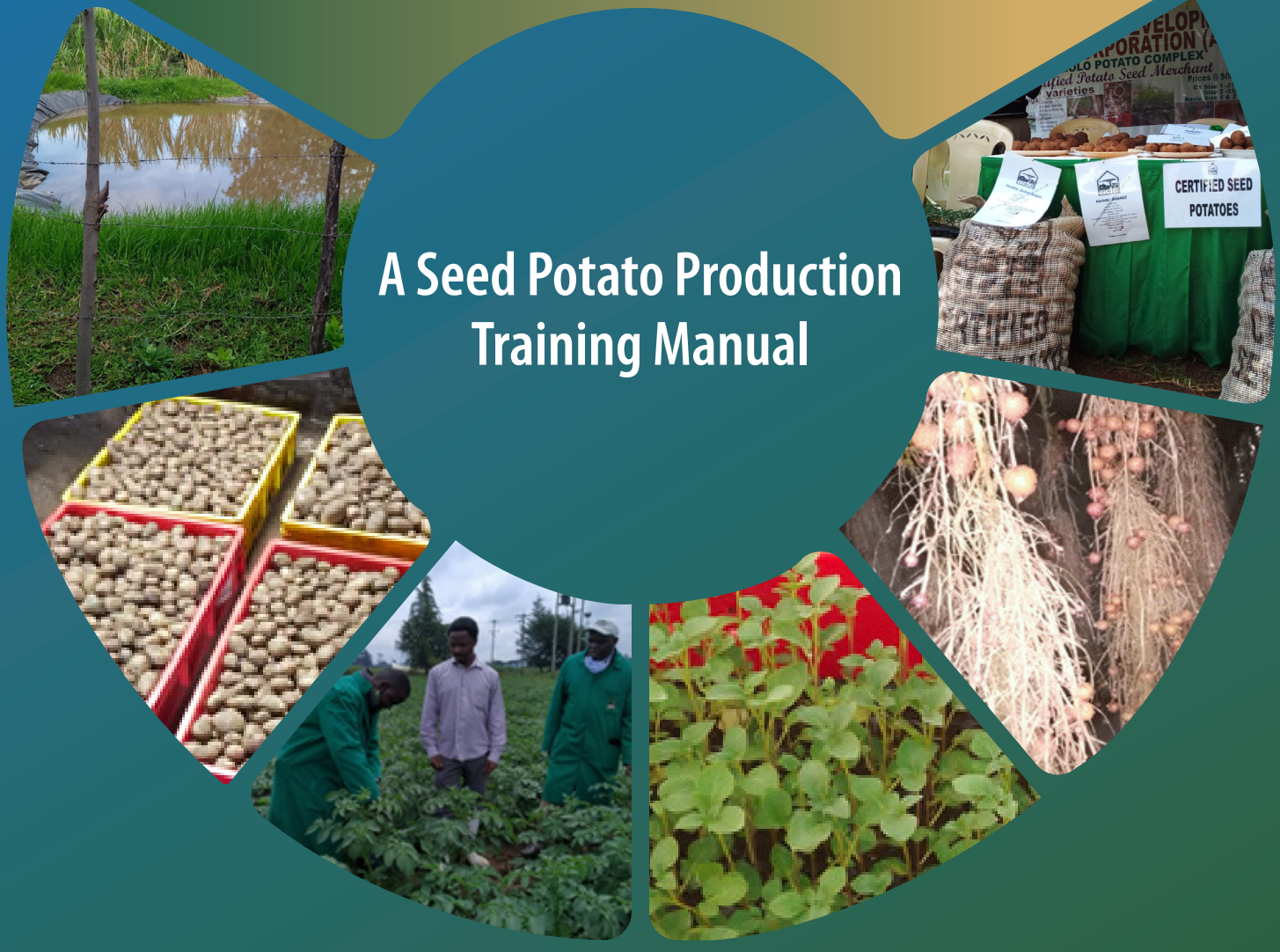
LINKING THEORY TO PRACTICE AND POLICY



A Seed Potato Production Training Manual

EGERTON UNIVERSITY

mastercard foundation

RUFORUM
Capacity Building in Agriculture

Linking Theory to Practice and Policy

A Seed Potato Production Training Manual

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ABREVIATIONS AND ACRONYMS

ABCD	Asset Based Community Development approach
CSA	Climate Smart Agriculture
SP-CARP+	The Seed Potato Community Action Research project Plus
CAWSA	Climate and Water Smart Agriculture
KCSAP	Kenya Climate Smart Agriculture project
TAGDev	Transforming African Agricultural Universities to Meaningfully Contribute to Africa's Growth and Development
TVET	Technical and Vocational Education and Training
TIMPs	Technical, Innovation and Management Practices
ADC	Agricultural Development Corporation
RUFORUM	Regional Universities Capacity Building Forum
IAP	Irrigation Acceleration Platform
IAPP	International Association of Public Participation
CIAT	
IITA	
IFAD	
KALRO	
PCN	potato cyst nematode

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ACKNOWLEDGEMENTS

This manual is the result of an intensive, participatory 4-day mini-writeshop process that involved generating, revising and editing of information materials, and which brought together resource persons, process facilitators, knowledge experts, researchers, farmers, traders, extension staff and editors.

We thank the key contributors to this curriculum for their time and effort in writing and revising the modules and session notes: We thank the entire staff of Transforming African Agricultural Universities to Meaningfully Contribute to Africa's Growth and Development' (**TAGDev**), led by Prof. Nancy Mungai. The Community Action Research Program (CARP+) project partners led by Anthony Kibe, for driving the process and bringing together the team in the mini-writeshop. Specifically, we appreciate the contribution of staff representing the County Government of Nakuru - Ministry of Agriculture Livestock and Fisheries, Agriculture Development Corporation (ADC) Molo, Kenya Plant Health Inspection Services (KEPHIS), Baraka Agriculture College, Egerton University staff and students. The names of the participants are provided in the annex. We also sincerely thank the Hope Consult team, led by Rahab Ngumba, for facilitating the process that led to the realization of this manual, and the editor, Tervil Okoko, for making sense out of the various ideas that resulted in drafts by the authors, and putting together this manual.

Additionally, all these would not have been possible without the financial assistance and our partnership with MasterCard Foundation and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM).

It is our strong belief that this manual will go a long way in contributing to the training of entrepreneurial farmers and students as well as promote the growth of seed potato enterprises in Kenya and in Africa at large. The weakest link in the potato value chain productivity is access to quality seed potato, which the CARP+ project partners have been addressing.

Prof. Anthony M. Kibe
Principle Investigator
Community Action Research Program plus (CARP+) Project
Egerton University

FOREWORD

The seed potato value chain (SP-VC) is important due to its contribution to the global economy in various ways; potato is consumed widely and acts as a source of raw materials for many agro-industries. In Kenya, the sector employs 3.5 million actors across the value chain. It contributes over 50 billion Kenya shillings (about US$ 5 million) per annum to the economy (KEPHIS, 2016).

The weakest link in the potato value chain is access to high quality seed potato, which greatly compromises its productivity at the production level. The Seed Potato Community Action Research project Plus (SP-CARP+) partners and other actors have been addressing the Seed Potato Value Chain (SP-VC) challenges by providing a model that other potato growing countries in Africa can adopt for increased seed production. In the next five years, the CARP+ project plans to continue strengthening the seed potato value chain by improving potato productivity and marketing for increased processing.

This training manual is the result of a four-year Community Action Research Project (CARP+) on seed potato and Climate and Water Smart Agriculture (CAWSA) Centre between August 2017 and July 2021. However, due to the Covid-19 pandemic, the project was extended to July 2022. These projects used the private sector-led multi-stakeholder approach. The projects, in collaboration with the TAGDev (Transforming African Agricultural Universities to Meaningfully Contribute to Africa's Growth and Development) Program, created synergy resulting in this publication, with content that is applicable across potato growing African countries.

Key outputs from the two projects include increased farmers' access to high quality seed in Nakuru and neighboring counties of Narok and Usin Gishu, commercialization of seed multiplication at Baraka Agricultural College (BAC) and Egerton University (EU), increased access to knowledge and research outputs (two PhDs', 16 Masters graduates thesis, 15 teaching case studies and 23 journal articles) and improved direct training of 600 students. In addition, the SP-CARP+ contributed technical and financial support for the development of the draft Nakuru County Potato Strategy (2021), formation of the Nakuru Potato Co-operative Union (NPCU), Nakuru potato platform (NPP), Nakuru stakeholders' platform (NSHP) and directly benefiting over 5,800 farmers.

The target users of this guide are extension workers, seed potato master trainers and faculty in Technical and Vocational Education and Training (TVET) institutions and Universities in Africa. The manual builds on the Seed Potato Production Guide produced in 2016. It is a step-by-step training manual with laid-out plans on how to effectively teach each session. It also has notes and references for each session. The manual was developed through a two-phased Writeshop approach. The first Writeshop, in February 2021, collated the various training materials used during implementation, while the second one, in 2022, pre-tested the session plans and notes. This draft was subjected to technical review, editing, layout and design.

The manual has four modules:

1. Climate Smart Agriculture, Gender Inclusion and the Community Engagement Process
2. Seed Potato Multiplication and Bulking
3. Post-harvest Handling, Storage, Records keeping, Marketing and Policy Advocacy
4. Rapid Seed Multiplication Techniques for potato

Use of rapid multiplication techniques shortens the times it takes to conventionally generate certified seeds from 4.5 years to 2.5 years

It is our strong belief that this manual will go a long way in contributing to the training of entrepreneurial farmers and students as well as promote the growth of seed potato enterprises in Kenya and Africa at large.

The manual is available at: ***tagdev.egerton.ac.ke, www.egerton.ac.ke (https://seedpotato.egerton.ac.ke)*** and ***www.ruforum.org***

Prof. Nancy Mungai (PhD)
Director (Research and Extension)/TAGDev Coordinator
Egerton University

OVERVIEW

One of the main challenges in reducing poverty in Africa lies in positioning agriculture as a massifier of change and opportunities for youth and as a mechanism for financial independence for millions of poor smallholder farmers to move them out of poverty.

In realization of this challenge, Transforming African Agricultural Universities to Meaningfully Contribute to Africa's Growth and Development' (TAGDev), a partnership program between MasterCard Foundation and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM), has been implementing an eight-year program (2016-2024) that seeks to transform African agricultural universities and their graduates to better respond to developmental challenges through enhanced application of science, technology, business and innovation for rural agricultural transformation. The program, implemented at Egerton University, Kenya and Gulu University, Uganda, is focused on transformation at individual, community, institutional, national and regional levels, and aims at piloting a new model of agricultural education at early adopter universities that connects tertiary agricultural education to rural communities, with an emphasis on smallholder farmers.

The TAGDev program has a component of community engagement and experiential learning through Community Action Research Program (CARP+) projects that seek to strengthen university-community linkages. This is through training of students jointly with private sector organizations, research institutions and farmers among other actors to nurture practical oriented graduates who appreciate role of entrepreneurship in community transformation. To achieve this goal, the projects' teams, consisting of faculty, students, farmers, TVETs and other partners, developed this training manual to be used for students' and farmer training and advisory.

Manual development

This manual is a compendium of training materials developed from experiences and lessons of the CARP+ technical team, at Egerton University. The multi –stakeholder Seed Potato Community Action Research Project plus (SP-CARP+), led by Prof. Anthony Kibe of Egerton University, from 2017 to 2022, partnered with Agricultural Development Corporation (ADC) – Molo Seed Complex, National Potato Council of Kenya (NPCK), Ministry of Agriculture – Nakuru County Government, Kenya Plant Health Inspection Services (KEPHIS), and Baraka Agriculture College. The partnership selected smallholder and large scale seed producers, and private sector actors e.g., Equity bank, Eclof Kenya, Syngenta, Lachlan, Corteva and others, to collectively address the problems in the seed potato value chain in Nakuru and neighboring Counties. This work was supported by additional funding from the SNV Irrigation Acceleration Platform (IAP) project (2017-2020), which established the Community- student- Industrial (nexus) demonstration-site called Climate and Water Smart Agriculture Center (CAWSA-C) in Egerton University, between March and December 2019. Through the CAWSA-C, agro-based industries, students, academia and farming communities have jointly learnt (i.e., experiential learning) from each other on best agricultural practices for potato cropping systems; from which this book has been developed. Further funding from the World Bank's Kenya Climate Smart Agriculture project (KCSAP – 2021 -2023) helped in training on the best Technical, Innovation and Management Practices (TIMPs) in Nyandarua, Elgeyo Marakwet and Nyeri. Technical officials from Narok and Uasin Gishu counties were also trained on Seed potato production and entrepreneurship.

This manual uses a competency-based approach. This implies that content as well as facilitation methods are used to contribute to the participants learning processes. "Learning by doing" and "Learning from each other" are the principles underlying the training and learning processes. Facilitation is highly interactive with the facilitators aiming to link the contents to the participants' personal experiences and expertise. All examples and cases for plenary exercises are from real life situations.

The manual is made up of four modules, complete with session notes that were drafted, reviewed and re-written before and during the 4-day mini-writeshop held on 16th to 19th February 2021. Overall, the modules in the training manual consist of a mixture of: Brief interactive lectures to introduce various concepts, principles and approaches (questions and discussions encouraged during the presentation); Plenary exercises; Brainstorms; Role plays; Group work, field practicums and field visits; demonstrations; and presentations and plenary discussions. It is expected that participants will not only increase their knowledge in potato seed production, harvesting, storage and marketing, they will also enhance their knowledge in climate smart agriculture. The uniqueness of the modules lies in the fact that it is fully based on real life examples of seed potato value chains stakeholders including farmers, seed potato stockists, agro-dealers and researchers among others.

Target Audience and Users

The manual is primarily designed for training seed potato farmers in Africa. Hence, it will be used by academia involved in outreach programs, local extension trainers/officers and lead/trainer farmers in potato growing communities. Since its developments is based on lessons from the seed potato CARP+ in Nakuru County, Kenya, the examples, case studies used are from the Kenyan experience. Whereas these problems and experiences cut across the African continent, users outside Nakuru County and Kenya may need to contextualize the learning to their specific context.

Course Content

This training manual equips extension trainers, lead/trainer farmers with knowledge and skills to train farmers and students to produce, store and market seed potatoes. It trains them on applying gender mainstreaming and community engagement principles. It also trainings them on how to identify problems in their farms and communities and find solutions through innovation, continuous learning, lobby and advocacy approaches. The four modules included here are:

Module 1: Climate Smart Agriculture (CSA) for Food Security, Gender Inclusion and Community Engagement Process

Module 2: Seed Potato Bulking and Multiplication

Module 3: Post-harvest Handling, Storage, Recordkeeping, Marketing and Policy Advocacy

Module 4: Rapid Multiplication System for seed potato generation

Methodology and delivery approaches

The training manual uses the experiential and competency-based approach that is anchored on the principle of "Learning by Doing". The manual uses the participatory approach to learning by encouraging group work and peer-to-peer learning and sharing. The approach is also based on the principle of starting from the "known" to the "unknown". Each module aims to stimulate each learner to action. Hence, at the end of the sessions and modules there is an application task/s and recommended further reading. The methodology used is a mixture of:

- Brief interactive lectures to introduce various concepts, principles and approaches
- Group discussions and buzz groups followed by plenary sessions where learners freely share and discuss their findings with the trainer/facilitator adding value based on their personal experience and expertise
- Question and answer techniques

- Case studies and role plays
- Field work in the local community
- Take home application assignments
- Reading assignments

Expected Learning Outcomes

The expected outcomes of each module and session are provided at the beginning of the module and sessions respectively. These will guide the trainer to train as well as evaluate whether learning has taken place. It is expected that at the end of the four modules, learners will be able to:

1. Practice climate smart agriculture for increased food and income security; mitigate against or adapt to climate change phenomena; as well as increase household resilience to climate change and variability
2. Mainstream gender and inclusive development using evidence based data
3. Use participatory community engagement best practice, principles and processes
4. Produce quality seed potato using best agronomic practices
5. Minimize loss during harvesting, post-harvest handling, storage and marketing
6. Regularly keep and examine records to ensure they are making profits and identify how to reduce production cost and increase yield and income
7. Do comparative analyses of seed potato enterprise before investing
8. Invest in rapid seed multiplication techniques (systems)
9. Lobby and advocate for significant change from state and private sector actors to develop market systems and improve policy and legal environment

Distribution and Use of the Manual

This manual is available in soft copy on the TAGDev web page at Egerton University at *www.tagdev.egerton.ac.ke*, *https://seedpotato.egerton.ac.ke/*and *www.ruforum.org*. It is the expectations of the authors that the trained farmers and students will be able to both grow and market seed potatoes or facilitate development of effective and efficient seed and ware potato value chains in Africa.

The authors welcome feedback from the trainers and will use the feedback to improve on the manual. Please send your feedback to Prof. Anthony Kibe: *kibeanto@gmail.com* cc *akibe@egerton.ac.ke*

Authors

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1 Egerton University; 2 Ministry of Agriculture, Livestock and Fisheries; 3 Inuka Agrisolution

MODULE 1

CLIMATE SMART AGRICULTURE FOR FOOD SECURITY, GENDER INCLUSION AND COMMUNITY ENGAGEMENT PROCESS

Overall objectives

At the end of this module, participants will be able to:

1. Explain climate smart agriculture (CSA) concepts and principles
2. Explain CSA technologies and practices used in seed potato production.
3. Apply gender sensitive approaches in CSA
4. Engage community stakeholders in seed potato value chain development

SESSION		DURATION (Hours)	
		Theory	Practical
1.1	Introduction to Climate Smart Agriculture (CSA)	2.00	
1.2	Climate Smart Agricultural structures for soil & Water conservation	2.00	3.00
1.3	Climate Smart Soil and Moisture Conservation Practices	3.00	
1.4	**On-farm (*In-situ*) soil moisture conservation practices for mitigating and or adapting to climate change**	2.00	
1.5	Irrigation as a CSA practice	2.00	
1.6	Integrated Soil Fertility Management (ISFM)	2.00	2.00
1.7	Gender Mainstreaming in Climate Smart seed potato production	4.00	
1.8	Community Engagement in Adopting CSA in seed potato production	2.00	
	Learning Assessment and feedback	1.00	
	SUB – TOTAL	**20.00**	**5.00**
	TOTAL		**25 Hours**

** **5 days training - 5hrs per day (9am – 3pm) inclusive of lunch break.**

Session 1.1: Introduction to Climate Smart Agriculture (CSA)

Duration 2 Hours

Description

This session introduces the concept of climate as a factor of food production and security. The participants will be equipped to contribute to increasing resilience among the smallholder farmers and, therefore, enhance food and nutrition security through implementation of CSA technologies.

Learning Outcomes

At the end of the session, the participants should be able to:

1. Explain concepts and terminologies used in Climate Smart Agriculture
2. Apply best practices applied in Climate Smart Agriculture.

Learning aids and material

- Flip chart or board, Marker pens
- CSA training module (FAO, 2018)
- LCD projector, Laptop
- Definition of terminologies

Procedures

Activity I: Introduction to CSA technologies (50Mins)

a. Divide participants into small groups and request them to:
    i. Discuss and define terms used in CSA and put them in flip charts. (see examples in session notes)
    ii. List Climate Smart Agriculture technologies and practices used in farming for food and income security.
b. Ask them to present their outputs in plenary as you correct.

Activity II: Presentation of CSA practices (1 Hour)

a. Illustrate (using video, power point or handout) various Climate Smart Agriculture technologies and practices.
b. Ask participants to identify CSA technologies and practices they can implement in their home locality/sub-county.
c. Ask them to present in plenary.

Conclusion  10 minutes

Summarize the session using the question and answer techniques

SESSION NOTES

Introduction to climate smart agriculture (CSA)

Climate-smart agriculture presents the opportunity to meet the world's food demands in the face of climate variability (Waaswa *et al.*, (2021), Totin *et al.* (2018). The triple win effect of CSA, which are:

i. Increased productivity,
ii. Mitigation, and
iii. Adaptation,

The above three are seen as practical solutions to climate change (FAO, 2010). CSA initiatives are more responsive to the achievement of Sustainable Development Goals (SDGs) 2 and SDG 13 that aim at increasing productivity by adapting to climate change (Rosa, 2017). Several CSA practices have been developed globally and among these include irrigation, chisel or deep-ploughing, crop rotation, mixed cropping, terracing, mulching, zero or minimum tillage and cover crops (Cramer *et al.*, 2017; Imran *et al.*, 2018; Lan *et al.*, 2018; Zahra *et al.*, 2019). Considering its geographical location, Africa has developed and adopted context-specific CSA practices like leaving cleared weeds and biomass to mulch on prepared land, use of hybrid planting materials (Akrofi-Atitianti *et al.*, 2018), crop-livestock diversification, diversification of income-generating activities and other good agronomic practices such as mixed cropping, agroforestry and perennial plantation (Fadina & Barjolle, 2018).

CSA presents a variety of benefits to the farmers and to the entire food value chain. A good example of the benefits of CSA in East Africa is the planting of mango trees to protect the soil from physical erosion and contribute to families' nutrition (Recha *et al.*, 2016). Additionally,

study findings by Akrofi-Atitianti *et al.* (2018) revealed that CSA practitioners had increased their income by 29% compared to conventional farmers. The difference is attributed to the ability of the CSA technologies to sustain yields under climate variability. According to research conducted in the Teso North Sub-county, Busia County of Kenya, 56.83% of smallholder farmers practice CSA for effective crop and field management, farm risk reduction, and sustainable soil management practices (Wekesa *et al.*, 2018). A study by Mbow *et al.* (2014) in western Kenya indicated that agroforestry reduced food insecurity during drought and flooding by 25% due to its ability to increase crop yields and income amidst calamity.

Like any other climate change vulnerable country, Kenya has responded to the global call to mitigate and adapt to climate change effects by launching a CSA strategy; which was designed as part of its development programmes that seek to achieve food security and sustainable development at the same time (GoK, 2017). Agroforestry, the use of bunds, water harvesting, composting, improved high yielding varieties, among others, have been developed as CSA technologies (Bernier *et al.*, 2015).

Key terms in climate smart agriculture

Climate Change or variability: Climate variability means changes in climate that occur within smaller timeframes, such as a month, a season or a year. Whereas Climate change – are the changes that occur over a longer period of time, typically over decades or longer.

Drought: it occurs when there is a prolonged period of abnormally low rainfall or rain failure that leads to a shortage of water and pasture and crop failure.

Floods: it is an overflow of a large amount of water beyond its normal limits, especially over what is normally dry land.

Temperature variability: It measures how much the temperature changes day-to-day or month-to-month within a single year at individual stations.

Green House Gas emissions: These are the bad gases produced when wood or oil is burned. Most factories produce green-house gases. Electricity is generated through burning fossil fuels or renewable sources e.g. hydro power stations, solar etc.

Carbon sequestration: This is the process of plants taking up carbon dioxide from the air during photosynthesis and producing oxygen in the air, and banking the carbon in the soil as carbon.

Climate change mitigation: It means avoiding and reducing emissions of heat-trapping greenhouse gases into the atmosphere to prevent the planet from warming to more extreme temperatures. Examples of Mitigation measures is switching from using petrol for irrigation to using solar pump or planting trees that absorb carbon dioxide from the atmosphere.

Climate Change Adaptation: It is the process of adjusting to current or expected effects of climate change. Adaptation can help decrease climate risk via the three risk factors: hazards, vulnerability and exposure. Impacts of climate hazards may be reduced with the help of ecosystem-based adaptation. E.g. Flooding risk can be prevented by raising river banks or reducing tree cutting in the highlands.

Deforestation: Deforestation is the purposeful clearing of forested land. Throughout history and into modern times, forests have been razed to make space for agriculture and animal grazing, and to obtain wood for fuel, manufacturing, and construction.

Resilience: the capacity to recover quickly from difficulties or hazards. An example is the capacity of a farmer to recover from a season of rain shortage.

CSA technologies

Farming practices can be considered as traditional or climate smart.

i. Traditional technologies: Traditional technologies are the old-time ideals and tools such as hoes, slasher or cutlass used by farmers for agricultural production.

ii. Climate Smart Agriculture (CSA)/Modern technologies: These are improved ideas, practices, equipment and tools used for ploughing, harrowing, planting, and improved varieties used in agricultural production. The modern agriculture practices, according to Deji (2012), are innovations resulting from research activities or farming experiences disseminated to the farmers with the aim of improving their livelihood and enhancing efficiency in production.

Examples of CSA technologies include:

- **Use of machines on farms.** This involves use of chisel plough, potato planters, motorized sprayer and harvesters. Mechanization saves on time spent on production activities. Use of machines allows farmers to grow large quantities of potato in a short period of time.
- **Certified potato seed:** These are able to resist diseases and pests and are fast maturing crops leading to high yields and increased income. Since they are resistant to most diseases and pests, the farmers spend less money on pesticides, which in return increases on their return on investment.
- **Inputs** e.g. slow release fertilizer, pesticides
- **Harvesting technologies** such as reapers.
- **Post-Harvest technologies** e.g. grading tools, cooling facilities - used by farmers to store potato seed in a cold room to keep them fresh until the planting season.
- **Rural transportation** such as bicycle, tri-cycle and other motorized transport.
- **Information and communication technology** such as mobile phone, rural radio, television, internet, and print media.
- **Irrigation of plants.** When rains fail, farmers use technology to irrigate their potato crop. These include: water pumps, tanks, sprinklers. Advanced water sprinkler systems, drips and misters are used to irrigate big farms. Some farmers mix nutrients in this water, so as to improve the growth of these crops

Figure 1.1: Hydroponic system technology

- **Hydroponic system.** This system is set up in a greenhouse and uses drip system to apply water and fertilizer to the root of the crop as shown in picture below.

Suggested readings (reference material)

Andrew Waaswa, Agnes Oywaya Nkurumwa, Anthony Mwangi Kibe & Joel Ngeno Kipkemoi (2021): "Climate-Smart agriculture and potato production in Kenya: review of the determinants of practice", Climate and Development, Taylor and Francis. ***https://doi.org/10.1080/17565529.2021.1885336***

Session 1.2: Climate Smart Agricultural Structures for Soil & Water Conservation

Duration 5 Hours

Description

This session will cover the best climate smart agriculture structures (measures) for soil and water conservation e.g. farm water conservation such as farm ponds. Participants will also evaluate the different roles played by each gender and its impact on soil and water conservation.

Learning outcomes:

At the end of the session participants should be able to:

1. Explain concepts and terms used in CSA soil and water conservation
2. Explain various soil and water conservation structures (measures) used.
3. Describe how water conservation is achieved on the farm.

Learning aids and material

- Writing board/flip chart, felt pens
- LCD Projector, Laptop
- Handout, Map, Posters

Procedure

Activity I: Discuss concepts and terms used in best CSA soil and water conservation for seed potato production (50 minutes).

a. The facilitator will ask participants to answer the following questions as she/he facilitates plenary discussion:
   i. Which are the terms and practices commonly used in CSA for soil and water conservation purposes? (see definitions in session notes)
   ii. Why would you apply Climate Smart (CS) soil and water conservation practices?

Activity II: Achieving Climate Smart Soil and Water conservation practices. (1 Hour)

a. Divide participants into small groups and ask them to:
   i. Explain the causes and types of soil erosion
   ii. Explain the best CSA practices for managing soil erosion
   iii. Explain the causes of water loss
   iv. Discuss the best CSA practices for preventing water loss
b. Ask them to present in plenary as you highlight key points

Activity 4: Field work (3 Hours)

a. The facilitator will arrange a visit to a farm/s with various best CSA soil and water conservation technologies and practices.
    i. On arrival at the farm, the owner will explain the various CSA technologies and practices in use.
    ii. In small groups, the learners will take a guided tour of the farm noting the CSA technologies and practices in their notebook
    iii. At the end of the tour, the facilitator will facilitate a question and answer session.
b. Ask participants to identify simple CSA technologies they can apply to conserve soil and water on their farms.

Summary/Conclusion 10 minutes

Conclude the session, by highlighting the importance of CS soil and water conservation.

SESSION NOTES

Concepts used in water and soil conservation

Key Terms and Concepts in Water and Soil Conservation

Soil Particles: Soil particles vary greatly in size, and soil scientists classify soil particles into sand, silt, and clay. The size of soil particles determines their ability to hold water.

Soil Moisture: Soil moisture is the water stored in the soil and is affected by rainfall, temperature and soil characteristics among other factors

Soil Fertility: Soil fertility is the ability of soil to sustain plant growth and optimize crop yield. This can be enhanced through organic and inorganic fertilizers to the soil.

Soil Erosion: Soil erosion is a gradual process that occurs when the impact of water or wind detaches and removes soil particles, causing the soil to deteriorate. Soil deterioration and low water quality due to erosion and surface runoff have become severe problems worldwide.

Soil Cover: Soil cover refers to vegetation, including crops, and crop residues on the surface of the soil. The various farming practices can be used in order to reduce soil degradation.

Water Infiltration: The infiltration rate is the velocity or speed at which water enters (or seeps) into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour.

Gabion: The main objective of gabion walls is to control land sliding on road sides, erosion and scouring on the rivers banks during flood.

Terraces: Terracing is a sloping piece of land that has had flat areas like steps built on it, for example, so that people can grow crops there.

Types of soil erosion

Figure 1.2: Sheet Erosion

Figure 1.3: Rill Erosion

Figure 1.4: Scalding

Figure 1.5: Gulley Erosion

Figure 1.6: Unprotected Stream Erosion

On-farm water conservation - farm ponds

On farm water conservation involves the collection and storage of water from rainfall or a stream. Rainfall is collected using roof, rock and water pan catchment structures. The construction of farm ponds is a practical method of supplying water in many dry regions. It can provide water for a part (or full) of the year depending on its size. These farm ponds can be constructed to collect excess water after rainwater is conserved through different in-situ measures.

Figure 1.7: Farm pond with water

Selection of site for construction of farm ponds

i. Should not be located on very sandy or shallow soil.

ii. It should be in accordance with the topography of the area so as to get sufficient water storage.

iii. Should have large watershed so as to provide for surface run-off.

iv. Should preferably be in permanent grassland or tree areas rather than cultivatable lands that are prone to soil erosion.

v. Should be free from septic tanks, house drains etc. as these are possible sources of infectious pathogens.

vi. Should have a safe spillway preferably a vegetative one.

Size of farm pond

Farm ponds having a capacity of 250-300m^3 for each hectare (ha) of land is ideal to collect run-off. For a 4ha farm the size should be 20m x 20m x 3m in clay soils. In red soils the pond can be lined with soil and cement in the ratio of 8:11 and smeared to a thickness of five centimeters to prevent initial spillage losses. The top width of the pond should be at least 18m for ponds up to 3.5m high (for each additional 1m height, the pond width should increase by at least 0.3m).

Precautions

i. Downstream slope of the pond should be protected with gravel or vegetative barrier to avoid erosion.

ii. A spillway must be provided for emergency purposes.

iii. A permanent fence must be built around the pond to prevent accidents of humans and animals.

References

https://agmip.org/making-climate-smart-agriculture-work. Conference proceedings May 2022

FAO, 2018 on CSA

Session 1.3: Climate Smart Soil and moisture conservation Practices

Duration 3 Hours

Description

This session will cover best practices in soil and moisture conservation in CSA, choice of particular CS soil moisture and soil conservation technologies, and application of the most appropriate practices.

