time and resources. RAB researchers recommend using the NPK17-17-17 fertilizer at a dose of 300 kg/ha at planting in the highlands of Kadahenda. But this dose can be split into two and applied at planting and 45-60 days after planting without much difference in terms of yields.

## 2.2. Introduction to the potato crop

### 2.2.1 The potato crop in the world

During the training, the facilitator presented CIP and its role in promoting the potato crop around the world. One of CIP's key roles is the maintenance of thousands of accessions for present and future use.

Originating in the Andes around Lake Titicaca in South America, from where it was spread all over the world by the Spaniards via Europe in the 16th century, the potato crop is currently the third food crop in the world, after wheat and rice. In the human diet, potato is the most consumed non-cereal food in the world. It produces more calories per unit area than any other crop that can grow in temperate climates. Among all root and tuber crops, potato tubers contain the highest protein concentration (more than 2% of fresh matter). Also, a medium-sized potato tuber is expected to contain half the recommended daily intake (RDI) of Vitamin C and a fifth of the RDI for potassium.

During this interactive course, participants were given opportunities to share what they know about the crop (Fig. 5). For example, they described the importance of stolons, which are different from roots, and they mentioned that when the stolons are not properly covered by the soil, they grow as new stems rather than producing potatoes.

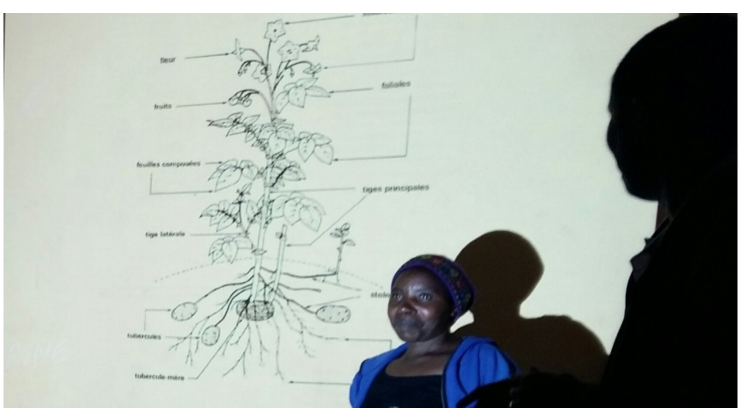
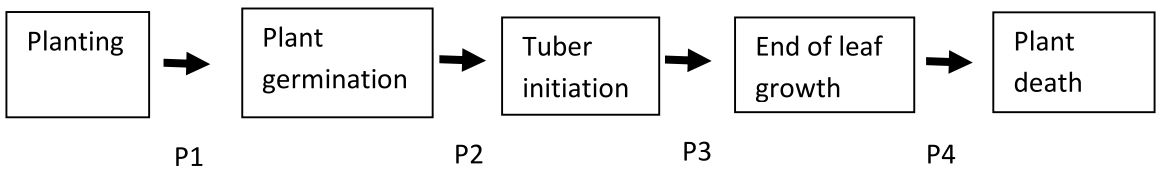



**Fig. 5.** A farmer describing the potato morphology during the training workshop (Photo: CIP/Harahagazwe).

The facilitator highlighted the high yielding ability of the crop, up to 100 t/ha in developed countries but with huge yield gaps in developing countries due to many challenges, as described in the presentation accessible through this link (http://www.slideshare.net/Harahagazwe/introduction-to-potato-crop-63530251). For example, it was reported that the average yield in Kadahenda is around 20 t/ha. Raising this yield requires understanding the following four phases of potato growth and development:




Participants were informed that Phase 1 (P1) is the most critical phase as it drives the crop success or failure, because seed quality is the major yield gap driver. It was also noted that many of the farmers lose their production by harvesting before the end of the tuber bulking phase, i.e. Phase 4. This is normally caused by lack of knowledge, being in a hurry to get to the market before others, desire to avoid theft, etc.

In his closing remarks, the facilitator insisted on the need to raise the current yields in order to respond to increasing demand, mainly created by potato-processing factories being established in the district. There are no alternatives for addressing this demand, because the population density, land sizes and conservation policies do not allow acreage increments. To this end, the facilitator recommended the use of quality seed, fertilizers, and chemicals against pests and diseases as a takeaway message.

### 2.2.2. The potato crop in Rwanda

Rwanda is currently one of the top five countries in Africa in production and consumption (125 kg/inhabitant/year). The facilitator presented a few statistics related to potato cultivation in Rwanda. Annually the country grows potato on 100,000 – 150,000 ha with a total production ranging from 1 to 1.5 million tons. This means that the national average yield is as low as 10 – 15 t/ha, due to various factors as described in the presentation (in Kinyarwanda) accessible at the following link (http://www.slideshare.net/Harahagazwe/potato-production-in-rwanda?utm_source=slideshow02&utm_medium=ssemail&utm_campaign=share_slideshow).

The presentation also focused on the varieties recognized in Rwanda and their performance in the field, including resistance to pests and diseases as shown in Table 1.

