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ACTION FOR LIVELIHOOD ENHANCEMENT IN NORTHERN UGANDA (ALENU)

IRISH POTATOES PRODUCTION TRAINING MANUAL

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Advance AFRIKA Where Dignity Matters

AFARD The Quest for A Better Society

GWED-G Gulu Women's Economic Development & Globalization

ACKNOWLEDGEMENTS AND **DISCLAIMER**

This manual was developed by Pascale Waelti of Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences HAFL and Robert Bakyalire of AFARD for a consortium consisting of four NGOs (Caritas Switzerland, Advance Afrika, Agency for Accelerated Regional Development, and Gulu Women Economic Development and Globalization) for the implementation of the Action for Livelihood Enhancement in Northern Uganda (ALENU) Project that is funded under the Development Initiative for Northern Uganda (DINU), a government of Uganda programme supported by the European Union (EU) and supervised by Office of the Prime Minister.

The manual formulation process included a review of a number of manuals for which we are indebted, namely:

- Biovision Infonet 2019. Potato. https://www.infonet-biovision.org/PlantHealth/Crops/Potato
- FAO 2020: http://www.fao.org/in-action/african-roots-and-tubers/countries/uganda/en/
- FIBL Manual OrganicAfrica 2019.
- Jawoko , 2014. Lead Farmer and Business Management Committee Guide
- PotatoPRO, no date. Potato Tuber Moth in World. https://www.potatopro.com/about/potato-tuber-moth

Pictures and text extract of these sources have been used in this manual.

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ABOUT
ALENU PROJECT

Under the Development Initiative for Northern Uganda (DINU), a Government of Uganda programme supported by the European Union (EU) and supervised by Office of the Prime Minister, Caritas Swit-zerland has received a grant to implement the Action for Livelihood Enhancement in Northern Uganda (ALENU). ALENU is implemented by a consortium consisting of four NGOs (Caritas Switzerland, Advance Afrika, Agency for Accelerated Regional Development, and Gulu Women Economic Develop-ment and Globalization).

Objectives and Results

ALENU is a 40-month action that focuses on improving livelihoods through increased and diversified food production, enhanced market opportunities and better maternal and child nutrition in six districts of the West Nile and Acholi sub-regions. Its **overall objective** is, "to consolidate stability in Northern Uganda, eradicate poverty and under-nutrition and strengthen the foundations for sustainable and inclusive socio-economic development." And the **specific objective**: is, "to increase food security, improve maternal and child nutrition, and enhance household incomes through support to diversified food production and commercial agriculture and through improving household resilience (notably to climate change) and women empowerment. The three main result areas are: **Result 1.1**: Increased production of diversified food; **Result 1.2**: Increased market accessibility; and **Result 1.3**: Improved nutritional status

Districts and Sub Counties

Agago (Wol and Lokole); Amuru (Amuru and Lamogi); Omoro (Odek and Lakwana); Nebbi (Erussi and Atego); Pakwach (Pakwach and Panyimur); Zombo (Kango and Athuma)

Main Activities

Result 1.1: Increased production of diversified food
Select HHs; develop Family Development Plans; develop seasonal Production and Marketing Plans; set up group demonstration gardens; conduct farmer field school sessions; facilitate outreaches by local government extension staff; organize seasonal agro-input fairs; build capacity of agro-input suppliers; form commodity-based cooperatives; train VSLA Mentor; train Farmer Group (FG) members in VSLA; link SACCOs/ progressive FGs with formal banks.
Result 1.2: Increased market accessibility
Provide FGs with Business Development Services; organize/ promote sub-county farmer markets; facilitate learning visits to model farmers/private sector actors; create added value for commodities; organize a multi-stakeholder platform and annual cross-sector dialogues; achieve progress in certification, quality control, branding and contracting.
Result 1.3: Improved nutritional status
Train VHTs/Health Workers on good nutrition practices, child health, family planning and WASH; empower cultural and religious leaders to sensitise community; increase access to prevention and curative health services; improve nutrition and sanitation practices at HH level; train VHTs on family planning, provide family planning services; conduct annual couples conference and community dialogues on family planning/GBV; conduct community dialogues for out-of-school adolescents on sexuality/ family planning, provide health services; advocate for supplies of FP commodities; facilitate debating clubs and youth peer groups in schools; collaborate with faith-based medical bureau.

Approaches

- **Holistic Family-Centered Approach:** All household members will benefit from a combination of bundled services customized to meet their specific needs, address their vulnerabilities and strengthen their capacities at the collective and the individual level and in view of reducing poverty and malnutrition.
- **Village Savings and Loan Association (VSLA) and Linkage Banking:** Provide simple savings and loan facilities in a community that does not have easy access to formal financial services. Strong VSLAs will be registered at district level and linked to formal financial institutions or federated into SACCOs for better financial inclusion.
- **Farmer Field School (FFS) with Peer-to-Peer Demonstration-based Extension Approach:** Promote practical knowledge among smallholders on improved technologies through participatory, experimental, problem solving and discovery-based learning and hence increase yields, food adequacy and

collective marketing for better market positioning.

- **Market Systems Development (MSD) and Value Chain Approach (VCA):** Make markets work for the benefit of the poor by tackling the underlying causes of market failure and strengthening the functions of market actors as well as the rules and norms that govern the market system.
- **Agro-ecology:** Apply ecological and social concepts and principles to the design and management of food and agricultural systems to optimize the interactions between plants, animals, humans and the environment while taking into consideration the social aspects that need to be addressed for a sustainable and fair food system (FAO).

Key stakeholders

Stakeholder	Role
Target farmers and their households	Main beneficiaries, participate in selection of market commodities and peer-extension agents (CBTs, Poultry Paravets, Agroecology Champions, VSLA Mentor and Market Committee Members), various capacity building activities and monitoring and learning meetings
Local Governments	Oversee implementation of activities and align the Action with the district priorities, involved from planning stage and play a major role throughout the implementation as advisors, extension workers, or beneficiaries of capacity building
Community members	(VHTs, cultural and religious leaders, senior women and male teachers, youth Mentors), contribute to changing attitudes and practices, involved at all project cycle stages.
Private sector	Expand market system and offer production inputs (seeds, tools, etc.), loans, services (market information, advisory service, quality control, vet services etc.), transport and, as traders and processors, purchase the products of target farmers and farmer groups
Advance Afrika, AFARD, Gwed-G	Local implementing partners, in charge of implementation based on a mix of geographical and technical division of responsibilities
Caritas Switzerland	Consortium coordinator and donor, ensures independent project supervision, in charge of MEL and quality assurance including capacity building of co-applicants, and the development of a network of strategic contacts with development partners
Ugandan Government	Supervising (OPM) and contracting authorities (National Authorizing Officer/ Ministry of Finance, Planning and Economic Development)
EU	Main donor

Beneficiaries total 35'900 individuals (farmers and their household members, local government officers, community and private sector members, and the staff of implementing partners).

0. Training concept

0.1. Pedagogical approach

The training is based on elements of the FFS approach and adult learning theories. The following elements are important:

- The training should be conducted in a participatory and highly interactive way because involvement and learning are enhanced when participants contribute to the discussion. It is therefore essential that participants are encouraged to share their own experiences before the theoretical material is brought to them.
- Similarly, practical exercises, where participants apply what they learn directly in a demonstration field, will enhance learning.
- The demonstration field should be located on the farm of one of the participants (host farm). All training sessions will take place in this field. The host farmer must look after the field between training sessions.
- The training plan must follow the cropping calendar for the product concerned, so that the farmer can apply what he has learned directly at home (see the proposed training calendar below). Ideally, the participants should meet every week or second week on a learning cycle comprising 8-10 meetings.
- Where appropriate, encourage participants to try different things and make small "experiments", either at home or on the demonstration field (for example, applying different types of fertilizer) and observe the effect these treatments can have on the crop.
- If possible, the facilitator should visit farmers in their fields to give them feedback on how they implement their crop at home and help them find solutions to the problems they face.

The participatory method and learning-by-doing will create a direct link between the training and the challenges farmers face when implementing new techniques at home. This will enable them to develop their observation and innovation skills and to find solutions on their own to the problems they may face. It is recommended to start each training session with the practical part, before the facilitator gives technical advice at the end of the training sessions.

Moreover, the training should promote as much as possible a production that includes the principles of agroecology. The general principles of agroecology are described in Chapter 0.2. These general principles can be explained and discussed during the first training session. Specific aspects of agroecology, such as soil fertility management, crop rotation, pest and disease management, are discussed in more detail in the corresponding chapters and in a separate booklets. They should be explained and discussed during training sessions devoted to these topics.

Recommended structure of a training session:

1. **Welcome**
2. **A look back at what has happened since the last meeting**. (10-20 minutes)
   In the participant fields: Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
   In the demonstration field: Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown? What disease problems can be seen? Do they find insects, other organisms? How is the soil, the humidity, etc.? Facilitators can ask the participants to focus on aspects related to the topic of the day.
3. **Introduction of the topic of the day and short brainstorming to identify what the participants know already about this topic.** (10-20 minutes)
   For each chapter, some guiding questions are proposed to stimulate the discussion.
4. **Exercises in the field (2 hours).** Practical aspects of the topic of the day are directly applied in the field by the participants, with the support of the facilitator. The participants shall then apply these techniques at home as well.
5. **Summary (20-30 minutes):** the facilitator summarizes important aspects of what has been learned during the sessions and give some more technical advice if necessary.

