Production and Marketing of African Indigenous Leafy Vegetables

Book · August 2021

DOI: 10.18452/23190

3 authors:

Judith Henze
Humboldt-Universität zu Berlin
10 PUBLICATIONS **3** CITATIONS
SEE PROFILE

Mary Oyiela Abukutsa-Onyango
Jomo Kenyatta University of Agriculture and Technology
70 PUBLICATIONS **653** CITATIONS
SEE PROFILE

Arnold Opiyo
Egerton University
27 PUBLICATIONS **171** CITATIONS
SEE PROFILE

Production and Marketing of African Indigenous Leafy Vegetables

Training Manual for Extension Officers and Practitioners

Production and Marketing of African Indigenous Leafy Vegetables

Training Manual for Extension Officers and Practitioners

By Judith Henze, Mary Abukutsa-Onyango, and Arnold Opiyo

With contributions from affiliates of the Centre of Rural Development (SLE), Elena Ammel, Emil Gevorgyan, Rebekka Goeke, Julia Legelli, Sönke Marahrens, Florian Neubauer, Colleen O'Connor, and Silke Stöber.

Funded by BMBF, BMZ, Senat Berlin

Federal Ministry of Education and Research

Federal Ministry for Economic Cooperation and Development

be Berlin
Senate Department for Economics, Energy and Public Enterprises

Published by: Humboldt-Universität zu Berlin
Seminar für Ländliche Entwicklung (SLE)
Hessische Str. 1-2
10115 Berlin
Telephone: 030-2093-46890
Fax: 030-2093-46891
Email: sle@agrar.hu-berlin.de
Website: www.sle-berlin.de

Editor: Carmen Aspinall

Cover photo: Nico Damm

Photography: All photos by Judith Henze unless otherwise mentioned

Design/layout: Carmen Aspinall

Print: Egerton University Press
P.O. Box 536, EGERTON
0739806719 KENYA

Distribution: Seminar für Ländliche Entwicklung (SLE)
Hessische Str. 1-2
10115 Berlin

ISSN: 1433-4585
ISBN: 978-3-947621-17-0

Dedication

To all passionate growers of African Indigenous Leafy Vegetables and those who will make our food even healthier and delicious in the future

Foreword

Today's mainstream food systems are broken, leaving many people hungry; while on the other hand, overweight and obesity are on the rise. More than 2 billion people suffer from hidden hunger or micronutrient deficiencies. Our food systems furthermore induce biodiversity loss, climate change, soil degradation, unequal power relations, etc. Agroecological production of nutritious foods can, however, provide an alternative for transitioning into sustainable, inclusive, and more nutritious food systems.

Diet-related diseases are among the main causes of death in the world today. They can mostly be related to not consuming enough 'healthy foods' such as vegetables, fruits, nuts, and whole grains and/or overconsumption of 'unhealthy' processed foods. If we wish to meet the WHO recommendation of consuming a minimum of five portions (400 grams in total) of fruits and vegetables daily, we will have to seriously increase our efforts to produce, market, and consume these healthy foods. Our food systems need to shift from producing mainly kilocalories into producing a diverse range of healthy, nutrient-rich foods and making these healthy foods available and affordable for low-income consumers.

Against this background, the present manual offers a timely and excellent resource to guide extension workers and practitioners on how to grow African indigenous vegetables. These are well adapted to local climates, pests, and diseases and often contain higher quantities of beneficial nutrients than imported counter vegetables such as cabbage or lettuce. Beyond nutrients, vegetables contain a number of substances that contribute to the prevention of cancer, diabetes, etc.

It is commendable that the HORTINLEA project scientists and collaborators went beyond producing multi-disciplinary scientific knowledge on AIVs and turned that knowledge into a practical guide for growing and marketing AIVs tailored to those who need it the most: the extension workers and practitioners or, in other words, the people producing the foods contributing to our health.

This manual, therefore, contributes a little piece to shaping food systems toward more sustainable, inclusive, and healthy outcomes.

Dr. ir. Céline Termote
Africa team leader, Food Environment and Consumer Behaviour lever
Alliance of Bioversity International and CIAT

Foreword

The joint German–African project HORTINLEA aims to improve the production and marketing of underutilised indigenous vegetable species in Kenya. This should help to better supply the population with healthy and diverse foods, particularly vulnerable groups. The project has shown that African indigeneous vegetables are relatively easy and quick to grow for the producer, reasonably cheap for the consumer, and rich in minerals and vitamins. They can contribute to agro-biodiversity as well as dietary diversity. Finally, they create good seasonal income opportunities, particularly for small farmers who produce food near markets and towns.

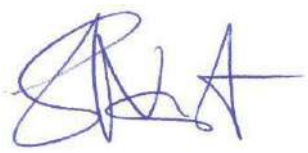
In the collaborative project, many young researchers from Africa were intensively involved in searching for solutions with small farmers and community organisations. Many of their joint research results were published in scientific journals, books, and magazines. However, all those involved in the HORTINLEA project felt strongly that practitioners on the ground should benefit from these results and proposed the development of this handbook. The challenge was to coherently compile the results of various sub-projects in different disciplines, derive recommendations suitable for specific local conditions and available resources, and communicate them in a practical way.

To guarantee all of these requirements, farmers involved in the research were invited to take a critical look at the manuscript and give their comments and make their suggestions for improvement before publication. Our special thanks go to these farmers for their commitment.

However, the handbook would not have been written if a small group of authors had not been particularly committed to compiling relevant information and recommendations from the multitude of results, reviewing individual parts, and summarising them in a language suitable for advisors and practitioners.

In addition to the authors, we must acknowledge the Centre for Rural Development's commitment, particularly from Dr Silke Stöber. We hope that the book will be widely disseminated and appreciated. To give as many people as possible access to it, it will also be made available for download as an e-book.

Prof. Dr. Wolfgang Bokelmann
Coordinator, HORTINLEA consortium
Humboldt-Universität zu Berlin



Dr. Susanne Neubert
Director, Centre for Rural Development (SLE)
Humboldt-Universität zu Berlin

Preface

It is unusual for young scientists to identify so strongly with the concerns and needs of their research subjects that they want to give them something substantial to help solve their everyday problems. Instead, it is common research practice that data on smallholder farmers' livelihoods strategies, behaviour, and working conditions are extracted for research purposes, solely to be published in articles in high-impact scientific journals.

In HORTINLEA interdisciplinary research programme, the 30 predominantly Kenyan, but also German and Tanzanian doctoral students agreed that they would not use their last summer term on statistics, scientific writing, or presentation techniques, but would use the term to hold a practical field day on AIV cultivation and marketing with and for smallholder farmers. This field day was intended to showcase innovative practices that are considered promising in applied research on production, socio-economics, marketing, and consumption of AIVs.

In preparation for this field day, which took place in December 2018 in Bondo, the idea of a handbook to translate scientific findings to practical farm advice in farmer-friendly language was born. It was expected that rural advisory services and trainers could use the handbook to teach improved production and marketing practices for AIVs. The most practical and important knowledge gained over the course of their research was extracted, verified, and prepared from the research findings for inclusion in the handbook. The first draft was prepared by Judith Henze based on the expert knowledge of farmers, doctoral students, and their supervisors. These recommendations were peer-reviewed by two farmer groups to check for comprehensibility and identify knowledge gaps.

Subsequently, the handbook was reviewed by scientists from Humboldt-Universität zu Berlin in the fields of soil fertility (Prof. Christof Engels), post-harvest management (Prof. Dr. Susanne Huyskens-Keil), and agricultural extension (Martin Ihm). A final review was conducted by Prof. Mary Abukutsa-Onyango from Jomo Kenyatta University of Agriculture and Technology (JKUAT) who has promoted farmer-friendly research in Kenya for many years and is a figurehead for the promotion of AIV crops in smallholder systems. Dr. Arnold Opiyo contributed to the concept of this handbook and gave it a final touch.

It is an art and a challenge to derive sound recommendations for upgrading smallholder production and marketing practices from scientific findings. The handbook contains the main steps for upgrading the AIV value chain from sowing and planting, tillage, pest and disease management, irrigation and water management, harvesting, and post-harvest activities. These steps are complemented by information on how to keep farm records and where farmers may obtain further information in Kenya.

With this handbook, the junior scientists have not only demonstrated their excellence in the scientific community, but proved that they strive for application- and transfer-oriented results with and for smallholder farmers. We hope the practical knowledge on agro-ecological intensification of AIV cultivation will be widely disseminated and that nutrient-dense AIV crops will be included frequently in daily meals to contribute to sustainable and healthy diets in Kenya and sub-Saharan Africa.

Dr. Silke Stöber
Centre for Rural Development (SLE)
Humboldt-Universität zu Berlin

About the authors

The Seminar für Ländliche Entwicklung (SLE)

The Centre for Rural Development (Seminar für Ländliche Entwicklung, SLE) has been engaged in international cooperation for more than fifty years. It offers services that range from a post-graduate study programme and advanced training courses for international specialists in Berlin to solution-oriented research and advisory services to development organisations and universities. With its wealth of experience and close links with the Humboldt-Universität zu Berlin, SLE guarantees academically sound concepts and methods, empirically saturated analyses, and practice-oriented tools and consultancy.

SLE has traditionally concentrated on rural development issues in the Global South, that is, 'classic' developing countries, fragile states, transition economy countries, and emerging countries, with special emphasis on marginalised groups. Due to changing economic, social, demographic, and ecological conditions, rural populations all over the world are undergoing change. As a result, SLE has broadened its horizon to include issues such as urban–rural relations, urban development, structural change, and migration.

Dr. Judith Henze

Judith Henze holds a B.A. in International Development and Global Politics from Nottingham Trent University, an M.Sc. in Environment and Sustainable Development from UCL, London, and and received a Ph.D. from Humboldt-University zu Berlin. Her research foci include aquaponics, urban agriculture, vertical farming, and ICTs for agriculture. She is currently exploring how AI technologies can be employed to support farmers monitor. During her research, she founded M-Samaki, an sms and mobile phone app-based ICT solution to support fish farmer in Kenya.

Prof. Mary Abukutsa-Onyango

Mary Abukutsa-Onyango holds an M.Sc. in Agronomy from the University of Nairobi and a Ph.D. in Horticulture from the Wye College, University of London. She is a horticulture professor at the Jomo Kenyatta University of Agriculture and Technology in Kenya. Since 1990, she has been researching and promoting the African indigenous vegetables that were her main staple foods during her upbringing in western Kenya. Her research activities focus on quality seed selection and production protocol development. Her career spans university teaching, research, administration, and leadership.

Dr. Arnold Mathew Opiyo

Arnold Opiyo is a senior horticultural lecturer at Egerton University in Kenya. He holds an M.Sc. in Horticulture from Nairobi University (Kenya) and a Ph.D. in Postharvest Physiology of Horticultural Crops from Zhejiang University (China). His research interest in African vegetables spans 27 years and he is widely published on the subject, particularly in postharvest technologies. His current research foci are the influence of shade nets on vegetable nutritive quality, reduction of postharvest losses, and biodegradable packaging.

Acknowledgements

PhD students

PhD students captured in this photo are: Last row: Allan Ndua Mweke, Dinah Kirigia, Shem Munuke Nchore, Henning Krause, Joseph Kanya Mwangi, Enos Ayiemba Onyuka, Judith Henze, Ruth Githaiga , Abel Benard Otieno, Nancy Munyiva Laibuni

Middle row: Evans Ngenoh, Catherine Mawia Mwema, Emmanuel Omondi Otunga, Daniel Mwangi Mureithi, Eliud Wafula, Noella Ekhuya, Dagmar Kunze, Oshingi Shila, Naomi Chelimo Ketter, Anne Aswani Musotsi, Jackline Kendi Mworia, Elisha Otieno Gogo

First row Emma Awino Oketch, Anna Maria Schulz, Winifred Chepkoech, Grace Akinyi Odongo, Abraham Wahid Luvona, Meike Brückner, Godfrey Nakitare Nambafu

PhD projects

Each of these PhD students participated in a specific research sub-project. Their sub-project number is listed after their name. An infographic of how each sub-project contributed to the overall project is provided on page 4.

The majority of information presented in this handbook was collected by doctoral students in the HORTINLEA researcher team. Our PhD research team (appearing in the photograph above) included:

- Meike Brückner (Sociology & Human Geography, SP7)
- Winifred Chepkoech (Community Studies, SP8)
- Noella Ekhuya (Horticulture, SP6)
- Elisha Otieno Gogo (Horticulture, SP4)
- Sabina Khatri Karki (Agricultural and Development Economics, SP9)
- Naomi Chelimo Ketter (Horticulture, SP1)
- Dinah Karimi Kirigia (Post Harvest Biology & Technology, SP4)
- Henning Krause (Agriculture & Development Economics, SP9)
- Barnabas Kiplagat Kurgat (Natural Resource Management, SP8)
- Nancy Munyiva Laibuni (Agricultural Economics, SP13)
- Abraham Wahid Luvonga (Food Science and Technology, SP5)
- Daniel Mwangi Mureithi (Crop Protection & Entomology, SP2)
- Anne Aswani Musotsi (Nutrition, SP7)
- Joseph Kanyua Mwangi (Agricultural Economics, SP11)
- Allan Ndua Mweke (Crop Protection, SP2)
- Catherine Mawia Mwema (Agricultural Economics, SP11)
- Jackline Kendi Mworia (Crop Protection, SP2)
- Godfrey Nakitare Nambafu (Soil Fertility & Plant Nutrition, SP3)
- Shem Bonuke Nchore (Plant Pathology, SP2)
- Evans Ngenoh (Agricultural Economics, SP9)

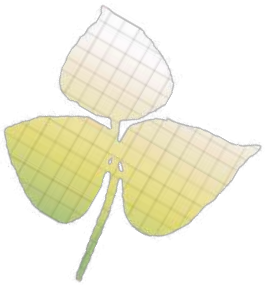
- Eric Gido Obedy (Agricultural Economics, SP7)
- Grace Akinyi Odongo (Molecular Medicine, SP5)
- Francis Osia Odula (Horticulture, SP1)
- Emma Laura Awino Oketch (Gender and Conflict Studies, SP10)
- Enos Ayiemba Onyuka (Agronomy, SP3)
- Abel Benard Otieno (Agricultural Economics, SP12)
- Emmanuel Omondi Otunga (Biotechnology & Genetics, SP6)
- Regina Chemutai Ronoh (Genetics, SP6)
- Oshingi Shilla (Vegetable Breeding, SP6)
- Eliud Nalianya Wafula (Food Microbiology & Molecular Biology, SP4)

Co-researchers include the farmers groups associated with extension officer Ruth Apondi in Kakamega and 'Sustainable Organic Farming and Development Initiatives' (SOFDI) in Vihiga County. Technical information was received from Alliance of Bioversity International and CIAT, World Vegetable Center (AVRDC), Forschungsinstitut für biologischen Landbau (FiBL), and the Horticultural Crops Directorate (HCD).

Two small-scale farmer groups in Kisumum and Kiserian also peer-reviewed the manual.

Farmers Peter Wambi, Odhiambo Odero and Akoth Pascal Gor attended the farmer review in Kisumu, coordinated by Emmanuel Omondi.

The Kiserian farmer team review, which was facilitated by Esther Kiruthi and Stephen Kamau (the coordinators of the 'Community Sustainable Agriculture and Healthy Environmental Program' (CSHEP)), was attended by Mary Luseno, Elisabeth Saitoti, Audrey Amoit Okwara, Hesbon Kamau, and Sarah Mbugua.



The views expressed in this document cannot be taken to reflect the official opinions of SOFDI, Alliance of Bioversity International and CIAT, AVRDC, FiBL and HCD.

'African Indigenous Vegetables are no longer weeds, but high profile commodities. With nutritional and unrivalled health benefits, besides, they have a role to play in food security, nutrition, income and sustainable development in Kenya and beyond; they are a gold mine to be harvested. ALL are invited to cash in and be healthy.'

Prof. Dr. Mary Abukutsa-Onyango, 2010

Contents

1

Introduction

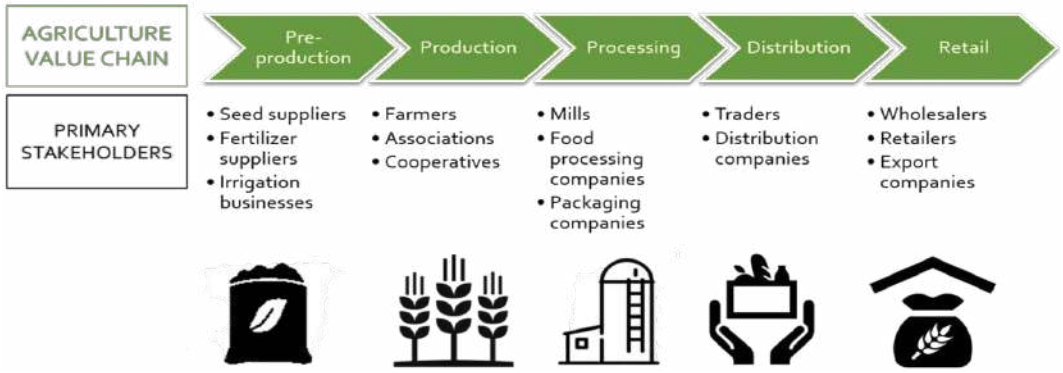
German, Kenyan, and Tanzanian universities and research institutions recognised the importance and benefits of AIVs and, with support from the German government through the Global Food Security initiative, created the 'Diversifying Food Systems: Horticultural Innovations and Learning for Improved Nutrition and Livelihood in East Africa' (HORTINLEA) project in 2013. The aim of the project was to research and improve the coordination of rural and (peri-)urban agricultural value chains for indigenous vegetables.

Agricultural value chain

A value chain is used to describe all the business activities undertaken to create a product from start to finish.

Farmers are involved in 'informal' chains when they sell products to neighbours, middlemen, or small local stores. 'Formal' value chains deliver the same product through commercial wholesalers to supermarkets or exporters.

Value addition to a value chain is the process of adding value to a product or service at each step along the value chain.



From Farming Data: Cultivating Insights for Agriculture in Asia, by G. Pillai and M. Leong, 2020, (https:iiixfoundation.org)

Intercropping

Growing two or more crops next to each other to increase yields and reduce pests and diseases.

Crop rotation

Crop rotation is the practice of planting different crops sequentially on the same plot of land to improve soil health, optimise nutrients in the soil, and combat pest and weed pressure; for example, growing maize, then cowpeas, and then pumpkin in the same field over three growing seasons.

Agroforestry

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland.

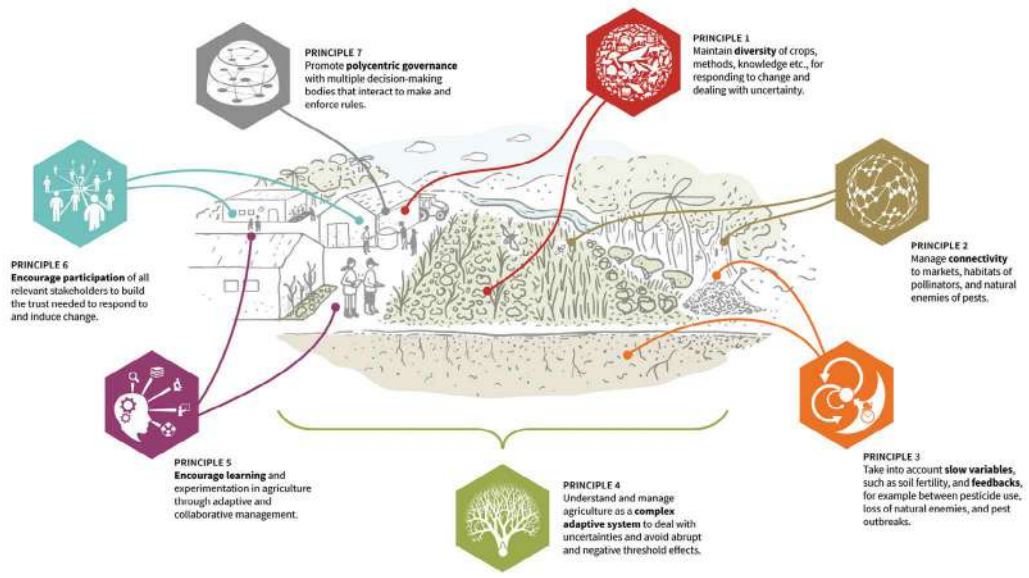
1.1 Agroecological principles in this book

The methods and techniques promoted in this handbook follow an agroecological approach. Agroecology, which combines agriculture and ecology, is a holistic approach that recognises the interconnectedness of animal, plant, human, and natural systems. Many of its principles are used in traditional farming methods to slowly and sustainably improve their production. To produce more crops, they apply ecological concepts and principles to farming such as intercropping, crop rotation, integrated crop and livestock farming, and agro-forestry.