Learning outcomes

At the end of the session participants should be able to:

1. Explain the conditions that govern choice of a particular CS soil moisture and soil conservation technology or practice
2. Suggest the **most appropriate** Climate smart soil and moisture conservation practices/ methods for a selected locality.

Learning aids and materials

- Writing board/flip chart, felt pens
- LCD Projector, Laptop
- Handout, Map, Posters

Procedure

Activity I: Selecting CS practices for conserving soil and moisture (40mins)

a. Divide participants into small groups of 3 or 4 participants and ask them to do the following:
   i. Identify causes of moisture lose in agricultural fields.
   ii. List the most important moisture conservation practices and conditions that govern choice of a particular practice.
b. Ask two groups to present findings in plenary
c. Conclude by highlighting key points

Activity II: Determine the most appropriate CS soil & water conservation practices for a given locality (2 hours)

a. Divide participants into small groups and ask them to:
   i. Discuss the practices commonly used in soil and moisture conservation?
   ii. List the factors that determine the choice and up-scaling of the best CSA soil and moisture conservation practices in seed and ware potato production?
b. Ask them to present their outputs in plenary.
c. Conclude the activity by presenting PowerPoint on SS soil and water conservation practices.

Conclusion 20 Minutes

Ask each learner to write down the CS soil and moisture conservation practices that she/he will apply on her/his farm.

Suggested readings

1. Andrew. W, Agnes. N, Kibe Mwangi. A., & Kipkemoi. Joel Ngeno (2021): ***Climate-Smart agriculture and potato production in Kenya: review of the determinants of practice, Climate and Development,*** DOI: 10.1080/17565529.2021.1885336. ***https://doi.org/10.1080/17565529.2021.1885336***
2. Chesterman, S. & Neely, C. (Eds.) (2015). ***Evidence and Policy Implications of Climate-Smart Agriculture in Kenya.*** CCAFS Working Paper no. 90. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available at: www.ccafs.cgiar.org.
3. Government of Kenya. (2018). ***National Climate Change Action Plan (Kenya) Volume 2: Adaptation Technical Analysis Report 2018-2022.*** Nairobi: Ministry of Environment and Forestry.
4. Government of Kenya. (2016). ***Climate Change Act,*** 2016; GoK, Ed.; No. 11 of 2016; The Government Printers: Nairobi.
5. "Operation Mwolyo Out (OMO)", ***Impact Newsletter Issue No 1:*** By Christian Impact Mission, 2011.

Session 1.4: Conservation Agriculture Cropping Systems for Mitigating and Adapting to Climate Change

Duration 2 Hours

Description

This session will cover the concepts and importance of climate smart cropping practices that assist farmers (& communities) in mitigating against and adapting to climate variability to realize food and income security.

Learning Outcomes

At the end of the topic, participants should be able to:

1. Explain concepts and their importance of on-farm (*in-situ*) soil and moisture conservation practices and contingent crop planning.
2. Explain the principles of crop rotation in seed potato systems.
3. Outline the principles that support the choice of cropping system with an aim of mitigation against or adapting to climate change in potato systems.

Learning aids and materials

• Cropping calendar	• Flip chart and marker pens
• LCD projector & computer	

Procedure

Activity I: Introducing (20Mins)

a. Ask learners to state and explain key terms used in cropping systems
b. Explain that the session would explain how these practices improve yields

Activity I1: Concepts and practices for applying Climate Smart cropping systems (1Hour 20Mins)

a. Divide participants into small groups and request them to do the following:
    i. Brainstorm on benefits of cropping practices that mitigate and/or adapt crops to climate change. (Examples include: *crop rotations, cover crops, contingent crop planning, inter-cropping, tie-ridges, catch pits, etc.*)
    ii. List principles and benefits of crop rotation in potato production.
    iii. Develop a cropping calendar that supports the choice of cropping with an aim of mitigating against or adapting to climate change (CC) in seed potato production.
b. Ask them to present their outputs in plenary

Conclusion  20 Minutes

Conclude the session by presenting PowerPoint or handout on cropping systems

SESSION NOTES

CONCEPTS & PRACTICES APPLIED IN CS CROPPING SYSTEM

Conservation agriculture (CA) for Sustainable Agriculture and Rural Development has evolved as a term, which represents an inter-acting and complimentary set of agricultural practices and concepts. Despite regional differences in the mix and emphasis of the different specific components making up CA practices, they depend on agro climatic zones, availability of farm power options, farming systems types, inputs, skills, etc.

The three basic principles that are always present in CA practices include:

a. Minimal soil disturbance (no-tillage/reduced tillage)
b. Permanent soil cover (cover crops, intercropping and associated practices)
c. Suitable and diversified crop rotations/associations.

While these three individual technologies are well known, it is their combination and the management of the combination that leads to new synergetic effects resulting in CA becoming more than just the sum of the individual practices.

Some of these practices are applicable to seed potato production, but others are not. The section below highlights the CSA technologies and practices applicable in seed potato production.

a. Surface planting in seed potato

A new method of surface planting has been introduced in the production of potatoes**.** After ploughing, the potato tubers are laid in rows and then earthed up. This saves the labor required

to dig trenches for planting. The potato productivity increases as the potato has soft soil to extend its roots.

b. Crop Rotation

A four (4) year crop rotation cycle must be strictly practiced for seed potato production. Crop rotation helps reduce the pest and diseases in the field related to potato crop. Crops suited for rotation are lucerne, desmodium and other crops not in the nightshade family solanaceae. Crops not to be crop rotated with potatoes include tomatoes, eggplant, nightshade, capsicum among others.

Further reading

1. *A Practical Guide to Climate-Smart Agriculture Technologies in Africa (Bell et al, 2018) for CCAFS.*
2. *Climate-Smart Agriculture Rapid Appraisal (CSA-RA) - A Prioritization Tool for out scaling CSA Step-by-Step Guidelines (Mwongera et al, 2015) for CIAT, IITA and IFAD.*

Session 1.5: Irrigation as a Climate Smart Agriculture Practice

Duration 2 Hours

Description

This session covers the importance of irrigation methods and technologies to mitigate drought and dry spells caused by climate change. The different types of irrigation methods and technologies and advantages and disadvantages will be covered.

Learning outcomes

At the end of the session participants should be able to:

1. Explain importance of irrigation as a climate smart practice for mitigating against drought or dry spell as occasioned by climate change.
2. Describe best irrigation methods and technologies to reduce energy cost and optimize water use.

Learning aids and materials

• Writing board/Flip chart, marker pens	• LCD Projector, laptop
• Attachment on irrigation methods	

Procedure

Activity I: Introduction (10Mins)

a. Ask participants to differentiate between drought and dry spell

b. Correct where necessary and define the two terms

Activity II: Group discussion (50Mins)

a. Divide participants into small groups based on their geographical work/farm proximity/experience and request them to:
   i. Discuss effect of drought and dry spells on crop growth and yield.
   ii. Identify various options of combating drought and dry spells.
   iii. Describe various methods of applying irrigation water to crops, their advantages and disadvantages.

b. Ask participants to present their findings in plenary.

Activity III: Group discussion (50Mins)

a. Ask participants to share their experience in using irrigation
b. What have been the successes and the challenges as these are list on a flip chart
c. Make a short lecture on importance of using solar technology to run water pumps, farm equipment and household lighting.
d. Do a cost benefit analysis comparing on- grid electricity and solar energy.

Conclusion/Summary 10 Minutes

Conclude the session by requesting them to ask questions or emphasis key lessons.

SESSION NOTES

Irrigation as a CSA practice

Other possible practical soil and moisture conservation interventions such as irrigation are applicable in CSA. There are different cost effective methods and technologies for irrigating crops. In the past the highest cost of irrigation was cost of running diesel or petrol pumps and water wastage. Fortunately, now with solar pump and precision irrigation systems it is affordable to even small holder farmers. Egerton University and partners in their Smart Water for Agriculture (SWA) project funded by SNV (Dutch Development Organization) established five Climate and Water Smart Agriculture Centers (CAWSA – Centers) where farmer would go and learn practically. We recommend that each extension officer of lead/trainer farmer, establish a CAWSA – Center in their location. More information on the project and CAWSA – Center are on Egerton University website: *www.cawsa-centre* . It was officially launched on 1st October 2019 jointly by Dr. Immaculate Maina, Minister for Agriculture, Nakuru County Government and Prof. Isaac Kibwage, DVC planning and Administration at Egerton University.

Figure 1.8: Dr. Maina, Nakuru County Minister for Agriculture, cuts ribbon for Climate and Water Smart Agriculture Centre (CWSA – C) at Egerton University on 1st October, 2019.

(Source: Community action research project plus [CARP+] partners)

The Centre displays various technologies and practices including low cost solar pumping systems for farm and house.

Irrigation Methods

Irrigation methods include the following:

Flood irrigation: The system is called flood irrigation since water is pumped or brought to the fields and is allowed to flow along the ground among the crops. This method is simple and cheap, and is widely used by societies in less developed parts of the world as well as in the U.S. The problem is, about one-half of the water used ends up not getting to the crops. Traditional flood irrigation can mean a lot of wasted water.

Bund Irrigation: It is similar to flood irrigation, but in this case the farm is divided into bunds. It is done in dry areas, where a farmer has constructed a water pan and can pump water.

Sprinkler Irrigation: This is the cheapest and easiest way to irrigate a crop. A sprinkler costs between Kshs 400 – 1000 (USD 4 – 10)

Drip irrigation: For irrigating fruits and vegetables, this method is much more efficient than flood irrigation. Water is sent through plastic pipes (with holes in them) that are either laid along the rows of crops or even buried along their root lines. Evaporation is cut way down, and up to one-fourth of the water used is saved, as compared to flood irrigation.

Figure 1.9: Drip Irrigation of rotation crop

(Source: Community Action Research Program Plus [CARP+] partner)

Mist irrigation: Spray irrigation is modern way of irrigating a crop using water spray instead of drip. The water is thrown upwards and falls down as a light mist/dew

Rotor Sprayer: This is an overhead sprinkler system that covers a wider than a normal sprinkler. The system has a long tube pivoted at the center. The tube has hole on the under-side that release the water as the rotor rotates. It uses gravity and is therefore very economical. This system was tested in the CAWSA – Center project in partnership with SNV and Practical Action. For more information contact Practical Action website:

Micro catchments: The term water harvesting describes a range of techniques for collecting and concentrating run-off. These systems harvest water directly from rain, or dew, or indirectly from run-off or streams for agricultural, livestock, or domestic use. A micro-catchment is a specially contoured area with slopes and bunds designed to increase run-off from rain and concentrate it in a planting basin where it infiltrates and is effectively "stored" in the soil profile. The water is available to plants but protected from evaporation.

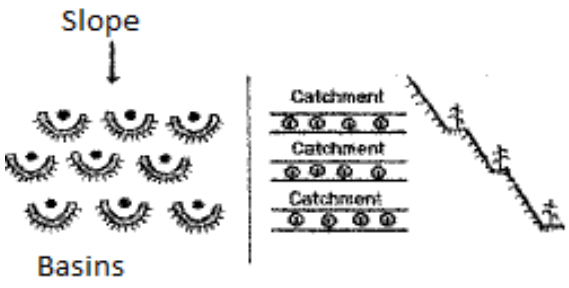

Figure 1.10: Bunds and terraces

(Source: Community Action Research Program Plus [CARP+] partner)

Run-off water is collected from a slope in a series of small basins or terraces for slowing down speed of water (to allow absorption) and plant abstraction.

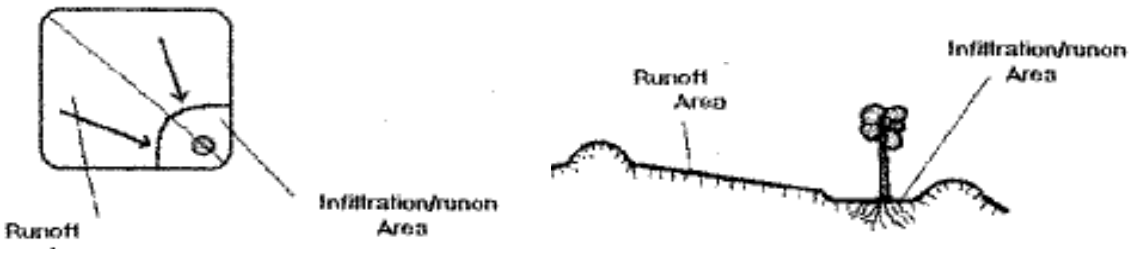

Figure 1.11: Sketch of basic micro-catchment

(Source: Community Action Research Program Plus [CARP+] partner)

Session 1.6: Integrated Soil Fertility Management (ISFM)

Duration 4 Hours (2Hrs Theory, 2Hrs Practical)

Description

This session introduces the concept of integrated soil fertility management (ISFM) and its importance in potato farming. The learners will contribute to sustainable food production of safe and nutritious food. The session will enable learners to initiate ISFM for improving, maintaining and restoring degraded soils.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain importance of various organic and inorganic fertilizers and farming practices.
2. Apply principles of ISFM in their farming practices.
3. Facilitate their communities in identification of infertile soils, their causes, and generation of context specific soil improvement remedies.

Learning aids and materials

• Flip chart, marker pens	• Manila papers
• CIAT, IITA and IFAD CSA manual	• Ash, small stones and sticks

Procedure

Activity I: Introduction to concepts and practices used in soil fertility improvement (30Mins)

a. Divide participants into small groups and ask them to:
   i. Brainstorm on the causes of soil
   ii. fertility degradation.
   iii. Discuss natural resources used for
   iv. improving soil fertility and their physical characteristics.

b. Ask group leaders to present their output in plenary

c. Summarize by highlighting key points

Activity II: Concepts and practices used in Integrated Soil Fertility Management (ISFM) (1 Hour)

a. Divide participants into small groups and ask them to:

   i. Discuss concepts and practices used in ISFM and their importance in seed potato production.

b. Ask them to present their findings in plenary as you highlight key concepts and practices and their importance.

Activity III: Participatory community mapping exercise (2 hours)

a. Divide learners into small groups and request each group to walk through their community as they:

   i. Identify problems related to soil infertility.

   ii. Identify organic resources that can be used to improve fertility

   iii. Note down their key findings

b. Ask them to present the identified soil infertility problems and organic resources identified in plenary.

Conclusion 30 Minutes

Present a handout or PowerPoint on common soil infertility problems and suggested ISFM solutions.

SESSION NOTES

Intergrate soil fertility management

Soil degradation, its causes and management

Soil degradation is the decline in soil quality because of improper land use activities such as inappropriate agricultural intensification and farming practices, intensive grazing and unsustainable urban or industrial expansion. It involves the decline of the soil's physical, chemical and biological quality. It can be the loss of organic matter, decline in soil fertility and structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding.

Soil degradation can impact directly on yield and yield quality, as well as the timing of tillage, planting and harvesting operations. This leads to gaps in continuity which can have a significant financial impact on growers and increase their reliance on imports to meet customer requirements. Soil degradation may occur naturally, due to climate change or human activities.

Causes of soil degradation

Physical Factors: Physical factors such as rainfall, surface water runoff, floods, wind erosion, tillage, and mass movements result in the loss of fertile top spoil thereby declining soil quality.

Soil erosion: Soil erosion refers to the wearing away of a land's topsoil by thenatural physical forces of water and wind or through forces associated with farmingactivities such as tillage. Causes and types of soil erosion were covered in session two (2)

Misuse or excessive use of fertilizers and chemicals

Excessive use and misuse of pesticides and chemical fertilizers kill organisms that assist in binding the soil together. When fertilizers and other agricultural chemicals are not correctly used, they denature essential soil minerals. This gives rise to nutrient loss destruction of the soil's biological activity and buildup of toxicities.

Improper cultivation practices

Improper tillage on agricultural lands breaks up soil into finer particles, which increase erosion rates. The decline of soil quality is accelerated by mechanization

Improper tillage on agricultural lands breaks up soil into finer particles, which increase erosion rates. The decline of soil quality is accelerated by mechanization of agriculture that gives room for deep ploughing, reduction of plant cover, and formation of hardpan due to compaction. Compaction of soil is the compression of soil particles into a smaller volume, which reduces the size of pore space available for air and water. Other improper cultivation activities such as farming on steep slope and mono-cropping, row-cropping and surface irrigation wear away the natural composition of the soil and its fertility, and prevent soil from regenerating.

Urbanization

It removes the soil's vegetation cover especially forest cover, compacts soil during construction, and alters the drainage pattern. Most of the runoff and sediments from urban areas are polluted with oil, fuel, and other chemicals. Increased runoff from urban areas also causes a huge disturbance to adjacent water sheds by changing the rate and volume of water that flows through them.

Overgrazing

Overgrazing destroys surface crop cover and breaks down soil particles, increasing the rates of soil erosion. As a result, soil quality is greatly affected.

Chemical factors

This is the reduction of soil nutrients due to alkalinity, acidity, water logging or removal of nutrients through crop harvests. The chemical factors are mainly alterations in the soil's chemical property that determine nutrient availability. They create undesirable changes in the essential soil chemical ingredients

This is the reduction of soil nutrients due to alkalinity, acidity, water logging or removal of nutrients through crop harvests. The chemical factors are mainly alterations in the soil's chemical property that determine nutrient availability. They create undesirable changes in the essential soil chemical ingredients.

Deforestation

Removal of trees and crop cover exposes soil minerals to adverse weather effects. Vegetation cover primarily promotes the binding of the soil together and soil formation, hence when it

is removed it considerably affects the capabilities of the soil such as aeration, water holding capacity, and biological activity.

Drought and aridity

Drought and aridity are problems highly influenced and amplified by soil degradation. The contributing factors to soil quality decline such as overgrazing, poor tillage methods, and deforestation are also the leading causes of desertification characterized by droughts and arid conditions. Soil degradation may also bring about loss of biodiversity.

Increased flooding

Soil degradation takes away the soil's natural capability of holding water thus contributing to more cases of flooding.

Pollution and clogging of waterways

Most of the soil eroded from the land together with the chemical fertilizers and pesticides utilized in agricultural fields are discharged into waterways and streams. With time, the sedimentation process can clog waterways, resulting in water scarcity. The agricultural fertilizers and pesticides also damage marine and freshwater ecosystems and limit the domestic uses of the water for the populations that depend on them for survival.

Solutions of Soil Degradation

Reducing deforestation

With the reduction of deforestation, soil's ability to naturally regenerate can be restored. Governments, international organizations, and other environmental stakeholders need to ensure there are appropriate measures for making zero net deforestation a reality to inhibit soil degradation.

Land reclamation

To restore the lost soil mineral matter and organic content, it would require land reclamation. Land reclamation encompasses restoring the previous organic matter and soil's vital minerals. This include planting of vegetation such as trees, crops, and flowers over the affected soils, addition of plant residues to degraded soils and improving range management.

Conservation tillage

Proper tillage mechanisms are one of the most sustainable ways of avoiding soil quality decline. Conservation tillage aims at making very minimal changes to the soil's natural condition and, at the same time, improving the soil's productivity. It involves leaving the previous year's crop residue on the surface to shield the soil from erosion, planting cover crops, crop rotations, intercropping and avoiding extensive deep plowing.

Soil erosion control

Surface cover is a major factor to control erosion because it reduces the impact of raindrops falling on bare soils and wind removing soil particles. It also reduces the speed of water flowing over the land. Erosion risk is significantly reduced when there is more than 30% soil cover.

Control run-off before it develops into an erosive force: Trees are often considered to be the universal answer to control soil erosion. Tree roots help prevent landslides on steep slopes and stream bank erosion

Soil fertilityand water management

Soil management is the application of operations and practices that enhance soil health and performance. These practices may be broadly classified as soil fertility management by application of fertilizers, adoption of practices that enhance maximum soil moisture retention and minimum plant nutrient losses or loss of soil biodiversity. Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided into the soil are maintained or enhanced without significantly impairing its functions.

Sustainable soil management is fundamental to effective soil function, particularly in intensive production systems where optimal plant growth is required to deliver maximal crop yield and quality. In intensive cropping systems, when sustainable soil management is not practiced, soil structural degradation in all forms is widespread and pervasive.

Soil Fertility Management (SFM) strategies center on the combined use of mineral fertilizers, locally available soil amendments and organic matter to replenish lost soil nutrients. They include:

Integrated soil fertility management (ISFM)

This involves a set of agricultural practices and germplasm adapted to local conditions to maximize the efficiency of nutrient and water use and improve agricultural productivity. ISFM strategies are anchored on the combined use of mineral fertilizers and locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost and green manure) to replace lost soil nutrients. This improves both soil quality and the efficiency of fertilizers and other agro-inputs. ISFM also promotes improved germplasm, agroforestry and the use of crop rotation and/or intercropping with legumes (a crop which also improves soil fertility). Fertilizers supplement plants with the vital nutrients needed for optimal, healthy growth. There exist two major categories of fertilizers: organic and inorganic. Organic fertilizers are derived from naturally occurring substances, such as plant or animal byproducts and mineral rock, but inorganic fertilizers are synthetically manufactured. Organic fertilizers undergo little processing and include ingredients such as composts and manure, while inorganic fertilizers are synthetic made.

Organic fertilizers

The cementing agent that binds the soil particles together is the organic matter, which is found in organic fertilizers. It is both of animal and plant origin. Besides adding necessary nutrients to soil, organic fertilizers boost soil fertility status by improving all soil physical, chemical and biological properties which most plants rely on for healthy growth and development. They play the following roles in the soils:

- Improves soil temperature regulation
- Improves soil aeration and reduces soil compaction.
- Improve infiltration rate
- Improves soil organisms population
- Improves soil water and nutrient holding capacity

Practices that increase organic matter in the soils include: crop rotations that contains high plants residues, leaving crop residues in the field, growing cover crops, use of low or no tillage systems, mulching, growing perennial forage crops, using optimum nutrient and water management strategies for healthy plants production with large number of residues and roots, growing cover crops and application of compost or manure. Apart from insitu organic matter accumulation, there exists a wide range of locally available organic amendments. They include farmyard manure, green manure, compost manure, sewage/sludge and marine by-products.

Farmyard Manure

Farm yard manure comes from livestock animals such as cattle, chickens, horses and sheep, although bat and bird guano are also effective organic fertilizers. Like compost, manure also does double duty by adding essential nutrients to the soil as well as improving soil quality and its water-retention ability. Because manure can cause food-borne illness, use either composted manures or apply fresh manure well in advance.

Legume/green manure

Green manure is made from crops that are generally grown for less than a growing season and are ploughed and incorporated in the soil before producing seeds. Examples of common green manure crops are: annual ryegrass, Sudan grass, Tithonia and Sesbania. Legumes are particularly beneficial since they are nitrogen-fixing species and are a good source of nitrogen. A particular advantage of implementing a legume/green manure rotation into the soil/cropping system is the added source of organic matter. Green manures also improve soil structure by reducing bulk density.

Biogas slurry

Slurry consists of the solid products formed during sewage treatment. It is not uniform in mineral composition but generally, it contains between 1 to 3% total nitrogen.

Compost

Compost is made from decomposed plant matter such as vegetable peels, eggshells, coffee grounds and other organic scraps. Regardless of the source, compost provides soil with a well-balanced mix of nutrients, including nitrogen, phosphorus and potassium.

Rock Minerals

Although mined rock minerals differ from other organic fertilizers in that they are not derived from a previously living organism, they are still considered organic fertilizers because they have not undergone extensive processing, and provide soil with nutrients vital to healthy plant growth and development. Common examples of mined rock mineral fertilizers include rock phosphate, greensand and sulfate of potash magnesia.

Mulch

This can be derived from organic or inorganic materials. Organic mulch improves soil fertility through decomposition of the materials. Examples of organic mulches include grass clippings, shredded leaves and old hay. Annual applications of mulch, along with compost, improve soil's ability to absorb nitrogen and other nutrients. Inorganic mulch contributes to soil fertility management through soil moisture retention and regulation of soil environment making it suitable for micro-organism action.

Inorganic fertilizers

Inorganic fertilizers come in single-nutrient or multi-nutrient formulas. Multi-nutrient formulas include compound and single fertilizers, which contain basic nutrients, such as nitrogen, phosphorus and potassium, as well as secondary and micronutrients such as calcium, magnesium, boron and manganese. The percentage of nitrogen, phosphorus and potassium contained in both complete and balanced fertilizers is indicated by three numbers on the package. For example, a 5-10-5 formula is a compound fertilizer, containing 5 percent nitrogen, 10 percent phosphorus and 5 percent potassium. Balanced fertilizers are those that contain equal nutrient amounts, such as a 10-10-10 formula.

Types of Inorganic Fertilizers

Inorganic fertilizers include slow-release formulas. These formulas contain larger molecules that are coated, helping them to break down slowly in the soil. A typical slow-release fertilizer releases nutrients over a period of 50 days to a year, reducing the chance of burning the plant or root system. Specially formulated inorganic fertilizers are those that are created for a specific type of plant. Specially formulated fertilizers are usually highly acidic and should be used only on the plants for which they are indicated.

Comparison of organic and inorganic fertilizers

	Organic	**Inorganic**
Composition	• Contain only plant- or animal- based materials that are either a byproduct or end product of naturally occurring processes • Low in soil nutrients	• Mineral processed fertilizer • Supplement the soil with macronutrients needed in large amounts: nitrogen, phosphorousand potassium
Nutrient Availability	• Rely on soil organisms to break down organic matter	• Provide this nutrition in plant-ready form
	• Release nutrients only when the soil is warm and Moist	• Nutrients may leach deeply into the soil and water table
	• Nutrients are released slowly	
	• Reduces the risk of nutrient leaching	
Application	• Bulk application	• Application is simple, easily mechanized -amount of a given Element
	• Analysis needed to determine the amount of nutrients being applied	• Rate of application can beeasily calculated
		• Expensive
Cost/ availability	• Locally available and relatively Cheap	• Expensive
Environmental	• Organic materials are able to fully decompose	• Heavy applications can burn crops
Impacts	• Lower release of greenhouse gas	• Build up toxic salt concentrations in the soil, which can create chemical imbalances
		• High release of greenhouse gas

Further reading

1. *A Practical Guide to Climate-Smart Agriculture Technologies in Africa* (Bell *et al*, 2018) for CCAFS.
2. *CSA training manual* – a reference manual for agricultural extension agents (FAO, 2018).
3. *Climate-Smart Agriculture Rapid Appraisal (CSA-RA)* - A Prioritization Tool for out scaling CSA Step-by-Step Guidelines (Mwongera *et al*, 2015) for CIAT, IITA and IFAD

Session 1.7: Gender Mainstreaming in Adoption of Climate Smart Agriculture

Duration 4 Hours

Description

This session covers the importance of evaluating gender roles in adaptation of CSA in potato farming. It will enable the participants to take action to engage all gender in various farming activities as well increase access to resources for the disadvantaged groups. It discusses the interactions of gender roles in adoption of CSA technologies. The session will empower the participants with skills for gender mainstreaming and evidence based advocacy.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain the importance of gender mainstreaming in the adoption of CSA.
2. Analysis gender roles in a household or community, present evidence and use it lobby and advocate for change or action
3. Guide their communities in gender mainstreaming for successful CSA seed potato production.

Learning aids and materials

• Flip chart/White board	• LCD projector, laptop
• Handout on gender mainstreaming	• CSA training manual

Procedure

Activity I: Introduction to Gender mainstreaming in agriculture (40Mins)

a. Divide participants into small groups and ask them to:

   i. Brainstorm on the concepts and terms used in Gender mainstreaming in agriculture. (15Mins)

b. Ask them to present their outputs in plenary as you emphasis key points (20Mins).

Activity II: Gender participation in Climate Smart Agriculture in seed potato production 1Hour 30Mins)

a. Divide the participants into small groups and ask them to:

   i. List the current gender roles of a male and a female couple, children, youth and elderly from morning to evening on a flip chart

   ii. Critic the role of each player and identifies areas for improvement (1Hour)

a. Ask them to present in plenary as you highlight key issues (30mins)

Emphasis the critical need to:

i. Involve children and youth in family farming for experiential learning and contributing to family labor.

ii. This requires that farmers collectively lobby the Ministry of Education to Agriculture to be a compulsory subject in rural and boarding schools as a food security (Family) and income security measures for family and schools.

iii. That all boarding schools that have land have an agri-enterprise unit.

iv. In addition, have a school calendar that helps contribute to family labor. I.e. long school holiday coincides with months with the heaviest farm labor demand. This happens in most developed economies, but is not the case in Kenya and other parts of Africa. In Kenya the longest school holiday is during the rainy season when 1st and 2nd weeding is need to maximum yields.

v. To do this and other lobby and advocacy campaign, farmers must be organized in producer groups from local, county and national level and target lawmakers at these levels with evidence and hard data that speaks for itself.

Activity IV: Gender differences in access to and adoption of CSA technologies (1 Hour 30Mins).

a. Divide participants in small groups and request them to:

   i. List the CSA technologies practiced in seed potato production (10Mins).

   ii. Discuss and tabulate the gender involvement in the practice of listed CSA technologies in soil moisture conservation (40Mins)

   iii. Discuss and tabulate the gender involvement in the practice of listed CSA technologies in soil erosion prevention (40mins)

b. Ask them to present their output in plenary as you highlight key issues

Conclusion  20 Minutes

The facilitator will solicit feedback from the participants on actions they will take to optimize on roles of the different gender groups in a household and community to improve practice of CSA and seed potato production.

SESSION NOTES

Gender mainstreaming csa potato seed production

In Africa women provide the largest share of agricultural labor yet get the least economic benefits in potato production. Women's role include: land preparation, variety selection, planting, weeding, harvesting, and sorting/grading. Men's role include: land clearing and ploughing, purchasing inputs, hiring of labor, making furrows, laying out of soil and water management structures, control of pest and diseases (spraying), and transportation of harvested produce.

Men and women participate in various roles in potato production. The seed potato value chain among smallholder farmers in Africa is in its early development stages and is still dominated by men. Women's role in crop production is often restricted due to their poor access to productive resources such as education and finance. The situation is further exacerbated by other roles like domestic and reproductive roles. Lack of women's' participation in commercial seed potato production is as a result of their lack of access to land and other production inputs. Owing to the differences in the tasks performed by male and female potato farmers, they have knowledge

differences in the production of these crops. The pictures below illustrate the different roles performed by women and men in potato seed production in Nakuru County, Kenya.

Figure 1.12: Women apply fertilizer

Figure 1.13: Men make furrows & potato seeds in Elburgon demo plot

Figure 1.14: Women collect potatoes

Figure 1.15: Men transport potato
(Source: Community Action Research Program Plus [CARP+] partner)

Gender differences in access to and adoption of CSA technologies

There are numerous studies that look at gender differences in technology adoption. There is much variability among these studies in the inputs, crops, and locations analyzed, as well as in study designs, sampling, sample size, quality of data collection tools and analytical techniques,

and in the indicator of gender used. Given this wide variability and the limited available empirical research for many types of technologies, it is hard to generalize patterns of gender differences. However, there are some key insights and general lessons from these empirical studies reviewed and they are discussed below.