Recommended training program

It is important that the training units are delivered at a time that is appropriate to the crop production schedule, so that participants are then able to apply the new knowledge gained directly at home. Where appropriate, some training units may be combined (e.g., common varieties (Unit 1) and tuber seed selection and pre-germination (Unit 3)). Other units may also be offered in two separate sessions to address or deepen different aspects (e.g., pest and disease management (Unit 8)).

Topic	Duration	Timing
1. Introduction: why growing Irish potatoes and which varieties to grow? What is agroecology	2-3 hours	4 weeks before planting time
2. Seed production 2.1 Site selection and land preparation 2.2 Positive selection	 2 hours 1 hour	4 weeks before planting time Include this part in the 2nd session of "Pests and diseases management" (5-10 DAP)
3. Site selection and land preparation (including planning the crop, rotation, intercropping, soil fertility management)	2-3 hours	4 weeks before planting time
4. Selection and pre-germination of Irish potato seed tubers	3 hours	4-6 weeks before planting
5. Planting	3 hours	Day of planting
6. Fertilizer and manure application	2 hours	5-6 weeks after planting
7. Weed management	3 hours	3-4 weeks after planting
8. Pests and diseases management	2 sessions of 3 hours	2-3 weeks after planting 5-10 weeks after planting (Flowering stage)
9. Harvesting	3 hours	Week 11-20 after planting
10. Post harvesting and handling	4 hours	Week 11-20 after planting
11. Record keeping and gross margin calculation	2 sessions of 2-3 hours	Before/during the cropping season. End of cropping season

0.2. What is agroecological farming?

Agroecology is farming that aims at feeding a growing population while conserving and nurturing the natural resource base. Agroecological farmers want to improve food yields for balanced nutrition, strengthen fair markets for their production, enhance healthy ecosystems, and build on traditional knowledge and customs. Their objective is to create stable food production systems that are resilient to environmental perturbations such as climate change and disease.

Agroecology views farmland as an ecosystem – a complex network in which every living and nonliving component of the system is important and affects every other component, either directly or indirectly. Since farmland provides many services to us humans (such as food production, clean water or biodiversity) we have to take care of it. Key principles of agroecological farming therefore include:

- Protect the environment and use natural resources efficiently and sustainably;
- Reduce the use of chemicals as far as possible;
- Make use of organic/biological measures and resources, and try to recycle what you can;
- Rather prevent problems (such as pests and diseases) than having to treat them;
- Let nature help you;
- Practice agriculture for the good of people and the environment.

Topics in which agroecological farming differs particularly from conventional farming are especially soil fertility management and pest and disease management

Soil fertility management

Instead of simply using chemical fertilizers to boost crop growth, agroecological soil fertility management considers crop rotations or intercropping with legumes (that can fix nitrogen from the air), the use manure and compost, and beneficial organic matter management to keep soils healthy and fertile. Reducing tillage operations and protecting the soil with a permanent cover helps maintaining the soil fertile and healthy. Some practical guidelines on how to prepare and use soil fertility amendments are given in a separate leaflet.

Pest and disease management

To reduce the use of chemicals as far as possible, agroecological pest and disease management applies many practices to prevent pests and diseases from building up and creating losses:

- Cropping patterns such as crop rotations, intercropping, or trap/catch/push crops can break pest and disease cycles (and provide numerous other benefits), while anti-parasite crops may scare away (repel) or trap certain pests;

- Use resistant and tolerant varieties (quality seed, seed treatments, …);
- Strong plants are less susceptible to pests and diseases (soil fertility, micro-climate, weeding, nurseries, effective micro-organisms and the like, …);
- Introduce and nurture beneficial organisms (habitat, e.g. agroforestry, to enhance diversity);
- Adequate fertilization and irrigation (not too much N or humidity);
- Physical control: traps, enclosures/netting, by hand, scaring away, removing diseased plants;
- Organic pesticides: produced by farmers, small businesses;
- Go regularly to the field and observe thoroughly.

Some recipes and guidelines to produce and use such measures are explained further-on or in a separate leaflet.

1 Why growing irish potatoes and which varieties to grow?

A. Learning objectives

After the training participants will:

- Know the origin of Irish potato and how it arrived in Africa
- Understand the importance of Irish potatoes growing for income and nutrition
- Have reflected on the reasons why they would like to grow Irish potatoes
- Know the characteristics of different varieties of Irish potatoes commonly grown in Uganda and be able to choose varieties adapted to the growing conditions of their farm and production objectives
- Understand the principles of agroecology

B. Duration

2 hours

C. Learning aids

- Flip chart,
- pens

D. Activities and exercises

Introduction (20 minutes)

The trainer will introduce the topic of the day. He may discuss the following questions with the participants:

- Why is it important for you to grow Irish potatoes? How will Irish potatoes production fit within your farms? For which purpose do you want to grow Irish potatoes (self-consumption, as a source of income)?
- What could be the benefit to grow Irish potatoes?
- What could be the main problems for you to grow Irish potatoes? How to overcome these problems?
- What do you know about agroecology? What does it mean in Irish potato production?

Exercise choosing the right variety (30-60 minutes)

The facilitator gathers on a table a sample of the Irish potato varieties available in Uganda (or pictures of them, if fresh Irish potatoes are not available).

The facilitator asks the participants to discuss (either in groups first, or directly in plenum) the following questions:

- Which of these varieties / plant types do you know; how do you call them?
- Which one have you already grown, eaten? Which one do you prefer and why?
- What advantages and disadvantages do you know from these varieties / plant types? Which criteria do you consider when selecting the varieties, you want to grow?
- Which varieties are more adapted to an agroecological production
- Which variety would you choose to grow for which purpose?

The exercise can be closed by a degustation of the different varieties! (in cooked form)

Summary by the facilitator (20 minutes)

- The facilitator summarizes the discussion by explaining the importance of growing Irish potatoes and giving information about their origin
- He summarizes the main principles of agroecology and point out that these principles will be addressed in specific sessions during the whole production cycle
- He explains which varieties of Irish potatoes are more adapted to an agroecological production and why.

E. Content

1.1 Origin and reasons for growing Irish potatoes

Potato originated in the highlands of South America before Spanish explorers brought the plant to Europe in the late 16th century. Around the turn of the 20th century the plant arrived in Africa where potato has grown in importance over the last years (Biovision). Uganda is the 3rd largest producer of potatoes in East Africa after Rwanda and Kenya. The highlands of Uganda are well placed to benefit from the growing demand for potatoes in the region (FAO 2020).

Irish potatoes in are essentially a food security crop with good prospects for increased domestic urban demand. The major growing areas in Northern Uganda are in the highland areas of Zombo and Nebbi districts. In these districts, potato is a main part of household diets and a source of income. Irish Potatoes are grown for two major reasons. These include being a:

1. Main source of food in many households

2. Major source of income if done at commercial level

Raw and unpeeled Irish potato contains energy value of 80kcal, carbohydrates in form of sugar and starch, fat, protein and water. In addition, it contains vitamin B1, vitamin B2, vitamin B3, vitamin B6, vitamin C, calcium, iron, magnesium, phosphorus, potassium and sodium (Jawoko 2014).

1.2. Irish potato varieties

There are many varieties of Irish potatoes in Uganda including Victoria, Nakpot1, Nakpot2, Nakpot3, Nakpot4, Nakpot5, Cruza, Rukutu, Kisoro, Malirahanda, Kabale, Rwangume, Kingi and Kapchot. Farmers can get information from the extension officer to find out which variety is suitable in a given geographic area. When selecting a variety, the following factors should be considered:

a. Yield potential
b. Eating quality
c. Maturity period
d. Disease tolerance or resistance
e. Drought tolerance
f. Storage period

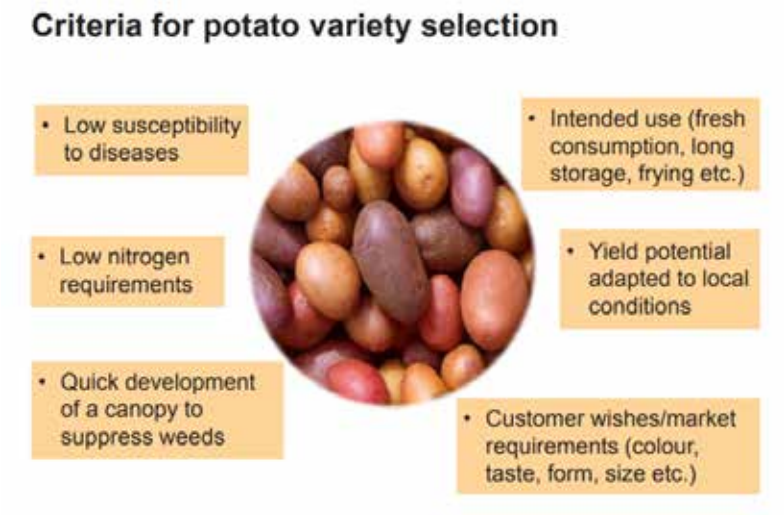

Figure 1:
Criteria for potato variety selection (FIBL organicafrica Manual 2019, 30)