Following agroecological principles of sustainable agriculture means learning from and working with nature. We must apply caution, care, and responsibility when farming and avoid risks and unpredictable methods and technologies that could disturb nature's balance. Practical experience, local wisdom, and traditional knowledge offer many good agroecological farming solutions. These include the use of local and tolerant plant varieties and traditional animal breeds as well as following the natural weather cycle, using manure or compost, and managing pests and diseases using pests' natural enemies (also called farmers' friends) such as ladybirds, or using bio-pesticides.

Agroecology especially suits smallholder farmers as it protects their biggest resources: fertile soil, clean water, and traditional crops and animals. Farmers that practice agroecological farming help protect and enhance diversity by growing many different traditional crops and livestock. Africa has a large variety of native and adopted plant species. It is important to conserve and protect these species as well as the knowledge on how to grow and prepare them.

Agroecology works without the use of any artificial fertilisers, chemical pesticides and pharmaceuticals, which can negatively affect soil fertility and pollute the ground water. Pesticides are harmful to pests, but also to other farm animals, humans, and local environments. They tend to control pests without killing them. For example, they might repel pests, disrupt their mating, or stunt their growth.



From "How are Agroecological Farmers Challenging the Industrial Way of Farming?", by Organic without boundaries, 2018, (https://www.organicwithoutboundaries.bio/)

Agroecological farming is often cheaper than farming with chemical inputs because it utilises resources that are available for free on most farms. The approach can be more labour intensive, though, as farmers have to more actively manage pests and diseases.

Some of the challenges that could be solved by adopting agroecological farming include:

- **Low soil fertility**: 'Soil fertility' describes how well soils can grow and support plants or crops. Important factors for good soil fertility are soil minerals (e.g., iron, zinc), soil nutrients (e.g., phosphorous, nitrogen). and many helpful small organisms such as bacteria, fungi, and earthworms. A decline in soil fertility is often caused by poor soil management, grazing too many animals for too long (overgrazing), and cutting too many trees (deforestation). In Kenya, pressure to produce more food is increasing due to increasing population. This, paired with unsuitable farming practices, leads to soil degradation. Land is farmed more intensively, often through monocultures (such as maize) that take a lot of nutrients from the soil. Soil fertility declines steadily if these nutrients are not returned to the soil and we can experience poor harvests as a result. Chemical fertiliser might seem to help regain soil fertility and achieve good harvests in the beginning, but chemical fertilisers like NPK (which include the three main plants nutrients nitrogen (N), phosphorus (P), and potassium (K)) are expensive and decrease soil fertility when used over a long period.
- **Land shortage:** Rapidly growing populations and land fragmentation due to cultural traditions in Kenya have resulted in shortages of land, increased land use intensity, and land conflicts. Agroecology helps to keep farmland productive so that we can produce enough food for our growing population. Agroecology can be practiced in small spaces, including within cities, using techniques such as bag/sack farming.
- **Inputs:** Rural farmers often have only limited access to conventional farming inputs, such as hybrid seeds, chemical fertilisers, pest and disease management agents, and farming tools and equipment such as tractors. Agroecological farming uses simple, inexpensive methods and materials that are already available on most farms or in most local shops. A good example of a simple method to replace expensive inputs with locally available (and free) inputs is mulching.
- **Market**: An increasing number of consumers are aware that pesticides used in farming might have a negative effect on their health and are willing to pay more for organically grown vegetables.

Improving soil fertility

See page 22 for more details on how agroecology helps to keep soils fertile using natural methods.

Bag/sack farming

The information on page 35 can help you plan your bag/sack farming initiative to help you grow more food in less space.

Mulching

Mulching is a common agroecological practice that helps build soil fertility, control weeds, and maintain soil moisture. You can find more information about mulching on page 35.

Organic alternatives

Agroecology practices a range of alternative strategies to fight pests and diseases; there are many strategies mentioned throughout the book and a recipe for biopesticide is provided on page 44.

1.2 Purpose and use of this handbook

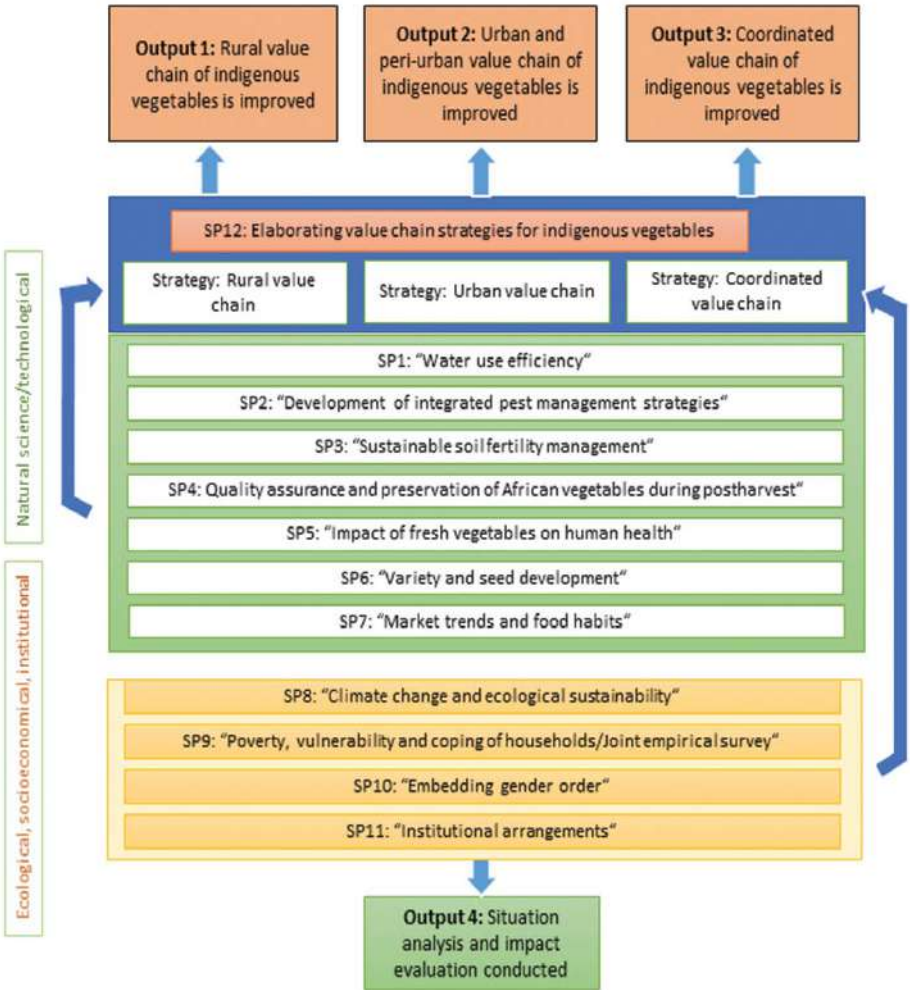
This handbook is the result of five years of research on AIV production and marketing to support small-scale farmers improve their farming practices. Research on five AIVs (African Nightshade, Amaranth, Cowpea, Ethiopian Kale, and Spiderplant) was conducted to improve their production, marketing, and consumption. Twelve sub-projects brought specific value-chain components into focus; for example, soil fertility, seed production, gender aspects, and marketing. The sub-projects are listed in the diagram below and the doctorate students working on each of the projects are listed in the Acknowledgements of this manual. The food systems concept was adopted to merge these aspects into a shared conceptual framework.

Food system concept

A food system includes all activities undertaken to get food from the field to our tables. It also comprises the required infrastructure, actors, relationships, and processes to grow, process, transport, trade, cook, and consume food.

Shared conceptual framework

With the overall goal of improving the livelihood and nutritional situation of the rural and urban poor in East Africa, HORTINLEA is an interdisciplinary research project which collaborates with 19 universities and research institutes in Kenya, Tanzania, and Germany on 14 subprojects (SP). This manual comments on the findings of 12 of the SP in different areas of research as detailed in the graphic on the right.



During the first research survey, farmers emphasised the importance of receiving training before trying something new. This handbook was designed first and foremost as a suitable resource for small-scale farmers and extension officers facilitating trainings and cultivating AIVs while improving their farming practices. We aim to support two groups of farmers: those who want to start growing AIVs for their nutritional and economic benefits and those who already grow one or more AIVs, but want to improve or increase the number of varieties they grow (called 'diversifying'). Both groups can inform themselves of new agroecological methods and will learn new practices and methods such as vermiculture, solar drying, and fermentation. We address their challenges by providing simple and practical solutions.

This handbook will also help extension workers advise on the farming and marketing of the five AIVs covered. They can use this manual during trainings, workshops, farmer field schools, and community-based study groups.

This book describes and promotes low-cost agroecological practices for the sustainable production and successful promotion of AIVs. A sustainable food and agriculture system maintains and improves the fertility of soil, safeguards and enhances the availability and quality of water, protects biodiversity, and produces healthy and safe food while helping farmers and farm workers earn fair incomes. It is necessary to understand agroecological methods and the interconnectivity of farming activities in order to produce high quality vegetables and good yields. This handbook provides an introduction to these methods and encourages farmers to use them when growing AIVs and other crops. More specifically, the handbook covers:

- The nutritional benefits of AIVs
- The benefits of using quality seeds
- How to do a germination test
- How to select a site to grow AIVs
- How to prepare land for planting
- How to prepare and apply organic fertiliser
- How to mulch plants
- How to manage the most common pests and diseases
- How to carry out partial or complete harvests
- How to build a charcoal cooler
- How to ferment AIVs
- How to market AIVs locally

Practical tip

It is very difficult to give precise and detailed advice that applies to all the regions in Kenya because of the different climates, soil types, and farming practices. We have added remarks on regional variations and alternatives when possible.

These practical needs are explained in easy-to-follow step-by-step tutorials that use inexpensive locally available materials. The tutorials present several options and approaches to the various aspects covered.

The language in the handbook is intentionally simple and uses local terms. Pictures have been added to show examples and illustrate processes, tools, and products where possible. We hope farmers are familiar with and can easily relate to these scenes. For those interested in more details or the scientific background of the provided information, we added suggested further reading materials, such as the HORTINLEA book published by CAB International and links to Kenyan organisation at the end of this handbook.

Farmers review handbook in Kisumu.

The handbook was tested by farmers from Kisumu and Kiserian in Narok County who verified the tools, materials, and techniques recommended in the handbook are widely known and accepted.

After this Introduction, Section 2 introduces us to each of this AIVs covered in this handbook and their many benefits. Sections 3 to 7 cover aspects encountered in the value chain, starting with pre-production and ending with marketing. The remaining section of the handbook gives practical support materials, such as contacts and learning activities (Section 8).

To make this handbook as clear and practical as possible, we have used the following symbols throughout the book.

Definitions: Because some technical terms may be new to our readers, we have provided definitions in the outer margin of the page. Each new definition is marked by a small HORTINLEA logo as pictured on the left.

Learning activities for trainers: People who use this manual may wish to extend their learning and train others in AIV production, processing, and marketing. To help them develop their training programme, we have created four activities and shared them in Section 8.1. We hope these activities help to actively engage learners, encourage open dialogue that values farmers' and other participants' own experiences and opinions, and increase the overall learning outcome. We have indicated where a small learning activity might be useful using the small symbol on the left.

Further information / links: In some instances, concepts within the text are closely linked or supplemented by other topics in this manual. In these instances, we have used the symbol on the left to indicate where you can find further, supplementary reading within this manual.

Practical tip: While we very much encourage farmers to explore new techniques and experiment on their farms, there are some instances where a simple practical tip may avert frustration, loss, or damage. These cautionary notes appear in shaded boxes in the outside margins of pages and are indicated with a small lightbulb.

Information boxes are larger boxes that provide detailed, practical explanations of concepts or guide you through step-by-step instructions on various agricultural activities; for example, building a compost pile or making your own biopesticides.

Lastly, we have added practical work sheets to section 4.8 to help farmers apply and record their farm activities and the results of the new methods introduced in this manual. All sheets are designed in a way that they can simply be copied and filled in by the user. Trainers can copy the sheets and hand them out to the participants.

2

African indigenous vegetables

2.1 What are African indigenous vegetables?

African indigenous vegetables (AIVs) are crops which either originated from the African continent or which have been grown for so long that they have adjusted to the conditions (climate, soils, etc) in Africa (Weinberger and Swai, 2006). There are over 400 species of leafy green vegetables domesticated or cultivated in Africa that have been grown and consumed on the continent for several centuries (Gockowski et al., 2003). They are an important component of food security and nutrition for rural smallholder farmers and urban dwellers, but are not considered cash crops despite their potential for income generation. Agricultural production of AIVs is linked to improved community nutrition and health. AIVs have been overlooked for a long time: they are subject to very little research and practical horticultural guidelines on their production do not exist.

Activity suggestion

To establish an understanding of what farmer already know about AIVs, consider conducting Activity 1 on page 63.

There is a growing demand for AIVs in Kenya, with a lucrative market especially in urban centres. AIVs grow very fast, especially nightshade, cowpea, and spiderplant, which can be harvested 3-4 weeks after planting. All AIVs can be harvested repeatedly, offering farmers a regular income. However, as AIVs have a very short shelf life, producers need to ensure good packaging, transport, and marketing, so that the vegetables are sold when they are still fresh.

AIVs are well adapted to sub-Saharan climatic conditions and are better able to withstand diseases and pests than exotic leafy vegetables, such as spinach. Hence, they require fewer inputs, which makes them cheaper and easier to grow. Many can be grown year round when irrigation is practiced.

The handbook focuses on the five most common AIVs, which are African nightshade, amaranth, cowpea, Ethiopian kale, and spiderplant. Two other AIVs (jute mallow and slenderleaf) that were not included in the HORTINLEA research project, but which stand out due to their high nutritional value, are also introduced.

2.2 Health benefits of AIVs

Health problems are on the rise in Kenya and other African countries and are thought to be caused, in part, by diets which lack nutrients. One of two children in Kenya under the age of five lacks the nutrients they need for growth and health. This affects their performance in school and leaves them more likely to suffer from serious illnesses such as blindness or anaemia.

Photo by Meike Brückner

In comparison with common exotic vegetables, African indigenous vegetables contain more vitamins, proteins, and minerals, such as iron and calcium. AIVs are nutrient dense and provide high quantities of protein, iron, calcium, and vitamins when eating 100 g of them daily. The recommended daily allowances (RDA) of calcium are met by consuming just a few spoonfuls of any AIV. 50 g of cowpea leaves fulfills your RDA intake of iron, 112 g of amaranth leaves cover your RDA of Vitamin A, and 25 g of jute mallow cover your RDA of Vitamin C.

Let's look at some of the health benefits of key vitamins and minerals:

- **Iron**: The human body needs iron to produce red blood cells, which are important for transporting the oxygen in the blood. Iron promotes a healthy pregnancy and increased energy levels.
- **Calcium:** Calcium is important to grow and maintain healthy bones. It also helps with heart rhythm, muscle function, and healthy teeth and gums.
- **Folic acid**: Folic acid helps produce new cells and is believed to prevent many types of cancer. It is especially important during pregnancy.
- **Vitamin A**: This is key for a healthy immune system, good vision, and cell growth.
- **Vitamin C**: The body needs Vitamin C for a healthy immune system and to protect itself against heart diseases, eye diseases, and health problems during pregnancy.
- **Vitamin E**: Vitamin E protects body cells from damage.
- **Fibre**: Fibre prevents or relieves constipation, helps to maintain a healthy weight, and lowers the risk of diabetes, heart disease, and some types of cancer.

AIVs must be cooked in the correct way and eaten in correct amounts for our bodies to benefit from their full nutritional value. The amount of nutrients in AIVs vary between different parts of the plant, their growth conditions, time of harvesting, and how long the AIVs are stored between harvesting and consumption. In general, shorter cooking times are recommended to maintain maximum nutritional benefits.

2.3 What farmer researchers discovered about AIVs during the HORTINLEA project

Photo by Abukutsa

To better understand AIV value chains, 700 AIV farmers from Kakamega, Kisii, Kiambu, Nakuru, and Kajiado of western and central Kenya participated in three household surveys. The results of the household surveys formed the basis of the overall project and its many diverse sub-projects. To help you get acquainted with AIVs, we will share some of the key findings from those surveys here.

The first unexpected discovery was that the face of AIV farming is a female one. Two thirds of small-scale AIV growers are women and 18% live in female-headed households.

The most commonly grown AIV is African nightshade, which was cultivated on 72% of the farms. On an average farm, four AIVs were grown for home consumption: nightshade, amaranth, spiderplant, and cowpea. The majority of farmers growing AIVs (69%) sell at least part of their leafy vegetable harvest in nearby open markets or over the fence to middlepersons. AIVs contribution to household income is rather small: if a family earns 10,000 Kenyan shillings per month, only 900 would be made from the sale of AIVs.

Photo by Nico Damm

While many farmers see AIVs as "weeds", AIVs are nutritious and more resilient to the impacts of climate change than exotic vegetables. This lower sensitivity to droughts, heat, and other climatic conditions is very important, because climate change is a growing issue for most farmers. Hotter dry seasons along with less rain per year are common for many and more-or-less pronounced depending on the specific location. Another general observation is shorter and more erratic rainy seasons.

There is a range of strategies that AIV farmers use to adapt to climate change. Some of the most common strategies are agro-ecological practices such as rotating crops, intercropping, growing more diverse varieties and species, and using organic manure. More complex adaptation strategies, such as investing in irrigation or water-harvesting schemes, growing improved seed varieties, or forming groups to improve bargaining power when buying inputs or selling produce, are less common. Despite being very relevant in ecological intensification of AIV value chains, less than one third of interviewed AIV farmers follow these strategies.

AIVs and climate change

This graphic summarises Kenyan survey participants' ideas on climate change, adaptation strategies, and AIVs.

2.4 Common AIVs

Here, we provide description of the five most common AIVs: African nightshade, amaranth, cowpea, Ethiopian kale, and spiderplant. Two other AIVs (jute mallow and slenderleaf) which stand out due to their high nutritional value, are also introduced.

African Nightshade (*Solanum spp*)

Local names

African nightshade is also called:

- *Swahili: Mnavu*
- *Kikuyu: Managu*
- *Luo: Osuga*
- *Luhya: Lisutsa*
- *Kamba: Ndulu*
- *Kisii: Rinagu*
- *Giriama: Mnavu*
- *Kalenjin: Isochot*
- *Pokot : Ksoyo*
- *Elgeyo: Kiso-chot*

African nightshades are grown in high and low-land areas in East and West Africa and can grow up to 1m tall. Plants either sprawl or stand erect. Flowers are white or yellow. Nightshades are sensitive to drought. Germination decreases during dry spells.

Nutrient content and medicinal properties

African nightshade leaves are rich in protein, vitamins A and C, iron, and calcium. Leaves can be used to treat stomach upsets, stomach ulcers, swollen glands and teething problems. The fruit is not eaten but used as a medicine for diarrhoea, eye infections, and jaundice.