Clearly, technology is valuable because of the possibilities it creates in women's lives and the improvements it can provide to their livelihoods. Productivity is vital, and for sub-Saharan African countries that rely heavily on agriculture, knowledge of new techniques that can increase productivity and growth is critical. Four main categories of technology inputs of importance to small-scale female farmers are: (1) inorganic fertilizer, (2) insecticides, (3) improved seed varieties, and 4) mechanical power. Inorganic fertilizer refers to a nitrogen-based chemical mixture used to improve soil fertility. Inorganic fertilizer is differentiated from organic fertilizer (such as animal manure, compost, or other living mulch) by its manufacture, chemical modification, and external purchase. Insecticides and pesticides (also called agrochemicals) are primarily synthetic spray-applied agents used to increase crop yields through pest, bacteria, and weed destruction or control. Improved and genetically modified seed varieties are artificially produced by cross-pollination to increase yield, uniformity, and resistance to disease. Mechanization means the introduction of mechanized farming tools or other equipment (tractors, seeders, and weeders) into the farming practice. Although rural women are knowledgeable about and use traditional technology, these traditional technologies are labor intensive, time consuming, and energy sapping and usually inefficient to generate the expected results. Available evidence indicates that agricultural technology development has largely ignored the needs and priorities of the women. Women are often subjected to the unintended side effects of modern technologies introduced for the benefit of others (FAO, 1997).

The table below provides distinction in Gender roles in Climate smart agricultural practices used for soil and moisture conservation

Table 1.1: Access to Soil Moisture Conservation CSA by Gender

	CSA practice	Male		Female		Both	PWD	ALL
		Youth (<35 y)	> 35	Youth (<35 y)				
1	MULCHING			*	*			
2	COVER CROP		*	*	*			
3	CONSERVATION TILLAGE					*		
4	ZAI-PITS							*
5	GREEN MANURING					*		
6	BROWN MANURE							*
7	BUNDS	*	*					
8	RIDGES & TIE RIDGES	*	*					
9	WIND-BREAKS (AGRO-FORESTRY)							*

Table 1.2: Access to Soil Erosion Management CSA Practices by Gender

	CSA practice	Male		Female		Both	PWD	ALL
		Youth (<35 y)	> 35	Youth (<35 y)				
1	TERRACING	*	*	*				
2	CONSERVATION TILLAGE					*		
3	CONTOURS							*

	CSA practice	Male		Female		Both	PWD	ALL
		Youth (<35 y)	> 35	Youth (<35 y)				
4	GABIONS					*		
5	STRIP CROPPING	*	*					
6	WIND-BREAKS (AGRO-FORESTRY)							*
7	WATER PONDS/PANS	*	*	**	**			
8	ROOF-WATER HARVESTING	*	*	**	**			
9	CHECK-DAMS	*	*	*				
10	LARGE WATER RESERVIORS (County governments/CDF/NGOS')	*	*					

Obstacles to women adopting CSA technologies

The obstacles preventing rural women's access to and utilization of appropriate technologies include the following:

a. Technologies are not gender-sensitive: New technologies and inputs are channeled primarily towards cash crops, which are always in the domain of men.

b. Agricultural technology development has largely ignored the needs and priorities of women.

c. Women lack money required to purchase farm inputs and new technologies.

d. Women lack knowledge and skills to apply new technologies.

e. Women are not consulted on their technology needs.

f. Agricultural extension and training resources, including appropriate technologies, are predominantly directed to men. Rural women are not particularly targeted and reached.

Solutions to the above challenges will be of tremendous benefits to rural women if the following actions are considered:

- Technology is gender sensitive
- Provision of credit facilities
- Adequate training on application of improved technology targeting women
- Peculiarity of culture of the different communities should be considered in fashioning out appropriate technology.

Gender Role-Change in potato & seed potato production

In recent times there have been changes in role performance of men and women in many gender-specific activities. Women are now performing agricultural production roles traditionally ascribed to men and vice visa. Additionally, women-headed households are becoming more involved in roles that were traditionally men's, i.e., land preparation, making of furrows, varietal selection and even marketing. For these reasons, it is necessary to learn the extent to which gender roles are changing and their impact on seed potato value chain.

Factors responsible for change of Gender Roles in seed potato production value chain

Various factors are responsible for the change in gender roles in potato production. These include:

i. Increase in rural-to-urban migration of men and youth, therefore, leaving behind female-headed homes. Furthermore, labor availability in the potato sector is declining. Women are currently being involved in making furrows.

ii. Funding opportunities to women through NGOs, Government initiatives i.e. Uwezo fund and Women Enterprises Fund.

iii. Additional responsibilities undertaken by women at the household level due to lack of support by their spouses. This makes women to look for additional means of sourcing for income by performing other agricultural activities that were traditionally meant for men.

iv. Increase in number of female-headed households: Many households are headed by women and so the need to provide for the family has led to changes in roles performed on gender bases; where women produce potato for commercial use.

v. Men have become disenfranchised from their traditional roles, and some have turned to be drunkards and irresponsible family heads, leading to separation of families.

vi. Youth do not consider agriculture as a potential career after finishing high school

vii. Youth lack the land and financial input to invest in agriculture

Women are becoming more involved in roles along the potato value chain that were previously dominated by males (e.g., marketing, hiring of farm labor). Women are prioritized in initiatives that provide finance and trainings, thus empowering them with critical resources that make them effective decision-makers. It is therefore, important to understand changing gender roles within the seed potato value chain and its impact on production, household income and stability of families.

Further Reading

Case study on gender (***See Annex 1.1***)

Food and Agriculture Organization (2010) Gender and Land Rights: Understanding Complexities; Adjusting Policies. Economic and Social Perspectives –Policy Brief No. 8 © FAO 2010

Food And Agriculture Organization (FAO) of the United Nations, (2013) governing land for women and men: A technical guide to support the achievement of responsible gender-equitable governance land tenure. Rome.

Session 1.8: Community Engagement Process for effective Adoption of Climate Smart Agriculture in Seed Potato Production (2 Hours)

Description:

This session covers the process and importance of engaging communities in adopting CSA technologies and practices. It also presents the challenges of community engagement in development of the seed potato value chain. It will enable learners to effectively facilitate interactions and engagement of all value chain actors in adoption of CSA technologies.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain importance of community participation in adoption of CSA

2. Apply principles of community engagement in developing a Seed Potato Value Chain
3. Facilitate the process of community engagement in CSA seed potato value chain development

Learning aids and materials

• Flip chart/Board, marker pen	• LCD projector, laptop
• Community engagement case study	• Handouts

Procedure

Activity I: Introduction (20mins)

a. Ask learners to:
   i. Define community engagement and participation
   ii. Explain four types of community engagement in agricultural development
   iii. Explain key concepts that apply to the types of community engagement
b. Ask them to present in plenary as you highlight key terms

Activity II: Case study on community engagement (1 Hour 20mins)

a. Divide participants in small groups as ask them to:
   i. Read the case study on community engagement (*See Annex 1.2*)
   ii. Identify the important community stakeholders
   iii. List the steps in process used to engage community stakeholders and its strengths
   iv. Identify the flaws, if any that led to some of the community members disengaging
b. Ask groups to present their findings in plenary

Conclusion (20mins)

Conclude the session by highlighting key steps of community engagement in developing the seed potato value chain and their importance.

Further reading

If you want to learn more about community engagement for disaster risk reduction using the community managed disaster risk reduction (**CMDRR**). Check the following resources:

a. *https://www.cordaid.org/en/publications/building-resilient-communities-training-manual-community-managed-disaster-risk-reduction*
b. *https://www.preventionweb.net/files/18799_cmdrrmakingoperationalfinal.pdf*
c. *https://www.slideshare.net/zula27/cmdrr-best-practise-of-acord-trocaire*

SESSION NOTES

Role of community engagement in adopting CSA in seed potato production

Community Engagement is the process of involving your target group and partners in the whole cycle of a project or activity. It involves engagement at personal level even within the formal institutions. It is the strategic process of working with identified groups of people

whether connected by geographical location, special interest or affiliation to identify and address issues affecting their well-being. (*https://aese.psu.edu/research/centers/cecd/engagement-toolbox/engagement/what-is-community-engagement*).

It is the process of establishing project buy-in and support by various actors who are critical for the success of the project. Community engagement infers to the concept of inclusivity in project implementation. It is the process of seeking approval and participation of stakeholders (leaders and inhabitants of a village/county) in a long-term relationship to achieve a common development goal. See Case study on approaches of community engagement.

Types of community engagement

a) Focus on community development or community building in CSA in seed potato

A lot of community engagement is focused on community development and community building. Community engagement in this context covers two aspects. First, involving community members is an important underpinning of many identified approaches (such as ABCD). Second, a feature of strong communities is high levels of social capital and, so community building often focuses on encouraging people to be actively involved in their community generally.

b) Consultation and decision-making in CSA

Many organisations including schools, health services, government departments such as agriculture sector (CSA) and planners need to consult communities about a range of issues. By involving the community in meaningful ways, this consultation can be more than tokenism. A tool that many practitioners find useful is the Spectrum of Public Participation by the International Association of Public Participation (IAP2).

The Spectrum provides a useful tool in thinking about the level of community involvement in consultation and decision-making. It is important to think carefully about the level of participation that is appropriate for the context and not to promise more than will be delivered. It is important to note that the first level – inform – is not really a level of community participation, as it is only a one-way process. It has a place in the spectrum, however, because it is an essential foundation for the other levels.

Atlee *et al* (2009) have identified seven principles of community engagement, which are useful when thinking about engaging the community in consultation and decision-making.

1. CAREFUL PLANNING AND PREPARATION

Through adequate and inclusive planning, ensure that the design, organization, and convening of the process serve both a clearly defined purpose and the needs of the participants.

2. INCLUSION AND DEMOGRAPHIC DIVERSITY

Equitably incorporate diverse people, voices, ideas, and information to lay the groundwork for quality outcomes and democratic legitimacy.

3. COLLABORATION AND SHARED PURPOSE

Support and encourage participants, government and community institutions, and others to work together to advance the common good.

4. OPENNESS AND LEARNING

Help all involved listen to each other, explore new ideas unconstrained by predetermined outcomes, learn and apply information in ways that generate new options, and rigorously evaluate public engagement activities for effectiveness.

5. TRANSPARENCY AND TRUST

Be clear and open about the process, and provide a public record of the organizers, sponsors, outcomes, and range of views and ideas expressed.

6. IMPACT AND ACTION

Ensure each participatory effort has real potential to make a difference, and that participants are aware of that potential.

7. SUSTAINED ENGAGEMENT AND PARTICIPATORY CULTURE

Promote a culture of participation with programs and institutions that support ongoing quality public engagement.

c) Improving service delivery and achieving organizational goals

There are many cases where community engagement is essential for organisations or businesses to achieve their goals. Many of the events held by charities and other not-for-profits rely on community engagement. Some benefits for businesses of community engagement identified include

- Morale building
- Professional development
- Brand or status recognition
- Recognised as a valued member of the community
- Aligning activities with the organisation's value.

d) Social change and voluntary community groups

Community engagement by social change movements and community groups can have similarities with the other types, but there are also differences. Often the focus of the first three types is where an organisation that is not part of the community (e.g., a government department) is looking to engage a community. Quite often these organisations are power holders and are able to implement decisions. Social movements and voluntary community groups are often part of the community and need to rely on others for funding or to implement decisions. This creates a different dynamic.

Key definitions

Participation

This is the active participation and inclusion of all community members and relevant stakeholders. I.e. the rights and voice are respected and contribution of each individual and institutions is valued and recognized.

Community Actors

These are the people in the community who are committed and capable to develop the community. Examples of community actors that should be engaged are: farmer, village elders, local administrative officer (chief), agriculture extension officer, elected leaders, church leaders etc.

Stakeholders

These are the strategic institutions that provide input supplies and business development support services to support the local farming communities. Examples include: Ministry of Agriculture, Agro-input suppliers, Business development Service providers, financial service providers, research institutions, regulators, among others.

Community Engagement Process

The process used in engaging the community stakeholders are:

1. Identification of common problem/need or opportunity e.g. need to improve the quality and quantity of potato harvested per acre.
2. Identification of required interventions - activities, expertise, technology etc. An example to above problem is to increase seed potato availability and reduce cost, sensitize farmers on the need to use quality seed potatoes for higher yields and income, lobby ministry of agriculture to have a subsidy for seed potato to avoid seed contamination, improve the seed potato marketing system and among others
3. Identification of required resources and which individual or institution will provide each? Use the Asset Based Community Development approach (ABCD) principles (insert web link)
4. Identify actors and their respective roles. Have MOU on objectives of collective action, joint work plan and expected outcomes, roles, contributions (in cash or kind) and level of partnership
5. Initiate establish a working rapport.
6. Implement activities in partnership with actors as per respective roles and project goal.
7. Regularly monitor and evaluate progress, as the team learns and improves performance

Asset Based Community Development Approach

Asset-based community development (ABCD) or asset-based community-driven development is a way of working with communities that focuses on community strengths and assets rather than on deficits and problems.

ABCD focuses on the half-full glass approach. The half-empty glass represents the notion that communities are deficient and have many needs. The half-full glass represents the notion that communities (and the people who live there) have many strengths, capabilities and assets. It is the half-full glass that gives us something to work with.

ABCD is built on four foundations (Kretzmann, 2010; Kretzmann & McKnight, 1993; Mathie & Cunningham, 2003):

1. It focuses on community assets and strengths rather than problems and needs
2. It identifies and mobilizes individual and community assets, skills and passions
3. It is community driven – 'building communities from the inside out' (Kretzmann & McKnight, 1993)
4. It is relationship driven.

References

Anthony M. Kibe & Rahab W. Ngumba (2020). Establishing and Scaling the Seed Potato Community Action Research Multi-Stakeholder Platforms: Lessons & Experiences from Kenya. ***International Journal of Innovative Research and Knowledge,*** Volume-5 Issue-12, December 2020, ISSN-2213-1356.

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MODULE 2


Shangi
Dutch Robjin
Kenya Karibu
Unica
Tigoni
Sherekea
Nyota
adc
Variety: Dutch Robjin

SEED POTATO BULKING AND MULTIPLICATION

SESSION		DURATION (Hours)	
		Theory	Practical
2.1	Meaning and Importance of Seed Potato Multiplication and Bulking	1 Hour 30mins	
2.2	Identification of Important Potato Varieties in Kenya	30mins	2 Hours
2.3	Classes of Seed Potato and Sources	2 Hours	
2.4	Seed Certification Procedure	1 Hour	
2.5	Seed Inspection Protocol	1 Hour	
2.6	Ecological Requirements for Seed Potato Production	1 Hour	
2.7	Site Selection and Land Preparation	1 Hour	2 Hours
2.8	Preparing Seed Potato for Planting	1 Hour	
2.9	Agronomic Practices and Management of Seed Potato Crop	1 Hour	2 Hours
2.10	Controlling Weeds in Seed Potatoes	1 Hour	1 Hour
2.11	Pest and Disease Management in Seed Potato	1 Hour	2 Hours
2.12	Harvesting Seed Potatoes	1 Hour	2 Hours
	Assessment of learning	1 Hour	
	Sub – Total	14 Hours	11 Hours
	Total	25 Hours	

**** 5 – day training of 5 Hours per day**

Session 2.1 Importance of Seed Potato Multiplication and Bulking

Duration 2 Hours

Description

The session will use the previous knowledge of the participants to build an understanding of the meaning and importance of seed potato multiplication and bulking for food security and economic development. This is necessary to provide learners with a background on which other topics will be built on.

Learning Outcomes

By the end of this session, the participants should be able to:

1. Define the concepts of seed potato multiplication and seed potato bulking.
2. Explain importance of seed potato multiplication and bulking in potato production.
3. Relate seed potato multiplication and bulking to food security and economic development.

Learning aids and materials

• Flip charts, LCD projector	• Publications, News articles
• Photos and diagrams	• PowerPoint

Procedure

Activity I: Introduction (20mins)

a. Through guide questions, use brainstorming to find out learner's existing knowledge on seed potato production.

b. Define concepts of seed potato multiplication and bulking.

c. Differentiate between bulking and seed multiplication.

Activity II: Group discussion and presentations (1 Hour)

a. Divide participants into small groups to discuss the importance of seed multiplication and bulking in potato production for food security and economic development (20Mins).

b. Ask them to present in plenary and consolidate the ideas (10Mins).

c. Present PowerPoint (PPT) on importance of seed potato multiplication and bulking for food security and economic development (20Mins).

Activity III: Potato Multiplication Process (30Mins)

a. Present a chart illustrating the different stages of growth in seed potato production.

b. Ask participants to make their observations.

c. Conclude session by explaining that seed producers play an important role in potato production

Summary 10 minutes

Reading Assignment: Ask participants to read on potato varieties and their uses in preparation for next lesson. E.g., Kenya participants can refer to National Potato Council of Kenya (NPCK) catalogue 2021.

SESSION NOTES

Different types of seed potato multiplication systems

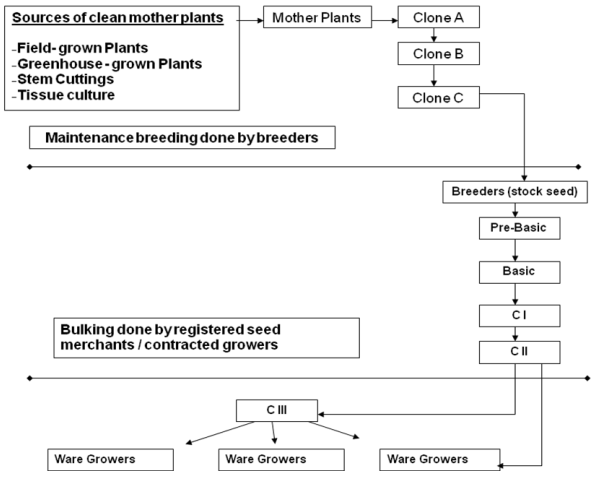


Figure 2.1: Seed multiplication flow chart

Figure 2.2: Production of Mini-tubers using aeroponics technique

Figure 2.3: Production of Mini-tubers through hydroponic technology

The flow diagram below shows the multiplication process from mother plant to seed potato

Figure 2.4: Mother plant

Figure 2.5: Apical rooted cuttings

Figure 2.6: Mini-tubers

Figure 2.7: Seed potato crop in the field

Figure 2.8: Harvested and graded seed potato in a store

References

KEPHIS (2016) Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.2: Identification of Important Potato Varieties

Duration 2 Hours (Theory 30 minutes; Practical 1 ½ Hours)

Description

The session will enable participants to identify important potato varieties, their uses and buyers. This will enable participants to select seed potato buyers and varieties to grow in their farms.

Learning Outcomes

By the end of this session, the participant should be able to:

1. Identify common potato varieties using visible characteristics.
2. Explain factors considered by farmers in selecting suitable seed potato varieties to grow.
3. Select suitable seed potato varieties to grow for their food security and economic development.

Learning aids and materials

• Potato catalogue (E.g., NPCK, 2021)	• Pictures, videos & sample potato varieties
• Flip charts, projector, computer	• PowerPoint presentation
• Demo Farm	

Procedure

Activity I: Introduction (10Mins)

a. Ask learners to mention different varieties and their uses (use questions below).

   i. Which potato varieties are grown in your Country and home area?

   ii. Which of these varieties are important according to you? Why?

   iii. What are the uses of each variety?

Activity II: Group discussion and presentations (30Mins)

a. Display tubers and pictures of different potato varieties (see *Manual for local seed potato multipliers. Improving access to quality seed by smallholder farmers* (International Potato Centre, 2018). (10Mins)

b. Ask participants to identify the various varieties displayed. **(20mins).**

Activity III: Visiting a demonstration plot (1 Hour)

Book the visit with the farmer, arrange transport if required and provide guide questions.

a. At the farmer's farm, ask learners to identify the varieties available in the demonstration farm as they take notes and pictures.
b. Farmer presents her/his seed potato agribusiness achievements, challenges and lessons
c. Learners ask the farmer questions.

Summary  20 minutes

Use question and answer techniques to ask participants what they have learnt.

Assignment: Each learner to write a field learning report including the following: Lessons learnt, seed potato variety selected for production and why, action plan for seed production.

References

Manual for local seed potato multipliers (2018) *Improving access to quality seed by smallholder farmers*. International Potato Centre

Potato catalogue (E.g., NPCK, 2021)

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.3: Classes and sources of seed potato

Duration  2 Hours

Description

This session will enable participants to explain the meaning and importance of various classes of seed potato and their sources. This is necessary to provide participants with knowledge on the importance of certified seeds and the implications of various classes on production. Participants will be exposed to various sources of certified potato planting materials.

Learning Outcomes

By the end of this session, the participant should be able to:

1. Explain meaning of seed potato
2. Differentiate classes of seed potatoes and their importance in seed production
3. Identify sources of certified seed potatoes

Learning aids and materials

• Seed potato catalogue	• List of companies/farms selling certified planting materials, e.g., KEPHIS website
• Flip charts, projector	• Pictures

Procedure

Activity I: Introduction (15Mins)

a. Ask participants to mention the different classes of seed potatoes.

b. Ask participants to mention possible farms/companies/institutions from which they can get certified planting materials.

Activity II: Presentation on different classes of seed potato (1 Hour)

a. Display table (Power Point/flip charts/handout) on different classes of seed potato and their sources.

b. Distinguish between the different classes

Activity III: Group discussion and presentations (30Mins)

a. Divide participants into small groups to discuss different classes of potato seeds they will select to grow.

b. Ask them to present their outputs and consolidate the lessons/ideas.

Summary  15 Minutes

Use question and answer technique to find out participants' level of learning

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.4: Seed certification procedure

Duration  2 Hours

Description

This session will enable participants to know the procedure undertaken to produce certified seed potato tubers. It will help the participants to know how to fill in the forms, which are to be submitted to the regulatory authority (e.g., KEPHIS in Kenya) for the registration of the farmer and the crops. The automated registration system used by KEPHIS in seed certification will also be presented.

Learning Outcomes

By the end of this session, participants should be able to:

1. Apply to be registered as a seed potato producer
2. Make an application for field inspection of certified seed potato seed crop by filling in SR5 (Seed Regulation No. 5) form.
3. Enumerate the stages of inspection and sampling of a potato seed crop using form SR9.

4. Log on to ***www.seed.kephis.org*** and submit applications for inspection.

Learning aids and materials

- Seeds and Plant Varieties Act Cap 326 Laws of Kenya
- SR5 form
- SR9 form

Procedure

Activity I: Introduction (10Mins)

a. Explain to the participants the stakeholders involved in the seed industry such as the breeder, merchant, and seed grower.

b. Explain the stakeholders' roles as described in the Seeds and Plant Varieties Act Cap 326 Laws of Kenya.

Activity II: Presentation and discussion on SR5 (30Mins)

a. Using a blank SR5 form highlight the mandatory spaces to be filled in when registering a seed crop.

b. Guide the participants on how to fill the various sections in SR5 form and explain to them why each of the spaces have to be filled with the right information. Note that it is this form that forms the basis of engagement between the farmer and KEPHIS, the regulatory authority.

c. Ask participants to fill a SR5 form with their details and register at least one crop as a sample.

d. Go through the collected filled SR5 forms and check for any mistakes and give feedback in the next session.

Activity III: Presentation (10Mins)

Display a sample SR9 form and explain the section that should be filled by the seed grower (farmer or merchant).

Summary  10 minutes

Ask one participant to outline the step-by-step procedure of seed certification. Correct where necessary.

SESSION NOTES

Seed certification

Introduction

Seed potato certification is a process conducted by certification agency in a given Country. In Kenya, Kenya Plant Health Inspectorate Services (KEPHIS) is the certification agency. It is

designed to ensure that seed producers maintain and make available to farmers a continuous supply of high quality seeds and propagating materials. It is a legally sanctioned system for quality control of seed multiplication and production.

Seed certification is conducted by KEPHIS in Kenya for the following reasons:

i. Enforce government regulations (e.g., CAP 326 Laws of Kenya).
ii. Promote agricultural trade (local and international) by complying with set regulations/agreement.
iii. To ensure that the best quality seed are produced and sold to the farmers.
iv. Curb the spread of weeds, pests and diseases, particularly the invasive type.
v. Meet customer demands for specified qualities.
vi. Cater for the needs of specialized farming.
vii. Comply with mechanization of agriculture.

Potato Seed Certification process

The certification involves the following stages:

i. Registration

The process of potato seed certification starts with registrations of seed merchants and seed growers. This is to ensure that potato seed production is only done by registered seed merchants and seed growers who have been vetted and have met the set requirements.

The difference between a seed merchant and seed grower is:

Seed merchant

A seed merchant is a person or an organization engaged in seed business of seed production, conditioning and marketing, and registered to do so by KEPHIS.

Seed grower

A seed grower is a person or a group of people contracted by seed merchants to grow potato seeds on their behalf. However, due to potato seed shortage, individual seed growers, farmer groups and cooperatives are allowed to register as seed growers without being registered as seed merchants but have to be introduced by the Ministry of Agriculture or KALRO.

NB: A seed merchant can also be a seed grower.

A seed grower identifies an isolated piece of land on his farm to do seed potato production and invites the regulator (in this case KEPHIS) for soil sampling for the purpose of testing availability of bacterial wilt and potato cyst nematode (PCN). This is because a farm identified for seed potato production should be negative for both PCN and bacterial wilt disease. Bacterial wilt disease and PCN are zero-tolerated in seed certification and therefore, testing the soils before seed potato is important.

After acceptance to be a seed merchant or grower the farmer fills a work order.

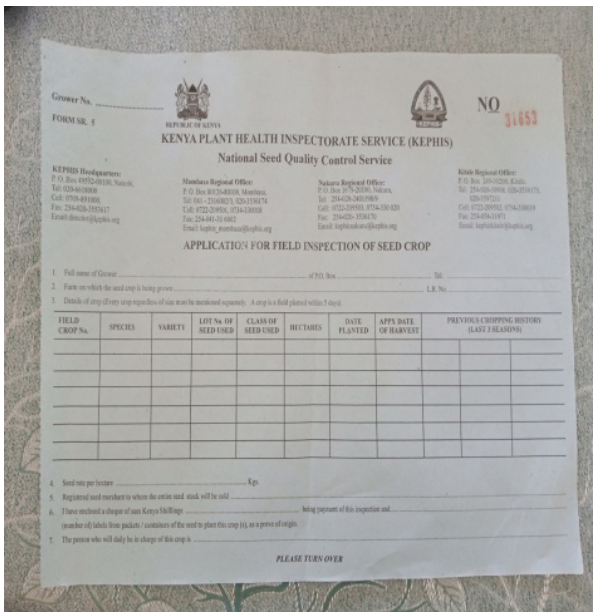
ii. Potato seed inspection

1. Field inspection application
2. Field inspection

1. Field inspection application

This is done after germination using form SR5 and the following information must be indicated clearly:

a. Name of the grower
b. Grower number
c. Contacts of the person in charge of the crop
d. Field crop number
e. Variety of the crop
f. Species of the variety
g. Lot numbers used
h. Size of the crop field in hectares
i. Date of planting
j. Apex date of planting
k. Cropping history of the farm
l. Details of the crop location


FORM SR. 5

KENYA PLANT HEALTH INSPECTORATE SERVICE (KEPHIS)

National Seed Quality Control Service

APPLICATION FOR FIELD INSPECTION OF SEED CROP

PLEASE TURN OVER

Figure 2.9: Seed application form SR 5

2. Field inspection of seed potato crop

In seed potato crop production, two inspections are carried out during the growing season. The first inspection is done at flowering stage or canopy cover (for non-flowering varieties) and the second inspection is done at tuber development stage.

During the inspections, parameters checked are the isolation distance (distance from other potato crops), diseases and off types and there are varying tolerance levels for each parameter depending on the class of seed.

NB: Potato seed crop can be rejected or approved by a seed inspector based on the tolerance levels of the parameters inspected for.

Separation and isolation of seed potato crop

A seed crop shall be separated from a neighboring commercial potato crops by distance as shown in the table below.

Isolation distance in meters (minimum) from a commercial crop

Breeders	Pre-basic	Basic	C1	C2 & C3
100 meters	100 meters	100 meters	50 meters	50 meters

A seed crop shall be separated from a neighboring seed crop by a space of at least 5 meters for basic seed and at least 2 meters for certified seed. In case of sloppy areas, appropriate measures are put in place to avoid contamination.

Isolation distance in meters (minimum) from another seed crop

Breeders	Pre-basic	basic	C1	C2 & C3
5 meters	5 meters	5 meters	2 meters	2 meters

Off-type

This is a plant of the same species with the seed crop but different in characteristics. It is one of the parameters considered during inspections and there are tolerance levels depending on the class of seed as shown in the table below.

Off types of other cultivars; Maximum number per 100 plants

Breeders	Pre-basic	basic	C1	C2 & C3
0	1 plants	2 plants	2 plants	3 plants

Diseases

Bacterial wilt disease, potato cyst nematode and black leg are zero-tolerated at all seed classes of inspection.

Inspection technique

Starting from a random position in the field, count 100 plants (equivalent to 30 meters or spaces) along a row, omit three rows and continue the count on the 4th row etc.

At final inspection, a potato seed crop is approved if it meets the minimum field quality standards. An inspector may advice destruction of foliage (dehaulming) and it depends on tuber size and the aphid pressure. The inspector may advice the grower on the appropriate time to dehaulm after approval which should be within 14 days. More information on inspection is covered in next session.

iii. Potato seed sampling

Tuber sampling is done after the final inspection where 400 tubers are picked randomly from the field and taken to regulatory authority laboratory e.g. KEPHIS for bacterial wilt and PCN testing. Potato seed crop, which tests negative for both parameters will then be harvested as seed and taken to a store for selection and grading.

Grading

Seed potatoes are graded into the following sizes:

Size 1: 28mm-45mm

Size 2: 46-55mm

iv. Lot examination

A lot is a consignment of potato seed with a maximum of 40,000 kgs. This inspection is done at the grading store.

The following diseases/abnormalities will be permitted up to the stated tolerance.

Disease/Abnormality	Basic	Certified
Rhizoctonia	10	30
Pink rot	0	0

Disease/Abnormality	Basic	Certified
Severe tube moth	2	5
Mis-shape and damaged tubers	0	5

Sampling for post control

A sample of 120 tubers per seed lot shall be taken for control testing.

Reasons for post control testing

- Seed certification according to Kenyan Law CAP 326 and OECD seed schemes is required to check the progress of a variety at different stages in the seed production.
- These tests are meant to ascertain that the preceding control measure have been effective. They ensure that varietal characters remain unchanged during multiplication.
- The tests are used to monitor the identity and purity of variety (being hybrid or non-hybrid), at various stages in the seed multiplication program.
- To detect possible mechanical admixtures, mutations, undesired cross-pollination and other unforeseen occurrences that could affect the quality of the seed.

v. Labeling

Labeling is done after lot examination. The grower applies for labels by attaching a work order and lot examination report to the application. A seed label contains the following details:

- Variety
- Species
- Lot Number
- Seed class

NB: Labeling is discussed in detail in module 3.

