

POTATO PRODUCTION & PROCESSING BUSINESS

TRAINING COURSE FOR YOUTH AGRI-ENTREPRENEURS

Ethiopian Agricultural Transformation Institute



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OVERVIEW OF THE MODULE

This training module is designed to equip youth and women groups, farmers and any groups interested to acquire knowledge and skill on potato tuber production and processing. This skill and knowledge enable the youth groups, farmers and others involved in potato tuber production, management and processing to apply the technologies so as to increase the production of potato tuber production thereby improves their income. The module consists of seven sections: ecological requirement of potato tuber production, agronomic practices for potato tuber production, potato crop protection, harvesting and post-harvest handling of potato tuber, marketing and distribution and financial feasibility and risk management of potato tuber production as business. The module also contains pre and post assessment questions at the end of each section to enable the trainee to evaluate their understanding about each topic.

The Agriculture-focused Dignified Employment for Youth (ADEY) program is implemented by the Ethiopian Agricultural Transformation Institute in partnership with the Mastercard Foundation to enable 611,343 inclusive and dignified work opportunities for young women and men and support youth entrepreneurship, employability, and sustainable livelihoods in the agribusiness sector.



INTRODUCTION

Ethiopia has a very high potential for potato production as much of the arable land is in the mid and high altitudes, which are suitable for potato production. Potato is an important food security and a hunger reliever crop during months of hunger when other cereal crops do not mature enough for consumption in several parts of the country. The growth cycle of potato is relatively short, around 100-120 days, depending on the variety and the local climatic conditions. Compared to cereals, potato is short duration crop that can give 30- 35 t/ha tuber yield in 3-4 months in Ethiopia. In Ethiopia, average tuber yield of potato showed an increasing trend of 12-15 t/ha during the last 20- 30 years. Likewise, the area planted with potato has also increased from 30,000 ha in the 1970 to over 0.32 million ha in 2021/2022. Potato has a great potential to create job opportunity for youth groups along the value chain. Youth groups are believed to be enrolled in several aspects of potato along the value chain such as production, processing, transporting, marketing and even in input supplying.

Therefore, this training model is prepared to equip youth groups and any interested groups with knowledge and skill of improved potato tuber production, management, and post-harvest handling. It is also intended to develop know how on making potato production, management and post-harvest handling a business so that they generate income from the practices.

Target groups: Target group of this module is youth and women groups, farmers and other groups who have an interest in potato tuber production.

Training methods: Group discussion, brainstorming, lectures, presentation, assignment, visit

Training materials: Flip chart, LCD, markers, white board

Training duration: 16 hours

SECTION 1. APPROPRIATE VARIETY & SITE SELECTION

Overview of the section

Ecological factors are one factors that determine the productivity and production of potato. These includes altitude, soil factors (such as pH and draining, fertility), temperature, relative humidity, rainfall etc. Hence, this section is intended to describe the ecological requirement of potato that will maximize the production and productivity of the crop.

1.1 VARIETY SELECTION

- Selected varieties should be well adaptable, high yielding, disease resistant/tolerant, have good storage and processing qualities, and grower/consumer preferred type.
- So far more than 45 potato varieties were developed and registered for production. Some of the varieties are summarized under Table 2.

NO	VARIETY	YEAR OF RELEASE	SUITABLE ALTITUDE	YIELD (T/HA)		RECOMMENDATION AREA
				Research	On-farm	
1	Birhan(CIP-312921.576)	2023	2700-3200	55.00		D.Berhan
2	Dagnawu(CIP-352929.532)	2023	2700-3200	50.00		D.Berhan
3	Worku (AD501645.9)	2022	1800-3000	42.50		Mid to central highland
4	Burka (CIP-391058.175)	2020	1800-3000	30.7		Central highlands
5	Horro (CIP-384321.30)	2015	2000-2800	35-40	27-30	Western Ethiopia
6	Dagim (CIP-396004.337)	2013	1600-2800	33.8- 47.2	24.4- 46	Wide adaptable
7	Bubu (CIP-384321.30)	2011	1650-2330	19.5		East & West Harergie
8	Belete (CIP-393371.58)	2009	1600-2800	47.2	28-33.8	Wide adaptable
9	Hundee (CIP-90147.8)	2006	2400-3350	21-51	28-54	South East Ethiopia
10	Ararssa (CIP-90138.12)	2006	2400-3350	20-42	37-50	South East Ethiopia
11	Gudanie (CIP-386423.13)	2006	1600-2800	29.2	21.0	Wide adaptable
12	Gabbisa (CIP-387096.11)	2005	1700-2000	40.0	31.0	East & West Harergie
13	Shonkolla (KP-90134.5)	2005	1700-2700	31.5	29.1	South Ethiopia
14	Bulle (CIP-387224.25)	2005	1700-2700	39.3	38.3	South Ethiopia
15	Chala (CIP-387412.2)	2005	1700-2000	42.0	35	East & West Harergie
16	Gera (KP-90134.2)	2003	2200-3200	25.9	20.6	North Ethiopia

1.2 SITE SELECTION

- Potato requires a fertile, well-drained sandy loam soil for optimal growth.
- The site should not have been cropped with solanaceous crops such as potato, pepper, eggplant, and tomato for at least the past three years, and free of bacterial wilt history
- Potato crop should be cultivated under open field, not under shade for it requires a minimum of 6-8 hours full sunlight for maximum growth.
- Important things to points of consideration during site selection
 - Select an area that receives full sunlight.
 - Sandy, quick-drying soils lead to rougher skins and raised scab infection.
 - Avoid clay soils and waterlogged areas.
 - Moist soil conditions during formation of tubers lead to netted scab.
 - Acidic soils, heavy in clay or contaminated with

- spores can lead to powdery scab.
- Avoid land with very deep ditches.
- Select soils rich in organic matter



Learning outcome

After this training session youth groups will be able to identify appropriate agro-climatic conditions for potato production



Duration: 20 minutes



Learning question

1. What are your expectations after this training?
2. List potato producing districts/Kebeles in your areas.

AGROECOLOGICAL SUITABILITY/OPTIMUM	OPTIMUM CONDITIONS
	• 700 to 2400 , but >2400 stunted growth, frost damage & long growth period & <700 stigma dryness, anther tip burning, poor pollen & flowers abortion
	• 21 to 27 day & 10 to 20 night, but >30 above stigma dryness, anther tip burning, poor pollen & <10 stunted growth & flowers abortion
	• 600 to 1400but, >1400 high pressure of diseases & < 600 aggressive insect infestation
	• deep, well drained, and sandy loam soils
	• 5.5 to 7.5, but <5.5 magnesium, molybdenum & phosphorus availability drop & > 7.5 zinc, manganese and iron become deficient



Key message

Ecology is the most critical factors that determine potato tuber production



Post assessment questions

- A. What are the critical ecological factors that determine potato tuber production?
- B. Which type of soil is suitable for potato tuber production?

