Training Manual on Bundled Climate Smart Agriculture, Climate Information Services and One-Health Technologies for Priority Value Chains

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About AICCRA Ghana Cluster

AICCRA-Ghana focuses on bridging the gap between the research institutes that produce improved technologies and the development organizations that promote the adoption of improved technologies including digital Climate advisories, for the purpose of enhancing the resilience of the country's agriculture and food systems in the face of climate change while improving livelihoods of hundreds and thousands of farmers. AICCRA-Ghana mutualizes existing expertise to strengthen the technical, institutional, and human capacity needed to move CGIAR innovations off the shelf and achieve impacts in the country. The project will specifically launch a "One-health platform for climate-driven pests and diseases". It is an advanced climate-informed One-health innovation that builds on CGIAR's track records in this area, framing the nexus of the crop, livestock, soil, and water health for improved human and ecosystem health, food safety and nutrition, and climate change as a complex public health issue. The project is anchored to CGIAR's multi-stakeholder platform of the Biorisk Management Facility (BIMAF) hosted by IITA's station in Benin, West Africa. AICCRA-Ghana will use the CGIAR's Scaling Readiness Tool to undertake assessments of CSA options for accelerated uptake of innovations. NFCS and innovation platforms including the private sector, Nourishing Africa network, and farmers will be capacitated towards identification, promotion and implementation of suitable CIS and best-bet CSA and One-health innovations. Media and mass-campaign awareness will be launched while developing business models and engaging champion women- and youth-led enterprises. Pilot sites will be identified and training provided to farmers for successful implementation of One-health and CSA technologies.

Contents

FORWARD

This training manual is a collaborative work between CSIR-Crops Research Institute, Kumasi, Ghana Meteorological Agency, Accra, Center for Agriculture & Bioisceinces International (CABI), Ghana, University for Development Studies (UDS), and Esoko Limited and International Institute of Tropical Agriculture (IITA) with funding from the World Bank under the "Accelerating Impact of CGIAR Climate Research for Africa" project. The manual is an addendum to the prioritized and bundled Climate Smart Agriculture (CSA) and Climate Information Services Innovations that is One Health Sensitive. It is designed as a reference manual for training farmers, agricultural extension agents, and other users that will empower them to sustainably produce crops for improved livelihood. The manual is designed as an extension and training tool for trainers of trainees (TOT) and extension agents to support smallholder farmers most especially stakeholders in AICCRA intervention communities. Users will find the manual very useful and it is hoped that Agriculture Extension Agents (AEAs), farmers, students, and other end users will apply the modules to increase crop production in the target agroecologies. Specifically, the manual provides climate information services, climate smart agriculture innovations and one health intervention that have been prioritized along maize, cowpea, yam, sweetpotato and tomato value chains. Relevant information from previous production guides prepared under projects such as the Ghana Grains Development Project, Food Crops Development Project, West Africa Agriculture and Productivity Program and Council for Technical, Vocational and Educational Training have been incorporated in this manual which we duly acknowledged.

ACKNOWLEDGEMENT

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INTRODUCTION

Global demand for food will increase during the coming decades, as is most likely even more true for the demand for grain cereals and legumes. At the same time, arable land and other production resources are limited, and area expansion for food production is not appropriate or recommended in the spate of urbanization and multiple land uses. With extensive urbanization and competition for farmlands, any increase in crop production should be met mainly by increased productivity i.e. improved crop yields per unit area than an increase in cultivated areas.

Sustainable food production technology is imperative to curb food insecurity, reduce poverty, and impact the livelihood of smallholder farmers. The role of maize, cowpea, yam, sweet potato, and tomatoes in ensuring food and nutritional security in Sub-Saharan Africa and Ghana in particular cannot be over-emphasized. However, the productivity of these crops over the years has been a challenge due to the effect of climate change. With the continuous increase in climate variabilities such as erratic rainfall, drought, increased temperature, pests, and diseases, smallholder farmers have become more vulnerable with very limited knowledge on adaptation and mitigation options. The Consortium of International Agricultural Research Centres (CGIAR) in collaboration with partners has developed innovations in climate-smart agriculture and climate information services that is One Health sensitive. The missing link is the limited access to the technologies and capacity to utilize these interventions by smallholder farmers. Developing a climate-smart technology, climate information services and One Health innovations training manual serves as means of creating information access and building the capacity of intermediaries and farmers. The manual will increase the resilience of smallholder farmers and improve the smallholder agriculture system.

OBJECTIVES OF THIS MANUAL

This training manual is intended to provide information and build the capacity of beneficiaries (farmers, extension agents and other stakeholders) for enhanced productivity along the AICCRA value chains.

The specific objectives:

- Build capacity of beneficiaries in the prioritized climate-smart agriculture innovations and climate information services
- Build capacity of participants in the prioritized One health Innovation
- Build capacity of participants on Gender and Social Inclusion concept

TRAINING MATERIALS REQUIRED

- Flip chart stand and sheets
- Markers (Black, Green and Blue)
- Coloured stickers
- Notebooks, Pens and Pencils.
- Printed posters for presentations where there is no projector.

PRACTICAL ACTIVITIES

- Group discussion and presentations
- Plenary presentations

POTENTIAL USERS OF THIS MANUAL

The training manual is tailored toward farmers, extension agents, policy makers, media, students, and other intermediaries.

Module 1: Basic understanding and utilization of Climate Information Services (CIS)

1.1.1. The Seasonal Forecast

Seasonal Forecasts are prepared and shared by the Ghana Meteorological Agency. It is a product that is provided shortly before the season begins and updated frequently throughout the season. In many countries, it is limited to probabilities of the total amount of rainfall for the season being above normal, normal, or below normal, compared to previous seasons. For agriculture and livelihoods, these can be used as a further source of information to help adjust existing strategies and plans. By the end of this module, farmers should be able to read, understand and interpret seasonal forecasts as well as calculate probabilities of rainfall for their locality/community.