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.5: Seed Inspection Protocol

Duration 1 Hour

Description

This session will equip participants with potato seed inspection skills. The participants will be able to understand what is done during field inspections. It will enable them to manage their crops in line with the inspection authority (e.g., KEPHIS) requirements.

Learning Outcomes

By the end of this session participants should be able to:

1. Explain factors and stages considered during inspections.

2. Distinguish healthy and sick plants.
3. Explain meaning of 'counts' and how they are made in a seed potato field.

Learning aids and materials

• Seeds and Plants Varieties Act Cap 326 Laws of Kenya	• Field of at least 2 potato varieties at flowering stage
• SR6 – Inspection report form	• Tape measure calibrated in meters
• KEPHIS field inspection manual	• Variety descriptor (e.g. from KEPHIS)

Procedure

Activity I: Introduction (10Mins)

a. Captivate participants by asking them to share their experiences with field inspections.
b. Explain the importance of field inspections as important steps in seed certification.

Activity II: Group discussions on field inspection (20Mins)

a. Divide the participants into groups and distribute copies of SR6 to each group.
b. Ask them to discuss the sections to be filled in the form.
c. Ask participants to highlight the issues to be observed during field inspection like isolation distance; diseases and off-types (Refer to previous session).

Activity III: Presentation of allowable tolerance levels (20 Minutes)

a. Explain, using the tables in inspection manual, the tolerance levels in different classes of seed based on off-types and diseases. (See Table 2.1 in the session notes below).

Summary 10 minutes

Ask participants to highlight key steps in seed crop inspection as you emphasis on key points.

SESSION NOTES

Figure 2.10: Healthy plants and sick plants

Area (ha)	Counts (each30m or 100 plants)	No. of Plants Counted
<1	10	1000
1-6	20	2000
6.1-8	24	2400
8.1-10	28	2800
10.1-12	32	3200
12.1-14	36	3600
14.1-16	40	4000
16.1-18	44	4400
18.1-20	48	4800

Table 2.1: KEPHIS guideline for number of plant counts during field inspections

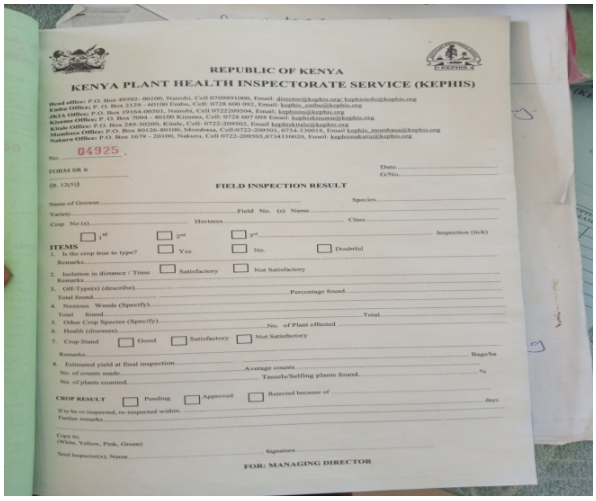


Figure 2.11: Field inspection form SR 6

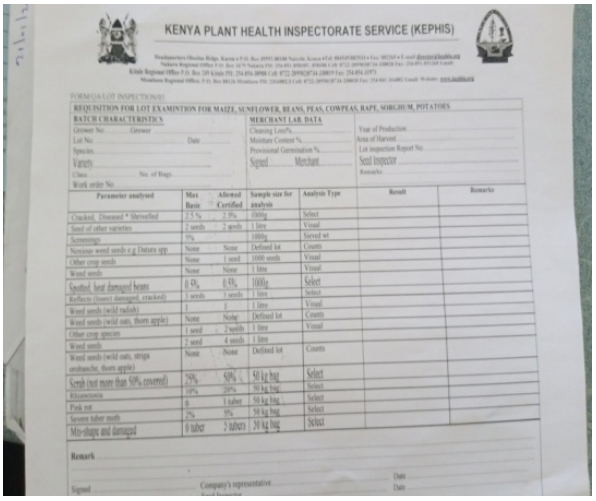


Figure 2.12: Lot examination form

Disease	Tolerance during any inspection				
	SS	PB	B	CI	CII
Bacterial wilt or Brown rot ***(Ralstonia solanacearum)***	0	0	0	0	0
Wart disease ***(Synchytrium endobioticum)***	0	0	0	0	0
Golden nematode/potato cyst nematode ***(Globodera rostochiensis)***	0	0	0	0	0
Ring Rot ***(Corynebacterium sepedonicum)***	0	0	0	0	0
Potato Spindle Tuber Viroid	0	0	0	0	0
Mycoplasma	0	0	0	0	0
Black leg ***(Erwinia spp, Pectobacteria spp, Dickeya spp.)***	0	0	0	0	0
Severe virus disease	0	0	0	0	0
(leaf roll, Y-group virus severe mosaic)	2	4	5	10	10
Mild mosaic visible in the field	0	5	10	13	15
Fusarium wilt, Verticillium wilt	0	1	2	3	3
Nematodes ***(Meloidogyne spp. and Ditylenchus spp)***	0	0	2	3	4

Table 2.2: Diseases levels of tolerance in various seed potato classes during field inspections

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.6: Ecological Requirements for Seed Potato Production

Duration 1 Hour

Description

Although potatoes are grown under many different ecological conditions, not all conditions are suitable for producing seed potatoes of good quality. This session is aimed at equipping participants with knowledge that will enable them to select and also advice on the optimum ecological requirements for production of quality seed potatoes.

Learning Outcomes

By the end of this session, participants should be able to:

1. Explain the optimum ecological conditions for growing seed potatoes.
2. Identify suitable conditions for growing seed potatoes, in terms of temperatures, rainfall and soils.
3. Relate ecological conditions to yields and quality of seed potatoes.

Learning aids and materials

- Flip charts, projectors, computer
- NPCK Potato Catalogue, 2021

Procedure

Activity I: Introduction (25Mins)

a. Introduce session by explaining importance of growing seed potato in right ecological conditions for optimal yields and quality

b. Divide participants into small groups and ask them to:

   i. Discuss about the potato growing areas they are familiar with,

   ii. And the kind of ecological conditions (rainfall, temperatures and soils) that are found in their locality and country

c. Ask participants to present their group reports as one of them captures the main points on a flip chart

Activity II: Interactive lecture (25 Minutes)

a. Present a suitable video or PowerPoint to highlight the optimum ecological conditions for seed potato production.

b. Ask participants about the effects of extreme rain and temperature conditions, and poor soils on the yields of seed potato.

c. Highlight the importance of ecological conditions to yield and quality of seed potatoes

Summary 10 minutes

Using question and answer techniques, lead participants to summarize the main points covered in the session.

Take home exercise: Ask participants to find out other conditions that seed potatoes need in order to grow well.

References

Manual for local seed multipliers, CIP, 2018

National Potato Catalogue, 2021

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.7: Site Selection and Land Preparation

Duration 3 Hours (Theory 1 hour; Practical 2 hours)

Description

This session will enable learners to select the best site for seed potato production. It also equips learners with land preparation knowledge and skills.

Learning Outcomes

By the end of this session, the participants should be able to:

1. Explain the factors to consider when selecting a good site for planting seed potato
2. Demonstrate process of preparing a seed potato field using correct equipment

Learning aids and materials

• Farm machinery and equipment	• Projector, Pictures, Flip charts
• Felt pens, tape measure	• Planting line

Procedure

Activity I: Introduction (40 Minutes)

a. Ask participants to discuss how to select a site and prepare land for seed potato.
b. Use participant's knowledge, to explain how to select a site to plant seed potato

Activity II: Practical (2 Hours)

a. Organize the participants into small groups and visit a demo site.
b. Allocate each group a plot to work on (about 5 meters by 5 meters).
c. Demonstrate different ways of preparing land for planting seed potato.
d. Ask participants to carry out land preparation on their respective plots.

Activity III: Summary (20 Minutes)

a. Ask participants to explain the process of site selection for seed potato production.

b. Lead the learners in reviewing the knowledge and experience gained in land preparation.

References

https://agritech.tnau.ac.in/agriculture/agri_tillage_tillageimplements.html

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.8: Preparing Seed Potato for Planting

Duration 1 Hour

Description

This session will equip participants with knowledge and skills on the process of preparing seed potato for planting.

Learning Outcomes

By the end of this session, the participants should be able to:

1. Explain the meaning and importance of dormancy and sprouting in potato tubers.
2. Explain different ways of breaking dormancy in seed potato.
3. Determine different stages in sprouting and link it to productivity.

Learning aids and materials

- Flip charts, Felt pens
- Projector, PowerPoint
- Seed potato tubers at various stages of sprouting

Procedure

Activity I: Introduction – preparing seed potato for planting (50 minutes)

a. Ask participants to share their knowledge on dormancy and sprouting in seed potato.

b. Explain how to break dormancy

c. Demonstrate the various stages of sprouting of seed potato.

Summary 10 minutes

Through guided questions, participants share what they have learnt on dormancy and sprouting.

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.9: Agronomic Practices and Management of Seed Potato Crop

Duration 3 Hours (Theory 1 hour; Practical 2 hours)

Description

This session will equip learners with knowledge and skills on planting and spacing requirements, seed potato nutrition, fertilizer management, ridging/earthing-up and field hygiene. Innovative methods such as surface planting will also be covered.

Learning Outcomes

By the end of this session, the participants should be able to:

1. Demonstrate planting and spacing of seed potatoes using furrows, ridges, and surface planting.
2. Explain fertilizer requirements and management in seed potato.
3. Explain different ways of ensuring field hygiene in a seed potato field.

Learning aids and materials

• Sprouted seed potato tubers	• Farm tools and equipment
• Fertilizers	• Pictures, Flip charts, projector, PPT/Handout
• Weighing scale	• Tape measure, planting line

Procedure

Activity I: Group discussion and presentations (1 hour 15 minutes)

a. Divide participants into small groups to discuss:
b. Planting and spacing of seed potatoes,
c. Fertilizer management,
d. Earthing-up/ridging and surface planting,
e. Good field hygiene practices
    i. Ask the groups to share their findings.
    ii. Consolidate their outputs and make presentation on best agronomic practices.

Activity II: Practical (2 Hours)

a. Divide participants into small groups and assign them the following tasks:

i. Each group to prepare furrows on half (1/2) their plot

ii. Each group to mix and apply fertilizers on the prepared plots.

iii. Groups to plant seed potatoes using correct spacing, earthing up/ridging.

iv. Each group to use surface planting method on remaining half plot.

Summary 15 minutes

Using question and answer techniques ask participants to share key points on agronomic practices in seed potato production.

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.10: Controlling Weeds in Seed Potatoes

Duration 2 Hours (Theory 1 hour; Practical 1 hour)

Description

This session will help participants to identify common types of weeds in seed potatoes and how to apply appropriate methods of controlling them in the field.

Learning Outcomes

By the end of this session, participants should be able to:

1. Identify and distinguish different types of weeds
2. Control weeds using appropriate methods.

Learning aids and materials

• Weed samples, Pictures	• Projector, laptop, PPT/handout
• Chemicals (herbicides)	• Tools (Knapsacks, forked ***jembe***)

Procedure

Activity I: Introduction/Brainstorming (10 Minutes)

a. Ask participants to explain the meaning of a weed and give examples of common weeds.

Activity II: Presentation (30 Minutes)

a. Facilitator asks participants to explain different methods used to control weeds.

b. Do a presentation on different types of weeds and their management.

Activity III: **Field Practical (1 Hour)**

a. Organize for participants to visit a potato field at weeding stage
b. Ask learners to collect different types of weeds and guide them in naming the weeds.
c. Demonstrate the use of different methods used in weed control.
d. Guide the learners to practice the use of different weed control methods.

Summary  20 minutes

Use probing question to find out participants' level of learning.

Session 2.11: Pest and Disease Management in Seed Potato

Duration  3 Hours (Theory 1 hour; Practical 2 hours)

Description

This session will equip learners with knowledge and skills for managing common pests and diseases in seed potato production.

Learning Outcomes

By the end of this session, participants should be able to:

1. Identify pests and diseases affecting seed potato production in their Country/area.
2. Demonstrate the management of pests and diseases in seed potato production.
3. Relate pest and diseases management in seed potato production to economic development and food security.

Learning aids and materials

• Demonstration plots	• Pictures, videos, Power point presentations
• Flip charts, projector, felt pens	• Samples of infected or infested potato plants

Procedure

Activity I: **Introduction (30 Minutes)**

a. Ask participants about their knowledge on common pests and diseases using the following questions:
   i. What are the common potato pests and diseases in Country/area?
   ii. What is the economic importance of these pests and diseases?
   iii. How can the pests and diseases be managed?
b. Ask a few groups to present as you highlight key points

Activity II: Group discussion and presentations (30 Minutes)

a. Display pictures and/or present a video showing different physical features at different parts of the potato plants affected by diseases and pests.

b. Explain the different methods used for pest and disease control.

Activity III: Practical in a demonstration plot (1 Hour 50 Minutes)

a. Divide participants into groups and ask them to:

   i. Identify various diseases and pests in the demonstration plot and their effects.

   ii. Ask them to write notes as they discuss

b. Demonstrate the different methods and agrochemicals used in potato pest and disease management.

c. Ask participants to practice the various methods of pest and disease management.

Summary  10 minutes

Use probing questions to help participants to reflect on what they have learnt in the session

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

Session 2.12: Harvesting Seed Potatoes

Duration  3 Hours (Theory 1 hour; Practical 2 hours)

Description

In this session, participants will be equipped with knowledge and skills on best practices in seed potato harvesting.

Learning outcomes

By the end of this session, participants should be able to:

1. Explain the best stage for de-haulming and methods used.
2. Explain how poor harvesting techniques cause post-harvest losses in seed potato production.
3. Demonstrate de-haulming and harvesting using manual, chemical and mechanized techniques.

Learning aids and materials

• Two demonstration plots (One for de-haulming and one for harvesting)	• Slashers, cutlass (***panga***), Forked ***Jembes***
• Herbicide, knapsack sprayer,	• Bags, weighing scales
• Flip charts	

Procedure

Activity I: Introduction (30 Minutes)

a. Divide participants into small groups and ask them to discuss de-haulming, harvesting and curing.

b. Ask them to present in plenary and summarize learning points.

Activity II: Presentation (30 Minutes)

a. Present PPT on causes and effects of poor harvesting techniques in seed potato production.

Activity III: Practical (1 hour 50 Minutes)

a. Demonstrate to participants how to de-haulm using manual, chemical and mechanized methods (**30 Minutes**).

b. Ask participants to de-haulm the assigned plots using manual method (**20mins**).

c. Demonstrate how to harvest the crop using manual and mechanized methods (**30mins**).

d. Divide participants into small groups, and ask them to harvest using manual and mechanized harvesting techniques (**30mins**).

Summary  10 minutes

Ask participants to share their lessons from the session.

References

KEPHIS. (2016). Seed Potato guideline and certification guidelines: *http://www.kephis.org/images/docs/seedpotatobooklet.pdf*

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MODULE 3

POST HARVEST HANDLING, STORAGE AND MARKETING OF SEED POTATO

OVERALL OBJECTIVES

At the end of this module participants will be able to:

1. Demonstrate knowledge in post-harvest handling of seed potato.
2. Explain the different storage systems used to maintain quality seed.
3. Identify the different diseases and pests affecting seed potato in storage.
4. Use 4 Ps of marketing and various techniques to sell seed potatoes.
5. Keep good and consistent records, analyze costs, sales and profits.
6. Undertake effective policy advocacy to improve the seed potato value chain

	SESSION/TOPIC	DURATION	
		Theory	Practical
3.1	Post-harvest Handling		
3.1.1	Transportation of seed potato from field	1 Hour	
3.1.2	Post-harvest Treatment	1 Hour	1 Hour
3.1.3	Sorting and Grading	1 Hour	1 Hour
3.1.4	Disposal of non-seed material	1Hour	
3.1.5	Lot inspection	30 Minutes	1 Hour
3.1.6	Packaging and labeling	1 Hour	
3.2	Storage of Seed Potato		
3.2.1	Importance and conditions of storage	1 Hour	
3.2.2	Different storage system and structures	5Hours	
3.2.3	Prevention of pests and diseases in storage	2 Hours	
3.3	Marketing and Selling Seed Potatoes		
3.3.1	Marketing and selling seed potatoes	2 Hours	
3.4	Record Keeping		
3.4.1	Importance and types of record keeping	1 Hour 30Mins	
3.4.2	Record keeping and profit calculation	2 Hours	
3.5	Lobby and Policy Advocacy		
3.5.1	Lobby and policy advocacy	2 Hours	
	Assessment	1Hour	
	Sub total	22 Hours	3 Hours
	Total	25 Hours	

Session 3.1 Post Harvest Handling

This section has six sessions and takes eight (8) hours and 30 minutes.

Session 3.1.1 Transportation of Seed Potato from the Farm to Grading Store

Duration  **1 Hour**

Description

The method of transporting seed potato from the field to the grading store is important in minimizing the losses due to damage and bruises. In this session the participant will acquire

knowledge and skill in appropriate modes of transporting seed potato from the field to the grading store.

Learning Outcomes

By the end of the session, participants should be able to:

1. Identify various modes of transporting seed potato.
2. Explain how best to transport seed potato to minimize damage and loss.

Learning aids and materials

• LCD projector and screen	• Flipcharts and marker pens
• Power point presentations	• Handouts
• Packaging materials/Crates	• Pictures

Procedure

Activity I: Introduction to Seed Potato Transportation (20 Minutes).

a. Divide participants into groups and ask them to do the following: -
   i. Discuss various transportation modes
   ii. Discuss experiences in transporting seed potatoes from the field to grading stores.

b. Ask participants to present in plenary.

Activity II: Presentation (30 Minutes)

a. Present PowerPoint or handout on importance of seed potato transportation

Summary/Conclusion  10 minutes

Using question and answer techniques find out participants level of knowledge on importance of transportation methods

SESSION NOTES

Importance of seed potato transportation methods

Seed potato transportation means the movement of seed potato from one point to another using either modern or traditional mode of transport.

Seed potato can be transported from the field where it is planted to the storage facilities or from the store to other farmers' field after purchase during the planting season.

There are various modes of transport that are used by local farmers to transport seed potatoes varying from donkey carts, hand cart, pickup lorries, bicycles, motorcycles, trucks among others.

The vessel that is used to transport seed potato should:

- Be clean and free from pest and disease-causing organisms.
- Ensure that consignments of different varieties and lots are not mixed.

- Not lead to deterioration caused by moisture loss, rain, greening or physical damage or contamination.
- Ensure that the seed potatoes are transported in wide meshed bags, crates, cartons or baskets that are well ventilated. Seed potatoes are packed in 50kg net bags.
- Be well labeled for traceability purpose.
- Be stacked well to avoid physical damage, e.g., up to a maximum of two to three stacked heights for pickups and trucks are advisable.
- Have temperatures between 7-10°C especially for seed potatoes that are being transported far from the storage facilities.

Relevant authorities should be notified when seed potato is being transported and special permission granted for those being transported from one country to another. In Kenya, the authority that gives such authorization is the KEPHIS. A special form called the transport notice form is filled online by the seed grower to notify the authority on the seed potato movement from the field to the processing plants or stores (where the stores are on separate land from the farm).

There are also regulations and Acts that govern the transportation of seed in Kenya. These include: Plant Protection Act Cap 324 and Crop (Irish Potato Regulation) 2019.

3.1.2 Post-harvest Treatment

Duration  2 Hours (1 Hour theory, 1 Hour practical)

Description

Postharvest handling of seed potato is an important factor not only in preventing postharvest losses but also in maintaining its safety and nutritional quality. There are certain practices and chemical treatment, which can be used to treat the seed potato and thus prolong their shelf or storage life. This session is about post-harvest treatment of seed potato. The participant will learn the importance and how seed potato is treated after harvest.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain the need for post-harvest treatment of seed potato.
2. Describe how to carry out post-harvest treatment of seed potato.

Learning aids and materials

• LCD projector and screen	• PowerPoint presentation
• Flipcharts and marker pens	• Seed potato and tools/material for post-harvest treatment

Procedure

Activity I: Introduction to post harvest treatment of seed potato (10 minutes)

a. Ask the participants what they know about seed potato post-harvest treatment.

b. Write the response on a flip chart

Activity II: Presentation on seed potato treatment (Power point/handout) (30 minutes)

a. Use a PPT or handout to demonstrate the steps in post-harvest seed potato treatment.

Activity III: Practical on post-harvest seed potato treatment (1 Hour)

a. Divide participants into small groups and provide seed potatoes and tools for treatment.

b. Ask participants to take turns in treating seed potato as per the recommendations.

Conclusion/Summary 20 minutes

Ask learners to share their outcomes and experiences of the treatment exercise in plenary.

SESSION NOTES

The four main objectives of applying post-harvest treatment to harvested potatoes are to:

i. Maintain quality (appearance, texture, flavor and nutritive value)
ii. Protect food safety
iii. Reduce losses between harvest and consumption
iv. Prolong its storage life.

Post-harvest treatment generally consists of cleaning, selecting, grading and packing of the fresh produce. However, potatoes and other root crops may require curing prior to long-term storage.

Drying and Curing

Always dry the harvested tubers in storage shed. All the damaged and diseased tubers should be immediately removed during sorting. Curing is done by storing potatoes in a dark store that allows air circulation and is at moderate temperature (18.5– 22) degrees Centigrade and relative humidity of 90%. Curing is essential for healing the wounds of tubers that result from cutting and bruising during harvesting. Exposure to direct sunlight must be avoided as it causes greening of potatoes. For optimum suberization ***(Suberization is a healing process of the wounded tissue of the harvested potatoes where the cell wall develops hard tissue by the development of a compound called suberin. These cell walls of the potato inhibit the water loss from the tuber and inhibit any fungal infection such as dry rot).***

Storage requirements are discussed in a later session.

Session 3.1.3 Sorting and Grading

Duration 2 Hours (1 Hour theory, 1 Hour Practical)

Description

Sorting and grading is an important post-harvest operation and when done properly will fetch good prices for the different grades. This session will equip learners with knowledge and skills in sorting and grading of seed potato.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain the importance of sorting and grading in post-harvest handling.
2. Demonstrate how to sort and grade seed potato.

Learning aids and materials

• LCD projector and screen	• Flipcharts and marker pens
• PowerPoint presentation, handout	• Seed potatoes for sorting and grading
• Grading tools e.g., size gauge	• Demo-farm

Procedure

Activity I: Introduction to sorting and grading seed potato (10 minutes)

a. Ask participants why is it important to sort and grade seed potato

b. Write their answers on flip chart

Activity II: Presentation on sorting and grading (20 minutes)

a. Present a PowerPoint or hand-out on sorting harvested seed potato and grading of seed potatoes into different sizes using size gauges.

Activity III: Practical on sorting and grading (30 minutes)

a. Divide participants into small groups and ask them to:
   i. Sort and grade seed potato as per standard recommendations.

b. Assess the groups' outputs in plenary and make comments correcting where necessary.

Activity IV: Field Visit to a potato seed producing centre (1 Hour)

The participants will visit one of the seed producing centers locally accessible to see procedures carried out in sorting and grading. In Kenya the centers available include ADC Molo, Baraka Agriculture College, Egerton University or small scale seed potato growers.

SESSION NOTES

Sorting

This involves the removal of unwanted rotten or odd shaped tubers, clods, stones and other foreign bodies such as crop remains. Sorting is done by the eye when the tubers pass on a flat bed or roller and unwanted material is removed by hand and deposited in bags.

Grading

Since humans first developed commercial agriculture, seeds have become the world's most essential crop. That's because seed is the bridge between one plant generation and the next. There isn't a single good reason for planting poor quality seed; yet poor smallholder farmers in Africa keep recycling potato seeds. Fortunately, more and more farmers are adopting the use of certified and clean seeds. For increased yield, the general rule is the larger the seed for any particular variety, the stronger and more vigorous the seedlings are likely to be. Larger seeds also produce plants with more tillers than those grown from small seeds (Chats).

Importance of seed potato grading

- It improves the germination percentage of seed lot as it removes immature, broken and undesirable seeds.
- It classifies seed materials based on the commercial value and usefulness of determinants of more than sorting.

  Examples of sizes:

Ware potato:	Over 60 mm.
SIZE II:	Seed potato= 46 – 60 mm.
SIZE I:	Seed potato= 28 - 45mm
Chats potato:	Less than 28mm

There is a metal grading tool that can be bought. But most farmers and seed merchants fabricate a grading frame. This is a slanted grading frame similar to maize sieve (found at the flour millers). Only that this one has bigger holes. The seed potatoes that fall through in first grader are chats. And those that fall through the second grader are size I. Those that fall through third grader three are size II and those that don't fall through are ware potatoes.

Other seed merchants train workers using the hand to master the grade size. After one – two days training, the workers can grade the potatoes. The picture below shows students at Egerton University being taught how to grade seed potatoes.

- Quality grading is economic: Seeds are living organisms and unless well looked after, will rapidly deteriorate. The value of high seed germination is obvious. However, the vigor of seedlings is just as important.

Figure 3.1: Seed Potato Grading machines
(Source: Community Action Research Project [CARP+] partner)

Figure 3.2: Egerton University students learn how to grade seed potato

Figure 3.3: CARP+ project Interns bag graded seed potato at Egerton University
(Source: Community Action Research Project [CARP+] partner)

Post -harvest handling of seed potato

- Before harvesting, the store and sorting area is identified and cleaned.
- During harvesting the potatoes should be kept under a shade and later taken to the store. Sacks and vessel being used in transportation of potatoes must be clean (hygiene MUST be maintained throughout the process).

When offloading the potato from the trailer or the transporting vessel, care should be taken in that the potatoes should not be thrown on the ground; this activity should be gently done.

- Potatoes are sorted as per sizes and removing the damaged ones:
    - Potatoes with more than 55mm (ware potatoes) are sorted and put in gunny bags, stored, and should be sold as soon as possible.
    - The damaged potatoes are put aside (***mateme, irregular shaped***).
    - Potatoes ranging from 46-55 mm are sorted and put in 50 Kg bag (size 2)
    - Potato ranging from 27-45mm are sorted and put in 50Kg bags (size 1)
    - Potato ranging from 15-26 mm is sorted as chats and put in 50 Kg bags.
- After sorting and correct weighing of the seed potatoes as per the 2019 regulations, a seed owner should electronically apply for the labels. Labels will take approximately two weeks to be delivered, which are then stitched on the bag when closing it to show that the seed is certified.
- At the store, the bags are arranged in a manner that will make it easy to do stock taking, to identify the sizes and most importantly to allow air circulation or placed on the shelves in potato seed store.
- All the damaged potatoes seed MUST be taken away (should not be stored together with seed potato).
- The seed store SHOULD allow circulation of air, light and prevent pests from damaging the potato seeds in the store.
- Allow the potato to chit evenly (the potato seed should sprout uniformly).

3.1.4 Disposal of non–seed material

Duration  **1 Hour**

Description

This session will enable the participants to appreciate the different ways of disposing the non-seed material of seed potatoes. Through the activities, the participants will be able to get the skills of discarding the non-seed material in an economic way.

Learning Outcomes

At the end of the session the participants should be able to:

1. Identify the non-seed material in seed potatoes
2. Explain how to dispose non-seed materials from the store

Learning aids and materials

Flipcharts and marker pens	Bag of seed potato, samples of non-seed materials

Procedure

Activity I: Introduction to disposal of non-seed materials (15 Minutes)

a. Explain the importance of disposal of non-seed material.
b. Demonstrate examples of non-seed materials.

Activity II: Group discussion on disposal of non-seed materials (30 Minutes)

a. Divide participants into small groups and ask them to:
    i. Remove non-seed materials from a given sample of seed potato.
    ii. Discuss the various methods of disposing non-seed materials including value addition.
b. Ask them to present in plenary as you highlight key points

Conclusion  15 minutes

Summarize the activity on the best ways of disposing non-seed materials.

SESSION NOTES

Identify non-seed material in seed potatoes

There are various ways of identifying non-seed materials. This are:

1. Under grades or chat sizes are considered non-seed materials but only if you want to sell as seeds, since under grades or chats cannot be labeled.
2. Unwanted varieties from the intended varieties are also considered as non-seed materials and need to be disposed of economically.
3. Damaged and diseased seed potatoes need to be disposed like burying them or using the waste for production of organic manure.
4. If shape of the potatoes is not the right one should be disposed, since mis-shape can be considered as a disease or a disorder.

Disposal of non-seed material

There are different ways of disposing non-seed materials:

1. Sell the large potatoes as ware potatoes
2. The cut/damaged ones can be used for household consumption
3. Bury diseased potato waste in a hole or pit
4. Use potato peelings and seed wastes for making organic manure e.g., use Black soldier fly to digest the waste
5. Use wastes in the production of biogas
6. Use it to feed livestock

Value addition of non–seed material

1. Starch production
2. Dehydrating potatoes
3. Potato flour
4. Potato wine
5. Making of chevda, crisps, chips and baked potatoes etc.

Session 3.1.5 Lot Inspection

Duration 30 Minutes theory, 1 Hour practical

Description

This session covers lot inspections of seed potato and why it is important in post-harvest handling. Lot inspection involves checking the conformity of the lot with the set standards. This activity is done by a certified crop inspector from a regulatory authority (in the case of Kenya, KEPHIS - Kenya Plant Health Inspectorate Services). All seed potato lots have to be certified and labelled before they are marketed and sold.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain what a lot is and its importance in post-harvest handling of seed potato
2. Describe the process of lot inspection and sampling.

Learning aids and materials

• LCD projector and screen	• Power point presentations, charts
• Flipcharts and marker pens	• Lot Inspection Form
• Various sizes of seed potatoes	• Potato gauge

Procedure

Activity I: Introduction to lot inspection (20 minutes)

a. Make a presentation on lot inspection (Power point/handout)

b. Explain and show a sample of the lot inspection form

Activity II: Demonstration on selection of seed potato for lot inspection (1 Hour)

a. Invite two volunteers to role-play - one representing the inspector and another representing seed potato grower.

b. Give instructions to the inspector and grower on what is expected of them.

c. Ask them to role-play in front of other learners

d. Discuss the outcome of the role-play.

Conclusion 10 minutes

Highlight the importance of lot inspection

SESSION NOTES

Lot inspection

Lot inspection is the visual examination of the seed potato tubers, packaging weight and packaging material; this activity is done by crop inspector's representatives from a regulatory authority e.g., KEPHIS for the case of Kenya, who will come and monitor the handling to ensure compliance with the regulations. During this process, the crop inspector takes a random sample of enough tubers, which gives an appropriate picture of the lot size and checks on the grading if done properly as per the two recommended sizes (Size I- 27 to 45 mm and Size II - 45 to 55 mm), and that no damaged potatoes or diseased tubers have been included. The inspector will also take a lot sample of graded and packed seed potato to be taken for post-harvest laboratory test to check on pest and diseases, if present, for example the Potato cyst nematodes and Bacterial wilt.

What a crop inspector needs during lot inspection are:

- Location of the place where the lot is.
- The reference number of the lot.
- The class of the lot.
- Quantity of the lot and the size of the lot.

