STRENGTHENING PRODUCERS' CLIMATE RESILIENCE CAPACITIES IN THE GAMBIA

Best Adaptation Practices

RICE AND VEGETABLE PRODUCTION UNDER A CHANGING CLIMATE

CURRICULUM AND TRAINING MATERIAL

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Foreword

Climate change remains an impediment to reaching global goals of poverty eradication and food security and sustainable development. It continues to be one of the exacerbating challenges of the Gambia's Agriculture Sector, affecting both crop and livestock value chains. Production and productivity levels have significantly decreased due to changes in temperature and increased pressure on water availability and quality, changes in pest and diseases as well as soil conditions.

Recognizing the fact that the agriculture sector of one of the key contributors of global GHG emissions, there is an urgent need to reduce the sector's contribution and to adapt agriculture systems to cope with the pressures of climate change. One of the main objectives the Nema-Chosso Project is to support the process of climate change adaptation by increasing producers' capacities in the use of climate resilient technologies for rice and vegetable production. To this effect, a strategic partnership has been forged the with the West Africa Rural Foundation (WARF) to work in collaboration with the Department of Agriculture in the development of a training curriculum as well as training materials to support the promotion of relevant climate resilience technologies and production practices. Within the same process, Nema-Chosso will also support and facilitate the setting up of Regional Training Teams that will provide resilience capacity strengthening support to rice and vegetable farmers in the country.

The curriculum and associated training materials and tools will increase farmers' capacities and facilitate their adoption of climate resilient technologies in rice and vegetable production. The anticipated results are increased rice and vegetable productivity and increased farmer incomes, which will contribute directly to improved livelihoods for rural populations and reduced poverty levels. The successful completion of this task by the West Africa Rural Foundation is a major project achievement that will further strengthen our strategic partnership in the achievement of the Project Development Goal.

Aji Oulaye Njie
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Acknowledgement.

The development of the producer curriculum is an initiative of the Nema-Chosso project and a collaborative effort of the Nema-Chosso Project Support Unit, West Africa Rural Foundation (WARF) and the Department of Agriculture (DoA). The aim of the initiative is to enhance the resilience capacities of rice and vegetable producers through locally appropriate on-farm adaptation practices.

Nema-Chosso appreciates the strategic partnership with the West Africa Rural Foundation, through which technical support was provided to develop the curriculum and training materials/tools and organize a training of trainers' workshop for selected Nema Focal Points and Subject Matter Specialists from the DoA.

We acknowledge the collaboration and contribution of the National Agricultural Research Institute (NARI), National Seeds Secretariat, Department of Water Resources and the DoA Special Services Units (Horticulture, Soil and Water Management and Plant Protection).. Mrs. Amie Fabureh and Mr. Essa Drammeh made significant contributions to the development of the curriculum and the successful implementation of the training of trainers' workshop.

Nema-Chosso also recognizes the active participation of all other stakeholders and actors and sincerely acknowledges their participation.

The Curriculum

USER GUIDE

The Curriculum and training materials to enhance climate resilience capacities of producers provide climate change adaptation techniques to trainers and learners with a wealth of practice-based adaptation knowledge. It is a key resource for field-level agricultural extension personnel who will be engaged in strengthening producers' climate resilience capacities across the country. The curriculum and training materials have a strategic focus on rice and vegetables, two agricultural value chains that are critical for rural and agricultural development in Gambia in the face of climate change challenges

The Curriculum is divided into four modules with associated training materials. The first module seeks to develop a shared understanding of key climate change and resilience ideas and terminologies. This is followed by two separate modules with themes that focus on climate resilience technologies and best practices for rice and vegetables respectively. The last module specifically presents training strategies and methods that can be used to help producers understand and adapt the climate resilient technologies.

The Nema-Chosso project encourages all trainers and learners to use the curriculum as a resource for strengthening the resilience capacities of rice and vegetable farmers, ensuring that appropriate focus and time are given to the relevant modules.
Nema-Chosso attaches great value to the use of this Curriculum for Natural Resources Managers, Climate Change Adaptation Experts, Extension staff of the Department of Agriculture and Rural Development Practitioners in general. It is hoped that the Curriculum as it gets implemented on a wide scale will put forth innovative tools and processes that will fit our climate change contexts for both rice and vegetable production.

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MODULE I

CLIMATE CHANGE CONCEPTS, TERMINOLOGIES AND ISSUES

PURPOSE

Understanding climate change and its effects on agriculture in The Gambia will help trainees better understand the need for climate resilient technologies.

TARGETED OUTCOMES

Increased knowledge and understanding of key climate change concepts and issues will position trainees to support farmers' to better understand climate change issues and challenges, the impact of climate change on agriculture and livelihoods as well as the importance of adopting relevant technologies for adaptation and resilience.

TRAINING CONTENTS

Climate and climate change concepts and terminologies; impact and consequences of climate change; challenges and benefits of adaptation to climate change.

TRAINING METHODS AND TOOLS

Climate change games, brainstorming and participatory group discussion sessions on the meaning and understanding of key climate terminologies, concepts and issues as they relate to agriculture and natural resources in The Gambia

TRAINING MATERIAL FOR MODULE I

TRAINING MATERIALS AND TOOLS FOR UNDERSTANDING CLIMATE CHANGE AND ITS EFFECTS ON AGRICULTURE IN THE GAMBIA

1. CONCEPTS AND TERMINOLOGIES

WEATHER

Weather refers to elements such as air temperature, rain, clouds, winds, pressure etc. that happens on a daily basis in the atmosphere.

CLIMATE

Climate is the "average" weather condition over a long period of time, say 30 - 35 years or more.

CLIMATE SYSTEMS

An interactive system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, forced or influenced by various external forcing mechanisms, the most important of which is the Sun.

SEASONAL VARIABILITY

It is a short-term change in climate caused by changes in the Oceans and Atmosphere. The impact of El Niño or La Niño is an example of climate variability. Climate variability is not the same as climate change. Climate change also triggers climate variability.

WHAT IS CLIMATE CHANGE?

Is a change of Climate which is attributed directly or indirectly to human activities and natural causes that alters the composition of the global atmosphere over a considerable period of time, say 50 – 100 years.

EMISSION

Emission is defined as the discharge of some substance such as a gas. It is the release of greenhouse gases into the atmosphere.

GLOBAL WARMING

Global warming is the observed increases in the average temperature of Earth's atmosphere and oceans. It is also referred to as climate change that causes corresponding changes in climate.

GREENHOUSE GASES

Greenhouse gases mean those gaseous constituents of the atmosphere caused by both natural and anthropogenic that absorbs and re-emits infrared radiation. Examples of greenhouse gases include CO2, H2O, CH4, NO2, CO, CFCs etc.

ADAPTATION
Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities. Adaptation is the ability to change to meet changing conditions caused by the climate.

MITIGATION
An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions; and enhancing greenhouse gas sinks.

CLIMATE CHANGE RESILIENCE BUILDING
It is the process of building capacity of the communities in order to cope with the effects of climate change and maintain sustainable socio-economic development. Both Adaptation and Mitigation actions are process of resilience building.

MAINSTREAMING CLIMATE CHANGE
To factor the impacts of Climate Change into development policies, programmes and initiatives. It is the informed inclusion of relevant environmental concerns into the decisions of institutions that drive national, local and sectoral development policy, rules, plans, investment and actions.

CLIMATE SMART AGRICULTURE (CSA)
Climate-smart agriculture (CSA) may be defined as an approach for transforming and reorienting agricultural development under the new realities of climate change.
FAO defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals".

2. SOME EFFECTS OF CLIMATE CHANGE

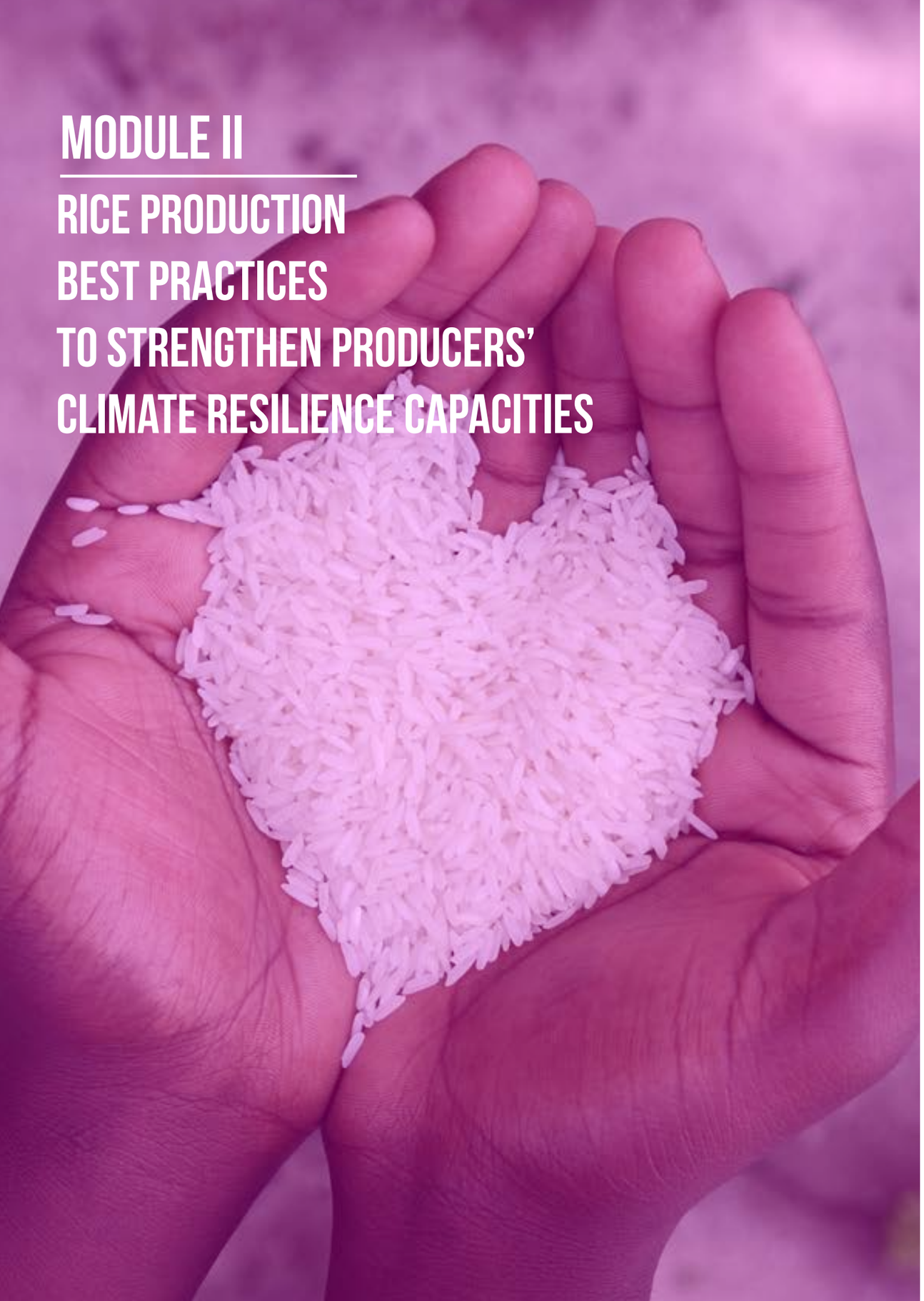
- Rainfall variability such as onset delay, excess downpour, drought or early cessation affects crop yields
- Flooding – submerging of crop fields, erosions and destruction of infrastructures
- Drought – loss of livestock and reduction of crop yields
- Mangroves - marine resources (aquaculture, oyster fishing) are reduced