Practical Activity 1.1. Reading and interpreting seasonal rainfall forecasts

1. Put farmers into groups and let each group discuss what they understand about the seasonal forecast and the benefits and limitations of the seasonal forecast.
2. Representatives from each group should present in plenary what the group discussed
3. The facilitator should print out copies of the seasonal forecast for Ghana
4. Print and give each group seasonal forecast data of the country. For example, you can use the seasonal forecast figures from the North and South of Ghana to support the discussion.
5. Point and explain to farmers that terciles divide the data into three equal groups- above normal, normal and below normal, the season for one station. An example is a seasonal forecast from the South of Ghana showing, 35 % chance of 'above normal' season, 40 % chance of a normal season, and 25% chance of below normal season.
6. Provide each group with a seasonal forecast graph with terciles and let them read and explain what they see for their area/community. To ensure that this is clearly understood you could ask the farmers to count the occurrences in each tercile.
7. Each group should present their results in plenary

Further activities:

Once the farmers/participants can read, understand and explain the seasonal forecast data, the group can further discuss the following and present to the plenary:

1. Farmers/participants should explain their satisfaction with using the seasonal forecasts and whether they think it is definitive and informative enough for their activities.
2. Farmers should discuss whether the forecast for the coming season has any implications for the crop /livelihood options they envisaged for the season. For example, if the forecast is below normal rainfall will their chosen cropping practice change? You could refer to a crop calender, maturity and water requirement to help with this.
3. Ask the farmers to mark any changes they wish to make based on their understanding of the seasonal forecast information.

1.2: Participatory Integrated Climate Services for Agriculture (PICSA)

1.2.1: Farmers' perception and historical records

The amount of rain that falls every day is measured using standard equipment at each weather station and recorded by a meteorologist for years. The number of years recorded depends on the availability of a weather station at the location. Daily rainfall totals are summarized and represented in a graph that displays seasonal rainfall over the period. The vertical axis of the graph shows the total amount for each year.

1.2.2. Understanding and interpreting historical climate information /graphs

Why is it useful for farmers to understand the historical climate information for their location? Historical climate information enables farmers to plan better.

Practical Activity 1.2. Reading historical climate information

1. The facilitator should explain to farmers/participants how historical climate information is recorded and presented.
2. Explain how this information can be useful in informing farmers' crop, livestock, and livelihood decisions.
3. Print and hand over copies of historical climate graph that shows total seasonal rainfall to farmers.
4. Explain what the horizontal and vertical axis represents. The horizontal axis displays the years while the vertical axis represents the total amount of rainfall recorded for the period under consideration.
5. Put farmers into groups and let them explore the data. They should discuss the following questions:

- Does the data show any differences in rainfall for the past 30, 40, or 50 years? (Are there any trends?).
- What is the magnitude of change from year to year in the past 30, 40, or 50 years? (Has variability increased, decreased, or stayed the same?)
- How does this information compare with farmers' perceptions of the weather and climate in the area over the past 30, 40, or 50 years?

NOTE: Read more graphs to find the start of the season, end of the season, season length, temperature, number of dry spells; length of the longest dry spell; timing of dry spells; extreme rainfall events.

Practical Activity 1.4. Calculating probabilities of weather and climate characteristics

Why is it helpful to calculate the probabilities of weather and climate characteristics?

Knowing the probabilities of different weather and climate characteristics can help farmers to make important decisions about crop varieties' planting times, management, and livelihood choices. Organize the farmers into groups to look at the graph of total seasonal rainfall as in previous activities.

1. The facilitator should help participants identify the period covered by the historical climate information. You can ask farmers/participants to identify the first and last years recorded on the graph and ask them to calculate the number of years.
2. Ask each farmer/participant to identify and point to a particular rainfall amount (500 mm) on the vertical axis of the graph.
3. Ask each participant to use a piece of paper to cover all the rainfall points that are below 500 mm
4. Ask the extension officers and farmers to count the rainfall points that are still visible – this tells them how many seasons in the past year's seasonal rainfall.
5. The next step is to divide the number of visible rainfall points by the total number of rainfall points on the historical climate graph to work out your probability
6. Help the participants to make this calculation with their graphs and to work out the probability that they will receive over 500mm of rainfall in the coming season
7. Once everyone has agreed on the probability then write clearly on a flipchart or board for everyone to see

NOTE: Discuss and explain to extension officers and farmers how these graphs and calculations can be of practical use.

MODULE 2: Gender and Social Inclusion (GSI)

Globally, women play important role in food and agricultural systems, and this should not be overlooked when planning and designing climate agriculture practices and climate information services interventions if such programmes would achieve their full potential. It is in order that this year's theme for the international women's day celebration has it as "Gender equality today for a sustainable tomorrow" and makes a call for climate action for women by (UN, 2022). Thus gender and social inclusion in CSA and CIS in farming systems is aimed to improve the productivity of smallholder farmers for improved food security. Climate smart agriculture and One health technologies should be gender-sensitive and responsive to be easily adapted by women. This will benefit both women and men as well as all other marginalised persons within the system. The gender smart framework is adopted for such intervention by the Accelerating Impacts of CGIAR Climate Change Research in Africa project (AICCRA).

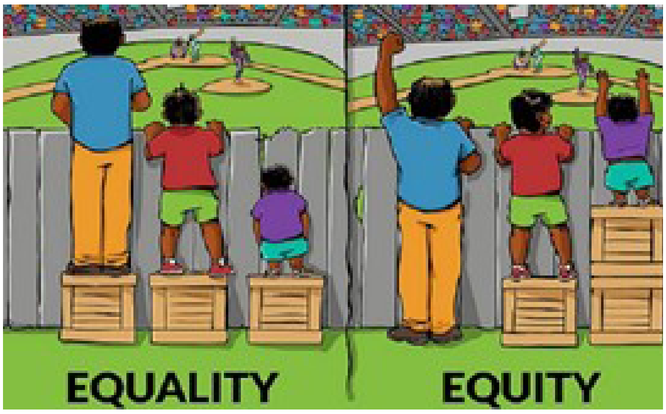
2.1: What are gender and Social Inclusion?

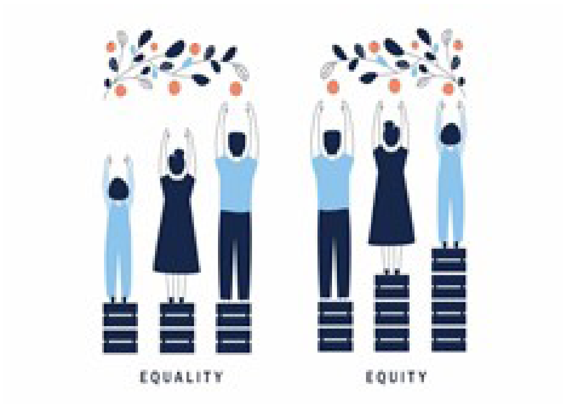
Practical activity 2.1

- Ask participants about their understanding of the word "Gender"
- Allow everybody to share their opinion and write down all responses on the flip chart
- What are the gender roles in this particular value chain? Write answers on a flip chart and discuss the dynamics with participants.
- Let participants explain what boys and girls are allowed to do and otherwise
- What do men do and do not do? What do women do and do not do?
- Discuss and write some of the reasons why some persons are excluded from our value chain.