Why do lot inspection? This is to ascertain that there is presence of pest and diseases, correct weight, right size grading, and packaging conforms to the required regulations. If conditions are not met, the inspector can take action against the seed owner denying him or her the right to apply for **labels.**

KENYA PLANT HEALTH INSPECTORATE SERVICE (KEPHIS)
NAKURU REGIONAL OFFICE

LABORATORY REPORT

Client Name:	EGERTON UNIVERSITY SEED UNIT		
Address:	N/A	E-mail address:	N/A
Telephone:	N/A	Number of samples:	1
Sampling Date:	30.07.2021	Sampler:	KEPHIS OFFICER
Date Received:	02.08.2021	Grower:	EGERTON UNIVERSITY SEED UNIT

Reference is made to ONE (1) *Solanum tuberosum* samples submitted to the Kenya Plant Health Inspectorate Service (KEPHIS) Nakuru Regional Office for testing of *Ralstonia solanacearum* that causes bacterial wilt.

1 Method

Laboratory	Description
Bacteriology	Conventional PCR was used for detection of *Ralstonia solanacearum*
Nematology	N/A
Mycology	N/A
Molecular	N/A

2 Results

Test Number	SRO No.	Sample Type	Class	Sample Origin	Variety	Test Done	Cost (Ksh)	Result
211400	1293	*Solanum tuberosum*	N/A	Njoro	Nyota	Bacterial Wilt	3,500	-VE

3. Observations/ Recommendations

Observations/ Recommendations	The samples tested NEGATIVE for *Ralstonia solanacearum* The sample can be used as seed.

4. Charges

Ksh. 3,500	Invoice No: PHL/NAKS/2021/278	Receipt No: N/A

5. Authorization

Analysed By:	MERCY VUTAGWA	Signature:	Date:
Confirmed By:	PHILIP CHEMELTORIT	Signature:	Date:
Approved By:	REGIONAL MANAGER	Signature:	Date:

For: Managing Director

.....END OF REPORT.....

NB: These test results relate only to the test samples submitted

REGIONAL MANAGER

KEPHIS NAKURU

Figure 3.4: Laboratory report of lot sample taken

Some of the reasons an inspector can stop the inspection process is when there is:

- Presence of disease and pest or presence of many diseased potato tubers exceeding the allowed threshold.
- If the lot identity is not provided.
- If the sample is interfered with.
- If the location of the lot sample is not accessible to the inspector.
- If the tubers are too dirty to be visually observed e.g., covered with mud and dirt and also if the tubers were cut.

The representatives doing the inspection will then prepare a small report with findings of the inspection. Example of the records placed by the inspector are: the varieties of the potato tubers; the class of the seeds; the lot number; tuber sizes and net weight or number of packs; the

sample size; inspection findings on tolerance to the standards; date of inspection; comments on lot inspected; and, lastly, the name of the inspector.

If grading and lot inspection has been done properly then the seed multiplier applies for the number of labels needed and seals the packed potato tubers.

Session 3.1.6 Packaging and labelling

Duration 1 Hour theory

Description

This session will equip learners with knowledge and skills to use the most appropriate packaging for seed potato and to correctly label the bags.

Learning Outcomes

At the end of the session participants should be able to:

1. Describe different packaging methods for seed potato, their advantages and disadvantages.
2. Explain information required on the labels and how to get the labels.

Learning aids and materials

• LCD projector and screen	• Power point presentations, Handout
• Sample of certification labels	• Various seed potato packaging materials

Procedure

Activity I: Introduction to Packaging and Labeling (10 Minutes)

3. Ask participants why they think packaging and labeling is important in seed production and marketing.
4. Write answers on flip chart and add where necessary.

Activity II: Power point presentation on packaging and labels (40 Minutes)

1. Present PPT to illustrate different packaging materials and certification labels.
2. Provide samples of packaging materials and labels and ask participants to discuss the unique features.

Conclusion 10 minutes

Ask questions to find out level of learning on types of packaging to use and why.

Packaging and weighing

Packaging materials and packaging of seed potatoes is an activity, which follows strict regulations and standards set out, for the case of Kenya, in 2019 by the Ministry of Agriculture and the National Potato Council of Kenya (NPCK). The CARP+ seed potato project, at Egerton University, partners contributed to the development of this legislation. There are two recommended packaging materials for seed potatoes, namely the normal sisal bags, and netted nylon bags. Crop inspectors also have to certify the kind of packaging used for seed potatoes. In Kenya for example, the legal maximum weight for each single bag or net/package is 50Kgs, which should be weighed by a properly calibrated weighing machine.

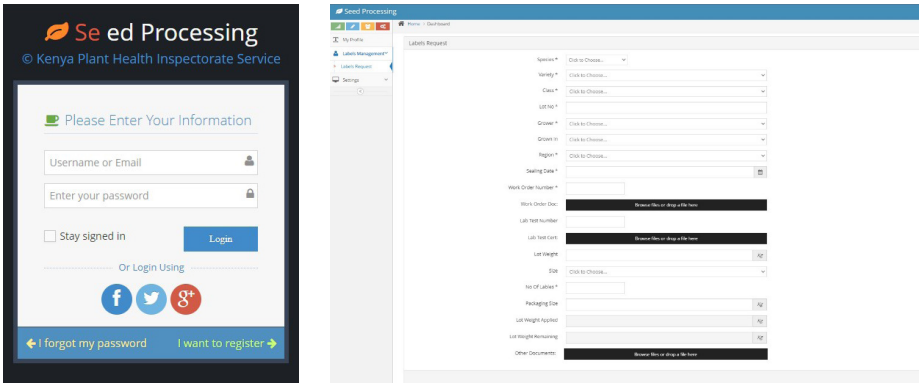
Note: Do not approximate the weight by size of the bag or the labels placed on the bag. Use a calibrated weighing machine.

The picture below shows packaged seed potato on display during the national potato conference at Kenya Agriculture and Livestock Organization (KARLO) on 19th – 20th May 20202) in Nairobi, Kenya.

Figure 3.5: Seed potato net packaging labeled (Source: Community Action Research Project [CARP+ partner)

Labelling

Sealing and labeling is the final stage done by the regulatory authority e.g., KEPHIS in Kenya. Labels are applied for from an online portal by the seed companies with confidential username and passwords on KEPHIS online platform. Then another online platform will load and this is where you will get your labels.



(a) *(b)*

Figure 3.6: (a) Online KEPHIS Portal for label application; (b) dialog box on the portal where you specify the crop, the class and number of labels. (Source: Community Action Research Project [CARP+] partner – Kenya Plant Health Inspectorate Services [KEPHIS])

The label specifies potato variety, seed size, net weight, seed generation, lot number, date of sealing, region grown. Hence, the seed multiplier applies according to what they have.

Each package will then be sealed and bear an official label, which has not been previously used. Labels colour for each class are different: White with a diagonal purple line is for Pre-basic seed; White is for Basic seed; Blue is for Certified seed – CI; Pink is for Certified seed - CII.

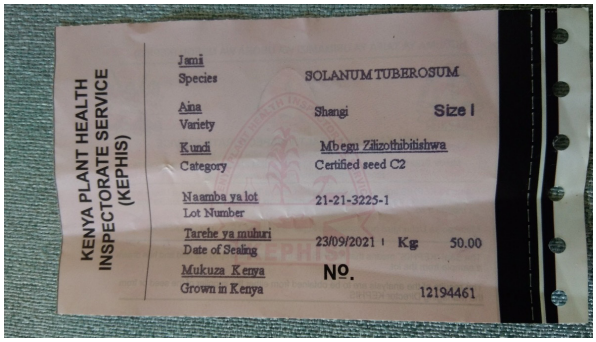


Figure 3.7: Pink for Certified Seed - C2

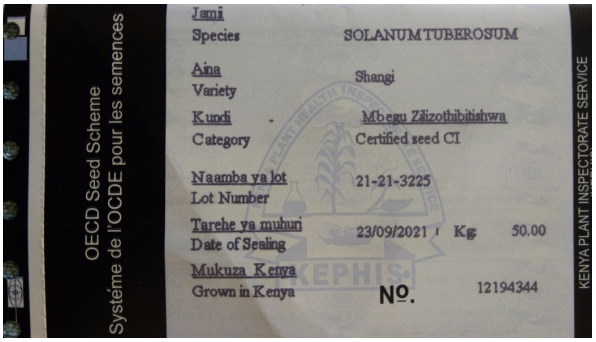


Figure 3.8: Blue for Certified Seed - C1

(Source: Community Action Research Project [CARP+] partner – Kenya Plant Health Inspectorate Services [KEPHIS]).

Session 3.2 Storage of seed potatoes

Session 3.2.1 Importance and conditions of storage

Duration 1 Hour

Description

This session will equip participants with knowledge on the importance and optimum conditions of storing seed potatoes. Through the activities, the participants will be able to understand the current status and challenges in the storage of seed potatoes.

Learning Outcomes

At the end of the session participants should be able to:

1. Explain the importance and conditions of storing seed potato
2. Discuss the environmental conditions favorable for storing seed potatoes

Learning aids and materials

• LCD projector and screen	• Power point presentations with pictures
• Flipcharts and marker pens	• Notebook and Pen

Procedure

Activity I: Introduction to seed potato storage (20 Minutes)

a. Divide the participants into groups and ask them to:
   i. Discuss the importance of proper storage of see potato
   ii. Discuss appropriate conditions for storing seed potatoes.
b. Ask the groups to present their outputs

Activity II: Presentation on ideal storage conditions for seed potato (30 Minutes)

a. Use a PPT or handout to discuss the ideal seed potato storage conditions

Conclusion/Summary 10 Minutes

Ask learners to mention the important conditions to observe in seed potato storage.

SESSION NOTES

Importance of proper storage of seed potatoes

1. To handle the seed potatoes conveniently
2. To prevent excessive shrinkage from moisture loss and decay
3. To fetch good price during the non-glut period
4. To break dormancy
5. For uniform sprouting

Storage requirements for seed potato

For proper seed potato storage, light, temperature and humidity are three critical environmental factors to be considered. Light is important in development of short, strong and colored sprouts. The temperature in the store depends on initial temperature of the tubers at the time they are placed in the store. Before storage the tubers have to be cured at cool (ambient) temperature. Air movement (ventilation) is necessary during storage to remove the heat generated by the potatoes. If a long storage period (longer than 5 months) is anticipated, the tubers must be stored at temperatures of 4- 8 degrees Celsius whereas, if such conditions are not available, the tubers may be stored in diffused light store conditions at ambient temperature until they start sprouting.

Up to 80% of potato tuber content is water and this need to be maintained to avoid loss of weight and vigor. Thus, in order to achieve this, maintain a 95% relative humidity at all times. High humidity is also essential for optimum wound healing and curing.

Storing potatoes for longer period in normal temperature is not possible as it is a living material and through respiration, the changes occur due to heat, resulting in loss of dry matter and ultimate deterioration of quality of tubers. At optimum condition, the quality of potatoes remains good in storage for 3-5 weeks. The best temperature and humidity condition for storage of potatoes are as follows:

Table 3.1: Ideal Storage Temperature and Relative Humidity

TYPES	TEMPERATURE (°C)	RELATIVE HUMIDITY (%)	REMARKS
SEED POTATO	0-2	90-95	No sprouting
WARE POTATO	0-2	90-95	Potato becomes sweet

Storage of potato under optimum conditions is very important part of supply chain in order to avoid glut-like situation in the market.

Important points to keep in mind for storage of potato

Air circulation: The air circulation inside the storage chamber during the loading of potato and pull-down period should be minimum 50 CFM/MT of Potato (85 CMH/MT of Potato).

Relative humidity: Maintaining high relative humidity (95% RH) in storage is very important to prevent tuber dehydration. It helps to control the total shrinkage loss.

Ventilation of cold stores: Always ventilate the storage chambers periodically. At least 2 to 6 air changes per day is good enough to maintain desirable level of CO2 level less than 4,000 ppm inside the storage room.

Storage cleanliness: Disinfection or cleaning of the storage facility is a good practice in all storages systems and is essential for seed producers. Cleaning of the store must be completed in time for the new harvest to begin.

References

1. Storage requirements for seed potato; April 2020; *https://npck.org*

2. Ajay Nair (2014); four factors to consider during storage; *https://www.growingproduce.com*

Session 3.2.2 Seed Potato Storage Systems and Structures

Duration 5 Hours

Description

This session will equip learners with knowledge and skills on different storage methods and structures used for storing seed potatoes. Through the activities, the participants will be able to appreciate the structures available for proper storage of seed potatoes.

Learning Outcomes

At the end of the session participants should be able to:

1. Differentiate between the various methods of storing seed potato.
2. Explain the different storage structures available for storing seed potatoes.

Learning aids and materials

- PowerPoint presentation/Handout
- LCD projector and screen
- Flipcharts and marker pens

Procedure

Activity I: Introduction to storage systems and structures (1 Hour)

a. Use a PPT or handout to explain the different seed potato storage systems and structures, and their importance.

Activity II: Visit a small and large scale seed potato store in your area (4 Hours)

a. Organize a visit to a small and large scale seed potato grower several weeks prior to visit, and arrange for transport. If there is no large scale producer, use video or PowerPoint to illustrate the different methods and structures.

b. On arrival to each site, introduce the owner/manager and participants, and explain purpose of the visit.

c. Invite the owner/manager to guide the learners through their seed storage systems.

d. Request learners to take note of activities in the store (environmental conditions surrounding the seed potatoes in storage, bags used, quantities per bag, labeling etc.).

e. At the end of each visit, invite participants to ask questions.

Conclusion/Summary (10 Minutes)

At the end of second visit compare the different methods used for storing seed potatoes in both farms. Highlight the correct storage systems and structures used for seed potato.

SESSION NOTES

Seed potato requires good storage to delay ageing process, sprouting and break dormancy. Good storage with cool temperature and good air circulation (proper ventilation) make the above processes more possible. Since potatoes respire (sweating and transforming sugar into energy, which causes shriveling) they require CO2 temperature to be controlled and high humidity level to be maintained. The temperature inside the store must be colder than the surrounding temperature. Before choosing a store design there are factors to consider; style of structure, ventilation, humidification, lighting and the needs of the seed grower. Potato storage serves two major purposes: It makes possible a longer marketing period for the crop, and it minimizes the amount of loss from moisture loss and decay.

There are various methods of storing seed potatoes and these include:

1. Heaping and covering them in pits
2. Traditional method of storing on top and under grass
3. Pallet flow racking (first in first out) optimizes on inventory
4. Stacking (pallet-less utilizes the floor space)

Figure 3.9: Seed potatoes stacked on wooden planks
(Source: Community Action Research Project [CARP+ partners)

Types of seed storage

There are three main types of stores used in storing and preserving seed potato:

1. Cold store
2. Diffused Light Store (DLS)
3. Pitting

Cold store

This type of store uses automated fans, insulation and refrigeration to control the temperature and airflow. They also have special humidification systems to maintain relative humidity. It has

the ability to keep seed potatoes in a temperature and relative humidity controlled environment. This helps in preventing the spoilage or decaying of the seed potatoes. This type of stores can store seed potatoes up to seven months.

Procedures followed at the cold stores or rooms

1. **Temperature control**
   a. **Pre-cooling:** After the potatoes are graded, they are taken from the storage room to the **Dry Wall** for precooling where they stay for not more than 24 hours with temperature reduced from 25°C to 16OC. There are three pre-cooling methods: natural pre-cooling, cold storage pre-cooling, vacuum pre-cooling. Precooling is stopped when the temperature reaches five degrees higher than the storage room temperature. "*The pre-cooling time is scheduled within 12 hours after harvest*".
   b. **Potato cold storage room: After pre-cooling the temperatures are then brought down to 12°C in** advance for 36 hours to help the potatoes better adapt to the low temperature environment of the cold storage. After which the cold storage room temperature is then brought down and maintained at 3°C - 5°C. The room temperature is required to reach this specified storage temperature within 72 hours and is required to be stable during the entire storage period, and the fluctuation should not exceed ±1°C.
   c. **Relative humidity control:** The relative humidity of the potato cold storage room is kept at 85%-90%. If the humidity is higher than this, the potatoes start to rot and germinate early; if the degree is too low, the potatoes start losing water and weight, become soft and shrink, and eventually losing their seed value. Therefore, the store manager has to **regularly check and control the relative humidity and temperature**.
   d. **Gas management of potato controlled atmosphere storage room:** Since potato is a living tissue and respires even after harvesting, the gas in the cold store has to be controlled. Oxygen concentration is maintained at 3%-5% and carbon dioxide concentration at 2%-3%. Potatoes with too low oxygen will lose their viability (germination ability), and it sometimes cause suffocating rot. Appropriate concentration of carbon dioxide can also slow down or delay the initiation of the respiratory process. A higher concentration of carbon dioxide raises the temperatures and may force the potato to undergo respiration without oxygen (anaerobic respiration), causing it to produce alcohol and lactic acid and an aldehyde causing faster aging and lose of energy, which will be required during germination process.

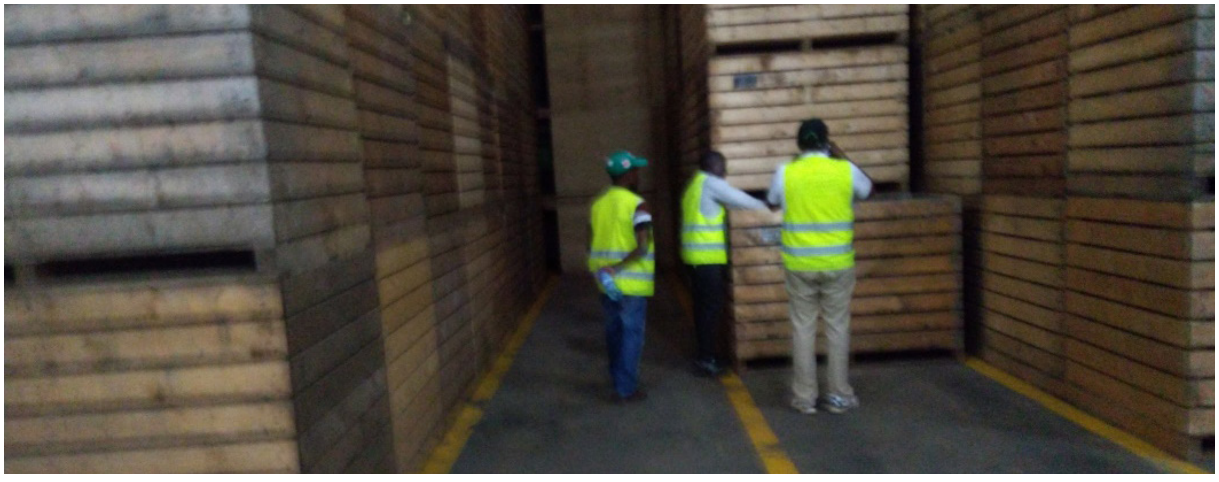


Figure 3.10: Potato racks in cold storage using FIFO method (First in first out)
(Source: Benjamin Kemboi at Agrico [a seed company] in Nakuru, Kenya)

Figure 3.11: Seed potatoes on pallets in cold store (Source: Benjamin Kemboi at Agrico [a seed company] in Nakuru, Kenya)

Figure 3.12: Cold storage at Agrico Company in Nakuru, Kenya (Source: Benjamin Kemboi at Agrico [a seed company] in Nakuru, Kenya)

When the seed potatoes are ready for sale, they are taken out of the cold storage for warming up slowly to prevent dew and deterioration of the seed potatoes caused by the excessive temperature difference. Since the seed potatoes are placed in racks with first in first out (FIFO) arrangement cranes are used for transportation to storage room temperatures are raised in reverse manner from 5°C to 12°C then to16°C.

Diffuse light store (DLS)

A diffuse light store is easy to construct using available materials like wood, mud or plastic. There are openings left on the walls that allow natural indirect light and air from the surrounding environment to circulate on the stored potatoes. The potatoes are stored on trays or shelves. Storage time for seed potatoes in a diffuse light store should be 5 to 6 months depending on the variety.

How Diffused light store works

Diffuse light store (DLS) works with surrounding light, ventilation from surrounding air and for protection of potatoes.

a. Light: it should be indirect sunlight, but sufficient to ensure that tuber sprouts are short, firm and coloured. Long and white sprouts are not good since it causes easy and fast shrinkage of the tuber. In the DLS, tubers are arranged up to 3 inches in layer to ensure that each tuber receives sufficient diffused light; diffused light is provided by translucent iron sheets.

Figure 3.13: Diffused light store (Source: Community Action Research Project [CARP+] partners)

Figure 3.14: Good Sprouting of a tuber (Source: Community Action Research Project [CARP+] partners)

b. **Ventilation:** This is the most important factor to supply efficient and sufficient air to maintain temperature and relative humidity for the tuber to breathe and respire. A lot of heat encourages fast and weak sprouts. In order to manage ventilation or temperature regulation, the gaps in the wall of a diffuse light store are spaced at least 3 inches to sufficiently provide for air circulation. In addition, the door gaps are widely spaced. If it is safe, the door can be open at night for cool air circulation. Temperature inside a diffused light store should range between 12oC to 15oC and relative humidity of not less than 80%. Relative humidity sometimes is maintained by misting and putting wet clothes at the corners of the store.

c. **Protection:** Diffused light store provides protection to stored seed potato from direct destroying agents such as rats and moths. The walls and trays can be constructed with small-fine nets to protect the entry of rats into the diffused light store.

Figure 3.15: Diffused light store with seed (Source: Community Action Research Project [CARP+] partners)

Figure 3.16: Close view of DLS tray (Source: Community Action Research Project [CARP+] partners)

Procedure followed in a Diffused Light Store

1. Paddocking/partitioning of the store

This is simply the way potatoes are arranged in a DLS. For example, a DLS with 4 rows with each row having 6 boxes can be paddocked into four i.e. Paddock A, B, C and D.

2. Placing of sorted and graded potatoes into boxes/trays

After seed potatoes have been graded into sizes and classes, they are poured into boxes for further curing.

3. Seed potato treatment

After seed potatoes are placed on the boxes, post-harvest treatment can be done on the seed potatoes by applying fungicide to prevent fungal disease spread.

4. Maintaining relative humidity

When the relative humidity goes down, there are practical ways to increase humidity by misting the DLS e.g., sprinkling water on the floor and placing wet clothes in the corners of the store.

Why store seed potato in a Diffused Light Store?

1. To encourage stronger, colored and firm sprouts of potato tuber.
2. To avoid weight loss and quality loss of seed potato.
3. To allow seed potato to break dormancy.

4. To allow time for Lot inspection and labeling of seed potato class and to look for market for the seed.
5. It is an affordable method for small scale seed growers.

Figure 3.17: External view of a DLS at Egerton University
(Source: Community Action Research Project [CARP+] partners)

Cost of building commercial DLS can range from Ksh. 100,000 to 1,000,000 (about US$ 800 – 8,000) depending on size, cost of materials and labour.

Session 3.2.3 Management of Pests and Diseases in Storage

Duration 2 Hours

Description

This session will equip participants with knowledge and skills in identifying and controlling the different pests and diseases affecting seed potato in storage.

Learning Outcomes

By the end of the session participant should be able to:

1. Identify the different pests and diseases affecting seed potatoes in storage.
2. Manage different storage pests and diseases affecting the seed potatoes.

Learning aids and materials

• LCD projector and screen	• PowerPoint presentation/Handout
• Flipcharts and marker pens	• Diseased seed potatoes
• Seed potato affected by pests	

Procedure

Activity I: Introduction to storage pests and diseases of seed potatoes (20 Minutes)

a. Ask participants to state pests and diseases that affect seed potato in storage and how to prevent them.

Activity II: Use Island method to identify affected seed potato (1 Hour)

a. Use the "Island method" display - on different tables for different groups place seed potatoes that do not look healthy and are spoilt.

b. Ask each group to identify the symptom/s, cause and discuss control measures to the problem in seed potato during storage.

c. Ask each group to present their results on the displayed/assigned samples.

Conclusion  40 Minutes

Summarize the activity by using a PowerPoint or handout with the specimen symptom/cause and control measures of common storage pests and diseases (*See session notes*).

SESSION NOTES

The following are the common storage pest and diseases of potato and control strategies:

1. Storage insect pests

Potato tuber moth ***(Phthorimaea operculella)***

The larvae of the tuber moth feed on both the growing plants and tubers of potato. At harvest, affected tubers may show little visible evidence of infestation but may be harboring eggs or young larvae. As the larvae feed on the tubers, damage becomes extensive with galleries developing just under the skin or deep in the tuber. Affected tubers may lose excessive moisture through the wounds, resulting in shriveling. Secondary infection by fungal pathogens can also lead to tuber rotting.

Control: Use clean seed potatoes, and an integrated control strategy in the field including fumigation of the storage facilities.

Figure 3.18: Symptoms of potato tuber moth larvae infestation on tubers (Photo Courtesy of International Potato Centre [CIP])

2. Fungal pathogen

Early blight ***(Alternaria spp)***

The two species, which affect potato are *Alternaria solani* and *Alternaria alternata*. Early blight differs from late blight in that there is no development of milky-white sporulation around the lesion on the underside of the leaf in humid conditions. Infected tubers may develop a largely superficial dry rot.

Control: chemical control by spray of fungicides such a mancozeb, metalaxyl.

Figure 3.19: Early blight symptom (Courtesy, CIP)

Late blight (*Phytophthora infestans***)**

Infected tubers usually develop a dark-brown, sometimes purplish, area on the tuber surface. The internal rot is a reddish-brown, granular rot, which can remain close to the surface or progress to the center of the tuber. Development of the rot is irregular and without a distinct leading edge; it can also be thread-like. Affected tubers often have firm flesh with brown areas but secondary infection can lead to a wet breakdown of the tubers.

Control: Prevention of tuber blight in harvested tubers by controlling the disease in the field. Field and store hygiene - destroy affected tubers.

Figure 3.20: Late Blight symptoms on potato tubers (Courtesy, CIP)

Powdery scab ***(Spongospora subterranea)***

Round, individual, raised scabs can be seen on tubers at harvest. The lesions erupt exposing brown powdery tissue (spore balls) with tattered fragments of skin along edge of lesion.

Infection at time of eye development can result in outgrowths (cankers) of varying sizes developing at rose-end of tubers. The inoculum is soil and seed-borne as is most prevalent on heavy soils and is favored by wet, cool conditions at tuber initiation.

Management: Use of resistant varieties and crop rotations are the most effective ways to control disease derived from infested land. Take care with irrigation, especially during tuber initiation. Field and store hygiene - destroy affected tubers.

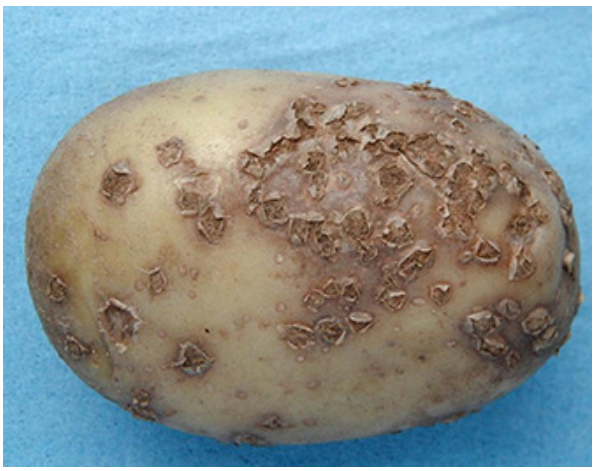


Figure 3.21: Powdery scab (Courtesy, CIP).

Dry rot ***(Fusarium spp)***

There are several different species of Fusarium causing slightly different symptoms: generally, dry rots develop around a wound leading to dehydration of the tuber. In the growing crop, planting seed tubers affected by dry rot can result in weak plants or non-emergence.

The pathogen is both seed and soil-borne and infection and disease progression are triggered by damage at grading and favoured by warm storage conditions.

Management: Minimize damage, apply fungicides, and use long crop rotations. Field and store hygiene - destroy affected tubers.

Figure 3.22: Dry rot on potato tuber (Courtesy, CIP)

Pink rot ***(Phytophthora erythroseptica)***

Tubers are rubbery and are usually affected at the heel end. Affected tissue turns pink on exposure to air within an hour. Rots develop at lenticels and eyes soon after harvest when conditions have been wet and warm just before harvest. Tubers can have a distinctive sweet smell and ooze a colorless, clear liquid if squeezed hard. The pathogen is mainly soil-borne and the infection is favored by high soil moisture and high temperatures. Rots develop at, or soon after, harvest.

Management: Crop rotation and drainage. Field and store hygiene - destroy affected tubers.

Figure 3.23: Pink rot symptom on potato tuber (Courtesy, CIP)

3. Bacterial pathogen

Black leg ***(Dickeya/Pectobacterium spp)***

The pathogen is seed-borne but spread can occur in the crop from diseased to healthy plants with the bacteria being carried in water droplets (rain splash/aerosols/irrigation) and by

insects. Contact with contaminated machinery and boxes are an important method of spread. Infection by both pathogens and disease development is favoured by wet growing conditions, but cool weather is more favorable for Pectobacterium spp. and warm for Dickeya spp.

The tuber will develop a soft, brownish-white rot that extends from the heel-end or lenticels. Affected area is bounded by a dark margin and it produces a distinctive fishy smell.

Figure 3.24: Black leg symptom on tuber and stem

Bacterial wilt *(Ralstonia solanacearum)*

The disease is mainly soil borne. Bacterial ooze emerges from the eye and stem end of the tubers. When the tubers are cut you can notice browning and necrosis of the vascular ring and in adjacent tissues. A creamy exudate can be seen on vascular ring.

Management: Crop rotation with other crop that is not in Solanaceae family. For field hygiene, destroy diseased plants and tubers, disinfect all farm implements/tools with bleach after they have been used in infected fields. Store seed potato tubers in clean and disinfected stores.

Other common damages include chilling injury, physical damages, shriveling and secondary growths.

Figure 3.25: Bacterial wilt on potato tuber (Courtesy, CIP)

Session 3.3.1 Marketing and Selling Seed Potatoes

Duration 2 Hours

Description

Marketing helps the seed merchant/farmer produce what the processors and consumers need and sell it at the best price. This session will equip learners with knowledge and skills of marketing and selling of seed potatoes, the 4 Ps of marketing and strategies to use to sell their produce.

Learning Outcomes

At the end of the session participants should be able to:

1. Differentiate marketing from selling seed potato.
2. Explain the four (4) Ps of Marketing
3. Apply strategies and tactics to market and sell seed potato.

Learning aids and materials

- LCD projector and screen
- Power point presentations/handout
- Flipcharts and marker pens

Procedure

Activity I: Introduction to marketing and selling of seed potato (30 minutes)

a. Divide participant into small groups and ask them to:
   i. Differentiate the terms 'marketing' and 'selling'
   ii. Ask them to discuss their experiences in marketing of seed potato.
   iii. Ask them to share their outputs in plenary as you provide more information

Activity II: Presentation on marketing (1 Hour)

a. Using a PPT presentation or handout explain:
   i. Four (4) components of marketing
   ii. Strategies used to market and sell seed potato

Conclusion/summary 30 Minutes

Summarize the activity by asking learners to identify strategies they will use to market their seed potatoes in their area and beyond.

SESSION NOTES

What is marketing?