SESSION 2. AGRONOMIC PRACTICES FOR POTATO PRODUCTION

Overview of the section

Use of appropriate agronomic practices helps better crop growth and ultimately result in higher tuber yield production of potato crop as it is sensitive to slight change in growing conditions and managements. This section presents the overall crop management practices in potato production from input preparation to field management such as tools and equipment, site selection & land preparation, variety selection, planting, fertilizer application, irrigation, and earthing-up.



Learning objectives

At the end of this training section the trainees are expected:

- Describe the importance of potato variety selection.
- Identify and know the major important potato production agronomic practices.

- Observe and understand criteria for site selection for better potato tuber production.
- Learn how land preparation affects potato production.
- To understand the best irrigation methods & time for better potato production.



Duration: 3 hours



Learning question

1. What is your expectation after this training?
2. What are the common varieties of potato produced in your location?
3. What is the better type of seed for planting?
4. How do you treat seed potato tubers before planting

2.1 LAND PREPARATION

2.1.1 LAND PREPARATION

Ploughing

- Plough the land at least 3 weeks before planting to a depth of 25cm
- If the land is virgin, it is recommended that 2 ploughing should be done at an interval of 1 week but if it is a cultivated land, 1 ploughing is sufficient.



Well prepared land

Harrowing and Levelling

- Harrow the ploughed land one week later to allow better soil working conditions.
- Carry out at least two harrowing to breaking up clods and smoothing the surface and creating suitable soil structure for planting, with the last one being done just before preparing of furrows or ridges so as to destroy young weeds for virgin land but for cultivated land 1 harrowing is sufficient.
- Levelling is done to allow uniform water distribution.
- Levelling is done along the contour



Oxen and mechanized harrowing and pulverization

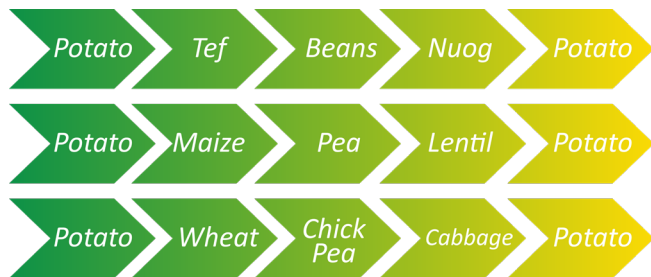
2.2 CROP ROTATION

- Rotating the land with non-solanaceous crops for a period of more than four years is recommended in potato production.
- It is a practice of growing a series of different types of crops in the same area across a sequence of growing seasons.
- This practice reduces the reliance of crops on one set of nutrients, pest and weed pressure, and also reduces the probability of development of resistant pests and weeds.



Key message

Appropriate variety and site with suitable elevation, temperature, edaphic and moisture condition determine the quality of potato seed tuber production

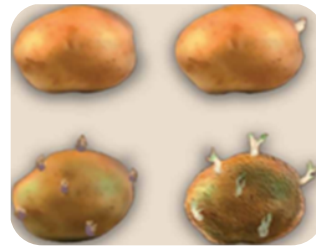


2.3 SEED TUBER PREPARATION

- Seed tuber must be obtained from known and certified sources such as research centres, accredited public and private seed producers and suppliers.
- Newly harvested seed tubers will not sprout until the variety's dormancy period is over therefore should not be used.
- The dormancy period will range from 30 to 90 days, depending on the variety and climatic conditions.
- Seed tubers with short and strong multiple sprouts are extremely important for a high yield.
- Use of medium sized (35-45mm) and well sprouted (3-4 sprouts) seed tubers that are not diseased and infected is vital.
- Two tons of medium sized seed tuber required for a hectare
- However, based on the potato varieties and seed tuber size 1.8-2.2 tons might be used
- Development of the sprouts is primarily affected by the light intensity.
 - If the tubers are well exposed to diffuse light, the sprouts will be slow in growth, colored and sturdy.
 - Seed tubers held in the dark will develop pale and long sprouts that are easily broken off. Long sprouts will deplete the seed tuber, which would also shrivel.
- Seed tubers with short, firm sprouts can be transported to the field with a minimal risk of sprout injury and also give high yields.
- It is better to select medium sized whole potatoes seed tubers than the chopped ones.
- Each selected seed tuber should have about 3-5 sprouts so that, one can harvest more tubers as well as more medium sized tubers.
- To control the fungal diseases on seed tuber, the tuber should be treated in the following ways
- Seed tuber should be dipped in the solution of 2

-3-gram fungicides in one litre of water before sun-light treatment.

- Sun-light treatment is the process of exposing the seed tubers on the sunlight for 20-30 days under the condition of 10- 20°C before the planting for getting a healthy, strong and uniform sprouts from each eye on potato.



Seed tubers stored under diffused light



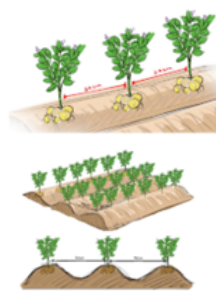
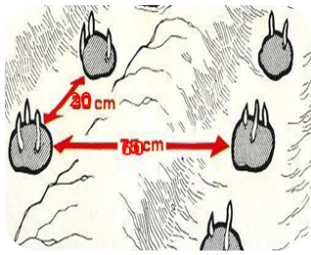
Seed tubers stored under dark

2.4 PLANTING AND PLANT SPACING/DENSITY

- Appropriate time should consider frost free time and sufficient moisture availability
- Furrows or ridges are prepared after harrowing and it should be opened just before planting at the depth of between 10 and 15 cm.
- The soils should be well drained, and the area should not be water-logged.
- Varieties with a short growing season should be planted at 75 cm inter row spacing, since these types generally produce smaller canopies.
- Varieties that are late maturing generally have larger canopies (planted at an inter row spacing of 80 cm).
- When potatoes are planted using machinery, the row spacing will be dictated by the wheel spacing of the tractor.
- For most released potato varieties in Ethiopia, a spacing of 75cm between ridges and 30cm between plants are recommended.