2.1.1. Gender equality and equity

Show the pictures (Fig. 1) and discuss with farmers their understanding of gender equality and equity. What would be equality and equity in the CSA interventions for this particular value chain? Write the responses down and discuss.





A **B**

Figure 1. Gender Equality and Equity:
Source Picture A: https://www.nwhu.on.ca/ourservices/Pages/Equity-vs-Equality.aspx
Source Picture B: Gender Equity Training You Can Take Anytime Online | Human Rights Careers

2.2: Why gender and social inclusion in CIS,CSA and One Health Approaches

Allow participants to list some disparities and discuss them together. Some real disparities are:

- Access to and the use of production resources
- Women are less likely to own lands
- Women have less access to or are less likely to use advanced technologies and purchase inputs such as seeds and fertilizers
- There is a disproportionate representation of men and women within the value chain
- Tasks within the different value chains are often gendered; Women conduct 70-80% of the farming in the developing world but their roles are not recognized.

Discuss why it is important to address gender inequalities.

Some reasons are:

- To help achieve MDG 1 and 3; for all the other MDG and agenda 2030 to be realised
- Economic efficiency requires a sustainable inclusion of all genders for development
- Gender differences in access to and control of resources leads to disparities in development outcomes
- Gender roles and relations affect the two critical human development indicators (food security and household welfare) and
- Gender equality is a basic human right. There is the need to create an environment in which every woman and girl can exercise her human rights and live up to her full potential.

NOTE: Allow participants to discuss what gender inequalities exist about CSA/CIS within your value chain. How do you address some of the inequalities identified?

2.3. Gender Analysis frameworks- Tools

There are several frameworks for doing gender analysis and for this training purposes we will use the Harvard Gender Analysis Framework. It focuses on resource allocation for men and women and CSA, it addresses resources related to CSA and CIS resources and information available for, and accessible to, men and women along the particular value chain. It also focuses on decision-making about CSA and CIS, which relates to control over the use of such resources and information for the mitigation of climate change effects and adaptation to ensure increased productivity and enhanced income of men and women along the particular value chain.

Table 1. Gender Analysis frameworks - Tools

Framework	Focus	Tools
Moser	Three concepts: women's triple role (reproductive, productive, and community work)	- Gender roles identification/triple role - Gender needs assessment - Disaggregating control of resources and decision-making.
Harvard	Resource allocation for men and women	- Activity profiles - Access and control profile to resources and benefits for women and men - Influencing factors
Women empowerment	Analyses equality by sectors but concentrate on separate areas of social life	- Measures levels of Equality - Women's Empowerment
Social Relations Approach	Analyses existing gender inequalities in the distribution of resources, responsibilities, and power.	-Framework of conceptualising, studying, and implementing empowerment - The Sen-inspired framework- ability to exercise choice - Resources , Agency and Achievements

Gender Analysis Matrix	To determine the different impact development interventions have on women and men	- Analysis of four levels of society – women, men, household and community - Analysis of four kinds of impact – labour, time, resources and social cultural factors
Capacities and vulnerability Analysis	To help plan aid in emergencies, and to meet immediate needs.	- Categories of capacities and vulnerabilities - Additional dimensions of "complex reality"
People Oriented Planning	Is an adaptation of the Harvard Analytical Framework for use in refugee situations	- Refugee Population Profile and Context Analysis - Activities analysis - Use of resource analysis and an adaptation of Harvard tool 2 women's socio-political profile compared to men's

2.3.1 Assessing the Gender Smartness of Value Chains

How does this value chain CSA intervention influence your decision-making at the household level on the following?

- Use of income
- Planning for the household
- Household labour use

Other activities related to the value chain

- Do men and women have equal access to resources such as land, credit, agricultural inputs for the adoption and implementation of CSA/CIS interventions?
- Are women part of leadership within your community?

Have participants discuss separately among the two genders, youth etc and later together and present their answers in a plenary. Ask participants to make recommendations for marking the CSA/CIS interventions gender smarter.

Module 3: Understanding the concept of One Health

3.1 Facilitator should discuss with participants the concept of one health

One Health is the interconnection between the health of humans, animals, plants and their shared environment (the health of the ecosystem). The health of these components of nature (the ecosystem) should be assessed by their sustainability, financial savings ,and social resilience achieved during any human economic operation. When assessing One-Health risk of an operation, identify what might go wrong (hazard) with humans, animals, plants and their shared environment (soil, water and air) now or in future and how it can occur due to the operation to evaluate the identified hazard and determine the needed measures to prevent or minimize the negative effects to the ecosystem's health (i.e. sustainability, financial savings and social resilience).

Practical Activity 3.1. Inclusion of One-health in CSA protocols

For each of the demonstration protocols in this manual, examine each operation (activities; equipment/products/inputs to use; where/when and how they will be used) and find answers to the following questions and take the set of actions proposed in the steps below:

- What is the potential harm this operation will have on other components of nature (the ecosystem)?
- What is the likelihood of it happening and severity on the ecosystem when the operation is undertaken?
- Who or what might be harmed? For example farm hands, water, useful soil fauna, natural enemies, other beneficial organisms etc can be harmed by a particular pesticide to be used.
- How will they be harmed? For example a polluted water is unwholesome for human and animal use and will cause a fortune to clean it; Targeted pest may develop resistance to the pesticide and call for more frequent and expensive pesticide usage.
- Evaluate the risks and decide what precautions/corrective measures to take. For example, observe the recommended dosage of pesticide to apply; Do not use the same active ingredient of pesticides repeatedly beyond 25 successive days on the crop; Alternate pesticides with respect to their different modes of action in order to delay or prevent resistance.

Practical Activity 3.2. How to develop One Health Action Plan

- Document the findings in Practical Activity 3.1. and develop an action plan to prevent or minimize the harm.
- Discuss how the action plans (precautions/corrective measures) can be incorporated into the demonstration protocols.
- Review the implementation and if necessary find ways to improve the operation by repeating the steps.