Marketing is finding out what the consumers want/need, planning and developing the product that will satisfy those wants, determining the best way to price, promote and distribute that product/service. It can be stated that marketing is a total system of business activities designed to plan, price, promote and distribute wants, satisfying goods and services to both present and potential customers (Stanton, W. J, 1971).

Marketing deals with understanding, creating, communicating, delivering customer value, and satisfaction and is at the very heart of modern marketing thinking and practice. It is the identifying of the best variety to grow, how it will be used, where to sell it, characteristics of the buyer and what price to sell it at. It can be referred to as the 'delivery of customer satisfaction at a profit' (Kotler and Armstrong, 2002).

What is selling?

Successful selling is the strategies and tactics used to sell the seed potato from the store to farmers' fields at the best price.

The four (4) Ps of marketing

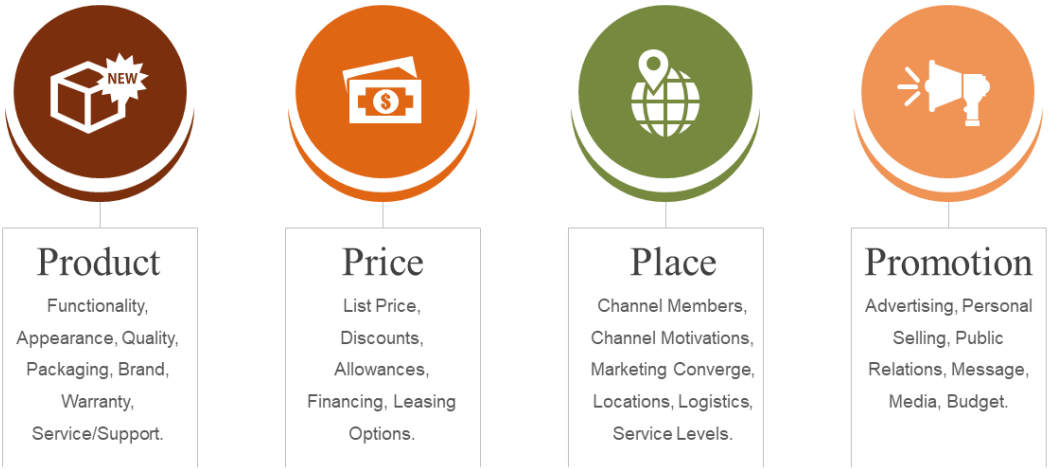


Figure 3.26: The four Ps of Marketing illustrated
(Source: The slide team blog on marketing strategy)

1. Product

In the production of seed potato, information on the preferred varieties will lead the marketer to know which varieties to propagate and produce. Before embarking on production, a market survey should be carried out on the market demand in terms of seed size, class, variety, use, and growth characteristics. There are different varieties of seed potatoes e.g., shangi, Dutch-robjin, markies, etc. available in the market; they are sold as tubers, mini-tubers and apical rooted cuttings (ARC).

2. Price

It is one of the most important components that involves consideration of many aspects such as the cost of production, variety, demand, competitor prices among other factors.

In Kenya, the cost of 50 kg bag of seed potato, as at March 2022, was ranging from Ksh.2500-3200, apical cuttings at Ksh. 3-5 and mini-tubers at Ksh.10-15 per piece, respectively.

3. Marketing strategies/Promotion

There are various strategies that have been used to promote use of seed potatoes and available varieties to farmers by different stakeholders in the industry. These give farmers information on the various varieties available in the market and where to source for the seeds.

The following are some of the strategies/ways used to promote various potato varieties:

1. Trade fairs/exhibitions, demonstrations and field days.

   They showcase different varieties of potatoes for farmers to appreciate growth characteristics so that farmers can demand for the varieties.

Figure 3.27: a) Prof. Kibe training in a field day, Elgeyo Marakwet, b) Mr. Enock (Master's student, Egerton University) teaching farmers on new high yielding varieties. (Source: Kenya Climate Smart Agriculture project [KCSAP] seed potato project).

2. Campaigns through local radio and TV stations e.g., Shamba shape up, Inooro FM, Farmers TV etc.
3. Utilization of farmer service centres or Training of Trainers (TOT) to aggregate orders.
4. Cooking demonstrations to showcase different cooking qualities of different varieties to create demand for the most preferred.
5. Attending marketing forums: these are forums that bring together seed merchants, farmers, potato buyers and processors. The seed merchant can be able to promote the varieties they are producing and also know the varieties that are preferred by the various buyers and processors.

4. Place or Distribution channels of marketing

Distribution is the process of making the product or service available for the consumer or business who needs it.

In Kenya, only the registered seed merchants are allowed to sell and distribute seed potato and most of the distribution is done directly to the farmers. The farmers buy the seed directly from the merchant and sometimes organize their own transport to collect the seed.

Some merchants provide transport, especially for bulk orders to encourage the farmer to buy more. There are also merchants of apical rooted cutting who use courier services such as G4S to deliver the cuttings to their clients as soon as possible.

Some marketing platforms such as:

1. Local Agriculture extension office. These officers know who the seed merchants are, and where to find them, which variety is suitable for that area and cost of the seed.

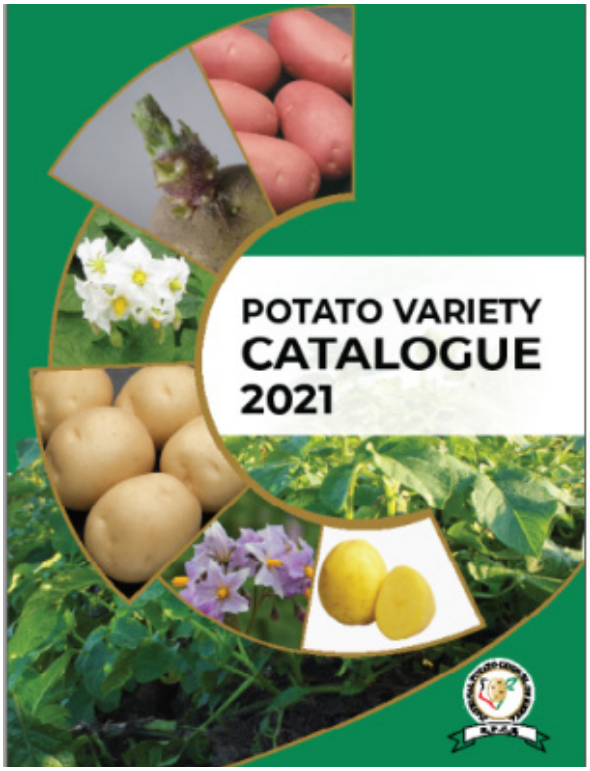


Figure 3.28: Annual potato catalogue explains the properties and performance of various potato varieties available in Kenya.

2. Publications: Potato variety catalogues e.g., National Potato Council of Kenya (NPCK) potato variety catalogue, potato seed production manuals, potato production manuals.
3. *Viazi-soko* digital, or e-platform run by NPCK, in Kenya assists farmers to order seed online and also organize transport at a cost. Farmers are advised to aggregate their order so that they can spend less on transport.
4. Websites: NPCK website, ADC Molo website, Agrico, Freshco.
5. Social media platforms, for example Facebook, WhatsApp platforms e.g., Nakuru County Potato WhatsApp group regularly sends updates on seed available in the region. This has emerged as a very cost effective method to market and source for seed potato.
6. Bulk SMS to farmers is, for example, used by NPCK and Agrico to promote various varieties.

See case study on food to market titled: "Not Only Shangi, plant other varieties", at annex 1.3).

References

1. Kotler, Philip and Armstrong, Gary (2004): Principles of Marketing Prentice-Hall of India
2. Private Ltd. New Delhi.
3. Stanton, W. J (1971): Fundamentals of marketing. New York, McGraw-Hill.
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Publishing Ltd. Nairobi.

Session 3.4.1 Record Keeping

Duration 1 Hour 30 Minutes

Learning Outcomes Description

Record keeping is an important part in seed potato production. It enables the producer to manage and trace the process of seed potato production from inputs to outputs and sales of produce. This session will enable the participants to acquire knowledge and skills in keeping records of their seed potato business.

At the end of the session the participants should be able to:

1. Explain the importance of having a traceability record.
2. Describe the records that can be used in seed potato production
3. Keep appropriate records for seed potato throughout production and sales.

Learning aids and materials

• LCD projector and screen	• Power point presentations , charts,
• Flipcharts and marker pens	• Seed potato records (samples)

Procedure

Activity I: Introduction to Record Keeping (20 minutes)

a. Explain the use and importance of records in production, storage and sales of seed potato.

Activity II: Group Exercise (1 Hour)

a. Divide participants into groups and provide the various record keeping templates
b. Ask them to discuss the templates
c. Ask them to present their outcomes in plenary

Conclusion/summary  10 Minutes

Discuss outcome of the exercise on record keeping of seed potato

SESSION NOTES

Farm records

Farming is a business like any other business. It involves buying/hiring of farm inputs, actual production and selling of farm produce. For better management of the business, farmers or managers are required to keep simple records and accounts.

Importance of Record Keeping

1. To know what income the farmer receives from the business and what was the cost of operations (i.e. how much the business receives and spends)/input to output ratio.
2. Determine the profitability of the farm/agro-business.
3. Determine total sales (gross output)
4. Aids in knowing the trends of the business and therefore assist to determine **what, when** and **where** to produce and sell.
5. Aids the farmer to decide on the best/suitable option available for farming enterprise to undertake.
6. The farm will be able to tell where he is overspending or making losses.
7. Well maintained records can be helpful in seeking financial assistance/loans acquisition.
8. Records show the creditors and debtors.
9. Records can assist in accounting for tax payments or justify non-payments of the same.
10. Shows the value of the business investment.

Types of Farm Records

1. Inputs/Outputs crop records.
2. Financial records (bookkeeping)
3. Labor records.
4. Assets inventory records.

5. Production records.
6. Harvest/stores records (farm to stores).
7. Sales records.
8. Transportation.
9. And many others

Production records help to track the movement of the inputs, shows how much was utilized and how much was spent on inputs. It will help in analyzing the processes of production so that the farmer will know where losses occurred in production.

Stores record help to track inventory, harvest from the farm, gains and losses from harvest, and how losses are incurred.

Farm asset inventory is important for calculating the total cost in production of a specific product. Depreciation of each asset is important to be able to apportion the real cost attributable to a specific enterprise per year.

Labour records help the farmer to track his/her workforce expenses, and provide transparency in remuneration, and for tax purposes.

Sample of Seed Potato Records

Table 3.2: Record of Fresh Harvest and Cost of Harvesting

Store Manager							
Supervisor							
Mode of Harvesting							
DATE	**VARIETY**	**FIELD**	**CLASS**	**TONNES HARVESTED**	**MANDAYS**	**RATE**	**TOTAL**

Table 3.3: Record of Harvest by Variety, Class and Grade

	TOTAL NUMBER OF BAGS - WANJIKU C1	158									
DATE	**CLASS**	**VARIETY**	**PADOCK**	**GRADE**	**MAN HOURS**	**RATE**	**TOTALS**	**TONNES**	**No. OF BAGS**	**UNIT PRICE**	**EXPECTED INCOME**
9/12/21	Certified 1	Wanjiku	P1,BoxA	GRADE 1	6	50	300	3000	60	3500	210000
9/12/21	Certified 1	Wanjiku	P2,BoxA	GRADE 2	6	50	300	3000	60	3000	180000
9/12/21	Certified 1	Wanjiku	P1,DOWN	DAMAGED	3	50	150	700	14	1000	14000
9/12/21	Certified 1	Wanjiku	P1,DOWN	CHATS	2	50	100	1200	24	2400	57600
		Total							158		
	Total Number Of Bags-Shangi C1										
9/14/21	Certified 1	Shangi		GRADE 1		50			0		
9/14/21	Certified 1	Shangi		GRADE 2		50			0		
9/14/21	Certified 1	Shangi		DAMAGED		50			0		
9/14/21	Certified 1	Shangi		CHATS		50					
	Total Number Of Bags-Shangi C2										
9/16/21	Certified 2	Shangi		GRADE 1		50					
9/16/21	Certified 2	Shangi				50					
9/16/21	Certified 2	Shangi				50					
9/16/21	Certified 2	Shangi				50					

Table 3.4: Record of Stored Seed Potatoes by Variety, Class and Grade

CERTIFIED 1			CERTIFIED 2			PREBASIC		
VARIETY	**GRADE**	**No. of BAGS**	**VARIETY**	**GRADE**	**No. of BAGS**	**VARIETY**	**GRADE**	**No. of BAGS**
Wanjiku	Grade 1		Wanjiku	Grade 1		Wanjiku	Grade 1	
	Grade 2			Grade 2			Grade 2	
	Chats			Chats			Chats	
	Damaged			Damaged			Damaged	
Shangi	Grade 1		Shangi	Grade 1		Shangi	Grade 1	
	Grade 2			Grade 2			Grade 2	
	Chats			Chats			Chats	
	Damaged			Damaged			Damaged	
Nyota	Grade 1		Nyota	Grade 1		Nyota	Grade 1	
	Grade 2			Grade 2			Grade 2	
	Chats			Chats			Chats	
	Damaged			Damaged			Damaged	
	PERCENTAGE DAMAGE =		(TOTAL HARVESTED −DAMAGED)×100					

Input/output crop record

The records contain:

a. The quantities of inputs (expenditure) used at unit cost. These inputs include the crop, fertilizer, labour, cost of machine hire, pesticides used, cost of land hire, transportation, statutory fees, etc.

b. outputs (sales) achieved; this is for the total harvest.

c. The total output value at the end of the season minus total value of inputs used, which is the profit.

Table 3.5: Example of a Computed Input/output Crop Record

Crop.....Seed Potato.....

Area (ha).....1.....Year.....2021.....

Date	Operation/Activity	Input Used		Remarks on inputs	Yields (Output) Realized	Value	Remarks on output
		Quantity and unit	Value Total Kshs				
12th March	Purchase of Seed potato (shangi)	18 bags of 50Kg @ Kshs 2500	45000	scarce supply			Poor weather
12th March	Purchase of fertilizer e.g. DAP	10 bags of 50Kg @ Kshs 3000	30000	Adequate supply			
	Land preparation						

Date	Operation/Activity	Input Used		Remarks on inputs	Yields (Output) Realized	Value	Remarks on output
		Quantity and unit	Value Total Kshs				
	Etc.						
15th June					400bags of 50Kg @ 3000	1200000	

Table 3.6: A blank copy of the Input/output Crop Record

Crop.....

Area (ha).....Year.....

Date	Operation/Activity	Input Used		Remarks on inputs	Yields (Output) Realized	Value	Remarks on output
		Quantity and unit	Value Total Kshs				

3.4.2 Record keeping for profit calculation

Duration 2 Hours

Learning Outcomes Description

It is very important for farmers to know whether they are making profit or loss from each enterprise. This is especially important in seed potato enterprise. This session will equip learners with knowledge and skills in calculating profit for their seed potato business.

At the end of the session participants should be able to:

1. Explain the importance of profit calculation and calculate profit.
2. Analyze data to find out whether they have made profit or loss.

Learning aids and materials

- LCD projector and screen
- Power point presentations , charts, seed potato records
- Flipcharts and marker pens
- Case study (exercise)

Procedure

Activity I: Introduction (10 minutes)

a. Ask a few participants to describe their experiences in keeping records used in calculating profit or loss.

Activity II: Group discussion (30 minutes)

a. Divide the participants into groups and ask them to:
   i. Discuss the importance of tracking and tracing costs of production e.g., seed, inputs, labour, land preparation and sales cost.
   ii. Outline challenges they encountered in record keeping and how to address them.
b. Ask them to present in plenary and make comments.

Activity III: Presentation (1 Hour)

a. Provide formats of various records used in seed potato production and sales.
b. Demonstrate how to fill in records – inputs, production and output stages and calculate profit.
c. Ask participants to calculate profit using a given example.

Conclusion/Summary  20 minutes

Summarize the session, by asking one participant to present their answer and make comments. Display for them the trainers pre-filled form.

SESSION NOTES

Importance of calculating profits in farming business

a. It informs the farmer of the status of his business in terms of profit making.
b. Profits help in having a sustainable and viable farming business. For accurate and reliable calculation of profits, it is important to be consistent in maintaining accurate records of inputs and outputs.
c. Keeping accurate records has its benefits like helping farmers plan and complete realistic forecasting for next season/year.
d. It aids in decision-making regarding the business.
   i. Whether to continue with the enterprise or give up.
   ii. Whether to upscale the business by injecting more funds.
   iii. To make decisions on re-strategizing so as to maximize on profits by addressing the areas where the business is making losses and take steps to correct the situation.

Exercise on calculating profits

Farmer Bidii leased one acre of land at a cost of Ksh.3000 to grow seed potatoes. He bought 18 bags of seed potato at Ksh. 2500/per bag. He bought 4 bags of fertilizer at Ksh. 3600 per bag. He

also bought 40 bags (100kg) of manure at Ksh.100 per bag. He bought fungicides for 6 sprays. Each spray cost Ksh. 3000. He bought 200 bags for packaging at Ksh. 60 per bag.

Farmer Bidii used 17 man-days (man-hours) at Ksh. 400 per unit. Manure application for 8 man-days at Ksh. 400 per unit. Planting took 15 man-days at Ksh. 400 per unit. Weeding/ earthing 1 and 2 took 20 man-days at 400 per unit while dehaulming took 4 man-days at Ksh. 400 per unit. Harvesting/transportation took 30 man-days at Ksh. 400 per unit and storage took 20 man-days at Ksh. 400.

The contingency interest rates and opportunity cost was estimated at 30%.

Farmer Bidii harvested 120 bags for the acre. The prevailing market rate at the time of harvest was Ksh. 2000 per bag.

Enter the data in the cost benefit analysis table and calculate the net income that Farmer Bidii obtained at the end of that season.

Trainer's Example: The table below calculates the cost benefit analysis of crop record (Seed Potato produce manual, 2016).

Table 3.7: Example of Cost benefit analysis record (Seed Potato production manual, 2016)

Crop.....seed potato.....

Area .....1 acre.....Year ..... 2016.....

Inputs	Quantity	Unit Cost	Cost per acre
A Materials			
Land lease	1 acre	3000	3000
Seed	18bags	2500	45000
Fertilizer	4bags	3600	14400
Manure	40bags (100kg)	100	4000
Fungicides and others	6 sprays	3000	18000
Packaging bags	200	60	12000
SUBTOTAL			**96400**
B. Labour			
Land preparation		400	6800
Manure application		400	3200
Planting		400	6000
Weeding/earthing- up 1&2		400	8000
Dehaulming		400	1600
Harvesting/transport		400	12000
Storage		400	6000
SUBTOTAL			**43600**
Total production cost			140000
Contingency, interest and opportunity cost (30%)			42000
Grand total (cost of production)			182000
Gross income per acre	120 bags	2000	240000
Net income			58000
Return on investment %			31.9

Conclusion: Farmer Bidii was able to get net profit of Ksh. 58,000.00 (a return of 31.9%).

Table 3.8: Copy of Cost benefit Analysis Record (Seed Potato Production Manual, 2016)

Crop.....

Area (ha.....Year .....

Inputs	Quantity	Unit Cost	Cost per acre
A Materials			
Land lease			
Seed			
Fertilizer			
Manure			
Fungicides and others			
Packaging bags			
SUBTOTAL			
B. Labour			
Land preparation			
Manure application			
Planting			
Weeding/earthing- up 1&2			
Dehaulming			
Harvesting/transport			
Storage			
SUBTOTAL			
Total production cost			
Contingency, interest and opportunity cost (30%)			
Grand total (cost of production)			
Gross income per acre			
Net income			
Return on investment %			

References

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Further reading

See: Annex 1.4: ***Net Profit Analysis of seed potato agri-business.***

Session 3.5.1 Lobby and Policy Advocacy

Duration 2 Hours

Description

Smallholder farmers continue to suffer declining productivity and increasing costs of inputs including seed potato. Farmers have a role to play to address these and other problems that they encounter. By coming together farmers can collectively buy inputs, sell their produce

and solve their problems. This session will equip participants with basic knowledge and skills in lobby and policy advocacy for them to take collective action on common challenges they encounter in accessing seed potato.

Learning Objectives

At the end of the session, participants should be able to:

1. Explain what is lobby and policy advocacy.
2. Mobilize other farmers for evidence-based advocacy

Learning Aids

- Flip chart and marker pens
- Handout or PowerPoint presentation

Procedure

Activity I: Introduction to Lobby and Policy Advocacy (15 Minutes)

a. Ask learners to explain the terms lobby and policy advocacy.
b. Correct as necessary.

Activity II: Simulation exercise on policy advocacy (1 hour 30 Minutes)

a. Divide the participants into small groups and ask them to:
   i. Come up with solutions to lack of easy access and high cost of seed potato in their community.
   ii. They should identify people who have the power to solve this problem.
   iii. Identify a step by step process or actions that they will take to have their problem solved.

Conclusion  15 Minutes

Ask the groups to present their outputs. Summarize by highlighting the key points.

SESSION NOTES

Lobbying

The act of influencing lawmakers by convincing them to introduce a motion or vote in a particular way that is favourable to a group.

Policy Advocacy

The deliberate process of informing and influencing decision-makers in support of evidence-based policy change and policy implementation, including resource mobilization.

Difference between Lobbing and Advocacy

Advocacy is education to make policy-makers more aware of what you do and how current policies negatively influence your work/business, while lobbying is asking legislators (local or national assembly) to take a particular position on a specific legislation.

Steps in Policy influencing or formulation

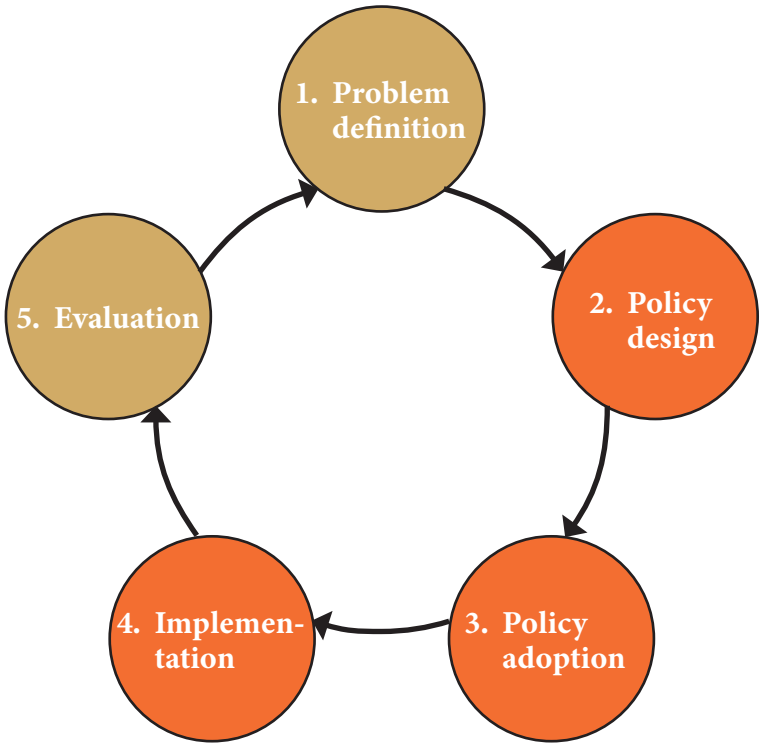

Figure 3.29: Steps in policy influencing or formulation (Source: Management Guru)

1. **Problem Definition:** This is the identification of the problem and its root causes. It also involves collecting evidence that clearly and easily shows how the problem is affecting the group e.g., farmers, community members, village members etc.
2. **Policy Design:** This is the identification of solutions that will effectively solve the problem and how they can be implemented. It also involves identifying the individual/s to whom the group will address their problem and suggested solutions. It also involves developing or packaging the message and identifies to who, when and where the message will be delivered.
3. **Policy Adoption:** This is the acceptance and inclusion of the solutions into policy and/or legislature (law). This process involves participation of interest groups and intense lobbying to ensure that the groups' interests are well addressed.
4. **Policy Implementation:** This is the putting into action the policy or law. It may involve addressing the teething problems that arise.
5. **Evaluation:** This involves evaluating the impact of the policy or law to see if it has effectively addressed the problem it set out to solve, or if there is need for changes.

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MODULE 4

RAPID MULTIPLICATION TECHNIQUES OF SEED POTATO

SESSION/TOPIC	DURATION
4.1. Introduction to rapid multiplication techniques of seed potato planting materials Introduction to rapid multiplication techniques (RMT's) in seed potato Apparatus and hygiene procedures in a tissue culture lab Process of producing ***in vitro*** materials Procedures of hardening in a greenhouse	4hrs 40mins
4.2. Production of Apical rooted cuttings (ARCs) 4.2.1 Importance of ARCs 4.2.2 Establishment of mother plants 4.3.3 Production of ARCs	3 Hours
4.3 Seed potato production under hydroponics system Demonstrate the set-up of a hydroponics unit Introduction to soil-less media; Definition and types 4.3.3 Advantages and disadvantages of using soil-less media 4.3.4 Planting of in-vitros and mini-tubers under hydroponics system	4 Hours
4.5 Seed potato production under aeroponics system 4.5.1 Introduction of terms, history and importance of aeroponic, Advantages and disadvantages of aeroponics 4.5.2 Factors to consider before setting up an aeroponics; Equipment required in the aeroponics 4.5.3 Ideal condition for establishing an aeroponics unit 4.5.4 Preparation/of planting an aeroponics system	5 Hours
4.4 Water & Nutrition management under hydroponics and aeroponic system 4.4.1 Different irrigation systems under hydroponics and aeroponic systems 4.4.2 Setting up and timing of the irrigation system 4.4.3 Preparation of Nutrient stock solutions 4.4.4 Plant water and nutrient management at various stages of crop growth	9 Hours
4.7 Greenhouse management Green house sanitation Green house rules Common pests and diseases in a green house Control of pests and diseases	2 Hours 30 minutes
4.8 Harvesting and Handling Mini-tubers Methods of harvesting Sorting and grading Conditions for storage of mini-tubers	1 Hour
4.9 Economic benefits of hydroponics and aeroponics Economic gain verses economic loss for hydroponic, aeroponic, and conventional potato production systems.	1 Hour

Session 4.1 Introduction to Rapid Multiplication Techniques of Seed Potato Planting Materials

Duration 4 Hours 40 Minutes

Description

This topic will introduce various rapid multiplication techniques and their importance in seed potato production. It will also explain the process of ***in-vitro*** propagation in a tissue culture lab and hardening procedures. It will lay the foundation for other topics in this module.

Learning outcomes

By the end of this session, the participant should be able to:

1. Explain the different rapid multiplication techniques
2. Explain the concept and process of producing tissue culture materials
3. Demonstrate the hardening process

Learning aids and materials

• RMT Standard procedures	• LCD Projectors/handout	• Nutrient media
• Tissue culture lab and green house	• In vitro(hardened, in media)	• Dust coat, gloves
• Forceps, scapels, sanitizers		

Procedure

Activity I: Introduction (10 minutes)

a. Ask the participants to tell the different rapid multiplication techniques (RMT's) and why they are important.

b. Present powerpoint/handout on RMT's

Activity II: Procedures of producing tissue culture materials (3 hours)

a. Show samples of tissue culture (***in vitros***) materials

b. Demonstrate the following procedures: stock preparation, media preparation, culturing and hygiene practices.

c. Divide the participants into small groups and let them practice the above procedures.

Activity III: Hardening procedures (1 hour 30 minutes)

a. Explain the procedures of preparing sand to be used in hardening.

b. Demonstrate the hardening procedures.

c. Ask participants to harden their tissue culture materials.

Conclusion

i. Ask Participants to read on rapid multiplication techniques.

ii. Ask participants to monitor their cultures

SESSION NOTES

Rapid multiplication techniques (rmts)

Introduction

Due to limited supply of certified seed, most farmers recycle seed tubers for many seasons causing an overall decline in seed quality due to accumulation of seed borne diseases through seed degeneration. The informal system has led to the use of poor quality seeds planting

material that has hastened the spread of seed-borne diseases such as bacterial wilt. Several seed production techniques are currently used worldwide to mitigate seed production problems. These include use of tissue culture (micro propagation) to produce plants for hydroponics, aeroponics systems and apical rooted cuttings.

Tissue Culture

It is a method of biological research in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function. The cultured tissue may consist of a single cell, a population of cells, or a whole or part of an organ.

Stock solution and media preparation (for 1 litre capacity)

Prepare 20 clean kliner jars or 24 clean plastic containers by swirling twice with sterilized distilled water and place cover or cap. Place on each container autoclave tape to show complete sterilization after autoclaving. Prepare a clean 1ltr conical flask and place next to containers. Measure stock solution 1-6 (Table 1) and pour the contents into conical flask. Add 20g sucrose to the conical flask and place a magnetic stirrer within the bottle. Allow contents to stir on the magnetic stirrer for 1 minute after which top up the solution by adding distilled water to make 1000mls. Allow the mixture to gently mix for 5 mins. Calibrate the pH meter and gently place the electrode into the media mixture to measure pH to a level of 5.8. If the pH is high lower by adding 96.4% of HCl and if too low increase by adding 0.01% of NaOH until the required pH is achieved. Measure 2.5g/l of solidifying agent phytagel and cover media contents. Transfer the mix to a pre-test to a autoclave machine together with kliner jars set at 121°C for 15 minutes. Once the media has cooled transfer the kliner jars and media contents into the autoclave and dispense media into the kliner jars. Label the container with date and media type, close the caps and allow media to cool. Two days later carry on with culturing of *in vitro*.

Table 1: MS (Murashige and Skoog) media

Stock solution	Salts/Vitamins	G/L	Amount of stock
1	NH_4NO_3	33g	50ml
	KNO_3	38g	
2	$MgSO_4.7H_2O$	18.19g	10ml
	$MnSO_4.4H_2O$	1.7g	
	$ZnSO_4.7H_2O$	0.86g	
	$CuSO_4.7H_2O$	0.0025g	
3	$CaCl_2.2H_2O$	33g	10ml
	KI	0.083g	
	$CoCl_2.6H_2O$	0.0025g	
4	KH_2PO_4	17g	10ml
	H_3BO_3	0.62g	
	$NaMoO_4.2H_2O$	0.025g	
5	$FeSO_4.7H_2O$	2.8g	10ml
	Na_2-EDTA	3.725g	
6	Inositol	0.05g	10ml
	Glycine	0.2g	
	Nicotinic acid	0.05g	
	Pyridoxine-HCl	0.05g	10ml
	Thiamine-HCl	0.5g	
	Sucrose		$20gL^{-1}$
	Agar		$7gL^{-1}$
	Total for media		1000ml

Hardening off

Soilless media preparation for hardening off

Sand

Ensure that the sand is sourced from areas that do not grow potato. Delivered sand should be well placed and covered when not in use. Using a spade and a wheelbarrow, place ¾ full sand in the wheelbarrow. Wash using clean tap water until the water coming out of the sand is clear. Drain all the tap water and Place cleaned sand in hot boiling water or boil it to ensure sterilization. Let the sand cool over night before use.

- **Cocopeat**

Soak untreated coco peat in water over night, add calcium nitrate at a ratio of 1000 liter: 5kg $CaNO_3$. Drain the water in the morning, and carry out three tap water washes.