3. BENEFITS TO ADAPTATION

- Use of Weather and Climate information enhances agricultural production in The Gambia, e.g. CCEWS Project pilot sites in URR
- Protection of lives and properties, especially in rural communities
- Application of new agricultural technology and mechanization geared towards enhancing crop production
- Improving the overall economy of the country

4. CHALLENGES TO ADAPTATION

- Lack of understanding of Weather and Climate information
- Challenges in dissemination of Weather and Climate information to communities
- Community perceptions of weather and climate information
- Slow changes in approaches to new technology
- Limited resources for capacity building, sensitization and awareness promotion



MODULE II

RICE PRODUCTION BEST PRACTICES TO STRENGTHEN PRODUCERS' CLIMATE RESILIENCE CAPACITIES

2.1 INTEGRATED WATERSHED MANAGEMENT TO COMBAT EROSION AND LAND DEGRADATION IN RICE CULTIVATION

PURPOSE

The purpose of the training on integrated watershed management is to strengthen capacities and skills in managing and controlling soil erosion and land degradation in upland and lowland rice fields resulting from major weather and climate related events such as floods, runoff, high winds, etc.

TARGETED OUTCOMES

Improved knowledge and appreciation will enhance the adoption of selected best practices and technologies for effective control and management of soil erosion and land degradation in upland and lowland rice fields. The consequential restoration of soil fertility and improved soil structure will contribute to increased crop yields and incomes of rice farmers.

TRAINING CONTENTS

Understanding the effects of soil erosion and land degradation on rice productivity, the use of terracing to control runoff and erosion, use of contour bunds to manage erosion and high runoff; gully plugs as an effective tool for addressing land degradation due to excessive water runoff and erosion in rice fields.

TRAINING METHODS AND TOOLS

Group discussions on the effects of erosion and land degradation on rice productivity; observational visits to appreciate the consequences of soil erosion and land degradation in rice fields; facilitated peer exchanges on coping strategies; group discussions (with illustrations) and practical demonstrations of best practices in the control and management of soil erosion and land degradation in rice fields.

2.2 ADDRESSING THE CHALLENGES OF ERRATIC AND INSUFFICIENT RAINFALL IN RICE PRODUCTION

PURPOSE

The Trainees should have the capacity to address water management issues and be able to effectively manage and reduce the adverse effects of erratic and insufficient rain fall in rice production.

TARGETED OUTCOMES

Increasing the capacity of producers in addressing the issues of erratic and insufficient rain fall in rice production will help them increase and maintain yields and incomes as well.

TRAINING CONTENTS

Importance of improving water use efficiency in rice production; water harvesting techniques, identifying and selecting early maturing rice varieties, use of drought tolerant rice varieties such as the NERICAs.

TRAINING METHODS AND TOOLS

Theoretical as well as practical considerations will be the main training methods. Tools will include flyers and guides to illustrate the idea of water use efficiency and best practices in water harvesting; illustrative flyers of early maturing and drought tolerant varieties in the field; on-farm demonstrations of early maturing and drought tolerant varieties in farmers' fields.

RECOMMENDED FIELD DEMONSTRATIONS

The Land and Water Management Unit/Expert of the project and personnel of the Soil and Water Management Services of DoA will provide technical backstopping for demonstrations of best practices in water harvesting.

2.3 MANAGING SALT INTRUSION AND SALINITY IN RICE PRODUCTION

PURPOSE

Salt intrusion, increased salinity and consequently yield reductions are often associated with decreasing rainfall. Under these circumstances, core extension field staff should be able to strengthen farmers' capacities to address these challenges that are clearly linked to climate change.

TARGETED OUTCOMES

Increasing the capacity of producers in managing salt intrusion and salinity in rice production will help them increase and maintain yields and incomes as well.

TRAINING CONTENTS

Trainees will be taught on the selection of salt tolerant rice varieties and the construction and management of anti-salt dikes and spillways.

TRAINING METHODS AND TOOLS

Theoretical as well as practical considerations will be the main training methods. Samples of relevant and available salt tolerant varieties of rice will be provided.

RECOMMENDED FIELD DEMONSTRATIONS

The Regional Training Teams will work closely with the Land and Water Management Unit of the Project for field demonstrations on drainage techniques, construction of anti-salt dikes and spillways.

2.4 MANAGING RICE PEST TYPES AND POPULATIONS IN THE FACE OF CLIMATE CHANGE

PURPOSE

Over the years producers have realized that there has been an increase in not only types of weeds, insects and rice diseases but marked increase in populations as well. This evolution is partly linked to climate change, which warrants producers to know these rice pests and how to manage them to realize reasonable increase in rice production under current climate trends.

TARGETED OUTCOMES

The training theme will help trainees increase their knowledge in vegetable pests and help in managing these pests. Producers' knowledge of how to manage the increase in rice pests to avoid severe loss in rice production will increase their production and incomes which will improve their economic and social wellbeing.

TRAINING CONTENTS

Trainees will be taught how to identify key rice pests and their increase or decrease in an area and how to manage these pests to avoid severe crop losses.

TRAINING METHODS AND TOOLS

Theoretical as well as practical considerations will be the main training methods. Samples of rice vegetable pests and how to manage them will be provided as part of the pest identification purposes. Field demonstrations of effective pest and disease management technologies will be undertaken in farmers' fields

RECOMMENDED FIELD DEMONSTRATIONS

The Regional Training Teams will work closely with the Plant Protection Services of the Department of Agriculture to carry out field observations and management of vegetable pests populations in farmers' fields.

TRAINING MATERIAL FOR MODULE II

RICE PRODUCTION BEST PRACTICES TO STRENGTHEN PRODUCERS' CLIMATE RESILIENCE CAPACITIES

1. INTEGRATED WATERSHED MANAGEMENT: AN EFFECTIVE OPTION FOR CONTROL AND MANAGEMENT OF SOIL EROSION AND LAND DEGRADATION

UNDERSTANDING SOIL EROSION

- Soil erosion is a natural process in which particles of soil are moved by wind and water, and displaced to another location
- When erosion occurs naturally, soil is relocated at about the same rate it is created, so no harm is done to the environment
- However, through development and agricultural processes, the rate of erosion tends to speed up and create harmful effects both to the natural land as well as to the people living there

SELECTED SOIL EROSION CONTROL AND MANAGEMENT PRACTICES CONTROL OF WIND EROSION

- Measures to reduce erosion by wind include optimizing vegetation cover,
- using rotational grazing to sustain rangeland vegetation quality, and
- planting windbreaks perpendicular to the prevailing winds

- The most natural and effective way to prevent erosion control is by planting vegetation
- Roots from plants, especially trees, grip soil and will effectively prevent the excess movement of soil throughout the ground

BEST PRACTICES FOR MANAGING AND CONTROLLING RUNOFF AND RESULTING SOIL EROSION

- Adoption of minimum to no tillage techniques combined with
- Optimizing soil cover (cover crops, residues, mulch).
- On steeper slopes, soil erosion can also be reduced by planting cross-slope vegetation;
- Using soil and water conservation structures, such as terraces, earth bunds and tied ridges

- Optimize water capture and infiltration; and creating grassed waterways to convey excess water safely off the slopes.
- Gully plugs can be effective for stopping rapid gully development and allowing gullies to heal over time,

Stabilizing the soil on the slope is the primary answer to soil erosion. Some ways to control soil erosion on the slope may include:

- **Baffles** or **barriers** are obstruction devices that slow down or divert water from flowing directly downhill. They consist of partially buried stone or timbers (laid parallel to the slope). These barriers work best for lesser slopes.