Table 1: characteristics of varieties of Irish potatoes grown in Uganda

Variety	Maturity	Attributes
Malirahinda	95-115 days	Tuber size is medium, skin color is white, flesh is white, takes 90 to 120 days to sprout. susceptible to blight, susceptible to bacterial wilt, adapted to highland areas.
Victoria	80- 95 days	Large tuber size, skin is red, flesh is white, takes 75-90 days to sprout, tolerant to bacterial wilt adapted to lowland and highland.
Nakpot 1	75-90 days	Tuber size is large, red skin, flesh is cream, takes 90 to 120 days to sprout, tolerant to late blight, susceptible to bacterial wilt adapted to low and highland area.
Nakpot2	90- 110 days	Tuber size is medium, flesh is white, takes 90 to 120 days to sprout, tolerant to late blight, susceptible to bacterial wilt, adapted to highlands.
Nakpot 3	85 to 100 days	Tuber size is medium, skin is white, flesh is white, takes 90 to 130 days to sprout, resistant to late blight, susceptible to bacterial wilt, adapted to mild attitude.
Nakpot4	85-110 days	Tuber size is large, skin is red, flesh is cream, takes 90 to 120 days to sprout, is resistant to late blight, susceptible to bacterial wilt, adapted to highland.
Nakpot 5	95 to 120 days	Tuber size is large, skin is red, flesh is creamy, takes 110 to 150 days to sprout. Nakpot 5 yields better in cool areas.
Rwangume	110-120 days	Tuber size is large, skin is purple, flesh is creamy.
Rutuku	90-20 days	Tuber size is large, skin is red, flesh is creamy, takes 110-140 days to sprout, is resistant to late blight, susceptible to bacterial wilt, adapted to highland.

2 Potato seed production

The quality of seed is highly relevant for successful potato production. The planting material should be free of seed-borne diseases. Whenever possible, farmers should buy certified seed potatoes, but such material may not be available or may be too expensive. One alternative is to produce seed potato at farmer level with the seed plot technique.

A. Learning objectives

After completing this training, the participants will

- Understand what plots are suitable for potato seed production.
- Know what positive seed selection means
- Understand how seed potatoes should be harvested and stored.

B. Duration

Approximately 2.30 h

C. Learning aids

- Flipchart
- Pens

D. Activities and exercises

Introduction (20 minutes)

The trainer Introduces the topic of the day. He may discuss the following questions with the participants:

- Where do you procure your seeds?
- Do you produce your own seeds?
- If yes, how? If not, why not?

Practical visit (2h)
The facilitator will organize a visit to a farmer who produces potato seeds. The different steps of potato seed production can be explained on site.

E. Content

2.1. Plot selection and preparation for potato seed production

Choose and prepare your plot for potato seed production:

- Seed plot should be on the top part of the slope in the farm
- Potato seeds must be cultivated with sufficient distance from ware potato fields to avoid infections by viruses and blight disease.
- In this plot no Irish potatoes, capsicums, eggplants or tomatoes should be grown for the last 5 years.
- If possible, the plot should have had a dense grass cover on it for at least one year during the last 5 years. Or land that has never been under fallow can be used.
- The plots should have full sunshine in highland areas and half shade in hotter areas.
- Make sure that the plot is well drained.
- Plough the land and make a raised bed of 15 cm height and 1.5 m width. A good supply of well composted farmyard manure before planting the potatoes is favorable. Apply compost or farm manure on the entire bed and mix it well
- Plant the seed tubers 15 cm deep at spacing of 30 x 30 cm, and cover with soil.
- Crop management should be done as for other potato crop including control of plants for diseases and pests on a weekly base to monitor the occurrence of aphids, potato tuber moths, bacterial wilt, viruses, as well as early and late blight (see chapter on pests and disease management). Weeding and hilling is done by hand to avoid the spread of disease by using tools (hoe).
- For the seed plot protection, it can be good to fence the plot in order to restrict movements that cause contamination. Maize plants can be planted around the potatoes to minimize aphid infestation. Planting at least four rows of maize is done 2-3 weeks before planting the seed potatoes. All tools, feet, shoes should be disinfected before entering the seed plot area.

2.2. Positive seed selection

- Positive seed selection is a procedure where any diseased plant particularly infected with bacterial wilt or viruses is removed from the field immediately.
- The healthy-looking plants at flowering are marked with sticks or pegs. These selected or marked plants should then be checked weekly for pests

(aphids, potato tuber moth) and diseases (bacterial wilt, viruses, early and late blight).

- The plants developing disease symptoms should be removed immediately, control mechanisms for pest might be found together with agricultural extension officers. Selected plants should not be near (not closer than 1 meter) from diseased plants were removed.
- The diseased plants including their tubers should be put in a 1-meter deep pit and covered with soil or be burnt.

Figure 2: Healthy Muvano potato (Biovision 2018)

Figure 3: Store seed potatoes under artificial light and thinly in wooden boxes or on the floor (Source: https://www.farmelec.co.uk/products/potato-storage/)

- The selected plants are considered the positively selected seed potatoes. For harvesting, the positive selected seed potatoes are harvested first before the rest of the field. This process stands in contrast to the harvesting done usually, where farmers harvest all tubers at once.
- When leaves begin to turn yellow, remove potato vines (haulms and steps) about 2 weeks before harvesting. It is important that the soil is dry when harvesting and pay attention not to damage the tubers. Following factors should be considered (Biovision):
  - Seed tubers must be unbruised measuring 2.5-5.5 cm in diameter. Larger tubers should be sold off as ware potatoes.
  - Selected seed tubers should be stored in diffused light and ample aeration. Do not store seed tubers in dark stores used for ware potatoes.
  - Store tubers of each variety separately. Do not store seed tubers in gunny bags.
  - Spread the seed tubers thinly on the floor or in wooden crates.
  - Some farmers have discovered that storing seed potatoes under saw dust keeps away tuber moths and keep the potatoes seeds longer.

3 Site selection and land preparation

A. Learning objectives

After completing this module, participants will:

- Understand the factors to consider in selecting a suitable site for Irish potato production
- Understand how Irish potato plants interact with other plants and how to plan crop rotation considering spatial and temporal arrangement.
- Understand why crop rotation is important and what crops are suitable to grow before and after potatoes.
- Learn and experience the best practices of land preparation for Irish potato production

B. Duration

3-4 hours (or 2 separate sessions)

C. Learning aids

- Hand hoes and other tools for land preparation
- Demonstration garden

D. Activities and exercises

Introduction and practical selection of the land for the Irish potatoes plot (1 hour)

This activity should take place directly in the area where the Irish potatoes plot will be implemented

1. The trainer introduces the topic of the day. He then asks the participants and discuss with them the following questions, possibly directly in the area where the Irish potatoes plot will be implemented:
   - How would you choose an appropriate site for growing your Irish potatoes?
   - Which aspects would you look at or take into consideration?

- What is the history of the field (crops grown the last 3 years, what diseases)?

2. Based on the discussion, the participants are asked to list the criteria on a flip chart.
3. The facilitator asks then the participants to choose the right location to implement the Irish potato plot and justify their choice. Alternatively, they can assess the plot that has already been selected using the criteria that have been discussed.

Exercise: preparing the land for Irish potatoes plantation (1 hour)

The participants, together with the facilitator, will practically prepare the land for Irish potatoes plantation. The first cultivation can be done during the session. The second cultivation, including ridging can be done at time of planting, hence in the session of planting.

Facilitator's summary (30 minutes)

The facilitator sum up important points of land selection and proper land for Irish potatoes production based on the aspects presented in the sub-chapter E. Content below.

E. Content

3.1 Site selection

When selecting and preparing land for Irish potatoes, the farmer should understand that Irish potatoes require the following:

- Irish potatoes grow well in well drained soils such as loam and sandy loam soils. Heavy clay soils are only suitable if well drained and ploughed. Sandy, light soils have the tendency to dry out quicker (Jawoko 2014).
- The soil should be deep, well drained, and loose for proper tuber development. Slightly sloping fields dry and drain quicker but the fields should not be too steep to avoid soil erosion (FIBL).

Figure 4: Suitable and unsuitable sites for potato cultivation (FIBL Organicafrica Manual 2019, 12)

- The site should be free from diseases like bacterial wilt, black leg, root nematodes (see chapter 6).

Crop rotation

- Proper crop rotation enhances soil fertility, increases soil organic matter, conserves soil moisture and helps maintain soil structure. In addition, it avoids build-up of soil-borne pathogens affecting potato, and reduces the level of soil infestation once the soil has been contaminated.
- Do not select a site that had Irish potatoes or a sister crop like tobacco, egg plants or tomatoes grown during the last 3 years (FIBL). Potatoes should not be grown more often than one season in three years in the same garden.
- After harvest, implement a rotation plan of 2-3 years to ensure that the pests and diseases are starved (see Manual on agroecology).
- An adequate cultivation break will help to control pests and diseases and enrich the organic matter in the soil. It is therefore very recommended to plant other vegetables before and after growing potatoes.
- Rotate using cereals like rice, sorghum, maize and millet or legumes to break the disease and pest life cycles (Jawoko 2014).
- Planting brassicas such as broccoli, cabbage and mustard plants before the potato crop helps reducing incidence of bacterial wilt and nematodes.
- Control volunteer potatoes and weeds in the rotation crop.