Determine the cocopeat Ec, should be less than 500 units. Add Magnesium Nitrate 1000ltrs 2kgs and mix properly, to charge the coco peat. Place treated and charged coco peat in bags and store in a cool place to avoid it loosing water, or use.

Plate 1: in vitro plants hardened ready for planting

- ***In vitro* hardening off**

Using treated coco peat and sand, mix at the ratio of 3:1, i.e. 3 parts coco peat and 1part sand. Place the mixed media in a clean tray that is lined with a clean polythene sheet to help in water retention. After placing the sand in the trays, water it with clean tap water and leave it over night before use. The following day dibble holes on the media in the trays.

In-vitro plants are carefully removed from the containers to avoid stem breakage. Wash off media from *in-vitro* plantlets under a soft running tap water to break off excess roots. Place on fungicide for more washing and dip in a pre-made GA_3 solution. Plant the plantlets in the already made holes; stem cuttings can be made based on the size of the *in-vitro* plants in use. After planting, slight tap watering is recommended, then cover the planted tray with a germination cloth or clear polythene paper. Routine monitoring is advised as the plantlets develops. Nutrient irrigation, fungicide and insecticide spraying is recommended after two weeks.

References

https://www.plantcelltechnology.com/blog/tissue-culture-of-potato-part2/

Session 4.2: Production of apical rooted cuttings

Duration 3 Hours 10 Minutes

Description

This topic will introduce learners to apical rooted cuttings as used in multiplication of seed potato. Learners will acquire skills on how to establish mother plant and carry out apical cutting propagation procedures at the right stage. Different types of media used in production of apical rooted cuttings (ARC's) will be introduced to the participants.

Learning outcomes

At the end of the session, participants should be able to:

1. Explain the importance of ARC's.
2. Establish the mother plant
3. Produce apical rooted cuttings

Learning materials

• Projector, computer, video clip	• Flip charts, white board and marker pens	• Greenhouse, seedling trays
• Forceps, Dust coats, Ethanol, Gumboots, Buckets	• Soil-less media; cocopeat and	• Potato ***in-vitro*** plants, mini-tubers and apical rooted cuttings

Activity I: **Introduction (10 minutes)**

a. Explain the importance of ARC's
b. Explain that the session will enable them produce apical rooted cuttings

Activity II: Establishing the mother plant (1 hour)

a. Demonstrate how to establish a mother plant from ***in-vitro*** plantlets
b. Ask participants to establish their own mother plants
c. Explain how to manage mother plants

Activity III: Producing apical rooted cuttings (2 hours)

a. Demonstrate how to establish a rooted apical cutting from a mother plant
b. Ask participants to establish their ARC's
c. Explain how to manage ARC's

Conclusion/Summary

Give the participants the case study on farmer Joseph Ndirangu's experiences on producing ARC's

SESSION NOTES

Apical rooted cuttings

An apical rooted cutting is similar to a nursery grown seedling except that it is produced through vegetative means and does not originate from a seed. Cuttings are produced from tissue culture plants in a screen house, and are clean and free of disease. Only those with irrigation can plant rooted cuttings as water is essential until the cuttings are established.

Importance of apical rooted cuttings

Integrating cuttings into seed systems reduces time to which high quality seed potato is available to farmers, while increasing efficiency of seed production compared to current practices. Productivity of cuttings surpasses that of mini-tubers produced by sand hydroponics and aeroponics by greater than 11 and 3-fold, respectively. High productivity is as a result of producing several rounds of mother plants from the initial tissue culture plantlet prior to producing cuttings. High tuber number per cutting further contributes to and compounds productivity of cuttings.

Establishment of mother plant

The ***in vitros***, well-rooted shoots (plantlets), should be taken out gently from the culture media and washed with sterile water to remove any traces of agar on the roots and dipped in fungicide solution for 20 minutes (soil borne disease). The plantlets should then be transferred to containers filled with sterilized sand for establishment. The plantlets are covered for 25 days to adjust (acclimatize) to the ambient growth environment. Plants should be fed with water till they reach their maturity. After cutting the apical tips mother plants are fed with nutrient solution to enhance sprouting of new shoots

Production of apical rooted cuttings

Before cutting the apical tips from the established mother plant, hands and scissors are disinfected with 70% ethanol. Apical tips of the established mother plants are cut with one node after the mother plant develops three and above nodes. After cutting the apical tip from the cutting, each mother plant should provide 1-3 shoots for cutting. The cuttings are rooted in trays filled with sterilized cocopeat. The cuttings takes two to three weeks to root after which they will be taken to the soilless media to produce seed tubers.

References

https://cipotato.org/cip-50/innovations/rooted-apical-cuttings/

Session 4.3: Seed Potato Production under Hydroponic System

Duration 4 Hours 10 Minutes

Description

This topic will introduce learners to the hydroponics system as used in Kenya for seed potato production. Learners will acquire skills on how to set up and manage a standard hydroponics unit. Different types of media and their uses will be introduced to the participants.

Learning outcomes

Upon successful completion of this topic, participants should be able to:

1. Describe components of hydroponic system and how it works
2. Identify the different types of soil-less media
3. Prepare the soil-less media and plant seed potato materials

Learning materials

• Projector, computer, video clip	• Flip charts, white board and marker pens	• A model hydroponics unit and greenhouse
• Forceps, Dust coats, Ethanol, Gumboots, Buckets	• Soil-less media; cocopeat, vermiculite, perlite, peat moss, sand, pumice.	• Potato ***in-vitro*** plants, mini-tubers and apical rooted cuttings

Activity I: Introduction (10 minutes)

a. Ask participants to describe a hydroponics system
b. Write down the responses received from participants on a flipchart or white board and guide them to the right definitions.

Activity II: Presentation on a hydroponics unit (1 hour)

c. Present slides/video on how a hydroponics system works.
d. Discuss the various components of a hydroponics unit.
e. Discuss the factors to consider before setting up a hydroponics system.

Activity III: Preparation of Soil-less Media (2 hours)

a. Show different media to participants and explain their uses.
b. Request the participants to differentiate samples of different media
c. Demonstrate how to prepare media for hydroponic use
d. Ask participants to prepare media
e. Ask participants to discuss the importance of treating media

Activity IV: Planting in a Hydroponics Unit (1 hours)

a. Ask participants to wash and disinfect their hands, put on clean dust coats ready for planting seed potato materials.
b. Demonstrate how to set up the irrigation system and timer
c. Demonstrate how to prepare and plant seed potato plantlets
d. Ask participants to prepare and plant at the drip emitters

SESSION NOTES

Introduction to hydroponics system

Hydroponics is the growing of plants on inert soil-less media such as coco peat, pumice, perlite, vermiculite, clay pellets and soft rocks. Plants in this system are grown in such a way that the plant roots draw nutrients from the media supplied through an appropriate irrigation system. The prepared nutrient solution is then mixed in the tank, which is pumped to the irrigation system set up. This system is useful in the production of mini-tubers. There are several types of hydroponics system. The basic types are: Wick system, Deep water culture, Drip hydroponic system, Misting hydroponic system, Nutrient film technique (NFT), Ebb and Flow hydroponic system. A number of crops can be grown under this technology which include vegetables, herbs, fruits and tuber crops like potatoes, although there are some crops to avoid like corn, squash crops and vining plants since they aren't space efficient.

The best hydroponic system for potato is the one that uses a supportive medium for the plants to grow in without continually wetting the potatoes or submerging them into solution. The system can be as simple as filling bucket/pots with growing medium on which potato is planted and supplied with nutrient solution. The pots can be watered separately or through a main delivery system. However, for much larger scale, troughs are more common due to economies of space utilized and number of plants supported.

Table 2: Hydroponics advantages and disadvantages

Advantages	Disadvantages
There are no soil borne pests and diseases- saving on cost of buying the pesticides.	High capital cost
Minimal nutrients loss since they are conserved in the tanks and nutrient efficient due to recycling.	It's requires time, experience and technical knowledge
Makes better use of space and location	It is limited to certain plants
Improved production/yield in the same amount of space.	
It's easy to agronomically manage this system	

Requirements for Growing Seed Potatoes under Hydroponics

- Water: should be clean, neutral pH and non-chlorinated.
- Sunlight: should be sufficient at least 12hrs of day light, the site must not be shaded.
- pH: should be in the range of 5.8 - 6.5 for optimal results.
- Temperature of 18 - 23°C are best.

Setting up Hydroponics System

i. Basic Elements of the Structure

The basic components of a hydroponics unit include:

- Growing media; Main function is to provide support. The most commonly used media for potato include coco peat, pumice, perlite or vermiculite. Growing medium hold all nutrients and will provide support to the growing plants roots. A blended medium is better than single medium with some of the best combination using perlite, vermiculite and peat.
- Nutrient solution: containing all the necessary nutrients elements. It is important to test for the electrical conductivity (EC) and pH of the solution.
- Nutrient reservoir: this is where the solution is placed for use before supply to plants. This can be a tank, plastic container or any equipment that can hold the quantity of water you need. Its recommended that its placed in a secured area.
- Pump: used for pumping water from the reservoir into the system. Water is aerated as it circulates ensuring it is fresh. The pump as well as the delivery pipes should be checked regularly so as to ensure there is no blockage.

Open and closed (within a greenhouse) hydroponics system

Mixing tanks and pump system

Power control unit

Laying out the planting troughs

ii. Materials and construction;

Construction of a hydroponics structure can be done using locally available material like timber for semi-permanent structures or using steel that makes a permanent structure. Planting vessels also vary from troughs, buckets, crates to bags.

iii. Preparation of plantlets for hydroponics planting

The process begins with preparation of plantlets from ***in-vitro*** plants by obtaining a 4-week old ***in-vitro*** plants, uprooting the plantlet from the culture jar, wash off media from the roots, dip the plantlet into a mild fungicide hen plant in already prepared soil-less media. They are covered with a clear plastic sheet for humidity regulation. Later the hardening process sets in.

Media Preparation for the Hydroponics

Coco peat is the most common planting material under hydroponics seed potato mini-tuber production. This is because it's easy to treat and use. Cleaning and treatment of coco peat is done as previously done under apical cutting session.

Planting materials sterilization

Troughs, buckets, pots to be used cleaned with soap water first then sterilized using Sodium hypochlorite or hydrogen peroxide and finally rinsed with clean water awaiting the planting media to be placed.

Transplanting

This involves using already hardened ***in-vitro*** plantlets or ARC's. they are carefully uprooted from the hardening trays/crates and later planted on previously wetted planting hydroponics media. Appropriate planting spacing of 10cm x 10cm should be used. Planting fertilizers eg DAP, NPK can be used. For the first week the plantlets are feed on water lo allow them to stabilize, latter fertigation is done.

References

Attachments

Handouts

Session 4.4 Seed Production under Aeroponic System

Duration 2 hours 40 minutes

Description

The session will introduce the potato entrepreneur to rapid multiplication of high status seed under an aeroponic system. The participants will be able to explain the merits and demerits of using an aeroponics system to produce seed. The entrepreneur will gain skill on requirement before setting up an aeroponic unit.

Learning outcomes

By the end of this session, the participant should be able to:

1. Explain components of aeroponic system and their functions.
2. Explain the advantages and disadvantages of an aeroponic system.
3. Identify factors to consider in establishing an aeroponic system.
4. Prepare and plant seed potato plantlets.

Learning aids and materials

• Plantlets (***in vitros***, rooted apical cuttings)	• Flip charts and marker pens
• Aeroponic unit/Model	• Sponge, forceps, gloves, sanitizers, PPEs
• Fungicides	

Procedure

Activity I: Introduction (10 minutes)

a. Through guide questions, the participants will brainstorm and provide answers based on components of aeroponic system and their function.

b. Summarise the discussion by highlighting key components and their importance.

Activity II: Group discussion (1 minute)

a. Divide participants into small groups and ask them to discuss the following;

   i. Advantages and disadvantages of aeroponic system

   ii. Factors to consider in setting up aeroponic system

b. Ask them to present in plenary as you highlight key points

Activity III: Planting in an aeroponic system (1 hour 30 minutes)

a. Demonstrate how to plant seed potato plantlets in a aeroponic system

b. Ask participants to plant the seed potato plantlets.

c. Turn on the irrigation system

Conclusion/Summary

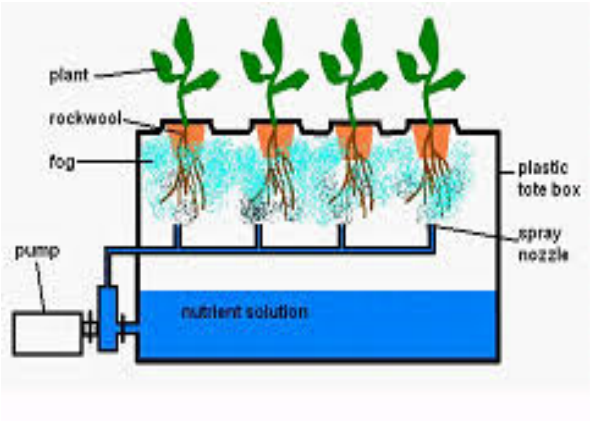
Conclude the session using question and answer technique.

SESSION NOTES

Seed potato production under aeroponics system

Introduction

The term "aeroponic" is from the Latin word "aero", meaning air, and "póno" meaning works. It is another method of soil-less cultivation for growing plants in a controlled environment. It works by applying nutrient rich water under pressure using misters on plant roots. Plants are planted in a dark box where they are suspended.



History of Aeroponics: Aeroponics technology was reported to have been first used in early 1920 by botanists to study plant root structure, and for many years aeroponics was used as a root physiology research tool. In 1966, this system was upgraded from use for laboratory analysis tool to use for commercial plant cultivation purposes. In 1996, the

nutrient fog system was introduced. In Kenya, Aeroponics technology was introduced in 2009 by a team of scientists from Peru who were working with local scientists at the International Potato Centre (CIP) – Nairobi. Seed potato mini-tubers were produced under the 3G (Generation) seed potato project that was then funded by the USAID.

Plate 2: Aeroponics plant roots forming mini-tubers

Reasons that have led to adoption of aeroponics in mini-tuber production.

The aeroponic system is one of the best systems for producing potatoes because:

1. Plant roots are quickly nourished under the aeroponic-controlled conditions which include uniform nutrient concentrations, pH, EC, humidity, spray time, interval, frequency, oxygen availability, temperature and light intensity.
2. Plants grow rapidly to the sterile environment and the availability of sufficient oxygen that improves tuber yield.
3. It uses little water quantities per plant, and is best with the water challenges experienced in Kenya.
4. Potato field farming is risky and uncertain due to unreliable weather conditions such as floods, blight, drought, and pests and diseases. Aeroponics technology has been adopted in Kenya for enhanced high status potato seed production.

Plate 3: Potato plants at vegetative stage growing under sterile conditions

Advantages of using aeroponics system	Disadvantages of using aeroponics system
Aeroponics techniques allow for higher growth rates and healthy, uniform, and vigorous potato tubers.	Growers need the appropriate knowledge and a specific level of proficiency to operate the system supplying the nutrients needed for plant growth.
Aeroponics techniques reduce the number of field generation steps and cost of production of high status seed potato multiplication.	It is important to provide nutrients at the desired concentrations. If there is an oversupply, plants will die, and no solid culture can absorb excess nutrients.

Advantages of using aeroponics system	Disadvantages of using aeroponics system
The crop can be planted all year round as it is not bound by the seasons, so the yield is higher.	Initial capital cost is high, the design materials and equipment are expensive. Because of the well-designed system, advanced equipment is required.
Aeroponics systems improve plant health and quality of the first field generation since they are produced from ***in-vitro*** plants.	
Aeroponics allow closer spacing of plants in the greenhouse, a limited land area may be used. Closer plant spacing can provide greater yields for the same area for certain crops.	
Aeroponics systems use little amount of water.	

Factors to Consider When Setting Up an Aeroponics Unit

1. **Greenhouse:** A normal greenhouse structure is important. It provides a safe environment. Construct a greenhouse with a higher roof and, where necessary, cover the plastic with a net shade to reduce temperature. Ensure green house is positioned well to allow enough light during daytime.
2. **A reliable** source of clean, accessible and available throughout the season water. The water should be of normal pH and EC.
3. **Electricity supply:** steady and stable power is important and a standby generator is recommended.
4. **Plant material:** already hardened ***in-vitro*** plantlets or apical cuttings are used.
5. **Irrigation system:** should be properly installed with right specifications of misters, pipes, pumps, tanks, filters.
6. **pH and EC meter:** this will be used to determine the water and nutrient solution suitability.
7. **Thermometer and hygrometer:** important as it helps to document temperature and humidity of the unit.
8. **Timers:** they control the feeding time for the system.
9. **Fertilizers:** they are the soluble hydroponics grade fertilizers that are used in computing the nutrient solution. They are documented in the nutrient management session.

Aeroponics Mini-tuber Production Standard Operating Procedure (SOP)

1. Ensure that the aeroponics pumps, filters and misters are working properly
2. Ensure that there are no leakages in the boxes and pipes
3. Clean the aeroponics tanks, misters, filters and boxes with soap and water
4. Sterilize with hypochlorite solution or hydrogen peroxide overnight.
5. The following day, rinse off the cleaning and sterilization solution using clean tap water.
6. Before planting place sufficient amount of water in the tanks, test that the whole system is properly working.
7. Planting is done using previously hardened plants that are at least 3 inches long.
8. Uproot them from the tray carefully, making sure that the roots have minimal breakage, wash under tap running water.
9. Place in a mild fungicide.

10. Rap the plantlets with a thin cut pre-paired and sterilized sponge.
11. Using forceps, place in the aeroponics holes. This should be slowly to avoid breakage of the plantlet.
12. While planting, the pumps must be working, and tanks should be filled with clean tap water. Avoid chlorinated water.
13. For the first two weeks, the pump setting should allow continuous misting during the day, and no misting at night.
14. Start introducing nutrient solution after one week.

References

https://cipotato.org-2014/08/

Session 4.5. Water and Nutrition Management

Duration 2 Hours

Description

This session aims to introduce seed potato growers to fertigation system used in the hydroponic and aeroponic unit. The learners will acquire skills in setting up and timing the irrigation system, preparation of nutrient stock solutions and their application.

Learning outcomes

By the end of this session, the participant should be able to:

1. Describe different fertigation systems in RMTs.
2. Set up and time the fertigation system.
3. Prepare nutrient stock solutions and apply it.

Learning aids and materials

• Hydroponic and aeroponic unit	• Plastic Containers
• Weighing balance,	• pH and EC meter
• Clean non-chlorinated water and nutrient (stock A & B elements).	• PPEs, Ethanol/disinfectant

Activity I: Introduction (30 minutes)

a. Discuss the components of the fertigation system and how it works.
b. Demonstrate the setting and timing of irrigation system and discuss when to best fertigate the plants.

Activity II: Preparation of stock solutions and application (1 hour)

a. Explain the different nutrients used in fertigation and their functions.
b. Demonstrate how to weigh and mix nutrient stock A and stock B.

c. Ask the learners to mix stock solution A and B.

d. Demonstrate how to mix the nutrient stock solutions A and B as recommended in the fertigation tanks.

e. Demonstrate how to measure the pH and Ec of the mixture and adjust to recommended range (pH 5.8-6.5 and Ec 0.5-2.0 mS/cm).

f. Turn on the fertigation system.

Conclusion/Summary

Using the question and answer technique, ask participants to explain importance of different nutrients used in fertigation and how to mix them.

SESSION NOTES

Water and nutrient management

Water and nutrients should be supplied periodically to ensure that plant gets in the required elements for growth and development and subsequently for good productivity. Water for irrigation should always be available, of good quality with the right pH (5.8-6.5), Electrical conductivity (0.5-2 mS/cm) and free from contaminants and chemicals (especially Chlorine). This can be rain water, tap or borehole water. Water whose quality is unknown should be filtered and sterilized using UV radiation.

Nutrients solution is supplied to plants through the fertigation system. The nutrient solution is recycled in the hydroponic system for a maximum of two weeks then replaced with freshly prepared solution. The pH and Ec should be monitored regularly to check suitability and correct when necessary. Irrigation and supply of nutrients is dependent on size and age of the plant and the climatic conditions. Nutrients should be supplied at half rate during the first 3 weeks of application and later supplied in full dose to avoid shock. Nutrition in hydroponics is a major factor to check for crop growth and yield.

The soil-less media used as a medium for growing the plants has minimal or no nutrients. Therefore, there is need to add nutrients for plant growth. The plants are left to run on water for a period of 2 weeks before a nutrient solution is introduced. The nutrients are supplied in two phases; stock A and stock B, which have several elements in each. Stock A elements are prepared by mixing into cold water while nutrient elements in stock B are mixed in hot water to avoid precipitation.

Table 3: Fertilizers making the stock A and B

1	Potassium Nitrate KNO_3
2	Mono-Potassium Phosphate KH_2PO_4
3	Calcium Nitrate $CaNO_3$
4	Magnesium Sulphate $MgSO_4$
5	Iron Fe- EDTA
6	Microsol B

STOCK A SOLUTION		MIXED IN COLD WATER
Mineral salts	1000 litres of water	
$MgSO_4$	246g	
Microsol B	12g	
Iron Fe- EDTA	18g	

STOCK B SOLUTION		MIXED IN HOT WATER
Mineral salts	1000 litres of water	
CaNO3	118g	
KH_2PO_4	136g	
KNO_3	46g	

When measuring the mineral salts, a sensitive electric balance has to be used for accuracy. An increase in weight of minerals changes the pH and Ec of the solution. The two nutrient stocks are mixed in the same tank and well stirred where Stock A comes first then Stock B follows.

Plant and Nutrient Handling in the Hydroponics System

The first nutrient application is done two weeks after planting the *in-vitros* into the troughs or pots. The nutrients are supplied together with irrigation water and runs for 30 to 60 minutes per day. This frequency continues at 2 days' interval for up to 2 weeks when the tank is cleaned and fresh nutrient solution added into the mix tanks.

As the crop canopy grows bigger, it requires more nutrient supply. The number of times to irrigate is increased to once per day at 30 to 60 minutes per session. This is about 6-8 weeks after planting as the foliage increases and tuber initiation begins. For a 3-month potato variety, the irrigation frequency reduces to every two to three days at 30 minutes per application at around the 10^{th} week, depending on weather (temperature and humidity). At this stage the crop water requirement is low as it approaches maturity. Irrigation ceases at one week to dehaulming.

Plant and Nutrient Handling in the Aeroponic System

The irrigation system at aeroponic system is turned on during the planting of the hardened ***in vitro*** plantlets. Once planted, the irrigation continues throughout the day, daily. Water is delivered through misters into the aeroponic unit; misters break the water into fog/mist. Irrigation continues for one week continuously except for the night when the pump may be switched off. After the first week, half strength of Stock A and B solutions are introduced and supplied continuously for one week after which full strength concentration is supplied. Continuous fertigation will continue until plants are about 1.5 months where 30 minutes off and on timing can be introduced, especially in the morning and evening hours. The pump is idle in the night as temperature and humidity allows.

Plants in aeroponic unit take longer than in the hydroponic. Harvesting is done only for mini-tubers that are ready and such tubers are washed with tap water to remove nutrient solutions on the skin. This will prevent damage and quality loss. After washing, the mini-tubers are placed under shade to dry and cure before packing and storage.

Session 4.6. Greenhouse Management

Duration 3 Hours

Description

This session aims at familiarising the participants with the sanitation and management guidelines for aeroponic and hydroponic systems. The participant will understand the major potato pests and diseases in aeroponic and hydroponic systems and their management.

Learning outcomes

By the end of this session, the learner should be able to:

1. Understand the sanitation and management guidelines in hydroponic and aeroponic units
2. Identify pests and diseases affecting seed potato and their control
3. Keep good production record

Learning aids and materials

• LCD projector, video clips, pictures	• PPEs, hand lens, pesticides, knapsack sprayer
• Greenhouse,	• Sample records
• Sample of greenhouse rules and guidelines	

Procedure

Activity I: Introduction (10 minutes)

a. Ask participants to list some common rules and regulations in a hydroponic/aeroponic greenhouse set-up.
b. Explain the importance of standard rules and regulations.
c. Lead participants in practicing the sanitation rules.

Activity II: Group discussion and presentations (1 hour)

a. Divide the participants into small groups and share samples/photos of affected plants.
b. Ask participants to observe signs and symptoms then identify pests and diseases.
c. Discuss management practices in a hydroponic/aeroponic greenhouse set up.

Activity III: Record keeping (30 minutes)

a. Discuss the different types of records and their importance in hydroponic/aeroponic greenhouse.
b. Demonstrate standard samples of records and how to fill them.

Conclusion/Summary

Ask participants to identify infected seed potato plants in the greenhouse.

SESSION NOTES

DISEASE AND PEST MANAGEMENT

Potato Late blight (*Phytophthora infestans L.*)

The most common disease in the aeroponics/hydroponics units is potato late blight (*Phytophthora infestans*). The disease causes pale green water-soaked spots on the leaves and light brown lesions on the stems. Spots and lesions enlarge rapidly and become necrotic. The blight may also infect the tubers if not managed. Infected tubers have hard slightly purplish depressions on the outside. The tuber is rusty brown in the flesh.

Management is by spraying with effective fungicides. The first application is done a day after planting. Ridomil Gold (Metalaxyl+Mancozeb) at the rate of 2.5-5g per litre of water is alternated with Infinito (Fluopicolide + Propamocarb) at the rate of 0.125-0.25ml per litre of water for first 30 days after planting. The rate is increased to 2.5-5g per litre of water for Ridomil Gold and 1.5-1.75 ml per litre of water for Infinito.

Red Spider Mites (*Tetranychus urticae*)

Spider mites are small microscopic 'insects' only visible with the aid of magnifying glasses. Spider mites are related to spiders but they are microscopic and have only one body section while spiders have two. There are several types of mites but red spider mites will all be red. The red spider mites are a common pest in the greenhouse. Plants infested with spider mites look unhealthy and have a dusty appearance on the underside of leaves. The leaves may also appear silver greyish. The dusty appearance are actually the mites. Sometimes there are webs on the underside of leaves and on stems.

Red spider mites are common in dry and hot conditions. They cause damage by sucking plant sap.

Control

Spider mites can be washed down by clean water applied on the plants using a hose-pipe or a watering can when plants are well established. The floor surfaces should also be showered with water to keep off dust.

The chemical abamectin (1.8g/L) gives good control when sprayed at the rate of 0.5 ml per litre of water.

White Flies (B*emisia spp.*)

Whiteflies are small white insects with soft bodies. They are winged and often found on the underside of leaves. They cause damage by sucking plant sap and producing a sticky substance (honeydew) which may cause fungal diseases on leaves. Infested plants may appear wilted from the leaves; turn pale yellow and may be stunted. Their eggs might also be visible on the underside of leaves as pale yellow when newly laid and brown when about to hatch.

Control

Disinfectants such as soapy water sprayed every morning on the crops may be effective under low infestation.

Chemical control using Thunder (Imidacloprid 100 g/l + Beta-cyfluthrin 45 g/l) at the rate of 0.5ml in 20 L of water for the first 30 days after planting. The rate increases to 5-10 ml in 20 L of water. The chemical is sprayed at the interval of 5 days alternated with Reldan (chlorpyrifos-methyl) at the rate of 25 ml into 20 L of water.

Potato Tuber Moth (*Phthorimaea operculella*)

The moth is small (12-16mm wingspan), and brownish grey in colour. Female moths lay eggs on the foliage and near eye buds on exposed tubers through cracks in the planting media. Caterpillars are up to 12mm long and whitish to pale greenish in colour. They feed as leafminers between the upper and lower epidermis and bore into the leaf leaves petiole and young shoots and later into the tuber. Caterpillars begin feeding on tubers immediately upon hatching. They pupate in a silken cocoon covered with soil particles and debris among dead potato leaves, soil litter, eye tubers and storage walls and floors.

Control

Spray soapy water on leaves daily or as often as possible. Hanging the pheromone bait among the potato crop in the greenhouse or using sticky traps can get rid of moths. Use insecticides such as Tihan, Indomectin, Occassion star.

Sanitation and Hygiene

The greenhouse facility should be such that there is a head-house with double doors. This ensures that at any one time, the doors of the greenhouse and head-house are not opened at the same time. Persons accessing the facility must disinfect their boots at a foot bath/booth installed at the entry. Ensure there is another clean set of clogs or shoes in the head-house. Persons accessing the greenhouse must wear this set and leave their pair of shoes at the head-house. There should also be at least two washing sinks, one at the main entry and the other at the head-house. The facility should admit a maximum of 10 persons at a time and they must be in clean dust-coats throughout their stay at the facility. Antibacterial soap should be available in the head-house for hand washing.

A clean towel and water is used to wipe surfaces on the aeroponic unit. The floor of the greenhouse is showered with clean water daily to avoid dust, which may harbour pests. Persons working in the greenhouse should use gloves while touching plants during inspection or disease and pest diagnosis. A glove should not touch more than one plant.

The area around the greenhouse must be well fenced to keep off unauthorized visitors. The environment must be free of weeds as they harbour pests and diseases. These can be killed using a broad spectrum herbicide such as glyphosate at the rate of 10-15 ml per litre of water. A dustbin is installed in the facility to dispose dirt, gloves and rogued plants. The trash should be properly disposed into a pit.

Session 4.7. Harvesting and handling of mini-tubers

Duration  **1 Hour**

Description

This topic is designed to introduce participants on how to harvest and handle mini-tubers in hydroponic and aeroponics units. Learners will learn how to sort, grade, pack and store mini-tubers. This will help in optimizing production and reducing damages on mini-tubers.

Learning outcomes

By the end of this session, the participants should be able to:

1. Differentiate between single harvesting and continuous harvesting.
2. Explain how to sort, grade, package and store and their importance.

Learning aids and materials

• Greenhouse with hydroponic and aeroponic unit	• Wheelbarrow, clean water, curing racks
• Clean buckets/crates, PPEs, Packaging bags	• DLS Store/Model

Procedure

Activity I: Introduction (10 minutes)

a. Through guide questions, use brainstorming to capture participants' existing knowledge between harvesting in hydroponic and aeroponic system.

b. Explain the importance of good harvesting techniques in hydroponic and aeroponic system.

Activity II: Harvesting in hydroponic unit (30 minutes)

a. Demonstrate harvesting potato mini-tubers in hydroponic unit.

b. Ask the participants to harvest mini-tubers on their own.

Activity III: Harvesting in aeroponic unit (30 minutes)

a. Demonstrate harvesting potato mini-tubers in aeroponic unit.

b. Ask the participants to harvest mini-tubers on their own.

Activity IV: Sorting, grading, Packing and Storage (30 minutes)

a. Demonstrate how to sort, grade, pack and store mini-tubers.

b. Ask participants to sort, grade, pack and store mini-tubers.

Summary/Conclusion  5 minutes

a. Through question and answer, ask learners to state what they have learned

Take home exercise: Participants to read on storage conditions for mini-tubers.