Growing conditions for nightshade

Suitable soils	Moist soils; high water holding capacity; slightly acidic (5.8-6.8); well aerated and high organic matter content
Light	Full sun, can tolerate partial shading
Water	Moderate rainfall, 500 - 1500 mm
Temperature	20-30 °C. Cannot withstand frost
Agronomic requirements	Seeds can be directly planted or transplanted. Seeds should be mixed with dry sand in the ratio of 1:10 and seeded in rows 30cm apart at a depth of 2-3 times the size of the seed. If transplanting, seedlings should be transplanted 30cm apart when they have at least six true leaves. Apply well decomposed manure at a rate of 6-8 tonnes per acre.
Planting time	Plant at onset of rains. African nightshade can be grown year round if access to water is reliable.
Pests and diseases	During the dry season, plants become more sensitive to pests and diseases. During the rainy season, African nightshades are rarely affected by pests and diseases, except blight and powdery mildew.

Harvesting

Nightshade leaves can be harvested 4-5 weeks after transplanting in weekly intervals for a maximum of 9 months. The terminal and lateral stems are cut 5-10 cm from the tip to stimulate the development of side shoots. Alternatively, harvesting can be done by uprooting the whole plant. Harvesting should be done early in the morning.

Preparation

Young shoots and leaves are blanched, boiled, or stir-fried with other vegetables or added to soups. Berries are usually not eaten, but can be used for making dyes.

Amaranth (*Amaranthus spp*)

Amaranth is one of the oldest food crops in the world and is believed to have its origin in Latin America. Some species, like Amaranthus blitum, are believed to have originated in Africa. The plant has green or red leaves and branching flower stalks. Amaranth can be grown in poor soils and is tolerant to heat and drought, but does not like the cold. Amaranth species are divided either into grain or vegetable types. This handbook focuses on the vegetable types.

Nutrient content

Vegetable amaranth is rich in protein; vitamins A, C, E, B2; folic acid; and especially calcium, potassium, phosphorus, and iron.

Local names

Amaranth is also called:

- *Swahili: Mchicha*
- *Kikuyu: Terere*
- *Luo: Ododo/Omboga*
- *Luhya: Litoto/ Tsimboka*
- *Kalenjin: Mborochot*
- *Meru: Terere*

Growing conditions for amaranth

Suitable soils	Light, sandy, well-drained, fertile loams. If soil is poor, add well-rotted cattle, chicken, or compost manure to the soil: 1 bucket/m² (1-2 tonnes per acre). Grows best at soil pH range 4.5 - 8
Light	Full sun
Water	Water regularly, cannot withstand waterlogging
Temperature	20-30 °C (germination) and 25-35 °C (growth). Tolerant to heat and drought. Does not like cold temperatures and stops growing below 8 °C
Agronomic requirements	Vegetable amaranths is normally propagated by seed. Land should be tilled to a fine tilth, as amaranth has very small seeds. To ensure even distribution, seeds are mixed with sand or fine soil in a ratio of 1:10 before seeding in rows 30-50 cm apart. 2-3 weeks after planting, seedlings should be thinned to 10-15 cm.
Planting time	Year round, especially if a reliable irrigation system is available
Pests and diseases	Amaranth is very resistant to pests and diseases

Caution

Amaranth is known to concentrate nitrates in the leaves. This is why chemical fertilisers with high nitrate content are not recommended. Consuming too much nitrates can lead to stomach cancers, blue babies, anaemia and other health problems.

Harvesting

Harvesting can be done by uprooting or by ratoon harvesting. The first harvest is done during thinning. Plants can be uprooted at 4-6 weeks after sowing.

Preparation

The leaf and tender stems are boiled, steamed, stir-fried or prepared as soup: stewed or pureed. Boiling amaranth in water should take at most five minutes. Nutrients are lost if boiled for a longer time. The water used for cooking the leaves should not be used in other food preparations. Vegetable amaranth is often cooked in combination with other vegetables like African nightshade, spiderplant, or pumpkin leaves.

Cowpea (*Vigna unguiculata*)

Cowpea is an ancient crop of African origin. Varieties are either creeping types that grow outward or vine-types that grow upwards (erect). The standing variety cannot withstand heavy rains and does not thrive well when it is too cold. Cowpea can be grown together ('intercropped') with yam, maize, cassava, groundnuts, sorghum, pearl millet, or other indigenous vegetables.

Nutrient content and medicinal properties

Good source of Vitamin E, iron, riboflavin, with some Vitamin C and very high levels of Vitamin B1 and B3. It is also high in minerals like iron, potassium, magnesium, and calcium. Cowpea leaves are a rich source of dietary fibre and have been known to ease stomach conditions, such as diarrhoea and constipation.

Local names

Cowpea is also called:

- *Swahili: Kunde*
- *Kikuyu: Thoroko*
- *Luo: Boo*
- *Luhya: Likhubi*
- *Kamba: Nyunyi*
- *Kalenjin: Kundeek*
- *Meru: Mathoroko*

Growing conditions for cowpea

Suitable soils	Well-drained and fertile soils (sandy, loamy, alkaline, or saline types), but prefers soil pH of between 6.0 and 7.5
Light	Full sun
Water	Water frequently
Temperature	20-35 °C
Agronomic requirements	When intercropping with pearl millet, sorghum, or maize, cowpea seeds are planted 20 to 40 cm apart. When produced as a green vegetable, they are commonly grown as a monocrop in rows 30 to 40 cm apart with 8 to 12 cm between plants.
Planting time	Seed should be sown 5-6 weeks before the rainy season starts rather than at the start of rains to lessen damages by pests and rotting of the seeds in the soil.
Pests and diseases	Often affected by spider mites and white flies

Harvesting

Harvesting can be done by uprooting or by ratoon harvesting. The first harvest is done during thinning. Plants can be uprooted at 4-6 weeks after sowing.

Preparation

Leaves and young pods are consumed as vegetables, while seed are used as a side dish and either cooked alone or mixed with other vegetables in sauces. Seeds have different colours including black, white, brown, grey, and striped .

Ethiopian kale (*Brassica carinata*)

Ethiopian kale originates from the Abyssynian highlands of Ethiopia where it is grown mainly for the seeds that are used to produce oil. As a leafy vegetable, it is often grown in eastern and southern Africa and less commonly in western and central Africa. Ethiopian kale can grow up to 1.5 m tall and flowers are pale to bright yellow. The crop is very tolerant to both cold and drought and can be grown at higher altitudes, unlike most leafy vegetable crops. The space between rows can be interplanted with shallots, parsley, and slenderleaves.

Local names

Ethiopian kale is also called:

- *Swahili: Loshuu*
- *Kikuyu: Kaguru / Thoro*
- *Luo: Kandhira*
- *Luhya: Kanzira*
- *Kalenjin: Saratiek*

Nutrient content

Ethiopian kale has good levels of Vitamin E, folic acid, and calcium and very high levels of Vitamin C.

Growing conditions for Ethiopian kale

Suitable soils	Grows in most soils. Sensitive to high saline levels; if soil salinity is too high, seeds may not germinate.
Light	Full sun
Water	Moderate (600-1200 mm). Cannot withstand waterlogging
Temperature	15-20 °C
Agronomic requirements	To reduce disease amongst seedlings, seeds can be mixed with ashes before planting. Seeds can be broadcast or planted 35-40 cm apart in rows that are 50-60 cm apart. The tiny seeds germinate rapidly in moist soils or in pots.
Planting time	5-6 weeks before the rainy season starts in order to reduce pest damage.
Pests and diseases	Ethiopian kale is sensitive to turnip mosaic virus and susceptible to black rot, black spot, damping off, and seedling root rot. Its most common pests are the cabbage and mustard aphid, cabbage weevil, flea beetle, and hurricane bug.

Harvesting

Leaves can be harvested after 7 to 10 weeks; earlier harvests produce tender leaves, good re-growth, and opportunity for further harvesting.

Preparation

Leaves and tender stems are eaten in salad, boiled, or pickled and, in most cases, leaves are mixed with African nightshade or spiderplant.

Spiderplant (*Cleome gynandra*)

Spiderplant is one of the most important AIVs in Kenya. In recent years, its status and consumption has risen significantly in western Kenya and beyond. It is now internationally recognised as a vegetable with high nutritional, medicinal, and economic potential. Spiderplant is tougher and more pest and disease resistant than other AIVs. Plants can grow up to 1.5 m tall and have many branches and hairy leaves. Flowers are white (sometimes with purple tinges) and seed pods are green or yellow. Spiderplant grows up to an altitude of 2,400 metres and is less common in very humid climates. It can be grown alongside African nightshade or amaranth.

Local names

Spiderplant is also called:

- *Swahili: Mgagani*
- *Kikuyu: Thageti*
- *Luo: Dek/Akeyo/Alot*
- *Luhya: Tsisaka/Esaka*
- *Kalenjin: Isakchat/ Sageet*
- *Kisii: Sageet /Chinsaga*
- *Kamba: Mwianzo/Sake*
- *Maasai: Lemba-e nabo*

Nutrient content and medicinal properties

The leaves of spiderplant are eaten as a cooked green vegetable, have a mildly sour taste, and contain good amounts of protein; Vitamins A, B, E, and C; calcium; phosphorus; and iron and very high levels of folic acid. The leaves have anti-oxidant and anti-inflammatory properties. Traditionally, spiderplant is given to women before and after birth to support pregnancy and recovery with iron.

Growing conditions for spiderplant

Suitable soils	Well-drained and fertile soils (sandy, loamy, alkaline, or saline); prefers soil pH of 6.0-7.5
Light	Sunny and partially shaded areas
Water	500-1,500 mm of rainfall in the growing season. Cannot withstand waterlogging
Temperature	18-25 °C. Does not like temperatures below 15 °C
Agronomic requirements	Spiderplant is seeded directly into the soil. Seeds and sand are mixed in a ratio of 1:10, sown in rows 30-50 cm apart, and covered with a thin layer of soil.
Planting time	Spiderplant is sensitive to cold, therefore planting between August and September should be avoided. Planting at the onset of rain is advisable for rainfed farms. Farmers with irrigation can plant spiderplant throughout the year.
Pests and diseases	Often affected by spider mites and white flies.

Harvesting

Three to four weeks after sowing, leaves are harvested when plants are thinned to achieve the required spacing. The second harvesting is done by pinching the terminal bud in to accelerate branching and delay flowering.

Preparation

The leaves, young shoots, and flowers are eaten boiled or in stews. They are normally cooked with vegetable amaranth, milk, groundnut paste, or tomato and oil.

Jute or Jew's mallow
(*Corchorus olitorius*)

Jute mallow is native to Africa and can be found throughout Africa. The plant has many English names: Egyptian spinach, bush okra, and West African sorrel. It is one of the most popular traditional vegetables in Western Kenya. The vegetable can be used in many ways: as a food, green manure, windbreak, erosion control, animal fodder, mulch, fibre, and medicine. It can grow 2-4 metres tall. Jute mallow can be grown together with amaranth (in different rows), maize, or beans. It tolerates hot climates and can sustain brief droughts. Jute mallow can cope with high rainfall and some flooding, but does not grow well in cold temperatures.

Local names

Jute mallow is also called:

- *Swahili: Mrenda*
- *Luo: Apoth*
- *Luhya: Murere*
- *Kalenjin: Murere*

Nutrient content

Jute mallow is rich in protein and a good source of calcium and iron. The leaves have very high levels of Vitamins A, B and C and folic acid. Historically, jute mallow has been used to treat fevers, congestion, and wounds. It is also known to have anti-inflammatory, analgesic, antitumor, antimicrobial and antioxidative effects.

Growing conditions for Jute mallow

Suitable soils	Well-drained sand and loam that is high in organic matter. pH of 5.5-6.8
Light	Full sun
Water	Moderate (600-2,000 mm per year); drought tolerant due to deep roots
Temperature	25-30°C . Does not like temperatures below 15°C
Agronomic requirements	Land should be prepared by adding well-composted manure at a rate of 6-10 tons per acre. Seed is mixed at the ratio of 1:10 with sand or dry soil, seeded directly in rows spaced at 30-40 cm apart, then thinned to 15-20cm between plants within rows.
Planting time	Best grown at the onset of the rainy season to withstand hot and humid months. It can withstand drought conditions. Seeds germinate very quickly, usually 2-4 days after planting.
Pests and diseases	Very low sensitivity to pests and diseases.

Harvesting

Harvesting starts six weeks after planting by cutting the growing terminal shoots to stimulate lateral growth.

Preparation

Leaves and tender stems are boiled, stirfried, or prepared as a juice, stew, or soup. Sticky leaf mass is used as vegetarian spread. The vegetable is mucilaginous. In order to lessen the tough texture, jute mallow is often mixed with other vegetables, especially cowpea, crotalaria leaves, and slenderleaf to soften or neutralise them.

Slenderleaf (*Crotalaria spp.*)

Slenderleaf or Crotalaria likely originated in Asia and is widespread in tropical regions, including about 550 species in Africa. In Kenya, it is planted around the Lake Victoria region and Western Kenya and is known for its bitter taste. Two species of slender-leaves are most common: *Crotalaria ochroleuca*, which has big and plump pods with a mild taste and *Crotalaria brevidens,* which has longer and narrower pods and has a bitter taste. Slenderleaf can often be found growing at the edges of swamps and flooded places.

Local names

Slenderleaf is also called:

- *Swahili: Marejea*
- *Luo: Mitoo/Muto/ Ambaro*
- *Luhya: Emiroo*
- *Kalenjin: Mityat*
- *Maasai: Oleechei/ Olotwalan*

Nutrient content and medicinal properties

Slenderleaf leaves are a good source of nutrients; they are especially high in Vitamins A, C, E, B1, B2, B6, and K; protein; calcium; potassium; and iron. The leaves are beneficial to skin and hair. In Western Kenya and the Lake Victoria region, slenderleaf leaves are eaten to reduce stomach problems, while the roots are used to treat malaria.

Growing conditions for spiderplant

Suitable soils	High organic matter, good drainage with a pH of 5.5-6.8
Light	Full sun
Water	500 mm, relatively low water requirement, tolerates drought very well
Temperature	20-30 °C.
Agronomic requirements	The seed is mixed with sand or dry soil at a ratio of 1:10 before seeding directly into well-prepared seedbeds in rows that are 30cm apart. Once established, its deep tap root helps it to tolerate water deficit conditions.
Planting time	Plant slenderleaf at the onset of the rains. When irrigation is in place, slenderleaf can be planted year round.
Pests and diseases	Low sensitivity to pests and diseases.

Harvesting

First harvest occurs when plants are thinned at 6 weeks or when plants are uprooted just before flowering at 8 weeks. Alternatively, one could use the ratoon system where the terminal shoot is plucked at 8 weeks and lateral shoots are subsequently harvested.

Preparation

Slenderleaf is often mixed with other vegetables such as jute mallow, cowpea, or pump-kin leaves. The leaves and tender stems are boiled or fried. Often, milk or groundnut sauces are added for a better taste.

3

Preparing to grow AIVs

A little planning before establishing your African indigenous vegetable garden can help you make the best decisions and prepare the right materials to support your flourishing garden. Planning will look different for each farmer and their family, but may include selecting the garden location and size, determining the types and varieties of vegetables to plant, thinking about what season to plant in, and considering how much of each vegetable to plant. In this section, we talk about how to prepare your land and organic fertilisers to support your garden, sourcing and testing seeds, and planting.

3.1 Considerations for before you plant

Activity suggestion

To help you understand land preparation practices and techniques, we suggest you conduct Activity 2 on page 73.

Land preparation is important to ensure that the field is ready for planting. A well-prepared field controls weeds, recycles plant nutrients, and provides a soft soil mass for transplanting and a suitable soil surface for direct seeding.

Site selection

Growing food in small spaces

People interested in growing AIVs who do not have access to large land holdings should not be discouraged. Urban agricultural systems like bag gardening can provide simple solutions. See page 36 for more information on bag gardening.

Before setting up an AIV vegetable field, think about where you would like to plant.

- Choose a sunny location, as most AIVs like direct sun. Most vegetables need at least 6 hours of sunlight daily.
- Do not grow vegetables next to the road or on the roadside, if possible. The exhausts that cars produce are toxic and make the vegetables unsafe for human consumption!
- Do not plant where weeds do not grow; vegetables will not grow well there either.
- Plant the garden near a water supply if possible. Is there a river, stream, pond, or well nearby? In many areas, a garden can grow without watering, but it is more likely to be successful if it is irrigated. Water is needed especially during long dry periods or when planting seeds.
- The soil should be well drained. Do not choose low areas where water stands or the soil stays wet. Remember, only African nightshade and slenderleaf like moist soils.
- Protect your crops from predators such birds, chickens, goats, and other animals. You may need to put up fences or nets.

Season

Kenya's different regions have different climates. The arid and semi-arid zones in the north and east of Kenya are very different from the tropical zones in the west. Local microclimates make it difficult to give precise and general advice at the national level.

- **Northern Kenya**: Northern Kenya is an arid region with year-round sunshine. Rainfall is limited with November generally being the wettest month. Average temperatures range from 20-40 °C. Annual rainfall is rarely greater than 400 mm.
- **Western Kenya**: The climate is tropical: hot and humid. All twelve months have mean temperatures warmer than 18 °C. Average annual rainfall is 1,800 mm spread between two rainy seasons: the short rains from October to December and the long rains from March to June.
- **Eastern Kenya**: This is a semi-arid zone with two rainy seasons bringing 500-1,050 mm of rain annually: the short rains from October to December and long rains from March to June, with highest rainfall from May to June. Temperatures range between 13 °C in cool months to a maximum of 34°C during the hottest months.

Land preparation

Before planting, invest time in preparing your field. Although burning and heavy ploughing are popular ways of clearing fields quickly, you might consider other approaches which are more gentle on the environment and lower cost. As part of your preparation:

- Remove any large stones from the field
- Add well-matured manure or compost to the soil to increase fertility
- If your soil is very compact, plough the field manually or with a cow or donkey. The use of heavy machinery for ploughing, such as a tractor, is not recommended as the thin, fertile layer of topsoil can get buried underneath the less fertile soil below.

Improving soil fertility

There are many options for building soil fertility without expensive chemical inputs. Read more about preparing and applying organic fertilisers on pages 22-23.

3.2 Organic fertiliser

What is healthy soil?

Healthy and fertile soil is an important concept in agroecology. All AIVs need good, fertile soils to better resist pests and diseases and produce high yields.

Remember: Healthy soil ⇨ healthy plants ⇨ healthy people

Farmers have their own ways of deciding whether soils are high or low quality. They may look at soil colour, compaction, or texture (stickiness or crumbliness). We consider a soil to be fertile ("healthy") when it:

- is rich in the nutrients that plants need to grow. Plants need many nutrients, but you are probably most familiar with nitrogen (N), phosphorus (P), and potassium (K);
- contains other nutrients that plants need smaller quantities of; for example, boron, manganese, and zinc;
- has a good amount of soil organic matter;
- has a pH in a suitable range for crop production (between 6.0 and 6.8);
- has a crumbly structure;
- contains living organisms; and
- has good water retention and supply.

Comparison of a soil with high organic matter and good water retention and a soil with low organic matter that is prone to drying/compacting. From Excel Fencing and Decking, 2020, (https://www.excelfencinganddecking.com).

Building healthy soils using organic fertilisers

Farmers are encouraged to apply organic fertilisers to their fields to improve soil fertility. There are many sources of organic fertilisers. In this section, we talk about manure and compost (which are very common) as well as vermicompost and compost teas. Farmers should consider what materials they have available at no cost or low cost to make these fertilisers, how much time and available labour they have to prepare them, and when they need them. Some farmers will make and use a number of these fertilisers, while others may be more limited in time, materials, or labour. Every small effort will yield results.