Preceding and following crops to potato

- The potato crop has a high nitrogen demand. It does therefore very well after crops that leave a loose soil and a high amount of easily degradable organic material behind. Suitable preceding crops are listed in Table 2 (FIBL).
- After harvesting the potato high amounts of nitrogen remain in the soil. Theses should be used in the soil by planting a succeeding crop with elevated nitrogen demand such as the ones listed in Table 3. In any case, the soil should be covered to catch the nitrogen and prevent erosion (FIBL).

Table 2: Evaluation of crops preceding potato (FIBL organicafrica Manual 2019, 28);

Evaluation of crops preceding potato

Preceding crop		Suita-bility	Comments
Grain cereal	Potato	+++	• Neutral pre-crop • Standard nitrogen fertilisation required to potato
Grain legume	Potato	+++	• Moderate nitrogen fertilisation required to potato
Green manure	Potato	+++	• No additional nitrogen fertilisation required • Nitrogen supply may be too high for potato
Brassica vegetable	Potato	++	• High nitrogen fertilisation required to potato • Brassicas contribute to nematode control
Root crops	Potato	++	• Not ideal (two root crops following each other) • Standard nitrogen fertilisation required
Maize	Potato	+	• Only in very fertile soils, as the soil is depleted after maize; Leguminous cover crop in maize can provide some nitrogen to potato
Nightshades	Potato	-	• Not recommended due to build-up of soil-borne diseases and pests (two nightshades following each other)

Table 3: Evaluation of crops following potato (FIBL organicafrica Manual 2019, 28)

	Following crop	Suitability	Comments
Potato	Grain cereal	+++	• Good uptake of nutrients provided by potato
Potato	Brassica vegetable	+++	• Good uptake of nutrients provided by potato
Potato	Maize	+++	• Good uptake of nutrients provided by potato
Potato	Vegetable	++	• Good uptake of nutrients provided by potato

Intercropping (Infonet-Biovision)

- Wide ridges or mounds are required for intercropping.
- Usually the potatoes are planted on the ridges and the second crop is planted in the furrows between the potatoes (FIBL).
- Potatoes can be intercropped with a wide range of annual crops such as sweet potato, maize, cocoyam, cabbage, beans, or even pyrethrum.
- Potatoes planted in rotation or intercropped with barley, maize, peas, or wheat prevents soil exhaustion. In this case, intercrops are planted at the bottom or at the edge of the furrows and the potatoes on the ridge.
- However in order to get full benefit from a potato crop such as high yields, weed suppression and ease of management, without building up high levels of soil-borne diseases: it is recommended to grow potatoes in a separate field and rotate the crop with others.
- Interplanting with a short season legume such as beans can increase total crop yield and help prevent spread of diseases.
- Other nightshade crops (tomatoes, eggplants, peppers etc.) and celery are not suitable to be intercropped with potatoes.

3.2 Land preparation

- Proper tillage is crucial for optimal yield.
- Land preparation should be done 6 to 8 weeks before planting by slashing present vegetation in the field and burry it with a hoe, a tractor or animal traction so it can decompose.
- The second cultivation is done four weeks after the first cultivation and allows removing the weeds, loosening the soil for proper drainage and aeration and preparing a fine seedbed suitable for planting.

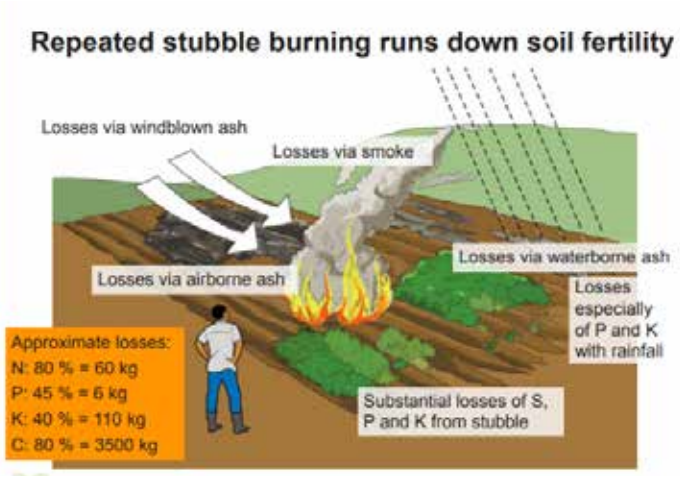

Figure 5: Effects of stubble burning on soil fertility (FIBL organicafrica Manual 2019, 4)

Best practices during land preparation

- When ploughing using animal traction, hand hoe or tractor the ploughing should be done across the slope to control soil erosion.
- Burning of vegetation should be avoided as this leaves the soil bare and exposes the garden to soil erosion.
- Adequate time should be given after the first cultivation to allow proper decomposition of organic matter into the soil.
- In stony areas, the stones should be gathered and put together or placed as bands along the contour lines to control soil erosion.
- Proper land preparation should eliminate or significantly reduce soil compaction and hard pans.
- After the second cultivation ridges should then be made at a width of 15-30 cm and a height of 45 cm.

Potatoes can be planted on flat land or on ridges.

Advantages of planting on ridges

- It allows proper drainage and easy management of weeds. Free movement between the ridges is possible.
- Ensures that the stolon are properly covered and more tubers are formed
- It conserves soil moisture

Figure 6: Potatoes on ridges (https://forgardening.org/plants/food/how-to-grow-potatoes/)

Potatoes can also be planted on flat land without ridging. Here, the hills are created at a spacing of 75cm between rows and 30cm between plants. After creating the hills, the sprouted tubers are planted at the same spacing as for the ridge planting explained above. Adequate tillage and drainage are essential to increase oxygen supply in the soil.

4 Selection and pre-germination of Irish potato seed tubers

A. Learning objectives

By the end of the training the participants are able to:

- Recognize the qualities of a good planting seed tuber.
- Understand the purpose and benefits of pre-germination.
- Practice pre-germination of potato seed tubers at home

B. Duration

3-4 hours

C. Learning aids

- Marker pen
- Flip chart
- Seed tuber

D. Activities and exercises

Introduction (30 minutes)

The trainer will introduce the session of the day. To stimulate the discussion, the trainer can ask the following questions:

- How do you plant Irish potatoes? Do you pre-germinate potato seed tubers? If yes, how do you do it (which steps, timing)?
- Why do you think it is important to pre-germinate potato seed tubers?
- What are attributes of pre-germinated seed tuber?
- Where do you procure you the seed tubers? How can you recognize quality seed tubers?

Demonstration on pre-germination (1 h)

A demonstration of proper pre-germination of potato seed tuber is carried out. The facilitator show to the farmers how potato seeds are pre-germinated and how pre-germinated seeds should look like. Discuss relevant factors for seed-germination.

Summary and discussion (15-30 minutes)

The facilitator summarizes the main points regarding potato seed tuber germination. The group can then discuss the critical aspect of availability of planting material and find solutions to how the situation can be improved.

E. Content

Potato is normally propagated vegetatively by small (40 to 100 g) tubers, called 'seed tubers' or 'seed potatoes'. It can also be propagated by pieces of tuber ('seed pieces') or by true seed. The seed rate (tubers) ranges from 1.5 to 4.0 t/ha. The first problem facing growers in developing countries is obtaining supplies of healthy planting material of a suitable cultivar at an acceptable price.

4.1 Pre-germination

Before planting, the potato seeds should be pre-germinated. This can increase yield safety, speed up emergence and the development of the tubers. Pre-germinated potatoes are 10 to 14 days sooner ready for harvesting than not pre-germinated tubers. This reduces the likelihood of infections like black scurf or blackleg and lowers the risk of late blight. Additionally, the number of sprouts and therefor number of stems per unit area of foliage are reduced. This will lead to fewer but bigger tubers (FIBL).

For pre-germination, the seed tubers are put in a **cool and bright place** avoiding direct sunlight. Select medium sized tubers without any damages or signs of pests and diseases if possible. This step should be carried out 4 to 10 weeks before the planting date depending on the variety and the pre-germination temperature. The ideal temperature is 10 to 12° C. If the temperature is higher, germination will take place faster (FIBL). The ideal temperature is rather theoretical because most of the farmers in the tropics do not have a cold store. The most important recommendation for the sprouting is to expose the seed potato tubers to the light (avoid direct sunlight) to allow formation of short sprouts.