**Table 1.** Irish potato varieties found at Rwanda Agriculture Board (RAB)

| Variety | Characteristics | | | | |
|---|---|---|---|---|---|
| | **Growth cycle (days)** | **Attainable Yield (t/ha)** | **Dormancy (days)** | **Bacterial wilt** | **Late blight** |
| Sangema | 110 - 120 | 20 - 25 | 100 - 120 | Tolerant | Sensitive |
| Kinigi | 120 - 135 | 20 - 25 | 120 | Tolerant | Resistant |
| Kirundo | 100 - 110 | 25 | 30 - 50 | Tolerant | Resistant |
| Mabondo | 100 - 110 | 25 | 50 - 60 | Tolerant | Resistant |
| Victoria | 100 - 110 | 25 | 30 -50 | Tolerant | Sensitive |
| Cruza | 120 - 130 | 25 | 20 - 30 | Resistant | Resistant |
| Gikungu | 100 - 120 | 35 | 70 | Sensitive | Resistant |
| Kigega | 100 - 120 | 40 | 70 | Tolerant | Resistant |
| Mizero | 100 - 120 | 41 | 60 | Tolerant | Resistant |

He also informed participants that clean seed potato certified by RAB accounts for 10 -15% of the total volume of seed used in the country. In other words, poor quality seed accounts for as much as 90%. This topic attracted the attention of the trainees, because they wanted to know the concept of seed generation (Gn) which was defined in detail in a separate session and is presented later in this report. Farmers were excited about this concept, which is very critical in their efforts to produce and maintain relatively good quality seed at their farms. In the end, farmers were advised to source from certified seed multipliers' earlier generations (G3-G4) for them to have quality seeds for the upcoming three to four seasons.

### 2.3. Planting techniques and fertilizer application

The facilitator explained the importance of preparing soils prior to planting, and the measurement and application of mineral fertilizers to increase the likelihood of having a good crop as detailed in the presentation (in Kinyarwanda) shared through this link (http://www.slideshare.net/Harahagazwe/land-preparation-and-potato-planting). Depending on tuber size, farmers in Rwanda plant 2 – 3 t/ha. More details on good practices for successful planting, in Kinyarwanda language, can be accessed through the following link (http://www.slideshare.net/Harahagazwe/seed-potato-and-planting).

### 2.4. Earthing up and weeding

As discussed at length in the session related to the potato in the world, when tubers are not well covered with enough soil, yield can be significantly reduced because stolons become stems. The practice of earthing up is crucial for root and tuber crops because the economic yield is underground, unlike other crops such as cereals. Therefore, farmers were sensitized on the importance of applying a good quantity of soil (Fig. 6), preferably two to three times depending on the land topography and quantity and frequency of rainfall. Weeding is already a common practice for farmers, but there was a need to emphasize its importance in potato fields, since the potato doesn't tolerate this kind of competition at all.


**Fig. 6.** At the training, farmers were advised to move backward when earthing up the potato crop (Photo: CIP/RAB).

### 2.5. Integrated pest and disease management

#### 2.5.1. Local knowledge on pests and diseases

Before lecturing on pests and diseases, the facilitators wanted to assess the local knowledge on this particular topic. The purpose of this exercise was to have an idea of what the participants knew about the pests and diseases that were attacking their fields, and how they dealt with them. To this end, breakout group discussions took place in three groups. Results were then presented in a plenary meeting (Fig. 7).

**Fig. 7.** One of the group members presenting discussion results to the plenary (Photo: CIP/Harahagazwe).

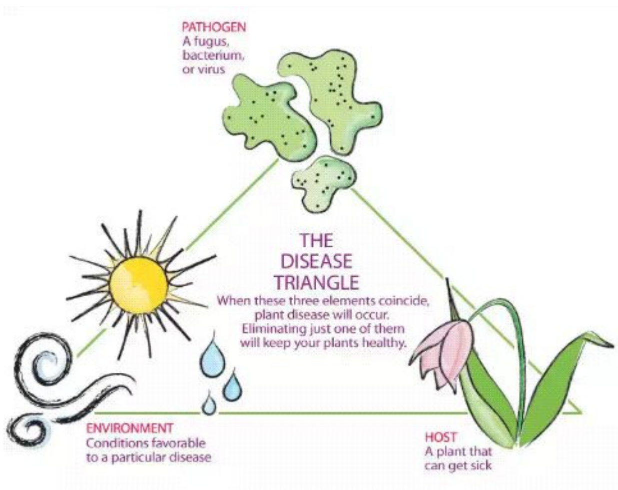
In principle, farmers seemed to be knowledgeable of major pests and diseases that were affecting their crops, namely cutworms, aphids, viruses, BW, and LB, as shown in **Annex 3**. But it was noted that they sometimes confused these biological constraints and therefore used inappropriate control measures. For example, one farmer confused symptoms caused by leafminers with those produced by late blight. When we visited his farm, we realized that he continued spraying fungicides, while the pest population continued to grow. Also, during the field demonstrations a few farmers revealed that they had mixed Ridomil with Dithane in the same sprayer, even though the former already contains the latter from the factory. Further, farmers indicated that they normally use different doses for Dithane and Ridomil: one tablespoon of Ridomil per 15 l spray (half of the recommended dose) versus four tablespoons of Dithane (twice the recommended dose). The measurement of current and recommended doses was conducted during the field demonstrations.