- **Riprap** is rough; loose stone (at least 6»-8» wide each). Usually granite, the stone is imbedded into or spread loosely onto the slope. Riprap slows and diverts flowing water. It is effective but can appear stark or harsh in some landscape designs. To soften the impact, you can plant the areas between the stones with a variety of ground covers or rock garden plants

- **Plants** can help control slopes. You can plant any of the slope control methods above or you can use plants alone. When plants are established, the roots help anchor the soil. However, getting them established on a slope can be difficult. Seeds and mulch wash away and planting holes erode before the plant gets established. Wildflowers, clump-forming ornamental grasses or other perennial native plants usually adapt quickly to slopes and unimproved soil

- **Turf grass** can control erosion on minor slopes if the grass is healthy. A grass such as annual rye can germinate quickly and help stabilize soil while perennial grasses get established. Compacted soil is a major contributor to runoff. Aerate if possible, and add organic matter such as compost to promote a healthy stand of grass

- **Mulching**: Applying a layer of mulch to the soil top allows the soil to slowly soak up water, as it protects against rain impact, and restores pH levels helping with erosion prevention

CONTOUR PLOUGHING

- **Contour ploughing** or contour farming or Contour bunding is the farming practice of ploughing and/or planting across a slope following its elevation contour lines
- These **contour** lines create a water break which reduces the formation of rills and gullies during times of heavy water run-off; which is a major cause of soil erosion
- **Contour ploughing** is a soil conservation technology that is practiced to mitigate the negative consequences of natural disasters on soil quality and composition.
- It is performed by following the natural contours when tilling the soil, planting and cultivating
- Good crop establishment leads to optimum yields
- Cultivation across slopes promotes stable crop establishment and reduces the risk of soil erosion and runoff
- Plough with the contour to:
    - increase crop productivity.
    - improve soil structure.
    - reduce the loss of soil, seeds and inputs.
    - reduce watercourse pollution
    - Use contour ploughing where slope, soil and crop conditions are appropriate

- Avoid working wet soils to reduce the risk of capping, compaction, erosion and runoff

TERRACING

- Terracing is the practice cutting flat areas of hilly or mountainous landscapes in order to grow crops
- Mostly practiced in Asia and Andes in South America
- The best use of terracing is in rice farming
- Used to control / prevent erosion and soil runoff
- Hillsides can remain productive for as long as the soil is properly cared for and terraces are maintained

2. ADDRESSING THE CHALLENGES OF ERRATIC AND INSUFFICIENT RAINFALL IN RICE PRODUCTION

CONCEPT OF RAINWATER HARVESTING

Capturing, concentrating and conserving water from rainfall in the field of special structures for use in the field during periods of variability and periodic dry spells. It means capturing rainwater where it falls or capturing the runoff, and then conserving it for use when needed in the field. Rainwater harvesting systems provide distributed storm water runoff containment while simultaneously storing water which can be used for irrigation. The rainwater collected can be stored for direct use in the field or can be recharged into the groundwater when water supply becomes limited, practical solutions can fill the gap.
Therefore, water harvesting can be undertaken through a variety of ways:

- Capturing runoff from rooftops
- Capturing runoff from local catchments
- Capturing seasonal floodwaters from local streams
- Conserving water through watershed management

These techniques can serve the following the following purposes:

- Provide drinking water
- Provide irrigation water
- Increase groundwater recharge
- Reduce storm water discharges, urban floods and overloading of sewage treatment plants
- Reduce seawater ingress in coastal areas

USE OF SHORT DURATION, EARLY MATURING AND DROUGHT TOLERANT RICE VARIETIES

Over the years, the rainfall period and window has shortened significantly.
An effective response to this would include the use of early maturing, short duration rice varieties. Examples of varieties that could be used, based on their adaptation to specific agro-ecologies, include:

Upland Varieties
- WAB105,
- IR19746

Rainfed Lowland Varieties
- SAHEL 134,
- IR19746,
- IR 64

Drought Tolerant NERICA Varieties
- Nerica 14,
- Nerica 1,
- Nerica 6,
- WAB 105

Improved crop management to increase water use efficiency

- A combination of erosion control actions and better drainage capacities will be needed.
- Land Preparation
- Ridging along the contour (control erosion)

- Minimal loss of soil nutrients from the soil through leaching (avoid over irrigation, use OM, mini tillage etc)

- Zero or minimal rates of rainfall run-off and soil erosion (ridge across, avoid deep tillage, mulching, build bunds etc)

- Ridging along the contour (control erosion)

- Minimal loss of soil nutrients from the soil through leaching
  (avoid over irrigation, use OM, mini tillage etc)

- Zero or minimal rates of rainfall run-off and soil erosion
  (ridge across, avoid deep tillage, mulching, build bunds etc)

Correct Time of Planting

- Appropriate time of planting will help the rice crop to escape terminal drought

Integrated Fertiliity Management

- Apply compost and animal wastes
  (retain water and nutrients and fix soil particles)

- Avoidance of over-irrigation, use of organic manure, practice of minimum tillage

- Broadcasting of urea fertilizer
  (volatilization to increase nitrous oxide- Green House Gas)

- Minimal application of inorganic fertilizer (Urea Deep Placement (UDP)
  technique - urea is made into “briquettes” of 1 to 3 grams that are
  placed at 7 to 10 cm soil depth after the paddy is transplanted.

3. MANAGING SALT INTRUSION AND SALINITY IN RICE PRODUCTION

Understanding salinity and its causes

- Limited recharge areas and disconnect with the mainland, these coastal aquifers are highly susceptible to the impacts of climate change through changing precipitation, evapotranspiration, and sea level rise.

- Sea level rise, just like overexploitation of coastal aquifers, increases the chance of saltwater intrusion in groundwater bodies, particularly in low-lying areas

- In general, reduced precipitations and increased water needs put groundwater resources at risk.

- A way of mitigating this threat is by systematically maintaining higher inflow of fresh water

MANAGING SALINITY AND SALT INTRUSION IN RICE FIELDS

Use of salt tolerant varieties such as

- ROK 5
- CK 73
- WAR 1
- WAR 77

CONSTRUCTION OF ANTI-SALINITY DYKES

- An anti-salt dam is a water retention structure to prevent the invasion of land by sea water and to protect and recover saline soils upstream of the structure
- It includes a dike and evacuator regulated by a sluice gate or spillway
- At the beginning of the wet season, the gate remains closed to allow runoff to accumulate in the basin. Part of the retained water infiltrates and contributes to groundwater recharging
- Salt accumulated in the soil dissolves in standing water. The valve is then opened to allow drainage of salt water
- The capillary rise from the groundwater through layers of saline soil and its evaporation lead to accumulation of salt on soil surface
- The gate is then closed to permit submersion again.
- Processes of submersion and drainage will continue until the threshold level of salinity is obtained
- At this time, land preparation is undertaken, followed by sowing or transplanting
- At the end of wet season, the gate is closed to help keep water in the lowland
- This allows rice to reach maturity and also prevents capillarity rise of salt water

4. MANAGEMENT OF RICE PEST TYPES AND POPULATIONS IN THE FACE OF CLIMATE CHANGE

RICE WEEDS

Climate change is expected to increase the range, or «damage niche» (also called «invasion niche») of many weed species. Research suggests that the composition of invasive weed will be changed under increasing temperatures, with new weed species appearing.

The effects of climate change on weed/plant interactions are likely to vary by region and crop type. The interactions between crops and weeds are «balanced» by various environmental factors. Local changes in these factors may tip the scale towards either crop or weed. The erratic rains help weed establishment before sowing of crops in The Gambia. Weed species such as Cyperus are observed to colonize new areas. If the invasion of new weed species can be detected, efforts can be made in advance to prevent and control their establishment.
Rice crop is associated with diverse weeds (especially wild rice) and this may result into severe losses and / or contamination. Weeds are plants growing where they are not wanted.

- The weeds compete with the crop for water, nutrients, space and light resulting to yield reduction
- Weeds act as alternative host for insect pest, disease pathogens (bacteria, fungi) and nematodes
- The presence of weeds under certain circumstances may have a beneficial effect in controlling soil erosion

- Weed seeds contaminate harvested produce
- In crops a complex of early season weeds do occur causing considerable yield reductions if they are not remove on time

Grasses (Poaceae)

The most common grass weeds in rice are Crow foot grass (Dactyloctenium aegyptium) and Crabgrass (Digitari horizontalis). The grass weeds are characterized by the presence of:

- 1 cotyledon at germination
- The leaf has parallel venation that is veins are arranged as straight lines
- Fibrous root systems

Crow foot grass

Crabgrass

The broad leaf weeds

The broad leaf weeds such as Sickle pod, black pigweed and the sedges are common in rice especially the upland; these weeds are characterized by the presence of:

- Dicotyledonous that is 2 cotyledons at germination
- Net venation in leaves
- Tape root systems

Sicklepod (Cassia obtusfolia

Black pigweed (Trianthema portulastrum)

The sedges such as Cyperus rotundus are also very common in rice both upland and lowland. The sedges are characterized by:

- Monocotyledon
- Parallel venation
- Tubers and Rhizomes as the root system

Cyperus rotundus

MANAGEMENT OF MAJOR WEEDS OF RICE

- The early season weeds are in the first instance taken care of by efficient land preparation at sowing in some cases
- From the economic standpoint hand weeding of fields although very efficient is laborious and time consuming
- The presence of weed-seeds (wild rice) in rice grains are contaminants reducing the quality and to remove them is difficult
- Depending on the types of weeds and the level of infestation several management options are available as listed below

(i) Physical control methods

- Hand hoeing by the use of the hoe
- Machine tillage, the use of draft animals such as the shine hoe to till the land before sowing
- Machine tillage is use in both seed bed preparation and inter-row cultivation
- Hand pulling, using the hand and hoe should follow the above for efficient weed control

(ii) Chemical control

- The following herbicides can be used in the control of weeds in rice,
- Propanil, stomp, Saturnil in rice

- Follow label information and safety measures by reading the labels and/ or contacting Plant Protection Services.

INSECTS

Climate change poses a threat to the control of pests because new pests may become able to invade previously uninhabitable areas. Climate factors that aid in pest and disease invasions are mostly temperature related and changes in rainfall patterns, and water shortages. Increasing temperatures contribute to a migration or expansion of many organisms. Positive physiological responses to increasing temperatures will allow for faster insect growth and movement. The increase in growth and numbers will likely result in an increase in insect invasions.