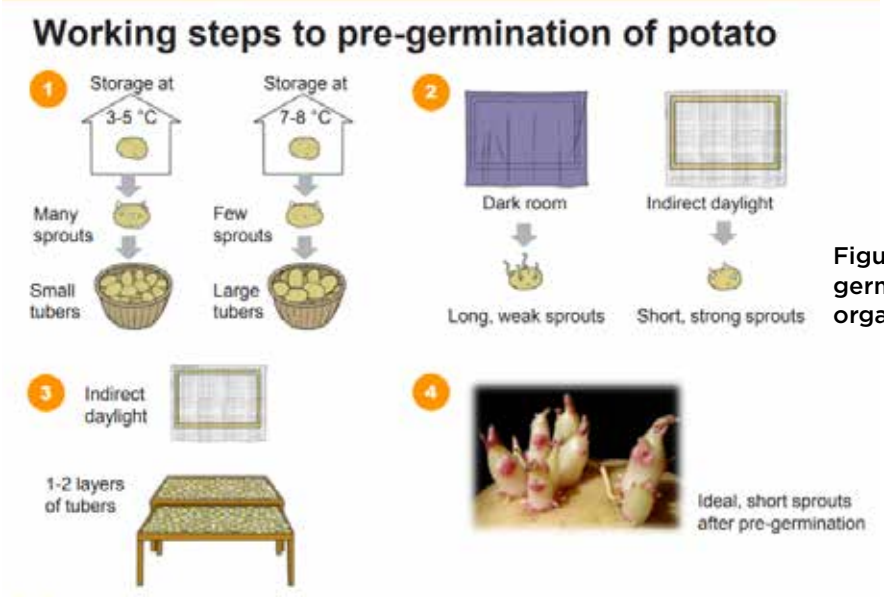

Figure 7: Working steps to pre-germination of potato (FIBL organicafrica Manual 2019, 35)

Farmers should put the following into consideration when selecting seed tubers for planting.

Tubers for planting should be fresh and free from injuries

- Farmers should ensure that the tubers to be planted should be accessed from a certified source to ensure they do not have diseases.
- Tubers to be planted should have 4-6 sprouts each

5 Planting

A. Learning objectives

By the end of the training the participants are able to:

- Apply the correct spacing and planting depth for planting.
- Apply the different recommended practices for Irish potatoes planting.

B. Duration

3 hours

C. Learning aids

- Marker pen
- Flip chart
- Well prepared demonstration garden
- Hoe
- Planting strings
- Farmyard manure, chicken manure
- Irish potatoes tuber seed ready for planting
- Demonstration garden

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

- **In the participant fields or at home:** Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
- **In the demonstration field:** Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction of the topic of the day (20 minutes)
The facilitator will shortly introduce the topic of the day and the purpose of the activity. To stimulate the discussion, the following questions can be asked:

The facilitator will shortly introduce the topic of the day and the purpose of the activity. To stimulate the discussion, the following questions can be asked:

1. How would you plant your seed tubers?
2. How would you select quality seed tubers?

The planting will then be done practically and at the time of planting in the group demonstration field.

Demonstration (2 hours)
The trainees, together with the facilitator will practically do the final land preparation (e.g. ridging » see chapter 3), manure application (see chapter 6) and transplant the seed tubers in the demonstration field of the group. The facilitator must explain all the different activities involved step by step. The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.

Summary (20 minutes)
The facilitator summarizes the main points of the topic of the day

E. Content

5.1. Planting

- Planting should be done at the onset of the rain to allow proper utilization of water.
- Potatoes are propagated vegetative by means of tubers (see chapter 3). Sprouted tubers with short and strong sprouts or buds are planted with the buds facing up.
- The tubers can be planted on ridges or on flat land (see chapter 3).
- The ridges should be 15-30 cm high, 60-100 cm apart.
- The tubers are then planted each 30-40cm in rows (Jawoko 2014).
- The closer spacing should be used in fertile soils and good rainfall areas to avoid the production of very large tubers.
- On top of the ridges a planting depth of 5-10 cm depth is optimal, the potato should be covered properly with soil after planting.

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6 Fertilizer and manure application

This unit can be done together with the second part of unit 3 (final land preparation) and unit 5 (planting of potato seed tubers).
This training unit can be completed with a session on the production and management of compost, manure and other organic fertilizers that will be available on a separate leaflet. Additional activities ane exercises are proposed in this leaflet.

A. Learning objectives

At the end of this session, participants will know

- Which nutrients are needed by Irish potatoes to insure a good yield?
- What kind of fertilizer is needed and how it can be applied?
- How soil fertility should be managed and how to prepare compost and manage manure (can be addressed in a separate session » see separate leaflet for Activities and exercises and content)

B. Duration

1-2 hours

C. Learning aids

- Hoe
- Organic manure
- Different kind of fertilizer

D. Activities and exercises

Introduction (1 hour)

The trainer introduces the topic to the participants and guides on discussions on the importance of fertilizer application, the correct timing of the application, the different types of organic fertilizer. Sample of fertilizers and the following questions

can be used to stimulate the discussion:

- Which type of fertilizer do you use (for Irish potatoes, for other crops)
- What are pros and cons of different fertilizers (organic, non-organic)
- Where do you procure fertilizers?
- How and when do you apply fertilizers in Potato growing?
- Do you produce organic fertilizer by yourself, how?

The trainer can then evaluate together with the participant the fertilizers based on their compliance with organic agriculture principles, fertilizing quality, costs and others. He can discuss different fertilizers and bring in new methods like compost making or green manure. Determine the acceptance of these new methods among farmers (FIBL).

Demonstration on fertilizer application (1 h)

The trainer demonstrates how to apply organic fertilizer like compost or manure while the trainees practically do it on the demonstration garden.

Exercice soil fertility management and compost and manure management

» see separate leaflet Soil fertility management

E. Content

6.1 Important nutrient requirements for potatoes

Irish potato like any other crop requires adequate soil nutrients for growth and development and for better yield.

The following three nutriments are important for potato growth:

1. The potato has a high nitrogen demand from emergence stage until the tuber initiation. Appropriate nitrogen supply within the first 35 days after emergence is optimal for leaf growth resulting in good tuber development. If the nitrogen supply is too high, new leaves and stems will develop constantly which results in large, dense foliage. This can delay tuber formation.
2. Potassium demand is generally high for potatoes and important for the development of starch. It also improves shelf life and reduces the number of damaged tubers. However, oversupply has negative consequences on dry matter and starch content of the tubers. Organic suppliers of potassium are wood ash, animal manure, slurry and compost. Wood ash could be incorporated in the furrow at the planting time as source of potash (but it must not be in contact with the sprouts to prevent scorching).
3. Phosphorus requirements are comparably low and are best met with compost or manure. If needed rock phosphates or organic chicken manure can be used (FIBL).

Soil testing would be a good method to determine the most limiting nutrients in the but soil testing equipment is usually costly. However, soil fertility can be evaluated easily without testing for specific soil nutrients (see Manual agroecology).

6.2 Fertilizer application

- Before using any inorganic fertilizers, available organic matter sources should be utilized. These may include animal excreta, vegetable wastes, straw, maize stover, and other organic materials. Organic fertilizer like compost and animal manure provides a good mixture of different ingredients.
- Organic matter should however be well composted and well decomposed before they can be applied to the soil.
- Organic matter improves soil structure, reduces soil erosion and regulates soil temperature as well as improves soil water retention. In addition, organic matter is valuable and acts like food for the soil organisms.
- Plough-under or incorporate available organic manures in the soil before planting to enhance the water-holding capacity and texture of the soil as well as to provide enough nutrients for a healthy crop. A high yielding potato crop under conventional farming removes 95 to 140 kg N (nitrogen)/ha, 35 kg P (phosphorus)/ha, 125 to 170 kg K (potassium)/ha and has relatively high needs for Mg (magnesium) and Mn (manganese). Organic farmers will need to identify organic sources for similar amounts of nutrients. Potatoes respond well to large amounts of compost or well-rotted animal manures.
- If organic fertilizers are not available: Apply NPK preferably 17:17:17 or DAP at the rate of 50kg per acre, Later top dress with urea at the same rate of 50kg/acre.

7 Weeding and Hilling

A. Learning objectives

At the end of the session, participants will:

- Understand the effect of weeds
- Identify the main weed that affect potato production
- Understand the importance of weed management
- Understand the importance of hilling
- Be able to apply different methods of weed management
- Understand the importance of the timing in weed management

B. Duration

1.30-2 hours

C. Learning aids

- Hand hoes
- Garden

D. Activities and exercises

Introduction (20 minutes)

The trainer will introduce the topic of the day. He can stimulate discussion by asking the following questions:

- Do you weed and hill up at home? How and why? If not, why?
- What is the effect of too much weeds on the potato plants?
- What is the effect of not hilling up the potatoe plants?
- Do you do earthing? How? Why is it important?

Demonstration (1-2 hours)

This training should be practically done in the group demonstration field.
In a first step, the facilitator can walk through the plot with the participants and ask them to identify the weeds that can be found there.
In a second step, the participants, together with the facilitator, will do the weeding, including earthing up is the timing is adequate.

The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.

Facilitator's summary (20 minutes)

The facilitator should really remind the trainees about the important of weeding and discuss some weeding calendar with the participants.

E. Content

7.1. Why is weeding important

- Weeds can reduce yields through direct competition for light, moisture and nutrients.
- Weeds may host pests and diseases that attack potatoes (Biovision).

7.2. What are the main weeds in potato fields?

- The major weeds in potato crops are annuals
- The following are the common weeds in potato garden in Zombo and Nebbi districts: Couch grass, lantana camara, Black jack, wondering jew, galinsoga paviflora.