#### 2.5.2. Pest and disease management as per facilitators

The different components of this topic were presented in the following sequence: theory of the disease triangle, fungal diseases, bacterial diseases, and pests. Due to limited time, viruses were not part of the presentation, which can be accessed through this link (http://www.slideshare.net/Harahagazwe/pests-and-diseases-management). But the work conducted in groups had shown that the participants did have an idea about viruses.

##### 2.5.2.1. Disease triangle

The theory of the disease triangle was presented to farmers as the basis for any control measures aiming at reducing or eradicating pests and diseases.




As shown in Fig. 8, three conditions have to be met for any disease outbreak. Therefore, diseases will never occur or survive when the host is not in place. On the other hand, the host cannot show any disease symptoms without the presence of a causal agent. Last, but not least, the pathogen can stay in the host for a long time without symptoms as long as the environmental conditions are not conducive to disease outbreak, a phenomenon well known as latent infection.

**Fig. 8**. Graphical representation of the disease triangle (Source: Web).

### 2.5.2.1 Pests and diseases prevailing in the Kadahenda sector

#### ***a. Fungal diseases***

*Late Blight*

Caused by *Phytophthora infestans*, Late Blight (LB) is the most damaging fungal disease in the world. The good news for this disease is that it is still being controlled by farmers in Kadahenda using the fungicides found on the market (Ridomil and Dithane, also called Mancozeb).

**Fig. 9.** Late blight disease symptoms in one of the farmers' fields in Kadahenda (Photo: RAB/Nzeyimana).

What was not clear to the farmers was the sequence in using these chemicals. Therefore, the facilitator suggested that they use Dithane (contact fungicide) just after plant germination and then spray Ridomil (systemic fungicide) two weeks later, i.e. around 45 days after planting (DAP) at a dose of about 3 g per liter. Subsequent sprays would use Dithane at two-week intervals until the canopy turns yellow due to maturity, except when LB symptoms are visible in the field. In that case they would have to spray Ridomil again, but in principle they should not spray more than twice in a season with this systemic chemical because of its cost and potential to induce pathogen resistance. During the discussions it became apparent that farmers were using different local names to identify this disease. But in the end they agreed to call it MIRIDIYU.

*Alternaria*

Alternaria is also commonly found in the region but with little impact on productivity, since it normally appears late in the growth cycle. Therefore, there should not be too much concern about it in the highlands of Kadahenda. Symptoms of Alternaria infection typically start as a small, circular, dark spot (Fig. 10). As the disease progresses, the circular spots may grow and the inner part becomes a hole. One of the differences between LB and Alternaria is that the former normally starts from the edge of the leaflets whereas the latter starts from inside.

**Fig. 10**. Typical symptom of Alternaria in the field (Photo: CIP/Harahagazwe).

*Fusarium*

Symptoms of Fusarium in the highlands are mostly found on tubers during storage. Tubers become too dry and die. The wilting symptoms found at lower altitudes are not common in cooler environments like Kadahenda. But famers have to be aware of the disease especially in storage: they will have to remove diseased tubers to prevent the disease from affecting the entire storage facility. This disease is one of the biggest biotic challenges affecting potatoes in storage in the Great Lakes Region.

### *b. Bacterial diseases*

Bacterial diseases are the most difficult potato diseases to deal with because they contaminate the soil and they cannot be economically controlled using chemicals. The most infamous in the region is Bacterial Wilt (Fig. 11) called KIRABIRANYA by farmers in Kadahenda.

**Fig. 11**. Plant affected by Bacterial Wilt and used for test at field demonstrations held in Kadahenda, Rwanda (Photo: CIP/RAB).

The positive aspect of this disease is that it can at least be easily detected in the field using a simple test with a glass of clear water. When the portion of stem is plunged into the water, the pathogen flows down in the glass in the form of smoke, as was noted by farmers in Kadahenda during the demonstration. As has been witnessed in various places, an integrated approach makes it possible to significantly reduce or even eradicate the disease from the field. This includes the use of clean seed, clean soil, long rotation systems with non-host plant species, removal of wilting and volunteer plants, sanitation, etc.

***c. Pests***

The major pests observed at Kadahenda are cutworms, leafminers, aphids, and the Potato Tuber Moth (PTM). During the training, farmers were introduced to various efficient techniques that will enable them to control these pests. It was noticed that farmers were already familiar with the chemicals normally recommended. The facilitator merely sensitized them on the need to be rational in their use: farmers should spray only when necessary, using the right doses in a bid to protect the environment and reduce the impact on production costs.

### 2.6. Post-maturity practices

Dehaulming, harvest, and storage techniques were presented at the workshop as post-maturity practices. The following paragraphs summarize these practices, but more information can be accessed through the following link to the presentation made at the workshop (http://www.slideshare.net/Harahagazwe/potato-post-maturity-management).

### 2.6.1. Dehaulming techniques for seed production

The facilitator presented the advantages of removal of potato shoots ahead of the complete death of the plant, normally two weeks beforehand. During the last physiological stage (Phase 4), all tubers are in principle formed. They merely increase in size. It is in this regard that dehaulming is done when the tuber size for seed (around 30 – 60 mm in diameter) is reached. Larger tubers are not cost-effective as seed.