MAJOR INSECT PESTS OF RICE

Rice crop is damaged by various insects and this may result into severe losses. At various stages of crop development farmers enter these pests but normally late since they do not monitor their fields. The major insect pests include the following:-

Seedling Pests (termites, cutworms)

The seedling pests feed on the grains or roots of the seedlings. The farmers should use healthy seeds and treat them using seedox before sowing

Stalk-eyed-fly (Diospsis thoracica)

Stalk-eyed fly's maggot is 18mm by 3mm wide, white color, with terminal yellow markings and very small heads. The pupae are red with brown dorsal bands fat and triangular in section because of their compression inside the rice stem. The adults are characterized by having two long horns on the head which carry the eyes.

Adult rice stalked-eyed-fly

This pest attacks rice and maggot feds on the central shoot of the young rice plant, causing a typical 'dead-heart'. Later generations of larvae feed on flower head. The larvae could be killed with the aid of systemic insecticides.

2.3 RICE GALL MIDGE

Rice Gall Midge is small mosquito like insect. Female lays eggs singly 3 to 4 on the leaf blade. Larvae feed on terminal bud causing galls and are a serious pest in irrigated rice.

Adult midge, damage and a colony

The management options include:

- Physical destruction of the galls
- Removal and burning of weeds
- Use of tolerant varieties

2.4 LEAF MINER

The leaf miner is important pest of rice and adult resembles the house fly. The female lays eggs on leaves in white cocoon and pupation takes place in the leaf. The leaf miner larva feeds on leaf veins and it is easily identified by the necrotic damage on the leaves.

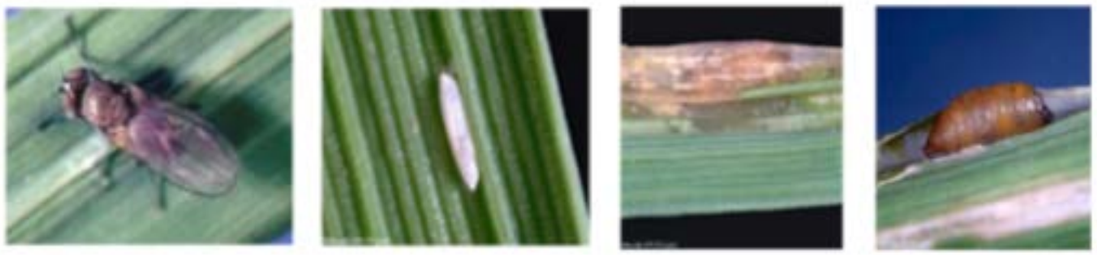


Figure 3: Adult miner, larva, damage and pupa

The management options include:

- Use of seed dressing chemical (seedox) to reduce the attack at seedling stage

DISEASES

Crop diseases can be fungal, bacterial, or viral in origin. Crop diseases are often spread through an insect vector. Fungal diseases are also common, and can spread via spores carried by wind. Dispersal plays a key role in the spread of crop diseases. Climate change can also aid in the dispersal of plant and crop disease. A local increase in rainfall due to climate change has been found to be responsible for the increase and spread of needle blight and other scenario include:

- Enhanced pathenogenicity (virulence)
- Symptom expression triggered(stunting, wilting, chlorosis)
- Improved crop substrate (available food)
- Infection conditions enhanced(moisture, humidity)
- Enhanced inoculums (more)
- Pathogen synergy (between pathogens)

MAJOR RICE DISEASES

Rice Blast (Pyricularia oryzae)

The incidence of Blast which is caused by P. oryzae has the most devastating in rice on susceptible varieties. All the above ground part of the rice plant can be affected by blast.

- In leaf blast: typical leave spots are grayish green or straw colored in the centre with a brown margin
- The size and the shape of the spots vary on different varieties and under different conditions
- On resistant varieties the spots are smaller and on susceptible varieties the spots often run together and the whole leaf withers
- In stems and neck blast: blast may attack the stem at the nodes or the neck region
- Infected neck turns blackish and breaks easily so the panicle falls over
- When neck rot occur, few or no seeds in the panicle is filled

Blast

Development and spread of rice blast

- Blast can attack at any stage of crop growth and grasses; volunteers, crop residues and seed borne inoculums are major source of the disease
- Spores are spread by wind and germinate in water on the leaf or stem
- Blast spreads rapidly in warm rainy weather and high humidity
- Upland rice and rice growing in the dry sandy soil is more severely affected
- The application of large quantities of nitrogen fertilizers increase susceptibility of the rice blast
- Many different races of the rice blast pathogen exist and varietal resistant is specific to each of the race

MANAGEMENT OF BLAST

- Use blast resistant varieties and avoid the use of excessive nitrogen fertilizers on crops
- Treat your seeds with seed dressing chemicals to reduce blast attack on the seedlings e.g. Seedox available at G.H.E
- Spray the crop with fungicides when severe cases are observed in the field e.g. blasticidin and ridomil

Brown spot on leaf and grain

- Rice stubble, volunteers, grasses, and rice seed are all sources of pathogen inoculum;
- The pathogen can survive for several years on the rice seed and debris
- Seedling grown from infected seeds become blighted
- Spores spread in the air and infection occur rapidly during the wet weather
- New spores are produced on the infected tissue in few days so epidemics progress rapidly
- Serious infestations are associated with potash deficiency, soil salinity and heavy shading, also deficiency of manganese, iron or magnesium also increases susceptibility
- Rice in the upland suffers more than the one in the lowland

MANAGEMENT OF BROWN SPOT DISEASE

- Use of recommended rates of fertilizer and application of manure, compost and ash
- Correct soil salinity problem and nutrient deficiencies
- Apply fertilizer in 2 or 3 split application during the season to prevent nutritional decline at the end of the growing period
- Cultivate soil well e.g. deep ploughing to avoid soil compact
- Use of resistant varieties and use of clean healthy seed from healthy plant
- Treat the seeds prior to planting with seedox

GENERAL RICE DISEASE MANAGEMENT

- Plant diseases are cause by three major pathogens fungi, bacteria and viruses
- About 8,000 plant pathogens have been recorded many of which attack several crops incurring serious damages
- It is necessary to identify which diseases are serious in a crop
- Understand where the disease comes from and how it spreads so that strategies to reduce it can be adopted on time

DISEASE DEVELOPMENT AND SPREAD

- Each pathogen develops and spread in a particular manner
- Plant diseases go through series of stages during their life cycle as follows

•(i) Primary source of the diseases

- The primary source of the plant pathogen inoculum is from diseased plants
- Diseased plant is either crop or weed, diseased seed or diseased crop residue
- The inoculum source may be infected soil

•(ii) Dispersal

- The pathogen may be in direct contact with plant e.g. a pathogen in the seed coat
- Soil pathogen which infects the roots
- Many pathogens must be spread from the primary sources by wind, water or by a vector (insects)
- Mechanically through pathogen with hand or tool and then touch the plant or plant part the pathogen can infect

•(iii) Infection and Symptom Development

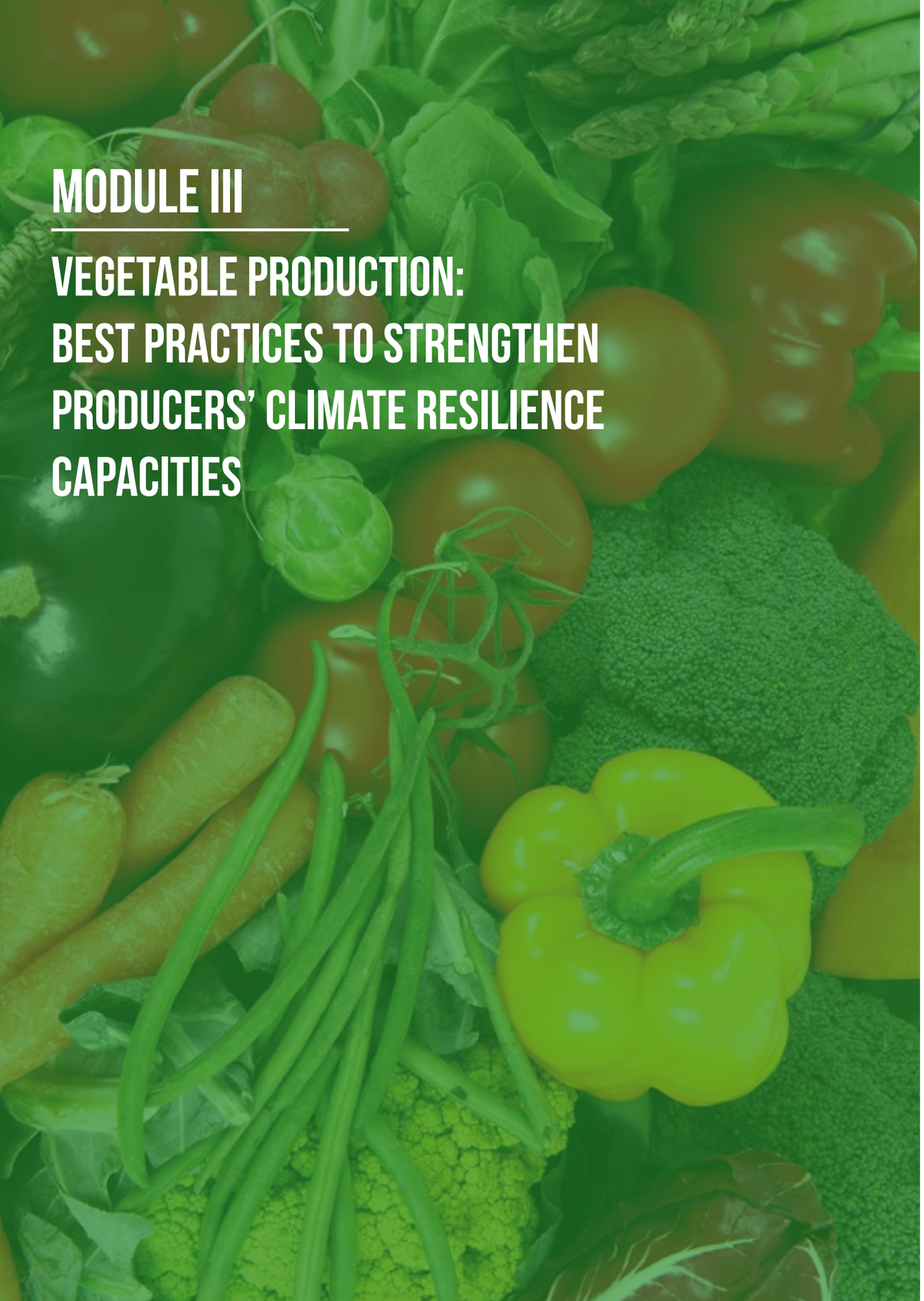
- If the pathogen comes in contact with the plant which is susceptible the pathogen will penetrate and grow in the plant in case of the fungus
- It will enter and multiply in the plant in the case of bacteria and virus
- When the pathogen succeeds establishing itself then signs and symptoms start to manifest
- A plant disease develops when the following 3 factors are present