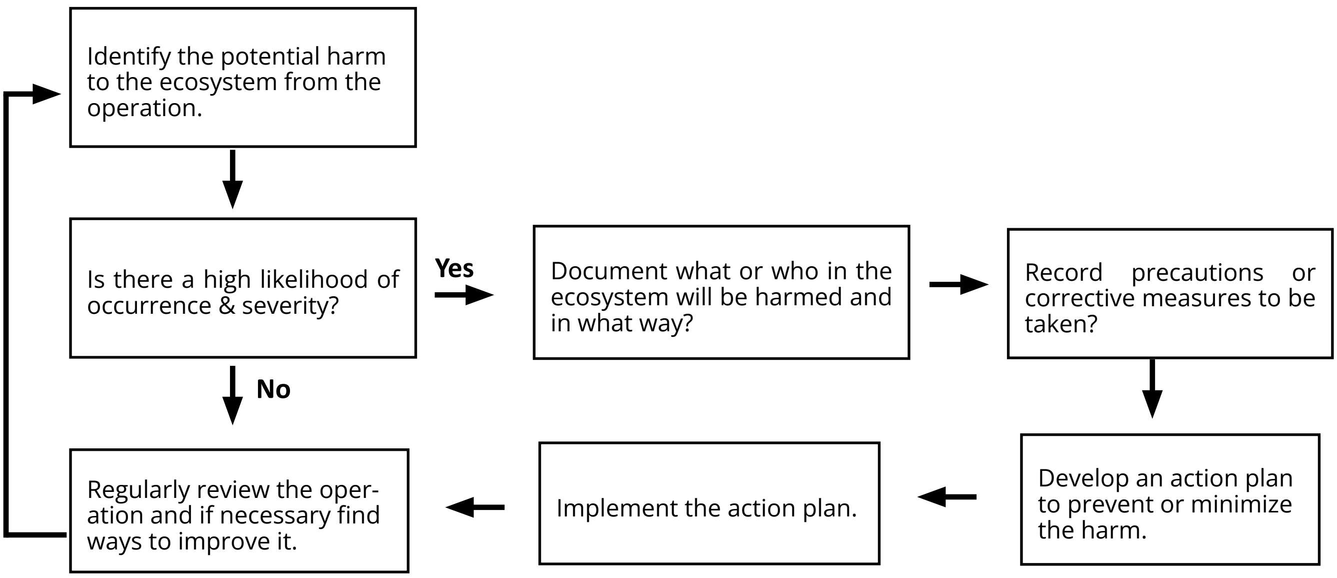


Fig. 2. Flow diagram of one-health decision support system

Module 4: Biological Soil and Seed Treatment

The negative effects associated with synthetic pesticides on the environment due to improper handling and application has necessitated the use of organic-based pesticides, which are preferred over synthetic pesticides for the sustainable management of insect pests, soil arthropods, and disease-causing pathogens. One such biocontrol option is the use of neem leaf powder for the control of seed-borne and soil-borne pathogens.

4.1 Neem leaf powder

Neem (Azadrichta indica) is a common plant that possess compounds called Azadrichtin which is potent with broad-spectrum anti-feeding properties against most soil-borne pathogens, soil arthropods, and plant-parasitic nematodes. It also serves as an all-purpose organic soil conditioner by increasing the humus content of the soil. It is biodegradable and breaks down quickly without releasing any harmful toxins to the environment.

Practical Activity 4.1. Preparation of neem leaf powder

Materials needed: Neem leaves, mat or jute sack, wooden mortar, wooden pestle, sacks for packaging

1. Harvest tender neem leaves from its tree.
2. Dry in an open but shady airy place until leaves are thoroughly dry and crispy.
3. Pound to powder using the mortar and pestle or better use a grinding machine
4. Pour and store the powder in an airtight sack or container for subsequent use.

Practical Activity 4.2. Seed treatment with neem leaf powder

1. Dissolve 100g of neem leave powder in a litre of water
2. Stir continuously to form a uniform mixture or solution
3. Immerse planting materials such as yam minisetts in the solution for 10 mins
4. Remove the planting material and dry under shade for one hour to dry before planting.
5. Repeat the process until all planting materials are treated.

Practical Activity 4.3. Direct application of neem leaf powder for soil treatment

1. Create a sizable hole for planting.
2. Spread 20 g of neem leaf powder in the hole created.
3. Apply a handful of soil to cover the neem leaf powder.
4. Place the planting material in the hole and cover it with soil. Repeat steps 1 to 4.

Figure 3: Neem leaf powder

Figure 4: Application of neem leaf powder

4..2: Use of wood ash for seed treatment

Wood ash is the residue obtained after the combustion of wood. It comprises organic and inorganic components and usually used as a biological control agent, especially in seed treatment for planting and storage. It contains about 25 % calcium carbonate, 10 % potash, 1 % phosphate, and other trace mineral components such as zinc, manganese, boron, and copper. Wood ash can easily be produced or obtained from households and combustion materials such as rice husks, coconut husks, corn husk, and corn cobs among other crop residues.

Practical Activity 4.4. How to treat planting materials with wood ash

1. Measure 1 kg of wood ash and mix with 1 L of water in a pan.
2. Stir the mixture until the solution is uniformly mixed
3. Immerse the planting material in the solution for about 10 minutes
4. Remove the planting material and dry under shade for them to dry before planting.
5. Repeat the process until all planting materials are treated.

Figure 5. Treating seed yam before planting

Practical Activity 4.5. Treating seed with wood ash for storage

1. Dip seed in ash until it is completely covered by the ash.
2. Store seed (still covered in ash) in a cool dry place.
3. From time to time, spread ash on the stored seed.

Self-Assessment

- Ask each participant to go through the outlined/demonstrated process and produce at least 500 g of neem leaf powder
- Demonstrate how to treat and plant seed with ash and neem leaf powder. Ask participants to do the activity individually while you supervise.

MODULE 5: Sustainable management of sweet potato weevils (Cylas spp)

Sweet potato weevil, Cylas spp. feeds and reproduces on sweet potato (Ipomea spp) and other plants belonging to the family Convolvulaceae. This pest attacks the vegetative, flowering, rooting, and post-harvest (in storage) stages. The larval stage is the most destructive as it feeds and creates tunnel through the base of stems and tubers. The insect has limited or almost non-existent flying activity. This means it is carried from place to place through the movement of plant materials. Many management options are available. The choice of management tactic depends on availability, cost, and effects on human, animal, and ecological health.


Figure 6: Larvae of sweetpotato weevil; Adult sweetpotato weevil. Sweetpotato weevil damaged tubers.

5.1 Agronomic /Cultural management

- Crop rotation: Alternate sweet potato with crops such as cowpea.
- Intercropping: Intercrop sweet potato with crops such as onions.
- Mulching: This prevents soil cracks which are major entry routes for sweet potato weevils.
- Sanitation: Destroy crop residue after harvest. Weevils hide and multiply in the residue left on the field.
- Clean planting materials: As much as possible, avoid cutting and using vines from the base of sweet potato. Weevils lay eggs in old vines if access to roots is not possible. If older/basal vines are used, ensure it is treated.
- Control alternate host: Some plants in the sweet potato family host weevils in the absence of sweet potato. Removing such plants during fallow periods reduces weevil infestation during sweet potato cropping season.
- Re-ridge around the base of plant to prevent cracks in the soil which serve as entry points for weevils.
- Plant resistant/tolerant varieties: Plant resistant or tolerant varieties if available.