7.3. How and when to weed?

- Weeding should be done early to avoid competition for light, nutrients and to avoid that weeds act as alternative host for pests and diseases.
- The first weeding is normally done 2 to 3 weeks after planting or the first weeding can be done when the plants are 10cm high and the second one when the plants are 25cm high. At this time, hilling / earthing up is also done.
- The use of synthetic herbicides should be avoided. Smallholder farmers usually use hoe for hilling and weeding. Whether it is done with a hand or a machine, it should be done without damaging the root at the sides of the ridge.
- The harvested weeds are best used by putting them into the ridges and cover them with soil. This can be used as additional manure (Jawoko 2014).
- Earthing up of Irish Potatoes is the bringing of more soil towards the plants, building up the size of the ridge. It is very important and its normally done during second weeding as the exposed stolon can become aerial stems and will not be able to produce tubers.
- Earthing up helps to increase the tuber number and size and it should be done approximately 6 weeks after planting. Hilling should be done carefully in order not to damage the delicate root hairs of the potato plants at the side of the ridges by mounding the soil around the shoots to leave only 1 to 2 cm exposed.
- Do not hill up or weed when the soil is wet to avoid soil compaction and clumps from forming. If possible, earthing up should be carried out when the soil is dry to avoid damage to the soil structure and when potato leaves are upright to reduce the risk of covering leaves with earth.

8 Pests and diseases management

A. Learning objectives

After completing this session, the participants will be able to:

- know the common pests and diseases affecting Irish potatoes and their effects.
- Recognize the signs and symptoms of different pests and disease attack.
- Apply the Integrated Pest and Disease management approaches in Irish potato production.
- Understand the critical stages of growth of different pests to target control in potato production
- Know how to check the garden to evaluate pests and diseases attacks.

B. Duration

Approximately 2.30 hours

C. Learning aids

- Demonstration garden
- Insect bottle
- Knapsack sprayer
- Jerrican
- Basin
- Soap
- Stationery
- Photo cards

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

- **In the participant fields:** Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their

successes and ask questions if they have any.

- **In the demonstration field:** Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction (20')

The trainer will introduce the topic of the day.
The following questions can be used to stimulate the discussion:

- What main pest and diseases affecting Iris potatoes do you encounter in your field
- What symptoms of pest attack and diseases have you seen on your potatoes?
- Which prevention measure do you know to avoid pest and disease attacks?
- Which organic treatment against pest and diseases do you know?

Practical exercise (2 hours)

How to observe the Irish potato field and the potato plant to detect pest attack and diseases?

The facilitator discusses with the participant how the field should be visited to monitor pest and diseases. Then, he discusses with them how single plants should be observed, which aspects should be looked at. An observation format could be developed by the group.

Practical observation of the field in subgroups

Each subgroup of 4-5 participants will observe one or two plants taking into consideration the criteria identified in the previous exercise. Parts of sick plants and insects can be collected. Insects can be collected and placed in bottle. The groups summarize their observations on a flip chart and try to formulate recommendations.

Presentation by the subgroups in plenum and discussion

The findings of each subgroup are presented and discussed. At the end of the discussion, the mains pests and diseases found in the field should have been identified and possibilities for prevention or treatments discussed.

Summary

The facilitator summarizes the main findings of the group works and discussions. He presents other important pest and diseases that may affect Irish potatoes.

In the next weeks, the groups may be doing scouting on their own and will be using the insect bottle to keep the insects and present to the Agricultural officers on the days they visit the groups. The knowledge got from the demonstration plot will be used by the trainees in their fields at household level.
A diary on pests and diseases and control mechanisms can be written to share the experience with peers.

E. Content

8.1. General pest and disease management practices

Proper determination of the disease is the first step for effective pest and disease management. Pests and diseases monitoring is very important, a regular field visit is required to monitor the crop. Preventing spreading and multiplication of pests and diseases is key in organic potato farming. It minimizes the need and costs for direct control measures. Organic potato farming should orient itself on a three (or for) step approach (see Figure 8, FIBL). The goal is to encourgase the first and second step on natural self-control of pests and diseases. With that the direct control measures (step 3) should be minimized. An integrated approach consideres:

- **First:** Choose resistant/tolerant varieties
- **Second:** Apply agronomic control strategies such as crop rotation (see chapter 1)
- **Third:** Use alternative organic treatments
- **Fourth:** Optimization treatments with forecasting systems (if available). (FIBL 49)

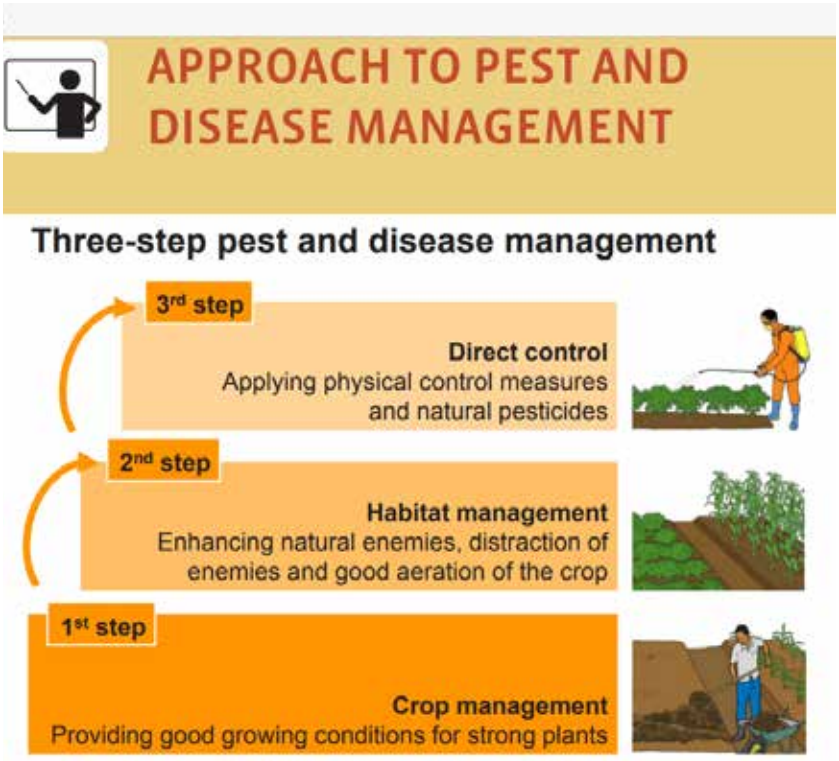


Figure 8: Three Step pest and disease management (FIBL Organciafrica Manual 2019, 49)

8.2. Bacterial wilt (*Ralstonia solanacearum*)

Bacterial wilt is caused by the bacterium ***Ralstonia solanacearum***. The disease can also affect other crops of the nightshade family such as chili, tomato or tobacco (FIBL)


Figure 9: Bacterial wilt symptoms on potato plants (Biovision 2018); Figure 10: Bacterial wilt: Rotting of vascular ring (Biovision 2018)

Symptoms and identification

Plants wilt without yellowing. As the disease develops a brown colored ring is visible when stems are cut. It can also be detected by cutting the tuber into two pieces. Black or brown rings of the vascular system are seen. Serious infections cause the tubers to rot which smells very badly (FIBL).

Management

Bacterial wilt cannot be controlled with chemicals. Management of bacterial wilt relies on removing sources of disease from the field by:

- Crop rotation. Rotate the Irish potatoes with non-solanaceous crops like legumes or cereals and root crops such as sweet potato. Don't cultivate potatoes or other nightshades on the fields where bacterial wilt appeared for several years (FIBL). Have at least four seasons before planting potato (or tomato,African egg plant, pepper or brinjal) in the same site.
- Remove volunteer plants that sprout from tubers left unharvested. Volunteer plants will be infected by BW allowing the disease to survive in the soil until the next potato crop is planted.
- In fields with serious infections, wait at least four years (8 seasons) before planting potato (or tomato, African egg plant, pepper, brinjal) in the infected site (International Potato Center, 2018).
- Use healthy seeds and resistant or tolerant varieties like Victoria, Kiser, Kruza.
- Proper disposal of infected plants (careful removal and burning of infected plants)
- Regularly application of compost to the soil
- Bio-fumigation: Incorporating especially mustard or radish plants in large amounts into the soil immediately before planting potatoes. This helps reducing and in the long term eliminating bacterial wilt from the soil (Biovision).
- Clean farming tools after use, disinfect with Jik or passing them over fire.

8.3. Bacterial soft rot, blackleg (Erwinia carotovora pv. Carotovora, E.c. pv. Astroseptica)

Figure 11: Irish plant affected by black leg and potato tuber affected by black leg

Symptoms

In the field potatoes are often attacked at the base of the stems, showing black colored lesions. Infected plants normally rot from the field and under storage and develop fishlike smell. Black leg is spread through infected tubers, air, water, soil, farming tools.

Management

- Apply the same management practices as for bacterial wilt.
- Avoid excess watering
- Store and transport tubers in dry, well ventilated conditions (Biovision).

8.4. Late blight (Phytophthora infestans)

Late blight is caused by a fungus Phytophthora infestans. It can cause high yield losses and acts very quickly especially in environments with high humidity and low temperatures (FIBL).

Symptoms

Infected leaves or stems show brown spots as if they were burned. The disease appears in high relative humidity, shown by the presence of water drops on leaves and cool temperature. White fungal growth (looking like flour) is developing. Late blight can be transmitted through wind, infected Irish potato tubers and plant

residue. Severe infections cause all leaves to rot, dry and fall off.