There are various dehaulming techniques, but farmers were advised to pull out the potato plant while stepping around its base to prevent tubers from coming out as well (Fig. 12). One of the advantages of this technique is to prevent any top-down migration of pathogens through the stems' inner part (straw) in the event that stems are just mechanically cut using tools such as a sickle. Tubers remain in the soil while the potato shoots are removed from the field and burned.

**Fig. 12.** Best practice of dehaulming potatoes in the field (Photo: CIP/Harahagazwe).

### 2.6.2. Harvesting techniques

Most farmers in the region harvest before time as they compete with their peers to get to the market first and obtain better prices. This practice goes with trade-off consequences. First of all, yields are low as the bulking period shrinks. When seed potato is harvested before optimal maturity, the tubers present longer dormancy, skin rubs off easily, and tubers lose a lot of weight in storage. Harvesting is done when the soil is dry using appropriate tools that do not wound tubers. When harvesting, farmers were recommended to separate directly rotten and/or damaged tubers from the healthy-looking tubers to be sold or stored. It is common practice to find that farmers simply leave rotten tubers in the field after harvest. Those tubers keep diseases in the field and are the source of inoculum for subsequent seasons.

### 2.6.3. Storage techniques

IP members were shown different pictures of low-cost storage facilities called Diffused Light Stores (DLS) used in different countries where CIP operates. Comments were also made on bad and good examples of seed storage. Bad examples showed how seed potatoes were kept in different DLSs but mixed with other things such as other crops, livestock feed, bicycles, and motorcycles. Good seed storage was qualified as one of the key factors for producing quality seed. To this end, farmers were reminded of the effect of bad storage on seed losses, where the average normal loss of 30-40% of seed caused by physiological processes can be as high as 100% when there are bad storage conditions.

### 2.7. Planning of potato production for the market

During the workshop, IP members were sensitized on the need to produce seed potato for themselves through cooperatives and reduce the cost of purchasing seeds outside their farms, where they are obliged to add transportation costs. A scenario was shown where farmers are producing potato for consumption and sell it at 100 Rwf/kg or less while they have purchased seed at 400 Rwf/kg. This happens when they are not working through cooperatives and sell individually. According to the facilitator, it is imperative for farmers to have an idea of the production cost. Otherwise their farm enterprise will never prosper.

**Fig. 12.** Potato market in Musanze, Rwanda (Photo: Imbaraga/Gafaranga).

The facilitator introduced IP members to marketing strategies that start with smart planning. To this end, they were advised to get to know the good market, where their produce can have extra value in terms of money and not to focus only on the local markets. More details on the presentation (in Kinyarwanda) can be accessed through the following link (http://www.slideshare.net/Harahagazwe/potato-marketing-in-rwanda).

### 2.8. Seed potato production systems

This important topic on seed systems was covered by two facilitators, one presenting the formal seed scheme in place, seed generations and quality (http://www.slideshare.net/Harahagazwe/seed-potato-systems-in-rwanda?utm_source=slideshow02&utm_medium=ssemail&utm_campaign=share_slideshow) and the other presenting the positive and negative selection techniques (http://www.slideshare.net/Harahagazwe/positive-and-negative-selections) while emphasizing the need for an optimal seed storage (http://www.slideshare.net/Harahagazwe/seed-potato-storage). All these presentations shared through above links were in the Kinyarwanda language.

It was important for facilitators to define what was meant by quality seed. Quality seed potato is characterized by genetic quality (i.e. well adapted to the area of production, higher yielding ability, and tolerant to pests and diseases found in the area of production). Physical quality: seed potato tubers must be free from damage caused by humans, insects or rodents and they must be of a single variety. Physiological quality: seed potato tubers must have reached full maturity, having full potential to germinate, and not shrinking (very old).

IP members were introduced to the potato seed scheme (Fig. 13) and how to produce different categories of seed which are Breeder seed or Minitubers (known as generation one (G1) in the Rwanda context, Pre-basic seed (known as generation two: G2), Basic seed (known as generation three: G3) and Certified Seed (known as generation four: G4). It was explained to IP members that in order for farmers to produce ware potatoes for consumption, they have to use certified seed.

Minitubers are produced from potato plantlets produced in the laboratory by tissue culture techniques and planted in appropriate screenhouses. When the seedlings are planted in the screenhouses, potato minitubers or generation one (G1) are harvested for first planting in the field. When harvested, the seed obtained falls into the category of pre-basic seed (G2) after fulfilling the certification standards. G2 is also planted in the open field for the next season to increase the quantity of seed and, when harvested, it falls into the category of basic seed or G3, assuming it also qualifies for the certification standards. Basic seed is also increased again by planting it in the open field for the next season to increase the quantity and, when harvested, it falls into the category of certified seed or G4 after fulfilment of the certification standards. The certified seed (G4) is then grown by farmers to produce potatoes for consumption but it can also be well grown and well treated to produce G5 or even G6.