5.2. Management with semiochemicals and attractants

Semiochemicals are organic compounds that insects use to convey specific chemical messages that modify behavior or physiology. Semiochemicals mediating interactions between interspecific individuals are called allelochemicals and those between intraspecific individuals are known as pheromones. The use of pheromone traps in sweet potato weevil management is a common practice. About two to four pheromone traps can be used per acre to attract male weevils for destruction.

Figure 7: Using pheromone traps in managing sweet potato weevils

Photo credit: Dr. Gadi V.P. Reddy, Uni of Guam

5.3. Biological control (Biocontrol) of the sweet potato weevil

Biological control is the use of natural enemies (beneficial organisms) to reduce the population of the pest to a level not harmful to the crop. Biological control agents are grouped into three. These are predators, parasitoids and beneficial pathogens. They include insects (predators and parasitic wasp), mites, beneficial nematodes (Steinernema and Heterorhabditis), microorganisms such as fungi e.g. Beauveria bassiana.

5.4: Integrated pest management (IPM) of sweet potato weevil

Integrated pest management combines multiple control measures in a sustainable and environmentally friendly manner. No single control tactic can effectively manage sweet potato weevil. Thus, IPM uses one or more tactics as stated in sections 5.1 to 5.3 to achieve sustainable management of the weevil.

Practical Activity 5.1. Group discussion on sweet potato weevil management

- Participants should discuss how sweet potato weevil enter new fields
- Participants should discuss the various options of managing sweet potato weevil
- Participants should discuss the advantages and disadvantages of using synthetic and organic insecticides

Self-Assessment

Participants should choose their best management option to manage the weevil and give reasons for their choice.

Module 6: Sustainable Yam Production

6.1 Seedbed Options

Seedbed management is critical in yam production. The type of seedbed used for cultivation has a significant impact on the shape of the yam tuber. Yam, like other tuber crops, needs pulverized soil for bulking. Mounds have remained the traditional seedbed for planting yams. It has however been seen to reduce the planting density of yam.

6.1.1: Ridging as an alternative to mounding

Ridges are raised beds usually higher than the surface of the soil. They are used generally to plant horticultural crops. Its adoption in yam production was necessitated by the need to mechanize seedbed operations to reduce labour and drudgery.

Planting yam on ridges has several advantages over planting them on mounds. Ridging:

- Allows for a higher planting density
- Allows for easy application of fertilizer and pesticides in row cropped yam.
- Limits farm traffic to the furrows, thereby limiting compaction.
- Allows for the use of minimum stakes.
- Allows for pulverized soil and increases aeration in the farms.
- Allows for easy weed control and the application of other inputs.
- Supports mechanized harvesting in yam production.

Practical Activity 6.1. Preparing ridges for yam cultivation

- Plough and harrow to a depth of about 20 cm – 40 cm to loosen the soil.
- With a mechanical ridger or hoe, construct ridges of about 30 cm – 40 cm high and with a width of about 40 cm – 50 cm.
- Leave alleys of 50 cm between ridges.
- Plant seed yam on the ridges at a spacing of 1 m.

Figure 8. Preparing ridges using a hoe

Figure 9. Ridges ready for planting

6.2: Minimum Staking

Twines and vines when left to crawl on the soil can easily contract diseases because of the high humidity created around the plant. Staking helps to raise the vines from the soil surface, allows for better air circulation around the plant which reduces disease incidence in the crop. Materials for staking can be wood (tree stems and branches, bamboo or live trees and shrubs), metal or rope (nylon, jute or plantain, and banana fiber).

6.2.1: Use of Trellis as a minimum staking option

Minimum staking options such as the trellis were developed to reduce the number of individual stakes used for staking in yam production, thereby reducing production cost. Yams are staked three months after planting when vines are well established.

Practical Activity 6.2. Trellis staking

Materials needed – Nylon or jute rope, metal bar or wooden pole of about 3-meter height

1. Dig a hole at one end of the furrow between two ridges and insert the wooden or metal pole to a depth of about 30 cm to 50 cm.
2. Cover the hole and firm the base where the pole was inserted.
3. Repeat points 1 and 2 at intervals of about 20 m to 30 m on the ridge until you reach the end of the ridge.
4. Tie one end of the nylon or jute rope to the first pole on the ridge.
5. Fasten the knot secure around the pole.
6. Stretch the rope and tie it around the second pole, securing the knot tightly
7. Repeat 4, 5, and 6 until the whole length of the ridge is done.
8. Starting again from one end of the ridge, hold the vines of the yam crop carefully as you direct it onto the rope.
9. You can tie one end of the vines carefully with a smaller size rope if the yam vines are too short. Tie the end of the rope to the rope directly above the yam crop.
10. Repeat all until the whole field is staked.

6.3. Seed Yam Multiplication Technologies

Yams can be produced using seed or ware tubers, and vines. The traditional method of deriving seed yams called milking remains dominant. However, several improved methods such as the use of minisett and vines; and generation of seed yam using aeroponics, hydroponics, and tissue culture are gaining ground.

6.3.1. Minisett technique

The minisett technique involves cutting yam tubers into small pieces of about 30 to 50 g, being mindful to leave a reasonable amount of the yam peel intact. Each yam minisett is treated with neem leaf powder or wood ash, pre-sprouted in sawdust before planting on already prepared ridges or mounds. Using minisetts gives a higher multiplication ratio than other traditional methods.

Practical Activity 6.3. Cutting minisetts for planting

- Identify and select a disease-free or clean yam.

Using a sharp clean knife, cut the tuber into pieces of about 30 – 50 g.

- Treat minisett with ash or neem leaf powder before planting

Figure. 12. Farmers cutting yam minisetts

Self-Assessment

- Ask participants/trainees to bring at least 2 disease-free yams. Ask and supervise each participant to cut the yam into minisett.

6.3.2. Aeroponics and hydroponics technologies for vine and seed yam generation

Aeroponic involves growing crops with the roots hanging in an enclosed chamber where nutrient is supplied intermittently through irrigation pipes with nutrient solution. Aeroponic cultivation does not involve the use of growth media. Hydroponics involves growing plants in a nutrient solution with or without a growth medium. Some common growth media are cocopeat, perlite, rockwool, peat, and vermiculite.