Furrow/ridge prepared for potato planting: hand planting (left) and machinery (right)



Potato planted at spacing of 30cm between plants and 70 cm between rows

2.5 IRRIGATION WATER REQUIREMENT AND APPLICATION

- Potatoes grow best with consistent soil moisture throughout the growing season.
- Potato can grow under rain-fed condition, under rain-fed supplemented with irrigation or under full irrigation.
- The most common irrigation methods for potato are furrow systems.
- In areas with water scarcity, drip irrigation is preferred, especially on soils with low water retention capacity.
- When possible, irrigate with 25 to 30 mm in one application
- Irrigation with 7-12 days interval sufficiently depending upon the climatic conditions, growth stage and soil type.
- The last irrigation should be withheld 10-15 days before harvest to allow the tubers to harden the skin.
- The irrigation water requirement can be distributed
 1. 20 % during the plant growth periods (first month)
 2. 70 % during tuber development, and
 3. 10 % during crop senescence



Poorly irrigated potato fields



Well irrigated potato fields

2.6 FERTILIZER RATE AND APPLICATION

- Potatoes plants generally require large quantities of nutrients to produce an acceptable production
- The rate application can vary from location to location depending on the soil fertility status of the production site.
- The types and rate of blanket recommendation for organic and inorganic fertilizer is summarized under Table 3.

FERTILIZER TYPE	KIND OF FERTILIZERS	RATE PER HA	TIME OF APPLICATION	APPLICATION METHOD
Inorganic	NPS	236 kg	At transplanting	Side dressing and incorporate with soil before transplanting
	Urea	140 kg	Half at planting and half 45 days after planting	Side dressing
Organic	Compost	10-12 ton	Before transplanting	Broadcasting and incorporate with soil two weeks before planting
	Vermi-compost	5-10 ton	Before transplanting	Broadcasting and incorporate with soil at planting
	Farm Yard Manure (FYM)	20-30 ton	Before transplanting	Broadcasting and incorporate with soil one month before planting



Mixing of NPS & UREA (left) and fertilizer application at planting (right)

Manure application

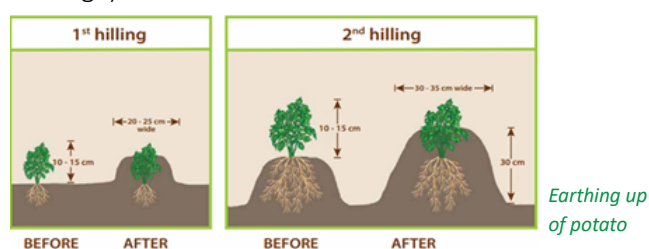
- Manure as an organic source of nutrients contains Nitrogen (N), Phosphorus (P) and Potassium (K) if well prepared.
- The best manure has the following characteristics.
- Not made from potato family crop residue.
- Well-decomposed manure so as to prevent occurrence of black leg diseases.
- Free from potato pests and other diseases.



Farmyard manure spreading on potato field

2.7 EARTHING-UP

- Earthing up potatoes is very important to increase the length of underground stems that will bear potatoes
- However, earthing up should be avoided when the soil is too wet
- Earthing-up or hilling should be done twice
- First at 75% crop emergence (20 to 30 days after sprouts emerge from the soil)
- Second time 2 to 3 weeks later (around the time of the second top dressing at the bud formation stage)



Benefits of earthing up potatoes include the following

- Facilitating nutrient assimilation while reducing risks of flooding conditions.
- Maintaining loose soil for smooth root, stolon, and tuber development.
- Reducing tuber exposure to sunlight which turns the tubers green.
- Keeps the tubers cool and hence reducing chances of brown spots due to high temperature.
- Prevent water logging in case of heavy rains.
- Reduce chances of infection with diseases.
- Reducing chances of Potato Tuber Moth (PTM) infestation, which can lead to heavy losses at the field or in the storage after harvest.
- Reduce chances of stolon developing into secondary and non-productive stems thereby increasing productivity of your land.



Potato earthing up by hand tools (left) and by machine (right)



Key message

Selection of appropriate site, seamless preparation and subsequent field and crop management is very critical to maximize potato tuber production



Post assessment question

1. What are major agronomic activities of potato production?
2. What are the advantages of earthing-up in potato field?
3. How should you apply water for irrigation?

SECTION 3. POTATO CROP PROTECTION

Overview of the section

The most important biotic factors that challenge potato production are disease, insect pests and weed species. Production and productivity are highly governed by the infestation level of the crop particularly by these pests. Hence, this section addresses the major potato diseases, insect pests, and weed species, their symptoms as well as possible management options.



Learning outcome

At the end of this section participants of this training should know:-

1. Describe how potato pests affect potato tuber seed production
2. Identify and know major diseases and insects affecting potato tuber seed production
3. Observes and describe the best practices practiced to management potato diseases and insects within their locality
4. Identify and understand potato diseases and insect pest diagnosis methods
5. Know and advise methods of diseases and insects management practices

Duration: 3 hours.



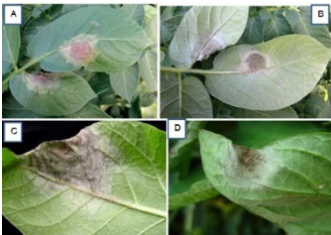
Learning question

1. What are your expectations after this training?
2. What are common diseases and insect pests that affect the production of potatoes in your location?
3. What are major management methods of potato diseases and insect pests in your localities?