**Fig. 13**. Sequence of seed potato generations (G0 – Gn) as defined by the National Potato Sub-Program of Rwanda (Photo: RAB/Ndacyayisenga).

At the end of this lecture on seed potato production, IP members were urged to meet the following requirements when they plan to undertake seed potato businesses. First of all, they were advised to use enough land – at least five hectares – for sustainable rotation systems. The second important element is to build a DLS for storing their seed potatoes. They must also be sure that they have enough money for purchasing initial clean seed stocks and other agro-inputs.

### 2.9. Nutrition

As part of the nutrition work in Rwanda under Humidtropics, IP members were introduced to basic concepts of nutrition and malnutrition as detailed in the presentation (in Kinyarwanda) accessible through the following link (http://www.slideshare.net/Harahagazwe/introduction-to-nutrition-and-malnutrition-to-ip-members). This introduction was a kind of preliminary work to a series of follow-up studies which will involve the same farmers of Kadahenda monitoring changes over time at the household level following the on-going research and development interventions. The previous training on nutrition had been conducted by an NGO called Gardens for Health International (GHI). The follow-up studies will be conducted by RAB in partnership with Bioversity International. The purpose of this training was to refresh the course given by GHI and assess the farmers' current knowledge on Nutrition and Malnutrition. To this end, some refresher questions were given after the presentation, and preliminary results show a very promising trend: 95% of respondents were able to spontaneously answer the following five questions correctly:

(i) What is malnutrition?
(ii) What are the causes of malnutrition?
(iii) What are the consequences of malnutrition for the family, society and country?
(iv) What are different types of malnutrition?

(v) What are the symptoms of each type of malnutrition?

In conclusion, IP members are aware of the importance of a complete and balanced diet. Since they have a strong commitment to being role models in healthy families, they are expected to trigger change in their respective neighborhoods.

**Fig. 14**. Participants in the training workshop having a well-balanced meal at the workshop (Photo: CIP/Harahagazwe).

## 3. Knowledge assessment of participants

### 3.1. Baseline assessment (before the training)

A baseline test was carried out to determine the initial level of knowledge of trainees, using a questionnaire that had previously been used in other countries for a similar course (Annex 4). It was noted that all participants were literate for questions translated into Kinyarwanda, except three who were supported by the extension agents and facilitators. Results are presented in Fig. 16.

### 3.2. Recap

Before starting the program of Day 2 of the workshop, there was a recap on what had been shared the day before. The team used a good methodology of entertaining the participants in a very joyful environment before questions were raised and answered. All the facilitators who had given lectures suggested two questions for each topic addressed. The technique consisted of throwing a small ball made of paper, and then the person who picked it up was the one to answer the question (Fig. 15). Almost 90% of the questions posed were answered perfectly well.

**Fig. 15**. Paper ball technique used at the workshop for recap after one-day training.

### 3.3. Post-training assessment

Just before the workshop came to an end, the same questionnaire was distributed to trainees in a bid to gauge the change in the level of knowledge. It appeared that most of the trainees had a good knowledge of the potato crop, as shown in Fig. 16. The overall knowledge level was improved by 10% but some of the famers raised their score by as much as 45%. Without taking into account the outliers, the same figure shows that the score range was much reduced after the training.

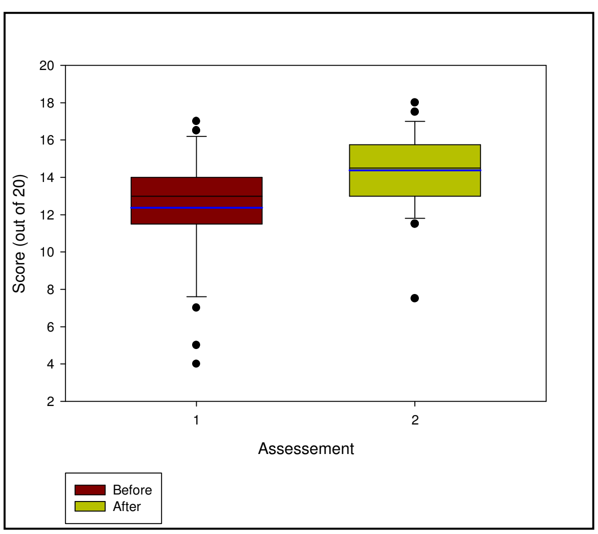



**Fig. 16**. Boxplots representing baseline and final scores of knowledge assessments conducted at the workshop.

## 4. Way forward

This training event was not designed to be a stand-alone activity. It is coupled with field activities so that farmers get an opportunity to practice what they learned through a continuous technical backstopping from the facilitators. For the current season, IP members who attended the training planted 4 ha using certified seed. Half of the seed used (4 t) was provided free of charge by the Cluster 4 Project through RAB, and beneficiaries paid the other half. CIP provided all the chemicals required to control pests and diseases. Furthermore, CIP is going to support four farmers who volunteered to build their own DLSs because they have decided to become seed potato multipliers.