Management

- Practice rotation with non-solanaceous crops (no tomatoes, eggplants etc.)
- Check the planting material for resistant or highly tolerant varieties with fast tuber growth.
- It makes sense to cultivate different varieties in separate rows.
- Pre-germination of seeds will uncover infected tubers and they can be removed and disposed.
- Choose well-ventilated locations and avoid narrow spacing as it will increase humidity and support late blight infections. Checking for symptoms should be carried out every second morning in order to be able to remove individual infected plants early (FIBL).
- If organic prevention measures are note enough: During rainy season, farmers should spray a preventive contact fungicide containing mancozeb or copper shortly after emergence and continue to spray weekly

8.5. Early Blight (Alternaria solani)

Symptoms

Brown and ringed spots appear on the leaves. The leaf spots are circular and up to 12 mm in diameter. On the potato tuber early blight results in surface lesion. The tissue shows a brown to black dry rot usually not more than 6mm. Early blight thrives best under warm, wet conditions (Blovision).

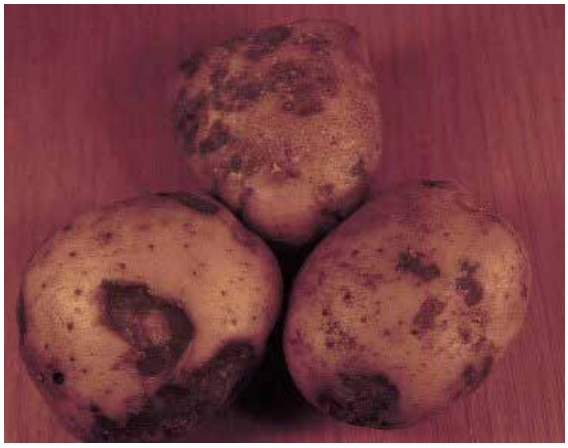


Figure 13: Browned ringed spots on leaves, a sign of early blight; Figure 14: Surface lesions (Biovision)

Management

- Use certified disease-free seeds
- Practice rotation with non-solanaceous crops.
- Practice good field hygiene. Remove infected leaves during the growing season and discard all badly infected potato plant debris at the end of each season.

- Avoid overhead irrigation, thick organic mulch can prevent soil splashing onto lower leaves (Biovision).

8.6. Potato tuber moth (Phthorimaea operculella)

Symptoms

Butterflies occur wherever potatoes are grown and besides potatoes the insect attacks also tomato and other nightshades (FIBL). Potato tuber moths (PTM) infect the crop in the field. They form mines in leaves and stems. Moth larvae penetrate tubers through the eyes and create tunnels in the tubers just below the skins. Excreta is pushed out of the initial hole made by the larva. Stems are damaged, the upper part of the stem wilts or the whole plant collapses. The tubers become drier than healthy ones. Tubers are becoming unsuitable for human or livestock consumption (potato PRO).

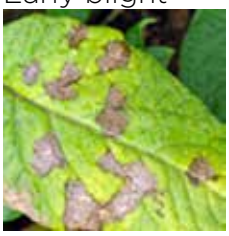
Figure 15: Potato tuber moth and potato tubers damaged by the moth (Biovision)

Management

Potato tuber moth can be controlled by:

- Using healthy, clean seed
- Good hilling up to protect the tubers or plant them as deep as possible (10 cm deep).
- Hilling/earthing up at least 3 times during growing season and ensure compact hilling to prevent moths from reaching the tubers (FIBL).
- Inspecting the tubers carefully before and during storage, removing each tuber showing openings in storage. Spreading leaves of natural repellent plants such as Lantana camara, Mexican marigold can help, or you can apply Actellic dust on tubers

8.7. Summary of diseases and pests with their control measures

Diseases/pests	Symptoms/ Identification	Effects	Control
Bacterial wilt 	The plant wilts without yellowing and dries up	It causes wilting of the plant and the plant may dry up completely	It is managed through integrated approach which includes: Practice of crop rotation, use of certified seeds, use resistant varieties, remove infected plants immediately.
Late blight 	Irregular, brown, dead patches on leaves	The stems, leaves, petioles and tubers are affected and this can cause 100% yield loss if not controlled	An integrated approach that combines the use of resistant varieties, destroying alternate host plants, practicing crop rotation.
Early blight 	Brown and ring spots on leaves	It causes premature defoliation ,hence reduced yield	Plant moderately resistant variety. plough under all plant debris and volunteer potatoes after harvest?, Plant disease free, certified seeds, destroy crop residue
Root-knot nematodes 	Galls on the tubers and roots	They feed on root juices of plants causing swellings. These swellings prevent movement of water and nutrients to the plants resulting to chlorotic and stunted plant growth.	Practices crop rotation, soil sterilization. Avoid planting potatoes for up to 7 years in infested fields (Biovision).

Aphids 	Green or black tiny insects that feed on the underside of the leaves, aphids transmit virus that causes leaf curl disease	Aphids transmit virus that causes leaf curl disease	Conserve natural enemies, check the fields regularly, younger plants are more susceptible, Remove all yellow flowering weeds and host plants around the fields (aphids are attracted to yellow colour). Neem products are useful (Biovision).
Potato tuber moth 	Carter pilers that barrow into the tunnel making black tunnel full of excreta	It leaves tunnel within the tuber. Tuber quality may not be sufficient for human or livestock consumption.	Use healthy seed potato tubers Plant as deep as possible and ridge at least twice to cover the tubers. Repellent plants such as Eucalyptus globulus and Lantana camara help to protect stored tubers.
Cutworms 	Cutworms are serious pests of Irish potatoes and normally attack the plants after immergence by cutting the seedlings and boring holes into the tubers.	The tubers are damaged.	Protect plants by wrapping them with collars. If necessary, spray neem extracts (Biovision). Direct control: • Apply neem products (powder and leaves) 3 times at weekly intervals. Leave overnight a mixture of powder and leaves of 1 kg per 40L of water and sieve before spraying. • Handpicking larvae during the evening that come out to feed on plants helps to control at the beginning of the outbreak (CABI Plantwise)

Sources pictures: https://nwdistrict.ifas.ufl.edu/hort/2019/08/22/beware-of-root-knot-nematodes-in-your-garden/, https://www.fwi.co.uk/arable/crop-management/pests/emergency-authorisation-for-sugar-beet-aphicide, https://studylib.net/doc/5329220/potato-tuber-moth; https://www.planetnatural.com/pest-problem-solver/plant-disease/early-blight/, https://onvegetables.com/2018/08/17/late-blight-confirmed-on-potato-in-simcoe-county/; https://www.dpi.nsw.gov.au/about-us/services/collections/scientific-illustrations/senior/potatoes/bacterial-wilt-potatov

9 Harvesting of Irish potatoes

A. Learning objectives

After this session, the participants will be able to:

- Recognize the signs of maturity of Irish potatoes
- Understand the correct stage of harvesting Irish potatoes
- Understand the different methods and practices of harvesting Irish potatoes

B. Duration

Approximately 2-3 h

C. Learning aids

- Training manual
- Hoes
- Containers

D. Activities and exercises

Look back at what has happened since the last meeting. (10-20 minutes)

- **In the participant fields:** Take a few minutes to ask participants what they have been able to apply at home since the last session and with what results. Allow participants to share their experiences with each other, highlight their successes and ask questions if they have any.
- **In the demonstration field:** Also take a few minutes to observe with the participants what has happened in the demonstration field since the last session. What has changed, how have the plants grown?

Introduction (20 minutes)

The trainer will introduce the topic and ask the following questions to stimulate the discussion:

- What are signs of maturity and ripening in the Irish potato crop?
- What is the correct stage of harvesting? When do you harvest your potatoes?
- What are the common mistakes made by farmers during harvesting of potatoes?

This can be directly in the field, so that participants can look at sign of maturities directly on the crop.

Demonstration (2 hours)

The participants, together with the facilitator, will harvest the Irish potatoes. This training should be done at the demonstration sites so that the farmers learn good harvesting practices and replicate in their fields at household levels.

E. Content

9.1. Harvesting

- Irish potatoes are generally mature when the plant starts to turn yellow. This is about 75 to 140 days after planting (see figure 16).
- Immature potatoes will often skin and bruise easily. When testing maturity in potatoes, if the skin is not set and is easily removed, delay the harvest.
- Dehaulm or cut the stem at 10-15 cm from the base of the plant at least two weeks before harvest to allow hardening of the tubers. Dehaulming (removing the foliage) is particularly important if the potatoes are stored and not sold immediately (Jawoko 2014).
- Harvesting is always done when tuber skin is sufficiently hardened. Take a tuber in his hand and rub it between the thumb and index. If the skin does not slip, then the seed tubers can be harvested.