Figure 13: Aeroponic system for seed yam production

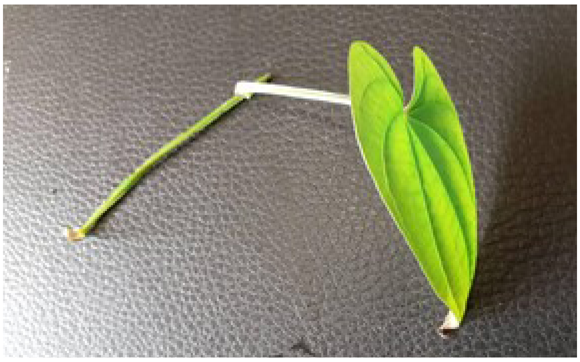


Figure 14: Single node vine for aeroponic/hydroponic planting

Figure 15: Micro tubers growing in an aeroponics chamber

Figure 16: Pre-germinated yam mini-tuber

Module 7: Sustainable Sweet potato Production

7.1 Land Preparation and planting of sweet potato vines

Sweetpotato can be planted on mounds, ridges or flat beds (depending on labour availability, finances and the usual practice of the community). The height of the ridge, mound or bed should give enough room for storage root initiation and growth to obtain higher yield. Yields on mounds and ridges are often higher than on flat beds. Ridges should be about 60-100 cm apart while mounds are often made at a spacing of 1m x 1m. The vines are cut about 20-30 cm long (depending on the variety's inter node length) with at least three nodes. Vines are planted at a spacing of 25-30 cm between plants. With this spacing, 33,333 plants can be planted on a hectare with ridges. However, with a spacing of 1m x 1m, on mounds, 30,000 plants can be obtained in a hectare. Planting on ridges helps farmers to get higher plant density compared to mounding. Before planting sweet potato vines, apply soil with neem leaf powder to manage soil borne pathogens such as nematodes. It is advisable to plant one vine per hole and fill plants that failed to establish.

7.2 Preparation of sweet potato planting materials.

1. Choose improved sweet potato varieties that are high yielding and tolerant to pest and diseases.
2. Select and cut vines from mother plants which are vigorous, healthy looking, and free from symptoms of pest and diseases.
3. It is advisable to cut vines from upper part or tip of the plant, since it is most actively growing portion.
4. Disinfect knife after every cut to reduce the spread of disease pathogens such as viruses
5. Treat cut vines by immersing in neem leaf powder solution for approximately 20 minutes before planting.
6. To prepare and apply neem leaf powder or wood ash solution refer to practical activity

7.3 Pest and Disease Management in sweet potato production

- To manage sweet potato weevil, refer to module 7.
- Apply neem leaf powder to manage soil borne pathogens such as plant parasitic nematodes
- Practice good field sanitation such as weed removal
- Practice crop rotation to reduce the build-up of pest and disease inoculum.
- Practice earthen up or re-ridging to avoid/minimize root exposure.

7.4. Harvesting and storage of sweet potato roots

- Loosen up the soil around the mature roots.
- Gently remove the matured roots from the soil.
- Collect harvested roots and clean by removing soil particles
- Ensure minimal or no bruise on roots when harvesting
- Separate weevil infested, diseased roots from healthy roots during harvest

Practical Activity 7.1. Planting of sweet potato vines

- Prepare ridges as shown in Practical Activity 6.1.
- Prepare sweet potato vines as shown in Practical Activities 4.2 and 4.4
- Participants should discuss the vine multiplication technology and share their experiences if any.
- Participants should demonstrate how to plant sweetpotato vines on a ridge or mound.

Self-Assessment

Participants should answer the following questions:

- Why is planting sweetpotato on ridges and mounds better than on flat beds?
- What is the spacing for planting sweetpotato vines on ridges?
- What are the benefits of planting early in the season?
- What is the disadvantage of planting all sweetpotato fields at once?
- What are the advantages of staggered planting?

8.1. Selecting and Growing Stress (drought, disease and pest) Tolerant Maize and Cowpea Varieties

To select a good maize and cowpea variety, a balance must be struck between yield and crop maturity period to avoid climate change-induced water stresses. For this reason, it is important to:

- Obtain climate information from designated institutions to make an informed decision.
- Choosing the right maize/cowpea variety is the first step towards achieving good crop productivity and also mitigate climate change.
- Select maize and cowpea varieties that have higher water and nutrient use efficiencies, tolerant to pests (insects and weeds) and diseases, water stresses (droughts), and higher temperatures.
- The seeds must be certified and obtained from licensed seed producers, seed companies, and local agro-input shops.

Table 2. List of improved maize varieties and their characteristics

Variety	Type of variety	Characteristics	Days to maturity	Yield (t/ha)	Yield (100kg bag/acre)
CSIR-Aseda	White normal hybrid	Drought tolerant	110	6.7	27
CSIR- pεaburoo	White normal hybrid	Drought tolerant	110	7.5	30
CSIR - Tintim	White normal hybrid	Drought tolerant	110	7.9	32
CSIR - Kpariyura	White normal hybrid	Drought and striga tolerant	110	9.0	36
CSIR-Denbea	Yellow hybrid normal	Drought and striga tolerant	90	6.5	26
CSIR-Similenu	White normal hybrid	Drought and striga tolerant	90	8.5	34
CSIR-Kom-Naaya	White normal hybrid	Drought and striga tolerant	85	5.5	22
CSIR-Wang-Basig	White normal hybrid	Drought and striga tolerant	85	5.5	22
CSIR-Omankwa	White OPV	Drought and striga tolerant	90	5.5	22
CSIR-Abontem	Yellow OPV	Drought and striga tolerant	80-85	4.7	19
Crops-Dzifoo	Orange normal hybrid	Normal, pro-vitamin A	110	6.1	24
Crops-Aho f	Orange normal hybrid	Normal, provitamin-A	110	6.1	24
Crops-Afriyie	White normal hybrid	Drought tolerant	80-85	6.5	26
Crops-Aho dzin	Orange OPV	Pro-vitamin A	110-115	4.0	16
Crops-Honampa	Orange OPV	Pro-vitamin A	110-115	5.2	21
Wari-kamana	White normal hybrid	Drought and striga tolerant	110	6.9	28
Kpari-Faako	White normal hybrid	Drought and striga tolerant	110	6.7	27
Kunjpr-Wari	Yellow normal hybrid	Drought and striga tolerant	90	5.7	23
Suhudoo	White normal hybrid	Drought and striga tolerant	90	5.8	23
Ewul-boyu	White normal OPV	Drought tolerant	105-110	5.6	22
Wang-dataa	White OPV	Drought and striga tolerant	90	4.7	19

OPV means open-pollinated variety; QPM means quality protein maize. Source: Adopted from CRI- Climate-Smart Maize Production Manual 2019.

Table 3. List of some improved cowpea varieties and their characteristics

Variety	Maturity dates (days)	Yield potential (t/ha)
Asomdwe	65-72	2863
Videza	68-77	3043
Hewale	64-72	3130
Tona	71-80	2390
Nhyira	65-68	2460
Asetenapa	63-70	2500
IT 89KD374-57	65-72	1360

Source: CRI, (2013, p13)

Note: Depending on the climate information, the pest and disease history, and the cropping history of the area, the above maize and cowpea varieties may be selected.