Farm manure is a low-cost fertiliser that helps farmers to achieve higher yields. There are different types of animal manure: dung from cows, goats, sheep, or rabbits or chicken droppings. Applying manure to fields will provide a quick release of nutrients to plants, but are often so high in some nutrients that applying them directly to plants in large quantities can burn the plants. For this reason, manures should be well rotted before being applied to plants.

Pile and pit method

There is a lot of information available on different composting techniques. Farmers should choose a technique that best works for their land and their family. In Box 1 and 2 of pages 22-24, we provide details on how to use pile and pit methods.

Another popular technique is composting. During composting, bacteria and fungi break down waste materials from plants and animals, so they can be better taken up by the plants. Because the bacteria and fungi work very slowly, composting takes time to produce high-quality fertiliser. The process can take up to 3-4 months, depending on the type of manure. It is good practice for farmers with livestock to collect any animal dung and continuously make manure in either a pile or pit method (see Box 1 and 2).

Box 1: Pile or pit composting methods

The pile method is especially suitable for high rainfall areas; whereas, the pit methods is best for dry areas. We start our description with the pile method. The description provided here was adapted from IIRR, 2000.

Materials

- Green materials: Green leaves from trees like calliandra, leucaena, and sesbania; food scraps; fresh grass; etc. Plants contaminated by pests or disease are not suitable, nor are the leaves from eucalyptus and cassia trees.
- Dry materials: dried grasses, hedge cuttings (tithonia is especially good), maize husks, rice straw, dried leaves, etc.
- Animal manure
- Ash
- Topsoil
- Water

Steps

1. Find an area to build your pile. It should be about 120cm (4 feet) wide and at least 150 cm (5 feet) long (the length depends on how much composting material you have). If your pile is wider than 120 cm, you will step on and compact the pile as you work.
2. Prepare the dry materials that you have by chopping them into segments using a machete. A length of no more than about 20 cm is ideal. This will help improve air circulation in the pile and make turning the pile easier.
3. Begin building your compost pile by putting a 30 cm layer of dry materials on the ground. Sprinkle water on this layer.
4. Apply a layer of animal manure or biogas slurry.
5. Sprinkle some ash or dust on this layer. The ashes contain valuable minerals.
6. Add a layer of green materials. This layer should be about 15 cm (6 inches) thick. Sprinkle water on this layer so the pile is moist throughout.
7. Sprinkle a little topsoil or old compost on top.

8. Continue adding more layers, starting with dry materials, then animal manure or biogas slurry, followed by wood ash, green vegetation, and topsoil. Sprinkle water on every layer. Build the pile to 1.5 m (5 feet) high.

9. To complete the pile, cover it with a 10 cm (4 inch) layer of topsoil then cover the whole pile with dry vegetation such as banana leaves to reduce moisture loss through evaporation.
10. Drive a long, sharp, pointed stick into the pile at an angle so that it passes through the pile from top to bottom. This stick will act as your thermometer.
11. After three days, decomposition will have started in the pile and the stick will be warm when you pull it out. Pull the thermometer out from time to time to check the progress of the pile. If the stick is dry, water the pile. If the stick is cold or is growing a white substance, decomposition has stopped.
12. When decomposition has stopped (usually after 2-3 weeks), turn the pile over.
13. After 2-3 weeks, turn the pile over to mix the layers to allow faster decomposition. Do not add any fresh materials. You may need to water it again.
14. The compost should be ready after 4 weeks. Check the temperature of the pile to make sure: if the stick feels warm when you pull it out, the pile is still composting and the compost is not ready. Finished compost should have a fresh, earthy smell.
15. Store the compost by covering it with a layer of banana leaves or polythene.

Pit method for low rainfall areas and seasons

If you are making compost during a period of low rainfall (for example, during the long dry season), you may wish to try the pit method. The method is very much the same as the pile method, except that you build your pile inside a pit in order to maintain moisture in the pile. This method is more work intense, so may not be suitable for all farming families.

To build a compost pit, dig a pit that is 1.2 m (4 feet) wide and 0.6 m (2 feet) deep and fill it with layers of compostable material as described above. You will need to insert a stick into the pile and water it just as you did when using the pile method. Since the pile is warmer and moister and contains more microorganisms from surrounding soils, it will decompose quickly; however, turning it every two weeks will help aerate it and mix layers for better decomposition.

To produce a regular supply of compost, many farmers have had good success digging three pits side by side. When one pit needs turning, it is turned from one pit into the next one. A new compost pile is then started with fresh vegetation in the empty pit.

Another form of composting is vermicomposting. This is the process of using worms ("vermi" is Latin for "worm") to turn organic waste into nutrient-rich soil or liquid fertiliser (called "worm tea"). Worms eat rotting waste and produce vermicompost. It is one of the best fertilisers as it has many nutrients and microbes that enrich the soil. Vermi tea increases plant growth and yields and suppresses plant disease and pest.

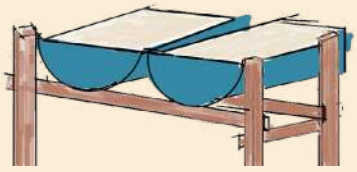
Box 2: How to construct a vermiculture barrel

Materials

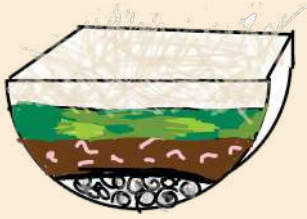
- Plastic barrel of 100-200 litres
- Handsaw
- Stand for the barrel
- Fine mesh or old rice bag
- Stones 3-6 cm in diameter
- Bedding material: Straw, rice husks, maize husks, coconut fibre, shredded paper, cardboard, or newspaper
- Clean water
- Earthworms (50 – 100)

Steps

1. Find a place which is not very hot or very cold to put your vermiculture barrel: worms are most productive in temperatures between 12 and 25 degrees. Ensure animals (especially chicken, mice, and rats) cannot enter the area.
2. Use a saw to split the barrel in half from top to bottom and either add slits or holes along the top rim for ventilation.
3. Attach a simple plastic tap to the bottom front of each half, where you can drain the liquid fertiliser later.



4. Place the barrel on a stand/rack/frame to give the barrels stability, so they do not tip over.
5. Add a 5 cm layer of stones to the bottom of each barrel; this is where the liquid fertiliser will gather.
6. Cover the stones with a layer of fine mesh, chicken wire, or a burlap bag to stop the worms from falling between the stones.
7. Add a 10 to 15 cm layer of "bedding" materials such as finely shredded newspaper, coffee husks, straw, coconut fibre, or shredded cardboard on top of the chicken wire/rice bag. The bedding always needs to be moist as worms need a moist environment. Make sure the bedding is not too soupy or too dry!
8. Place a 5 to 10 cm layer of soil or cattle, pig, sheep, or goat manure on top of the bedding. Green manure, such as tree leaves or grass cuttings, may be substituted. Moisten the organic materials before introducing the worms.
9. Release the earthworms onto the moist bed and give them time to bury themselves.



10. Cover the bed with a thick layer of paper, banana leaves, or straw to stop odours, keep the worms warm, and shield them from direct sun.
11. The bucket top needs to be covered to keep out rain and predators.

Worms in a vermiculture bin

Farmers show the top layer of their vermiculture bin. Note the moist, dark compost created by the worms.

Earthworms commonly used for vermiculture in Kenya are:

- **The tiger worm (Eisenia foetida)**. This species is raised in Kenya by several flower farms in the Central Highlands and Rift Valley
- **African night crawler (Eudrilus eugeniae)**
- **Earthworm (Perionyx excavatus)**

To feed the worms, add a 3-cm layer of fresh foods such as tea bags, maize husks and cobs, grains, beans, old breads, fruit and vegetable trimmings, eggshells, coffee grounds, and weeds to the top of the barrel. Adding a layer of bedding (newspaper, coconut husk, or dry leaves) to the top of the pile will help prevent bad odours.

Liquid compost drains naturally from your vermicomposting worm farm through the drainage holes or tap in the bottom of the bin. In a healthy worm farm, the amount that drains is limited to the amount of excess water that is generated by the actions of the worms. This fertiliser is often referred to as "worm tea" or "vermi tea". It is a very rich fertiliser and is also effective for suppressing plant diseases. The tea needs to be diluted with water (1:10) before applying it as a fertiliser.

Caution

Do not add onions, citrus, meat products, dairy products, or oily products to your vermiculture barrel. These foods won't harm your worms, but the worms will avoid them and those scraps will break down and rot in the bin.

The vermicompost is ready after three to six months, when there is very little food or bedding material left and the mix has a dark and equally fine texture. There are several methods of collecting the vermicompost:

- **Method 1:** If you do not want to empty the barrel, you can push the compost that is on top of the stones to one side then add new bedding and food scraps (worm food) to the now empty space. Leave the bin to sit for 2 or 3 days will give the worms time to move to the side of the barrel with the new bedding and food in it. You will then be able to remove the old vermicompost and use it.
- **Method 2:** Prepare a second worm barrel with fresh bedding and food. Place a large plastic sheet, polythene or other firm surface on the ground and empty the contents of the first worm farm. Pick out the worms and place them into a new worm barrel.

Vermicompost can be mixed directly into the soil. It can be applied to any crop at any stage, but is most beneficial when mixed into soil after broadcasting. The approximate rate of application, according to Rana (no date), is:

- **Field crops:** 5-6 kg/10 m^2
- **Vegetables:** 10-12 kg/10 m^2
- **Flower plants:** 100-200 g/sq ft
- **Fruit trees:** 5-10 kg/tree

Even experienced vermiculture farmers have difficulties with their vermiculture barrels from time to time. Here is a summary of common problems and solutions, adapted from "The Worm Guide: A Vermicomposting Guide for Teachers".

Problem	Possible causes	What you can do to fix it
Strong, foul odour	Not enough air in the worm farm	Incorporate air by manually fluffing the bedding; ensure bedding and compost are not blocking the air holes
	Too much food in the worm farm	Food worms less food or less often
	Meat, dairy, or oily substances are in the worm farm	Remove any meat, dairy, or oily substances from the worm farm
	Too much moisture has created anaerobic conditions	Add bedding material to absorb moisture
Fruit flies	Top layer of food is exposed	Add bedding to the top of the pile
Ants		Place the feet of the stand in water or use ant repellent such as neem oil or chilli solution (see biopesticide recipes on page 44)
Mites		Avoid adding food with very high moisture content, such as fruit
Wet, leaking pile	Too much water added to bedding	Stop adding water; add paper or other absorptive bedding material to soak up some of the water
	Too many high-moisture foods added to the pile	Add fewer fruit/vegetable scraps and more dry foods like leaves and grass

3.3 Seed selection

Caution

Spiderplant and African Nightshade seeds need to rest after harvesting. Germination tests and seeding should not be done for 2-3 months after harvesting. Jute Mallow should not be sown within 4 months of harvest.

Selecting high-quality seeds can save farmers time (labour) and money. Look for seeds that

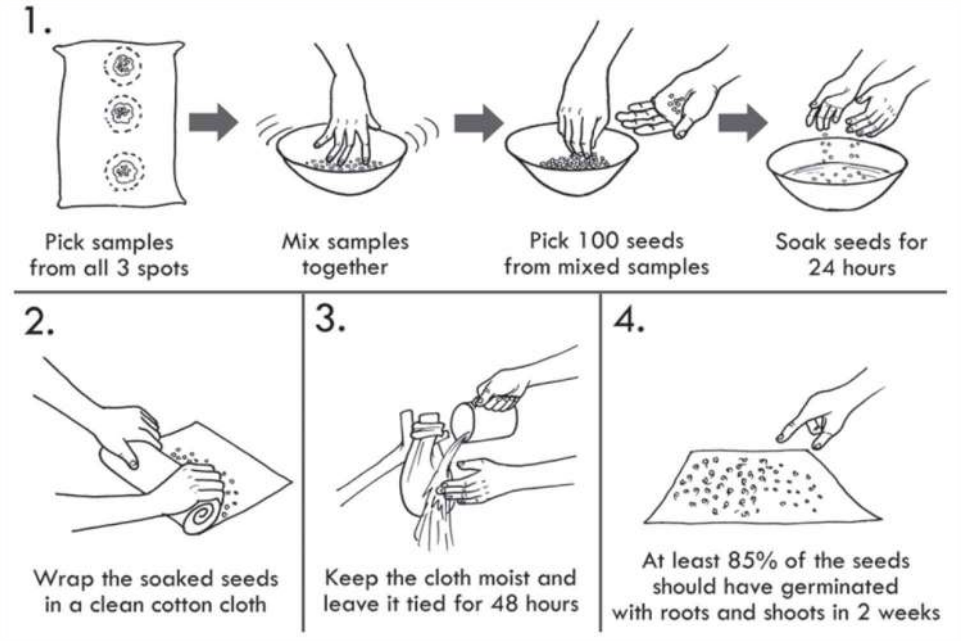
- are not mixed with any other seeds,
- have a high germination rate (85 out of 100 seeds are able to germinate),
- produce healthy seedlings, and
- are not damaged.

Germination tests

Every seed that fails to germinate means a food and profit loss for the grower. It is therefore critical to ensure the seeds are capable of germinating by running a germination test 2-3 weeks before sowing. Instructions on how to conduct a germination test are provided in the box on the next page. If the germination test shows that the germination rate is low (fewer than 85 of 100 seeds are able to germinate), the seeding rate could be adjusted to account for lack of germination or the farmer might consider finding another seed source.

Box 3: Germination testing

Before sowing, test seed for viability and germination potential by conducting a quick germination test.



Steps

1. Collect seeds from the top, middle, and bottom of the seed bag. If you have more than one bag, take samples from each bag. Count out 100 seeds (use 50 seeds if you have only a small amount of seeds). Soak the seeds in water.
2. After 24 hours, drain the water and wrap the seeds in a cotton cloth. Fold the cloth so that it can be tied to a stick to encourage drainage from the cloth.
3. Lightly water the bag three times a day to keep the cloth lightly moist.
4. After 48 hours, untie the cloth and count the seeds that have fully germinated (only count those in which both the shoot and roots have emerged).

If the shoot and root of at least 85 of the 100 seeds (or 43 out of the 50 seeds) have emerged within 2 weeks, the seeds are good quality and can be used for planting. If less than 85 sprout, farmers should increase the seeding rate at planting. If less than 40, farmers should abandon the seeds, since they will lead to poor yields.

Sources of seeds

Unlike farmers growing hybrid varieties of vegetables, farmers planting AIVs may source seeds from many places. Community seed sharing of open-pollinated varieties helps farmers avoid paying for seeds and maintains the right to those seeds in the community. Seeds can be bought in open markets and agrovets (shops that sell agricultural inputs). Farmers may request improved varieties of AIV seeds from research institutions, such as KALRO with local extension workers and university researchers. These institutions work with farmers over the long term to develop varieties that are reliable, high quality, and meet farmer and consumer preferences. Seed companies also produce good seeds that are not necessarily improved in terms of traits, but, ensure checks such as purity.

Caution

The quality of seeds is greatly reduced if stored for more than two years. When buying commercial seeds, it is important to check the packaging dates indicated on the packets. The seed are also not necessarily improved and sometimes the variety traits are not indicated and therefore may be disappointing after growing e.g. for spiderplant.

Seeds should be sealed in airtight containers such as polythene bags, plastic containers, or bottles to prevent contact with moisture. Traditional calabashes can also be used. Before sealing the seeds into containers, mix ash with the seeds until the seeds are completely dusted. This helps prevent fungal growth and deters weevils.

4

Growing AIVs

4.1 Planting your crop

Activity suggestion

To help you understand land preparation practices and techniques, we suggest you conduct Activity 3 on page 74.

Local weather and climatic conditions and the planting recommendations for each plant must be considered when choosing the best time to plant AIVs in your field. Generally, farmers in all regions of Kenya should sow at the onset of rains during either or both of the two rainy seasons or the one rainy season in the northern and northeastern areas of Kenya.

Best time to plant

The best time for sowing depends on the individual crop requirements and the individual requirements as highlighted on pages 12-18 of Chapter 2.

There are two common ways of planting seeds: planting seeds in a nursery then transplanting seedlings into the field later or planting seeds directly into the field (see Box 4). African nightshade and Ethiopian kale do best when they are grown in a nursery then transplanted. When planting in a nursery, it is advisable to plant the seeds in the seedbeds three weeks before the expected onset of rains, so that they are ready for transplanting when the rains come.

Locally constructed nursery. Farmers should adapt their nursery designs according to available materials, their own needs, and their own environment.

Farmers wishing to construct their own nurseries can do so using simple materials. When constructing, be sure to use sturdy poles and untorn netting with a fine mesh to prevent birds and rodents from entering the nursery. Using netting from mosquito bednets is strongly discouraged. Netting is inexpensive and can be found in most agricultural supply stores. Constructing a roof is necessary to prevent birds from eating seedlings. While this picture shows a fairly large walk-in nursery, it is also perfectly acceptable to sow seeds into a regular bed and to completely surround that bed with netting supported by sticks.

Caution

African nightshade and amaranth seeds are very small. If not evenly distributed, too many seeds will grow in the same spot and result in overcrowding, competition for soil nutrients, and reduced yields.

When transplanting, the following spacing guidelines are recommended.

AIV	Spacing		Germination	Direct seeding or transplanting
	Between rows	Between plants		
Nightshade	30 cm	15 cm	5 – 6 days	Both
Amaranth	30 cm	15 cm	2 – 3 days	Direct
Cowpea	Creeping types: 50-60 cm Standing types: 10-15 cm	15 cm 10 cm	3 – 4 days	Direct
Ethiopian kale	50-70 cm	35 – 50 cm	3 – 4 days	Both, but transplanting more common
Spiderplant	50-60 cm	20-30 cm	5 – 9 days	Direct

Box 4: Planting methods

Method 1: Nursery and transplanting method

Seeds can be planted in a nursery either in small pots or into a seed bed. Using pots protects the seedling roots during moving and transplanting.

Materials

- Plastic trays or small pots made from banana leaves/old newspaper sealed with wooden toothpicks (optional)
- Good-quality soil, sand, and compost (if available)
- Seeds
- Shade cloth or other materials that can be used to shade young seedlings

Steps

1. If planting in beds, build sunken/raised beds during the dry/rainfed season and flat beds during the rainy season. Ideally, the soil in your nursery should be a mixture of soil, compost, and sand in a ratio of 3:2:1.
2. Mix the seeds with sand in a ratio of 1:4 and sow in rows in beds or pots.
3. Leave the seeds to germinate for three week.
4. Regularly irrigate the beds/pots. Care should be taken to not overwater to avoid dampening off seedlings which will encourage disease
5. After three weeks, transplant the seedlings. The best time for transplanting is the late afternoon when the sun is less hot. When uprooting the seedlings, be careful to include the soil around the root to avoid damaging the roots. Transplant intertwined seedlings together rather than risk damaging the roots while untangling them. Transplant the seedling in 8-10 cm deep holes following the recommended spacing for each crop (see opposite page).
6. During the first week, it may be necessary to shade the beds/pots.
7. Water the seedlings thoroughly after transplanting

Method 2: Direct planting

Material

- Seeds (2kg per acre)
- Well-decomposed compost and dry soil mixed in a 1:10 ratio (8kg per acre)
- Empty water bottle
- String

Steps

1. Mix the seeds with the soil/manure mixture in a bowl and tip it into a bottle.
2. Use a string and short sticks to make rows as per the spacing recommendations given on the opposite page.
3. Use a stick to make a 1 cm deep farrow under the string.
4. Tip the seed/soil mix from the bottle along the farrow then cover with 1 cm of soil
5. Water the seedlings lightly (particularly amaranth, cowpea, and spiderplant), but do not use excess water as it may cause the seeds to rot or wash away.
6. After three weeks, thin plants to the recommended spacing by removing the weaker/excess plants.

4.2 Irrigating your crop

Irrigation

Supplying water to land or crops to help growth.