SESSION NOTES

Harvesting, sorting and grading

In hydroponics, the plants are dehaulmed 2 weeks prior to the exercise. This is done to ensure that the medium (cocopeat) is dry enough for easy harvesting. Clean buckets/trays are needed during the exercise to hold the harvested mini-tubers. Clean and disinfect the hands before the exercise. Put on gloves during harvesting to avoid injuries on the tubers, which may be caused by long finger nails. Harvesting is done by lifting the stems up from the medium (cocopeat) then removing tubers from the main stem one after the other. Harvesting should be done early in the day before the greenhouse heats up. The method of harvesting in hydroponic is known as single harvesting.

In aeroponics, continuous harvesting methods are used; where the plants are harvested systematically for approximately 3 months. On average, one plant can produce up to 30 mini-tubers. Harvesting is done through the windows. Windows are lifted up and the mature mini-tubers are picked one by one then put in the trays. After harvesting the mini-tubers are washed with tap water and then dried for one week on drying trays.

Packaging and storage

The harvested mini-tubers are packed in net bags and then taken into storage. In this facility they are stored at the temperature of 8-15 °C and a relative humidity of 95%. Mini-tubers take 200 days in storage to sprout depending on the variety. The stored mini-tubers are left to sprout awaiting planting in the field.

Session 4.8. Economic analysis of rapid multiplication techniques

Duration 2 Hours 30 minutes

Illustration

Pictures (successful farmer with lots of money)

Description

The session will demonstrate yield and economic returns of RMTs in seed potato production. The concept of risk management will be discussed. This session will encourage participants to invest in aeroponics, hydroponics and apical rooted cuttings systems for seed potato production.

Learning outcomes

By the end of the session, participants should be able to:

1. Differentiate between economic gains and economic loss in seed production.
2. Avoid economic loss and how to recover from economic loss.
3. Identify the economic benefits of soil-less media compared to open field production.

Learning aids Materials

- Factsheets and case studies
- Flip chart and marker pens

Procedure

Activity I: Introduction (10 minutes)

a. Ask participants to state the advantages and disadvantages of RMTs.
b. Explain that the session will enable them to calculate the economic benefits of RMTs.

Activity II: Economic analysis (2hrs)

a. Using excel sheet demonstrate how to calculate profit margin.
b. Ask participants to calculate profit margin using a given example.
c. Demonstrate how to calculate return on investment.
d. Ask participants to calculate return on investment using a given example.

Conclusion/Summary (20 minutes)

Ask two participants to present their results in plenary and comment making corrections where necessary.

SESSION NOTES

Introduction

An economic profit or loss is the difference between the revenue received from the sale of an output and the costs of all inputs used, as well as any opportunity costs. In calculating economic profit, opportunity costs and explicit costs are deducted from revenues earned.

Table 4: Projected production of seed potato tuber numbers from different technologies starting from a single tissue culture plantlet (Source: Monica Parker, 2019).

	Greenhouse Production (G1)[a]		Pre-basic Seed (G2)	Basic Seed (G3)		Certified 1 (G4)	
	Time (mo)		# seed tubers	# seed tubers[e]	Time (mo)[f]	# seed tubers	Time (mo)[f]
Cuttings	120 rooted cuttings	5	912[c]	9,125	17	91,200	23
Aeroponics	35 mini-tubers	8[b]	280[d]	2,800	20	28,000	26
Sand hydroponics	10 mini-tubers	8[b]	80[d]	800	20	8,000	26

[a] G = generation. [b] Inclusive of tuber dormancy. [c] Assuming 8 tubers/rooted cutting and 95% survival rate. [d] Assuming 8 tubers/mini-tuber. [e] Each field generation after pre-basic assumes 1:10 production ratio from each tuber. [f] Total time to next seed class inclusive of dormancy, each field generation is assumed 3.5 months production and 2.5 months dormancy

Table 5: cost estimates and economic return for the aeroponic system

Cost estimates			
Aeroponics	**Quantity**	**Unit cost**	**Total**
Greenhouse (standard 8mx30m)	1	300000	300000
Floor (concrete) 40 tonnes	40	3000	120000
Tanks	2	8000	16000
Installation (boxes)	10		0
Pipes	1	10000	10000
Pumps (2hp)	2	35000	70000
			0
Misters	280	400	112000
Boxes	10	10000	100000
ball valves, filters..	1	10000	10000
	subtotal A		738000
Plumbing and labour	25% of total		184500
	Subtotal B		922500
Initial seed (invitros)	6000	20	120000

Cost estimates			
Aeroponics	**Quantity**	**Unit cost**	**Total**
Media	0		0
Water (m3)	20	2000	40000
Nutrients (one time 5 yrs)	1	60000	60000
Hormones	0	0	0
Fertilizers (foliars)	1	3000	3000
Pesticides	1	6000	6000
Power costs	720	16	11520
Man days	464	300	139200
Supervisor	12	15000	180000
PPEs	3	8000	24000
Tools (forceps, pumps, scapels, panga, buckets, containers, trays)	1	5000	5000
Consumables (strings, sponge, sanitizers, tapes, kerool)	1	50000	50000
	Subtotal C		638,720
	Grand Total		1,561,220
Yield	12000	40	480,000
Sales	480000	10	4,800,000
Profit			3,238,780

Table 6: cost estimates and economic return for the hydroponic system

Cost Estimates			
Hydroponics	**Quantity**	**Unit cost**	**Total**
Greenhouse	1	300000	300000
Floor (concrete) 40 tonnes	40	3000	120000
Tanks	2	8000	16000
Installation (troughs)	360	320	115200
Beds	4	30000	120000
Drip lines	1	10000	10000
Pipes and fittings	1	10000	10000
	subtotal A		691200
Plumbing and labour	25% of total		172800
	Subtotal B		864000
Initial seed (***in vitros***)	4500	20	90000
Media	50000	6	300000
Water	20	2000	40000
Nutrients	1	60000	60000
Hormones	0	0	0
Fertilizers (foliars and basal)	1	10000	10000
Pesticides	1	6000	6000
Power costs	720	16	11520
Labour	232	300	69600
Staff (expert)	12	15000	180000
PPEs	3	8000	24000
Tools (forceps, pumps, scapels, panga, buckets, containers, trays)	1	5000	5000

Cost Estimates			
Hydroponics	**Quantity**	**Unit cost**	**Total**
Consumables (strings, sponge, sanitizers)	1	50000	50000
	Subtotal B		846,120
	Grand Total		1,710,120
Yield	9000	10	90,000
Sales	90000	10	900,000
Profit			-810,120

Table 7: cost estimates and economic return for the rooted apical cuttings system

Cost Estimates			
Apical rooted cuttings	**Quantity**	**Unit Cost**	**Total**
Greenhouse	1	300000	300000
Floor (concrete) 40 tonnes	40	3000	120000
Tanks	2	8000	16000
Installation (beds/bench)	4	30000	120000
Seedling trays	800	150	120000
Misters	42	400	16800
Pipes and fittings	1	10000	10000
	subtotal A		702800
Plumbing and labour	25% of total		175700
	Subtotal B		878500
Initial seed (***in vitros***)	7000	20	140000
Media	17000	6	102000
Water	20	2000	40000
Nutrients	1	60000	60000
Hormones	10	5000	50000
Fertilizers	1	3000	3000
Pesticides	1	6000	6000
Power costs	720	16	11520
Labour	232	300	69600
Staff (expert)	12	15000	180000
PPEs	3	8000	24000
Tools (forceps, pumps, scapels, ***panga*** (machete), buckets, containers, trays)	1	5000	5000
Consumables (strings, sponge, sanitizers)	1	50000	50000
	Subtotal B		741,120
	Grand Total		1,619,620
Yield	120000	10	1,200,000
Sales	1200000	10	12,000,000
Profit			10,380,380

References

https://ainfo.cnptia.embraba.br/digital/bitstream/item/88828/1/arione-technical-and-economic-analysis-of-aeroponics-and-other.pdf

ANNEXES

1.1. Gender Case study

Betty Wamaitha looks at Climate Smart Agriculture through the gender lense

Betty Wamaitha Thuo is a Masters of Arts (MA) student at Egerton University in the department of Gender and development studies. She had difficulties in deciding which area she was going to research on at the end of her coursework. She kept on changing her mind over different ideas and titles for her study, and this discouraged her. But this was not until she was involved in the Seed Potato Value Chain Community Action Research project in 2020, during the Covid- 19 pandemic peak. The project organized farmer field days to train farmers on best Climate Smart Practices in their demo-plots at the CAWSA-C (Climate and Water Smart Agriculture Centre) at Field 7, within Egerton University. Betty was actively involved in the planning of the field days and was also assigned to register the farmers and training them on the various Climate Smart Agricultural (CSA) practices in seed potato production. This built her confidence to a level that she could talk and address a large group of people, something she could not do previously. During her interaction with the farmers, she realized that women were side-lined, especially in decision-making, adoption of technologies and access to extension information. Additionally, she realized that male household heads tend to attend community meetings, forums, field days and training sessions at research centers while women lack the time, due to domestic chores, and resources to also do so.

Linking gender and CSA

This prompted her to start toying with the idea of linking gender and CSA in potato production. This prompted her to carry out her research study in this area and ended up with a title of her proposal that reads; "Gender disparities on Climate Smart Agriculture (CSA) among potato producers in Ol-Kalau, Nyandarua County". The reason why she chose Nyandarua County is because it is leading in potato production in Kenya.

She gained research and community engagement skills through experiential learning and got an opportunity to gain practical skills and linkages by exposing her to interact with different potato farmers in Kenya. She was also exposed to the field data collection during a Potato Survey Value Chain among individual farmers, seed producers, Co-operatives, MOALF Nakuru County. Betty got a chance of learning the challenges women go through when it comes to decision making in issues to do with seed potato production value chain and it came out clearly that cultural norms hinder them from making the decisions and only men can do that as they are the heads of the family. Also, women are not able to participate fully in adoption of CSA in seed potato value chain because they do not own land and thus the men dictate on what to be done in the farm and women do not have the freedom to decide on their own. In addition, women are not able to access extension information on CSA technologies and this has led to women lack of knowledge on certified seeds, apical rooted cuttings and use of organic fertilizers. After completing her coursework, Betty successfully defended her research proposal. She was happy that she could proceed to the field for data collection. This activity enriched her with practical knowledge and skills on how to conduct an interview, data collection and this made her field data collection easy and fast. Also, Betty was optimistic that the findings of her study will help policy makers improve seed potato production by formulating gender specific policies that will encourage women and men to adopt the CSA technologies. It will also inform policy on gender and CSA.

"CARP+ projects may be the best option for every postgraduate student to get engaged in their activities so that they are able to gain practical research skills that they have learnt in theory during the coursework," she says. African university graduates, she says, lack practical skills, but getting them involved in research projects with practical approaches, like CARP+, will make it easier for them to complete their research studies within the stipulated time. "Additionally, they (students) will get results that are relevant in solving practical community problems, such as gender disparity, that are still dragging farmers from achieving theirs goal in CSA seed potato farming," she adds.

1.2. Community engagement case study

Developing and Scaling-up of Seed Potato Multi-stakeholder platforms in Nakuru county of Kenya

Introduction:

Potato is the second most important staple food in Kenya. Its national average productivity stands at 10 t/ha against a productivity potential of 30 to 40 t/ha, depending on growing environment. Access to high quality seed that is free from tuber borne pest and diseases is a major constraint along with availability of sufficient clean soils to grow seeds. Due to this and the challenges of handling a bulky and highly perishable commodity, certified seed potato is expensive, costing between KES50 – 70/kg (about US$ 0.5 to 0.7/kg seed, or KES2,500 to 3,500 per 50 Kg bag).

Interventions

With funding support from RUFORUM-MasterCard Foundation, researchers at Egerton University, from 2017 to 2022, set out to enhance community access to high quality seed potato for increased incomes amongst smallholder farmers in Nakuru County of Kenya.

Identifying seed potato growers: With the help of the Nakuru County Ministry of agriculture officers, the researchers with previous community links and identified five lead small holder seed potato farmers and other growers to partner with in a multi-stakeholder platform which included community based organisations (CBOs). The researchers used the Nakuru Smallholder Farmers Association (NASFA) as an entry point, and the smallholder farmers were divided into five clusters (Elburgon-Mbaria; IDP-Turi - Njoroge; Mau Narok-Joseph; Mauche-Pastor and Kasambara - Mwenja) to conduct demonstrations. A technical and vocational training institute (Baraka Agricultural College) in Kuresoi North and Egerton University's Tatton Farm (as the host) were also picked to conduct the demonstrations.

Joint training: The smallholder farmers in the five clusters or demonstration farms were then trained jointly with community members on best practices for growing high quality seed potato in a small holder setting. The Agricultural Development Corporation (ADC Molo), Agrico, Stockman Rose/CIP, Lachlan Africa and County Government of Nakuru's Ministry of agriculture, and the researchers from Egerton University and Baraka Agricultural College were involved in the demonstrations.

Input and extension support: The project then supported the smallholder farmer groups in the five clusters with inputs, agronomic advice and awareness creation for enhanced marketing outlets.

Capacity building for business: The five lead farmers were then trained in developing the seed potato business and engagements in the platforms to expand markets.

Results:

Lead farmers were invited for stake-holder meetings in 2017-18 for planning and training sessions. The stake holders that attended included public and multinational seed potato producers, agro-chemical companies based in Nakuru, farmers, NGO, community based organizations (CBO), academic and research institutions.

Two 50 kg bags of shangi and Jelly seed potato were given for establishing the demo plots in April-June 2018 long rain season. Agro-chemicals were provided to combat/control late diseases and pests, as needed.

By July 2018, only three of the farmer groups managed to harvest about 16 to 19 t/ha of seed potato. These were Elburgon, mau Narok and Kasambara. BAK and EU (the TVET and University institutions) also recorded similar production levels, which were good.

The IDP-Turi had neglected its management. Reasons were: 1) the lead farmer who had been introduced was not an active farmer. The group members engaged were IDP youths, whose parents sent them to manage the demo. They had little interest and no experience in potato farming. They were not a homogeneous organized group, but a group that was quickly brought together to access the donations.

For the second short-rain season (Oct – Dec 2018), only Elburgon-Mbaria, and Kasambara along with the two educational institutions, i.e., Baraka and Egerton, managed to produce another crop. The four, out of six were able to attend and participate in the Potato trade fair, held in BAK. This helped to showcase their seed potato produce and consequently started being recognized as small seed producers. The Mau Narok group sold their potato produce and used the money for other purposes. They didn't participate in the trade fare. They expected more donations for the subsequent seasons, but this was not provided.

Till date only the Elburgon, BAK and Egerton are producing seed potato. Kasambara are still multiplying the old seed, but their soil environment (which has stony soils and hotter growing seasons) is not very conducive for getting high yields. Profit margins are therefore smaller and continued participation requires injection of resources from other income generating activities.

Due to the high costs required for KEPHIS certification, only BAK and EU are producing certified seed potato. Eburgon-MB, being a small scale farmer, continues to produces "clean seed" and has even gotten further training and support from other stakeholders to venture into the production of mini-tubers from apical rooted cuttings, a Climate smart agriculture technology.

Challenges

1. Timely availability of resources (e.g., cash for timely procurement of inputs, transport for speedy delivery of services, skilled personnel that had their primary focus in providing crop-husbandry solutions and administrative project management and accounting) is key to the smooth running of the project, sustainability of the multi-stakeholder platforms and continued community engagement.
2. Other stakeholders picked up from the lessons learnt and began their own stakeholder platforms. They got support from other organizations that had donor funding and poached the same stakeholders. Due to this, there has been duplication of multi-stakeholder platforms that now include the potato value chain amongst its focus crops. These include, KCEP-CRAL, CGA-FTMA, AGRICO, which work with the MOAL&F.

Lessons learnt

1. The need for a good, generous & patriotic people
2. Set mutually beneficial objectives that interest participating partners
3. Need for institutional reforms to house the MSP
4. Identify & recruit sincere and hard-working Co-workers to serve (foot-soldiers)
5. Having strategic partners
6. Be patient and very flexible
7. Maintain accountability to donor partners and stakeholders

Conclusion: While by nature projects have a start and finish timeline, a multi-stakeholder platform should continue so long as members are addressing critical value chain issues and getting value. From associated community engagement research findings, it is not possible to sustain a seed potato business with less than an annual income of US$ 6000 (KES 600,000/-) or monthly income of KES 60,000/- (US$ 600).

1.3 "Not Only Shangi, plant other varieties"

Author: Lenah Mwangi

Despite its massive popularity, Shangi is neither the highest yielding variety nor the best in mechanization, processing, or storing in Kenya. For a long time, potato farmers have crowded Shangi's production, leading to flooded markets after harvesting, lower prices and less income for farmers. Many potato farmers are less knowledgeable about the existence of other potato varieties with better yielding, long shelf life and wider uses rather than just household consumption, crisps and chips. Other viable varieties, besides Shangi, for example, include ***Wanjiku***, ***Sherekea***, ***Dutch Robjin***, Rudolph, ***Unica***, Kenya Karibu, Arizona, Destiny, Manitou, and Markies among others, which are high yielding and good for processing. The only challenge with these varieties is that they have a longer dormancy as compared to Shangi.

Gauging farmer knowledge levels

Inuka AgriSolutions (which is currently serving as a farmer service center in the Farm to Market Alliance, FtMA program) conducted a training of farmers in Egerton, Njoro Sub- County on the 21st of September 2021. The venue for the training was at Joseph Mwangi's home. Mwangi is a lead farmer from Rosalin area in Egerton. The training aimed at gauging the knowledge levels of farmers on other potato varieties besides *Shangi*. The training was conducted in partnership with Agrico EA, a seed potato multiplier and distributor of up to 13 different potato varieties. The training featured sessions on good pest and diseases management, good nutrition, and best pre- and post-harvest management- all that lead to quality tubers. After the training, it was noted that farmers knew very little about other potato varieties and did not know where to source them. To help build farmer capacities, the FtMA program established demonstration plots, each measuring 1/8 acre, at the lead farmers' land. Agrico's agronomy expert recommended four varieties namely, *Arizona, Destiny, Manitou*, and *Markies* as suitable for the region since they are the best for ware and processing. In the demo plots Agrico varieties were compared with *Shangi* variety under the same treatment of nutrition, and pest and disease management. To further their knowledge, FtMA program took the farmers to tour Agrico center in Kabarak, Nakuru. This was to offer an extension of the training the farmers had been given on the ground.

Better yields

The new varieties performed well despite the adverse weather characterised by minimal rainfall that was experienced between the time planting was done and crop maturing, and blight. The table below shows the production levels for each variety after harvesting on the 26th of January 2022.

Agrico Varieties	Quantity yield in kgs per 1/8 acre
Manitou	1625
Markies	1400
Destiny	1325
Arizona	875
Control Variety	
Shangi	825

Challenges and Lessons

There was minimal rainfall and blight, and this affected the yield a little from the expected 1850 kgs per demonstration plot.

Agrico varieties require very strict care.

The Agrico varieties fetch higher prices compared to *Shangi.*

Shangi is highly popular in the consumer markets compared to Agrico varieties, which are still new and are trying to penetrate the market.

Marketing Agrico varieties that are used for processing is sometimes a challenge to the farmers as they are not aware of the buyers like Norad and Sereni Fries.

Lessons

Manitou and Markies are also highly resilient to blight.

Farmers are willing to plant the new varieties only after they are assured of the market.

The market is available for the processing varieties but farmers have to follow the nutrition, pest and disease management practices to the letter.

Recommendations

Farmers intending to do processing varieties should start with small portions of land where after harvesting they send samples to the buyers/processors for quality testing before they can fully embrace producing the varieties in their bigger land portions.


Farmers at Agrico during the Agritour learning about different planting technologies including surface planting

At the lead farmers plot during the demo planting

Good quality crisps results

Poor quality potatoes that burn during cooking

References

https://magipofarm.com/?p=86

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1.4 Net Profit Analysis of seed potato agri-business

By *Chelal C. Hillary*[1]

One of the weakest links in the Irish potato value chain is seed potato access. This is because farmers prefer to use their own saved seeds or buy seed from other farmers. It is propagated vegetatively and thus its productivity declines overtime as it progresses to successive generations. In addition, potato pests and disease can be transferred from one generation to the next generation or from one farm to another through the use of infected tubers or soils. Hence, seed potato business is an important component in the Irish potato value-chain. It is a high value enterprise in potato growing regions as there is a ready market. Farmers are aware of the importance of using certified seeds because it increases productivity as well as reduction of seed borne diseases such as bacterial wilt, viruses and the cysts nematodes.

The profit realized in this investment is calculated by getting the total revenue on sales of the seed potato and subtracting the total expenses that are incurred in the production process.

These costs cut across land preparation, input purchases, labour, crop protection from pests and diseases, harvest, to post harvest handling and marketing. Farmers need to be encouraged to venture into seed potato production so that they can supply the much needed seed as well as make profits. Seed production has higher returns on investment compared to ware potatoes where local middle-men are earning large profit margins. The data below shows the net profit analysis for seed potato production in an acre of land in Nakuru County of Kenya in 2018.

Table 1: Net Profit Analysis for Seed Potato Production

	Activity	Yield per acre in 50kg bags	Seed market price	Total income	Net Profit
Seed purchase cost	48,000	150	2500	375000	
Transport of seed	2,000				
fertilizer DAP	6000				
CAN	4000				
land preparation	3000				
Surface planting	3000				
weeding and moulding	6000				
pest and disease control	3000				
Gunny Bags	3200				
Harvesting using 100kgs bag	10000				
Transport	1000				
Sorting and Grading	2000				
Mesh potato bags	6000				
certification cost	4000				
Total Expense	**101,200**				**273,800**

Note:

1. The expense of the inputs and other materials can go higher as a result of inflation and some government policies or go down as a result of subsidy and favourable agricultural policies. The farmer can adjust accordingly.
2. The certification cost is charged according to mileage at KES.58 per kilometer to seed potato field and KES. 60 per label attached to every 50kg bag harvested.

Assignment:

1. Calculate the net profit/loss for your seed potato agri-business
2. How does your net profit/loss compare to your colleagues or the example above?
3. What are the causes for some of your expenses being higher or lower than example above?

References

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1.5 Seed potato rapid multiplication systems: A case of Egerton University

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The average yield of potato in Kenya stands at 8 t/ha against a potential of 30 t/ha for most varieties grown. Accessing high quality seed potato is a major cause of low yields in potato producing counties. Many farmers in these regions have resulted to use of own seed which in many cases in infested with pests and diseases. One way to enhance accessibility and availability is to build the capacity of small scale farmers to bulk/multiply their own starter materials. The seed potato Community Action Research Program (CARP+) works with farmers in Nakuru county to enhance their skills in seed potato production. Through experiential learning and community action research approach, the project has engaged more than 10 farmer groups. The groups were provided with one to two bags of certified 1 (C1) of high yielding seed potato varieties for multiplication and bulking into C2 and subsequent generations. However, due to the small quantities provided, it would take the group more than two years to bulk seed enough for about 5 acres. By this time, the seed potato would already have passed the recommended generations for bulking and multiplication as certified seed meaning they would have to come back to start over from C1 all over again. In addition, multiplication in the fields leads to build-up of pests and diseases quickly. Farmer groups and individuals multiplying seed potato could adopt rapid multiplication techniques such as rooted apical cuttings (ARCs), aeroponic and hydroponic system that can allow them shorten the multiplication cycle.

Intervention

Through funding from the (Mastercard Foundation) MCF-Ruforum, the seed potato CARP+ installed a facility for rapid multiplication of seed potato under aeroponic and hydroponic system.

The facility consists of a hydroponics and aeroponic units both of which can support 2000 ***in vitro*** plants. The aeroponic unit can support 264 plants while the rest is supported by the hydroponics units. The yield under the aeroponic system varies from variety and can go as low as 30 mini-tubers per plant to as high as 60 mini-tubers per plant while the average in the hydroponics system is 10 mini-tubers per plant. The CARP+ collaborated with Agricultural Development Corporation (ADC) Molo who provided technical assistance, training and ***in vitros*** plantlets for multiplication and bulking into the two systems. Two graduate interns and 6 staff members from Egerton University and Baraka Agricultural College were trained on tissue culture, hydroponics and aeroponic propagation at ADC-Molo Complex.

Figure 1: Aeroponics unit (in the background in black cover) and the hydroponics units (troughs) at Egerton University Teaching and Research field 7.

In addition, the CARP+ project acquired rooted apical cuttings (ARCs) from CIP through Stockman Rozen Naivasha. At least 6,000 were acquired in 2018 through 2019. The ARCs were then distributed to farmers across Nakuru county where training demonstration plots were established at Elburgon, Bahati, Gilgil, Molo, Njoro and Likia. Some of the cuttings were established at Egerton university field 7 where the Ministry of Africulture, Livestock and Fisheries (MoAL&F), Kenya Agricultural Research and Livestock Organisation (KARLO)

Tigoni, Agrico EA, Toyota Tsusho-Baraka fertilizers, Mavuno Fertilizers, and Corteva partnered to set up a demo site for training on good agricultural practices. Three varieties of rooted apical cuttings (*Shangi*, *Mayan Gold* and *Wanjiku*) were planted alongside conventional tubers of *Sherekea*, *Dutch Robjin*, *Unica*, *Manitou* and *Rudolph* from ADC Molo and Agrico EA. The demos were used to train farmers during field days that were held at various stages of growth. At least 20 farmers and students were directly involved in planting and managing of the demos and another 300 trained during field days. Furthermore, 10 farmers were given at least 100 rooted apical cuttings to establish at their farms.

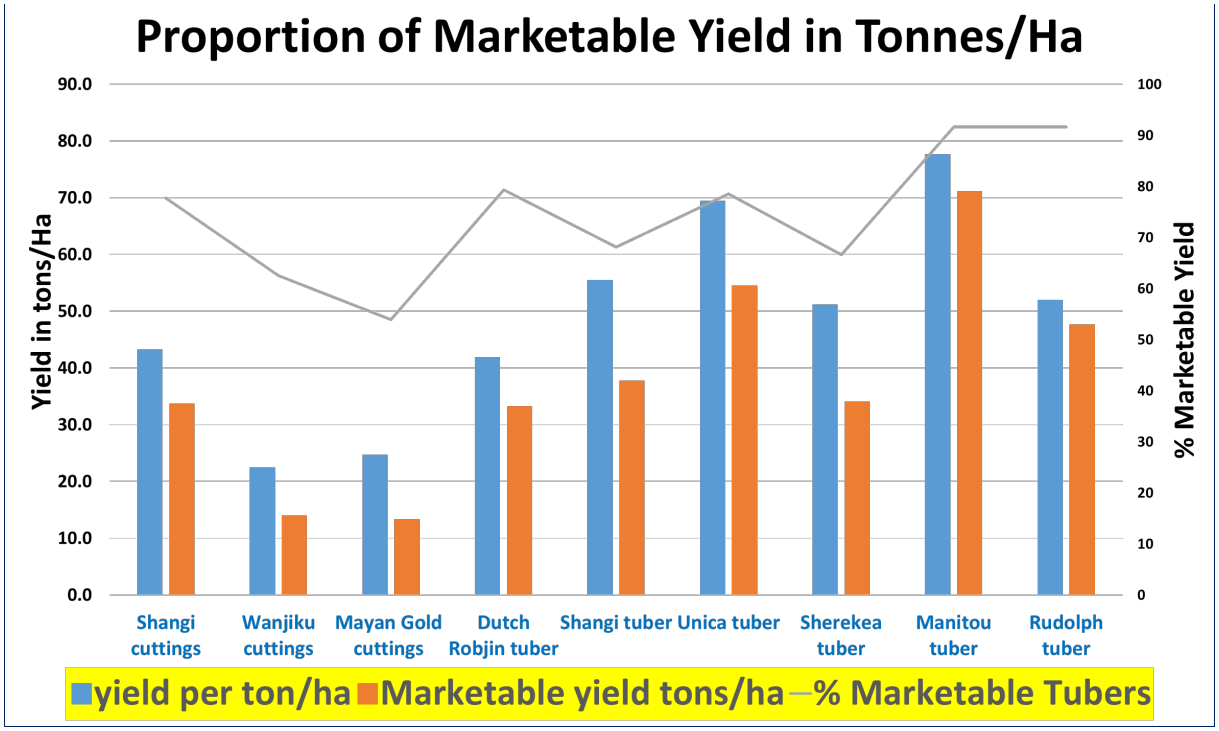

Figure 2: Performance of rooted apical cuttings and conventional tubers at Egerton field 7 demo site (May-Aug 2019).

Results

At sEgerton University, the first crop in the hydroponics unit was planted on 1st November 2018. A total of 650 seed potato ***in vitro*** plantlets were planted in troughs in coco peat + pumice media. This crop showed high mortality and near total crop loss was observed. It was noted that the plants had not been properly hardened before planting and thus they were severely shocked upon planting. In addition, the greenhouse did not have a shade-net installed and, therefore, the temperatures in the greenhouse were too high (above 25°C). Therefore, most plants were scotched. Furthermore, the stock solutions had not been delivered from suppliers on time and were not ready when required for application. The first crop was, therefore, a complete failure and plans were made to replant.

In the second planting, properly hardened ***in vitro*** plantlets of ***Shangi*** and *Unica* varieties were planted on 3rd December 2018. This crop exhibited 98 percent survival rate. Irrigation was carried out during the day at intervals of 1 hour on and off and switched off during the night. The greenhouse floor was watered using a house pipe to help cool the environment during the day. Insect pest and diseases were controlled on time and other sanitation and greenhouse hygiene measures were followed. On 27th January 2019, top dressing with urea was done. One week after this top dressing, more than 80% exhibited wilting symptoms. In three weeks that followed, almost all the crops were dead and the few that remained showed stunted growth. In summary, the second crop was another costly lesson learnt.

Following these challenges, a training course on seed potato tissue culture production was organized in July 2019 for students and staff from Egerton University and Baraka Agricultural College. Following this training, three varieties (*Kenya Karibu*, *Sherekea* and *Shangi*) were successfully propagated under hydroponics system and more than 10,000 mini-tubers harvested from the first cycle. From this, 9,000 mini-tubers were planted in the field as pre-basic seed, which was inspected and certified by the Kenya Plant Health Inspectorate (KEPHIS). These seed were bulked further into basic and certified one (C1) generations and have ever since been sold as certified seed to farmers.

Challenges

- Lack of expertise. The research assistants engaged had limited experience in managing a hydroponics/aeroponics system. Plans were not made to train them at ADC Molo as had been suggested before the start of propagation.
- Slow procurement system leading to untimely delivery of inputs.
- Power/Electricity failures. This were curbed by a petrol generator, which was not very reliable as it was small and not suitable for the system.
- Lack of safety gears and essentials such as washing sinks, sanitizers, and PPEs.
- The aeroponic unit kept failing due to problems associated with installation and power fluctuation and has not worked successfully to date.
- The CARP+ project did not renew contracts of the interns/research assistants citing limited funding and as such, production at the hydroponics system stopped in January 2021.

Recommendations

- Engagement of qualified experts to run the aeroponics and hydroponics units is key to the success of the system. The units as well as the field bulking and multiplication of seed should be commercialized and returns raised should be able to support this.
- Installation of a working power back up system.
- Organized administration and supervision is necessary. An accountable farm manager/ production officer reported directly to the project coordinator must be engaged for success.

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