Practical Activity 8.1. Selection of maize variety for an agro ecological area

- Identify your agroecology (your AEA can help you know your agro ecological zone
- Identify the rainfall pattern (the onset and length) in your area. This information can be obtained from AEA or the designated Ghana Meteorological Agency (GMET).
- Depending on the length of the rain season, choose your variety from one of the following maturity groups: Early maturity: 80 – 85 days, Intermediate maturity: 85 – 95 days, Late maturity: 110 – 120 days.
- Contact your AEA to help you identify where to get certified seeds of the selected variety.

Self-Assessment

- Trainees should discuss the benefits of using improved maize/cowpea varieties over landraces.

8.2: Promotion of Dual-Purpose Cowpea

Dual-purpose cowpea varieties are those with the potential to produce good grain yield and quality fodder for farmers. Dual-purpose cowpea varieties are available at registered seed companies.

Table 4. Some dual-purpose varieties available in Ghana include

CRI- Tona	CRI- Soronko	CRI- Asontem	Padituya
Kum-Zoya	Asare-Moya	Saka-Buro	Aduapa
UCC- Early	Aluba-Kpole	Yor-Kpitio	

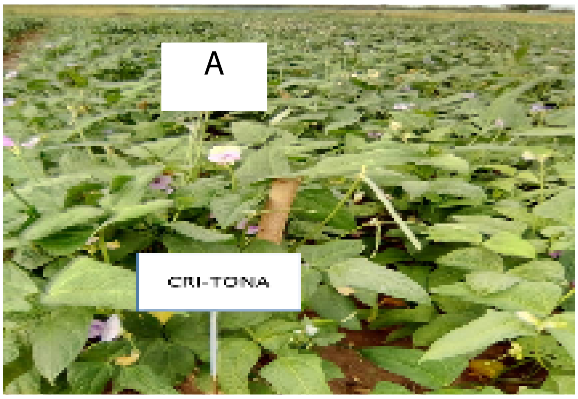


Figure.17. Ariel view of CRI-Tona at early pod set (A) and full maturity (B)

Practical Activity 8.2. Group discussion on good agronomic practices in cowpea production

- Participants should discuss good agronomic practices for cowpea production.
- Participants should discuss their experiences with dual-purpose cowpea varieties.

Self-Assessment

- What are some available dual-purpose cowpea varieties in Ghana?
- What are the benefits of dual-purpose cowpea?

Module 9: Soil Health management for Sustainable Crop Production

9.1. Use of locally available organic materials as soil amendments to improve soil health
Some common organic amendments include poultry manure, cattle manure, pig manure, green manure, sheep/goat manure, composts from crop and animal residue, and many others.

Practical Activity 9.1. How to apply organic amendments

1. Determine the area of your farm with the help of surveying personnel or by an experienced person.
2. Manure should be obtained from nearby poultry farms, cattle ranches, pig farms, or sheep/goat pens.
3. At the farm, get a basin, bucket, or wheel barrow (whichever is available) and weigh the required amount of the manure with a simple scale into them. Measuring one bucket, basin or wheel barrow full is enough to determine how many of them should be applied to make the recommended rate.
4. The recommended rate of manure application to maize /cowpea is 5 t/ha or 2 t/acre (an acre is about 4 plots (100 m x 100m) of land) or dependent on the manufacturer's recommendation if it is from a commercial source.
5. Distribute the manure at various locations on the farm and spread it evenly on the farm to about 5 cm depth with a rake or hoe.

Practical activity 9.2. Preparation of Compost

Plant and animal residues and household waste can be used to make compost for soil application. Locate an area on the farm that is not shaded, flooded, or prone to erosion for composting activity. Composting can be done in a compost pit, on the soil surface as a heap, or in a compost bin. The pit types are recommended for drier areas while the heap types are recommended for wetter regions.

To prepare compost:

1. Collect available plant and animal residues such as freshly cut grass, fresh leaves, cowpea residue, twigs, tree bark, kitchen scraps, animal manure, pumice from breweries, cocoa pod husks, and the like as nitrogen sources; and maize stalks, dried leaves, straws, rice husks, crop residues as carbon sources. Wood ash, water, and/or animal urine should be added to accelerate decomposition.
2. Dig a compost pit of 3m x 3m x 1m deep in the non-shaded, dry location. If possible, another pit should be dug beside it for easy turning of the compost.
3. Put coarse materials such as twigs, cocoa pod husks, rice husks at the bottom of the pit. Water it to be moist, not wet.
4. Add fresh or wilted grass, weeds, legume residues, kitchen scraps, palm kernel cake.
5. Add a mixture of animal manure, soil, and wood ash and moisten the layer with water and urine if available.
6. Repeat the process until the pile reaches desired height. Then place poles in the pile to allow for aeration. Cover the pile with straw to prevent the pile from drying out.
7. Cover the pile with broad leaves like banana or plantain leaves. Turn the compost every two weeks until 3 to 4 months when it is fully decomposed and ready for application. Compost is hot when still decomposing. Cured compost has a fresh earth smell and ambient temperature.

Figure 18. Compost-making process. Composting in North-East Ghana (Sabab-lou.de).

Practical Activity 9.3. Maize-cowpea/Mucuna pruriens intercropping

1. Plant cowpea/mucuna at 37.5 cm x 20 cm planting distance to put them in between the maize rows
2. Incorporate cowpea/mucuna pruriens residue in the soil with a rake/hoe
3. Alternatively, leave cowpea/mucuna pruriens residue as cover on the soil surface to decompose

Figure 19. Maize-cowpea intercrop

Self-assessment

- Participants should discuss the importance of building soil carbon and adding organic matter to the soil and their plants
- Participants should also discuss the benefits of maximizing land resources by growing two or more crops (in terms of income and balanced diets)

Module 10: Efficient Tillage Practices for Improved Farming System

10.1. Minimum tillage

No-till is usually established after one or few tillage operations, after which crop residues are left annually as cover to protect the soil surface and to add organic matter after decomposition. The residue intercepts rainfall, reduces soil detachment, improves infiltration, protects the soil from erosion, and increases soil organic matter. In drought-prone soils, the soil cover reduces excessive evaporation from the soil surface.