- Organism that causes disease a virulent pathogen
- A plant which is susceptible to that disease a susceptible host
- Temperature, relative humidity, moisture which are suitable for disease development that is a favourable environment
- Disease management aims to reduce losses due to disease by altering these 3 factors so that disease will not develop
- Removing diseased plants
- Avoiding the source of the pathogen by growing plants which are resistant to the disease and

CROP MANAGEMENT IN RICE DISEASE CONTROL

To prevent or minimize the development and spread of crop diseases, thus increase yield and quality the practices below are used:-

- Healthy crops are less affected by diseases than the crops growing under stressed conditions
- Follow the recommendation on fertilizer, manure, time of planting, spacing, seed rate , crop type and variety and suitability of the soil
- Weeds compete with plants for nutrients, water, space and light
- Weeds harbor pathogens, insect pest, hinder crop harvest and contaminate the agricultural products like cereal grains
- Therefore the removal of weeds during the crop life before harvest is important
- Destroy crop residues immediately after harvest burning or by deep burial
- Rotate your crop to avoid the carryover of pathogens from one season to the next
- Don’t grow the same crop in the same plot for more than once in 4 years by alternating crops e.g. legumes, cereals, tuber crop, cereals and then fallow your land
- Timely removal of infected plants or affected plant parts before the pathogens spread to other plants or contaminates seed
- Some diseases are seed born, therefore select and plant healthy seeds in a site free of pathogen and fertile
- Use resistant varieties
- Uproot and transport, transplant carefully, don’t cut or damage roots, branches and leaves
- Plants which are damaged, weak, or with disease symptoms should be discarded during transplanting
- Monitor and control the vectors as early as possible to reduce the spread of the diseases
- Insect vector control



MODULE III

VEGETABLE PRODUCTION: BEST PRACTICES TO STRENGTHEN PRODUCERS' CLIMATE RESILIENCE CAPACITIES

3.1 WET AND DRY SEASON LAND PREPARATION TECHNIQUES (BED LAYOUT)

PURPOSE

The bed layout practiced during the rainy season is raised beds which is different from that of the dry season bed layout which emphasizes sunken beds. The main reason is to improve drainage during the rainy season and conserve water during the dry season.
This knowledge of bed layout during the rainy and dry seasons will help the trainees encourage producers to put this water conservation practice as a climate resilient best practice into good use.

TARGETED OUTCOMES

The raised beds during the rainy season will facilitate proper drainage within the garden while sunken beds will conserve water during the dry season when water is scarce. These techniques will increase producers' yields and income.
Training Contents
Trainees will be taught how to properly lay out vegetable beds during the dry and rainy season.

TRAINING METHODS AND TOOLS

Theoretical as well as practical considerations will be the main training methods.

RECOMMENDED FIELD DEMONSTRATIONS

The Regional Training Teams are expected to work with producers to conduct the step down training of producers by properly laying out beds for all the vegetable gardens within the Project areas.

3.2 WET AND DRY SEASON VARIETIES

PURPOSE

Due to difference in tolerance of water by vegetables and the difference in temperature during the dry and rainy season, vegetables perform differently. As a result of this, trainees must know which varieties of vegetables to use for dry and rainy seasons.

TARGETED OUTCOMES

Trainees must know which varieties of vegetables are recommended for the dry and rainy seasons and help increase producers' capacities in their choice of right varieties to increase their yields and incomes.

TRAINING CONTENTS

Climate variations during the dry and rainy season and sensitivity of vegetables to these climate variations form part of the training content for the training of trainees. The identification and selection of the seasonal vegetable varieties is an important consideration in the choice of the training content.

TRAINING METHODS AND TOOLS

Much emphasis will be placed on practicals with theoretical back up. The choice of right varieties of vegetables for the dry and rainy seasons is very important in enhancing producers' yields and incomes.

RECOMMENDED FIELD DEMONSTRATIONS

All the producers' vegetable gardens in all the Project areas should use the recommended dry and rainy season varieties of vegetables.

3.3 COMPOSTING AND ORGANIC MANURE TECHNIQUES

PURPOSE

The idea of increasing the capacities of trainees in composting and organic manure techniques is to ensure that producers make savings by reducing the use of commercial fertilizers by knowing how to compost and use organic manure in their gardens.
The huge vegetable waste biomass generated in gardens provides the best opportunity for composting and use of the organic manure by producers.

TARGETED OUTCOMES

Trainees helping to increase producers' knowledge on how to make compost and proper use of organic manure will help producers increase their yields in vegetables, their incomes and improve the soil conditions of their gardens.

TRAINING CONTENTS

The knowledge of how to make compost and the use of organic manure form the training content of the climate resilient training theme.
Training Methods and Tools
Composting and organic manure techniques are better conducted practically with some relevant theoretical back up.

RECOMMENDED FIELD DEMONSTRATIONS

The practice of composting and use of organic manure should be widely demonstrated in all the Project areas so that all the producers adopt the technology for better rice and vegetable production.

3.4 CONSERVATION AGRICULTURE (SOIL COVER, MINIMUM TILLAGE, ROTATION)

PURPOSE

To address the issue of climate change challenge in agriculture, conservation agriculture should be widely practiced. One of the purposes of the ToT is to increase trainee capacities in the use of soil cover, minimum tillage and crop rotation.

TARGETED OUTCOMES

Conservation agriculture teaches conserving the soil through cover, minimum disturbance of the soil profile and the practice of crop rotation. These technologies help sustain soil and water for crop production.

TRAINING CONTENTS

Trainees of the ToT will be taught how to properly cover the soil, practice of minimum tillage, and crop rotation to maintain proper soil conditions.
Training Methods and Tools
The training method will emphasize practicals with a theory back up.

RECOMMENDED FIELD DEMONSTRATIONS

The practice of soil cover, minimum tillage and crop rotation should be adopted by all producers of rice and vegetables being assisted by the Project.

3.5 AGRO-FORESTRY (LIVE FENCING, ACACIA ALBIDA, ETC)

PURPOSE

The protection of gardens and upland rice fields and maintaining their fertility are major challenges for rice and vegetable producers. The use of live fencing for protection and acacia species for soil fertility maintenance are the main purposes for the training of trainees in agro-forestry.

TARGETED OUTCOMES

Live fencing and maintenance of soil fertility in gardens and upland rice fields through agro-forestry are more affordable and sustainable.

TRAINING CONTENTS

The types of live fences and the different tree species to be used and the acacia species that help increase soil fertility will be discussed.
Training Methods and Tools
The main training methods are theory and practice.

RECOMMENDED FIELD DEMONSTRATIONS

After acquiring the relevant knowledge and skills, the Regional Training Teams are expected to work closely with producers to establish live fences and use acacia species for maintenance of soil fertility in gardens and upland rice fields.

3.6 MANAGING VEGETABLE PEST TYPES AND POPULATIONS IN THE FACE OF CLIMATE CHANGE

PURPOSE

Over the years producers have realized that there has been an increase in not only types of weeds, insects and vegetable diseases but marked increase in populations as well. This increase is likely due to unfavorable climate change which warrants producers to know these vegetable pests and how to manage them to realize reasonable increase in vegetable production.

TARGETED OUTCOMES

The training theme will help trainees increase their knowledge in vegetable pests and help in managing these pests. Producers' knowledge of how to manage the increase in vegetable pests to avoid severe loss in vegetable production will increase their production and incomes which will improve their economic and social wellbeing.

TRAINING CONTENTS

Trainees will be taught how to identify vegetable pests and their increase or decrease in an area and how to manage these pests to avoid severe vegetable crop loss.

TRAINING METHODS AND TOOLS

Theoretical as well as practical considerations will be the main training methods. Samples of vegetable pests and how to manage them will be provided as part of the pest identification purposes.

RECOMMENDED FIELD DEMONSTRATIONS

The Regional Training Teams will work closely with the Plant Protection Services of the Department of Agriculture to carry out field observations and management of vegetable pests populations in farmers' fields.

TRAINING MATERIAL FOR MODULE III

VEGETABLE PRODUCTION BEST PRACTICES TO STRENGTHEN PRODUCERS' CLIMATE RESILIENCE CAPACITIES

1. WET AND DRY SEASON LAND PREPARATION TECHNIQUES (BED LAYOUT)

Wet season vegetable bed preparation

- A thorough land preparation is important in enhancing early crop establishment and adequate weed control
- Field must be well cleared, thoroughly ploughed (30cm deep) and harrowed.
- Raised beds are ideal during the wet season in order to improve drainage.
- It facilitate proper/good drainage during the rainy season and heavy rains especially in the tropics
- Raised bed also helps the plants roots to grow easily and spread when the soil is loose.