3.1 MAJOR POTATO DISEASE AND THEIR MANAGEMENT TECHNIQUES

There are several types of diseases that affect potato tuber production in Ethiopia

The most common disease of potato, their symptoms and management are summarized as follows (Table 3)

DISEASE	SYMPTOMS	MANAGEMENT PRACTICES
Potato bacterial wilt (BW) disease - Caused by <i>Ralstonia solanacearum</i>. - an economically serious problem - Has no well-defined mechanism of management. - Its management involves use of various practices as there is single curative solution to it - If a field is infected, the disease can remain in it for 5 or 6 years	Leaves - Wilting- like water stressed - Yellowing of leaves - Stunted plants - Green wilting and rapid collapse of plants happens  Stem - browning Inside the stem vascular - Bacterial slime oozing from the cut - Bacterial slime oozing from infected stem suspended in clear water in glass seems like a tread  Tuber - Brownish-grey near the point of attachment of the stolon - Bacterial ooze discharge through the eyes - soil may be stuck to the bacterial ooze - cut tubers, pockets of white to brown pus or browning of the vascular tissue which, if left standing, may discharge dirty white globules of bacteria 	- Use healthy seed tubers (certified seed from reliable sources). - Rotate crops with non-solanaceous families more than 4 years. - Clean farm implements - Inspect crops regularly and remove and destroy diseased plants, tubers - Plant in areas where bacterial wilt hasn't occurred previously. - Don't allow irrigation water to run freely over or below the soil surface - Removal volunteer plants - Awareness creation about the disease 
Potato Late blight - Caused by <i>Phytophthora infestans</i>. - can result into crop failures in a short period	Leaves - Small water-soaked spots and lesions at the tips, margins or any other parts of the leaf which enlarge to form irregular dark brown lesions surrounded by a light green halo - During morning hours, a whitish mycelia growth of the pathogen is visible on the under surface of the leaves surrounding the lesion 	- Plant tolerant varieties - Use healthy seeds and planting materials, - crop and field sanitation and adjustment of crop planting dates. - Removal volunteer potato plants. - Earthing-up to protect tuber infection - Fungicide control: - Mancozeb, Ridomil, Matco - Ridomil Gold 2-3 kg/ha is the most frequently used and effective fungicide. - Spray the fungicide when the infection starts and repeated after 10 to 14 days interval depending

DISEASE	SYMPTOMS	MANAGEMENT PRACTICES
Potato bacterial wilt (BW) disease - Caused by <i>Ralstonia solanacearum</i>. - an economically serious problem - Has no well-defined mechanism of management. - Its management involves use of various practices as there is single curative solution to it - If a field is infected, the disease can remain in it for 5 or 6 years	Stem - The lesions appear on the stem near the growing point when the inoculum of the fungus comes from the infected plants. - The infection can also start at nodes and extend both up and down the stem and the plant topples down under congenial weather conditions. - The infected portions of the stem bear white fungal growth especially visible in early  Tubers - Infected tubers show irregular, shallow or sunken reddish-brown patches. - The lesions are dried and no smell 	 

Table 4. Major disease of potato, their symptoms and management

3.2 MAJOR POTATO INSECT PETS AND THEIR MANAGEMENT TECHNIQUES

- There are several types of insect pests that affect the production and quality of potato tuber in Ethiopia
- The most commonly known potato insect pets, their key symptoms and management are summarized under Table 5.

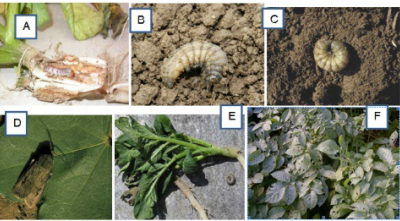
DISEASE	SYMPTOMS	MANAGEMENT PRACTICES
Potato tuber moth - Is both field and storage pest. - Larva tunnels into foliage stem and tubers which lead to loss of leaf tissue, death of growing points and weakening or breaking of stems. - In tubers, irregular shaped galleries are seen with excrements near tuber eyes.	- Larva tunnels into foliage, stem and tubers - Galleries are formed near tuber eyes 	- Select healthy tubers - Avoid shallow planting of tubers. - Plant the tubers to a depth at 10- 15 cm deep - Collect and destroy infested tubers - Do not leave the harvested tubers in the field overnight - Adopt intercropping with chilies, onion or peas - Do earthing up - Cover the upper surface of potato tubers with the branches of Lantana and Eupatorium or Eucalyptus to repel the ovipositing moth. - Insecticide Spray (apply Aim 10% EC, Dimeto 40% EC, Karate 5% EC at the rate of factory recommendation). But in the DLS use 1 kg of insecticide for 1 ton (10 quintal) of tuber seeds.
Aphids - Feeding the crop - Transmit different viral diseases	Adult aphids are prominent on the leaves and stems 	- Planting only certified seed - Avoid planting of cabbage and grass pea near to potato field - Rogueing of infested plants - Use Garlic and motor oil mixtures (100 gm garlic powder, half lite water, 10 gm of powder soap, 2 spoon of motor oil). Mix garlic powder and motor oil and stay for 24 hours. Then mix with water and soap. - After this dilute the mixture 1:20 ratio and spray it to the field (example 1 liters of mixture will be diluted with 20 liters of water). - Application of insecticide (Dimeto 40% EC, Actellic 50% EC, Agro-Thoate 40% EC, Closer 240 SC, Hunter 40 EC etc.. at the rate of factory recommendation) - Use fermented cow urine - Use Tobacco
Cutworms - Are polyphagous insects active at night. - Hibernation can occur either in the larval stage or as a chrysalis; egg laying can be abundant when the weather is favorable.	- Young larvae feed on the epidermis of the leaves. - Older larvae come out at night and feed young plants by cutting their stems. - They also damage the tubers by eating away part of them. 	- Deep plowing to expose the pupae to natural enemies and sun light - Remove alternate hosts - Kill the larva by digging the soil - Use wheat bran and molasses traps by mixing with chemicals to poison the larvae (mix 25 kg trap with 1 kg of Sevin 85% WP and small water to wet the mixture and spread it to the field uniformly so that the larvae can eat and poison them) - Apply insecticides (Diazinon 60% EC, Dursban 48% EC, Carbaryl (Sevin 85% WP etc at the rate of factory recommendation and apply starting at dusk to night to kill the larva)