Importance of irrigation and water management

Sufficient watering is important for good quality crops. A good irrigation system, such as drip irrigation, helps farmers prolong the growing season and produce crops year round. This ensures higher prices for AIVs during dry seasons when there is little or no rain and the vegetables supply is low in the market. An irrigation system also allows farmers to use parts of their land that would otherwise be less productive or too dry to grow crops and helps conserve water.

Irrigation methods

There are many ways to irrigate crops. To choose the right irrigation method, consider

- the source of available water,
- the size of the land to be irrigated, and
- the amount of money that the farmer is willing and ready to invest.

Many irrigation systems are very affordable to farmers with small farms, for example watering by bucket, hose, channel, or watering can using well water or other domestic water supply, hand pumps, or treadle pumps. Modern methods use a pump system to deliver water through pipes to overhead sprinklers, drip irrigation lines (see picture), or underground pipes (sub-surface irrigation). These modern methods are water-saving and require less labour since they are automated.

Watering rules for different soils

- **Sandy soils** that dominate northern and eastern Kenya require more watering (up to 3 times a week)
- **Loamy sandy soils** are often found in central Kenya and require moderate watering (twice a week)
- **Clay soils** are common in Nyanza and the Rift Valley and drain slowly and hold more water (once a week)

It is important to water the right amount for each crop. Watering too little reduces the size and quality of crops and when plants are watered too much

- plants grow too fast,
- nutrients and pesticides are washed out of the soil into waterways,
- diseases and weed seeds spread with the overflowing water, and
- it is expensive in terms of labour and water costs.

Best time to water plants

It is better to irrigate in the late afternoon (after 5 pm) to avoid evaporation from the soil surface caused by strong heat from the sun. This helps to save water. Farmers with large land holdings and limited labour or irrigation equipment could irrigate during the day, or when using drip irrigation.

Pouring method

Always water the soil directly. Overhead irrigation can increase the spread of diseases and leads to water loss through evaporation before the water reaches the root.

Pauline Omondi waters her plants using a treadle pump using water harvested during the rains.

Photo by CCAFS is licensed under CC BY-NC 4.0: https://ccafs.cgiar.org/resources/photos

AIVs' water requirements

African nightshade, amaranth, cowpea, Ethiopian kale, and spiderplant are eaten green and fresh. They need enough water from planting to harvest. When water is not enough, the plants become shorter with smaller, darker and sometimes bitter leaves.

While specific recommendations for each AIV are provided below, a general rule of thumb for watering AIVs is: Once there is a uniform growth, give around 2 litres per m^2 every time you irrigate then increase the amount of water to around 3 litres per m^2 when the growth increases and to 4 litres per m^2 just before harvesting.

- **African nightshade**: African nightshade requires frequent watering in the first week after transplanting, particularly during the dry season. After that, watering can be reduced to about three times a week, depending on the season, soil, temperature, rain, and mulching. After partial harvesting, regrowth is slow, so plants should be watered more often.
- **Amaranth**: Frequent watering is essential for this fast-growing crop that flowers late. If plants get too little water, they will begin to flower and stop producing leaves. Water needs depend on the crop growth stage, type of soil, and weather conditions (hot or cold and/or windy).
- **Cowpea**: Cowpea builds very deep roots. Cowpea tolerates drought, which makes it a good crop for semi-arid areas. Although cowpea tolerates drought, it is necessary to water regularly when it is being grown as a leafy vegetable. Overwatering cowpea lowers the soil temperature and slows growth. If the crop is grown for seeds, it is very important to water well during flowering and pod formation. Avoid standing water at all stages of growth for maximum yield and quality.
- **Ethiopian kale**: Ethiopian kale has a long and complex root system, making it able to tolerate having little or no water for a short while. For high yields and better quality, frequent watering is advised. When plants receive too little water, they stop producing new leaves, start flowering, and produce poor quality seeds. Ethiopian kales cannot survive overwatering. Water the crop soon after fertilising the soil surface at the end of the first harvest.
- **Spiderplant**: Spiderplant need medium amounts of water throughout their growth. Too much or too little water will cause them to flower early or develop small leaves. When soil starts cracking around the plant, apply mulch to preserve water.
- **Jew's mallow**: Jew's mallow is usually grown as a rainfed crop. In peri-urban production, growers manually water at least 6mm during the dry season.

Water storage

Irrigation water can be obtained from rivers, streams, individual or shared wells, boreholes, and rain water. Irrigation water can be shared in communities where there is a common water source where water can be channelled to every farmer using pipes or ditches.

This small dam of rainwater is pumped using solar power to crops during the dry season. Simpler systems are equally beneficial.

Store water when it is plentiful during the rainy season to use during the dry season when it is scarce. Stored water helps to improve management of irrigation water, irrigation planning, and irrigation scheduling while helping supply water consistently. Water can be harvested during the rainy season and stored in plastic water tanks, concrete water tanks, or dams.

Water quality

The quality of irrigation water is very important. Water quality is determined by pH, presence/absence of heavy metals and hard water salts such as calcium and magnesium that can clog irrigation systems, and presence/absence of distinct toxic ions. It is therefore vital to establish the presence or absence of soluble salts by carrying out water tests in a laboratory that is equipped to test water for irrigation purposes.

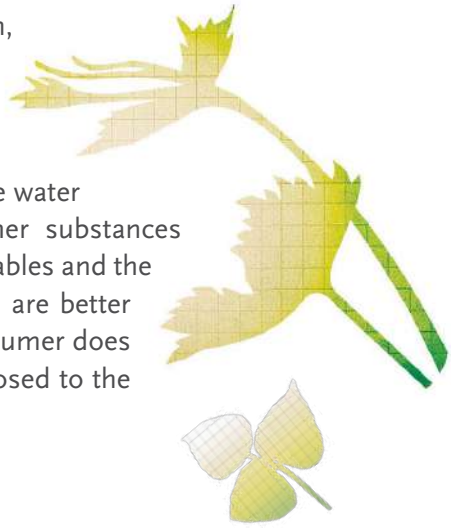
Caution

If you see white patches on the soil surface when the soil is dry, then you need to test the water for pH.

Water used in agricultural production should be clean and free from any kind of waste that is harmful to human health. This is because the waste is taken into the plant stem and leaves and will end up in the body, which is harmful to human health and can cause diseases.

To ensure good water quality

- do not dispose of waste near water bodies (lakes, rivers, and dams)
- do not use water your plants with water that may contain industrial waste, pesticides, or human and animal waste,
- cover water storage tanks to avoid contamination,
- use filters to clarify water prior to irrigation, and
- be careful when using recycled water from households or wastewater on your crops. These water sources may include faecal coliforms or other substances which may compromise the quality of the vegetables and the health of the consumers. These water sources are better used on tree crops or other crops that the consumer does not eat parts of the plant which have been exposed to the contaminated water.



4.3 Mulching your crop

Mulching is not new to Africa, in fact, smallholder coffee producers mulched their plots as early as 1883. While inexpensive and effective, mulching does not get enough attention in Africa. Covering the soil surface around the crops helps to create a better environment for crops. Mulching has so many great benefits to farm productivity, soil health, and the environment:

African Nightshade crop protected by a mulch layer of dried grass

Mulching

Mulch is a protective layer of material which is spread or left on the soil. Mulch is usually organic in nature (for example, straw, leaves, wood chippings, dry grass clippings, rice husk, etc).

- Mulching reduces evaporation from the soil and, thus, allows farmers to reduce the number of times they need to water their crops.
- It also reduces soil erosion caused by heavy rains which means that the most fertile top soils are maintained.
- As the mulch decomposes over time, it creates a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and helps water infiltrate the soil.
- Mulching reduces the growth of weeds as it deprives them of sunlight
- Mulching creates shade and cools the soil, allowing tender roots and young plants to thrive in hot conditions.
- In cases where the aesthetics of your produce is important (strawberries, for instance), mulching reduces the amount of soil and water splash on fruits.
- Don't use wet or green material for mulching.

Box 5: How to mulch your vegetables

The best time to mulch is when the plant growth is uniform and the stems are strong enough to withstand some manipulation as the mulch is applied (usually 3-4 weeks after transplanting).

Materials

Dry grass, old leaves, wheat straw, wood chips, sugar cane trash, banana leaves, cereal, fodder crop straws and stalks. Green materials cannot be used. Be aware of potential weed seeds in the mulching material to avoid bringing weed seeds into your field.

Steps

1. Cut mulch material into pieces of 10-12 cm using a machete.
2. After weeding around the plants, place mulching material between the plants and between rows. Avoid direct contact with plants as wet mulch which is placed directly against stems may bring about diseases.
3. Cover the soil completely with a 2-5 cm layer of mulching material.

4.4 Controlling weeds in your crop

Weeding your crop means that more resources like soil nutrients, water, and light will be available to your crop. Some manual weeding is usually required as well.

Weeding should be done during thinning (especially for cowpea, Ethiopian kale, and spiderplant) to remove other plants as well as weak plants, off-types, and diseased plants. Remove weeds before they flower to reduce the number of weed seeds in the soil. Late season weeding is not recommended, as crops can be injured by the manipulation and diseases spread among plants as weeders move between plants.

Bag gardens

Bag or sack gardens are tall sacks filled with a mix of soil and humus to grow vegetables. This cultivation method is especially suitable for farmers with very little available space or when healthy soil is not available, for example, in urban settings.

Box 6: How to create a bag garden

Materials

- Bags can be bought at some agrovets (REAL IPM is a common brand)
- If commercial bags are not available in your community, use 2m of fine, dark netting or shade cloth to create a cylindrical bag
- Soil and compost manure
- Palm-sized stones
- Plastic or aluminium can with both bottom and top removed

Steps

1. Add 1 foot (30 cm) of soil/manure mix to the bag and compress it firmly.
2. Place the tin can upright in the middle of the bag and fill it with stones.
3. Surround the tin can completely with compressed soil/manure then slide the can up (leaving the stones in a column in the middle of the soil) and continue packing soil/manure around the can until the bag is full. Compact equally on all sides, otherwise the bag will weaken and collapse!
4. Water the whole bag until the water pours out of the bottom.
5. Make holes in the bag one hand-width apart.
6. Plant seedlings in the holes and on top.
7. Add a 1-metre long wooden stick at the centre of the bag to deter birds.
8. Add 20 litres of water once a week and again before final harvest so that roots can be taken out easily.

4.5 Managing pests & diseases in your crop

The first and best defense against plant diseases and pests is a healthy plant. Preventing and managing plant pests and diseases begins even before planting with farmers selecting suitable sites and crops that grow well on that site. It carries on through the plant life cycle with the farmer providing good nutrition and regular watering to plants to make them stronger and more able to cope with attacks from pests and diseases.

Pest and disease management should be part of farmers' daily routine. Checking fields regularly allows farmers to take swift action as problems appear. The most critical issue for profitable management of pests and diseases is getting the correct diagnosis. Extension workers can advise on pest and disease identification and management.

Plant diseases

The most common diseases seen in AIVs in Kenya are blight and black/leaf spot.

Disease	Description	Symptoms	Control
Blight	Blight is caused by bacterial, fungal, or viral infections resulting in sudden wilting and dying of affected plant parts. Rain, overhead irrigation, insects, or gardening tools spread the disease. High temperatures and wet, humid conditions promote its rapid spread. Undernourished and stressed plants are often attacked.	Symptoms first appear on the lower, older leaves as small brown spots with concentric rings that form a bull's eye pattern.	• Keep the soil under plants free of wastes. Add a layer of organic compost. • Reduce fungal spores by pruning affected leaves or plants. • Remove and destroy all remains of infected plants after harvesting and practice crop rotation the next planting season. • Burn or bag infected plant parts and do NOT use for making compost.
Black/ Leaf Spots	Pathogen-caused black spot or leaf spot diseases are caused by bacteria and by fungus. They spread in humid and warm temperatures. Prevention and treatment of both types involve the same practices.	Infected plants have brown or black water-soaked spots on the foliage, sometimes with a yellow ring, and are very similar in size. The spots grow larger and larger under wet conditions. As spots become more numerous, entire leaves may yellow, wither, and drop.	• Use a thick layer of mulch to reduce weeds and prevent the disease pathogen from splashing back onto leaves. • Prune plants to improve air circulation. Clean and disinfect your pruning tools after cutting affected plants. • Ensure seeds and transplants are from disease-free stock. • Spray neem oil (do not use when pollinating insects including bees or other beneficial insects are present). Baking soda may burn some plant leaves. Spray only a few plants then check for a reaction before applying every two weeks.

Plant pests

As previous stated, the first and best defense against plant diseases and pests is a healthy plant. Weed control, removal or incorporation of plant remains (the parts that are left after harvesting), and proper watering are important practices that can prevent and reduce pest infestations.

Remember the "Golden Rule": The best pest control method is to prevent pests in the first place!!!

IPM

Integrated pest management is a key component of agro-ecology and an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices: setting economic thresholds for crop loss, active monitoring, prevention, and control.

Farmers are well advised to use an integrated pest management, or IPM, strategy that involves a combination of pest-control techniques. In Kenya, chemical pesticides are used widely by smallholders despite their awareness of the risks to human health and the environment. They should be viewed as a last resort. When pesticides are needed, the least toxic product should be used. Biopesticides are recommended over chemical pesticides and are seen as substitutes to synthetic products, not accompaniments. Some biopesticides, such as those derived from neem (Azadirachta indica) are in common use in Kenya. Soap or cleaning detergent (which you can buy at the agrovet, like Teepol) are also effective on aphids, mites, and mealy bugs.

Biopesticides

Biological pesticides or "biopesticides" are pesticides derived from nature: animals, plants, bacteria, and minerals. Biopesticides usually work through predatory, parasitic, or chemical relationships.

It is important to identify pests and their damage symptoms in order to effectively control them and minimise yield losses and pest control costs. Agricultural extension workers may also be able to advise on pest identification and management. The below description of common pests may also be useful.

There are different groups of insect pests that damage African leafy vegetables.

- Sucking arthropods such as aphids, red spider mites, mealy bugs, whiteflies, and leafhoppers pierce plant tissue and suck plant juices. Damaged foliage is usually mottled; other symptoms may be wilting, scorched leaf tips, or puckering and curling.
- Thrips cause yellowing in leaves and restrict growth.
- Caterpillars, beetles, and grasshoppers chew and make holes in the leaves.
- Other common pests on AIVs are leaf miners, stem borers, and fruit borers.

Biological control

Natural enemies include predators, parasitoids, and pathogens. Predators, such as lady beetles and lacewings, consume a large number of prey during their lifetime. Parasitoids are species whose immature stage develops on or within the host, ultimately killing the pest. Many species of wasps and some flies are parasitoids. Pathogens are disease-causing organisms including bacteria, fungi, and viruses. They kill or weaken their host.

Another component of an integrated pest management strategy is to use pests' own natural enemies to reduce pest populations. This is sometimes called biological control. Natural enemies of AIV pests include ladybirds, lacewings, and predatory mites.

Where pest infestations are affecting the field, it is recommended to apply approved bio-pesticides in combination with releasing natural enemies or attracting natural enemies. Mulching also reduces beetles, thrips and leaf miners.

Natural enemies or "Farmers' helpers"

Ladybird

Parasitic wasp

Zelus spp.

Soldier bug

Photos by Jackline Mworia

a) Cowpea aphid

Cowpea aphids are shiny black or dark brown insects with white and black legs. They live in large groups on cowpea and other vegetables. They are often the culprits in fields of wilted plants that seem to be covered in sooty moulds.

Photo by Jackline Mworia

Which crops do they attack?	Cowpea
Where can you find them in the garden?	• Aphids are found on young leaves, stems and pods of cowpea and other vegetables. • They leave a blackish substance on leaves, shoots, and pods called 'honeydew'. After some time, honeydew turns into back soot and attracts flies. Large swarms can be noticed. • During wet weather, an unpleasant rotting smell is released from infected plants when the crop is disturbed e.g. by walking through.
What damage do they cause?	• Limit growth when attack occurs early • Late flowering • Late onset of podding • Low yields
How can I control them?	• Use a resistant cowpea variety such as Ken Kunde 1(KK1). • Apply biopesticide (ICIPE 62). • Intercrop cowpea with cereals like maize. • Boost natural enemies like lady beetle larvae and adults, lacewing larvae and adults, hover fly, and parasitic wasps. This can be done by using friendly biopesticides and maintaining flower strips in or around the field that provide food for the enemies (pollen and nectar).

Box 7: Use of ash in pest control

Wood ash is alkaline and therefore useful as a fungicide and a pesticide. Insects that come into contact with wood ash are burned. It can be used to fight aphids and cutworms.

For cutworm control, sprinkle ash around the base of the crop when transplanting seedling. For aphid control, sprinkle/dust infested plants with ash.

Be very careful to keep the wood ash at least 5cm or 2 inches away from the stem of the plant. Once ash gets wet, it loses it deterring properties. Continual use of ash in this way may increase the soil pH too much or cause high salt levels which are harmful to plants.

b) Nematodes

Nematodes are small worms that cannot be seen with the naked eye. While most of the thousands of nematode species on Earth are not harmful, some cause diseases in humans and other animals or attack and feed on living plants.

Which crops do they attack?	Amaranth, African nightshade, spider plant, jute mallow, and cowpea
Where can you find them in the garden?	• They are in the soil where they mainly feed on plant roots. Some types of nematodes feed on the shoots. • You may first notice a nematode infection when you see circular or oval patches of stunted plants in the field.
What damage do they cause?	• Yellowing of leaves • Early dropping of leaves, flowers, and fruits • Drying and early aging of the plant • Poor yield • Below ground symptoms include: abnormal root development; root swellings; and spots, scars, or dry rots in tubers and root vegetables
How can I control them?	• Use nematode-free planting materials. • Apply compost or manure to strengthen plants; remember: stronger plants are better able to withstand pests and diseases. • Practice crop rotation with maize, sorghum, and millet. • Soil solarisation. This means that solar energy can be used to heat soil to a high temperature to control soilborne pests. It is often done by deep ploughing to bring infected areas to the surface and/or by using plastic mulch to increase soil temperature. • Use repellent or trap crops (Mexican marigold). • Remove and destroy infested plants.

Nematode damage to a nightshade crop
Photo by Jackline Mworia

Nematode damage to a root system
Photo by Jackline Mworia

Use caution: If you see one or more harmful insect species growing on your plants, ACT IMMEDIATELY! Look for their eggs and young and act before the insects become adults and multiply.

c) The black bean aphid

This is a soft-bodied, black or very dark brown insect, sometimes with a greenish colour. It looks very similar to cowpea aphid. It is also commonly called blackfly or beet leaf aphid. Like the cowpea aphid, it also live in colonies and can seriously weaken the plant by sucking its sap.

Which crops do they attack?	Nightshade, cowpea, amaranth
Where can you find them in the garden?	• On the undersides of leaves and the growing tips of plants • You will notice the presence of honeydew. Honeydew is a sugar-rich, blackish, sticky liquid secreted by aphids and some scale insects as they feed on plant sap.
What damage do they cause?	• Drying, wilting, or dying of leaves • Dwarfing. This means that infected plants will be too small • Death of plants
How can I control them?	• Destroy crop remains and weeds. • Rotate crop with non-host crops. • Conserve natural enemies like lady beetle larvae and adults, lacewing larvae and adults, hover fly, and parasitic wasps. • Inspect and spot spray during early infestations.

Box 8: Controlling birds in your fields

Common pests in fields and nurseries, in particular, are birds. To protect your crops against birds, some farmers add scarecrows to their fields.

Steps

1. Construct a cross by tying two wooden sticks together with twine.
2. Drape old clothes or rice bags over the cross to create a human shape.
3. Add ribbons or noisy rattles (for example, strings with bottles tops) which will create movement when they blow in the wind.
4. Move the scarecrow to different locations every few days.

Controlling birds in nurseries

For more information on how to build a bird-proof nursery, see Box 4 on page 31. A photo of an inexpensive, locally-made nursery is provided on page 30. Information on using shade nets to protect against birds is on page 45

d) Beet webworm moth

The beet webworm is a moth found world-wide, but mainly in the tropics. Its larvae (caterpillar) feeds on plants and weaves them together in a web. Larvae are a trans-lucent green with white striping along the body and grow to about 2cm long. It is also called Hawaiian beet webworm.