Importance or Aims of Land Preparation

- Loosen the soil to facilitate the penetration of plant roots.
- Improve the aeration.
- Increase infiltration of water.
- Reduce evaporation.
- Prepare beds on which seeds and seedlings will be planted and transplanted
- Repair soil compaction caused by previous act

Sample of a raised bed

Framed raised bed

Dry season vegetable bed preparation

- Sunken beds are ideal during the dry season. It conserves moisture.
- Top soil is dug and set aside then deeper clay soils is dug and use to create hills in between the row.
- Then the top soil is returned to the trench along with soil amendments such as compost

Framed raised bed

Demarcation using 3 – 4 – 5 method

2. WET AND DRY SEASON VARIETIES

- Proper seed selection is a prerequisite in a successful vegetable production.
- Varieties to be grown can determine its marketability and profitability.
- Various climatic factor such as climate type, temperature, relative humidity, incidence of light, rainfall and stable supply of water.
- Cool and warm season varieties
- Short and long duration varieties
- Rainy and dry season varieties

3. COMPOSTING AND ORGANIC MANURE TECHNIQUES

- The sustainable upkeep of our tropical soil is presently a point of concern to enable us maintain crop quality and vigour for high yields.
- Drought in the last decade and deforestation, with extensive and continuous usage of our farmlands rendered our fertile soils poor.
- Therefore composting will conserve the fertility of our soils to enhance production and productivity.
- The use of compost is not only means of fertilizing the soil but also aids in maintaining a sound soil structure texture and improves environmental sanitation.
- The increment of organic matter from composting can improve the soil condition in terms of structure, circulation of water, air and nutrients.
- Compost added to sandy soils increases the water retention capacity consequently water stays longer in the soil and thus remains available to plants for a longer time particularly during drought periods.
- A good soil structure can better resist the impact of rain and wind.

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- A good soil structure can better resist the impact of rain

PRINCIPLES OF COMPOSTING

1. MATERIALS

- Good compost needs mixed organic materials, micro-organisms, a little soil and water. Vegetable and field crop residues with animal manure can be used.
- Stones, thin pottery, pieces of metal, wire plastic bottle, sheet plastics, rubber, nylon and other man – made fibres with hard thorns and the roots of persistent perennial should be removed.
- Infected vegetables and plant waste should also be avoided.
- In building compost, moisture within the materials is very important in the composting process. Moisture content below 30% on a fresh weight basis will slow down the biological reactions in the compost heap.
- Too much water however causes water-logging and will prevent the movement of air within the heap.
- The optimum moisture content is 50-60%, and it is important to ensure adequate water supply throughout.

AERATION

- Adequate air supply to all parts of the compost is necessary to supply oxygen for the organisms and to flush out the carbon dioxide produced.
- Inadequate air will kill the essential organisms causing acidic preservation of the compost, thereby producing bad odours.
- Proper air circulation could be achieved by turning the material regularly.
- Optimum turn-up of materials also helps to break up larger pieces of material, exposing fresh surfaces to attack by the organisms and ensures that most of the materials are subjected to highest temperature reached.

NUTRIENTS

- The provision of nitrogen for cell proteins is also important for the composting process.
- It is the most important nutrient, and in general, if sufficient nitrogen is available in the organic. Most other nutrients will also be available in adequate quantities.

- Under our environmental situation fresh green wastes such as weeds could be used with animal refuse.
- Nitrogen may also be added to compost heaps in the form of organic fertilizers such as bone meal, oil cakes and dried blood.
- Also inorganic nitrogen fertilizers such as urea and ammonium nitrate may also be used.
- In - order to maximize the nutrient content of the product compost. It is important to reduce serious leaching from the heap by protecting it against heavy rain and water logging.

TEMPERATURE

- High temperature helps in accelerating the decomposition of organic materials.
- This is possible because the beneficial micro – organisms are active at a certain temperature level 60 - 70 C.
- In decomposition some of the energy released by the breakdown of material is given off a heat and this causes a rise in temperature.

COMPOSTING METHODS

Several methods are used to build compost. The method used would generally depend upon the following:

- The environmental situation surrounding you.
- The type of wastes available, whether they easy to breakdown and contain many pathogens
- The quantity of materials required for the process.
- The allowable cost in terms of time, labour, equipment and space
- The use of which the compost will be put.

QUICK COMPOSTING

- Millet husk, rice husk, or saw dust 10 parts
- Animal manure – 5 parts
- Top soil – 1 part
- Vinegar - 1 bottle
- Sugar - 1kg
- Urea - 1kg
- Water - 20 – 40 litres (as a start)

METHOD

- Mixed the millet husk or any waste with the top soil;
- Sprinkle the solution of vinegar, sugar, urea and water to the mixture;
- Then add extra water to the mixture to make it moist. Press the mixture with your hand, when it is wet then the moisture content is enough;

- Place it under the shade and covered the post with plastic bags for 70-10 days and it will be ready for harvest.

Note

- Top soil contains some humus, which makes and helps decomposition faster.
- Vinegar also contains acids, which helps and agitates the organism to do their work.
- If you don't have vinegar, water from sour milk can be used or after washing rice before cooking you can use that water.
- Urea helps decomposition faster hence contains nitrogen, which can dissolve easily; chicken manure can replace urea.

4.CONSERVATION AGRICULTURE (SOIL COVER, MINIMUM TILLAGE, ROTATION)

Sustainable Farming

- Organic horticulture claims to be sustainable. In the context of agriculture, sustainability refers to the successful management of resources of agriculture to satisfy human needs while at the same time maintaining or enhancing the quality of the environment and conserving natural resources.
- Sustainability in organic farming must therefore be seen in a holistic sense, which includes ecological, economic and social aspects. Only if the three dimensions are fulfilled, an agricultural system can be called sustainable.

Ecological Sustainability

- Recycling the nutrients instead of applying external inputs
- No chemical pollution of soil and water
- Promote biological diversity
- improve soil fertility and build up humus < prevent soil erosion and compaction < animal friendly husbandry < using renewable energies

Economic Sustainability

- Low costs on external inputs and investments
- Crop diversification to improve income safely
- Value addition through quality improvement and on-farm processing
- High efficiency to improve competitiveness

Social Sustainability

- Sufficient production for subsistence and income
- A safe nutrition of the family with healthy food
- Good working conditions for both men and women
- Building on local knowledge and traditions

Benefits of Organic Horticulture

- soil conservation and maintenance of soil fertility
- less pollution of water (groundwater, rivers, lakes)
- Less utilization of non-renewable external inputs and energy
- less pesticide residues in food
- No hormones and antibiotics in plant products
- Better product quality (taste, storage properties).

Importance of organic matter

- Soil organic matter helps to build up a loose and soft soil structure with a lot of pores. This leads to better aeration, better infiltration of water and an easier penetration of roots.
- The visible parts of organic matter act like tiny sponges which can hold water up to five times their own weight. Therefore, in dry periods more water is available for the plants for a longer time. This is especially important in sandy soils.
- The non-visible parts of organic matter act like a glue, sticking soil particles together, thus forming stable crumbs. Such aggregates improve the soil structure, especially in clay and sandy soils.

Cover crops and green manures have a number of benefits

- They suppress weeds and protect the soil from erosion and direct sunlight.
- If leguminous plants are used, nitrogen is fixed from the air into the soil.
- Some green manures and cover crops can be used as fodder plants or even to provide food for human consumption (e.g. beans and peas).
- By decomposing, green manures and cover crops release all kinds of nutrients for the main crops to utilize, thus improving their yield.
- The incorporated plant material builds up organic matter in the soil and activates soil organisms. This improves soil structure and water holding capacity

Mulching

- Mulching reduces the stress of plants growing in dry soils by slowing down the rate of evaporation.

- Add a thick layer of organic mulch around plants as they emerge to keep soil cool and help retain moisture.
- Using straw or compost will also add extra organic nutrients to the soil.
- Therefore, mulching plays a crucial role in preventing soil erosion.

Sources of mulching material can be the following

- Cover crops and grass
- Crop residues (straw etc.)
- Pruning material from trees and hedges
- Wastes from agricultural processing or from forestry.

Application of Mulch

- On vegetable plots it is best to apply mulch only after the young plants are somewhat hardier, as they may be harmed by the decomposition products from fresh mulch material.
- If mulch is applied prior to sowing or planting, the mulch layer should not be too thick in order to allow seedlings to penetrate it.
- Mulch can also be applied in established crops, and is best done directly after planting
- It can be applied between the rows, directly around single plants (especially for tree crops) or evenly spread on the field.

Crop Rotation

- If the same crop is grown for several consecutive years on the same land yields will normally decline (or more fertilizer will be needed to reach the same yield) and health problems will arise in the crop or field.

- Weeds that are well adapted to the conditions offered by the crop (e.g. good light conditions, typical soil cultivation), may spread and require increased efforts to be controlled.

Benefits of Crop Rotation

- When different crops are grown in sequence in the same field, each crop uses the soil in its own particular way and thus reduces the risk of nutrient depletion.
- A well-balanced alternation of crop species also prevents the development of soil-borne diseases.
- Therefore, cultivation pauses must be respected for the same crop and among crops of the same plant family.
- A change between deep and shallow rooted crops and between crops building high stalks and species producing a great leaf mass that covers the soil quickly also helps to suppress the weeds.

5. AGRO-FORESTRY (LIVE FENCING, ACACIA ALBIDA, ETC)

- Agro forestry is the integration of trees, plants and animals in conservative, long term, production systems.
- Live fences is a fence in which the posts are living trees, or in which the entire fence consists of closely-spaced trees or shrubs.