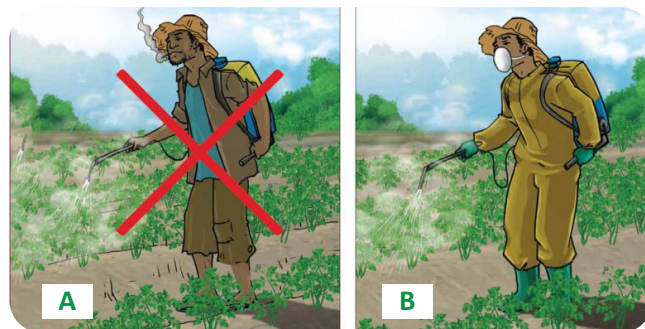
Table 5. Major Insect Pests Potato, their symptom and management techniques

Safety rules to be followed during chemical sprays

- The person applying the chemicals (the operator) must wear a mask, long-sleeved clothes, and solid shoes when spraying.
- Avoid putting trousers inside your high boots because this can create a flow of the chemical to your feet and the chemical may accumulate inside the boots.
- Read the first-aid instructions and always handle the chemical cautiously in a well-ventilated or open space.
- When mixing liquids, eye and hand protection are also required. A dust mask is required when mixing powder formulations. Wash gloves before removal to avoid potential contamination.
- Wash your hands after every contact with chemicals.
- Avoid touching the eyes. In case anything gets into the eye, rinse well for 5 minutes with running water and then get medical help. If you feel sick after applying or handling agrochemicals, contact your doctor immediately.
- Do not eat or smoke when handling chemicals.
- Do not mix chemicals before consulting the label and the chemical's database instructions.
- Use the recommended dose and avoid unnecessary
- Protect the natural enemies of the crop pests and other fauna.

When to apply the pesticides and safety cautions

- Spraying should be done in the early morning or in the (late) afternoon.
- Do not spray in strong sunlight hours as the spraying may scorch the plants (especially oil-based materials).
- Do not spray when rain is expected or soon after the rain, as the moisture on the plants may wash off the chemicals.
- Avoid spraying in days with strong winds and always spray in the wind direction
- (never against it).
- Prefer pesticides that are bee friendly.
- In any case, it is best to spray when the bees are not active (late in the afternoon), if possible not during flowering, and always after informing neighbour beekeepers.
- Always respect the minimum days from the chemical application until the harvest of the product. Read the product label.



Safety during pesticide spraying; A) wrong safety; B) Somewhat right safety

3.3 WEED MANAGEMENT IN POTATO PRODUCTION

- Weeds compete directly with potato plant for light, water and nutrients.
- They restrict the growth of the potato and result in smaller and poor-quality tubers.
- Weeds also restrict air flow through the crops, which increases the potential for disease development.
- Weeds may also serve as alternate hosts for diseases and pests.
- Weeds also harbour pests and diseases
- 43% reduction observed in total potato yield compared to a weed-free control
- After emergence of the first potato shoots, it is important that the first weeding to be done
- Weed control is important from planting to the time of harvesting.
- The first step in weed control is repeated ploughing which helps to destroy weeds and prepare fine seedbed for plant growth



Weed infested potato field



Weed free potato field



Key message

Managing potato disease, insect pest and weeds reduces both field and post-harvest losses.



Post assessment questions

1. What are the common field symptoms of potato bacterial wilt?
2. What are the major insect pests and their management methods for potato?
3. What are the most effective measures to control viral diseases?
4. Why is it important to control insects such as aphids and whiteflies in a seed multiplication field?

SECTION 4. POTATO HARVESTING AND POST-HARVEST HANDLING

Overview of the section

Improper harvesting and post-harvest handling of potato contributes to post harvest losses. In Ethiopia, on average between 30-50% post-harvest loss of potato crops reported to be caused by pests of stored products, spoilage during handling and transportation. Storage losses are caused by transpiration (water loss), respiration (dry matter loss due to biological process), sprouting, changes in chemical composition, physical damage and disease.

The purpose of this section equip youth and small business groups with proper harvesting and post-harvest handling as well as processing practices of potato. Hence, this section addresses harvesting, postharvest handling, storage, processing and value addition of the crop.



Learning outcome

At the end of this section participants of this training should know:-

1. Know the different harvesting techniques of potato
2. Acquire knowledge on how to sort, grade and pack potato tuber
3. Learn how to handle harvested potato tubers properly
4. Recognize how and where to store their harvested potatoes
5. Comprehend how to add value on the raw products



Duration: 3 hours



Learning question

1. What are your expectations after this training?
2. What are common post-harvest management practices in your location?

4.1 DEHAULMING

Dehaulming is the removal or destruction of the haulm to allow the skin to harden and reduce the damage to the tubers during harvesting and transportation

- Dehaulming is the removal or destruction of the haulm (the plant part above the ground level) to harden tuber skin so as to reduce damage during harvest.
- It improves the storability of potato tubers and prevents diseases from spreading from the plant stem to tubers especially viral diseases, late blight and stem rot.
- It is easier to detach the tubers from the stolons

at harvest, resulting in less tuber damage when dehaulmed.

- Helps to stop tuber growth in order to obtain uniform-sized tubers
- Prevents the spread of plant pathogens through different vectors, including aphids
- For plants infected with bacterial wilt, it is too risky to assume that the infection has not spread to the tubers simply by removing the haulm. The infected plants should be removed totally (roots, stems and tubers) and destroyed.

When and how to dehaulm

- De-haulm two weeks before harvesting when the crop has attained physiological maturity and at least 70% of the haulms have started to turn yellow.
- This can be done using hand tools or uprooting the entire stems from the ground or use of herbicides.



From left to right: manual dehaulming; Chemical dehaulming

4.2 HARVESTING AND CURING

4.2.1 WHEN AND HOW TO HARVEST

- First uprooting some plants at random, examining the tubers and rubbing (Thumb Test) the ends to see if the skin peels off easily or it has hardened.
- When the skin does not slip readily, the tubers are deemed to have achieved skin set and may be safely harvested.
- Harvest when the soil is dry.
- Harvest when it is relatively cool with cloud overcasts.
- Do not expose harvested tubers to sunlight for a long time so as to prevent them from drying out too quickly, and avoid greening of the white skin varieties, which would reduce their keeping quality and consumer acceptance.
- Avoid harvesting when the soils are wet in order to avoid pathogens sticking on tubers.
- Shield harvested tubers from rain to avoid the risk

of rotting.

- When packaging into bags ensure you fill the bags halfway for ease of lifting and transporting from the farm.