Practical Activity 10.1. A step by step approach to start minimum tillage

1. Slash and mulch (not burn) forested lands or lands fallowed for more than two years to maintain soil microbial biodiversity. Trees or plant residues should be used as mulch.
2. Plough cleared forest or fallowed land if it has no problem with compaction.
3. On compacted soil or soil heavily infested with perennial weeds like speargrass (Imperata cylindrical), the soil should have two plough passes and one harrowing.
4. Alternatively apply recommended dose (3-4 L/ha) of glyphosate-based weedicides before ploughing and a harrowing. Bullock ploughing may be used if there is no access to tractors.
5. Ploughing should be done across the slope to reduce erosion. Very tall grasses should be slashed and allowed for new regrowth before glyphosate application.
6. Practice reduced tillage practices on land that is continuously cropped.
7. In shallow soils, plant on ridges to conserve water.

Self-assessment

- Participants should be asked to share their thoughts on the benefits of minimum tillage.

10. 2. Contour Tillage Farming

Contour tillage farming is a water harvesting and conservation technology. It involves several techniques such as contour planting, contour stone bunding, semi-circular bunding, contour ridging. Contour tillage techniques are usually applied on sloping fields to reduce runoff water and aid in water retention and infiltration. This application makes contour tillage a climate smart agricultural technology.

10.3. Contour stone bunds

Contour stone bunds are embankments made of stones or quarry rocks, along the natural contours in an agricultural field to retain and conserve moisture in-situ. The stone bunds form a barrier that slows down runoff water, allowing rainwater to seep into the soil and spread more evenly over the land. Planting is done in the soil or area left between the stone bunds.

Farmers usually combine contour tillage farming with other seed bed and soil fertility management techniques such as zai pit, tied ridging, intercropping with leguminous cover crops etc.

Figure. 20: Contour stone bunds. Source: https://farmingfirst.org/2012/09/stone-bunds-as-soil-and-water-conservation-measures-in-sahelian-countries/

Practical Activity 10.2. Construction of contour stone bund

1. Identify the contours in your field.
2. A surveyor can help you to identify the contours.
3. Dig a trench of about 5 cm – 10 cm deep and 35 cm to 40 cm wide along the identified contours.
4. The land terrain and slope would determine the spacing between contours (can range from 5 m to 50 m).
5. Fill the trench with stone and build the bund to a height of about 30 cm.
6. Make sure to put the stone firmly together to increase the stability of the bund.
7. Plant your crop in the space between adjacent stone bunds.
8. Walk along the contours from time to time to rebuild displaced bunds.

10.4. Contour ridging

When contour bunds are made of soil or sometimes sandbags into ridges, they are referred to as contour ridges. In several instances, crops are planted directly on these ridges when several ridges are formed one after the other along the contour. Crops planted on these ridges have the advantage of assessing moisture retained or held in the ridges.

Figure 21. Contour ridges. (Traorea et al. 2004)

Practical Activity 10.3. Construction of contour ridges

1. Identify the contours in your field.
2. A surveyor can help you to identify the contours.
3. With a mechanical ridger or hoe, construct ridges of about 30 cm high along the identified contours.
4. Leave alleys of 1 – 2 cm between ridges.
5. Create a V-shaped narrow trend at the base of the ridge facing uphill. This is to help stabilize the ridge and prevent flood from washing the ridge away.
6. Tie ridges at every 3 to 5 m (optional)
7. Plant crops on the ridges.
8. Walk along the contours from time to time to rebuild displaced areas
9. Once a year, sediments or litter trapped in between the ridges or the stone bunds should be removed and discarded to maintain them.

11.0. Types of irrigation facilities

11.1 Drip Irrigation

Drip irrigation (also known as trickle irrigation), like other pressurized systems, convey water to the base of a crop through a series of pressurized pipes. In some cases, the water is pumped into an overhead tank and distributed by gravity through laterals to the drip emitters. Drip irrigation systems can save up to 80% water and give an option for efficient fertigation. Choosing a drip irrigation system is influence by the type of crop. Drip irrigation systems are also classified according to the type of emitter. There are different types of emitter such as point-source or drip bubbler emitters (Fig. 22) (drip bubbler), in-line drip emitters (Fig. 23), basin bubblers (Fig. 24), flag emitters (Figure 25). Flag emitters and point source emitters are ideal for greenhouses whilst the others are ideal for in-field cultivation. The in line and flag emitters are also ideal for subsurface installations.

Figure 22: Drip bubbler emitter Source: https://www.digcorp.com/homeowner-drip-irrigation-products/adjustable-bubbler-on-stake/

Figure 23: In line drip emitter Source: https://www.agrivi.com/blog/drip-irrigation-as-the-most-efficient-irrigation-system-type/

Figure 24: Flag emitter. Source: https://www.youtube.com/watch?v=jv_Je7W8_Pc

11.1.2: Operation and maintenance of the drip irrigation

- Drip irrigation systems are susceptible to clogging. Clean and flush your drip irrigation filters on a daily basis.
- Check drip irrigation lines for excessive leaking, and look for large wet areas in the planting area indicating a leaking tube or defective emitter.
- Repair or replace leaking pipes and fittings.
- Frequently clean dirt, sand or organic debris out of mainlines and laterals by flushing out water to the fields.
- This should be done after harvest or when there is no crop on the field.
- During flushing out, end caps on a lateral or drip tape must be removed with valves on laterals left opened.
- Occasionally move round the field to tighten all bolts and nuts.
- When moving the laterals or drip tapes, make sure that they are not damaged or pushed into the soil.
- Replace all worn fittings such as washers in the sprinkler system after every six months.
- Check all equipment at the end of the season and make any repairs and adjustments before the start of a new planting season.

11.2: Sprinkler Irrigation

Sprinkler irrigation involves the conveyance and distribution of water using pressurized pipe networks. The pressurized system produces aerosols, fog or mist, usually above the crop foliage. Undulating areas and areas located at higher elevation than the source water can be irrigated using sprinkler irrigation systems. The irrigation water should however meet the quality requirement to avoid the introduction of disease-causing pathogens to the crop.

The choice of a particular sprinkler system is influenced by the size of the crop field, topography, cost of sprinkler system, water source, tillage equipment, climate, and soil type.

11.2.1 Operation and maintenance of the sprinkler irrigation system

- Frequently clean dirt, sand or organic debris out of mainlines and laterals by flushing out water to the fields.
- This should be done after harvest or when there is no crop on the field.
- During flushing out, all sprinkler sets must be removed with valves on laterals left opened.
- Filters should be checked and cleaned frequently.
- Occasionally move round the field to tighten all bolts and nuts.
- When moving the laterals or sprinkler heads, make sure that they are not damaged or pushed into the soil.
- Replaced all worn fittings such as washers in the sprinkler system after every six months. Check all equipment at the end of the season and make any repairs and adjustments before the start of a new planting season.

Further Reading

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