## 5. Conclusions

According to the beneficiaries, the Executive Secretary of Karago and local facilitators, the potato course held in Kadahenda was a great success compared to other similar workshops that had taken place there in the past. At the field demonstrations, the farmers' representative in his closing remarks gave the facilitation team a score of 24 out of 20. This was due to the rigorous preparation involving a lot of players, including the beneficiaries, with a very transparent mechanism in sharing roles and responsibilities. We do believe that the same training can be scaled out in other locations and the approach can be adapted to other crops using this document and all the supporting materials shared through hyperlinks. Based on experience acquired so far, we can draw a few key lessons. The first lesson learned is that there is a need to develop a comprehensive training manual on integrated potato crop management for smallholder farmers in Sub-Saharan Africa which values partnership and participation. The second lesson is that when dealing with communities with oral tradition, field work should take more time than training sessions held in a meeting room with modern technologies. Last but not least, we realized that by the end of the training, partners engaged in the facilitation become empowered as well, because they then feel confident to replicate the training without external support.

## Acknowledgements

We would like to acknowledge Humidtropics and the CGIAR Fund Donors for their provision of core and project-specific funding without which this research could not deliver results that eventually positively impact the lives of millions of smallholder farmers in the tropical Americas, Asia and Africa. We also thank all Innovation Platform (IP) members and stakeholders who contributed to the success of this training. We are very grateful to the Government of Rwanda for having enabled this workshop to take place.

**Annex 1: Workshop Program**

**TRAINING SCHEDULE:** ***Day 1: Thursday, 28 April 2016***

| Time | Activity/Topic | Contents | Facilitator |
|---|---|---|---|
| 09:00 | Registration of participants | | Pacifique Imfurayacu |
| | Self-introduction | | Felix |
| | Welcome address by the Local Authority | | Athanase |
| | Background information and Workshop objectives | Presentation: Humidtropics, objectives, expectations and logistics | Athanase |
| | Knowledge assessment | Baseline test | Thomas |
| Module 1: General Introduction and Production Techniques | | | |
| | *Tea break and group photo* | | Pacifique |
| | Introduction to the potato crop | Origin, value, morphology, phenology, yield | Dieudonné |
| | Introduction to the potato crop (continued) | Overview of potato production in Rwanda | Theophile |
| | Soil conservation and fertility management | Land degradation, land restoration, crop rotation, intercropping, etc. | Athanase |
| | Lunch break | | Pacifique |
| | Soil conservation and fertility management(cont'd.) | Which fertilizers, which formulas/doses, when, etc. | Athanase |
| | Potato husbandry | Land preparation and planting techniques | Felix |
| | Potato husbandry (continued) | Seed potato, Planting, Weeding and Earthing up | Claude |
| 17:30 | *End of Day 1* | | |

***Day 2: Friday, 29 April 2016***

| Time | Proposed activity/topic | Proposed contents | Facilitator |
|---|---|---|---|
| 08:30 | Recap of Day 1 | Pre-defined questions from all facilitators of Day 1 | Felix |
| | Local knowledge on pests and diseases | Breakout group discussions (3 farmers' groups and 1 group for technicians) and presentation in a plenary session | Thomas |
| | Potato husbandry (continued) | Dehaulming (Why, when and how), harvesting, and post-harvest handling (storage) | Dieudonné |
| | Seed Potato value chain | Production of potato mini-tubers, pre-basic, basic and certified seed | Theophile |
| | Seed Potato value chain (continued) | Positive and negative selection, seed storage and dormancy and variety/seed degeneration | Claude |
| | Seed Potato value chain (continued) | On-farm seed production | Gafaranga |
| Module 2. Integrated Pest and Disease Management | | | |
| | The Disease Triangle | What is the basis of disease outbreak in the field? | Dieudonne |
| | Major fungal diseases | Late Blight, Early Blight and Fusarium | Dieudonné |
| | Major bacterial diseases | Bacterial Wilt and Soft Rot/Blackleg | Dieudonné |
| | Major potato pests in the region | Cutworms, aphids, leafminers, Potato Tuber Moth | Dieudonné |
| | | | |
| Module 3: Post-maturity management and value addition | | | |
| | Lunch | | Pacifique |
| | Productivity and market opportunities | Why, what data to collect, and how to calculate the profit | Gafaranga |

| | | | |
|---|---|---|---|
| | | Market opportunities and linkages | |
| | Healthy diet (nutrition) | Current status, why and how to achieve balanced diet | Godelieve |
| | Final knowledge assessment | Same test using the baseline questionnaire to assess the change | Thomas |
| | Field and storage planning | Data collection, field management (fertilizers, chemical, etc.) and DLS | Dieudonné |
| | Drinks | | Pacifique |
| 18:30 | End of Workshop | | |