Which crops do they attack?	Amaranth and African nightshade
Where can you find them in the garden?	• The adult moth lays eggs on young leaves and other growing parts. When the eggs hatch into larvae, they feed on leaves.
What damage do they cause?	• Larvae feed and cause netting of the leaves and growing tips. • You may notice larval waste on leaves (frass). • Leaves start rotting.
How can I control them?	• Remove weeds from the farm and surrounding areas. • Plant resistant plant varieties when pest population are low. • Use biopesticides based on fungus, bacteria, etc. • Boost natural enemies.

e) Red spider mite

Spider mites are tiny tick-like crop pests with an oval shaped body which may be greenish-yellow, transparent, brown, and red-orange in colour. Once you notice an infestation, you will likely find red spider mites everywhere on the plant. Take care of the infestation before the plant becomes permanently damaged!

© Jackline Mworia

Which crops do they attack?	African nightshades, Amaranth, Jew's mallow
Where can you find them in the garden?	• Spider mites are found in colonies, mainly in tight webs that they form on the underside of leaves, and feed by cutting into the leaf tissue and sucking the plant fluids.
What damage do they cause?	• They first cause spots on leaves. • Leaves may change colour from yellowish the brown. • Leaves become deformed and fall off.
How can I control them?	• Plant resistant/tolerant varieties during the wet and cool seasons when mite populations are low. • Remove and destroy infested plant material. • Boost beneficial insects, such as ladybugs, lacewings, and predatory mites. • Monitor and make spot applications of biopesticides on infested sections or plants on the farm.

f) Whitefly

Whitefly (Trialeurodes vaporariorum) is a very small insect that sucks the juices from the underside of new leaves, which can cause stunted growth, leaf yellowing, and reduced yields. As a result, plants become weak and vulnerable to diseases.

Which crops do they attack?	African nightshades, Amaranth, Jew's mallow
Where can you find them in the garden?	• Whiteflies often attack in crowds and can be found on the undersides of leaves. When infested plants are disturbed, groups of the winged adults fly away from the plant. • Like aphids, whiteflies produce honeydew, so leaves maybe sticky or covered with a black sooty mould.
What damage do they cause?	• Both nymphs and adults damage plants. • Whitefly suck sap and secrete large amounts of honeydew that supports harmful infestations of sooty mould. • They inject saliva that may harm the plant more than either the mechanical damage of feeding or the growth of the fungi. • The whitefly transmits almost 60 viral plant diseases.
How can I control them?	• Add yellow sticky traps to monitor and suppress adult populations. • If possible, spray plants with a strong stream of water and reduce pest numbers. • Boost natural predators like ladybirds, which feed on their eggs and the whitefly parasite, which destroys nymphs and pupae. For best results, make releases when pest levels are low to medium. • Spray neem oil on affected vegetables to kill eggs, larvae, and adults. Mix 1 oz of oil to every gallon of water and spray all leaf surfaces (including the undersides of leaves) until completely wet.

Yellow sticky traps

Whiteflies are attracted to yellow paper. To make your own sticky trap, buy yellow polyphane paper (of at least an A5 paper size), smear it with molasses or sticky glue, and hang the card in your garden.

Box 9: Homemade biopesticides

Recipe 1: Garlic–Chilli mixture for aphids, whitefly, and fungi

By expert Stephen Kamau (CSHEP)

Materials

- 2 bulbs of garlic
- 3 pieces of fresh chilli
- 4 cups of water
- Sprayer

Steps

1. Mash and mix all ingredients very well.
2. Strain the mixture with a sieve.
3. Pour the mixture into a sprayer and spray generously onto your crops (Should be used immediately after production).
4. Repeat after 2 weeks.

Recipe 2: Mexican Marigold (Mubangi) for pests and fungi

By expert Stephen Kamau (CSHEP)

Materials

- 3 handfuls of Mexican marigold leaves
- Water
- Molasses
- Sprayer

Steps

1. Soak the Mexican marigold leaves in 5 litres of water for 7 days.
2. Mix with fresh water at a ratio of 1:2 solution and water.
3. If the smell is too bad, mix with molasses.

Recipe 3: Neem oil for white fly, aphids and red spider mites

Sourced from Dr. S. Sridhar (https://agritech.tnau.ac.in/itk/itk_crop_traditional_pesticides.html)

Neem (Azadirachta indica) is a tree native to Asia, which is planted widely around the world for its use as a natural pesticide. In addition to being an insecticide, it has been used against fungi, nematodes (worms), and bacteria. Neem repels insects and stops their digestion, metamorphosis, and reproduction.

Materials

- 500g of neem seeds
- Sprayer

Steps

1. Wash and remove the husk of mature neem seeds and allow to dry completely.
2. Grind twelve handfuls of dry seeds into a fine powder, mix with 12 litres of water, and soak overnight (alternatively, use 500 grams per 10 litres water).
3. Strain the liquid and apply with a sprayer.

Box 10: How to apply biopesticides

Adapted from FiBL and BioRe (2014)

The correct application

- Clean your pump before use to avoid contamination from previous content.
- Use biopesticides prepared just before use as they are the most effective.
- Only the plants that you spray are protected! Always spray the whole leaf area, from top to bottom and all four sides. Try to apply the spray to the underside of the leaves as well, as this is where most pests hide.
- Protect yourself by covering up. Wear long sleeved shirts and trousers when spraying. Protect your mouth, nose, and eyes.
- Empty the pump completely after use and wash with water.

The correct time

- Insects are most active in the morning and late evening time, so you should spray during these hours.
- Some products can react with the sunlight and cause leaf burn to the plant. Therefore, never spray during midday on clear, sunny days
- During rainy season it can be difficult to find a good moment to spray. For biopesticides to work, spray at least two hours before the next rainfall.

4.6 Using shade nets

Agricultural nets can help improve the development and yield of vegetables. They help to increase or decrease air temperature and the quality and intensity of the sunlight. They also protect the crops from wind, heavy rain, or drought as well as birds, insects, and pests. Shade netting is low cost and can be used repeatedly, if handled carefully.

Agricultural nets are available in different colours. Most common in Kenya are dark green and black nets, which can be bought in larger towns or cities at irrigation specialist stores or companies that construct greenhouses. In 2018, one m^2 cost about 80 KES. Mesh sizes vary between 0.6 to 70 mm and have different shading factor as shown below.

Application	Mesh size in millimetre	Shading in %
Shading	0.6 – 3.0	90 – 25
Windbreak	1.8 – 7.0	70 – 30
Anti-hail	2.5 – 4.0	25 – 10
Anti-insect	0.2 – 3.1	20 – 10
Anti-bird	30.0 – 40.0	15 – 5

If only a small piece of shade net is available, it can be used in nursery beds to help seeds germinate. After adding the seeds to the soil, cover the area with black netting. The net will keep the heat and moisture close to the seeds and speed up germination.

Young African nightshade seedlings, in particulary, are eaten by birds. To protect seedlings, place 1m wooden sticks around the nightshade bed or field. Extend the netting across the top. When the plants are longer than 30-40 cm, remove the sticks and netting.

Scarecrows

While using shade nets is suitable for controlling birds in small areas, using scarecrows might be a better option for large areas. See page 41 for instruction on how to build one.

4.7 Factoring in climate change

How is climate change affecting farmers?

In the humid zone (Kakamega), semi-humid zone (Nakuru), and semi-arid zone (Kajiado), farmers have experienced

- increased temperatures,
- erratic rainfall patterns (rain starts late and ends early and seasons are unpredictable),
- more intense and more frequent droughts, floods, and dry spells, and
- more intense and more frequent extreme weather events such as storms.

Climate change

Climate change is a change in the climate parameters (temperature and rainfall) continuing for several decades or longer—usually at least 30 years.

How has climate change impacted AIV production in Kenya?

Long dry spells cause a decline in yield, therefore, many farmers producing AIVs have stopped dry season production as water shortages have been increasingly common and current irrigation infrastructure is insufficient.

Farmers are reporting more pest and disease attacks, especially during the dry season. The most common complaints include aphids, whiteflies, and rust in vegetable cowpea during the dry season. African nightshade crops are experiencing moderate outbreaks of red spider mites, whiteflies, aphids, and bacterial wilt in the dry season and severe bacterial wilt and bacterial blight and moderate powdery mildew during the wet season.

Current research

On pages 9 and 10, observations around climate change in Kenya made by HORTINLEA researchers working on AIVs are shared.

What can farmers do to adapt?

- Invest in rain water harvesting and management technologies, like building and/or purchasing water storage tanks, to save water for irrigation
- Invest in technologies like drip or sprinkler irrigation to use water more efficiently
- Plant trees around the farm to act as windbreaks, reduce soil erosion, enrich soil, filter water, improve water quality, and provide shade for shade-loving plants
- Practise crop rotation, for example: Cowpea or Jute Mallow > Slenderleaf > Spiderplant > Maize > Ethiopian kale > African Nightshade > Maize > Amaranth
- Apply mulch between crops to preserve soil moisture
- Change planting dates on rainfed farms to coincide with the start of the rains
- Plant more than one crop on the same plot, for example maize, cowpea, and amaranth to maximise productivity
- Use improved, drought-tolerant seed varieties

Which AIVs are most climate-change resistant and why?

We encourage farmers to plant pumpkin (malenge, seveve), wild amaranth, slenderleaf, jute mallow, and Indian spinach (nderema). These crops are more tolerant to changing climate conditions, pests, and diseases.

- Pumpkin (malenge, seveve) harbours pests, but is not attacked by them. Its roots along its stem can utilise water from surrounding soil. Pumpkin represses weed growth since its leaves and stems completely cover the soil surface (self-mulching)
- Amaranth (terere) has a long taproot, enabling it to get water from under the soil
- Slenderleaf (mitoo) is bitter and hence not preferred by pests
- Jute mallow (mrenda) is slippery, hence does not offer a surface for pests to hide
- Indian spinach (nderema) is slippery hence less attacked by pests. It does not require a lot of water because of it stores water in its succulent stems

4.8 Keeping records as you grow AIVs

Good record keeping is as a major determinant of farm efficiency. Record keeping helps farmers consider their past actions, make better decisions, and plan for the future. By knowing what crop grew well and under which conditions (for example, when the field was fertilised) and what approaches were more or less successful (for example, selling at the local market or growing a new maize variety) will help you make better decisions in the future.

By keeping records farmers can monitor and reflect on many aspects of farming:

- On what part of the farm do different vegetables grow better?
- What plots on the farm need more fertiliser?
- Which parts of the farm are more dry/wet?
- What varieties grow better?
- Which pests and diseases attack which crops and when?
- What method helped to fight this pest best?

Farm production plan

Draw a plan of your farm. Plan what crops you will grow and where. Consider adding one or more smaller patches for testing a new crop or new variety. After harvesting, you can return to the farm production plan and see if you met your targets. You can plan ahead and improve in the next farming season, based on your past experiences.

Here is an example of a farm production sheet that can give you ideas about the type of information you might record.

Season/ Year	Crop	Land size (Acres/m^2)	Expected yield	Total yield (bags or kg)	Notes (Challenges, changes)
May-Nov 2018	Cowpea (Variety X)	7m x 15m = 105 m^2	300kg	150kg	• Less yield because of too little water during first 1-2 months • Grow more draught resistant variety or grow another crop
May-Nov 2018	Spiderplant	5m x 10m = 50m^2	100kg	125kg	• Very good variety • No pest and diseases recorded • Achieved good prices on the market

Production sheets

Below, we give an example of one type of production plan. On the following pages, you can find additional templates on how to create farm production records. Please feel free to adapt the examples to better suit your needs; for example, using bags, bunches, kilograms, grams, or other measurements to record yield.

Financial record keeping

Keeping financial records of all the expenses and income from your farm will help you understand

- which of your crops are the most profitable (give you the most profit);
- what are your main costs (inputs, labour, transport, etc);
- whether you are making a profit or a loss when selling your vegetables;
- when input prices increase, so you know when to look for alternatives (for example, by making your own fertiliser);
- when and where you get the highest profits (what market or trader); and
- areas where you can set new goals/targets (for example: increase profits by 20% in the next season).

In addition to recording your sales (income), be sure to include your expenditures too. These might include:

- Inputs (fertiliser, compost, pesticides, seeds),
- Labour (during field preparation, weeding, or harvesting);
- Transport
- Packaging
- Market fee

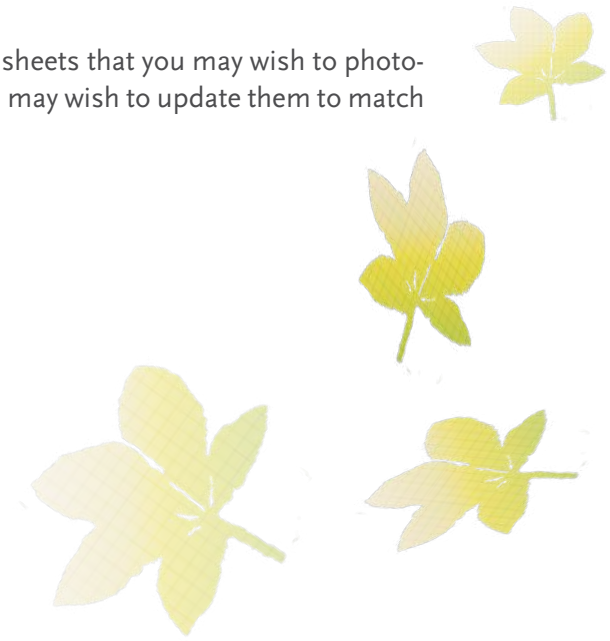
Financial record keeping

Here, we provide an example of a financial record sheet. On pages 49 and 50, you will find a template which you can photocopy or copy into your own notebook and make your own recordings on farm income and expenditures.

Here is an example of a financial record keeping sheet

Date	Description	Income	Expenditure	Comments
2. Oct. 2018	Bought biopesticide from Kisii Agrovet	-	500 KES	Price has increased from last year > see if other agrovet sell cheaper or if I can use other products instead
15.Oct. 2018	Sold 20 bundles cowpea	240 KES	-	

Next, we provide some farm record sheets that you may wish to photo-copy and use on your own farm. You may wish to update them to match your own particular situation.



A) Farm production record

Crop: _____ Variety: _____ Year/Season: _____

Topic	Pre-planting	During planting season	Post-harvest	What worked / did not work? Why?
Soil type and preparation	Compost added? Yes/No What type of compost: Suitable soil for the crop? Yes/No	Compost well absorbed? Yes/No		
Seed source	Source: Date bought/ harvested: Germination test done: Yes/No Germination rate: ____%	Good leaves size: Yes/No Good plant size: Yes /No Was the crop / variety productive? Yes/No	Taste? Bitter/ Not bitter Good plant size: Yes /No Good seeds: Yes /No	
Water quantity and quality	Type of irrigation	How often: How much: Source of water:		
Mulching		Mulching material: Date of mulching:		
Pest and diseases	Pests in this field or crop in the last season: Diseases in this field or crop in the last season:	Pests in this field or crop: Method(s) of reduction: Effective: Yes/No Diseases in this field or crop: Method(s) of reduction: Effective: Yes/No	No/medium/ small/good/ very good harvest Estimated yield loss due to pest attacks: Estimated yield loss due to diseases:	

Farm production record

Production records are used to document everything that is produced on the farm and the conditions on the farm. This is a very simple example of a record sheet that can be used at the end of each season. You may find that you wish to design your own record sheet which can be prepared every week then summed up at the end of the month and end of the year. Or, you may adapt the examples to better suit your needs; for example, using bags, bunches, kilograms, grams, or other measurements to record yield.

B) Multiple season/year production record

Season /Year	Crop & Variety	Land size used	Expected yield	Total yield (bags or kg)	Comments • What could be improved in the next session? • Goals for the next season?

Production record

This is another format of a production record. Used over multiple seasons or years, you will start to have a better understanding of how much of certain crops you want to grow (if at all) and on how much land in order to gain maximum profit. Copy this form into your own notebook and add more rows. You may update the form so that it better suits your needs, if you wish. For example, you might find that writing yield as kilograms or bunches may be easier for you.

C) Financial record keeping sheet

Name: _____ Year: _____ Farm size: _____

Date	Description	Income (KES)	Expenditures (KES)	Comments

Financial record sheet

This is a very basic form to help you assess how much money you spend on your farm and how much you make from it. Copy it into your notebook and add more rows as needed.

5

Harvesting AIVs

Over 50 % of produce is lost (which means it is not fit for human consumption) from the field to the consumer due to poor production conditions and handling at harvest. Farmers are partially accountable for this food loss:

- They are unaware of the best harvest time for each crop and may harvest too early or late.
- They use poor harvesting methods.
- They use poor post-harvest storage methods (usually meaning that AIVs are stored in a place that is too warm and dry).

5.1 AIV harvesting technique

Caution

When harvesting, pick only the edible leaves of AIV and leave the stem, shoots, and roots in the soil. This will help maintain nutrients in the soil.

Studies have shown that, compared to maize, AIV production significantly increases the carbon in soil (Engels et al, no date), which improves soil fertility. The best way to add carbon to the soil is to NOT pull the plant with its roots completely from the soil, but to follow a continuous harvesting technique. In this technique, leaves and tender branches are pinched off and harvested every 7-14 days. Farmers can further improve their soil by digging all inedible plant residues back into the soil after the final harvest.

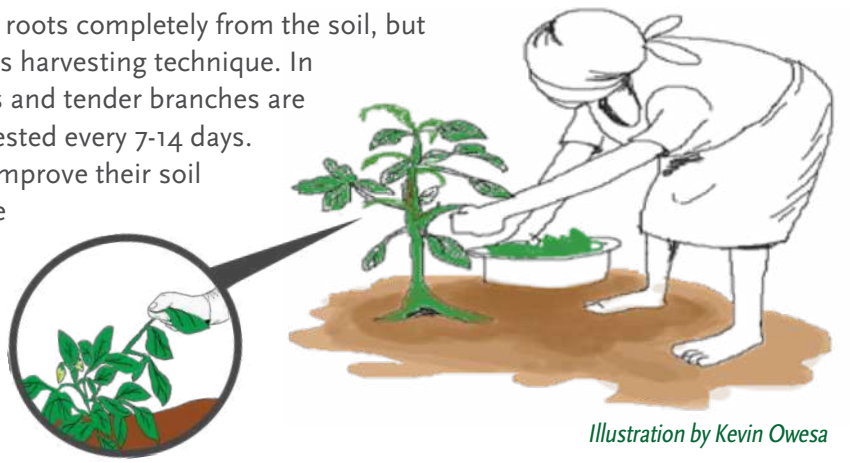


Illustration by Kevin Owesa

5.2 Best time to harvest your crop

The best time to harvest AIVs are listed in the table below:

AIV	Maturity	Harvest method
Nightshade	4 weeks after transplanting or 40-60 days after direct planting.	Stems are picked approximately 15 cm above the ground. This allows new side shoots to develop. Picking is done weekly
Amaranth	45 days after planting	Leaves and tender stem are picked every 1-2 weeks at 15-20 cm above the ground until flowering. The harvest can continue for 4 months, especially in local varieties
Cowpea	2-4 weeks after planting	Continuously pluck tender leaves before they get tough and stringy. Always leave 3-4 leaves and buds to prevent the plant from dying.
Ethiopian kale	35 days until 10 weeks	Pluck tender leaves. Repeat through growing season.
Spiderplant	About 20 days (3wks)	Whole plant can be uprooted while still young and tender. Can be harvested repeatedly until flowering

5.3 Saving seeds while harvesting

Quality seeds are important for good crop production. Seeds collected and processed at home are good quality, if processed and stored well.