Why Agro-forestry

- Agroforestry systems make maximum use of the land.
- Every part of the land is considered suitable for useful plants.
- Emphasis is placed on perennial, multiple purpose crops that are planted once and yield benefits over a long period of time.
- Such benefits include construction materials, food for humans and animals, fuels, fibers, and shade.
- Trees in agroforestry systems also have important uses such as holding t he soil against erosion and improving soil fertility (by fixing nitrogen or bringing minerals from deep in the soil and depositing them by leaf-fall).

Common uses of trees in agroforestry systems are:

- Individual trees in home gardens, around houses, paths, and public places.
- Dispersed trees in cropland and pastures.
- Rows of trees with crops between (alley cropping).
- Strips of vegetation along contours or waterways (planting along contours for erosion control
- Living fences and borderlines, boundaries. Windbreaks.

TREES OR LARGE SHRUBS WITH EDIBLE PRODUCTS FOR AGROFORESTRY SYSTEMS

Species	Common Name	Edibility	Principle Uses
Anacardium occidentale	Cashew	Seeds, fruit	Garden, fence, pasture
Cajanus cajan	Pigeon Pea	Seeds, leaves	Nitrogen fixation, fuel,Hedgerows
Cocos nucifera	Coconut	multiple food uses	pasture, roadside, construction
Gliricidia sepium	Mother of Cacao	flowers	living fence, feed, fuel
Leucaena leucocephala	Leucaena	leaves, young pods	Alley cropping, nitrogen,fixation, fuel
Ziziphus mauritianaa	Jujube	Fruit	Erosion control, fuel

Leucaena leucocephala

Gliricidia sepium

Acacia albida

Limitation of Agroforestry

Agroforestry does have certain negative effects

- Possible competition of trees with food crops for space, sunlight, moisture and nutrient which may reduce crop yield.
- Damage to food crops during harvesting of trees.
- Potential of trees is serving as hosts to insects and birds. Rapid regeneration of profile trees may displace food crops and take over entire field

6. MANAGING VEGETABLE PEST TYPES AND POPULATIONS IN THE FACE OF CLIMATE CHANGE

1. Weeds

Introduction

Like in rice the effects of climate change on weed/plant interactions are likely to vary by region and crop type. The interactions between crops and weeds are «balanced» by various environmental factors. Local changes in these factors may tip the scale towards either crop or weed. In vegetables, variations in temperature relate to the types that can be grown in wet or cool season. The wet season vegetables tend to suffer from heavy weed competition and weed species such as grasses and sedges observed to colonize new areas. In the dry season watering regime create adequate environment for continues growth of weeds.

Major vegetable weeds

Bulb Crops (Onion, Garlic, Shallot)

Bulb crops include onions, leeks, garlic, and shallots. Bulb crops do not shade out weeds that emerge in the rows. Also, many of the crops, such as onions require a long growing season. Where herbicides are limited weed management is through cultivation. Onions and leeks are fairly shallow rooted, and care must be taken not to prune these roots with cultivation, especially when onions begin to bulb. Hand pulling or hoeing broadleaf weeds, while labor intensive, may be preferable when plants are older and bulbing.

Weed infestation in onion

Many weed problems can be reduced by preparing the land well ahead of planting and using pre-emergence and early post emergence herbicides (Stomp) may control many weeds for 4–6 weeks. Obtain consistent results by reading the herbicide label and other information about proper application.

Cabbage, Cauliflower, Mustard

The Brassica leafy vegetables range from major crops such as cabbage to very minor ones, including mustard. Optimal production of these crops depends on successful weed control.

Weed competition in Cabbage

Weeds reduce yields by direct competition for nutrients, water, and light. Weed control is especially important early in the season when weed competition can substantially reduce vigour, uniformity, and overall yield. Weeds in and around the field can harbour insects and disease pathogens that can invade or spread to the crop soon after planting.

Cucumber, Squash and Watermelon

Establishing a good crop stand in which plants emerge and rapidly shade the ground is an often overlooked tool for reducing weed competition. The plant that emerges first and grows the most rapidly has the competitive advantage. Good production management practices, such as fertility, well-adapted varieties, proper water control (irrigation, drainage), and establishment of adequate plant populations, are very helpful in reducing weed competition. Everything possible should be done to ensure that the crop—not the weeds—has the competitive advantage

Weed competition in Cucumber

Mechanical Control

Mechanical control includes field preparation by plowing or disking, cultivation, mowing, hoeing, and pulling weeds by hand. Mechanical control practices are among the oldest weed management techniques. Seedbed preparation by plowing or disking exposes many weed seeds to variations in light, temperature, and moisture. For some weeds, this process breaks

weed-seed dormancy, leading to early season control with herbicides or additional cultivation.

Mulching

Polyethylene mulch has been shown many times to increase cucurbit yield and earliness. Properly injecting fumigants under the mulch controls nematodes, soil insects, soil-borne diseases, and weed seeds. Mulches act as a barrier to the growth of many weeds.

Eggplant

Eggplant is present in the field in some area of the country every month of the year. Mechanical control includes disking, plowing, and cultivating the fields either off season or during the cropping season to reduce weeds in between the rows.

Okra

Okra is grown throughout the country during the wet and dry seasons. During this time annual weeds can be a serious problem in the field. Cultivation is commonly used in okra, either with sweeps or rolling cultivators. Care should be taken not to throw soil too far up on the okra stems.

Pepper

Peppers are present in the field in some areas every month of the year. Over this period, variable climatic conditions influence the diversity of weed species present, as well as the severity with which weeds affect peppers. Careful cultivation such hoeing and hand pulling of large weeds.

Tomato

Weed control has always been an important component of tomato production. The increased incidence of several viral disorders of tomatoes also reinforces the need for good weed control. Common weeds, such as the difficult-to-control nightshade, and volunteer tomatoes (considered a weed in this context) are hosts to many tomato pests, including sweet potato whitefly, bacterial spot, and viruses. Control of these pests is often tied, at least in part, to control of weed hosts.

Conclusion

There are many other weeds of importance in vegetables which are not presented here. The management options mentioned above are by and large applicable to them also in an Integrated Weed Management Farmer Field School approach.

2. Insects

Introduction
In vegetable crops a complex of insect pests attack at the same time and like in rice the severity depends on Climate change factors because new pests may become able to invade previously uninhabitable areas. Climate factors that aid in vegetable insect invasions are mostly temperature related and changes in rainfall patterns, and water shortages and watering methods.

The microenvironment in the vegetable production systems favours the development of many insect species. The effect of high temperature and relative humidity shortens life-cycle stages of insects resulting in several generations if food is available. Moisten breaks diapauses and also enhances larval development into pupae. In some insects adults lay eggs in the soil where larvae emerge in one to two weeks, depending on temperature. The larval stage may last eight to 30 days, depending on food supply and temperature.

Vegetable Insect Pests

Flower Thrips

Flower Thrips attack flowers of many crops groundnut, cowpea, sweet potato, cassava, banana and tomato. Adults and nymphs feed in the flowers and scrape the tissue from young leaf buds which then produce distorted leaves

Management

- Thrips can be carried from crop to another on the wind
- Put in place a barrier across the wind with maize, millet or sorghum crop to help prevent thrips from migrating from neighbouring crops
- Crop residues should be burnt
- Chemicals effective in the control of thrips include decis and deltamethrin

Onion Fly

Directly seed grown onions have more problems from onion fly. The fly is 2 winged greyish in colour and look like a house fly. It attacks young onions, shallots, garlic and leeks. The fly lays its eggs by the base of the onion then hatches into maggots that eat the base and roots. The maggots after eating their way into the developing bulb hollowing it out move to the next bulb. One onion fly maggot or larvae often destroys 3 or 4 onions before it becomes full grown and pupates at the same time bacteria may enter the bulb, causing a rapid rotting of the root. You can see the small maggots so identifying the problem is straightforward

Flower Thrips

Onion Fly

Onion White Rot

White rot is a serious problem with no real cure. The disease lives in the soil and causes a white mould to grow on the base of the plant, ruining it for storing or eating. The disease is very easily transferred from one patch of soil to another on your boots.

Signs of white rot

Management

- If you have white rot, lift the onions and burn them
- Do not use them in compost making
- Be careful not to transfer the disease to the clean soil, just a dirty fork is enough

Onion Rotting in Store

Grey mould on onions in store and general rotting is usually caused by the onions being insufficiently dried out prior to storing or damp storage conditions.

Management

- Check regularly and discard rotting onions before the problem spreads to the rest
- Field or artificial curing at 27oC with a relative humidity of 80 per cent;
- Don't leave mature crops in the field too long;
- Careful handling during harvesting and grading;

Neck rot

The fungus causing the disease is carried on the seed. It remains inactive during the growing stages of the crop and generally there are no visible symptoms of neck rot until onions have been stored for 8 to 10 weeks. A dusty-grey mass of spores develop on infected onions, the neck softens and occasionally black structures called sclerotia form beneath the scales and a soft-brown rot develops and moves into the bulb

Signs of neck rot

General Management of storage diseases

- Use good crop hygiene which includes proper crop rotations, sound growing practices and disposal of crop residues
- Turn onions frequently during field curing and avoid windrowing during periods of wet weather
- Handle bulbs carefully at harvest to minimize damage and the bulbs continually dry after harvest

- Maintain good airflow and ventilation, low temperatures less than 20oC, and a low relative humidity during storage of less than 80 percent.

Pepper

Bacterial spot

This bacterium is one of the most common and most destructive agent of diseases of peppers. It affects all above ground plant parts especially the leaves and fruits and it is also common on tomato crop.

Complete crop failure has occurred due to this disease. Marketable yield is reduced both by defoliation and damaged fruit. Defoliation reduces crop productivity and also exposes the fruit to sunscald. Fruit lesions can provide entry points for soft-rotting organisms

Management

- Buy certified seed from a reputable source or use seed treatments to reduce transmission
- Rotate fields to avoid carryover on volunteers or crop residue
- Use at least a one year rotation to crops that are not hosts
- Keep fields free from volunteers and weeds

Conclusion

- There are many other diseases of importance in vegetables which are not presented here. The management options mentioned above are by and large are applicable to them also in an Integrated Disease Management Farmer Field School approach.