**Annex 2: List of participants**

| Number | Full name | Age (years) | Sex | Marital Status |
|---|---|---|---|---|
| 1 | Ayinkamiye M. Chantal | 44 | F | Married |
| 2 | Dusabemariya Agnes | 38 | F | N/A |
| 3 | Gakwasi Celestin (Extensionist) | 34 | M | Married |
| 4 | Gasore Gilbert | 30 | M | Married |
| 5 | Harerimana Gilbert | 45 | M | Married |
| 6 | Kabanyana Esparance | 54 | F | Married |
| 7 | Kabari Bosco | 38 | M | Married |
| 8 | Kamanzi Celestine | 44 | F | Married |
| 9 | Kankundiye Hilalie | 31 | F | Married |
| 10 | Karangwa Timothee | 42 | M | Single |
| 11 | Karera Emmanuel | 46 | M | Married |
| 12 | Mukagatare Alphonsine | 45 | F | N/A |
| 13 | Mukarugwiza Clemence | 37 | F | Married |
| 14 | Mukaruhigiro M. Solange | 39 | F | Married |
| 15 | Munoceli Bernard | 59 | M | Married |
| 16 | Munyakarambi J. Baptiste | 39 | M | Married |
| 17 | Munyaneza Theoneste | 37 | M | Married |
| 18 | Murorinkweri M. Louise | 30 | F | Married |
| 19 | Musabyimana Francine | 34 | F | N/A |
| 20 | N.Bunane Angelique | 34 | F | Married |
| 21 | Ndarifite Emmanuel | 34 | M | Married |
| 22 | Ndibwami Joseph | 74 | M | Married |
| 23 | Niyitegeka Gilbert | 27 | M | Married |
| 24 | Nsengimana J. de Dieu | 38 | M | Married |
| 25 | Ntamuhanga Innocent | 60 | M | Married |
| 26 | Ntamukunzi Mediatrice | 46 | F | Married |
| 27 | Nyiramusore Zilipo | 67 | F | Married |
| 28 | Nyirandungutse Leonie | 37 | F | Married |
| 29 | Nzanwenimana Anne Marie | 39 | F | Married |
| 30 | Rwikangura J. Claude | 43 | M | N/A |
| 31 | Sinamenye Theoneste | 34 | M | N/A |
| 32 | Uwamahoro Oliva | 30 | F | N/A |
| 33 | Uwamariya Beatrice | 41 | F | Married |
| 34 | Uzabakiriho Christine | 28 | F | Married |
| 35 | Yadufashije M. Josee | 45 | F | Married |
| 36 | Yankurije Theogene | 40 | F | Married |

## Annex 3: Results from group discussions (in Kinyarwanda)

### ITSINDA RYA 1 (Group 1): KINIGI

### IKIBAZO:Tanga ibyonnyi n'indwara z'ibirayi zigaragara mugace mutuyemo,Kadahenda.Garagaza ibimenyetso n'uburyo bwo kuzirwanya

| No | INDWARA | IBIMENYETSO | UBURYO BWO KUYIRWANYA |
|---|---|---|---|
| 1 | **Kirabiranya** | Kuma cyangwa kuraba | -Kurandura ibirayi bigaragaraho kirabiranya ukayitwarana n'ubutaka bwayo ukajya kubita kure y'ibindi birayi.<br>-Kuraza umurima<br>-Guhinduranya ibihingwa mumurima |
| 2 | **Indwara y'imvura** | -Gushya kw'ibirayi<br>-Guhinduka ku ruti rw'ikirayi. | Gutera umuti(Dithan na Ridomil). |
| 3 | **Imfunyarazi** | Gukanyarara kw'amababi | Gutera umuti nka Dithan na supermetrine |
| | **IBYONNYI** | **IBIMENYETSO** | **UBURYO BWO KUBIRWANYA** |
| 1 | **Inanda** | Gukata ibirayi no kubica kabiri | Kuyishaka impanda y'ikirayi no kuyica<br>Gutera umuti wica udukoko nka cypermetrine |
| 2 | **Ifuku** | Kurigitana ibirayi Mw'itaka | Kuyitega ukoresheje imitego |
| 3 | **Umuntu** | -Kwibwa<br>-Gukura ibirayi biteze | -Kurindisha<br>-Gukurira igihe |

### ITSINDA RYA KABIRI (Group 2): GIKUNGU

| NO | INDWARA | IBIMENYETSO | UBURYO BWO KUZIRWANYA |
|---|---|---|---|
| 1 | **Kirabiranya** | Ibibabi biraraba | Guhinduranya ibihingwa<br>-Kurandura<br>-Kuraza umurima |
| 2 | **Imfunyarazi** | Amababi aramfunyarara | Gushaka imiti y'amoko menshi |
| 3 | **Indwra y'imvura** | Amababi arababuka | Gutera imiti |

| | IBYONNYI | IBIMENYETSO | UBURYO BWO KUBIRWANYA |
|---|---|---|---|
| **1** | **Inanda** | Guca umugozi w'ikirayi | Kuyishakisha bakayica |
| **2** | **Amafuku** | Kuzamura ubutaka | Kuyitega |
| **3** | **Amatungo** | Kurya amababi y'ikirayi | Kuyarinda |
| **4** | **Uburima** | Ubusimba bwinsh buba buri kumababi | Gutera umuti nka cypermetrine |