Using quality seeds ensures

- high germination rate (usually above 85%);
- strong seedlings/plants;
- equal/uniform crop;
- fast growth;
- resistance/tolerance to pests and diseases;
- plants reach maturity at the same time; and
- climate-tolerant crop.

To ensure good quality seeds, harvest from healthy plants only (many plant diseases can be transmitted/passed on through seeds) and wait until fruits are fully mature before harvesting. The best approach is to choose some of the best plants in your field, leave them to mature (without harvesting any leaves!), then collect their seeds. Seeds can also be harvested from good plants after picking the leaves during the final harvest.

There are two main techniques for seeds processing: dry processing and wet processing.

- **Dry processing:** After drying pods 2-3 days in the sun, they are lightly beaten to crush the pods. After drying, the seeds are winnowed, which means they are thrown in the air to blow the outer part of the seeds and any dirt away. The seeds are caught in a woven basked or any other suitable container.
- **Wet processing**: Fruit is picked (Pic. 1). The berries or fruits are put in a bag with small holes, before water is added, and the bag is closed (Pic 2). Fruits are crushed and squashed repeatedly until the pulp (fruit skin and flesh) separates from the seeds. The seeds and water are poured into a basin (Pic. 3). The seeds will float to the top. Separate the floating seeds from the mixture by scooping the seeds from the top (Pic. 4). Seeds need to be cleaned and dried carefully with a cloth. Then place seeds under the shade until they are completely dry (Pic. 5).

Caution

Hybrid seeds are produced from two parents of two different varieties. They often show better characteristics/features, which are lost in the next generation. These plants are NOT suitable for seed saving and replanting.

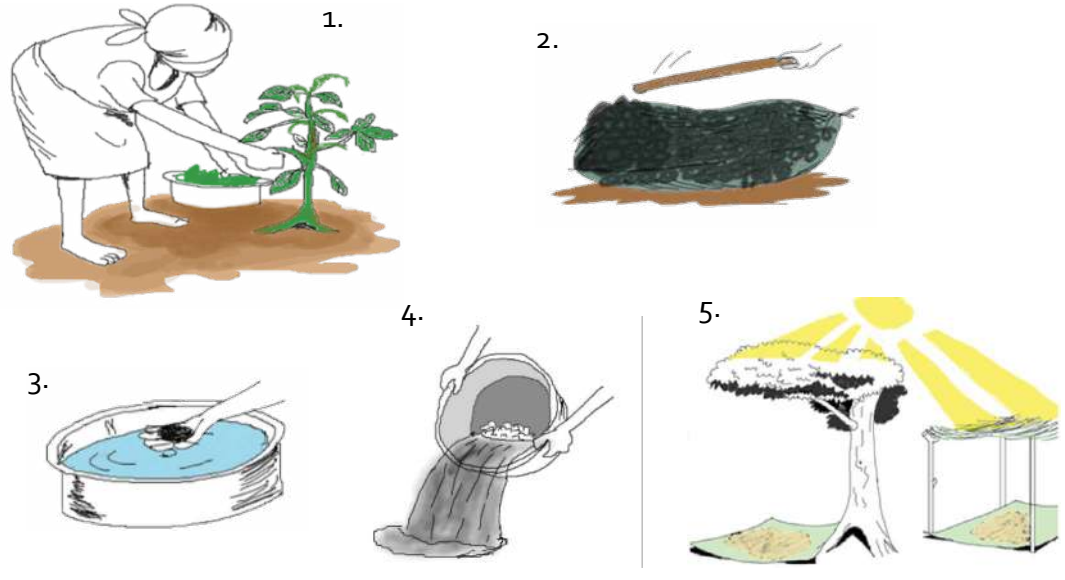


Illustration by Kevin Owesa

AIV	Type of processing	Seed harvest time
Nightshade	Wet	Fruits are black and shiny when seeds are mature. Harvest fruits and leave them for 24hrs in a dry, warm place before wet processing.
Amaranth	Dry	Small, black, mature seeds will fall out of the seed head/ flower when it is tapped. Some amaranth (grain types) have yellow/cream seeds.
Cowpea	Dry (to prevent germination)	Harvest when pods turn yellowish/brown and seeds are black and white or brown. Crop rotation is important to avoid brunchos (insects that eat beans from the inside).
Ethiopian kale	Dry	To protect against bean weevil, seeds can be dusted with wood ash to deter weevils during storage.
Spiderplant	Dry to prevent germination	Harvest when slightly dry pods turn yellowish brown and seeds are black and no longer stick to the pod. Spiderplant pods shatter easily, so they should be harvested when they are yellowish or just turning brown.

Caution

We do NOT recommend fermenting (soaking in water for several days) fruits/berries before processing as it reduces seeds quality.

Seed storage

- Clean seeds thoroughly using dry or wet processing to prevent contamination with bacteria and fungi which can cause moulding. Bad seeds should be removed.
- Seeds should be stored in a cool and dry place.
- Container should be airtight, so that seeds do not absorb water. Consider using jars or tins. Traditional storage containers like calabashes provide dry conditions and are also suitable.
- Ashes can be used to help preserve the seeds. Before storing, mix the seeds thoroughly with ash from the fireplace. Once the seeds are completely covered in dust, they can be stored in a cool, dry place.
- To maintain good germination, storage time should not exceed 2 years.
- If seeds are stored in plastic bags, keep them off the floor or away from places where mice and other rodents can reach them.

Seeds should be stored in sealed containers to prevent them from absorbing water and to prevent rodents. Simple plastic bags and bottles can be used, as can traditional gourds.

Avoiding cross pollination

Many AIVs, such as spiderplant, can easily be cross pollinated. Collecting seeds from cross-pollinated plants will mean that the plants grown from those seeds will be a cross of the different plants or varieties and may not be viable or have strong traits. For farmers growing different varieties, it is important that different varieties are kept apart from each other. Legumes like cowpea require 200 – 500 metres. All the nightshade family members, such as tomatoes, potatoes, eggplant, and African nightshades, need to be planted a distance of 1000 metres apart. Growing in green houses also helps prevent cross pollination.

Selling seeds

Currently, in Kenya, over 80% of smallscale AIV farmers are using seed that is not obtained from the seed companies. They use self-saved seeds or seeds bought from the local open-air market. Seed production regulations are very strict in Kenya. Farmers who want to produce and sell quality seeds must be registered with and meet the requirements for seed certification of the Kenya Plant Health Inspectorate Services (KEPHIS).

A community seed bank is as a central storage location for all seeds from a community. In many villages, there are farmers who are known among community members for keeping and maintaining seeds. Unlike other farmers, they are keen to produce seeds for sale or trade.

Seeds are also collected and maintained by KALRO stations in some regions.

Seeds can be marketed in simple packaging which clearly states the type of seed, variety, date of harvesting, and weight/amount of seed in each bag.

Box 11: How to set up a Community Seed Bank

Adapted from FAO (2014)

Steps

1. All farmers and other community members should be involved when setting up a community seed bank. They should agree on the establishment of the bank as well as the objective(s) of the bank; for example, whether it is primarily to act as a supply seed stock in times of crises, to conserve indigenous seed varieties, and/or to earn income through the sale of seeds to neighbouring communities. Other issues that should also be addressed include which, how, and where seeds will be stored and maintained as well as who and how the bank will be managed (process and operational rules).
2. Establish a community management committee to manage the seed bank, according to the group rules.
3. Set up a clean and safe storage place. The storage place should be a room that is dry and cold and difficult for mice and rodents to access. Seeds stored in paper or plastic bags should NOT be stored on the floor to avoid rodent attacks and getting wet (in case of heavy rains).
4. Collect and select the seeds.
5. Record information about the seeds:
    - Name (local/other name)
    - Specific variety name or species
    - When it was collected
    - Where it comes from (seed source)
    - Year of harvest
    - Germination test (date & result)
    - Maturity data (from past experience)
    - Main characteristics of the plant (e.g. productivity, growth, colour, shape and size of the fruit)
    - Disease resistance or vulnerability
    - Expected time to be kept in the bank

6

Post-harvest handling and processing of AIVs

Nearly 50% of harvested African indigenous leafy vegetables do not reach the market or the consumer's table. Sometimes those that reach the market are not in good condition.

In order to reduce these losses, AIVs need to be stored and processed well after harvest to ensure freshness and quality. Suitable storage facilities are often unavailable after harvesting, during transport, and while they are in the marketplace. As a result, most harvested fruits and vegetables are stored in the open where they are exposed to dust, high temperatures, direct sun, and humid conditions while they are distributed and marketed.

AIVs that are consumed directly should be harvested shortly before preparation, then washed with clean water, and prepared immediately to avoid losing nutrients.

Products that are sold fresh need to be

- harvested quickly in the morning (or late in the evening, if vegetables are to be transported a long distance),
- stored in a cool place (see Charcoal cooler, below),
- packaged well (see page 66),
- transported by proper means without crushing them, and/or
- preserved or processed for value addition by using solar drying (p.64) or other techniques.

6.1 Keeping your harvested crop fresh

A big challenge for marketing freshly cut green vegetables is cold storage. Refrigerators are not widely available and, in places where they are available, they are too expensive for most small-scale AIV farmers, traders, and consumers. Additionally, electricity is unreliable, unavailable, and unaffordable to most AIV farmers, traders, and consumers. As such, many farmers lack cooling facilities.

Charcoal coolers or charcoal freezers are excellent, affordable alternative technologies to preserve the quality of freshly harvested fruits and vegetables without electricity. The system design lowers the air temperature and increases the moisture inside the cooler and can keep any vegetables and fruits fresh for up to 5 days. Small charcoal coolers can be used to keep produce fresh during transportation to market.

Box 12: How to build a large charcoal cooler

Materials (for a 4m² cooler)

- 12 wood posts (cedar, if possible): Length 1.8 meters, diameter approx 10cm
- 12 pieces of timber or wooden rafters
- 16 - 18 m² chicken wire
- 12m mesh wire
- Charcoal
- Polythene
- Nails
- Sawdust

Tools

- Hammer
- Thermometer

Steps

Start by constructing the base and walls:

1. Erect posts to mark the size of the cooler.
2. Put up three support timbers or rafters – at the bottom, top, and middle around each side of the posts.
3. Add chicken wire from the top to bottom of the inner side of the cooler and fix it in place with nails.
4. Add five layers of wire to make the chicken wire more firm
5. Now start with the outside: fix 3 feet of chicken wire.
6. Fill the gap between the inner and outside layers with charcoal and fix it in place with one line of mesh wire.
7. Repeat until reaching the top.
8. Seal inside and outside with polythene (leave no gaps or holes)

Next, construct the roof then floor.

9. Add timber or rafter on top leaving gaps of two feet between the rafter.
10. Add lanes of barbed wire.
11. Cover the whole roof with chicken wire.
12. Fill completely with charcoal of around ½ foot (15cm).
13. Alternatively, add grass to the roof. Make sure the grass is in a slanting/tilting position, so that rain will run off. Note that grass/makuti roofing needs to be replaced more often.
14. Insert door.
15. Pour sawdust onto the floor till ½ foot. For areas with many termites, do not use sawdust!

Starting the cooler:

16. Add water to the charcoal sides till it reaches the bottom
17. Leave to set for 3 days.
18. Add shelves to store vegetables

Note: The cooler needs to be watered every time the temperature exceeds 18° by adding water from the top. Always close the door and repair holes in the walls.

6.2 Preserving through drying

Drying is one of the oldest methods of food preservation. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Vegetables are often traditionally dried in the direct sun, but many nutrients are lost from the vegetables in the process. Instead, we recommend using a solar dryer.

Box 13: How to construct a solar dryer

Materials (for a 4m² solar dryer)

- 10-12 thick sticks or thin poles – depending on the size of planned solar dryer, each 1.5-2 metres long
- 20 m² transparent or light-coloured polythene sheets
- 40-50 thin nails
- 8-10 sticks to construct drying shelves
- 9-10 m² chicken mesh

Steps

1. Erect a frame using poles and tie or nail in place
2. Cover sides and the top with polythene, being sure to leave a door/entrance
3. If dryer is large, add a pole in the centre to support the roof and drain rain water
4. Construct shelves from chicken mesh

How to dry AIVs

- Wash the vegetables to remove dirt
- Chop vegetables to the size required for cooking (2-4 cm)
- Spread thinly on chicken wire
- Dry in a solar dryer for about three days
- When the vegetables are brittle and can be crushed, they are dry
- Package the dried vegetables to sell or consume during the dry season. Dried vegetables can be stored in paper or sealable bags and kept for up to 1 year.
- Store in a dry and clean place, away from mice and other rodents
- Note that if the colour turns darker, the vegetable may no longer be suitable for consumption

6.3 Preserving through fermentation

Fermentation process

Washed and dried leaves

Appropriate storage container

Day one

Day three

Day five

Photos by Eliud Wafula

Fermentation is a cheap and easy method of vegetable processing and preservation. In this method, selected lactic-acid-producing bacteria are used to prevent the growth of harmful food pathogens (germs). After fermentation, vegetables can be kept for up to one year without losing most of their vitamins and minerals. They taste and smell good, take less time to cook, and can be incorporated into high-energy biscuits, healthy juices, sauces, stews, and other foods.

Fermentation does not require specialised equipment; however, you should ensure that the container you use is clean and has a lid. Clean leaves can be fermented in whey, starter culture, or brine (salt). The water used for fermenting should be free from contaminants, so it is best to use boiled water. The fermentation process only occurs in an anaerobic environment, so the vegetables should be completely covered and weighed down to prevent them from floating. After fermentation is complete, the vegetables should be stored in a cool storage place.

How to incorporate fermented AIVs into your meals

- Wash your hands and utensils before handling the container of fermented AIVs to avoid contamination.
- Remove the amount of vegetables you need with a clean spoon.
- Cover the remaining vegetables in the milking basket. Ensure that they are covered in solution and a lid is placed firmly on the milking basket.
- Cut the vegetables in smaller pieces.
- Steam for 2-3 minutes or fry with other ingredients.
- Fermented AIVs can also be blended with yoghurt or juice to make a drink.

Caution

Fermented vegetables must remain in the solution. Avoid any contamination and always wash your hands and the clean ladle before removing any fermented vegetables from the milking can..

Box 14: How to ferment vegetables

Materials (for a 4m² solar dryer)

- 5L fermentation vessel or milking basket
- Heavy weight (for example, heavy pans or plates)
- 1 kg of AIV leaves
- 60-70% lactic bacteria starter cultures which can be purchased at Jomo Kenyatta University of Agriculture and Technology in Juja (Food Science and Technology).

Fermentation solution

- 3 litres of water
- 30 g sugar
- 30 g salt

Steps

1. Prepare the fermentation solution by mixing sugar and salt into water and boiling for 3 minutes. Let it cool completely.
2. Wash the vegetables in plenty of water.
3. Drain the leaves by putting them on a clean cloth and air drying for 5-10 minutes.
4. Put leaves into the milking basket.
5. Add the cooled sugar/salt solution to the milking basket.
6. Press the leaves with a heavy, clean weight, so that the leaves are completely immersed in the solution.
7. Sprinkle lactic bacteria starter culture on top of the water and swirl gently.
8. Leave to rest/ferment for 5 days after which AIVs can be eaten.

6.4 Packaging your harvest

Packaging protects AIVs from losses and contamination during distribution and marketing. In 2017, the Kenyan government banned the use of ordinary plastic bags ('jwala') commonly used in packaging of fresh commodities. Unfortunately, there are currently no standard packaging materials for AIVs. Most farmers use ganny bags ('gunia') or old newspapers ('gazeti') for distribution and marketing. These packaging materials can spoil very quickly and can have a negative effect on the quality of the AIVs.

Packaging materials

- Biodegradable packing materials look and feel just like ordinary clear plastic bags and can be used to reduce loss and preserve the quality of AIVs. They are easy to carry, durable, water resistant, and come in different sizes. They are suitable for marketing AIVs.
- Non-woven carrier bags extend the shelf life of AIVs by three days. They are available in Kenyan supermarkets for as low as Ksh 10.

AIVs are commonly sold in busy markets such as this one. This type of packing causes vegetables to spoil quickly. Producers and market vendors should consider using other packaging materials to deliver a higher quality product and gain their customers' repeat business.

6.5 Transporting your harvest

Transporting AIVs from the farm to the consumer's plate can take time and cover a long distance. To reduce losses from crushing, wilting, and spoiling by contamination, a good transport system with good packaging is required. The traditional 90 kg gunny bags (gunia) that are very often used are NOT recommended for packaging AIVs. In those large bags of overpacked vegetables, the sensitive leaves get damaged by crushing and spoiling as the bags get very hot.

AIVs should be transported in lightly packed plastic crates with good flow of air. To avoid spoiling due to high temperatures during the day, overnight transportation is recommended when vegetables must travel long distances to markets. Early morning or late evening transport is best to cover for short distances. For high value markets, single bag packaging is recommended to lengthen shelf-life and freshness for several days. The bag should be made of biodegradable plastics.

This typical market scene in Juja shows how AIVs are commonly sold. While this cart makes transport easier, it also restricts airflow and crushes vegetables.

Transporting and packing vegetables in stacking crates such as these allows for better air flow and reduces crushing.

Illustration by Kevin Owesa

7

Marketing AIVs

Due to the rising consumer awareness on the nutritional and health benefits of AIVs compared to exotic vegetables such as spinach and kales, their consumption has increased in recent past and they are now traded in various market outlets in Kenya. While production of AIVs has increased in Kenya, yields do not yet meet the consumer demand, especially during dry periods/seasons when the majority of farmers do not produce AIVs due to lack of irrigation technologies. To meet consumer demand for AIVs in urban markets, farmers need to consider these aspects: producing a premium (high-quality) product, adding value (processing) their product, and producing their product at the right time. We will address each of these factors briefly below.

Activity suggestion

To help you understand land preparation practices and techniques, we suggest you conduct Activity 4 on page 74.

Premium products: Urban consumers would buy more AIVs if prices are cheaper, but just as many are willing to pay more money if the quality of the vegetables is high and they can be sure that only potable and clean water was used for farming and cleaning the vegetables.

Value addition

Value-added products and particularly processed vegetables are fairly new to Kenyan markets. Kenyan consumers are interested, but also rightly skeptical. They want reassurance of the safety of the products, particularly in regard to the hygiene and water that was used during preparation. An important step will be gaining customers' trust through personal contact or through a reliable supermarket chains (such as Tuskys, Naivas or other local supermarkets).

Value-added products: Market research shows that most urban consumers eat AIVs four times per week. AIVs are usually bought fresh in the market and consumers prepare and cook them at home. However, AIV preparation takes time, which can make consuming AIVs regularly difficult for households with adults engaged in full-time work outside the home. A way to increase profits from AIV sales is to provide these new, wealthy, and busy customers with ready-to-eat AIV products. This may include washing, plucking, cutting, and bagging them before selling. Some producers may also boil the vegetables before bagging them. Additional ingredients such as onion, tomato, or herbs might be supplied to the consumer as part of the package. Preparation needs to be done in very good, hygienic conditions. This means washing the vegetables in potable water, using clean kitchen utensils, cooking in clean pots, and adding only fresh ingredients (onion, herbs, etc).

Well-timed products: The short shelf life of AIVs paired with consumer demand for the product creates a constant demand for AIVs throughout the year, regardless of the season. In the dry season, very small quantities of AIVs are available on the market. Farmers who supply AIVs to urban markets at this time are rewarded with a significantly higher price for their products. For farmers who want to produce AIVs during the dry season, they need to water their crops very regularly to ensure high productivity of a high-quality crop. In the rainy season, however, prices drop because the supply of AIVs is high since many farmers are able to produce AIVs, making it very difficult to compete during that time of the year.

Illustrations by Kevin Owesa

As a "golden rule", when selling in small, local markets, sell vegetables in bundles on a clean, enhanced surface

7.1 Collective marketing of AIVs

A big challenge for farmers is that they get very limited market information about urban (high value) markets. The costs of production and transport prevent individual farmers from making good profits. Farmers wishing to specialise in AIVs and access upscale markets are advised to join formalised farmer collective groups or well-established cooperatives or set up one of their own with neighbouring farmers. The group must be officially registered with the relevant national or county government authorities.