4.2.2 POTATO HARVESTING USING HAND HOES/ STICKS

- Hand hoe harvesting should not be used because it will result into more damaged tubers, takes a lot of time and many tubers are left underground.
- A better tool to use, if other options are too costly is, the garden fork which causes less damage to tubers than the hand hoe.



Harvesting of potato using a garden fork & animal drawn lifter/digger

4.2.3 MECHANIZED HARVESTING

- A mechanized harvester saves time and labour costs.
- The machine should be used with care to avoid severe tuber bruising, which results in blackening of the flesh underneath the bruise area.



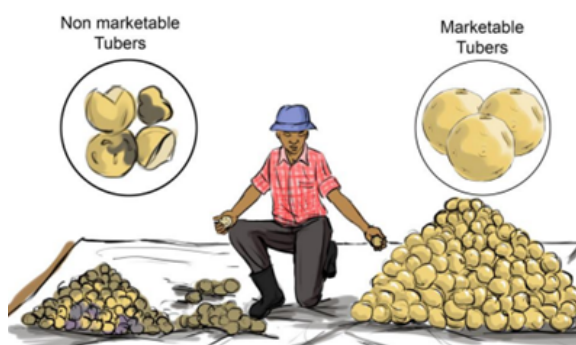
Harvesting potato using tractor mounted harvester

4.2.4 CURING

- Curing is putting harvested potato tubers in a place conducive to encourage the skin to harden and heal bruises that happen during digging
- Curing is essential for healing the wounds of tubers by developing epidermal layer resulted from cutting and bruising during harvesting.
- Cure by storing in a warm, humid room for 5-10 days. A temperature of 25-30°C and a relative humidity of 80-90% is ideal.

4.3 SORTING AND GRADING

- All the damaged and diseased tubers should be removed during sorting.
- Grading is classifying potato tubers according to their size as marketable and non-marketable.
- Marketable sizes are tubers with >60 mm diameter



Sorting and grading of ware potato

- The marketable potato should always be dried under shade quickly to remove excess moisture from the surface of tubers for improving their keeping quality.
- Do not store the tubers immediately if they were exposed to rain during or after harvest.
- Benefits of Sorting & Grading

- Grading helps the potato producer and seller to determine the price.
- It reduces the cost of marketing and helps the consumers to get standard potato at fair price.
- It has a direct influence from utilization point of view, as the small to medium sized tubers are prepared for seed tubers while large sized tubers are destined for processing purpose.
- Maximum utilization of produce, fetch high price
- Produce high quality products
- Avoids transmission of diseases from mechanically damaged, insect damaged and diseased tubers

4.4 PACKAGING AND TRANSPORTING

- Harvested potato should be carefully transported
- While transporting, bags with tubers should not be piled up in order to prevent damage and the bags should be protected from sun.
- If the potato farm is far from the store or homestead, packaging and transporting from the field using crates, carts, wheelbarrows, pickups etc. is needed.
- Package the potatoes in bags weighing not more than 50 kilograms for ease of handling and to avoid damaging the tubers.



- Transporting potato: Left wrong way loading potato; right recommended packaging of tomato to transport to store.

4.5 STORAGE

- During peak production seasons, the existing markets may not absorb the surplus produce. As a result, the price of potato decreases significantly. So, to overcome such a problem there is a need to store ware potatoes and to extend the supply time over larger period.
- Ware potatoes can be stored up to 3 to 4 months in tropical highlands without significant losses depending on variety, health status of the tuber,

storage temperatures

- Smallholder farmers in Ethiopia store their potato on the floor, granary or leave on the farm unharvested until the next planting season.
- Leaving potatoes unharvested, storage in the field, faces different challenges like unforeseen rainfall that hastens tuber rotting, and tuber moth, which causes considerable yield loss.
- There are also improved potato storages for fresh/table purposes. Such stores are well aerated/ventilated dark stores.
- Low cost ware potato storage structure technology could also be constructed and used by potato producers until proper market price exists

4.5.1 IMPROVED WOODEN STORE

- Good storage keeps tubers alive, reduce deterioration from natural process of starch breakdown, reduce storage pest infestation and damage, and reduce storage losses through rotting, greening and increase tuber dormancy period.
- Potato store constructed using local materials
- **Size:** 5m x 4m x 3.5m length width and height respectively

Construction materials:

- Strong poles, timber to cover walls to minimize light.
- Strong timer for floor construction or with cement if available.
- Rat proof net to be attached as expanded metal on the floor.
- A false ceiling can be placed before the corrugated iron roof with a layer of straw for the warmer areas.
- A ventilation window facing the common direction of wind is placed at the top corner of the roof. This window is only opened at night to let out warmer air from the store.
- The walls should be lined with papyrus mats to further minimize light in the store.



Left: external outlook of improved wooden ware potato store. Right: ware potato stored in bags inside the store

4.5.2 IMPROVED AMBIENT POTATO STORAGE

- A large-scale modern facility for long-term storage (around 3 months or more) designed to control air temperature and relative humidity using natural weather.
- It is made of compressed straw bales, strong timber strut frames on a metal super structure and sits on a re-enforced gabion foundation.
- A wind vent is fitted at the corner opposite to the door to enhance ventilation control.
- The floors are made of strong timber struts covered with expanded metal to reduce rat damage while allowing floor ventilation.
- All walls are plastered with cement to protect the straw from rodent and weather damage.
- A corrugated iron roof on a timber pole frame should be placed to cover the ambient store.



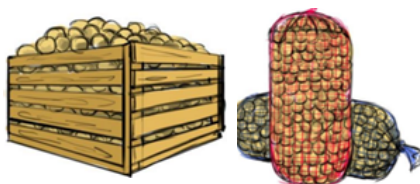
External outlook of ambient ware potato store with vents and iron-sheet protective roof and ware potato in chambers within and ambient ware potato store

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- A corrugated iron roof on a timber pole frame should be placed to cover the ambient store.

4.5.3 MANAGEMENT OF CONDITIONS IN AMBIENT STORE

- Open vent at night to allow sucking out of warm air while cool air enters through the floor and gabion.
- The wind vent is closed during day to retain the cool night air inside the store.
- Humidity should be monitored and if it lowers buckets of water should be placed on the floor of the store.
- The store should never be opened unnecessarily to maintain the ambient conditions.
- Potato should be monitored regularly for any quality deterioration and either lots sold off or discarded as may be guided by the store management.
- The temperature should be kept at a range of 7-10°C and relative humidity of 95-98%.
- The store should be sprayed with insecticides to kill tuber moth adults.
- Spread the tubers on crates and turn once in a day to prevent spoilage or use jute bags but not polythene sacks. In this case stacking should not be of more than two bags on top of each other.