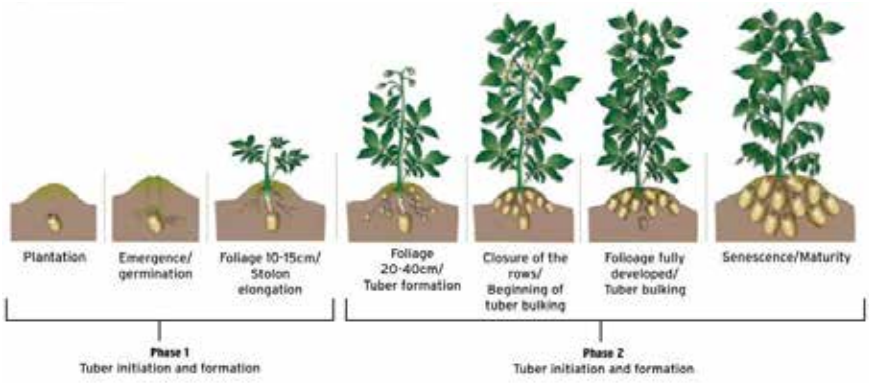


Figure 16: Development of the potato plant (Source: https://www.farmersjournal.ie/potato-nutrition-pushing-for-yield-potential-357517)

- Harvesting should be done in dry weather and under slight moist soil conditions. Harvest is done using hoes which are forked to reduce the rate of tubers damaged by an ordinary hoe.
- It is important to be careful not to cut off tubers during harvest.
- Consider grading the potatoes in the field to remove tubers that have been cut, diseased and make sure the tubers are ordered according to their sizes
- After harvesting, the field should be cleaned from remaining plant parts and tubers. Post-harvest field sanitation is an important part of controlling pests and diseases, as it removes potential sources of contamination for the next crop.

10 Post-harvest handling

A. Learning objectives

At the end of the training, the trainees will:

- Know the different stages of post-harvest handling of Irish potatoes.
- Be able to identify common mistakes during post-harvest handling that affect quality and quantity
- know basic technologies in post-harvest handling

B. Duration

Approximately 1.30 hours

C. Learning aids

- Hoe
- Panga
- Poles
- Grass

D. Activities and exercises

Introduction (20 minutes)

The trainer will introduce the topic of the day. The following questions can be used to stimulate the discussion:

- How do you handle Irish potatoes after harvesting ?
- to which aspects should you pay attention?
- how do you control storage pests and maintaining quality during storage?

Demonstration (2 hours)

This training should be at the time the farmers are harvesting so that the knowledge the farmers will get they will use at their household level. Participants, together with the facilitators, will apply post-harvest operations. Particular: the trainer explains to the participants the importance of Diffused Light Storage (DLS); the trainer also

practically demonstrates how to construct a DLS..

Summary (30 minutes)

The facilitator will summarize important aspects of post-harvest handling of Irish potatoes

E. Content

important in maintaining the quality and ensuring safety of tomatoes at all handling stages. In many cases farmers pay keen attention on good agronomic practices of tomato production but pay less attention to post-harvest handling and end up with a lot of post-harvest losses in terms of quality and quantity.

10.1. Handling after harvest

- The harvested potatoes should be packed in boxes, baskets or basins for transportation. The damaged tubers should be removed as soon as possible. The tubers should be dried in a shade to avoid tuber greening.
- After drying the potatoes can be stored in Diffuse Light Storage (DLS) with good ventilation as tubers need air circulation. Otherwise, the temperature inside the store may increase, thus favoring early and undesired sprouting. Inside the DLS, tubers are laid on beds in thin layers (2-3 tubers) for easy inspection of all tubers and to avoid too much darkness inside the pile.
- Diffuse Light Storage (DLS) is a simple storage built from locally available materials that can be used to store large amounts of seed potatoes (Figure 17. For a seed potato storage facility, the following points need to be considered:
  1. Roof must be grass thatched, not made of iron roof as this heats the storage area.
  2. Roof must be wide enough to cover the full storage.
  3. Shelf height must be at least 30 cm above the ground to prevent any water splashing onto the tubers.
  4. If possible, it should be built under the shade.
  5. Protect the tubers from theft
- Periodically (twice a week) check the tubers and remove damaged, rotten / spoilt ones.

Figure 17: Diffuse Light Storage (DLS) is used to store potatoes

Storage of Ware Irish Potato

Storing quality potatoes begins in the field during the growing season

- Only store good quality potatoes. If any potatoes are rotting, damaged or coming from diseased fields, these potatoes must be eaten or sold at harvest
- During the growing season, mark areas infected with bacterial wilt to avoid storing potatoes harvested from these infected areas
- Do not store potatoes from plants infected with bacterial wilt, these potatoes should be sold right after harvest
- Do not store potatoes that have been damaged during harvest or are starting to rot, these potatoes should be sold right after harvest

Harvest practices for better storability

- Only store potatoes harvested from mature plants
- De-haulm plants 10 – 15 days before harvesting
- De-haulming is killing the plant above the soil – usually by cutting the stem at the soil line
- De-haulming is essential if potatoes are to be stored as this allows the skin to thicken to protect from handling and transport injury, as well as postharvest diseases
- De-haulm during dry conditions
- Harvest potatoes gently, most injury to potatoes occurs during harvest

Storage Facility for Ware Potato inside the Store

Crates

- Store in crates if there is a possibility of rotten or damaged potatoes. If some potatoes are rotten the crates will limit the spread of rot to more potatoes in the store
- Crates also make it easier to trace when different harvest lots are put in the store
- Suitable for long term storage, 2 – 3 months

Bulk

- Potatoes can be bulk stored if all potatoes are of good quality and there is low risk of a few rotten potatoes creating a rotten nest in the middle of the piles
- A bulk pile up to 2 m in height
- Bulk piles can be right up to the walls, no need to leave a space between the pile and a wall
- Bulk piles are suitable when it is not necessary to trace certain potatoes to a harvest lot or owner
- Suitable for long term storage, 2 – 3 months

Bags

- Do not store potatoes in nylon or plastic bags as they restrict air flow thus if a rotten potato is in the bag, the remaining potatoes can rot quickly
- Potatoes should only be stored in jute bags for short term storage, maximum to 3 weeks
- Store bags upright, not on their side
- Only store good quality potatoes in jute bags
- Stack the jute bags on a raised platform

11 Record keeping

Activity 1: Introduction to record keeping

A. Learning objectives

After this session participants will:

- Be aware of the importance of record keeping and be able to record costs and income of the target crop.
- Know how to calculate the gross margin in order to assess the profitability of a crop and find out ways of potential improvements.

B. Duration

2-3 hours

C. Learning aids

- Flip charts,
- markers,
- calculator.

D. Activities and exercises

Introduction

The trainer will introduce the topic of the day. He will stimulate the discussion by asking the following questions:

- Do you know how much profit you generate with the target crop the last season?
- Do you know which expenditures are most important in the production?
- Do you know if your costs were higher or lower than your income?

Practical exercise

1. The facilitator asks the group to list all the expenses and costs (means of production and labour) they had for the target crop during the last crop year (or other crop). Producers are invited to mention them from memory.

Do not forget the value of family labour and the costs of paid labour. The facilitator records the costs mentioned by the producers in the table below (on a flip chart).

2. Once the production costs are listed, the facilitator asks the group about the income: What have you done with the harvest product? Did you sell the entire production or only part of it? How much did you earn from the sales? Do you still have a remaining stock, how many bags/kg? The facilitator writes the cash income or the value of the production (in case of no cash value) in the table under part B. Income. (**See Page 52**)
3. The facilitator explains how to compute the gross margin, which is total income minus the total costs. Then he asks the group whether the production of this crop is profitable or not (see if the gross margin is positive or negative).
4. The facilitator asks who wants to try to keep a record for the target crop during this season. The facilitator distributes the above table to the participants. The latter should write down their expenses (materials and labor). At each session, the host farmer could present his data (or in turn). It could serve as starting point for a group discussion on the similarities and differences in the record keeping among the participants. And report on the difficulties faced in filling the table.

Table for the calculation of the costs and income for a crop

Name of farmer:	**Village/district:**		
Date of calculation:			
Time period (season from/to):			
Crop:			
Total field area (ha):			
Total yield (kg):			
	Quantity	**Unit cost (Ushs)**	**Total (Ushs)**
A. Production costs (input)			
Materials			
Seed	3 bags	600	1800
Organic fertilizers:			
- Manure			
- Compost			
Mineral fertilizers:			
- NPK			
Pesticides:			
Packaging bags			
Labor (Person-days)			
Soil preparation	2 man days	2000	4000
Manure application			
Planting			
Weeding/ Hilling up 1			
Weeding/ Hilling up 2			
Dehaulming			
Harvesting			
Threshing			
Transport			
Total production costs (a)			
B. Income (output)			
Sales			
Home consumption*			
Remaining (storage)*			
Others*			
Total income (b)			
Gross margin (b - a)			
Profit per acre (Gross margin divided by field area)			

Convert in monetary: kg multiplied by market price.

Activity 2: Gross margin analysis

A. Learning objectives

By the end of the training the participants are able to:

- analyze the record keeping and the gross margin, and identify how to improve the profitability of the target crop

B. Duration

2-3 hours

C. Learning aids

- Flip charts,
- markers,
- calculator

D. Activities and exercises

- The host farmer and each participant who recorded his costs and income present them to the group. Before the session, the facilitator can help the producers to copy the table on a flipchart to make it easier to read during the session.
- The facilitator initiates the discussion on the analysis of the results by asking the following questions. What are the reasons for the different figures/results between the producers? What does a positive or negative gross margin mean? What are the factors that influence expenditures and income? If the gross margin is low or negative, which expenditures could be reduced and how? Which price should you sell your products to make a profit?