Being part of a formal farmer collective action group (or cooperative) has many advantages to individual farmers. Here, we list a few.

Reduced costs

- As a group, farmers can buy inputs (like organic fertiliser, biopesticides, etc) in bulk or share production equipment (such as water tanks, drip irrigation, solar pumps, etc). This will significantly reduce costs.
- Adopting a shared production and cropping calendar with other farmers allows farmers to better plan for inputs requirements

Better lobbying position for pro-farmer policies and rights

- Being part of a registered and recognised growers association allows farmers a more firm stance to have their concerns raised at value-chain platforms coordinated by the government. Farmer group representatives can advocate for changes to local regulations which could better support farmers, their families, their farms, and their ecosystem.
- When organised as a group, farmers can negotiate with local market authorities (called 'Market Management Committees') for actions which help them access markets more freely, for example, reducing market fees, booking high-pedestrian-traffic areas of the market, etc.
- Farmers organisations have power and voice to make their lobby efforts heard. For example, there may be room for lobbying for the adoption of the crate system as a common measurement unit as has been done with tomatoes and onions.
- Sizable growers associations may represent the majority of farmers who would, otherwise, supply individually to grocers. Organised as one unit, grower organisations are better able to negotiate with supermarkets since they represent the majority of their growers. They may, for example, negotiate for decentralised procurement systems which would allow local supermarkets to buy from local farmers, following the former Uchumi system of local distribution centres.

Transportation and packaging/branding

- Communal transport of AIVs to markets significantly reduces costs for individual farmers.
- Farmers within organisations can share standardised plastic crates for transportation and marketing. Groups should write their name, production location, and perhaps a logo on each crate to increase visibility of their group. This will help to build a brand that consumers know and understand to be safe, healthy, and locally sourced. Once your organisation's "brand" is established, your group can engage in other packaging/branding strategies together, for example, you could provide AIV recipes on your packaging.

Packaging and branding

An example of how your farmer organisation can use AIV recipes as a marketing strategy is provided on page 70. Add your farmer group's name and telephone number so that customers can order vegetables.

Higher revenues

- If farmers jointly market their harvested products, they can provide markets with more variety and higher quantities. Where farmers combine their harvests, it is easier to meet the constant quantity and quality requirements of high-value buyers like supermarkets throughout the year. This can be achieved if farmers adopt a shared production and cropping calendar
- By pooling their resources, farmers can access professional services to grow their business. For example, they can hire a consultant to optimise production or a broker that works only in the interest of the farmers and finds the most profitable markets for their crops.
- Farmers who are organised in associations are better positioned to bargain for good prices and other conditions when signing contracts with supermarkets or traders

Farmer group set up

For farmer groups to work, it is very important to have well defined tasks, roles, and rules among all members. Financial transactions need to be fully transparent and need to be recorded for several years, so that disputes can be settled easily.

You can find more information at:

http://www.farmlinkkenya.com/link-to-farmer-cooperative-societies/

https://cak.coop

Cooperative Alliance of Kenya is the apex organisation for all cooperatives in Kenya (i.e. working on issues at the national and international level and representing the broadest range of cooperatives).

7.2 Marketing contracts

Farmers should demand and negotiate contracts with bulk buyers. These contracts should include:

- **Contract period:** Start and end date
- **Cultivation practice:** What AIVs need to be produced and how (organic or conventional)
- **Production limits:** How many kg or bundles?
- **Quality agreement:** What quality standards should vegetables meet?
- **Collection/delivery:** Is the final produce being collected or does it need to be delivered to a central collection point?
- **Price agreements:** The price per kg or bundle for each crop
- **Payment procedures:** When are farmers paid and how?

When farmers have fixed a contract on quantity, quality and price of the AIVs, they do not need to negotiate those terms each time they sell. This saves time, allowing the farmer spend time doing other things like optimising production, supervising hired labourers, or spending time with the family.

When selling to supermarkets, it is very important to sign 'tight contracts' that regulate the exact quantities of vegetables and regular delivery schedule, for example, delivery of five crates of Nightshades and three crates of Amaranth every Monday and Thursday at 7am.

Tight contracts also have detailed payments agreements and payments dates. Contract should avoid the 'consignment model of paying' where the farmer only gets paid for the vegetables that are sold by the supermarket. It is very difficult for the farmer to pick up unsold vegetables or to prove the amount of vegetables sold. Supermarkets can use unsold vegetables to produce pre-prepared, ready-to-eat meals.

If farmers work together as farmer organisations or marketing organisations, they will increase their power to negotiate the terms of the contract and supply larger quantities of produce.

Benefits of marketing contracts

- Contracts provide more stable prices and allow long-term production planning. When farmers know how much and when they need to deliver AIV, they can better anticipate land, labour, and input needs. For example, they will be better able to plan when to prepare compost and when to start seeds in a nursery.
- Long-term planning is important when purchasing inputs. Some inputs are in short supply or expensive. When farmers and buyers agree on a certain quantity and quality of AIVs for a certain time, those expenditures can be planned ahead of time and farmer can make purchases when input costs are lower.
- Having a contract may help farmers access credit since their marketing agreement serves as proof of regular income.

Disadvantages of marketing contracts

- Changes in the weather, pests, and diseases might make it difficult for farmers to supply the amount and quality of output agreed in the contract.
- Individual farmers may find it difficult to supply the quantities required by buyers.
- Farmers might not be able to sell all their produce if it does not meet the quality standards agreed in the contract. To avoid this situation, farmers are advised to look for alternative markets.
- Farmers might find it difficult to bargain for reasonable prices, especially if they approach the market as individuals among other competing individuals.

Caution: Do not break the contract that you or your farmer group established with a school, hospital, supermarket, or other contractor: do NOT sell to someone else who might be offering a better price!

Getting a contract is very difficult and should be honoured from both sides. Your contract partner's trust may prove impossible to regain. If you break your contract, your contract partner may quickly look for another reliable source of vegetables, which means you lose out for good.

Spiderplant

Preparation and cooking 35-40 minutes

Wash vegetables 2-3 times and drain (**5 min**)
Pluck vegetables and place in a pan (**15 - 20 min**)

Add about ½ cup of water and cover with a lid
Boil/steam (**15 min**)

Fry onions in oil until brown
Add tomatoes and fry until soft (**5 min**)
Add vegetables and mix well
Add milk or cream
Simmer (**5 min**)

Serve

INGREDIENTS

Spiderplant: 3 bunches
Amaranth: 1 bunch
Cooking oil
Tomatoes
Onions
Groundnut paste
or Fresh Milk
or Cream

African Nightshade

Preparation and cooking 35-40 minutes

Wash vegetables 2-3 times and drain (**5 min**)
Pluck vegetables and place in a pan (**15 - 20 min**)

Add about ½ cup of water and cover with a lid
Boil/steam (**10 min**)

Fry onions in oil until brown
Add tomatoes and fry until soft (**5 min**)
Add vegetables and mix well
Add milk or cream
Simmer (**5 min**)

Serve

INGREDIENTS

Cooking Oil
Tomatoes
Onions
Cream
or Fresh Milk
or Groundnut Paste
Amaranth: 1 bunch
African Nightshade: 3 bunches

Marketing

Here, we provide examples of recipes that you can use to help market your AIVs. Copy the recipes and add your farmers group's name and telephone number so that consumers can order directly. For more information, please see page 67.

8

Additional resources

8.1 Teaching/Learning activities for trainers

This handbook is designed to support farmers as well as trainers and extension officers. To transfer the methods and principles of growing AIVs to farmers in trainings and workshops, we suggest trainers and extension officers maximise their impact through thorough preparation.

BEFORE the training

- Read the entire handbook thoroughly.
- Plan topics (harvesting, marketing, etc) to incorporate into the training. Consider which suggested exercises and methods you wish to include and the structure of the training (length, practical exercises, break times, etc). Bear in mind the number of participants and their background (age, gender, type of farmer).
- Consider which visual aids, props, or practical exercises can be used to communicate and visualise the content.
- Plan a visit or hold the training at a farm where AIVs are already grown and some of the methods that are introduced in this book are being used. Most people learn best by seeing new tools and practices demonstrated as well as from feedback from other practitioners. In the words of Confucius, "I hear and I forget. I see and I remember. I do and I understand."
- Arrange materials, stationery, and supplies including photocopies well in advance.

DURING the training

- Explain and agree upon the training course topics and structure with the farmers. Try to find out and incorporate their needs and specific challenges.
- Select a timekeeper and agree upon rules for participants.
- Encourage participants to ask for clarification when they do not understand.
- Keep time and have regular breaks.
- Make the course active by engaging the participants, for example by conducting exercises together. You can use some of the activities in this section.
- At the end of the training, ask for feedback about your facilitation and aspects of the training. Evaluation/Feedback from the farmers could include the following questions:
    - What are the most important farming practices you learned during this training?
    - Which part of the training was the least relevant to you?
    - Which of the introduced practices will you adopt?
    - What changes will you make as a result of this training?
    - Was the pace of the training: a) good b) too fast c) too slow
    - What topics would you like to learn more about?
    - How can this training be improved?

AFTER the training

- Reflect on the training: Did you stick to the topics and structure you planned?
- Reflect on your "lessons learned" from the training and make notes on what worked well and what you might want to change if you conduct a similar training for farmers.
- To continue to support farmers' progress, give them options to contact you when they have questions.
- Conduct a follow-up meeting a few months later.

Activity 1

Aim: Conduct this group exercise to get an understanding of how familiar farmers are with AIVs at this point. You can use this also to identifying knowledge gaps or determine the focus of future training sessions.

Method: Group work and collection of answers

Time frame: 30 minutes, depending on group size

Step 1: Hand each group a paper and ask them to answer the following questions:

- Which AIVs or 'old traditional vegetables' do you already know?
- Which ones have you grown in the past or are growing on your farm now?
- What are some of the traditional knowledge/uses of particular AIVs?
- For what purpose (food, selling, or medicinal) do/did you grow AIVs?

Step 2: Discuss and document the following questions on a flip chart or poster.

- What are your main challenges growing AIV?
- Where do you get your seeds?
- What pests or diseases affect your AIVs and what do you do to fight them?
- When do you harvest each AIV (after how many weeks)?
- How do you harvest AIVs (uprooting, cutting at the base, or pinching)?
- Do you sell any of the AIVs? If yes, where?

Advice: Keep the posters/flip charts and revisit those challenges and practices at the end of the training. Identify those that could be better addressed using the new strategies and improved methods this handbook proposes.

Activity suggestion

This activity was designed to introduce participants to the topics covered on page 8 of this handbook.

Activity 2

Aim: Conduct this group exercise to get an understanding of current land preparation practices and adaptation strategies.

Method: Group work and plenary

Time frame: Try to limit the exercise to 30 minutes, depending on group size

Step 1: Ask farmers to form groups. Hand each group a sheet of paper to record their answers to the following questions:

- When do you start to prepare your land for cultivation?
- Do you have any problems with the soil (too dusty, not fertile, etc.)? If so, what do you do about it?
- What kind of fertiliser do you use?
- Do you make compost from animal manure?

Step 2: In plenary, ask the participants to share their answers. For each point raised, be prepared to supplement answers with solutions from the handbook.

Activity suggestion

This activity was designed to introduce participants to the topics covered on page 20 of this handbook.

Activity 3

Aim: Conduct this group exercise to get an understanding of the current agronomic practices applied by farmers.

Method: Group discussion

Time frame: Try to limit the exercise to 30 minutes, depending on group size

Step 1: Sit in a circle and ask each farmer:

- How often do you water your plants?
- What is the source of your water?
- What tools do you use?
- Do you practice mulching?
- What are the most common pests that attack your crops?
- What are the most common diseases that affect your crops?
- What do you to do minimise those pest and diseases?

Activity suggestion

This activity was designed to introduce participants to the topics covered on page 30 of this handbook.

Activity 4

Aim: Conduct this group exercise to establish what marketing activities farmers currently conduct and how these can be improved.

Method: Group discussion

Time frame: Try to limit the exercise to 30 minutes, depending on group size

Step 1: Sit in a circle and ask each farmer:

- Do you sell or consume at home?
- How much of your harvest do you sell? For example, "I sell half of my bean harvest while the rest we consume at home."
- Where do you sell your AIVs?
- To whom do you sell your AIVs (e.g. middlepersons, consumers, or other retailers)?
- Do you usually get the price that you want?
- Are you organised in a farmers group?
- What are some challenges you face in selling your AIVs?
- Do you do any processing before selling or consuming to add value?
- Are you aware of other uses of the AIVs (e.g. adding to other foods like bread) other than direct consumption?

Activity suggestion

This activity was designed to introduce participants to the topics covered on page 66 of this handbook.

8.2 Where to seek further assistance

Information on agroecology: FAO http://www.fao.org/agroecology/home/en/

Government Institutions

KALRO
Website: www.kalro.org
Email: info@kalro.org
Phone: +254 722206986/722206988

Research Organisations

Jomo Kenyatta University of Agriculture and Technology (JKUAT) Department of Horticulture

Centre of Excellence for Research and Innovation on Indigenous Bio-Resources and Climate Change Adaptation (CERIIBioCCA)
Website: http://www.jkuat.ac.ke

- Professor Mary Abukutsa (abukutsa.mary@gmail.com and +254722676907)
- Professor John Wesonga (jwesonga@agr.jkuat.ac.ke and +254-724944014)

Egerton University – Dr. Arnold Matthew Opiyo, Faculty of Agriculture, http://foa.egerton.ac.ke

Alliance of Bioversity International and CIAT c/o ICRAF
P.O. Box 30677, 00100 Nairobi, Kenya
Tel. (+254) 20 722 4513
Website: https://www.bioversityinternational.org
Email: bioversity-kenya@cgiar.org
For information on AIVs:

- https://infonet-biovision.org/indigenous-vegetables
- https://infonet-biovision.org/about-us

Support Organisations

Community Sustainable Agriculture and Healthy Environmental Program (CSHEP)
P.O. Box 665 Kiserian
Email: cshepkenya@gmail.com
Tel: Esther Kagai 0727977009
Stephen Kamau: 0720 841233

Rural Outreach Programme (ROP)
http://www.ruraloutreachafrica.org

Anglican Development Service
Website: http://adskenya.org

Kenya Organic Agriculture Network (KOAN)
Website: https://www.koan.co.ke

Sustainable Agriculture Community Development Programme (SACDEP)
Thika P.O. Box 6123-1000 Upper Hill Rd
Email: sacdepkenya@iconnect.co.ke
Website: https://www.sacdepkenya.org

Sustainable Organic Farming and Development Initiatives (SOFDI)
Website: https://sofdi.com

BIOVISION Organic farmer magazine
http://www.infonet-biovision.org/indigenous-vegetables

Seed suppliers

SIMLAW Seeds
Mobile: 0722 - 200 545 / 0734 - 811 861
Website: http://www.simlaw.co.ke
Email: info@simlaw.co.ke

Kenya Seed Company
Mobile: 0722 -205 144 / 726 141 856
Website: http://kenyaseed.com
Email: info@kenyaseed.co.ke

ICT solutions

WeFarm
https://wefarm.org

8.3 References and recommended reading

Abukutsa, M. O. O. (2010). African indigenous vegetables in Kenya: Strategic repositioning in the horticultural sector. Jomo Kenyatta University of Agriculture and Technology.

Belmont Acres Farm, "Ethiopian kale". 1 Nov, 2018. Online image. Flickr.

Cook, S., Silici, L., Adolph, B., and Walker, S. (2015) Sustainable intensification revisited. IIED Issue Paper. Retrieved from: http://pubs.iied.org/pdfs/14651IIED.pdf

FAO (2014) Facilitators' guidebook for farmers' field schools, FAO, Apia. Retrieved from: http://www.fao.org/3/a-i7110e.pdf

FAO (2014). Community seed banks - Junior Farmer Field and Life School - Facilitator's guide. FAO, Rome. Retrieved from: http://www.fao.org/3/a-i3987e.pdf

FiBL and BioRe (2014). How to spray: Guideline for an effective application of self-made organic pest control products. Retrieved from https://systems-comparison.fibl.org/fileadmin/syscom/documents/Leaflets/11_Application_ENG.pdf

FiBL (2012). African Organic Agriculture Training Manual. Version 1.1 December 2012. Edited by Gilles Weidmann and Lukas Kilcher. Research Institute of Organic Agriculture FiBL, Frick

Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., ... & Wiedenhoeft, M. (2003). Agroecology: the ecology of food systems. Journal of Sustainable Agriculture, 22(3), 99-118.

Gockowski J., Mbazo'o J., Mbah G., Moulende F.T. (2003). African traditional leafy vegetables and the urban and peri-urban poor. Food Policy 28: 221- 235.

IIRR - International Institute of Rural Reconstruction. (2000). Sustainable Agriculture Extension Manual. Retrieved from: https://betuco.be/voorlichting/Sustainable%20agriculture%20extension%20manual.pdf

IIX Foundation. (20. December 2016). Farming Data: Cultivating Insights for Agriculture in Asia. Retrieved from https://iixfoundation.org/farming-data-cultivating-insights-agriculture-asia/

Kulinski, K. L. (2018). Cultivation, marketing and economic viability of African Indigenous Leafy Vegetables in dry season considering food losses. Masters Thesis.

Leary, M., Moulton-Patterson, L., Paparian, M., Marin, R., Mulé, R., Peace, C., & Washington, C. (2004). The Worm Guide: A Vermicomposting Guide for Teachers (State of California, California Integrated Waste Management Board, Education and the Environment). Retrieved June 7, 2012.

Mandloi, L. S., Utz, C., Zweifel, J. and Verma, R. (2014). Farming Systems in the Tropics. Leaflet series: "Preparation and Application of self-made organic pest control products". FiBL. Retrieved from: https://systems-comparison.fibl.org/en/scp-publications/leaflets-brochures.html

Mwai, G. N., Onyango, J. C., & Abukusta-Onyango, M. O. (2007). Taxonomic identification and characterization of African nightshades (Solanum L. section Solanum). African Journal of Food, Agriculture, nutrition and development, 7(4), 1-16.

Organic without boundaries (2018). Agroecological Farming Principles Illustration_Photo courtesy of E. Wikander/Azote. Retrieved from https://www.organicwithoutboundaries.bio/2018/08/08/agroecological-farmers-rethink/rethink_res_princ/

Rana, S.S. (no date). Biological Intensive Nutrient Management: Vermicompost. Retrieved from: https://mafiadoc.com/vermicompost_5b8ad23b097c4705368b4684.html

United Nations Children's Fund (UNICEF) (2013). Improving Child Nutrition: The achievable imperative for global progress. Retrieved from: https://www.unicef.org/publications/index_68661.html

Weinberger, K., & Swai, I. (2006). Consumption of traditional vegetables in Central and Northeastern Tanzania. Ecology of Food and Nutrition, 45(2), 87-103.

„[T]he HORTINLEA project scientists and collaborators went beyond producing multi-disciplinary scientific knowledge on African indigenous vegetables (AIVs) and turned that knowledge into a practical guide for growing and marketing AIVs tailored to those who need it the most: the extension workers and practitioners or, in other words, the people producing the foods contributing to our health."

Dr. ir. Céline Termote
Africa team leader, Food Environment and
Consumer Behaviour lever
Alliance of Bioversity International and CIAT

„It is an art and a challenge to derive sound recommendations for upgrading smallholder production and marketing practices from scientific findings. The handbook contains the main steps for upgrading the AIV value chain from sowing and planting, tillage, pest and disease management, irrigation and water management, harvesting, and post-harvest activities. These steps are complemented by information on how to keep farm records and where farmers may obtain further information in Kenya."

Dr. Silke Stöber
Senior scientist
Centre for Rural Development (SLE)
Humboldt- Universität zu Berlin