Potato packed in crate and jute bags to easy aeration

4.6 PROCESSING

- Potatoes are used for a variety of purposes, and not only as a vegetable for cooking at home.
- In fact, it is likely that less than 50 percent of potatoes grown worldwide are consumed fresh. The rest are processed into potato food products and food ingredients; processed into starch for industry; and re-used as seed tubers for growing the next season's potato crop.
- Fresh potatoes are baked, boiled, or fried and used in a staggering range of recipes: mashed potatoes, potato pancakes, potato dumplings, twice-baked potatoes, potato soup, potato salad and potatoes au gratin, to name a few.
- Moreover in Ethiopia, different recipes can be prepared from potato tuber (Table 6)

RECIPES	PROCEDURE
Pasta: 	Peeled long potato tubers will be cut using knife in to thin and long form or in pasta shape and cooked in the same procedure of pasta
Kinche 	Peeled potato will be cut using knife into pieces in similar size of Kinche of Barley, wheat or Oat and the ways of preparation is similar to the kwon table Kinche.
Starch 	Peeled potato will be cut using either knife or rubbing rough metal materials and dry in oven or sunlight until constant weight was achieved in order to pack it for future use.
Starch	Peeled potato will be rubbed with rubbing rough metal materials and socked in water in the bucket for ten minutes for settling. It is schussed in another bucket and again socked for ten minutes for schussing in the same manner as above. Socking and schussing was continued until clear water drops from schussing. The schussed liquid was stayed for 24 hours again for settling and the water was carefully removed next day and dry the white dough found below the settlement from this process which is called starch after drying.
Crisp 	Peeled potato will be cut in circular or in diameter in thinner depth which is washed by clean water and put for partial drying. Then roasted in drier than chips in oil until golden color developed.
Chips 	Peeled potato will be cut in length or longitudinally in pencil thickness which is washed by clean water and put for partial drying. Then roasted in oil until golden color developed.
Genfo 	Peeled potato tubers will be made cut in to pieces and grinded into dough like structure which is placed in small boiled water and mixed and again cooked to 30 minute through continuous mixing. Then ready for eating after taken out of stove or fire and placed in dish by Deeping in central part for pouring boiled oil or butter together with salt, red pepper and spices to get good flavour for eating
Shiro wot 	Peeled potato tubers were made cut in to pieces and grinded in to dough like structure which is placed in cooked onion in oil and water, and mixed in order to again cooked to 30 minute through continuous mixing. Then ready for eating after taken out of stove or fire to gather with Enjera or bread after salting and spicing

Chechebsa 	Peeled potato tubers were made cut in to pieces and grinded into dough like structure which is mixed with dough made from durum wheat. As soon as possible mixing was completed; place all dough in baking materials through flattening for baking. It became ready for eating after cutting baked bread into pieces and mixed with boiled oil or butter together with salt and spices
Enjera 	Yeast and teff flour will be mixed with water first day and next day peeled potato tubers were made cut in to pieces and grinded in to dough like structure which is mixed with dough. After making thinner by boiled water, Enjera was baked
Bread 	Yeast and wheat flour are mixed with water first day and next day peeled potato tubers were made cut into pieces and grinded in to dough like structure which was mixed with mixed dough and baked in to bread
Firfir 	Peeled and boiled potato will be cut in to somewhat large size and added to cooked egg or meat which is eaten together with Enjera or bread.

Table 6. Different recipes prepared from potato tuber (Source: Egata Tolessa et al., 2019)



Key message

Improper harvesting and postharvest handling contribute to more than 30% of potato yield loss



Post assessment questions

1. What are indices used to determine right time of harvesting of potato?
2. When and how to harvest potato in your local area?
3. What are the best transporting instrument of potato and why?
4. List some of value-added products of potato.

SECTION 5. FINANCIAL FEASIBILITY

Overview of the section: Financial feasibility describes whether agri-business is financially viable. It involves determining initial investment (resource) requirement to start the business, estimating production cost, operation expenses, and sales revenue. These are used to determine the initial investment requirement, profitability of the business, break-even point (minimum level of production) to attain the profit zone, and pay-back period (number of years required to recover initial investment). These series procedures are used to make wise decisions to accept or reject the agribusiness investment alternative.



Learning outcome

At the end of this section participants of this training should know:-

1. How to determine initial investment requirement to start the business
2. How to estimate periodical production costs, operating expenses, and sales revenue of the business
3. How to determine profitability and cash flow of the business
4. How to calculate break-even point (minimum level of production) to recover total cost and generate profit.
5. To calculate payback period (time requirement to recover initial investment)
6. How to make decision to accept or reject the investment alternative



Duration: 4 hours



Learning question

Do you know how to determine financial feasibility of the given specific agri-business to make wise investment decision?

5.1 INITIAL INVESTMENT

- Initial investment is the minimum capital requirement to start the business.
- Example of initial investment requirement to start seed production business includes tools and equipment, seed storage, land, tractor, working capital, etc

DESCRIPTION	TOTAL COST	REMARK

Table 5: Template to estimate initial investment requirement for agri-business

5.1.1 LONG-TERM INVESTMENT

- Long-term investment in agri-business involves all asset requirement for the business which can serve for more than one year.
- Example tools and equipment, tractor, storage, land, etc

TYPES OF INVESTMENT	UNIT OF MEASUREMENT	QUANTITY	UNIT COST	TOTAL COST

Table 6: Template to calculate total cost for acquisition of long-term investment

5.1.2 WORKING CAPITAL

- Working capital for the planned agri-business includes all payments requirement for day-

to-day operating activities such as production costs and operating expenses.

Example

- Production costs include cost of seed, fertilizer, chemical, labor cost etc
- Operating expenses includes administrative salary, sales commission, promotion, etc
- Working capital excludes long term investments such as warehouse, tools and equipment, land, tractor, and etc

A. Production cost

- Production costs are a key component in agri-business.
- It includes all costs associated with production including value addition to make the product ready for sale.