MODULE IV

TRAINING STRATEGIES MODULE

1.1. PRACTICAL DEMONSTRATIONS

PURPOSE

"Seeing is believing" best describes the use of practical demonstrations in teaching producers who have experience in the subject matter being taught. Practical demonstrations offer hands on practice as a tool for producers to understand how the technology works.

TARGETED OUTCOMES

Once the technology is understood and aptly demonstrated by the producers and they see the results of the newly acquired technology, producers scaling up of the technology is assured and producers' incomes increase as a result of adopting the technology.

TRAINING CONTENTS

During the Training of Trainers, trainees should be able to know what is practical demonstration, its uses, advantages, limitations, physical requirements, and procedure to use it.

TRAINING METHODS AND TOOLS

All the climate resilient practices in rice and vegetable production being taught to the trainees should be adequately demonstrated so that trainees not only know the theory but can demonstrate the technology. In this way the trainees can teach producers during the step down training.

RECOMMENDED FIELD DEMONSTRATIONS

Each of the climate resilient practice in rice and vegetable production being taught should be demonstrated in the producers' fields whenever possible to enhance the adopting of the climate resilient practice.

1.2. EXPERIENCE EXCHANGE

PURPOSE

Experience exchange offers the adult learners or trainees of the new technology the opportunity to share what each of them has been putting into practice over the years with regards the technology being taught.
This peer learning is a training strategy that should be encouraged to enhance the speedy adoption of the technology.

TARGETED OUTCOMES

The sharing of ideas between producers through experience exchange once established in a farming system is more sustainable, more effective and cheaper than the formal extension system.
The trainees of the Training of Trainers should use the experience exchange training strategy extensively in teaching producers the climate resilient practices in rice and vegetable production.

TRAINING CONTENTS

During the Training of Trainers, trainees should be able to know what is experience exchange, its uses, advantages, limitations, physical requirements,
and procedure to use it.

TRAINING METHODS AND TOOLS

Allowing the trainees or producers to talk about and if possible demonstrate their experiences during the training helps in identifying those with suitable ideas and experience about the technology for all to share this practice.
The recommended minimum set of inputs needed for the successful demonstrating of the idea should be made available.

RECOMMENDED FIELD DEMONSTRATIONS

During training of trainers and producers training, the use of experience exchange should be optimized as this helps to allow peer learning and a system of exchanging ideas amongst producers as well.

1.3. USE OF INDIGENOUS SPECIALIST (MASTER FARMERS)

PURPOSE

Over the years some gifted producers have been able to learn about and even document technologies in rice and vegetable production with or without formal extension services. These producers are known as indigenous specialist or master farmers. They should be used to help other producers adopt the climate resilient technology.

TARGETED OUTCOMES

Using indigenous specialists or master farmers as a training strategy in rice and vegetable production helps to increase the confidence of other producers in accepting the ideas of indigenous specialists within the community. Once this confidence within indigenous specialists is established within the community, other producers keep working with them to help adopt technologies.

TRAINING CONTENTS

Trainees should be able to know how to identify indigenous specialists or master farmers, their uses, advantages, limitations and physical requirements, as well as procedures for using master farmers.

TRAINING METHODS AND TOOLS

During the step down training of producers, the Regional Training Teams should identify indigenous specialist or master farmers within the communities benefiting from the Project and use them in helping other producers adopt the climate resilient practice.

RECOMMENDED FIELD DEMONSTRATIONS

Indigenous specialist or master farmers within the communities should be used extensively in the adoption of climate resilient practices being recommended by the Project.

1.4. DISCUSSION GROUPS

PURPOSE

The teaching and learning process of adults is best done through group discussion which offers all the participants the opportunity to share their experiences.

TARGETED OUTCOMES

Encouraging group discussion helps encourage peer learning and is one of more sustainable and cost effective training strategies in adult teaching and learning.

TRAINING CONTENTS

During the Training of Trainers, trainees should know the meaning of group discussion, its uses, advantages, limitations, physical requirements, and procedure to use them.

TRAINING METHODS AND TOOLS

During the Training of Trainers program all the trainees will work in groups to exchange ideas about group discussion and make a presentation during plenary.

RECOMMENDED FIELD DEMONSTRATIONS

The teaching and learning process of adults is best done through group discussion which offers all the participants the opportunity to share their experiences.

1.5. FIELD VISITS

PURPOSE

Field visits offer adult teaching and learning process the opportunity to see the idea put into practice in the field. Producers learn best through “seeing is believing” and field visits to successful demonstrations of the climate resilient technology should be encouraged.

TARGETED OUTCOMES

Theory and practice are complimented through successful ideas demonstrated in the field. Such fields should be used as field visits as training strategies.

TRAINING CONTENTS

During the Training of Trainers, trainees should know meaning of field visits, their uses, advantages, limitations, physical requirements, and procedure to follow to use them.

TRAINING METHODS AND TOOLS

Trainees will be formed into groups during the Training of Trainers to discuss field visits and present their work to others during plenary. These group presentations will be collated and the final product shared amongst all the participants.

RECOMMENDED FIELD DEMONSTRATIONS

Field visits offer the teaching and learning process of adults the opportunity to see for themselves the idea put into practice in their fields/farms.

Selected Issues and Tips on Training Strategies

1. PRACTICAL DEMONSTRATIONS

Meaning of Demonstration

- an act of showing by doing
- involves knowledge, skills and attitude change
- two types i.e. result and method

Some of the uses of a Demonstration

- clears doubts about whether a technology works
- increases knowledge, skills and attitude change

Important advantages of a Demonstration

- evidence that the idea works
- mass transfer of technology
- teaching and learning process is enhanced

The major limitations of a Demonstration

- resources to conduct demonstration may be limited
- time consuming and labour intensive
- managing the procedure may be a challenge due to many people

The Physical Requirements to carry out a Demonstration

- resources such as land and other materials
- willingness of farmers to participate

The Procedure to follow in a Demonstration

- need identification
- assemble required resources
- inform participants about the date, venue and time
- conduct demonstration step by step
  ask questions all the way
- summarize at the end of the demonstration

2. EXPERIENCE EXCHANGE

The meaning of Experience Exchange

- group of people
- who meet
- to share ideas, knowledge, and skills on a particular activity
  establish a common understanding

Some of the main uses of Experience Exchange

- to educate one other
- adopt new technology or experience
- help change attitudes

The main Advantage of Experience Exchange

- Increases the chance of adoption of a technology
- Cost effective
- establishes good working relationships

The Limitations of Experience Exchange

- time consuming
- overriding others' opinions
- dominance by one individual
- language barrier

Physical Requirements to carry out Experience Exchange

- focus group discussion
- a convenient medium of exchange
- conducive environment

The procedure to follow in use of experience exchange

- use of a common language
- share topics/ideas of exchange
- inform all those involved on the venue, date and time
- all ideas are given enough time to be exchanged
- chairperson and secretary needed

3. USE OF INDIGENOUS SPECIALISTS

Who is an indigenous specialist?

- local farmer/producer
- has developed his/her specialist knowledge, skills and attitude
- over a long period of time

Some of the uses of an indigenous specialist

- evaluation of climate resilient technologies
- use of local resources in adoption of technologies

Some of the Advantages of Indigenous Specialist

- teach other farmers about climate resilient technologies
- enhances the use of local resources in the adoption of technologies
- cost effective in helping other farmers acquire knowledge, skills and attitude change

The Limitations of Indigenous Specialist

- limited or no formal education
- limited number of indigenous specialists

Physical requirements for the use of indigenous specialist

- other farmers accept their knowledge, skills and attitude
- learning from their specialists areas
- use of local resources required for adoption of their ideas

Procedure to follow in use of indigenous specialist

- identify the climate challenge issues to addressed
- carry out a baseline survey of indigenous specialists in area
- agree with them on helping with the climate change challenge

4. DISCUSSION GROUP

Meaning of Discussion Group

- a group of people;
- who meet together discuss informally and deliberate;
- a topic of mutual concern.

Some uses of a Discussion Group

- to develop a nucleus of leadership for community service;
- to identify, to explore and seek solutions to problems and to develop plans of action;
- to change attitudes through discussion and the examination of information.

Some of the advantages

- group discussion permits full participation;
- it can establish concensus democratically;
- it pools the abilities, knowledge and experiences of all to reach a goal;

The Limitations of a Discussion Group

- it can consume time especially when backgrounds of participants are different;
- a bossy leader or few members may dominate the discussion;

The physical requirements of a Discussion Group

- face-face discussion around a roundtable;
- informal and relaxed atmosphere is conducive for discussion group.

The procedure to follow in a group discussion

- group governs itself and a leader is selected to moderate the discussion ;
- timing depends on the group and topic to be discussed ;
- secretary or recorder takes the minutes of the meeting and reports progress.

5. FIELD VISIT

What is a field visit?

- trip by a group of people
- to a place of interest for the group
- to learn about an idea or set of ideas

Some uses of a field visit

- Awareness creation
- Learning new ideas of doing things
- Identify and solve a problem or problems

Some advantages of Field Visit

- exposure to new ways of doing things
- obtain first-hand information about the ideas
- increases the chances of adoption of the new idea(s)
- collective learning is enhanced
- cost effective

The major Limitations of Field Visit

- can be costly if many farmers are involved and areas are far
- logistical problems such as transportation, accommodation and catering etc

The physical requirements

- transportation facilities may be needed
- accommodation and catering may be needed
- Field should be taken good care of

The procedure to follow in a field visit

- Planning needed ;
- Informing members and host for the field/site to be visited
- Host to lead the discussion
- Chairperson and secretary needed
- Summarise at end of field visit

Investing in rural people
Investir dans les populations rurales
Invertir en la población rural
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