**ITSINDA RYA GATATU (Group 3) : DUHINGE NEZA**

| NO | INDWARA | IBIMENYETSO | UBURYO BWO KUZIRWANYA |
|---|---|---|---|
| **1** | **Miridiyu** | Gushya kwa mababi n'uruti twayo | -Gukingira ibirayi bikimera utera Ridomil yonyine gusa<br>-Guhingira kugihe |
| **2** | **Kirabiranya** | Kuraba kw'ikirayi kiteze(Amababi n'uruti) | -Kubikura mu bindi,ubirandura<br>-Gusimburanya ibihingwa<br>-Guhingira kugihe. |
| **3** | **Imfunyarazi** | Kugwingira kw'amababi n'uruti | -Kurandura ikirayi kirwaye n'itaka<br>-Gutera imbuto nziza |
| | **IBYONNYI** | **IBIMENYETSO** | **UBURYO BWO KUBIRWANYA** |
| **1** | **Amatungo** | Gukokora amababi n'uruti | -Kurinda<br>-Kuzitira |
| **2** | **Inanda** | Gukata uruti | Kuraha ubutaka,kuyikuramo no kuyitwika. |
| **3** | **Abajura** | Kwangiriza | kurinda |
| **4** | **Igihombogoro** | Gumfumagura ibirayi mwitaka | Kuyishaka mubutaka mukayitwika |
| **5** | **Uburima** | -Ubusimba bw'uzura ku mababi<br>-Gukura byageraho bigahagara bitari byera | Gutera umuti urwanya ubukoko |

**ITSINDA RYA KANE (Group 4): KORA WIGIRE (Rigizwe nabashinzwe iyamamaza buhinzi = Extensionists)**

| | **INDWARA** | **IBIMENYETSO** | **UBURYO BWO KUZIRWANYA** |
|---|---|---|---|
| **1** | **Kirabiranya** | -Irangwa no guhonya<br><br>-Kuraba amababi hanyuma akuma<br><br>-Iyo uranduye ikirayi usanga imishoro y'ibirayi bihari bizana amashyira mumaso. | -Kuraza umurima<br><br>-Guhinduranya ibihingwa<br><br>-Gukoresha imbuto y'indobanure |
| **2** | **Indwara y'imvura** | -Kuzana urubobo Amababi ahinduka umuhondo no kumigozi<br><br>-Umurima urababuka | Gutera Ridomil na Mancozeb |
| **3** | **Imfunyarazi(Virus)** | Amababi arereruka<br><br>-Amababi aramfunyarara agashinga umutwe<br><br>-Amatwi y'amababi amera nk'amahembe<br><br>-Ikirayi gishora uturayi duto kuko imigozi ntikura neza kandi iba migufi | -Gutera imbuto nziza zitarwaye kandi y'indobanure<br><br>-Kurandura ibirayi birwaye<br><br>-Gutera umuti wica udusimba dukwirakwiza iyi ndwara. |
| | **IBYONNYI** | **IBIMENYETSO** | **UBURYO BWO KUBIRWANYA** |
| **1** | **Inanda** | Gucamo ibirayi mo kabiri(Uruti) | Gutera imiti yica udukoko |
| **2** | **Uburima** | Uburima bupfukira ku mababi<br><br>-Amababi arapfunyarara | Imiti yica udukoko(insecticide nka cypermetrine) |
| **3** | **Ubuzukira** | Ikirayi kirarabirana | Imiti yica udukoko |

## Annex 4: Questionnaire for knowledge assessment

***Note: Each good reply equals 1 point out of 20.***

## MODULE 1: General Introduction and Planting Techniques

1. Mention at least 2 improved varieties that you know:

_____________________________________________________________________________
_____________________________________________________________________________
____________________________________________________

2. What is the meaning of $G_1$, $G_2$ and $G_3$ seed potato system?

_____________________________________________________________________________
_____________________________________________________________________________
____________________________________________________

3. What crops are appropriate to sow/plant after potato?
   a) Maize ( )
   b) Tobacco ( )
   c) Wheat ( )
   d) Chili pepper ( )
   e) Sweet pepper ( )
   f) Eggplant ( )
   g) Beans ( )
   h) Sweet potato ( )
   i) Sorghum ( )
   j) Tomato ( )

4. What is the planting density normally recommended?

_____________________________________________________________________________
____________________________________________________________

5. Why does a potato crop need water to grow?

________________________________________________________________________________
_______________________________________________________________

6. What are the mineral fertilizers that are recommended for the potato crop in Rwanda? At which dose?

________________________________________________________________________________
_______________________________________________________________

7. What are 3 key factors for a good potato production?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________

8. Why is it important to add soil to the potato crop?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________

**MODULE 2: INTEGRATED PEST AND DISEASE MANAGEMENT**

9. What are the 3 key components of disease occurrence in the field (Disease Triangle)?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
______________________________________________

10. How can we control potato late blight in the field?

________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
________________________________________________________________________________
_____________________________________

11. What is the meaning of positive selection?

12. What is the chemical normally used to control potato bacterial wilt?

13. What is the best time to spray a potato field?

14. What are the major potato pests in Kadahenda?

15. During which period of the year is it appropriate to produce seed potato? Why?

**MODULE 3: Harvest, Storage and Sustainable Development**

16. Why must we dehaulm the potato crop, and how?

17. When is it appropriate to harvest a potato field?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________

18. How must we store seed potato?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
_________________

19. Why is it important to work in associations?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
_________________

20. Why is it important to calculate the cost of production?

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
_________________