TYPES OF INVESTMENT	UNIT OF MEASUREMENT	QUANTITY	UNIT COST	TOTAL COST
Total				

Table 7: Template for estimating production cost per hectare for onion seed production

B. Operating expenses

- Operating expenses are all costs not directly associated with production.
- They are common costs incurred for administrative and selling activities.

Example administrative salary, promotion cost, sales commission, transport cost to sale,

TYPES OF COSTS	TOTAL COSTS

Table 8: Template to estimate operating expenses for agri-business



5.2 ESTIMATED PRODUCTION AND SALE REVENUE

- Production volume is the main source of revenue for the agri-business to generate profit.
- Producers should determine the estimated average production volume from the planned production season.

Formula -1

Total production volume = Average production per hectare X Land size

- After determining the estimated volume of production, it is possible to determine the expected sales revenue for the planned production.

Formula -2

Total sales revenue = Total production volume X unit selling price

A	B	C	D	E	F
Types of product	Land size (ha)	Estimated production/ha	Total production (b X c)	Estimated selling price/unit	Total sales revenue (f X g)

Table 9: Template for estimating volume of production and sale revenue

5.3 PROFIT AND LOSS STATEMENT

- The primary objective of any business is to generate profit.
- Profit and loss statement is the main tool to calculate profitability of the business.
- It is used to accept or reject the investment based on estimated profit.

Formula -1

a. Gross profit = Total sales revenue – Cost of goods sold

b. Net profit = Gross profit – Total operating expenses

DESCRIPTION		
Sales Revenue		
Cost of production (-)		
GROSS PROFIT		
Operating Expenses (-)		
NET PROFIT		

Table 10: Template for profit and loss statement preparation



5.4 BALANCE SHEET

- Balance sheet used to know the total resource owned, amount of claim by creditors and amount of owners' equity
- Balance sheet contains asset, liability, and own capital
- Assets are all resources available for use or for sale
- Example cash, inventory, warehouse, land, equipment etc
- Liabilities are all debts obtained from bank, microfinances, individuals or others
- Own equity/capital involves own/member contribution, grant/donation, etc

Formula - 4

Total Asset = Total liability + Total own

DESCRIPTION		
Asset		
Current asset		
Cash		
Inventory		
Total current asset		

DESCRIPTION		
Asset		
Current asset		
Cash		
Inventory		
Total current asset		
Fixed asset		
Tools and equipment		
Warehouse		
etc		
Total fixed asset		
Total asset		
Liability and Capital		
Liability		
Loan		

Total liability		
Owners capital		
Own capital contribution		
Grant/donation		
Total owners' capital		
Total liability and capital		

Table 17: Template for balance sheet preparation

5.5 CASH FLOW STATEMENT.

Cash flow is all cash inflow and outflow for any purpose in the business operation

• Example

- Cash inflows include sale of seed/seedling, debt obtained from banks, members capital contribution, etc
- Cash out flow includes purchase of input, payment for construction, repayment of debt, payment for salary, etc

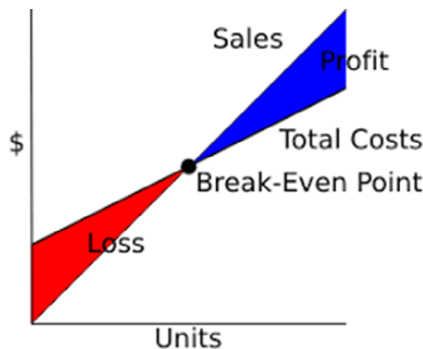
Formula - 5

Beginning cash balance + total cash inflow = ending cash balance

DESCRIPTION	AMOUNT OF OUTFLOW	AMOUNT OF INFLOW
Owners' investment		
Debt		
Grant		
Sales revenue		
Waste house construction cost		
Purchase of equipment		
Purchase of input		
Land rent		
Irrigation cost		
Labor cost		
Cash Operating costs		
Ending cash balance		
TOTAL		

5.6 BREAK EVEN ANALYSIS

- Break even analysis is used to determine the minimum level of production to cover total cost
- At break-even point no profit no loss
- To make profit, level of production and sale should exceed/greater than breakeven point.
- Fixed cost are fixed in total amount regardless of increase/decrease in volume of production.
- **Example:** depreciation, warehouse rent, administrative salary, promotion cost, etc
- Variable costs varied in total in response to increase/decrease in level of production
- **Example:** production costs, packaging cost, loading and unloading, etc



Formula - 6

Break-even point = Fixed cost / (Unit selling price – unit Variable)

5.7 PAYBACK PERIOD

- Payback period is used to determine number of years/periods it takes to recover initial investment.

Formula - 7

a. When the annual profit of the business is uniform/equal

Payback period = Initial investment / annual profit

b. When the annual profit fluctuate/vary from year to year

Pay back period = # of year before coverage + uncovered amount / profit of the next year



Payback Period

The amount of time it takes to recover the cost of an investment.



Key message

Analyzing financial feasibility of agribusiness enables to pre-determine the applicability of the business in terms of initial investment requirement, profitability, and sustainability.



Post Assessment Questions

- Which of the following is part of working capital
 - Purchase of fertilizer,
 - Purchase of tractor,
 - Transportation cost,
 - Purchase of chemical
- Which of the following should include in profit/loss statement
 - Purchase of tools and equipment
 - Sales revenue
 - Debt
 - Owner investment
- Which of the following is variable cost
 - Purchase of seed
 - administrative salary
 - Depreciation
 - Rent of storage

SECTION 6: POTENTIAL RISKS AND MITIGATION MEASURES

POTENTIAL RISKS	MITIGATION MEASURES
Limited demand driven input/early generation seed supply	Create strong, sustainable, and diversified linkage with suppliers through contractual based early generation seed production
Climate change	Use climate adoptive crop varieties, use irrigation scheme, use climate prediction information and trends of climate change, use diversification, understand effective crop calendar
Inflation/market fluctuation	Conduct effective demand assessment, understand competition in the business, apply cost-based pricing strategy, understand the market trend, use diversified market outlets
Limited access to finance	Create strong linkage with diversified source of finances such as banks, microfinance, use family/friends/partner, develop saving,
Insects and disease	Use quality and certified seed, apply crop rotation, understand the type of the insects/disease and use chemicals/manual mitigation method
Security	

